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MEASURING MARKET EFFICIENCY THROUGH VALUATION TECHNIQUES: THE CASE OF VISEGRAD COUNTRIES STOCK MARKETS

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Abstract:

Company valuation stands as the most controversial topic in the field of financial management. The study investigates the extent to which stock prices of the companies listed on Czech, Polish, Hungarian, and Slovak equity markets deviate from their estimated intrinsic value. DCF model was employed using Monte Carlo simulations with 500, 1000, and 10000 trials to generate estimated intrinsic value and compare them to market prices. The results of the study show that the Bratislava Stock Exchange (SAX) on average holds the lowest gap between intrinsic value per share and market prices with only 82% deviation, followed by PSE with 116% deviation, WIG20 with 207% deviation, and BUX with 246%. SAX appears with the best performance from 2009 to 2019, where the shares on average were traded with only 82% deviation from their estimated equilibrium price (intrinsic value). Findings regarding the differences between book value per share and stock prices are different, where SAX leads with 71% deviation, WIG20 with 181%, PSE with 188%, and BUX with 545%. Outcomes of the work are of interest to financial investors that seek to diversify their portfolios on the equity stocks. The study offers a new conceptual framework for testing the market efficiency of equity exchanges through company valuations techniques. From the policy perspective, institutions in charge get inform on the measures to be taken that would improve efficiency and strengthen the importance of the Visegrad equity markets.

Key words: *Market Efficiency; Visegrad Countries; Stock Markets; Intrinsic Value; Estimated Equilibrium*

1. Introduction

Valuation is a critical process in identifying the financial position of firms in the marketplace. Determining the proper value of the private and public companies is one of the most complex topics in the field of financial management. In contrast to publicly listed

firms, private companies generally suffer from a lack of transparency since their financial reports are not publicly available. Standard theoretical paradigms indicate that price equilibrium is achieved when the demand and supply for stocks intersects. Prices are important elements of market signals which enable efficient allocation of financial recourses. Incorrect stock prices generated from the information asymmetry might lead to market failure and presents the need for government intervention. Fama (1970) considers that efficient stock prices fully reflect all available information's where deviations from the firm intrinsic value (estimated equilibrium) are random. Besides, Fama (1970) claims that abnormal returns are hardly achieved in the long run since market mechanisms adjust their excesses. Moreover, Roll (1994) considers that it is incredibly difficult to constantly beat the stock markets, even in the case when they are extremely inefficient. In contrast, Shiller (2003) claims that stock prices are prone to speculative elements even in the long run, and from time to time are likely to generate bubbles. The efficient market hypothesis (EMH) remains a contentious subject among scholars but still provides a solid theoretical framework for financial investors. According to Damodaran (2012) company value is not linked with the present state of the firms since rests on the expectations for future cash flows. The future is unknown since is influenced by the unmade decisions done by the government, people, nature, and so on. The possible equilibrium condition on the market must create incentives (profits) in order to attract the market participants (Grossman and Stiglitz, 1980).

Stock markets of the Central and Eastern European (CEE) countries reopened after communism fell apart in the 1990s and the capitalist system was taking place. The integration into the European Union (EU) allowed CEE countries to experience a substantial improvement in the standard of living and boom into the equity markets. Since the early days of their existence, stock markets of CEE countries were permanently considered as weak-efficient-form where stock prices hardly reflected domestic and international context. Earlier study performed by Nivet (1997) showed that trading's on the Warsaw Stock Exchange did not follow the random walk and equity prices hold for the weak efficient form. Moreover, Worthington and Higgs (2004) by using the unit root test and multiple variance ratios test concluded that Czech, Polish, Russian, and Hungarian stock markets are exposed to the weak-form efficiency. In contrast, Chun (2000) considers that the Budapest Stock Exchange (BUX) is the only exception from Eastern European stock exchanges where prices follow the random walk. To reinforce this fact, the BUX stands as the most well-diversified index that offers higher diversification benefits for the investors compared to WIG20 and SAX (Aliu et al., 2019). Random walk theory which gave popularity to the EMH, suggests that stock prices follow identical distributions that are independent of each other. The theory infers that outperforming the equity market is an incredibly hard task since future stock prices do not rely on past events.

