THE EFFICIENT MARKET HYPOTHESIS AND THE UKRAINIAN STOCK MARKET

by

Dedov Maxym

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Abstract

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Chairperson of the Supervisory Committee: Professor Anatoliy Voychak
Director of the Christian University

The paper overviews the historical development and peculiarities of the concept of efficient markets, investigates the behavior of the Ukrainian over-the-counter stock market returns by testing the weak form of efficient market hypothesis, examines time variance property of return volatility and its influence on the market returns themselves, identifies some implications of the empirical findings. Application of the heteroskedasticity consistent variance ratio tests to weekly stock returns results in rejection of the joint hypothesis of weak-form efficiency and the random walk model of price behavior. GARCH(p,q) models estimated for the same data confirm the assumption of volatility clustering of returns, and suggest no significant effect of conditional volatility on returns.

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GLOSSARY

Akaike information criterion (AIC). A guide to the selection of the number of terms in an equation. It is based on the sum of squared residuals but places a penalty on extra coefficients. Under certain conditions, the length of a lag distribution is determined, for example, by choosing the specification with the lowest value of the AIC.

Autocorrelation coefficient. A measure of linear association between two values of a time series that are a chosen number of periods apart.

Autoregressive Conditional Heteroskedasticity (ARCH) models. The class of models was proposed by Engle [1982] to capture the serial correlation of volatility of a dependent variable. The time-variant volatility is represented as a distributed lag of past squared innovations.

The week-end effect. The observed phenomenon that security price changes tend to be negative on Mondays and positive on the other days of the week, with Friday being the highest of all.

Efficient Market Hypothesis (EMH). The concept in financial economics which states that capital market prices utilize all available information instantaneously and reflect it correctly. One of the direct implications of the EMH is impossibility of abnormal returns while trading on available information. For empirical purposes a set of available information is split into three parts, hence the forms of the EMH.

Generalized Autoregressive Conditional Heteroskedasticity (GARCH) models. The class of models introduced by Bollerslev [1986] as a way to model persistent movements in volatility without estimating a very large number of coefficients of the lag polynomial of an ARCH model. Changing volatility is conditional on past squared innovations and its own lagged values.

January effect. A well-known anomaly based on observation of inexplicably high stock returns in January, with small firms performing relatively better than large firms.

Schwarz information criterion. An alternative to the AIC with basically the same interpretation but a larger penalty for extra coefficients.

Stock split. An accounting decision to change the number of shares outstanding without selling any more to the public. A stock split can be either a forward (direct) split or a reverse split.

Volatility clustering. This property of volatility of stock returns to change over time and be serially correlated. Practically, volatility clustering implies that large returns (of either sign) tend to be followed by large returns and vice versa.

Chapter 1

INTRODUCTION

The concept of the efficient market hypothesis (EMH) in relation to security prices was rigorously developed about two decades ago. Since then it has been one of the central research paradigms in financial economics. The available theoretical and empirical findings represent different stages of the development of the concept reflecting various views of researches.

The early empirical findings based primarily on the data of developed stock markets implied that security prices reacted instantaneously to all publicly available information. These findings formed the basis for the early definitions of "capital market efficiency" (Fama, Fisher, Jensen, Roll [1969], Fama [1970]). The concept of "efficient capital markets" was viewed in close connection with the broader theory of rational expectations.

Later empirical work produced the results that were not so much consistent with the earlier findings. The evidence of stock prices both under- and over-reaction to various events such as, for example, earnings announcements implied that markets deviated systematically from what was defined "efficient" (Ball [1978], De Bondt and Thaler [1985, 1987]). The evidence of the anomalies (day-of-the-week, January effects, etc.) in stock prices behavior resulted in stronger qualification of economists' views on capital markets.

The definition of "market efficiency" incurred debate. Further, theoretical models were developed refuting the possibility of securities prices perfectly reflecting all information (Grossman and Stiglitz [1980]).

Therefore, the first part of the paper is exploratory. It is focused on the history of economic thought in the area of efficient capital markets so as to assess its plausibility as the basis for empirical work. Alternative definitions

of market efficiency are surveyed and the differences in empirical findings are explained. We reach the conclusion that the EMH is an encompassing theoretical framework for empirical research of stock market price behavior.

It is difficult to overstate the importance of a well-functioning stock market for a developing economy. We argue an efficient stock market possesses sufficient conditions to be defined as well-functioning. As a result, certain implications of stock market efficiency for a developing economy are introduced. The implications relate i) to the quality and perception of the privatization process in a developing country and ii) to the likelihood that benefits of a well-functioning stock market are realized by the economy.

The second part of the paper attempts to contribute to the evidence on the extent of informational efficiency and the relationship between risk and return for emerging markets. Using data of the Ukrainian stock market, tests of weak-form efficiency are performed. The efficiency tests are based on the random walk assumption of price behavior. Additionally, the characteristics of return volatility are examined. The joint hypothesis of weak-form informational efficiency and random walk behavior of the stock market indices is strongly rejected. Also it is found that volatility of market index returns changes over time and is serially correlated. However, changing volatility does not have significant effects on returns themselves.

We conjecture the violations of certain conditions necessary for an efficient market. Improvement of these conditions will lead to a relatively higher efficiency level of the Ukrainian stock market.

The paper is organized as follows. The second chapter explores the theory and available evidence on efficiency of capital markets. The third chapter introduces the methodology for empirical research. The fourth chapter reveals the institutional characteristics of the stock market segment chosen for empirical research. The fifth chapter presents the empirical results and their implications. .The sixth chapter summarizes and concludes the paper.

Chapter 2

THE EFFICIENT MARKET HYPOTHESIS

2.1 Development of the concept

Rational expectations hypothesis

The idea of efficient markets emerged as early as the beginning of the twentieth century in the work of Bachelier [1900] and empirical research of Cowles [1933]. More rigorous study of market price behavior was carried out in the work of Samuelson [1965].

The concept of the "efficient capital markets" is now recognized as an application of the broader theory of rational expectations. Muth [1961], who founded the doctrine of rational expectations, supposed that the way to ensure rationality of expectations was to require them be consistent with the models used to explain behavior of economic agents. Formally, if $f(X_t|I_{t-1})$ is defined as the conditional probability density for the random variable X_t, given the information set *I* available at time *t-1* then

$$E[X_t|I_{t-1}] = \int_a^b X_t f(X_t|I_{t-1}) dX_t$$

is the conditional expectation corresponding to this density function. An error of a forecast is defined as $\varepsilon_t = X_t - E[X_t|I_{t-1}]$. The error has two main properties:

i) $E[\varepsilon_t|I_{t-1}] = 0$, which states that the expectation of a forecast error (conditional on the information available at time t-1) is zero;

ii) $E[\varepsilon_t \cdot I_{t-1}|I_{t-1}] = 0$, which states that forecast errors are uncorrelated with any information available to economic actors, or no improvement of the forecast (by incorporating this correlation into it) is possible. The implication of it is that only unanticipated impulses acting on the system can cause the actual value of a variable to differ from its permanent path.

Muth [1961] defined economic agents' subjective, psychological expectations of economic variables as mathematical conditional expectations of those variables. If we let ${}_{t-1}X_t^e$ be the subjective, psychological expectation for a variable X_t, then it follows that ${}_{t-1}X_t^e = E\left[X_t \middle| I_{t-1}\right]$. Hence, there is a connection between the beliefs of individual economic actors and the actual stochastic behavior of the system.

