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MARKET EFFICIENCY IN BALTIC STOCK MARKETS

BACHELOR THESIS

SUMMARY

Uziela, P., Market Efficiency in Baltic Stock Markets [Manuscript]: bachelor thesis: economics. Vilnius, ISM University of Management and Economics, 2012.

This bachelor thesis conducts research of market efficiency in the Baltic stock markets. The aim is to estimate market efficiency using statistical tests and strategies based on historical stock returns. The aim is achieved by steps indicated as objectives of the thesis. Firstly, analysis of the Baltic stock markets development, infrastructure and specifics related to market efficiency is conducted. Then, review of theory and empirical studies of market efficiency is performed. This is followed by empirical part of the thesis where autocorrelation analysis and Augmented Dickey-Fuller tests are applied to examine if stock prices in the Baltic stock markets follow the random walk. Finally, research is conducted to examine if superior risk-adjusted returns can be achieved using momentum trading strategy and if there are any day-of-the-week effects.

Thesis documents that specifics of the Baltic stock markets provide both arguments for and against market efficiency in the Baltic stock markets. By belonging to the Nasdaq OMX group the Baltic stock markets ensured for themselves modern stock exchange infrastructure and state-of-the-art trading system. On the other hand, during recent years the Baltic stock markets have been on the decreasing trend of average company capitalisations, average turnover and number of companies.

Autocorrelation analysis shows significant positive autocorrelations for both daily and weekly continuously compounded returns. Test for unit root indicates nonstationarity of stock prices, however, significant coefficients for lagged returns are found in the test. From autocorrelation analysis and unit root tests it is concluded that the behaviour of stock prices in the Baltic stock markets is not fully described by AR(1) random walk model and stock returns have some predictability which could, but does not necessarily mean market inefficiency.

Test of the day-of-the-week effects evidence that there are no statistically significant differences between different weekdays. Moreover, calendar hypothesis that Monday returns are three times higher than returns on other days is also not rejected.

Results from momentum strategy indicate market inefficiency. Significant risk-adjusted underperformance of sell portfolio, consisting of stocks that performed worst in the last 3 months, has been found. Moreover, zero cost contrarian strategy of buying past best performers and selling past worst performers has positive and statistically significant mean quarterly returns of 10.32%, which can not be explained by systematic risk of the portfolio.

Keywords: market efficiency, Baltic stock markets, momentum, day of the week effect.

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SANTRAUKA

Uziela P., Rinkos efektyvumas Baltijos akcijų biržose [Rankraštis]: bakalauro baigiamasis darbas: ekonomika. Vilnius, ISM Vadybos ir ekonomikos universitetas, 2012.

Šis bakalauro darbas atlieka rinkų efektyvumo Baltijos akcijų biržose tyrimą. Tikslas - nustatyti rinkų efektyvumą naudojant statistinius metodus bei prekybos strategijas, paremtas istorinėmis akcijų grąžomis. Tai pasiekiama žingsniais, kurie sutampa su darbo uždaviniais. Pirmiausia atliekama Baltijos akcijų rinkų vystymosi, infrastruktūros ir specifikos, susijusios su rinkų efektyvumu, analizė. Tuomet apžvelgiama teorija ir empiriniai darbai apie rinkų efektyvumą. Empirinėje bakalauro darbo dalyje naudojant autokoreliacijos analizę ir Augmented Dickey-Fuller (ADF) testą tikrinama, ar akcijų kainos Baltijos akcijų biržose kinta pagal atsitiktinio klaidžiojimo procesą. Galiausiai darbe nustatoma, ar galima pasiekti didesnes nei rinkos akcijų grąžas (įvertinus riziką) naudojant „momentum" strategiją bei patikrinama, ar egzistuoja savaitės dienos efektas.

Baltijos akcijų biržų specifika suteikia argumentų tiek rinkų efektyvumo egzistavimui, tiek jo nebuvimui. Priklausydami Nasdaq OMX grupei Baltijos akcijų biržos užsitikrina modernią akcijų biržų infrastruktūrą bei inovatyviausias prekybos sistemas. Kita vertus, pastaraisias metais krito vidutinės kapitalizacijos, vidutinė apyvarta bei įmonių skaičius.

Autokoreliacijos analizė rodo reikšmingas teigiamas akcijų grąžų autokoreliacijas tiek dienos, tiek savaitės laikotarpiams. ADF testas parodo akcijų kainų nestacionarumą, tačiau taip randama statistiškai reikšmingų koeficientų prie kintamųjų, žyminčių buvusias grąžas. Iš autokoreliacijos ir ADF testo galima daryti išvadą, kad Baltijos akcijų biržose akcijų kainos nėra pilnai paaiškinamos AR(1) atsitiktinio klaidžiojimo procesu ir akcijų kainų pokyčiai turi nuspėjamumo, tačiau tai nebūtinai reiškia rinkų neefektyvumą.

Savaitės dienos efekto testas rodo, kad Baltijos akcijų biržose nėra statistiškai reikšmingų skirtumų tarp akcijų grąžų skirtingomis savaitės dienomis. Be to, negali būti atmesta ir kalendoriaus hipotezė, teigianti, kad akcijų biržų grąžos pirmadieniais yra tris kartus didesnės nei kitomis dienomis.

„Momentum" strategijos rezultatai rodo rinkų neefektyvumą. Buvo rasta, kad „pardavimo" portfelis, kurį sudaro blogiausius rezultatus per pastaruosius tris mėnesius pasiekusios akcijos, pasiekia reikšmingai mažesnes rizikai įvertintas akcijų grąžas. Taip pat buvo nustatyta, kad nemokama strategija pirkti geriausiai pasirodžiusias akcijas ir parduoti blogiausiai pasirodžiusias akcijas turi teigiamą ir statistiškai reikšmingą 10.32% vidurkį, kuris negali būti paaiškintas sistematinės rizikos buvimu.

Raktiniai žodžiai: rinkų efektyvumas, Baltijos akcijų biržos, momentum strategija, savaitės dienos efektas.

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INTRODUCTION

Market efficiency is the subject that never gets outdated and that comes under discussions in the academic world now and again. Efficient market hypothesis states that prices should reflect all information. There are three forms of market efficiency that can be tested. Markets are considered to be weak form efficient if historical price movements do not predict future returns. Semi-strong market efficiency states that market prices include all publicly available information. Strong form efficiency requires that market prices reflect all public and inside information. If markets were efficient, capital resources would be allocated in the best possible way (Fama, 1970).

Market efficiency topic in the Baltic stock markets is also relevant. The Baltic stock markets are considered as niche markets from the global perspective. Market capitalisations and trading volumes are relatively low. As Baltic markets are still developing, are not deeply researched and covered by analysts, market efficiency there could be lower than in developed markets. This would mean that capital in the Baltics is not allocated properly.

This bachelor thesis will contribute to the knowledge about the Baltic stock markets by conducting research on weak form market efficiency. Tests will be applied in order to find out if market returns indeed follow the random walk model and if there are strategies based on technical information that could bring better than market results.

Problem. How efficient are the Baltic stock markets?

Aim. Estimate market efficiency using statistical tests and strategies based on historical stock returns.

Objectives.

- Analyse the Baltic stock markets development, infrastructure and specifics related to market efficiency.
- Analyse theory and empirical studies of market efficiency.
- Examine if stock prices in the Baltic stock markets follow the random walk by using serial correlation analysis and unit root test.
- Test if superior risk-adjusted returns can be achieved using trading strategies based on historical stock returns.

Research methods. Augmented Dickey-Fuller test for unit root and serial correlation analysis will be performed to examine if returns in the Baltic stock markets follow the random walk model. Weak form efficiency will be researched further by measuring day-of-the-week effect and momentum strategy returns. OMX Baltic Benchmark GI index and stocks from the Baltic main and secondary lists in the period of 2003-2011 will be used as a data sample. For statistical calculations EViews will be employed.

Structure. In the first part, infrastructure, development and other specifics of the Baltic stock markets will be analysed and the concept of market efficiency introduced. In the second part, theory and previous research of the market efficiency and investment strategies that are built on technical information will be examined. This would lead to introduction of the research methods that will be used in this thesis. In the final part of the paper, empirical research on market efficiency will be conducted.

Relevance. Research of market efficiency would improve the knowledge of the Baltic stock markets. This would contribute to the development of markets as more information and transparency may attract investors, increase trading activity. If profitable investment strategies will be found, this could improve market efficiency as investors would exploit these strategies.

1. SITUATION ANALYSIS

1.1. The role and importance of efficient capital markets

According to Harris (2011), the main functions for the financial system are to give ability for people: to save money for the future, to borrow money for current use, to raise equity capital, to manage risks, to exchange assets for immediate and future deliveries, to trade on information. In addition to these purposes financial system is also responsible for the discovery of the rates of return that equate aggregate savings with borrowings and for the allocation of capital to the best uses. In the aftermath of the global financial crises there are many discussions if the current financial system is able to achieve these goals. There are arguments that the financial markets are not rational, that irrational behavior results in formation of bubbles and disruptions of the system. In order to understand these topics, the behaviour of the stock markets is frequently analysed. Very often, efficient market hypothesis comes under scrutiny as efficient stock markets are essential for the financial system to function in the best way possible.

The Baltic countries are not an exception and topics about financial system`s behaviour, market efficiency in Lithuania, Latvia and Estonia are also very important. Well functioning financial system with the ability to allocate resources for the most efficient uses is crucial for emerging economies like the Baltics. As a result, it is very significant to increase the knowledge about the Baltic capital markets as these markets are still young and little researched.

As it was mentioned in the introduction, there are three forms of market efficiency: weak form, semi-strong form and strong form efficiency (Fama, 1970).

Weak form. "In the weak form of the efficient market hypothesis, security prices reflect all past market data, which refers to all historical price and trading volume information" (Clearly, Atkinson, Drake, 2011, p. 135). This means that technical analysis of stock prices would not bring any knowledge that would be useful in predicting future outcomes of stock movements. So unless the Baltic stock markets are weak form efficient, superior returns can be achieved by analyzing historical trends and behaviour of prices. According to Bodie, Kane, Marcus (2008), technical analysis is usually not expensive and much time consuming, so it would be possible to exploit weak form inefficiencies by undertaking profitable trading strategies. In this way market and capital allocation efficiency would be improved. As a result, it is relevant to have the knowledge about weak form efficiency in the Baltic stock markets.

Semi-strong. Prices reflect all publicly known and available information including financial statement data and financial market data. Semi-strong efficiency also includes weak form efficiency (Clearly et al., 2011). As a result, no one could take advantage by analysing information that other market participants could also obtain. As with the weak-form efficiency, knowledge about semi-strong market efficiency in the Baltic stock markets is also important as financial analysts are eager to know the benefits of analysing public information and fundamentals of the Baltic companies. Moreover, if markets are not semi-strong efficient, capital is not allocated effectively.