Studies by various scholars on the efficiency issue of the CEE stock exchanges are often contradictory. The study by Guidi et al. (2011) investigated EMH problems linked with the CEE stock markets by using different statistical techniques on the time interval from 1999 to 2009. Their results show that autocorrelation tests reject the RMH while run tests show for the improved efficiency of these exchanges. Moreover, Dragotă and Ţilică (2014) studied inefficiency problems linked with 20 Eastern European equity markets

(including countries that are part of our study) and their results raise doubts concerning their efficiency level. A recent study by Miloş et al. (2020) investigated the degree of efficiency associated with the seven stock markets of the CEE countries. Results of their work suggest that equity prices in the CEE countries do not follow a random walk which violates the EMH. Market anomalies such as the Monday effect, January effect, liquidity effect, and so on are patterns that follow markets and create space for abnormal returns. The work by Ajayi et al. (2004) on the day-of-the-week anomalies for the eleven Eastern European equity markets indicate negative Monday return for the six exchanges and a positive return for the other five. Besides anomalies, the inefficiency of the CEE stock markets is possibly fed by an insignificant number of listed firms, information asymmetry, liquidity problems, inexperienced investors, and insufficient international attention. Although some studies show an improvement in the efficiency level of the CEE stock exchanges, most prices contain speculative elements that might lead to market failure.

To conclude, speculative prices displayed on the marketplace deliver wrong signals for the financial investors. The fundamental idea behind the EMH claims that is impossible to gain abnormal returns from mispriced equity stocks when markets absorb all possible information. For this purpose, the first objective of this study is to investigate the extent to which individual equity stocks on the Visegrad countries deviate from their estimated equilibrium (intrinsic value). The second objective tends to measure the difference between the book value of the listed firms and their equity prices. In contrast to the previous studies, our work measures the efficiency level of Czech, Polish, Hungarian, and Slovak stock markets by using company valuation techniques. So far, valuation as a process is not covered with a standardized methodology and recognizes its limitations. Standing on the identified problem and the importance of measuring the stock market efficiency, the work provides an innovative and dynamic form for tracking this phenomenon. Recognizing the identified problem concerning the equity markets of Visegrad countries, the following questions were asked:

RQ1: How large is the deviation between estimated intrinsic value per share and market prices of the firms listed on the V4 Stock Exchanges?

RQ2: To what extent does the estimated intrinsic value per share differ from the book value per share of the firms listed on the V4 Stock Exchanges?

RQ3: To what extent does the book value per share differ from the market prices of the firms listed on the V4 Stock Exchanges?

2. Literature review

Price changes are one of the most discussed issues among scholars, investors, media, and financial managers. Basic microeconomic principles consider that under fully informed participants, demand and supply intersections equilibrate markets for goods and services. Under the identical mechanism, the equity stocks bring the equilibrium condition in the marketplace, known as the market prices. The demand for equity stocks is broadly driven by the way firms operate, the regulation in place, and the macroeconomic environment. Firm-specific factors, such as profitability, liquidity, solvency, cash flow, and

so on, can explain up to 50% of the price changes (Drummen and Zimmermann, 1992). Most of the studies attempt to identify the factors influencing changes in the stock prices by mainly focusing on the developed countries (Ratanapakorn and Sharma, 2007; Nieh and Lee, 2001; Fama and French, 1993; Campbell and Shiller, 1988). Publicly available financial statements reduce information asymmetry by allowing investors to observe the extent to which the firm internal performance is integrated into the equity prices. The pioneering study by Ball and Brown (1968) increased the considerable attention among scholars and investors on the importance that firm financial indicators have on equity prices.

Companies listed on the capital markets regularly disclose their quarterly financial reports, to inform stakeholders about the dynamics of the firms' operations. Results of the work by Gajewski and Quéré (2001) on the French Capital Markets consider that interim reports do not play an important role in the stock price changes. Moreover, the authors cast doubts on the importance that non-audited financial statements hold for financial investors. Unlike the evidence for the French listed firms, the results for the Spanish stock market indicate the opposite where interim financial reports are significant elements of the price movements (Pellicer and Rees, 1999). However, there are limited studies that show the impact of firm financial data in the equity prices of the CEE countries. The study by Jindrichovska (2001) investigated the relationship between accounting items and stock prices of the companies listed on the Prague Stock Exchange (PSE), from 1993 to 1998. The empirical evidence of her work suggests a permanent relationship between the stock prices of the listed firms and their accounting items. Ligocká and Stavárek (2019) examined the level to which firm-specific factors influence stock prices of the food companies listed on Polish, Austrian, and Swiss Stock Markets. Results of their work show that ROE stands as a significant component in the case of the food companies listed on the Austrian Stock Exchange while ROE, ROCE, and NWC in the case of the Warsaw Stock Exchange.