To sum up, expectations "are rational if, given the economic model, they will produce actual values of variables that will, on average, equal the expectations" [Sheffrin, 1996, p.7]. Expectations will diverge from actual values because of some unforeseeable uncertainty in the system.

It is not necessary for all individuals to have identical expectations. As Sheffrin [1996] point out if there is enough arbitrage activity the market will behave as if it is rational, even though many individuals in the market may be passive. This perspective leads to the understanding that the rational expectations hypothesis could be especially applicable to markets where arbitrage is relatively costless such as financial markets[1].

However, the theory of efficient capital markets was not originally introduced with the intent to justify the concept of rational expectations. Its formulation was the effect of "large empirical work that preceded the development of the theory" [Fama, 1970, p.384]. Empirical methods were the primary means for establishing market efficiency. The failure to find any systematic inefficiencies in the past was used so as to formulate the concept.

Definition of market efficiency

In the process of development of capital market efficiency it is possible to recognize two different approaches [Ball, 1989]. The "empirical" tradition of Chicago school, developed by Fama [1970, 1976], established earlier formal foundations of the EMH. The "information economics" approach was followed

[1] In the paper the terms "efficient market hypothesis" and "capital market efficiency" are used interchangeably.

in works of Rubenstein [1975], Beaver[1981], Lathem[1986] who introduced alternative definitions.

The early work on capital markets followed the implications of competitive equilibrium models. Publicly available information is taken to be costless. A competitive equilibrium, thus, requires expected returns of trading on information be zero. In the spirit of Samuelson's [1965] work, price changes under the efficient market hypothesis (EMH) are assumed to follow random patterns[2]. That is, the price of a security today is equal to the conditional expectation of the tomorrow's price. The change in the price between today and tomorrow is analogous to the forecast error in the rational expectations concept.[3].

Fama [1970] states that prices in an efficient market always "fully reflect all available information" [p.383]. The sufficient conditions for market efficiency defined by Fama [1970] concern capital market environment. In a market where a) there are no transactions costs, b) all relevant information is costlessly available to all market participants, c) all agree on the implications of current information for the current price and distributions of the future price of each security, the current price of a security should "fully reflect" all available information. These conditions ensure that investors possessing available information can not earn above-competitive returns. A violation of any of the conditions does not immediately imply inefficiency. For instance, the market "may be efficient if a sufficient number of investors have ready access to available information" [Fama, 1970, p.388]. However, violations of

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[2] In the context of security returns Fama [1970] presents the generalizing "fair game" model. Specifically, the market equilibrium conditions are stated in terms of expected returns based on some information set I_t: if $z_{j,t+1} = r_{j,t+1} - E[r_{j,t+1}|I_t]$ is an excess return, then $E[z_{j,t+1}|I_t] = 0$. The sequence of excess returns is a "fair game" with respect to the information sequence $\{I\}$ (Fama, [1970, p.385]). The random walk model is recognized as an extension of the "fair game" model.

[3] Samuelson [1965] stated that in an informationally efficient market price changes must be unforecastable if they are properly anticipated, i.e. if they fully incorporate expectations and information of all market participants.

these conditions may potentially impede efficient adjustment of prices to information.

Further Fama [1976] refines the initial definition stressing that the market uses all available information correctly. The essence of the correct current price is that it utilizes all available information efficiently and, hence, "fully captures the uncertainties about the future" [Keane, 1983, p.18]. Therefore, the probability distribution of future prices assessed by the market at a point in time is identical to the "true" distribution, both of them conditional on all available information at that time. Fama's definitions display an important characteristic inherent to the "empirical" tradition. Empirical school ignores the process of aggregation from individual to the market treating it as a "black box"[4].

Fama [1970] also puts forward the classification of different information sets. "Weak" form efficiency assumes the information set that includes past prices. "Semi-strong" form asserts that prices reflect all relevant publicly information. "Strong" form adds information held only by some market participants to all publicly available information. The purpose of the categorization was to trace the information level where the EMH breaks down. It must be noted that the distinction between semi-strong and strong forms of the EMH was recognized to give a misleading impression [Keane, 1983]. Only weak and semi-strong efficiency levels can strictly be related to the securities' pricing mechanism. Since the strong-form set includes information that is not received by the market, the evidence against market efficiency in the strong sense pertains to the corporate information disclosure practices rather than to securities pricing markets.

The "information economics" school attempted to formalize the EMH considering individual investors and concentrating on consequences of information dissemination. Beaver [1981] defined a market to be efficient with respect to some information signal if it generates security prices identical

[4] Individual beliefs that may be heterogeneous are not given importance. Instead it is stressed that the marginal investor who determines the price is informed and rational. Uninformed or non-rational investors are assumed inframarginal and do not have a consequential effect on the price.

to those that would be generated in a market where each individual investor knows that signal, given preferences and endowments are the same in both markets. Latham [1986] defined efficiency relative to some information that if revealed to all investors would not alter prices and portfolios. As pointed by Ball [1989] the definitions, although logically coherent, are of limited additional use for empirical researches. The "identical world" where all investors costlessly possess information available to only some of them in the "real world" is never observed. Therefore, a researcher has to assume a price-generating mechanism, or an equilibrium model. This is essentially the methodology that was proposed by the "empirical school".

Other alternative definitions by Jensen [1978] and Malkiel [1992] stress the properties of trading rules. They state that the efficiency with respect to an information set implies that it is impossible to make economic profits by trading on the basis of that information set. Therefore, the market efficiency can be judged by measuring profits made by trading on the information. On similar grounds Keane [1989] distinguishes among four degrees of efficiency. In the extremes they run from "perfectly efficient", which allows for no superior returns even for experts, to "grossly inefficient" where superior returns are apparent even to informed lay investors.

Market modeling

In the spirit of information economics approach Grossman [1976, 1978] developed the models to investigate a possibility of prices fully reflecting all available information.

Grossman [1976] analyses the market with n-types of informed traders where each gets "a piece of information". The price is viewed here as performing the function of aggregating information, and the equilibrium price is a statistic that summarizes all the information available in the market.

However, in subsequent works Grossman [1978] and Grossman and Stiglitz [1980] present the model where prices partially reflect the information that arbitrageurs possess. The price system makes publicly available the

information received by informed individuals to the uninformed, but does it imperfectly. In the economy with two types of traders, informed and uninformed, there would be little incentive to collect information if the market price were perfectly informative. In the model of Grossman and Stiglitz [1980] the uninformed individuals are not able to obtain the information about the return on the risky asset by simply observing the market price. The price is a "noisy" signal to the uninformed traders, because there is an additional source of uncertainty—the supply of risky assets. In equilibrium a trader is indifferent between being informed or uninformed. The number of informed traders and the extent to which prices are informative are determined. The price system never remains totally informative, because otherwise there would be no incentive to collect the information.

This work incited the development of a large body of literature attempted to redefine the notion of the efficient markets. Bray [1981] introduced a model where information about the demand side of the market interfered with the information from the supply side and that kept the market price from revealing all the information. Allen [1981] showed the possibility of a rational expectations equilibrium that reveals all the information if there are more prices and markets than there are uncertainties. Black [1986] conjectures a model where highly liquid markets are not characterized by efficient pricing. His model takes noise trading as a factor encouraging market liquidity. Prices in such a market become very noisy estimates of the value at a point in time.