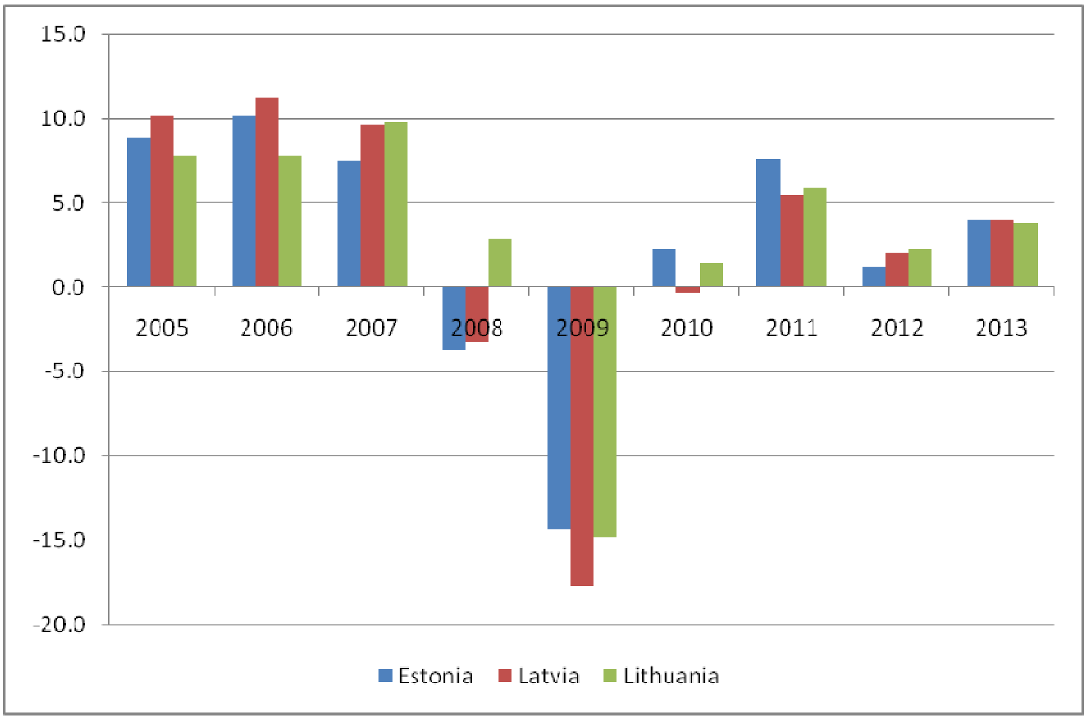
Strong form. Security prices fully reflect both public and private information. This includes both weak form and semi-strong efficiency (Clearly et al., 2011). So with strong form efficiency one can not earn abnormal returns even by using inside information. Strong form efficiency in the Baltic stock markets would have both positive and negative sides. On the positive side, strong-form efficiency would mean that capital is allocated for the best uses. On the negative side, strong-form efficiency would discourage investors, as without private information they would be disadvantaged against insiders.

1.2. Economies of the Baltic countries

It is beneficial to quickly review Baltic economies before research of the stock markets. Many investors use top-down approach in choosing their investments. In the top-down model, analysts start securities selection process by firstly analysing economic environment (Nagorniak & Wilcox, 2011). Better economic outlook is favourable to stock markets and could lead to more market activity. As a result, capital markets and economic development are interrelated and with the notion about the Baltic economies it is easier to understand the specifics of the stock markets.

Economic downturn hit all Baltic countries really hard. In the build-up of the economic crises small but open economies were fuelled with cheap credit. Economies were booming, asset prices were increasing and banks were lending carelessly as risks seemed to be low. This created classical “bubble” that was based on irrational behavior and that bursted together with the global financial crises and the prices in stock markets. In 2009 all Baltic economies experienced double digit decreases in their GDP (see Figure 1). However, all Baltic countries managed to rebalance their economies. Internal devaluation with price level and wages deflation helped countries to regain competitiveness and this resulted in the current account surpluses. Currently economies seem to be robust and well prepared to continue recovery from the deep crises with the positive projected growth in the coming years (see Figure 1).

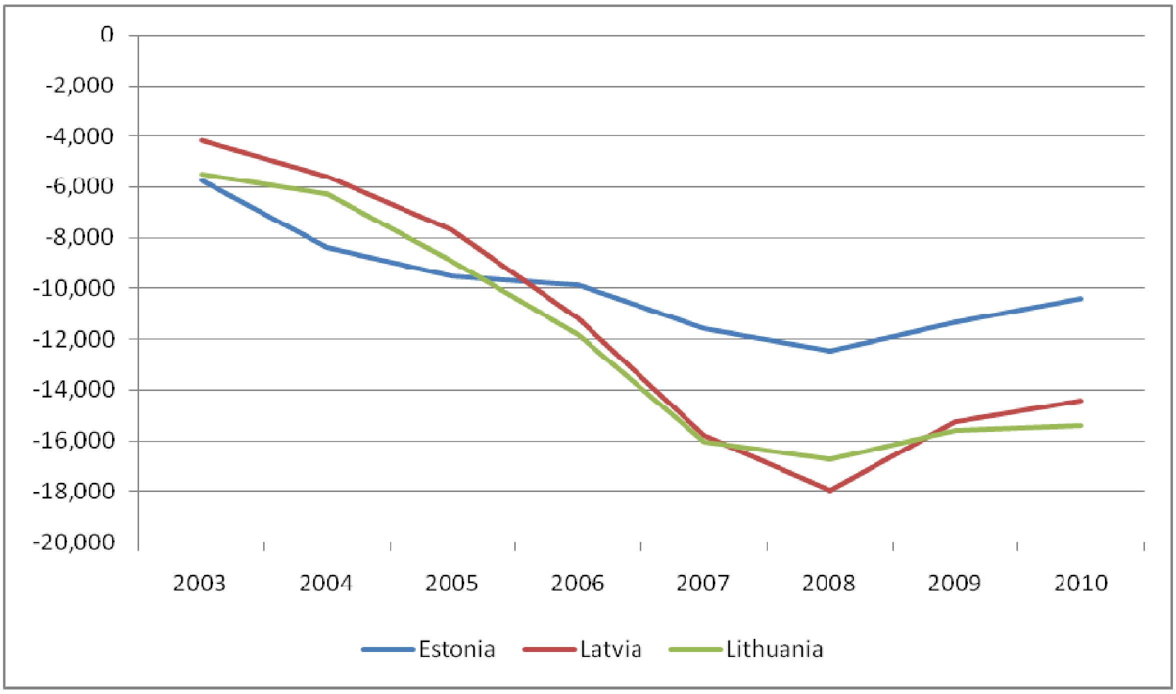
Figure 1. Change in real GDP, %



Source: Composed by author on the basis of Eurostat database

Net international investment position (NIIP) is another macroeconomic indicator that is relevant when analysing capital markets. Before the economic crises, all Baltic states had decreasing NIIP (see Figure 2). Admission to the European Union and fast growing economies encouraged investors to put money in the Baltic countries. This was favourable for the stock markets, as they enjoyed more attention and investments by the foreigners. However, in 2009 and 2010 NIIP deficit began to shrink. Nevertheless, the Baltic countries managed to avoid large capital outflows from their economies and this indicated than even steeply declining economies did not discourage international investors. The Baltic economies did not devalue their currencies, controlled their public finances in the prudent way and this would lay an attractive ground for foreigners to invest in the stock markets in the future.

Figure 2. Net international investment position, millions of EUR



Source: Composed by author on the basis of Eurostat database

1.3. Trading system and environment of the Baltic stock exchanges

Baltic stock exchanges are integrated into Nasdaq OMX group – one of the leading operators of stock markets. This ensures continuous development of the Baltic stock markets infrastructure and innovative improvements to the trading system. For example, a recent introduction of Nasdaq OMX INET trading system "has ushered in the arrival of algorithmic trading and the even more complex high-frequency trading on the Baltic markets" (Nasdaq OMX Group [NOG], 2011, p. 4) giving new opportunities for investors. Nasdaq OMX Vilnius and Nasdaq OMX Tallinn have euro as trading and settlement currency and this makes markets more easily accessible for foreign investors. Nasdaq OMX Riga is planning to introduce euro in its stock market in the nearest future. What is more, Baltic stock markets pay high attention to investor relations and corporate governance with Baltic Institute of Corporate Governance and Baltic Market Awards as the main contributors (NOG, 2011).

The Baltic stock markets are divided into three lists (see Table 1). The Baltic main list has the strictest requirements on market capitalisation, free float, operating history and accounting principles. Companies that are traded on this list tend to be the most liquid, transparent and attract the most attention from investors. Currently, there are 37 companies on the Baltic main list. Baltic secondary list has lower requirements and most notably no minimum free float requirement which often results in companies being illiquid. There are 43 companies on this list. First north Baltic list is the least regulated and is still quite unpopular with only 1 company being floated there.

Table 1. Requirements for being listed

Baltic Main List	Baltic Secondary List	First North Baltic
Regulated market	Regulated market	Alternative marketplace
Market cap of at least EUR 4 million	Market cap at least EUR 1 million in Nasdaq OMX Tallinn and Nasdaq OMX Vilnius (with exceptions applied)	No minimum requirements
25% free float or at least EUR 10 million	No minimum free float requirements	No minimum requirements
Three year operating history	2 year operating history in Nasdaq OMX Vilnius (with exceptions applied)	No minimum requirements
IFRS/Generally Accepted Accounting Principles	IFRS/Generally Accepted Accounting Principles/ local standards (Riga)	Local standards or IFRS

Source: Nasdaq OMX Group (2011)

1.4. Development and performance of the Baltic stock markets

The Baltic stock markets are still underdeveloped. Despite deep economic crises and slow recovery of GDP, market capitalisation as a share of GDP was only 7.8% at the end of 2011, almost as low as in 2008 (see Table 2) while the average for European Union was 56.65% for 2011 (Eurostat, 2012). The surprising fact is that despite relatively low market capitalisation as a share of GDP, the number of companies listed was decreasing steadily from 2005 until now. Companies were choosing to be delisted and the IPOs market was very small. Average company capitalisation in the Baltics is only 65.1 million euros. Market turnover is also on the decreasing trend. From 2.6 billion in 2005, it decreased to only 401 millions in 2011.

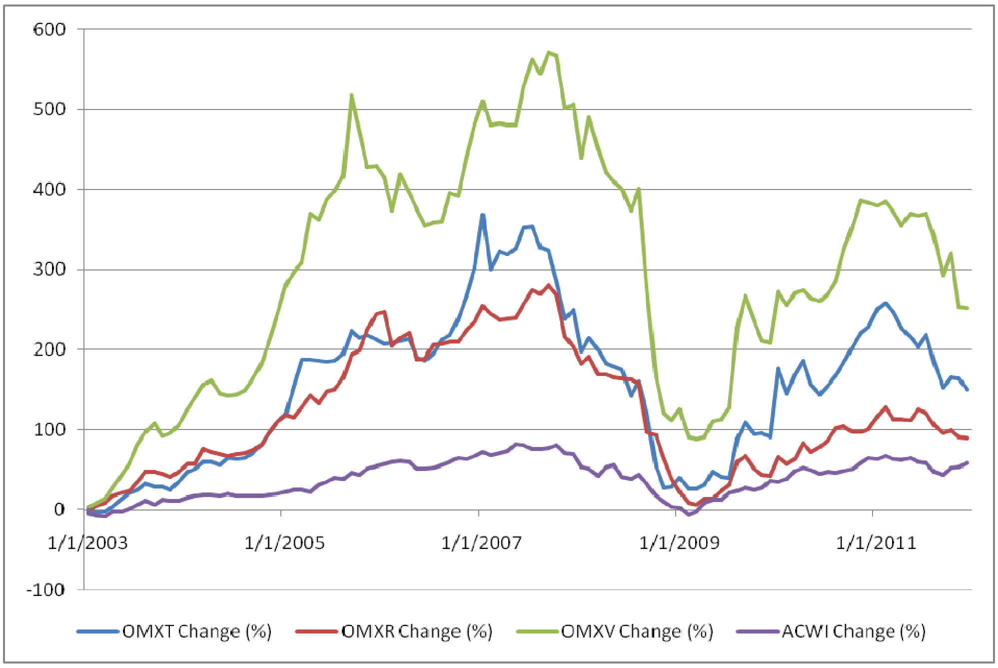
Table 2. Baltic stock markets statistics

	2004	2005	2006	2007	2008	2009	2010	2011
Market capitalization (MEUR)	10587	12081	14341	13096	5178	6386	6846	5206
Market turnover (MEUR)	1065	2603	2460	2386	978	495	488	401
Number of companies	95	104	98	99	94	90	87	80
Number of IPOs	1	3	3	3	1	0	2	0
Average company capitalisation	111.4	116.2	146.3	132.3	55.1	71	78.7	65.1
Market cap (% of GDP)	27.1	26.8	26.8	19.9	7.2	10.8	11.4	7.8

Source: Nasdaq OMX Group (2011), Eurostat database

On the positive side, all three stock exchanges in Lithuania, Latvia and Estonia performed well (see Figure 3) and brought returns that are superior to those in the most developed markets. From the beginning of 2003 to the end of 2011, OMX Vilnius grew at the most rapid pace with the overall index change of 252.42% and yearly geometric average of returns equal to 15.02%, OMX Tallinn brought the index change of 150.00% with yearly geometric average of returns equal to 10.72% and OMX Riga increased by 89.27% with yearly geometric average of returns equal to 7.35%. These returns compares well with the world index that is constructed by MSCI and that includes both developed and emerging markets. This index brought a total return of 58.84% with geometric average of 5.28% (see Figure 3) which is significantly lower than returns in the Baltic markets. The limitation is that this comparison does not account for risk. However, favourable historical returns and positive economic outlook in the Baltic countries may be the reasons for investors to increase their attention to these markets.