The underlying logic of the price mechanism assumes that when earnings are increasing (good news are released), investors' confidence is higher and stock prices go up. Since most of the listed companies on the CEE stock markets are multinational in scale, the worldwide macroeconomic situation is additional elements that cause instability in the equity prices. The study by Aliu et al. (2020) shows that stock prices of international companies listed on Prague Stock Exchange possess less speculation than domestic companies. Hanousek et al. (2009) by using intraday data explored the impact of macroeconomic news on the Polish, Czech and Hungarian stock exchanges. Their work indicates that the EU macroeconomic announcements hold a spillover effect on Budapest and Warsaw Stock Exchanges, while Prague Stock Exchange is more influenced by U.S news. The relationship between monetary policy and changes in equity prices has been extensively studied in developed countries. In the context of eastern European countries, the work by Stoica et al. (2014) shows that domestic and international interest rates negatively influence movements on the stock markets of the Czech Republic, Poland, Rumania, and Hungary. The negative impact of the interest rates on the price changes of the Visegrad equity market has been confirmed by Pražák and Stavárek (2017). Moreover,

their work shows that the macroeconomic factors which hold an influence on the Visegrad equity markets are GDP, inflation, unemployment, interest rate, and money supply.

The difference between book value and market prices shows the extent to which investors value the firm above and below what the accounting inputs display. Gornik-Tomaszewski and Jermakowicz (2001) studied the deviation between book value (BV) and market value (MV) of the 77 firms listed on the Warsaw Stock Exchange, from 1996 to 1998. The results of their work indicate the gap MV/BV ratio in the range of 0.61 (61%) which is quite lower than other European countries. In the case of the Czech equity market, Hellström (2006) separated the study into two parts, analyzing the market to book value ratio from 1994 to 1997 and the rest from 1998 to 2001. His study shows that the MV/BV ratio decreases from 0.74 (74%) to 0.57 (57%) between the two periods. The work by Juhász (2004) investigated the percentage gap between the market to book value ratio for the Budapest Stock Exchange and confirms a range of 1.0 or 100% deviation. In contrast, the work by Korányi (2008) considers that shares in the Budapest Stock Exchange are traded 150% higher than their accounting figures. However, when considering the international context of the equity markets the results of the MV/BV ratio are diverse with the gap being more pronounced in the developed countries. Boulton et al. (2000) explored the differences within market prices and book value per share of 10000 US-listed firms, from 1978 to 1998. Their work shows that US stock prices were standing 95% higher compared to their book value per share. Microsoft being an exception wherein 1999 the market capitalization reached the level of USD 600 bn while the book value was USD 31.6 bn. Analyzing continental Europe, King and Langli (1998) used the sample of 14,643 listed firms to investigate the MV/BV ratio for the stock exchanges of Germany, UK, and Norway, for the period from 1982 to 1996. Their work claims that in the case of Germany the MV/BV ratio was 0.41 (41%), for the UK was 0.63 (63%) while in the case of Norway was 0.58 (58%). Arce and Mora (2002) examined eight major European equity indexes from 1990 to 1998 with a sample of 22436 listed firms. The results reveal that the lowest deviation between BV/MV occurred in Germany (0.56), followed by Netherland (0.66), UK (0.67), Belgium (0.78), France (0.78), Spain (0.88), Switzerland (0.89), and Italy with 0.99 deviation. Balance Sheet items are registered based on historical costs and do not necessarily reflect the market value of the companies.

Earlier studies on V4 stock exchanges were focused mainly on macroeconomic factors that influence changes in the stock prices while no study on the impact of a firm's internal factors. A limited number of scholars investigated the gap between the accounting value of firms listed on the Visegrad Stock Exchanges (VSE) and their market prices. In contrast to prior work done on VSE markets, our study examines systematically the deviation on the intrinsic value of listed firms as opposed to their market prices. Furthermore, it is the first study that attempts to use firm valuation techniques and procedures to measure the efficiency level of the equity markets. The results provide only the estimated intrinsic value of the listed firms on the VSE stock markets since other scholars might bring different valuation outcomes.