Conclusions

To sum up the facts of the historical development and formalization of the EMH, it is important to emphasize the following points:

i) Although the EMH is recognized an illustration of the rational expectations hypothesis, its formulation was the result of numerous empirical tests that preceded the theory. Considering that market efficiency was

established through statistical methods by failing to observe systematic inefficiencies the EMH is essentially an empirical issue;

ii) The general development of the definition of market efficiency can be regarded in light of two different approaches. The "empirical" approach emphasizes the role of competitive equilibrium models, while the "information economics" approach relies on the properties of information and does not provide an alternative framework for empirical researchers. Further, market efficiency was defined in terms of economic profitability of trading with respect to a specific information set;

iii) Following the definitions of capital market efficiency and its link with the rational expectation hypothesis it can be inferred that failures to reject the EMH suggest a) that prices adjust rapidly enough to new available information to eliminate any possibilities of abnormal returns (speed of price adjustment) and b) financial market prices are rational assessments of fundamental values (quality of price adjustment);

iv) There are models of the interaction of informed and uninformed traders in a market. The results suggest that prices can never reflect all available information entirely correctly. Therefore, prices are concluded noisy signals to market participants.

2.2 Evidence on stock market efficiency

The early empirical work generated the evidence that was later interpreted as indicating weak-form efficiency of the stock market. The origins of this research lay mainly in the random walk literature. The results of Kendall [1953], Granger and Morgenstern [1963] demonstrated that price movements displayed no serial dependence sufficient for their prediction. Alexander [1964] showed that certain filter strategies could not generate abnormal returns after transaction costs were taken into account. The results of Fama and Blume[1966] gave further evidence of no superiority of various filters relative to buy-and-hold strategies. Although the findings indicated some statistical significance of departures from the EMH, from an economic

viewpoint they could not be regarded as refuting market efficiency [Fama, 1970].

Testing the semi-strong form of market efficiency was initially carried out in the form of event studies for individual securities. The tests were concerned with speed and correctness of price adjustment to new events or information such as stock splits or earnings announcements. The evidence from these tests is sometimes referred to as direct [Keane, 1983]. Fama, Fisher, Jensen and Roll [1969] studied the reaction of 940 stocks to split announcements and concluded that market prices adjusted correctly to the information implicit in a split. Ball and Brown [1968] investigated if accounting earnings announcements contributed to establishing market prices. They found that investors were not able to trade profitably on the basis of announcements since the relevant information had already been reflected in stock prices by the time of an announcement. The study by Dann, Mayers and Raab [1977] pointed at the speed of market reaction. Price reaction to large block trading was found fast enough to prevent earning a return sufficient to cover transaction costs.

The indirect evidence of market efficiency was generated by comparing the performance of professionally managed funds against a naïve buy-and-hold strategy. Fama [1970] classifies such techniques as tests of strong-form efficiency. However, it can be argued that investment managers rarely have monopolistic access to information. Fund managers in most cases base their judgements about stock prices on the relevant information that is available to at least some other market participants.

Jensen [1968] was one of the first to show that funds on average were unable to outperform the naïve strategy. Other studies produced similar findings[5].

Later empirical work generated the results that were not so much consistent with earlier findings.

[5] See, for example, Firth [1977].

The evidence of individual stock prices over-reaction to information implied that markets deviated systematically from the EMH (De Bondt and Thaler [1985, 1987]). The results were explained in light of the behavioral decision theory of Kahneman and Tversky [1982]. The results suggested that strategies of selling past winners and buying past losers could generate abnormal returns. More recent findings (Lakonishok, Shleifer and Vishny [1994]) show that various ratios that include a stock price can signal about future performance of the stock.

Also, there is evidence that individual stock prices persistently under-react to earnings announcements (Ball [1978] surveys the early findings). Recently, in their long-term returns study Ikenberry, Renkine, and Stice [1996] attribute post-split positive abnormal returns to market under-reaction to the information signaled by a split.

Summers [1986] challenges the power of statistical tests of efficiency of speculative markets. He concludes that failures to reject the EMH do not establish that market prices rationally reflect fundamentals.

Other evidence identified systematically repeated anomalies (week-end, January, holiday effects, etc.) in stock prices behavior (Ikenberry and Lakonishok [1989]). Notwithstanding logical explanations of the observed anomalous effects, they were regarded as strong evidence of predictable patterns in returns. A number of studies were interpreted that the market is persistently inefficient with respect to estimation of future inflation rates (surveyed in Keane [1983]).

Following the recognition of apparent controversy of the accumulated evidence various judgements of it emerged.

First, the emergence of large anomalous evidence can partially be explained that earlier researchers tended to overlook it until it could not be ignored. In addition, the nature of research changed over time. Later empirical studies were carried out in the areas where anomalies were more likely to be observed. The statistical techniques improved while larger data sets became available.

Second, the position against market efficiency proposition based on the accumulated evidence should be evaluated critically. The tests of market efficiency rely on particular equilibrium models of market prices. The widely used models (present value model, capital asset pricing model, arbitrage pricing theory, etc.) do not account for such market facts as supply of shares, heterogeneity of beliefs, costs of private information production, seasonality, etc. Therefore, the "bad" model problem apparently prevents a researcher from drawing valid inferences about price adjustment to equilibrium.

Refuting the market efficiency as a price formation description one has to specify an alternative equilibrium description [model] incorporating inefficiencies and testable empirically[6].

Consequently, most long-term return anomalies tend to disappear when subjected to different models and statistical testing methods (Fama, [1997]). Further, Fama [1997] argues that anomalous evidence of over- and under-reaction can be attributed to chance. Examples of these anomalies may be taken as split randomly which is consistent with zero expected abnormal returns. Additionally, some anomalies were found consistent with rational asset pricing[7].

The above facts about the evidence on the EMH suggest the following general conclusions:

i) The evidence against the EMH should be given proper weight as it signals about directions of research to resolve it;

ii) The evidence in favor of the EMH comes primarily from developed capital markets. This suggests that such markets have institutional characteristics sufficient for efficient pricing.

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[6] For example, some formalization attempts mentioned above assert that a) in the presence of supply uncertainty market prices can never reflect all information perfectly [Grossman and Stiglitz, 1980]; or b) high liquidity of financial markets implies less efficient pricing as prices become very noisy estimates of the value [Black, 1986]. The evidence of inefficiencies coming from developed markets can be interpreted as a consequence of bringing in more noise when a number of market participants and market size increase. These modeling propositions together with the empirical evidence may imply that the market is incorrect in its "fundamental valuation" activity.

[7] Fama and French [1996] find that long-term return reversals are captured by a multi-factor model.

iii) The evidence against the EMH in developed markets is not robust to rigorous verification. On the contrary, it is fragile with respect to alternative models and testing techniques suggesting limitations of knowledge on asset pricing.

iv) Properly functioning securities pricing markets are good instances of competitive structures and are expected to be efficient with respect to information processing. The evidence against the efficient market may be interpreted, to some extent, that the market is marginally inefficient for some investors at some periods, but efficient for the most. Hence, the EMH remains an encompassing framework for empirical research of the stock market behavior.