Figure 3. Returns of the Baltic stock markets and world stock index



Source: Composed by author on the basis of Nasdaq OMX Baltic and MSCI data

1.5. Factors contributing to and impeding market efficiency in the Baltic stock markets

The specifics of the Baltic stock markets are two sided. While on the one hand the Baltic stock exchanges have modern infrastructure and regulation, improving investor relations, on the other hand there is diminishing activity in the markets. It is essential to examine implications of Baltic stock markets properties to market efficiency. According to Clearly et al. (2011), the main factors that can affect market efficiency are market participants, information availability, financial disclosure and limits to trading. These impediments now will be analysed for the Baltic stock markets to evaluate if they could prevent Baltic capital markets from performing its task – to allocate capital efficiently.

1.5.1. Market participants

A large number of investors, high trading activity and financial analysts that cover the markets increase market efficiency as mispricing is quickly noticed and disappears (Clearly et al., 2011). This implies that in an active market with a lot of participants overvalued and undervalued securities will not trade far from their intrinsic ("fair") values as investors will take profit opportunities and discrepancy between market and intrinsic value will vanish.

As a result, emerging stock markets that are usually covered by fewer analysts in theory should be less efficient than well developed stock markets. As it is seen from Table 2, which was analysed previously, market activity in the Baltic stock markets is low and has even been decreasing. Reducing number of companies, lower capitalisations and declining turnovers could all contribute to market inefficiencies. With these trends in line, it is harder to attract investors and to increase market coverage as mutual funds and professional investors are attracted by markets with better investment opportunities and higher liquidity. Their trades in the Baltic stock markets could be limited as illiquidity could prevent from entering and closing positions in stocks and thus profiting from mispricing.

1.5.2. Information availability and financial disclosure

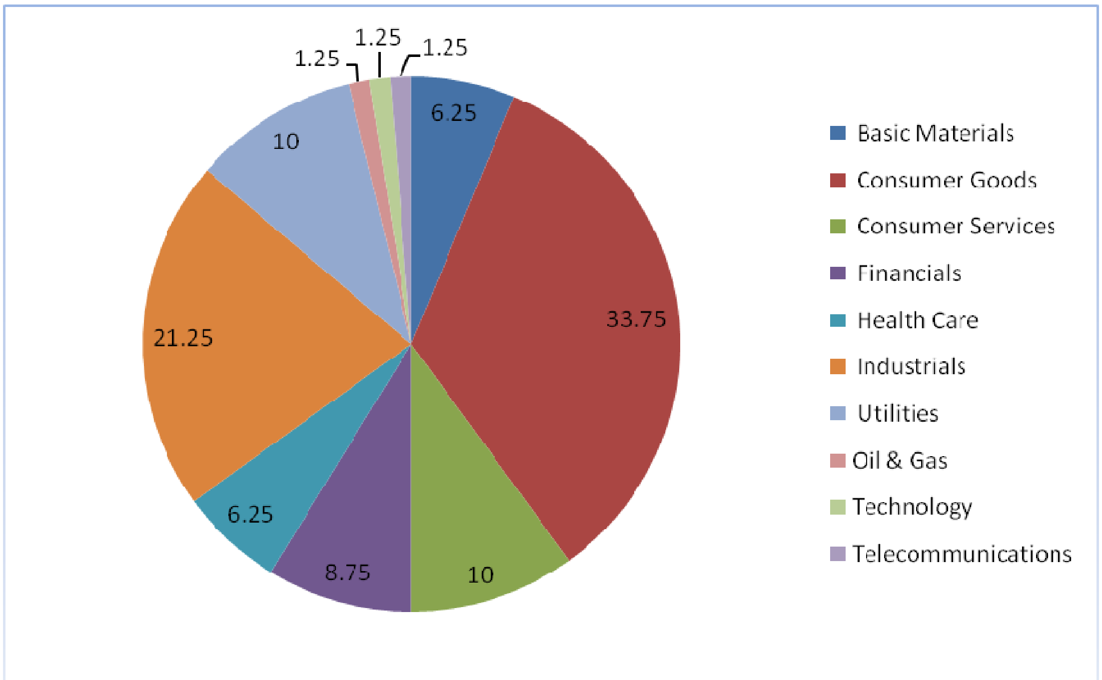
Information availability regarding traded companies and trading activities, deep market coverage, fair and equal financial disclosure procedures improve market efficiency (Clearly et al., 2011). Without available and timely information, it would be complicated to evaluate stocks fairly and companies may be traded at market values deviated from their intrinsic values for prolonged periods.

Rules regarding financial disclosure in the Baltic stock markets are similar to those in more advanced markets. Companies must disclose any material information that could affect stock prices without delay and to all market participants simultaneously to guarantee equal opportunities to all investors (NOG, 2011). These rules protect investors from discrimination and enhance their confidence in markets.

However, companies in the Baltic stock markets do not have a long history of being listed. As a result, lack of experience provides a challenging task for companies to keep their investor relations at a high level and this area could possibly constrain market efficiency in the Baltics. In order to improve the way companies communicate and behave with investors, Nasdaq OMX Baltic Market Awards were established. The criteria for evaluation are the quality and timeliness of annual reports, corporate governance reports, interim reports, announcements to the stock exchange, company websites and overall availability, reliability and the quality of information disclosed by the company (Nasdaq OMX Baltic, 2012). This initiative contributes to the development of investor relations tradition in the Baltics, but the improvement is hard to measure.

Belonging to Nasdaq OMX group is beneficial for the Baltic stock markets not only because this provides modern trading infrastructure, but also because this ensures that relevant statistics and information about the Baltic stock markets will be published and accessible for investors. For example, from the February 1, 2012, OMX Baltic started to use Industry Classification Benchmark to divide companies into different sectors (see Figure 4). Moreover, Nasdaq OMX Baltic provides wide variety of information products to vendors with distribution agreement, including real time information, trading data with 15 minutes delay, basic analysis data or batch data. Listed companies can also use services of GlobeNewswire, a Nasdaq OMX company, to distribute their news efficiently and effectively (NOG, 2011).

Figure 4. Companies in each sector, percentage



Source: Composed by author on the basis of Nasdaq OMX Baltic data

To sum up, companies in the Baltic stock markets have a good ground to have effective and high quality investor relations consisting of rules that ensure fairness, information channels that guarantee effective distribution of news and Nasdaq OMX Baltic exchange that secures the quality of statistics. On the other hand, companies do not have much experience of being listed and this may be an impediment to market efficiency.

1.5.3. Limits to trading

Clearly et al. (2011) states that market efficiency is also impeded by operating inefficiencies that result from difficulties in executing trades in a timely manner, various limits to trading, prohibitively high trading costs or lack of transparency in market prices. With these obstacles present, it is harder to trade actively and benefit from mispricing, to conduct arbitrage operations and to bring prices to their fair values.

The Baltic stock markets are easily accessible for investors. Nasdaq OMX Baltic has a common trading system, rules and requirements for Vilnius, Tallinn and Riga exchanges and this allows investors to trade and settle efficiently between the three markets. Investors with an account in one of the three countries can access other Baltic markets without opening a new account. Overall, there are

37 Nasdaq OMX Baltic members through which investors can reach the Baltic markets. Moreover, modern trading system INET ensures timely execution of trades. (NOG, 2011).

The impediment to market efficiency could be the fact that short selling is not allowed in the Baltic stock markets. This restriction does not enable investors who notice overpriced securities to take advantage of mispricing of the security. However, the effect of short selling to market efficiency is a disputable question. Many analysts and other participants in the financial markets argue, that short selling may be damaging. They propose that short sellers may start borrowing and shorting stocks of even healthy and fairly priced companies, distressing their stock prices. Decreasing prices attract even more short sellers and declining stock value becomes a self fulfilling prophecy. These arguments are hard to examine, but the fact is that very often during financial turmoils short selling is banned by regulatory agencies to avoid such cases.

1.6. Summary of the situation in the Baltic stock markets

Market efficiency topic in the Baltic stock markets deserves attention due to the importance of well functioning financial system. Baltic countries are emerging and evolving economies and efficient capital allocation is crucial for their development. These countries attract investors because of prudent economic policies and higher growth opportunities than in Western Europe. Moreover, the Baltic stock markets have modern stock exchange infrastructure and regulatory environment. Eventually, this may lead to higher market efficiency in the Baltics. On the other hand, decreasing capitalisation, average turnover and number of companies in the Baltic stock markets are the factors that could impede market efficiency. Lower trading activity and less coverage can be the obstacles for securities to be fairly priced.

To sum up, there are both arguments for and against market efficiency in the Baltics, so it is essential to research the situation more deeply in order to make the situation in markets more transparent.

2. THEORETICAL BACKGROUND AND EMPIRICS

2.1. Market efficiency in theory

2.1.1. Market efficiency and its forms

According to Bodie et al. (2008), efficient market hypothesis states that stocks already reflect all available information. New information is impossible to predict and this results into unpredictability of stock returns. If one would be able to predict stock price movements and profit from that, this would mean that all available information was not included in prices and markets are inefficient.

Fama (1970) indicated sufficient conditions for market efficiency: no transaction costs, information costlessly available to all market participants and there is an agreement about implications of current information for the current price and distribution of future prices. In the real world these conditions are not met, but as Fama stated, markets may be efficient if these conditions are met sufficiently, not necessarily perfectly. Other factors that may impede market efficiency have already been discussed in the section 1.5 and will be also discussed in the behavioural critique section.

Forms of market efficiency have also been introduced, but as these concepts are so important they will be reviewed below in a more detail. This framework was first time proposed by Fama (1970), where he divided market efficiency into three forms of weak form, semi-strong form and strong form depending on the kind of information prices should incorporate.

The weak form efficiency. According to Bodie et al. (2008), in the weak form efficient market prices should reflect all information that can be derived from market trading data including the history of past prices, trading volume and short interest. The trend analysis is fruitless, as market data is publicly available and can be cheaply obtained. If there were profitable trading strategies with reliable signals, all investors would rush to exploit that and signals would loose value. So in the weak form efficient markets there is no use of analysing technical information.

There are two general approaches to test weak form market efficiency: one approach is to see if there is serial correlation in historical stock returns which would indicate predictable pattern and another is to test various trading strategies based on historical market data (Clearly et al., 2011). There are many technicians who argue that trading on market data is profitable. Technicians believe, that “if the stock price responds slowly enough, the analyst will be able to identify a trend that can be exploited during the adjustment period” (Bodie et al. 2008, p. 235-236). So by looking at the history, they expect to profit on sluggishness of price changes.

The semi-strong form efficiency. Bodie et al. (2008) states that semi-strong efficient market prices should reflect all publically available information regarding the prospects of the firm, which, in addition to past prices, includes fundamental data on the firm`s product line, quality of management, balance sheet composition, patents held, earnings forecast and accounting practices. As semi-strong efficiency also involves the weak form efficiency, in semi-strong efficient markets investors could not benefit from all types of public information.