3. Methodology

We have structured the methodological part in two sections. In *Section 3.1* we have presented the valuation issues. *Section 3.2* explains the inputs used in the simulations model.

3.1. Valuation issues

In the real world, various factors make possible the existence of differences between stock prices and intrinsic values: abilities and power in negotiations, anomalies (e.g., week end effect, end-of-the-month effect, etc.). However, a systematic deviance between these two values can be interpreted as a lack of market informational efficiency (Fama, 1970).

There is an ongoing discussion about how to determine firms' intrinsic value per share. However, the practitioners' dominant viewpoint favors the discounted cash flow method since it reflects the buyer's perspective. In this study, we have estimated the intrinsic value of shares starting from the enterprise's value (CV0), based on DCF well-known formula:

$$CV_0 = \sum_{t=1}^{\infty} \frac{CF_t * (1+g)}{(1+WACC)^t} - DEBT_0 + RA \quad (1)$$

where CV0 represents the value of the company (at present moment) estimated through discounted cash flow method of the firms, CF indicates Free Cash Flow to the firm (FCFF), and RA are the redundant assets (assets that have a market value if they are sold on the market, but do not generate the cash flows accounted (1) and DEBT is the total nominal debt of the company. The final value of the firm based on DCF is obtained by subtracting the nominal value of the debt while WACC stands for the Weighted Average Cost of Capital.

The firm's risk level is reflected in the Weighted Average Cost of Capital (WACC), used as a discount rate (r). Capital Asset Pricing Model (CAPM) stands as a widely used metric for pricing financial securities. Together, WACC and CAPM are adapted with the company risk profile and economic outlook of the country (in our case adjustments are done for the Czech Republic, Poland, Hungary, and Slovakia). WACC is calculated as a weighted average between the cost of equity (CAPM) and the cost of debt (interest rate, kd, corrected with tax shields):

$$WACC = \left[\left(\frac{MV(Debt)}{MV(Equity)+MV(Debt)}\right)\right] * kd * (1 - \text{tax rate}) + \left[\left(\frac{MV(Equity)}{MV(Equity)+MV(Debt)}\right)\right] * ke \quad (2)$$

In this relation, we have assumed a stable capital structure in time, for the entire period of prediction. The interest rate is obtained by dividing a firm's interest expenses with the firm's total debt. Market capitalization has been captured from the stock market prices and the number of shares outstanding. The market value of the debt has been considered that equals the nominal value of debt. We have considered that the historical cost of debt is equal to the future cost of debt. The growth rate of the firms is represented by g. We estimated the growth rate having as a starting point the long-run growth rate of the sector. We consider this choice appropriate as our purpose is to use the growth rate on a long run in our model and the sector growth rate is more suitable to this long-run approach than the

estimation of the present growth rate of the company. The following formula indicates the cost of equity-based on the Capital Asset Pricing Model (CAPM):

$$k_{equity} = RFR + \beta(RM - RFR) \quad (3)$$

Risk-Free Rate (RFR) is obtained from the interest rates of the short-term government bills of the individual countries. Market Returns (RM) are collected from the average yearly arithmetic returns of the following exchange: PSE, WIG20, BUX, SAX, from 2009 to 2019. The beta coefficient (β) was analyzed by regressing weekly returns of V4 capital markets with the share price of individual companies listed on those markets. The beta coefficient reflects the firm's level of risk only in cases when capital markets are efficient. Furthermore, the firm's stock prices and the market itself must be efficient so that all risk components are integrated into stock prices. On the contrary, when markets are inefficient, many risk dimensions related to firms' internal issues (corporate governance, concentration of assets and debt, off-balance-sheet records, ongoing legal issues etc.) and the external environment in which it operates are not involved in prices. Given that in these countries there are doubts concerning the efficiency of the capital markets, the beta coefficient does not necessarily include the overall risk of the firms. Free cash flow to firm for the first period considered in analysis was estimated based on the relation:

$$FCFF = CFO + \text{interest expenses} * (1 - \text{tax rate}) - CAPEX \quad (4)$$

Free cash flow to the firm (FCFF) is obtained from the cash flow from operations (CFO), the firm's interest expenses over the years, corporate income tax, and capital expenditures (CAPEX). After the first year, CFt is determined based on the relation:

$$CF_t = CF_{t-1}(1 + g) \quad (5)$$

The tax rate indicates the level of the profit tax on corporations for the individual countries. In all our calculations, we have considered the statutory tax rate, and not the effective tax rate, even some differences can occur (Țâțu et al., 2011). We have made this choice considering that we have some doubts regarding the stability in time of effective tax rate, and, also, that it seems more plausible that the investors to make their judgments for the future period considering statutory tax rate.