2.3 Implications of stock market efficiency for a developing economy

Policy makers in a transition economy face a challenging task. Such an economy is likely to experience an overall economic decline when the central control over domestic savings and investment is given up and new markets and market-based institutions are still underdeveloped. Long-term investment credit is indispensable for the economy to revive production and make industries more competitive. In the process of financial sector reforms banks are usually given prior attention, while non-banking institutions are lagged behind. However, facing macroeconomic uncertainty and lack of experience, banks do not provide the economy with badly needed long-term credit. At the same time, enterprises in the economy may be unable to distribute part of their profits for financing long-term investment.

Thus, it is difficult to overstate the importance of a stock market for a developing economy. The primary benefits of a well-functioning stock market are: a)mobilization of savings; b) fund term matching with efficient allocation of investment resources; c) acceleration of economic growth.

A stock market encourages savings by letting investors use various instruments to better satisfy their liquidity needs and risk preferences. Further, it gives equity finance possibilities for non-financial corporate sectors. There

is evidence of a significant contribution of equity markets to investment expenditures of the corporate sector in developing countries [Singh and Hamid, 1993]. The allocation function is carried out through correct share-pricing. Better managed firms should face lower cost of capital while their shares are valued higher. It has been shown that a stock market accelerates economic growth through a) eliminating premature liquidation of capital invested in firms, which increases firm productivity and b) reducing liquidity risk, which encourages investment [Levine, 1991].

Other macro level benefits of a developed stock market include a) increased efficiency of the whole financial system as a consequence of enhanced competition for investable funds; b) possibility of debt-equity swaps; c) privatization of productive activities through an orderly transfer of shares to private investors.

A large-scale privatization program is one of the most critical policy steps in a transition economy. Following establishment of equity markets, some transition countries become able to carry out privatization sales through stock exchanges. As a result, a boost in a stock market indicated by increases in capitalization can be taken as a direct effect of launching privatization programs.

Privatization also produces indirect effects on developing stock markets. New listings of privatized firms help to resolve a low-listing trap and expand diversification possibilities. Increased diversification potential creates an externality for all investors that is further reinforced through induced entry and reduced volatility of the market [Pagano, 1993].

The recent studies also find special tasks carried out by privatization process [Perotti and van Oijen, 1999]. It is argued that a consistent privatization program results in resolution of regulatory and legal uncertainty, e.g. by strengthening property rights and institutional reliability. The authors show that reduction of political risk is achieved by actual implementation of sustained privatization perceived as irreversible. Using panel data on emerging markets, they find the impact of decreases in political risk on stock market

development to be considerable. In a developing market these effects are among other things reflected by relative growth of market capitalization and turnover (that implies enhanced liquidity and improvement of institutional setting).

The concept of efficient markets developed by "empirical economists" includes the necessary conditions for a market to exhibit a relatively higher efficiency level (Fama [1970]). In the context of a developing country these stylized conditions can be interpreted as a) relatively low transactions costs meaning i) a transparent and reliable clearing and settlement system and ii) proper legal protection of investors' rights and strict contract enforcement b) all relevant information availability at low costs meaning availability of stock quotes, comprehensive disclosure requirements and insider trading regulations and c) an increasing number of participants that insures high liquidity given a sufficiency of those that agree on implications of the available information.

The conditions above also pertain to identification of the market as being well-functioning. Hence, tests of the efficiency of a stock market have implications for:

i) Generally, the degree of its development and, consequently, for the extent to which the benefits of a well-developed market are being realized by the overall economy;

ii) Specifically, the quality of privatization policies since a consistent and sustained privatization policy through its direct and indirect effects is conducive to stock market efficiency.

The recent research of equity markets in developing countries reaches mixed results[8]. However, there is evidence that emerging stock markets exhibit various degrees of efficiency often close to those of developed markets [Hanousek and Filer, 1997].

[8] See, for example, Cornelius [1993], Agrawal and Tandon [1994].

Chapter 3

METHODOLOGY OF EMPIRICAL RESEARCH

Based on the classification of the forms of the EMH testing for weak-form efficiency is carried out.

The subset of past prices, or equivalently returns, is used. As noted above the early evidence of weak-form efficiency was based mostly on the random walk models [Fama, 1970]. The random walk model implies that interaction of investor tastes and generation of new information repeatedly produces equal return distributions. The model generates equilibrium expected returns that are constant over time. The "fair game" property requires zero expected excess gains. The choice of the model was dictated by our investigation of short-period returns whose expected value is assumed to be constant.

Specifically, the weakest form of the random walk model is adopted. We assume that the natural logarithm of prices $p_t = \ln P_t$ follows a drifting random walk:

$$p_t = m + p_{t-1} + \varepsilon_t ,$$

where $m + \varepsilon_t$, representing a continuously compounded return, has the property that $Cov[f(\varepsilon_t), g(\varepsilon_{t+k})] = 0$ for $\forall k \neq 0, \forall f(\cdot) \; and \; g(\cdot)$ linear. In other words, this process assumes uncorrelated, but not independent increments. The assumption allows for the so-called volatility clustering inherent to most financial data. With this effect present, volatility of stock returns is heteroskedastic, i.e. changes over time and is serially correlated. Practically, volatility clustering implies that large returns (of either sign) tend to be followed by large returns and vice versa.

The empirical investigation involves two stages. In the first stage a general test of the adopted price generating model jointly with the market

efficiency is performed. In the second stage returns are modeled explicitly. This modeling is used to confirm if there is a statistically significant relationship between the market returns and their volatility that changes over time.

To allow for general forms of heteroskedasticity, including deterministic changes in the variance and ARCH processes, in testing whether market prices possess uncorrelated increments the approach of Lo and MacKinlay [1988] is employed. This approach exploits the fact that the variance of random walk increments must be a linear function of the time interval[9]. Specifically, under our assumptions the following equality holds asymptotically:

$$\overline{VR}(q) \overset{a}{=} 1 + 2\sum_{k=1}^{q-1}(1-\frac{k}{q})\hat{\rho}(k),$$

where $\overline{VR}(q)$ is the estimated variance ratio, q is the number of base observations aggregated to form the variance ratio, $\hat{\rho}(k)$ is the kth order autocorrelation coefficient of $\{r_t\}$[10].

If we let $r_t = \mu + \varepsilon_t$ then the following null hypothesis is defined:

$$H_o : E[\varepsilon_t] = 0 \text{ for } \forall t, \text{ and } E[\varepsilon_t \varepsilon_{t-t}] = 0 \text{ for } \forall \tau \neq 0$$[11],

which under our assumptions is equivalent to the statement of the asymptotic equality of variance ratio to one .

To perform standard inferences the asymptotic variance of the estimated variance ratio has to be computed. Let $\theta(q)$ and δ_k be the asymptotic variances of $\overline{VR}(q)$ and $\hat{\rho}(k)$ respectively and take the number of

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[9] The q-period variance ratio statistic satisfies

$VR(q) \equiv Var[r_t(q)] \cdot (q \cdot Var[r_t])^{-1}$, where $r_t(q) \equiv r_t + r_{t-1} + \cdots + r_{t-q+1}$.

[10] Ljung and Box [1978] developed the statistic (Q statistic) to test the null hypothesis of all autocorrelaton coefficients (the number of successive lags is chosen) simultaneously equal to zero. Q-statistic for different lag values in different subsamples is reported to find out if significant autocorrelation is inherent to a particular subset of data. However, the test is not sufficiently powerful.