Common approach to test semi-strong efficiency is event studies, where researchers look at how quickly stock prices adjust to new information such as stock splits, earnings announcements or dividend changes. If prices are slow to react and there are trading opportunities some time after announcement is made, markets are not informationally efficient (Clearly et al., 2011).

The strong form efficiency. This is quite extreme hypothesis, as it requires that stock prices include all information relevant to the firm, even the information known only by the company insiders (Bodie et al. 2008). Nevertheless, there are laws against insider trading, as using private information would discriminate other investors. In the strong form market efficiency, capital would be allocated in the best way possible. However, as investors would be discriminated against groups with inside information, this would reduce confidence and transparency in the capital markets.

To test strong – form efficiency, researchers look if investors can earn abnormal returns trading on non-public information (Clearly et al., 2011).

2.1.2. Market efficiency models

The expected return model. In one of the most important papers on market efficiency, Fama (1970) stated that early works on market efficiency had concentrated on "expected return theories" that were based on assumption that market equilibrium can be stated in terms of expected returns, which could be described notationally as:

$$\mathrm{E}(\tilde{\boldsymbol{p}}_{\boldsymbol{j,t+1}}|\Phi_t) = [1 + \mathrm{E}(\tilde{r}_{j,t+1}|\Phi_\mathrm{t})]\boldsymbol{p}_{\boldsymbol{jt}}$$

where E is the expected value operator; $\boldsymbol{p}_{\boldsymbol{jt}}$ is the price of security j at time t; $\boldsymbol{p}_{\boldsymbol{j,t+1}}$ is its price at t+1; $r_{j,t+1}$ is the one-period return; Φ_t is information that is assumed to be "fully reflected" in the price at t; and the tildes indicate that $\boldsymbol{p}_{\boldsymbol{j,t+1}}$ and $r_{j,t+1}$ are random variables at t. So in the efficient markets, the expectation about the price in the future $\tilde{\boldsymbol{p}}_{\boldsymbol{j,t+1}}$ is dependent on all available information Φ_t today.

Fama (1970) also introduced "fair game" variable $\tilde{x}_j$, which is the expected excess price of the stock and is equivalent to zero:

$$\mathrm{E}(\tilde{x}_{j,t+1}|\Phi_\mathrm{t}) = 0$$

According to Fama (1970), this theory meant that all information $\Phi_\mathbf{t}$ must be utilized in determining equilibrium expected returns no matter what theory on expected return was used. This theory lead to a "fair game" model – expected excess profit of any trading strategy is zero. This notion that in the efficient markets all available information must be included and that there should not be any trading strategies that can bring excess returns are the core of efficient market hypothesis and many of the empirical tests fall within this model.

The submartingale model. The lying fundamentals of this model are pretty simple and easy to test. According to Fama (1970), model can be explained by the equation:

$$\mathrm{E}(\tilde{r}_{j+1}|\Phi_t) \geq \mathbf{0}$$

which means that if expected returns conditional on $\Phi_{\mathbf{t}}$ are non-negative, trading rules based on $\Phi_{\mathbf{t}}$, where investor decides when to hold, buy or sell security can not be more profitable than buy and hold strategy. As expected returns on equities are indeed positive, in efficient markets the optimal strategy would be for investors to hold maximum amount of securities in all periods.

The random walk model. According to Fama (1970), the underlying assumption for the random walk are that the successive price changes are independant and identically distributed. The model can be decribed as:

$$f(r_{j,t+1}|\Phi_{\mathrm{t}}) = f(r_{j,t+1})$$

which means that the conditional and marginal probability distributions of an independant random variable are identical and do not depend on informations available. So in the random walk model, each period return should not depend on previous periods returns and should have the same distribution through time with constant expected returns.

However, the random walk model is stricter than the expected return model and market efficiency does not require for stock returns to follow the random walk. For example, if large price changes tend to be followed by large price changes, but the sign of the successor change is random, this will violate the random walk model, but not the market efficiency. Moreover, market efficiency does not require expected returns to be constant through different periods, but the random walk model does (Fama, 1970). Nevertheless, the random walk model is still widely used to test market efficiency.

2.1.3. Impediments for researchers of market efficiency

Research of market efficiency is a complicated matter. Bodie et al. (2008) indicates these factors that make the conclusion of market efficiency hard to reach: the magnitude issue, the selection bias issue, the lucky event issue and the issue of risk premiums.

The magnitude issue. According to Bodie et al. (2008), it is hard to answer the question “Are markets efficient” because this is very subjective. 0.1% increase in returns with an active trading strategy would not be noticeable for small investor, but would constitute a large profit for a mutual fund. Difficulty to conclude the magnitude of mispricing that would lead to market inefficiency makes “How efficient are markets” the more proper question to answer.

The selection bias issue. Efficient market researches may be biased because of the selection bias, as positive outcomes of market efficiency may have been preselected in favor of failed attempts. Investors who find profitable strategies are eager to exploit them rather than to report to others and in that way make strategies useless (Bodie et al., 2008).

The lucky event issue. Bodie et al. (2008) indicated another caveat to conclusion about market efficiency: even if profitable strategies are found, this may be because of pure luck or because of data mining, as with so many trading strategies some will be profitable only by chance.

Risk premiums or inefficiencies? Bodie et al. (2008) also stated that some of the market anomalies may be because trading strategies that reach abnormal returns include riskier stocks. So research of efficient market hypothesis is also impeded by the need to use reliable asset pricing models.

2.2. The behavioural critique

Information processing and behavioural biases

School of behavioural finance has long been an opposing side to efficient market hypothesis and to models that assumes rational behaviour. Behavioural finance approach argues that some financial phenomena can be understood using models in which not all agents are fully rational. Agents may not process information correctly, or even using correct information still make suboptimal choices (Barberis & Thaler, 2003).

Information processing**.** Bodie et al. (2008) distinguish forecasting errors, overconfidence, conservatism and representativeness as information processing biases that could lead to irrational behaviour and market inefficiency. As authors conclude, these biases could be responsible for anomalies observed in markets. For example, conservatism may lead to momentum properties of stock markets, as information may be reflected only gradually in the stock prices.

Behavioural biases. Bodie et al. (2008) summarise biases that could lead to inefficient use of information: framing, mental accounting, regret avoidance and prospect theory. These biases can also explain market anomalies. For example, mental accounting could lead to momentum in stock markets, as investors owning successful stocks may become less risk averse and by buying more of the same stocks push up prices even higher.

Limits to arbitrage

According to Barberis and Thaler (2003), even when mispricing is noticed, strategies to exploit mispricing can be both risky and costly, limiting the ability for rational agents to bring asset prices back to their fundamental values. Consequently, even if there are no strategies that can bring risk-adjusted excess returns, this does not mean that markets are efficient. Assets may be traded deviated from their fundamental values and this could induce inefficient capital allocation. Limits of arbitrage can be grouped as fundamental risk, noise trader risk, model risk and implementation costs.

Fundamental risk. According to Barberis and Thaler (2003), when investors attempt to benefit from mispricing, they can not avoid risk that unfavourable news will adversely affect their position. As a result, trying to exploit mispricing in stock markets is not a risk free arbitrage.

Noise trader risk**.** Another impediment for arbitrage that was noted by Barberis and Thaler (2003) is that mispricing can continue for prolonged periods. Arbitrageurs may be forced to liquidate their position before they benefit from security going back to its intrinsic value. This adds risk and makes arbitrageurs more cautious.

Implementation cost. According to Barberis and Thaler (2003), bid-ask spread, transaction costs, commissions, short-sale constraints are also among the factors that limit arbitrage. Finding and learning about mispricing can also be classified as implementation costs.

Model risk. Bodie et al. (2008) indicate another limit of arbitrage: arbitrageurs can be wrong about the mispricing. Their models may be incorrect and arbitrageurs must be highly certain about the mispricing to undertake arbitrage.

Summary

Behavioural finance offers explanation for the behaviour that should not occur in the efficient markets. Anomalies could result from psychological biases of economic agents as they do not process or use information rationally. Moreover, many impediments exist to arbitrageurs and even when mispricing is noticed, it may be hard to take advantage and bring back assets to their intrinsic values.

2.3. Overview of existing studies (weak form efficiency in the stock markets)

In this thesis only weak form efficiency of the Baltic stock markets is tested, so only previous research on weak form efficiency will be reviewed. There are mounting amounts of empirical work on this topic, so it is impossible to examine all the relevant research. However, most influential papers will be presented.

2.3.1. Studies on market efficiency in the Baltic stock markets

Butkutė and Moščinskas (1998) investigated 25 stocks listed in the Baltic stock markets. After using Augmented Dickey-Fuller test and autocorrelation analysis, authors indicated, that for 9 stocks weak form efficiency can be rejected.

Kvedaras and Basdevant (2002) analysed weak form efficiency for the period of 1996-2002. Authors used variance ratio methodology and stated that Lithuania`s and Estonia`s stock markets were moving towards weak form efficiency with slight autocorrelations left. However, huge inefficiencies were found in the Latvian stock markets.

Levišauskaitė and Jūras (2003) investigated weak form market efficiency for Vilnius, Riga and Tallinn stock markets using data from the period of 1998-2001. By conducting autocorrelation and random walk analysis for different stocks, they concluded that weak form efficiency can not be accepted for any of the markets. However, they also argued that significant autocorrelations would not necessarily mean that investors can earn excess profits.

To sum up, empirical studies for market efficiency in the Baltic stock markets are scarce. Mainly by using autocorrelation and random walk analysis, researchers found some evidence of market inefficiency, however, they could not conclude that profitable strategies can be adapted to earn abnormal returns. Moreover, researchers did not elaborate on the aspect that autocorrelations and non-random walk behaviour do not necessarily mean market inefficiency, rather, as Fama (1970) stated, this could be the outcome of changing required risk premiums. Furthermore, previous research lacks testing market efficiency by conducting different trading strategies or analysing other anomalies (such as calendar effects). So there is obviously a need for more research which would also include recent data samples.

2.3.2. Serial correlation tests for other markets

In a review of early work on market efficiency, Fama (1970) indicated that possible market inefficiencies occurring from serial correlations and other anomalies do not have much economic meaning as it could not be exploited profitably. Fama (1970) concluded that "evidence in support of efficient markets model is extensive, and (somewhat uniquely in economics) contradictory evidence is sparse" (p. 416).

Conrad and Kaul (1988) examined serial correlations of continuously compounded weekly returns in the NYSE stock markets for the period of 1962-85. They constructed 10 portfolios based on market value. Conrad and Kaul found that all portfolios experienced significant first order autocorrelation which decay over longer lags. The first order autocorrelation was highest for the portfolio with the lowest market capitalization stocks (0.41) and declined consistently for larger stock portfolios (0.09 for largest portfolio). This may indicate, that smaller capitalization stocks are slower to adjust to their true values and thus are less efficient. Lo and MacKinlay (1988) found similar results on almost the same data set. They discovered significant autocorrelations of weekly and monthly holding period returns. Authors rejected random walk hypothesis and concluded, that rejection was not due to infrequent trading or changing volatilities.

Fama and French (1988) discovered significant negative autocorrelations for returns beyond 1 year for the 1926-1985 period in the NYSE stock markets. They found that first order autocorrelations for increasing return horizons form U shape. Negative autocorrelations become negative for 2 year returns, reach minimum values for 3-5 year returns and move towards 0 for longer horizons. Results were in line with the theory that stock prices have slowly decaying stationary component, which according to authors, may be missed and is harder to notice for short-horizon returns. They also concluded that autocorrelations may occur due to the market inefficiency or time varying expected returns.

In another influential paper, Poterba and Summers (1987) found that returns are positively serially correlated over short horizons and negatively autocorrelated over long horizons. They also highlighted that very high variability in required returns would be needed to explain the degree of mean reversion in prices.

To sum up, serial correlation analysis as a mean of testing weak form efficiency is widely used for different markets. Researchers tend to find positive serial correlations for shorter periods and negative serial correlations for longer periods.

2.3.3. Day-of-the-week effect and momentum strategy in other markets

Jegadeesh and Titman (1993) found the momentum properties in stock returns for NYSE and AMEX stocks. By using strategy of buying best and selling worst performers during last 1-4 quarters and keeping this strategy for 1-4 quarters they managed to achieve abnormal returns. Conclusion was that these abnormal returns are not due to systematic risk or delayed reactions to common factors, but rather because of delayed price reactions to firm specific information. Moreover, authors documented, that abnormal returns for past winners tend to reverse if you keep stocks longer than 1 year. In another influential paper, Moskowitz and Grinblatt (1999) found momentum behaviour for industries. According to their calculations, buying stocks from past winning industries and selling stocks from past losing industries are highly profitable even after controlling for risk. Various momentum findings, however, not consistently, were also confirmed by other researchers.

Day-of-the-week effect is another market anomaly that is well documented by researchers. In extensive analysis across different markets, researchers found that asset returns vary between days of the week. For example, early researchers indicated Monday effect when asset returns on Monday are consistently negative or lower than on other days of the week. Cross (1973) found this anomaly using New York Stock Exchange data for the period of 1953-1970. French (1980) tested two hypotheses: trading time hypothesis under which stock returns are generated only during trading days, and calendar time hypothesis, under which stock generating process is a continuous process and expected return on Monday should be three times higher than expected returns on other days. Results from the period of 1953-1977 were found inconsistent with both hypotheses, as returns on Monday were negative and significantly lower than on other days. By analysing US stock markets, Gibbons and Hess (1981) confirmed Monday effect using different data sets and could not find reasonable arguments for this phenomenon. They also discovered, that variance on Monday is higher than on other days.

Both momentum strategy and day-of-the-week effect contradicts market efficiency. Moreover, the fact that these anomalies are found using different data samples and different stock markets seem to deny that findings are caused by biases reviewed previously (see section 2.1.3.).

2.4. Empirical methods

Statistical tests

In the first part of the weak form efficiency analysis of the Baltic stock markets, serial correlation tests will be conducted. As Fama (1970) states, “observations of a “fair game” variable are linearly independent. But the “fair game” model does not necessarily imply that the serial covariances of one – period returns are zero” (p. 392). So in order to test the Baltic stock markets on the ground of “fair game” model, it would not be correct to run serial correlation tests of stock returns. Rather, it would require to test if excess profits adjusted to expectations are serially correlated. In a "fair game" model expectations of stock returns are allowed to vary, so it would be very complicated to conduct such tests, as their results would highly depend on the success of correctly measuring expected returns in each period. Thus, in this research serial correlation analysis will be conducted in line with the "random walk" model. As it is mentioned in the description of the "random walk" model, market efficiency does not require random walk. However, Fama (1970) states that "random walk" assumption does not greatly affect results of covariance tests and serves as gross approximation from the viewpoint of the general expected return efficient markets model. To further test "random walk" assumption and to get more information about time series of the Baltic stock markets returns, unit root test will also be performed.

2.4.1. Autocorrelation analysis

The k-th order autocorrelation can be described by the formula:

$$r_k = \frac{\sum_{t=k+1}^{T}(Y_t - \bar{Y})(Y_{t-k} - \bar{Y})}{\sum_{t=1}^{T}(Y_t - \bar{Y})^2}$$

This gives us the correlation between observations that are k periods apart (Hill, Griffiths, Lim, 2011). Identical equation is used by EViews and consequently in this paper.

To test for the significance of the serial correlations Ljung-Box Q-statistic is used:

$$LB = n(n+2)\sum_{k=1}^{m}\frac{\rho_k^2}{n-k}$$

where n is sample size, k is lag length and ρ is estimated autocorrelation. Using this statistic, it is possible to test hypothesis that all correlations up ρ_k are zero. Ljung-Box Q statistic follows chi-square distribution with m degrees of freedom. If computed Q statistic exceeds the critical Q value (χ with m degrees of freedom) from chi-square table, H_0 can be rejected that all ρ_k are zero (Gujarati, 2004). EViews automatically calculate p-values associated with Ljung-Box Q-statistics, so p-values will be used for hypothesis testing.

H_0: all autocorrelations up to ρ_k are zero

H_A: at least one autocorrelation up to ρ_k is not zero

In addition, each autocorrelation ρ_k will be tested for significance separately. According to Gujarati (2004), if time series is purely random and exhibits white noise, in large samples the sample autocorrelation coefficients are approximately normally distributed with zero mean and variance equal to 1/T. So using Z values from standard normal tables, confidence intervals can be constructed for ρ_k. To be significantly different from zero at 0.05 level of significance, ρ_k must be outside interval

$$\pm 1.96 * \frac{1}{\sqrt{T}}$$

To be significantly different from zero at 0.01 level of significance, ρ_k must be outside interval

$$\pm 2.58 * \frac{1}{\sqrt{T}}$$

Data. Daily and weekly continuously compounded returns of OMX Baltic Benchmark GI benchmark will be used to compute correlations between returns and lagged returns. OMX Baltic Benchmark GI index includes most liquid and highest capitalisation companies and will serve as a proxy of the Baltic stock markets. Period: 2003-2012 March 31.

2.4.2. Unit root test

According to Koop (2006), autoregressive AR(1) model can be described:

$$Y_t = \alpha + \Phi Y_{t-1} + e_t$$

where Y_t is dependant variable, $Y_{t-1}$is explanatory variable (dependant variable lagged by one period), α is intercept and e_t is residual. If $\Phi = 1$, Koop describes the behavior of the time series variable as unit root nonstationary, and if $|\Phi| < 1$ as stationary. If Y_t is nonstationary, then autocorrelations will be near one and Y_t will have long memory – autocorrelations will not drop much for higher lags. In this case, ΔY_t will be stationary and referred as difference stationary series (Koop, 2006). Stationary time series will have time invariant mean and variance while covariance between variables will only depend on the length of time separating variables, not on the actual time period taken (Hill et al., 2011). This has important implications to the random walk model that will be tested, as AR(1) model with $\Phi = 1$:

$$Y_t - Y_{t-1} = \alpha + e_t$$

is defined as random walk with drift. So if AR(1) model regression is run for stock prices and it is found that $\Phi = 1$, it can be concluded that stock prices are nonstationary, exhibits random walk with drift behaviour and the returns of stocks are an intercept α with a random error e_t (Koop, 2006).

While testing if stock prices in the Baltic stock markets have unit root and experience random walk behaviour, more general autoregressive model will be used. In addition to one period lag Y_{t-1}, more lags will be included in the autoregressive model as they could also be important in explaining time series properties and without them testing for unit root may not be valid (Koop, 2006). Lag length will be selected automatically by EViews. Moreover, deterministic trend δ_t will be included as trend behaviour can be a simple function of time with so called deterministic trend. So the model can be described as:

$$Y_t = \alpha + \Phi_1 Y_{t-1} + \ldots + \Phi_p Y_{t-p} + \delta t + e_t$$

and after subtracting $Y_{t-1}$and rearranging we get

$$\Delta Y_t = \alpha + \rho Y_{t-1} + \gamma_1 \Delta Y_{t-1} + \ldots + \gamma_{p-1} \Delta Y_{t-p+1} + \delta t + e_t$$

where $\rho, \gamma_1, \ldots, \gamma_{p-1}$ are simple functions of Φ (Koop, 2006).

This is the final model that will be used to test if the stocks in the Baltic stock markets have unit root and experience the random walk. In hypothesis testing, ρ will determine our conclusion about unit root and random walk: "$\rho = 0$ implies that the AR(p) time series Y contains a unit root; if -2 < ρ < 0, then the series is stationary." (Koop, 2006, p. 149). P-values associated with Dickey-Fuller tau statistics are used for hypothesis tests concerning ρ. t distribution is used to test significance of other coefficients.

Data. Daily and weekly prices of OMX Baltic Benchmark GI benchmark will be used to test for unit root. To fit data into linear regression, natural logarithms of prices will be taken. Period: 2003-2012 March 31.

H_0: stock prices contains unit root $\rho = 0$

H_A: stock prices do not contain unit root $\rho < 0$

0.05 level of significance is used in tests.

2.4.3. Day-of-the-week effect

Tests will be applied in order to find out if there are any day-of-the-week effects in the Baltic stock markets. If, for example, it will be found that one of the weekdays experiences significant negative returns, it would contradict submartingale efficient market model and would make trading strategies based on rules when to buy, hold and sell securities theoretically possible (at least when transaction costs are not included). Two hypotheses, offered by French (1980), will be examined. First one is trading day hypothesis, which states that returns between different weekdays should be the same. The second is calendar day hypothesis, which states that returns on Monday should be three times higher than returns on other days, as Monday returns account for three calendar days.

Trading day hypothesis

Most of the previous researches, including influential paper by Gibbons and Hess (1981), used this equation to test day-of-the-week effects:

$$R_t = b_1 D_{1t} + b_2 D_{2t} + b_3 D_{3t} + b_4 D_{4t} + b_5 D_{5t} + {}_t$$

where R_t is the return in period t, D_{1t} is dummy variable with value 1 if the day is Monday, and value 0 otherwise, D_{2t} is dummy variable with value 1 if the day is Tuesday, and value 0 otherwise and so on. ${}_t$ is error term which is assumed to be independently and identically distributed. The coefficients that are calculated with OLS method are the mean returns from Monday to Friday.

H_0 is that means are equal

$$H_0 : b_1 = b_2 = b_3 = b_4 = b_5$$

H_a is that at least one mean is statistically different from others.

To test this hypothesis, ANOVA F-statistic will be used. Hypotheses are tested at 0.05 level of significance.

Calendar day hypothesis

Regression for calendar day hypothesis will be the same as used by French (1980):

$$R_t = \alpha(1 + D_{1t}) + b_2D_{2t} + b_3D_{3t} + b_4D_{4t} + b_5D_{5t} + {}_t$$

where values of dummy variables are the same as in trading day regression, α measures one third of Monday return, ${}_t$ is error term which is assumed to be independently and identically distributed.

H_0: if returns on other days are one third of returns on Monday, coefficients b_2 through b_5 should not be significant.

$$H_0: b_2 = b_3 = b_4 = b_5 = 0$$

H_a: at least one coefficient is statistically significant.

Data. Daily continuously compounded returns of OMX Baltic Benchmark GI benchmark will be used to test the day-of-the-week effects. Period: 2003-2012 March 31.

2.4.4. Momentum strategy

The common approach of researchers who test momentum properties is to use 3-12 months intervals. Using shorter intervals are transaction intensive and may be biased because of lack of liquidity or due to bid – ask spread, while in longer periods abnormal returns of the momentum strategy tend to diminish (Jegadeesh & Titman, 1993).

Building portfolios. Momentum strategy will be constructed based on 3 months interval. Strategy will be similar to the one described by Jegadeesh and Titman (1993). Trading rule will be to buy 10% of stocks that performed best (buy portfolio) and sell 10% of stocks that performed worst (sell portfolio) during the last 3 months period and to hold the portfolio for 3 months. All stocks in the portfolios will be equally weighted and the portfolios will not be rebalanced through the holding period.

Liquidity requirements. There were many illiquid stocks during the period of our interest (2003-2012 March 31). Therefore, it is necessary to adapt liquidity requirements for the sample from which stocks can be selected in the portfolios. Sample in each 3 months period will be constructed using the following procedure. First, all shares that were listed on the Baltic stock markets during the quarter analysed and had the turnover higher than 0 will be taken. Then, the average turnover per share will be calculated. In calculating average turnover per share, stocks that accounted for more than 30% of the total Baltic stocks markets turnover will be excluded to avoid distortions due to unique events such as when shares are traded very heavily before being delisted. Finally, shares, which had the turnover lower than 20% of the average turnover per share, will be deleted. Liquidity requirements will reduce distortions of stock returns that can occur due to high bid-ask spreads and the absence of illiquid stocks will also make momentum strategy easier to execute.