[11] Given returns heteroskedasticity, the following conditions are added to permit some form of the Law of Large Numbers, the Central Limit Theorem and for computational simplicity while testing the null hypothesis: i) the second moments are assumed to be finite ii) the autocorrelation coefficients $\rho(k)$ are uncorrelated iii) a restriction is imposed on the maximum degree of heterogeneity of returns.

return observations in a sample to be nq. Then, under the null hypothesis (Lo and MacKinlay[1988]):

i) the following is the heteroskedasticity-consistent estimator of δ_k :

$$\hat{\delta}_k = \frac{nq \sum_{j=k+1}^{nq} (r_j - \hat{\mu})^2 (r_{j-k} - \hat{\mu})^2}{\left[\sum_{j=1}^{nq} (r_j - \hat{\mu})^2 \right]^2},$$

where $\hat{\mu}$ is the sample mean of returns;

ii) the following is the heteroskedasticity consistent estimator of $\theta(q)$:

$$\hat{\theta}(q) \equiv 4 \sum_{k=1}^{q-1} (1 - \frac{k}{q})^2 \hat{\delta}_k .$$

Therefore, in the presence of general heteroskedasticity, the standardized test statistic z(q)

$$z(q) = \frac{\sqrt{nq}(\overline{VR}(q) - 1)}{\sqrt{\hat{\theta}(q)}} \overset{a}{\sim} N(0,1)$$

is used to test the null hypothesis. A rejection of the null hypothesis will mean the presence of significant autocorrelations in price increments. The rejection will, therefore, violate both the weak-form efficiency statement of full incorporation of past information in the present return and the assumptions of the price generating model chosen.

To model the market index returns explicitly taking into account volatility clustering a generalized autoregressive conditional heteroskedasticity (GARCH) modeling framework is employed [12]. A variant of the GARCH framework known as GARCH-in-mean, or GARCH(p,q)-M, is used. This allows for mean returns to be specified as a linear function of time-varying conditional second-order moments. The representation of the GARCH(p,q)-M involves the following system of equations (as in Mecagni and Sourial [1999]):

[12] The GARCH model was introduced by Bollerslev [1986] as a way to model persistent movements in volatility without estimating a large number of coefficients in the ARCH model developed by Engle [1986].

$$r_t = u_t + \delta_1 \sigma_t + \varepsilon_t,$$
$$\varepsilon_t \mid \Omega_t \sim N(0, \sigma_t^2),$$
$$\sigma_t^2 = \alpha_0 + \alpha_1 \varepsilon_{t-1}^2 + \ldots + \alpha_q \varepsilon_{t-q}^2 + \beta_1 \sigma_{t-1}^2 + \ldots + \beta_p \sigma_{t-p}^2,$$

where r_t represent a return at time t; u_t is a vector of past returns representing the information set on which the efficiency is tested. The GARCH(p,q)-M model allows for stock returns, r_t, to be determined by the past returns and by its conditional variance, σ_t^2. The conditional variance, σ_t^2, may vary over time as a result of the linear dependence on past squared innovations ε^2 (up to lag *q*, indicated by non-zero α coefficients) and as a result of its own temporal persistence (up to *p* periods, indicated by non-zero β coefficients). The squared innovation terms imply that volatility shocks will continue to be large if they were so in the past. Thus, the effects of volatility clustering will be captured. The following restrictions are placed on the parameters in the variance equation :

$$\alpha_0 > 0$$

$$\alpha_i \geq 0, \text{ for } i = 1, \ldots, q$$

$$\beta_i \geq 0, \text{ for } i = 1, \ldots, p$$

to ensure that the conditional variance σ^2 is positive[13].

The estimation is done in two stages. The first stage, intended to assess significant serial correlation in returns at specific lags, involves modeling the return series as an autoregressive (AR) process. While searching for the optimal lag length of past returns minimum values of the Akaike and Schwarz information criteria are considered given that the estimated partial correlation coefficients are statistically significant.

[13] It was shown that the persistence of shocks to volatility depends on the sum of α and β parameters. The sum that is lower than unity implies a decay of the volatility over time. The rate of decay decreases as the sum approaches unity. If the sum is equal to or greater than unity there is indefinite volatility persistence to shocks over time. The results section reports the sum of the estimated parameters.

In the second stage the modeled AR(k–the number of lagged returns) representation is conditioned for the presence of GARCH effects. Fitting GARCH-M to the return series involves joint re-estimation of the modeled AR(k) process and GARCH(p,q)-M starting from a GARCH (3,3) specification. Least significant (p,q) terms are sequentially eliminated while the Akaike and Schwarz information criteria are taken into account.

The relation between the stock returns and volatility is captured by the coefficient of s, the standard deviation of the conditional distribution of returns. A statistically significant estimated coefficient, $\hat{d}_1$, will indicate the reward to investors in periods of relatively low and high volatility.

Chapter 4

MARKET AND INSTITUTIONS

Ownership relations in Ukraine have been reformed mainly by way of privatization of state-owned enterprises' assets. Since independence Ukraine introduced a series of laws specifying the principles and mechanisms of privatization. In 1992-94 privatization was carried out through employees' buy outs. Mass privatization with privatization and compensation certificates was launched in 1995. The certificates could be used to purchase shares directly in voucher auctions or to invest in privatization funds. Within that period mostly small-scale businesses were privatized. Until mid 1997 the privatization of medium and large-scale enterprises that accounted for about 75% of the economy's fixed assets remained slow. Starting only in 1998 international commercial tenders and offerings of share packages on stock market fields replaced voucher auctions as the primary way of privatization. Besides, enterprises that were turned into joint-stock stock companies implemented additional issuance of shares. The privatization process has been the major source of supply of corporate securities that initially provided new listings, expanded diversification possibilities, induced entry of traders to the stock market fields being formed in Ukraine.

There are six stock exchanges and two informational-trading systems currently registered in the country. The stock exchanges include: the Ukrainian Interbank Currency Exchange, the Ukrainian Stock Exchange, the Kiev International Stock Exchange, the Donetsk Stock Exchange, the Pridneprovska Stock Exchange, the Crimean Stock Exchange. The two informational-trading systems are the Over-the-counter stock trading system (PFTS) and the Southern informational trading system. These trading venues represent separate segments of the market with different supply-demand conditions, quotes and trade prices. Operation of these market segments is

regulated by the State Commission on Securities and the Stock Market (SCSSM) which was established in 1995[14].

The nominal value of securities issuance in the privatization process began to grow steadily since 1995[15]. This caused subsequent growth of the stock market. However, the size of the Ukrainian stock market the relative to GDP has remained low in comparison to other transitional countries (Figure 1).

The existing Ukrainian stock exchanges are not primary organizers of large trade. Transactions on the stock exchanges have been of low volumes and involved mainly auctions of privatized enterprises and occasional stock trades to redistribute ownership.

The PFTS is the largest trading field [16]. It was organized in July 1996 in the form of an over-the-counter electronic trading system[17]. The reasons for its relatively higher liquidity partially overlap with the characteristics conducive to stock market efficiency : i) lower costs of trading including a more reliable settlement system (being introduced "delivery against payment") and information disseminating facilities (quotes, reporting requirements), ii) uniform internationally recognizable standards[18]. In a year after its establishment liquidity of PFTS-listed securities improved significantly[19]. The

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[14] The SCSSM structures its activity mainly on the basis of the 1991 "The Law on Securities and Stock Exchange", the 1996 "Law on State Regulation of the Securities Market", the 1994 "Law on Investment Funds and Companies" and the 1998 "Law on the National Depository System and Peculiarities of Electronic Circulation of Securities in Ukraine".