Calculating returns. Portfolios will be formed based on discrete returns formula:

$$R_t = \left(\frac{P_t}{P_{t-1}} - 1\right) * 100$$

where R_t is return at time t, P_t is stock price at the end of the period, P_{t-1} is stock price at the beginning of the period. This equation accounts only for capital appreciation, so stock selection will be slightly biased. It will be harder for dividends paying stocks to get into buy portfolio and easier to get into sell portfolio.

Returns for the strategy in each period are calculated using discrete total returns formula, which assumes that any dividends are reinvested immediately and thus shows total return for shareholders:

$$R_t = \left(\frac{P_t}{P_{t-1}} - 1\right) * \left(1 + \frac{D_k}{P_k}\right) * 100$$

where R_t is return at time t, P_t is stock price at the end of the period, P_{t-1} is stock price at the beginning of the period, D_k is dividends at time k, P_k is stock price at time k (t-1 ≤ k ≤ t).

T statistics will be used to evaluate if mean returns of zero cost strategy returns are significantly different from zero. 0.05 level of significance will be used.

$$H_0: R = 0$$

$$H_a: R \neq 0$$

Adjusting returns for risk. Riskiness of the both buy and sell portfolios will be calculated by estimating betas. The market model equation will be used, which, according to Singal (2011) can be written as a regression:

$$R_p = \alpha + \beta R_m + \varepsilon$$

where R_p is portfolios return, R_m is market return, α is an intercept that in CAPM would be equal $\alpha = R_f(1 - \beta)$ and ε is the error term which is assumed to be independently and identically distributed.

Data. Two data sets will be used. For constructing portfolios stock returns data from OMX Nasdaq Baltic will be taken. Data from Bloomberg will be used to calculate returns of portfolios (this data is superior as it accounts for dividends). OMX Baltic Benchmark GI will be a proxy for market returns in the market model regression.

3. EMPIRICAL ANALYSIS OF MARKET EFFICIENCY

3.1. Statistical tests

3.1.1. Autocorrelations analysis

Daily returns. Results for autocorrelation analysis of continuously compounded OMX Baltic Benchmark GI daily returns are seen below (see Table 3). P-values of Ljung-Box Q statistic are lower than our level of significance of 0.01 for all lag lengths. So H_0 that all autocorrelations up to ρ_k are zero can be rejected at the significance level of 0.01 for all autocorrelations up to lag 20. This implies that there must be significant autocorrelations. This is confirmed when autocorrelations are analysed separately. As it is seen from the table, autocorrelations are significant with 0.01 level of significance for lag lengths of 1, 2, 3, 4, 6, 8, 9, 10, 11, 13, 14, 16, 19. Autocorrelations for lag lengths of 5, 7 are significant with 0.05 level of significance. Autocorrelation is the highest for lag 1, but starts to diminish for lags higher than 14. All autocorrelations up to lag 14 are positive suggesting that high daily returns tend to be followed by high returns and low returns tend to be followed by low returns.

Table 3. Autocorrelations for daily returns

Lag length	Autocorrelation	Q statistic	p-value
1	0.162**	61.657	0.000
2	0.066**	72.108	0.000
3	0.066**	82.515	0.000
4	0.061**	91.339	0.000
5	0.046*	96.405	0.000
6	0.064**	106.06	0.000
7	0.053*	112.82	0.000
8	0.089**	131.58	0.000
9	0.076**	145.31	0.000
10	0.088**	163.51	0.000
11	0.054**	170.42	0.000
12	0.033	172.93	0.000
13	0.066**	183.36	0.000
14	0.091**	202.83	0.000
15	-0.008	202.97	0.000
16	0.072**	215.40	0.000
17	0.035	218.34	0.000
18	0.009	218.53	0.000
19	0.054**	225.45	0.000
20	-0.021	226.52	0.000

Source: Author`s calculations

* indicates that autocorrelation is significant at 0.05 level of significance
** indicates that autocorrelation is significant at 0.01 level of significance

Weekly returns. Results for autocorrelation analysis of continuously compounded weekly returns are seen below (see Table 4). As it was the case with daily returns, p-values of Ljung-Box Q statistic for weekly returns are lower than our level of significance of 0.01 for all lag lengths. So H_0 that all autocorrelations up to ρ_k are zero can be rejected at the significance level of 0.01 for autocorrelations up to lag 12. This implies that there must be significant autocorrelations. This is confirmed when autocorrelations are analysed separately as autocorrelations with lags 1, 2, 3 and 9 are significant at the 0.01 level of significance and autocorrelation with lag 6 is significant with 0.05 level of significance. All significant autocorrelations are positive meaning positive linear relationship. The highest autocorrelation is for lag lengths 1, 2 and 3 and diminishes afterwards.

Table 4. Autocorrelations for weekly returns

Lag length	**Autocorrelation**	**Q statistic**	**p-value**
1	0.184**	16.411	0.000
2	0.231**	42.369	0.000
3	0.173**	56.979	0.000
4	0.005	56.990	0.000
5	0.047	58.068	0.000
6	0.091*	62.099	0.000
7	0.064	64.093	0.000
8	0.042	64.965	0.000
9	0.129**	73.189	0.000
10	-0.042	74.047	0.000
11	0.089	77.935	0.000
12	0.033	78.477	0.000

Source: Author`s calculations

* indicates that autocorrelation is significant at 0.05 level of significance

** indicates that autocorrelation is significant at 0.01 level of significance

Implication to market efficiency. Results of autocorrelation analysis indicate momentum properties of the Baltic stock markets where high returns are followed by high returns and vice versa. However, this does not necessarily mean that the Baltic stock markets are inefficient as market efficiency does not require returns to be uncorrelated: “Autocorrelation may reflect market inefficiency or time – varying equilibrium expected returns generated by rational investor behavior” (Fama and French, 1988, p 266). As Fama and French (1988) stated, autocorrelated mean reverting expected returns cause temporary swings in asset prices, without any long term influence and this could cause autocorrelation in stock returns.

Moreover, the highest daily autocorrelation is 0.162 (for lag length 1). This implies that only 2.624% of variation in return today is explained by the variation of return yesterday. The highest autocorrelation for weekly returns imply that variation in returns two weeks ago can explain 5.336% of stock returns variation this week. So it is arguable if profitable investment strategies can be constructed. However, even if using autocorrelations could not result in constructing profitable trading strategies, this does not mean that autocorrelations does not have the economic meaning. As Barberis and Thaler (2003) argued, economists should be concerned not by the existence of the trading opportunities, but rather by the fair valuation of asset prices. Taking opportunities of mispricing is not risk free and costless (see section 2.2) and mispricing of securities could cause inefficient capital allocation (and thus market inefficiency) even when arbitrageurs can not trade profitably.

Fama and French (1988) argued, that short term autocorrelations are harder to detect and predictability of stock returns are more notable for longer horizons (3-5 years) where slowly decaying price components account for large part of variation in returns and cause mean reversion of returns. Unfortunately, this proposition is impossible to test for the Baltic stock markets as data sample is too scarce to test autocorrelation for longer horizons.

The momentum properties of the Baltic stock markets will be closer investigated using momentum trading strategy. Nevertheless, autocorrelation analysis indicated, that there may be some inefficiency in the Baltic stock markets. Time series of the Baltic stock markets will be further examined using Augmented Dickey-Fuller test for unit root.

3.1.2. Unit root test

Daily prices. First, unit root test was performed for OMX Baltic Benchmark GI index`s natural logarithms of daily stock prices. Deterministic time trend and intercept were included in the test. However, results showed that deterministic time trend coefficient δ had p-value of 0.1206, which was not significant at 0.05 level of significance, indicating that daily stock prices are not a simple function of time. As a result, deterministic trend variable was omitted from the model and Augmented Dickey-Fuller test was rerun.

Results of the test are in the table below (see Table 5). ρ (coefficient on Y_{t-1}) has p-value of 0.2337, which is higher than our significance level of 0.05. Consequently, null hypothesis that ρ = 0 can not be rejected at our level of significance. It can be concluded, that daily stock prices of the Baltic stock markets have unit root and are nonstationary. γ_1(coefficient on ΔY_{t-1}) has p-value of 0.0000, which is lower than significance level of 0.05. Thus, null hypothesis that $\gamma_1$is equal to 0 is rejected. As a result, it can be concluded that daily stock prices of the Baltic stock markets are not fully described by AR(1) random walk model. $\gamma_1$is statistically significant and the residuals of the AR(1) would not be "white noise" and would be autocorrelated. The most important conclusion from this test is that yesterday`s return of the stock market has explanatory power for return today as $\gamma_1$is significantly different from zero. This is in line with what was found in autocorrelation analysis, where autocorrelation with lag length 1 was significantly different from zero.

Table 5. Unit root test for daily stock prices

	Coefficient	t-stat	P-value
$\boldsymbol{\alpha}$	0.007465	2.222973	0.0263
$\boldsymbol{Y_{t-1}}$	-0.001177		0.2337
$\boldsymbol{\Delta Y_{t-1}}$	0.160708	7.910847	0.0000
Adjusted R-squared = 0.027145			

Source: Author`s calculations

Augmented Dickey-Fuller test was also conducted for daily continuously compounded returns that were computed by taking first difference from data used in previous test. Results of the test are presented in the table below (see Table 6). Coefficient ρ (coefficient on Y_{t-1}) has p-value of 0.0000, which is lower than our significance level of 0.05. Consequently, null hypothesis that ρ = 0 can be rejected at our level of significance. It can be concluded, that daily stock returns of the Baltic stock markets do not have unit root and are stationary.

Table 6. Unit root test for daily continuously compounded returns

	Coefficient	t-stat	P-value
α	0.000336	1.472536	0.1410
Y_{t-1}	-0.838468		0.0000

Source: Author`s calculations

Weekly prices. Deterministic time trend variable for natural logarithm of weekly prices was also not significant at 5% level of significance with p-value of 0.3845. So Augmented Dickey-Fuller test was rerun without it.

Results of the test are in the table below (see Table 7). ρ (coefficient on Y_{t-1}) has p-value of 0.1787, which is higher than our significance level of 0.05. Consequently, null hypothesis that ρ = 0 can not be rejected at our level of significance. It can be concluded, that as with the case of daily stock prices, weekly stock prices of the Baltic stock markets also have unit root and are nonstationary. Differently from the test for daily stock prices, weekly Augmented Dickey-Fuller test results have more significant lags. All γ_1 $\gamma_2$and γ_3(coefficients on ΔY_{t-1} ΔY_{t-2} and ΔY_{t-3}) are significant at 0.05 level of significance with p-values that are lower than 0.05. Consequently, weekly returns of previous 3 weeks have explanatory power for this weeks` stocks return. γ_1 $\gamma_2$and γ_3 coefficients are positive, which means that the higher returns were in the previous 3 weeks, the higher return tend to be this week. So unit root test for weekly stock prices reveals that stock markets in the Baltic countries are not fully described by AR(1) random walk model behaviour.

Table 7. Unit root test for weekly stock prices

	Coefficient	t-stat	P-value
α	0.046646	2.337309	0.0198
Y_{t-1}	-0.007490		0.1787
ΔY_{t-1}	0.121116	0.121116	0.0079
ΔY_{t-2}	0.189500	0.189500	0.0000
ΔY_{t-3}	0.111393	0.111393	0.0143
Adjusted R-squared = 0.088734			

Source: Author`s calculations

Augmented Dickey-Fuller test was also conducted for weekly continuously compounded returns that were computed by taking first difference from data used in previous test. Results of the test are in the table below (see Table 8). ρ (coefficient on Y_{t-1}) has p-value of 0.0000, which is lower than our significance level of 0.05. Consequently, null hypothesis that ρ = 0 can be rejected at our level of significance. It can be concluded, that weekly stock returns of the Baltic stock markets do not have unit root and are stationary.