[15] The nominal volume of all issued securities totaled UAH 4727 mln in 1996 relative to only UAH 749 mln in 1995.

[16] In 1999 around 53% of the aggregate volume of trading was carried out at the PFTS.

[17] The United States Agency for International Development, KPMG and Barents Group teamed up to open the PFTS [Berdnick, 1999].

[18] The PFTS association members trade on the electronic equipment. And unlike other exchanges, the PFTS members are not charged commission on the deals they strike electronically. If disputes arise over deals, the PFTS association has two committees that arbitrate between parties. The proximity of trading standards to those prevailing in OTC markets of developed countries attracted to the PFTS relatively higher demand of foreign investors. In various periods, up to 80% of contracts concluded through the PFTS were non-residents' orders.

[19] In 1997 the total PFTS turnover was about USD 190 mln compared to just USD1.6 mln for the six months of 1996. The membership of the PFTS association grew from 84 to 183 and the number of stocks listed from under 100 to 160 during that year.

largest part of all secondary share trades have been carried out at the PFTS[20]. The PFTS is also the only trading field in Ukraine that has been included in the IFC Frontier Index.

However, despite some positive idiosyncratic characteristics the PFTS system is not recognized sufficiently liquid. This is reflected among other things by often large bid-ask price spreads, small number of actively traded stocks, small size of lots available at quoted prices[21]. It is believed that anywhere from 20% to 50% of equity trading volumes by the PFTS members remain unreported. Further, in some cases transactions with institutional size share packages are settled off-shore. As a result, monthly volumes of the PFTS stock trades barely exceeded USD 10 mln in 1998 before the crisis and fluctuated between under USD 5 mln to a little over USD 30 mln after the market displayed some revival in the second half of 1999 (Figure 2).

To sum up, the observed characteristics of the Ukrainian stock market suggest the following conclusions:

i) The privatization process has been the major factor that incited the organized stock market in Ukraine. Therefore, investigation of the informational efficiency of the market has direct relation to the quality, perception and benefits of the privatization in the country.

ii) The PFTS is the only market segment that allows for a meaningful analysis of price behavior on the Ukrainian secondary stock market. This determined the choice of the PFTS-based stock indexes as input data for the empirical tests.

iii) In spite of some specific advantages conducive to higher demand for assets (relatively lower transaction costs of trading), the PFTS does not possess all the characteristics to expect its price behavior be consistent with the EMH. In particular, the liquidity of the market (reflected by its relative capitalization and trade volumes) is still low. Further, given trades executed

[20] Currently the PFTS operates daily. Market capitalization of the PFTS was USD 2.4 bln in 1999. More than 73% of all secondary trading took place at the PFTS in 1999 (PFTS [1999]).

[21] To improve its liquidity level and ensure higher stability the PFTS system announced the implementation of market making in the second half of 1999.

outside the PFTS system, it is safe to assume that some relevant information does not become readily available to all market participants. These facts can be regarded as signals of violation of some sufficient conditions for an efficient market outlined above.

Chapter 5

TESTS OF INFORMATIONAL EFFICIENCY OF THE UKRAINIAN OVER-THE-COUNTER STOCK MARKET

To test the hypothesis of the informational efficiency based on random walk model of price behavior nominal market indices are considered. Two indices are taken in order to check the robustness of the results with respect to the composition of the data. Weekly stock returns are used to avoid possible biases in the data associated with non-trading, the bid-ask spread, asynchronous prices, etc. (Lo and MacKinlay [1988]). At the same time weekly sampling still allows for a sufficiently high number of observations. The weekly stock returns are computed from daily market indices[22]. Specifically, the indices are:

i) ProU-50 Index was developed by the company "Prospect Investments" and started on January 3, 1997. The index is based on the PFTS quotes of the 50 largest issuers representing the leading sectors of the national economy[23]. The list of enterprises used in calculation has changed several times since the index was first calculated. The changes brought in relatively more attractive and liquid issuers. The base value of the index has been corrected according to the changes made. Currently the structure of the included enterprises reflects primarily the privatized part of the economy. The sample covers the index values from January 3, 1997 to January 21, 2000. The full sample of weekly returns of the Pro-U index consists of 159 observations (Figure 3.1).

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[22] The stock market returns are defined as continuously compounded. One-period return at time *t*, r_t, is calculated as the difference of the natural logarithms of the close market index between two dates *t* and *t-1:* $r_t = \ln P_t - \ln P_{t-1}$. The weekly return is computed as the return from Friday's close index to the following Friday's close. If the following Friday's index is missing, then the next available index is used.

[23] The issuers included in ProU-50 mainly represent the following sectors of the economy: metallurgy, chemical industry, machine building, electric power industry, oil and gas industry.

ii) Wood-15 Index was developed by the investment company "Wood and Company" and started on June 13, 1997. The method of composition of the index follows the recommendations of the International Financial Corporation. The index contains the 15 issuers with the largest capitalization on the PFTS. Depending on market capitalization the list of enterprises included in the index is revised quarterly and the relative share of each enterprise is corrected daily. The index is calculated in dollar terms. The sample includes the index values from June 13, 1997 to January 21, 2000. The full sample of weekly returns of the Wood-15 index includes 136 observations (Figure 3.2).

The sample summary statistics for these stock index returns suggest the following conclusions (Table 1):

i) Mean returns for the two indices are close to zero with Pro-U mean return being negative (smaller than that of Wood-15). Median returns, exhibit the reverse ranking. Volatility of Wood-15 returns is significantly lower than that of Pro-U returns. Generally, the graphical representation displays some evidence that small (large) returns generally follow small (large) returns of either sign (Figure 3) . In particular, for both returns volatility increased in the second part of 1998. This implies volatility clustering effects.

ii) Pro-U returns exhibit significant negative skewness. The null hypothesis of the skewness coefficient equal zero (that of the normal distribution) is rejected at 1% significance level. Both returns display statistically significant excess kurtosis suggesting that their distributions have thicker tails than a normal distribution. The hypothesis of (unconditional) normality is rejected by the Jarque-Bera test.

The autocorrelation statistics for the index returns highlight the following (Tables 2, 3):

i) Both returns exhibit a degree of time dependence. Sample autocorrelations are positive and decay slowly for both indices. Ljung-Box Q-statistic with five and ten autocorrelations is significant for both returns at the conventional

significance levels. Wood-15 returns sample autocorrelation coefficients are of a significantly larger magnitude than those of Pro-U returns.

ii) The subsample autocorrelations demonstrate that autocorrelations of comparable magnitude are inherent to the data irrespective of a chosen period. Returns in the second subsample, however, display a slightly lower degree of time dependence than in the first subsample (except for the first-order subsample autocorrelation of Pro-U returns).

iii) The economic significance of the time dependence in returns can be realized by observing that first-order sample autocorrelations of returns are square roots of the coefficient of determination of a regression of returns on a constant and its first lag. Therefore, autocorrelations of 38% and 66% imply that 14.4% and 43.6% of the variation of Pro-U and Wood-15 weekly returns respectively can be predicted using the preceding week's index return. Further, including several autoregressive terms may improve predictability of the regression model.

Weak-form market efficiency based on the random walk model assumption

The autocorrelations in Tables 2 and 3 suggest variance ratios greater than one and this is confirmed by the results in Table 4. The table reports variance ratios and, in parenthesis, heteroskedasticity consistent asymptotically standard normal test statistic z(q) as defined above. The results show:

i) The variance ratios are greater than one for both indices. They increase with the number of base observations aggregated to form the ratio. The ratios calculated on the basis of Pro-U returns are lower in absolute value than Wood-15 return ratios at every reported number of base observations.

ii) The joint hypothesis of uncorrelated increments (random walk behavior) of stock prices and weak-form stock market efficiency is strongly rejected for both indices at every number of base observations using the heteroskedasticity corrected test statistic. Thus, given the adopted model of price behavior, the conclusion is made that the PFTS market segment is not informationally efficient with respect to the set of past prices. In other words,

the relevant market information was only gradually reflected in stock price changes.

The result suggests that the necessary conditions for an efficient stock market are being violated. The lack of institutional characteristics necessary for an efficient market may imply a) insufficient operational efficiency of the market, b) underdeveloped information disclosure standards, c) ineffective dissemination and processing of available information (this may suggest the limited role of professional financial intermediaries). Further, given the violation of the necessary conditions for informational efficiency is identified, the market is unlikely to be well-functioning. This implies that the privatization policies are still not perceived as sustained and irreversible. Thus, the privatization process is not recognized to have led protected property rights and institutional reliability. As a result, potential equity demand (mostly foreign, since the level of wealth of residents is still inappropriate to tangibly increase domestic demand for securities) is limited. Finally, the market does not fully provide the outlined potential benefits to the economy.

Returns and volatility, ARCH and GARCH effects, shock persistence

Explicit modeling of stock index returns directed mainly to assess the impact of volatility on stock pricing and the significance of ARCH and GARCH effects and shock persistence exhibited the following results:

i) The hypothesis that volatility is a significant determinant of stock pricing is rejected for both stock returns. The estimated parameter $\hat{d}_1$ capturing the influence of volatility on stock returns is positive, but statistically insignificant for both returns[24]. Thus, the full sample estimates does not confirm a positive relation between risk and return for the PFTS market segment postulated by the portfolio theory.

[24] Engle, Lilien and Robins [1987], and Bollerslev, Chou and Kroner [1992] conclude that the sign and magnitude of the risk-return parameter depends on investors' utility function and risk preference , and the supply of assets under consideration. The available empirical findings are mixed. In particular, Thomas [1995] found that the risk-return parameter was positive and statistically insignificant for the Bombay Stock Exchange daily returns.

ii) The presence of statistically significant terms in the variance equation rejects the hypothesis of time-invariant conditional volatility for both stock index returns. The significant $\hat{a}_1$ and $\hat{b}_1$ parameters ($\hat{b}_1$ in the Wood-15 model is significant at 8% significance level) imply that the conditional variance changes over time. This confirms the volatility clustering supposition indicated by Figure 3. The findings also imply a relatively long-term memory of volatility shocks. The measure of volatility persistence given by the sum $\sum_i \hat{a}_i + \sum_j \hat{b}_j$ is rather close to unity for both returns. This implies that the effects of shocks to volatility tend to decay slowly (i.e. within several time lags).

Chapter 6

CONCLUSIONS

The purposes of this paper were i) to explore the development of the theory of capital market efficiency , ii) to investigate empirically the behavior of the PFTS stock returns, the informational efficiency of this market segment, and the relationship between volatility and returns, iii) to identify implications of the empirical findings.

The conclusion is reached that despite the controversies in empirical results on developed markets the EMH remains a plausible research framework.

The empirical analysis found that distributions of the stock market index returns deviate from normality with volatility changing over time and being serially correlated. Application of the methodology consistent with these findings resulted in rejection of the joint hypothesis of weak-form stock market efficiency and the random walk model of price behavior.

The result has a variety of implications. The first group concerns the institutional characteristics of the stock market segment being analyzed. Specifically, they refer to the level of transactions costs of trading, the effectiveness of reporting standards and disclosure requirements, availability of professional processing of new information. The inefficiency of the stock market following from the violation of the necessary conditions for an efficient market also implies unprotected property rights and institutional imperfections. This leads to the conclusion about perceived inconsistency of privatization policies. The other group of implications is related to realization of the benefits of a well-functioning stock market by the economy. The weak-form inefficiency of the stock market is most likely caused by the lack of its development. Thus, the economy does not enjoy the full potential benefits of a developed stock market.

Further, the analysis does not support the existence of a significant relationship between the conditional volatility measures and PFTS stock returns. The full sample estimates indicate that the risk return parameter is positive, but highly statistically insignificant that violates the basic postulate of the portfolio theory.

Table 1. Unconditional distribution statistics for weekly stock index returns.

	Pro-U	Wood-15
Sample period	01:10:97- 01:21:00	06:20:97- 01:21:00
No. of ob-ns	159	136
Mean	-0.007	0.001
Median	0.005	0.001
Standard deviation	0.078	0.051
Maximum	0.166	0.189
Minimum	-0.284	-0.152
Skewness t-statistic[25]	-1.218 -6.270	0.118 0.532
Kurtosis	5.354	4.624
Excess kurtosis t-statistic[26]	2.354 6.522	1.624 3.866
Jarque-Bera normality P-value	76.052 0.000	15.260 0.000

Table 2. Autocorrelation in weekly Pro-U stock index returns.

	Pro-U		
Sample period	01:10:97- 01:21:00	01:10:97-07:17:98	07:24:98-01:21:00
No.of ob-ns	159	80	79
$\hat{r}_1$	0.380	0.324	0.403
$\hat{r}_2$	0.332	0.361	0.297
$\hat{r}_3$	0.220	0.293	0.172
$\hat{Q}_5$ P-value	50.205 0.000	28.052 0.000	25.555 0.000
$\hat{Q}_{10}$ P-value	59.698 0.000	40.872 0.000	30.155 0.001

[25] The test statistic is calculated as t=(Skewness-0)/SE(Skewness)where SE(Skewness)=square root(6/T), T is the number of observations.

[26] The test statistic is calculated as t=(Kurtosis-3)/SE(Kurtosis) where SE(Kurtosis)=square root(24/T), T is the number of observations

Table 3. Autocorrelation in weekly Wood-15 stock index returns.

	Wood-15		
Sample period	06:20:97- 01:21:00	06:20:97-10:02:98	10:09:98-01:21:00
No. of ob-ns	136	68	68
$\hat{r}_1$	0.661	0.703	0.456
$\hat{r}_2$	0.502	0.545	0.274
$\hat{r}_3$	0.356	0.365	0.153
$\hat{Q}_5$ P-value	120.870 0.000	68.070 0.000	22.604 0.000
$\hat{Q}_{10}$ P-value	137.450 0.000	72.138 0.000	26.265 0.003

Table 4. Variance ratios for weekly stock index returns[27].