Table 8. Unit root test for daily continuously compounded returns

	Coefficient	t-stat	P-value
$\boldsymbol{\alpha}$	0.001313	0.965445	0.3348
$\boldsymbol{Y_{t-1}}$	-0.647474		0.0000
$\boldsymbol{\Delta Y_{t-1}}$	-0.204003	-4.556916	0.0000

Source: Author`s calculations

Implication for market efficiency. Unit root is a necessary condition for random walk behaviour (Koop, 2006). It was found, that the stock prices in the Baltic stock markets have unit root which could be an argument for market efficiency. However, unit root tests showed that the Baltic stock markets are not fully explained by AR(1) random walk model as there were significant coefficients for lagged returns. As it was mentioned previously, market efficiency does not require AR(1) random walk model to hold. AR(1) model is more restrictive than “fair game” model of market efficiency. However, the predictive power of previous returns for today`s return makes market efficiency in the Baltic stock markets questionable and emphasises the need of further and deeper investigation. As in case of significant positive autocorrelations found in the previous test, the significance of $\gamma_1 \gamma_2 \gamma_3$ may be because of the changing risk premiums required by the investors and this would not deny market efficiency.

Adjusted R-squares of Augmented Dickey-Fuller models for daily and weekly prices are 0.027145 and 0.088734 respectively. This indicates low explanatory power of the model and trying to build more precise predictive models could be useful to examine time series properties of the Baltic stock markets further.

3.2. Trading strategies

3.2.1. Day-of-the-week-effect

Descriptive statistics of the different weekdays can be found below (see Table 9). During chosen sample period, the lowest returns were on Mondays – a negative value of -0.000145. On Wednesdays and Fridays the returns were higher than the average daily returns with values 0.000879 and 0.000631 respectively. Mondays not only experienced the lowest returns, but they also had the highest volatility with standard deviation of 0.012203. These results are in line with Monday effect found by previous researchers.

Table 9. Descriptive statistics of different weekdays returns

	Monday	**Tuesday**	**Wednesday**	**Thursday**	**Friday**	**Daily**
Mean	-0.000145	0.000304	0.000879	0.000341	0.000631	0.000404
Standard deviation	0.012203	0.011402	0.010841	0.011053	0.010545	0.011218
Observations	468	477	479	468	467	2359

Source: Author`s calculations

Trading day hypothesis

Descriptive statistics indicated differences between weekday returns. However, to verify if these differences in returns are statistically significant, regression analysis is used and F-statistic is calculated (see Table 10). F-statistic has a p-value of 0.6949, which is higher than our significance level of 0.05. So H_0 that different weekdays have the same mean can not be rejected at the 0.05 level of significance. P-values of the regression coefficients also confirm that returns in the Baltic stock markets can not be explained by the day of the week. All coefficients from b_1 to b_5 have p-values that are higher than our significance level of 0.05, which mean that coefficients are statistically insignificant. Autocorrelation analysis that was conducted previously indicated that daily returns are autocorrelated. This would be a violation of OLS assumption of no autocorrelation. However, Durbin-Watson statistic has a value of 1.675548, which is close to 2, meaning that autocorrelation does not distort results significantly.

Table 10. Day-of-the-week regression (trading day hypothesis)

	coefficient	**t-statistic**	**P-value**
$\boldsymbol{D_{1t} = Monday}$	-0.000145	-0.279267	0.7801
$\boldsymbol{D_{2t} = Tuesday}$	0.000304	0.590776	0.5547
$\boldsymbol{D_{3t} = Wednesday}$	0.000879	1.714880	0.0865
$\boldsymbol{D_{4t} = Thursday}$	0.000341	0.656978	0.5113
$\boldsymbol{D_{5t} = Friday}$	0.000631	1.214751	0.2246
F-statistic for equality of coefficients = 0.555657, p-value = 0.6949 Durbin-Watson stat = 1.675548			

Source: Author`s calculations

Calendar day hypothesis

Results from regression for testing calendar day hypothesis can be seen below (see Table 11). F-statistic has a p-value of 0.672485, which is higher than our level of significance of 0.05. So H_0 that coefficients from b_2 to b_5 are all equal to zero can not be rejected. Therefore, calendar day hypothesis that Monday returns are three times higher than returns on other weekdays is not rejected at the significance level of 0.05. P-values of the regression coefficients also confirm this result. All coefficients from b_1 to b_5 have p-values that are higher than our significance level of 0.05, which mean that coefficients are not statistically significant. Durbin-Watson statistic has value of 1.770024, which is close to 2, meaning that autocorrelation does not distort results significantly.

Table 11. Day-of-the-week regression (calendar day hypothesis)

	coefficient	t-statistic	P-value
α	-4.83E-05	-0.104634	0.9167
$D_{2t} = Tuesday$	0.000352	0.541646	0.5881
$D_{3t} = Wednesday$	0.000928	1.429464	0.1530
$D_{4t} = Thursday$	0.000389	0.596154	0.5511
$D_{5t} = Friday$	0.000679	1.039949	0.2985
F-statistic = 0.586435, p-value = 0.672485 Durbin-Watson stat = 1.770024			

Source: Author`s calculations

Implication for market efficiency.

Both calendar day hypothesis and trading day hypothesis were not rejected. The Baltic stock markets do not experience statistically significant differences in returns during different weekdays. Moreover, it is also can not be rejected that returns on Monday are three times higher than returns on other weekdays. Therefore, no matter which model is used for expected returns during different weekdays, market efficiency is not denied in the Baltic stock markets.

3.2.2. Momentum strategy

Descriptive statistics. Descriptive statistics for portfolios 3 months returns are seen below (see Table 12). Be reminded that "buy" portfolio is formed by selecting 10% of stocks that performed best in the last 3 months and is held for 3 months, "sell" portfolio is formed by selecting 10% of stocks that performed worst and is held for 3 months, buy-sell portfolio is zero cost strategy consisting of being in the long position of buy portfolio and in the short position of sell portfolio. OMX is OMX Baltic Benchmark GI index.

Table 12. Descriptive statistics of momentum strategy returns

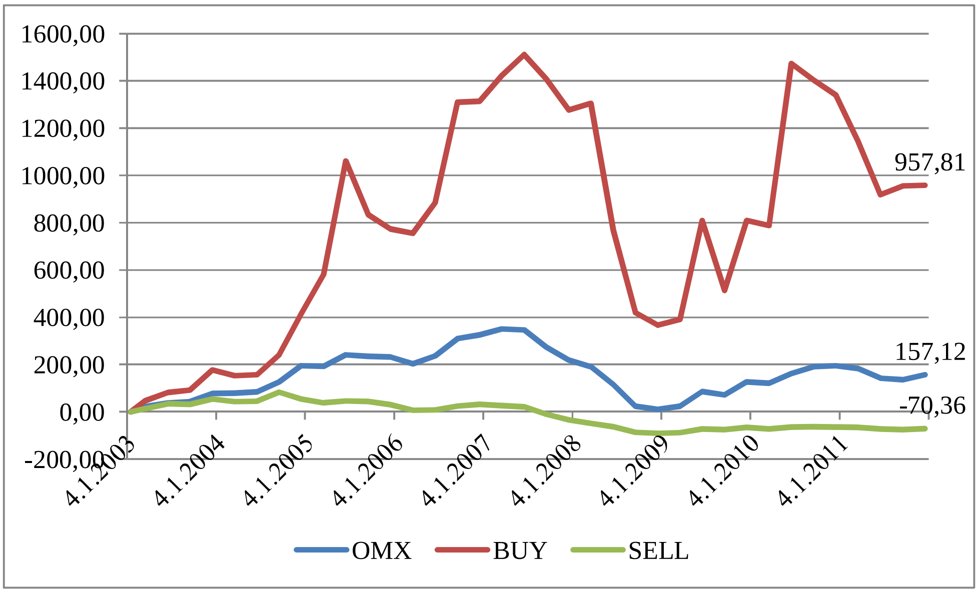
	Buy	Sell	Buy - Sell	OMX
Mean, %	10.74	0.42	10.32	4.16
Standard deviation, %	30.91	29.63	23.88	17.56
Observations	36	36	36	36

Source: Author`s calculations

As it seen from table 12, buy portfolio had mean returns of 10.74%. This result was more than two times higher than arithmetic average of returns by the OMX Baltic Benchmark GI index which was equal to 4.16%. In the meantime, sell portfolio experienced much lower returns of 0.42%. Returns quarter by quarter of buy-sell, buy, sell and OMX portfolios can be found in appendices (see Appendix 1). Results indicate the momentum properties of the Baltic stock market. Momentum properties have already been notified in the autocorrelation analysis. However, autocorrelations were analysed for daily and weekly periods. In the momentum strategy case, it can be seen that momentum for longer periods are also significant. Moreover, high returns by buy portfolio were achieved with almost the same total risk as sell portfolio`s. Measure of total risk – standard deviation was 30.91% for buy portfolio and 29.63% for sell portfolio. These numbers were higher than for OMX Baltic Benchmark GI index, but this is not surprising, as OMX portfolio was better diversified and had only systematic risk, while buy and sell portfolios also experienced firm specific risks.

Compounded returns for different portfolios can be found below (see Figure 5). The outperformance of buy portfolio is striking. If investor invested money in 2003 April 1 into buy portfolio, and rebalanced it every quarter using momentum strategy, in 2012 April 1 he would have had a total gain of 957.81%. Sell portfolio, on the other hand would have brought a negative return of 70.36%. While theoretical performance of buy portfolio is very impressive, in real world it would have been lower due to transaction costs and bid-ask spreads. Moreover, it is likely that buy portfolio tends to pick stocks with higher systematic risk. This hypothesis will be analysed by using capital market model to estimate betas.

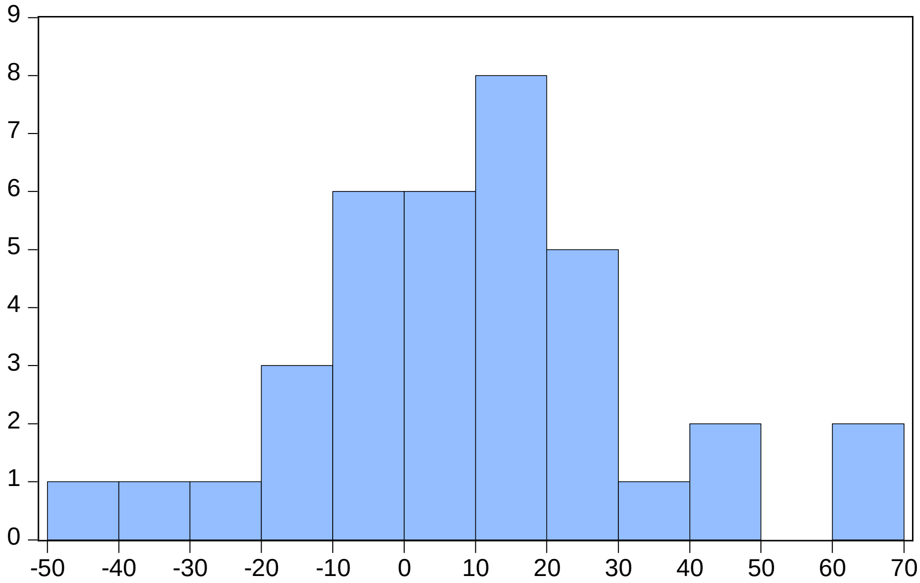
Figure 5. Compounded returns of different portfolios



Source: Composed by author

Buy-sell portfolio. Momentum strategy of buying buy portfolio and selling sell portfolio brought the average return of 10.32% with a standard deviation of 23.88%. Histogram of buy – sell portfolio returns may be found below (see Figure 6). It is seen, that buy-sell strategy returns remind normal distribution with the most returns falling in the region between 10% and 20%. However, there are a few extremes with large negative and positive returns.

Figure 6. Histogram of zero cost buy-sell portfolio returns



Source: Composed by author

As a zero cost strategy, positive mean of buy-sell portfolio may indicate market inefficiency. However, it may be the case that stocks in the buy portfolio had higher systematic risk than in sell portfolio and thus buy-sell portfolio may have a positive beta, for which compensation of positive returns may be reasonable. Therefore, to check this assumption and to better evaluate buy-sell portfolio`s systematic risk, betas of buy and sell portfolios will be calculated using capital market model. Moreover, buy-sell portfolio return may not be statistically different from zero, so t-statistic will also be calculated.

Hypothesis testing. Null hypothesis that the mean of buy-sell portfolio returns is equal to zero has t-statistic 2.592016 and associated p-value of 0.0138. Therefore, null hypothesis can be rejected at the significance level of 0.05. Mean of buy-sell portfolio returns is significantly different from zero.

Adjusting for risk. Results from capital market model regressions can be found below (see Table 13 and 14). In one case dependent variable was buy portfolio and explanatory variable was OMX portfolio and in another case dependent variable was sell portfolio and explanatory variable was OMX portfolio. Results can also be written as equations. Return for buy portfolio:

$$R_t = 4.435291 + 1.514093 * \mathrm{OMX_t}$$

and return for sell portfolio:

$$R_t = -5.496966 + 1.421771 * \mathrm{OMX_t}$$

As it seen from results, both buy and sell portfolios have betas that are over 1. Buy portfolio has β (coefficient on $\mathrm{OMX_t}$) of 1.514093 and sell portfolio has β of 1.421771. Both coefficients have p-values that are lower than significance level of 0.01. So they are statistically significant at 0.01 level of significance. From the capital market regression, it can be concluded that both buy portfolio and sell portfolio have significantly higher systematic risk than the market. Whereas buy-sell portfolio would have β of 0.0923, which is the difference between buy and sell portfolios betas and indicates positive systematic risk.

Table 13. Capital market model regression for buy portfolio

Variable	Coefficient	t-statistic	P-value
$\boldsymbol{\alpha}$	4.435291	1.617581	0.1150
$\mathbf{OMX_t}$	1.514093	9.834379	0.0000
R-squared = 0.739892			

Source: Author`s calculations

Table 14. Capital market model regression for sell portfolio

Variable	Coefficient	t-statistic	P-value
$\boldsymbol{\alpha}$	-5.496966	-1.980237	0.0558
$\mathbf{OMX_t}$	1.421771	9.121670	0.0000
R-squared = 0.709910			

Source: Author`s calculations

Implication for market efficiency. Momentum strategy indicates market inefficiency in the Baltic stock markets. Zero cost strategy of buy-sell portfolio has positive quarterly returns of 10.32% which cannot be fully explained by systematic risk, as portfolio that is in a long position has almost the same beta as portfolio in a short position, giving buy-sell portfolio beta of only 0.0923. Significant buy portfolio outperformance of the benchmark could be explained by more systematic risk and more investigation is needed to conclude if buy portfolio has abnormal risk adjusted returns. This could be done by estimating various ratios used for portfolios performance. In the meantime, sell portfolio has more systematic risk than market portfolio and significant underperformance indicates market inefficiency. However, important limitation of the study is small data sample, as the period that was used (2003 – 2012 March) does not even consist a full economic cycle.

3.3. Practical implications, limitations and recommendations for future research

Autocorrelation analysis and test for unit root do not indicate that profitable trading strategies can be constructed using previous returns as explanatory power of models would be too low to account for transaction costs. However, if investors want to open equity position, it is more prudent to buy stocks after positive previous day or week returns, as stock returns exhibit positive autocorrelation for these periods. Furthermore, building more precise statistical predictive models would be useful in order to find out if better forecasting results can be achieved. Moreover, future researchers should test autocorrelations for longer horizon returns to check if there are any long term mean reversions. Furthermore, models which allow expected returns to vary should be employed to make stricter conclusions about market efficiency.

Day-of-the-weak test does not indicate any anomalies in the Baltic stock markets. So investors should not time their investments depending on the weekday. Future researchers could test other calendar anomalies. For example January effect (returns on January tend to be higher than on other months) or turn-of-the-month effect (returns at the end and at the beginning of the month tend to be higher) (Clearly et al., 2011).

Momentum strategy indicates, that investor, whose holding period is three months should avoid stocks that performed poorly during previous three months. Contrarian strategy of buying past winners and selling past loosers would not be possible to execute, as short selling is not allowed. Moreover, there is no guarantee that past tendencies that were indicated by momentum strategy will repeat in the future. Investors may exploit these inefficiencies and bring excess returns to zero. However, momentum anomaly has been well documented long before the beginning of a sample period and this did not prevent momentum strategy from bringing abnormal returns. Future researchers could test momentum properties in the Baltic stock markets using other holding periods.

The main limitation of empirical research that was conducted in this thesis is small sample, as the period from 2003-2012 March 31 does not even include the full economic cycle. Moreover, momentum strategy returns would have been more precise if overlapping periods were used.

CONCLUSIONS

1. By belonging to the Nasdaq OMX group, the Baltic stock markets ensured for themselves modern stock exchange infrastructure and state-of-the-art trading system. Companies listed on Nasdaq OMX Baltic exchanges must adhere to strict rules of information disclosure and investor relations. Moreover, these countries attract investors because of prudent economic policies by their governments and higher GDP growth opportunities than in Western Europe. Furthermore, Baltic stock markets performed really impressive during the last decade outperforming world index significantly. Eventually, these factors may lead to more investors being attracted, deeper market coverage, more trading activity and thus higher market efficiency.

On the other hand, during recent years the Baltic stock markets have been on the decreasing trend of average company capitalisation, average turnover and number of companies. These factors prevent the Baltic stock markets from being more inviting for larger investors such as mutual funds. Resulting low trading activity, low liquidity and little coverage can be obstacles for securities to be fairly priced and impede market efficiency. Furthermore, short-selling is not allowed in the Baltic stock markets which makes more difficult to profit from mispricing.

2. The notion of the efficient market hypothesis is fairly simple - stock prices should incorporate all relevant information (Fama 1970). However, market efficiency is a complicated matter. Researchers face impediments, such as data mining bias, that make strict conclusions about market efficiency difficult to infer. Behavioural school, which is the main opposition of efficient market hypothesis, has been becoming more and more active in providing evidence and models explaining market anomalies by referring to irrational behaviour of separate economic agents.

There have been extensive amounts of papers on market efficiency. Researchers tend to find positive serial correlations in stock prices for shorter periods and negative serial correlations for longer periods. Researcher also documented many profitable trading strategies that could result into excess risk-adjusted returns. For example, momentum – strategy of buying past winning stocks and selling past loosers tends to outperform the market. Another anomaly that is widely researched – day-of-the-week effect, when returns are not equal during the weekdays and usually lower on Monday.

3. Autocorrelation analysis indicates significant autocorrelations for both daily and weekly continuously compounded returns. All daily autocorrelations up to lag 4 and all weekly autocorrelations up to lag 3 are statistically significant at 0.01 level of significance. The highest autocorrelation for daily returns is for lag 1 and is equal to 0.162 and the highest autocorrelation for weekly returns is for lag 2 and is equal to 0.231. All significant autocorrelations are positive suggesting momentum properties of the Baltic stock markets where high returns are followed by high returns and vice versa. Significant autocorrelations do not necessarily mean that markets are inefficient as autocorrelations could also result from changing required risk premiums which would not deny market efficiency.

Using Augmented Dickey-Fuller test it was found that both daily prices and weekly prices have unit root and are nonstationary. Nonstationarity is a necessary condition for the random walk (Koop, 2006). This would suggest that stock prices in the Baltic stock markets are unpredictable. However, Augmented Dickey-Fuller test also showed significant coefficients for lagged returns.

From autocorrelation analysis and unit root tests it can be concluded that the behaviour of stock prices in the Baltic stock markets are not fully described by AR(1) random walk model and stock returns have some predictability which could, but does not necessarily mean market inefficiency. Models which allow expected returns to vary should be employed to make stricter conclusions about market efficiency.

4. Two hypotheses were tested in day-of-the-week analysis of the Baltic stock markets. Trading day hypothesis was that every weekday should have the same mean. Calendar day hypothesis stated that returns on Monday should be three times higher than returns on other days as Monday accounts for three calendar days. Using regression analysis, both hypothesis could not be rejected. This implies that no matter which model (trading day or calendar day) is used for generating expected returns during different weekdays, market efficiency is not denied in the Baltic stock markets.

Momentum strategy confirms momentum properties in the Baltic stock markets that are also indicated by autocorrelation analysis. Buy portfolio, consisting of 10% of the stocks that performed best in the last 3 months would have brought investors mean return of 10.74% during the next 3 months. Sell portfolio, consisting of 10% of the stocks that performed worst in the last 3 months would have brought investors mean return of just 0.42% during the next 3 months. The average 3 months return of OMX Baltic Benchmark GI is 4.16%, meaning that when returns are compared, buy portfolio outperforms and sell portfolio underperforms the market. Buy portfolio has beta of 1.51, which indicates that outperformance of the market may be explained by systematic risk. However, sell portfolio has beta of 1.42, which means that it underperforms the market even having higher systematic risk. As a result, sell portfolio`s performance indicates market inefficiency. Moreover, zero cost strategy of buy-sell portfolio (long buy portfolio and short sell portfolio) has positive quarterly returns of 10.32%. This return cannot be fully explained by systematic risk, as portfolio that is in a long position has almost the same beta as portfolio in a short position giving buy-sell portfolio beta of only 0.09. As a result, buy-sell portfolio also indicates market inefficiency.

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APPENDICES

Appendix 1. Momentum strategy returns period by period, percentage

Date	OMX	BUY	SELL	BUY-SELL
6/30/2003	23.38	48.21	12.89	35.32
9/30/2003	12.00	22.59	19.48	3.11
12/31/2003	4.06	6.24	-2.48	8.71
3/31/2004	23.83	43.68	17.16	26.52
6/30/2004	0.44	-8.88	-6.73	-2.14
9/30/2004	3.45	1.75	0.69	1.05
12/31/2004	22.53	32.54	26.47	6.07
3/31/2005	30.10	51.37	-15.71	67.08
6/30/2005	-0.64	32.12	-9.86	41.98
9/30/2005	16.59	70.32	5.43	64.90
12/30/2005	-2.14	-19.54	-2.22	-17.32
3/31/2006	-0.81	-6.40	-8.50	2.11
6/30/2006	-8.45	-2.14	-18.31	16.16
9/29/2006	10.75	14.86	1.08	13.78
12/29/2006	21.73	43.44	14.81	28.62
3/30/2007	4.03	0.26	5.66	-5.40
6/29/2007	5.93	7.71	-4.06	11.78
9/28/2007	-0.90	5.88	-3.65	9.53
12/28/2007	-16.28	-6.40	-25.96	19.56
3/31/2008	-14.89	-8.74	-25.96	17.22
6/30/2008	-8.54	2.05	-23.43	25.48
9/30/2008	-25.72	-38.23	-26.94	-11.28
12/30/2008	-42.40	-40.17	-62.30	22.14
3/31/2009	-11.32	-10.14	-35.08	24.94
6/30/2009	11.67	5.26	36.46	-31.20
9/30/2009	50.51	85.15	125.33	-40.19
12/30/2009	-7.52	-32.41	-7.95	-24.46
3/31/2010	32.26	47.86	33.13	14.73
6/30/2010	-2.72	-2.21	-19.55	17.34
9/30/2010	18.50	77.08	29.01	48.08
12/30/2010	11.39	-4.51	5.10	-9.61
3/31/2011	1.20	-4.21	-3.75	-0.46
6/30/2011	-3.83	-13.53	-4.49	-9.04
9/30/2011	-14.47	-18.19	-17.78	-0.41
12/30/2011	-2.82	3.67	-12.59	16.27
3/30/2012	8.93	0.19	19.76	-19.57

Source: Author`s calculations