Sample period	N-r of ob-ns, *nq*	Number *q* of base ob-ns aggregated to form variance ratio		
		2	4	8
Pro-U				
01:03:97- 01:21:00	159	1.393 (3.137)**	2.065 (4.637)**	2.760 (4.980)**
Wood-15				
06:13:97- 01:21:00	136	1.676 (4.854)**	2.744 (7.044)**	3.764 (7.900)**

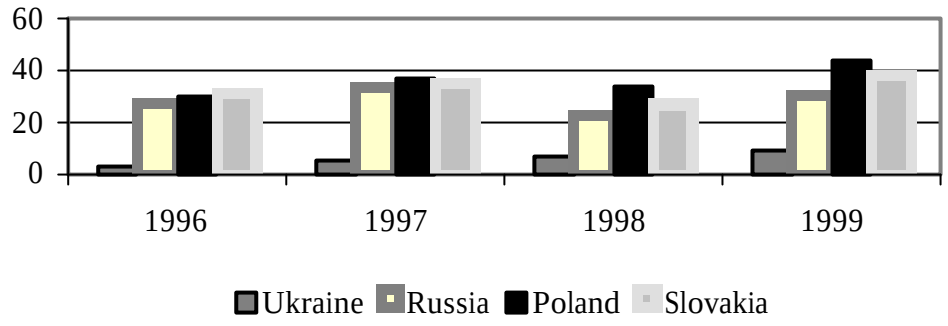
[27] ** indicates statistical significance at 5% significance level.

Table 5. Estimates of AR(k)-GARCH-M(p,q) model for weekly stock index returns[28].

Parameter	Pro-U	Wood-15
Sample period	01:03:97- 01:21:00	06:13:97- 01:21:00
Number of ob-ns	159	136
(p, q)	(1,1)	(1,1)
AR(1)	0.280 (2.911)**	0.666 (9.155)**
AR(2)	0.292 (3.095)**	--
$\hat{d}_1$	0.012 (0.128)	0.092 (0.182)
$\hat{a}_0$	0.00004 (1.300)	0.0002 (1.617)
$\hat{a}_1$	0.127 (2.107)**	0.225 (1.789)*
$\hat{b}_1$	0.783 (7.055)**	0.622 (3.558)**
$\sum_i \hat{a}_i + \sum_j \hat{b}_j$	0.910	0.847
R^2	0.183	0.445
Q-statistics of residuals	Non-significant	Non-significant

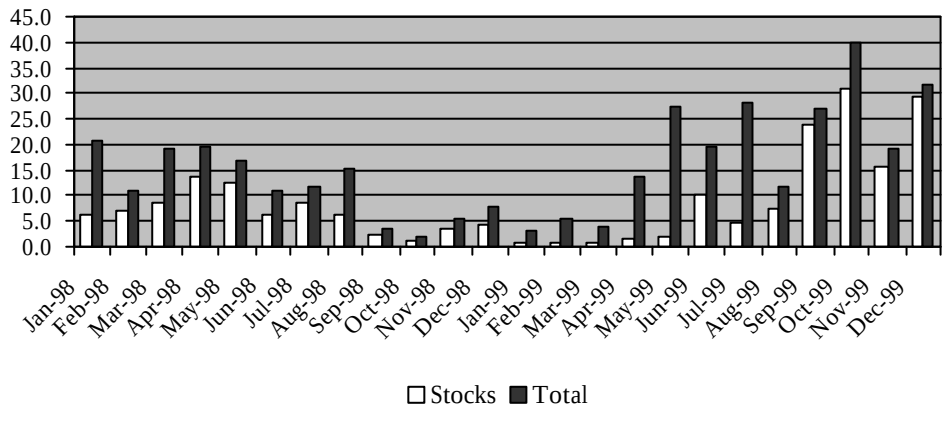
[28] ** and * indicate statistical signifcance at 5% and 10% significance levels respectively.

Figure 1. Stock market capitalization to GDP ratio, %



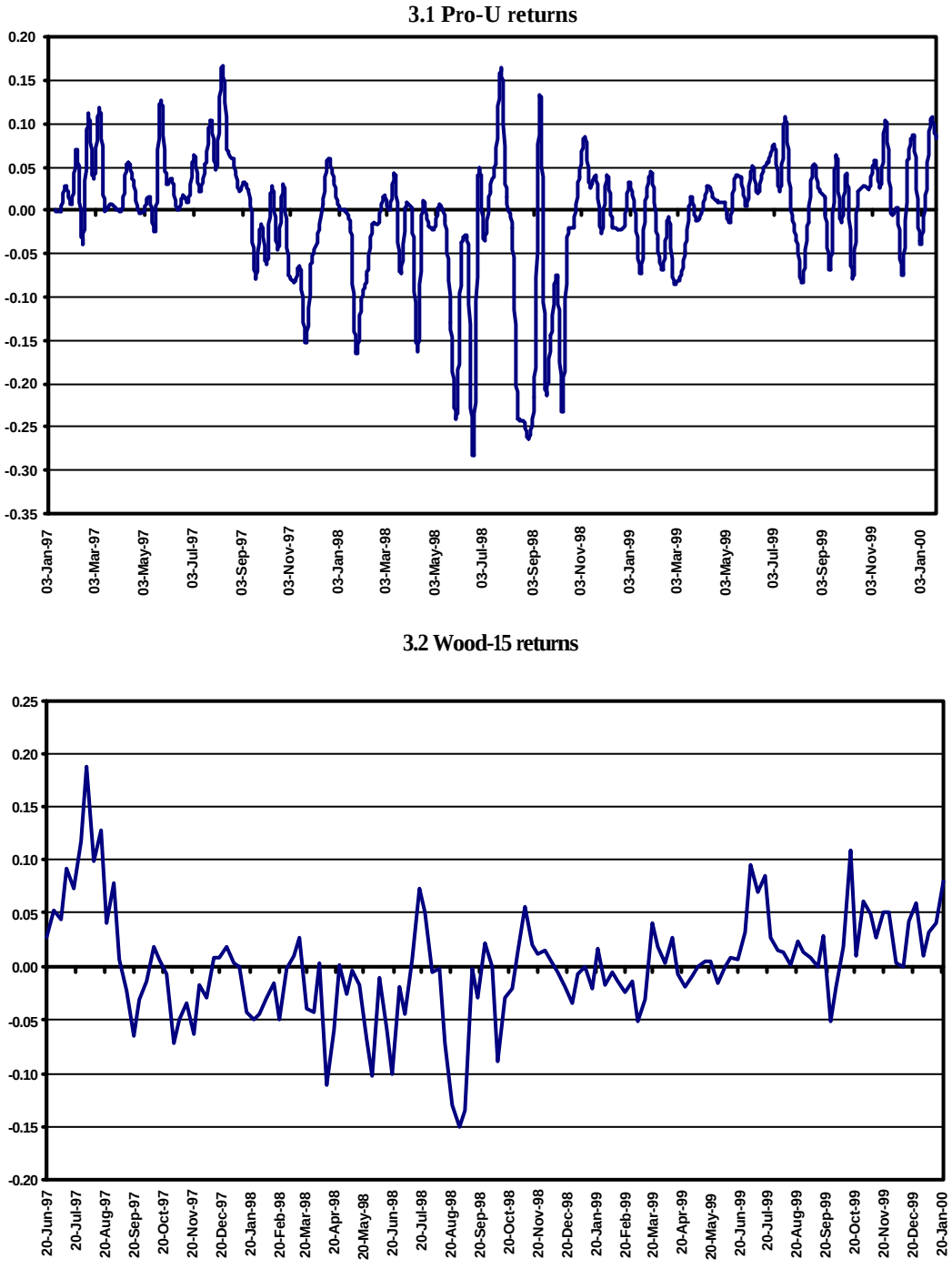
Source: Alfa-Capital Investment Company, Ukraine

Figure2. PFTS monthly volume of trade (mln USD)



Source: Alfa-Capital Investment Company, Ukraine

Figure 3. PFTS market index weekly returns.



Source: Interfax-Ukraine

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