Table 1 show the inputs used in the financial model and their positions. The growth rate (g) obtained from the Damodaran database stands as the only input simulated in the Monte Carlo model. To randomly generate the growth rate, Percentage Point Function (PPF) was used with the three following parameters: 1. Percentage standard deviation of future growth rate; 2. Randomly generate a number where x is between zero and one (0<x<1); 3. Growth rate obtained from the Damodaran Online Database.

Table 1: Inputs used in the financial model

Inputs	Notation	Position	Numerical Simulations	Distributions of the Variable
Free Cash Flow to the Firm	FCFF	Fixed	0	Constant
Firm future growth rate	g	Random	500, 1000, 10000	Normally distributed with standard deviation at the

				mean of 1%.
Discount rate (WACC)	r	Fixed	0	Constant

Source: Authors' elaboration.

The number of random growth rates within the geometric progression is identical to the number of simulated trials (number of years simulated). Moreover, trials hold their independent randomly simulated growth rates. Based on the number of trials, the simulation samples were repeated under the same conditions and independent from each other. Percentage Point Function indicates the x-values within the cumulative distribution function, where: $P(X \geq x)=p$, and p indicate a randomly generated number. The study measures only the percentage deviation between the estimated intrinsic value and market prices of the listed firms in V4 stock exchanges. However, it does not consider when prices are above intrinsic value (the case of undervalued firms) or below intrinsic value (the case of overvalued firms). Mathematically the formula of the PPF function can be expressed as:

$$\Pr[X =< G(\alpha)] = \alpha \tag{6}$$

the alternative form stands as:

$$x = G(\alpha) = G\big(F(x)\big) \tag{7}$$

The parameters explained are important inputs in constructing the Monte Carlo Simulation model. Components used on the simulation model stand as follow: Annual Free Cash Flow to the Firm (FCFF), yearly discount rate represented through WACC, number of years to be simulated, and number of simulated samples or trials. The second process requires identifying the firm's value by calculating the cumulative DCF-s. Besides, the cumulative DCF stops adding additional values when the percentage difference between two consecutive DCFs is less than 6%. The maximum number of years that can be generated on the geometric progression is limited to 30 years. Since we consider that cumulative DCF-s after 30 years does not influence total firms' value. For this purpose, the number of years concerning the geometric progression could be less than those defined in the program.

All the companies used for our study are simulated with three different trials, such as 500 samples, 1000 samples, and 10000 samples. The programs used to generate our results are as follows: Python 3.5.3 (Language Program) and Jupiter Notebook (Development Environment). To generate the random growth rate was used "norm.ppf" function was obtained from the library "scipy.stats" (version 1.2.1). Normal distribution and DCF cumulative plots were received by using Matplotlib Library version 3.0.2 (pyplot functions). The figures of the best-performing companies in the results section have been generated with the R-program *(the program concerning the implantation of the entire process is provided on request)*.

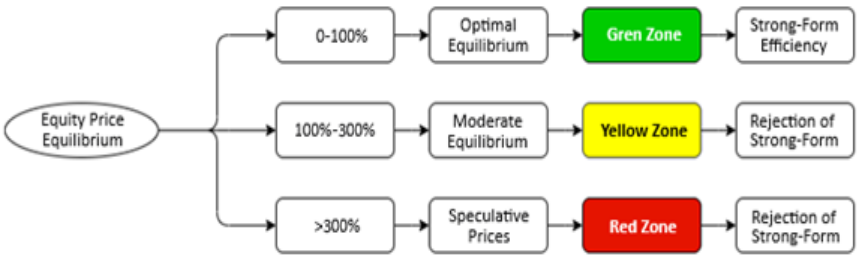


Figure 1: The layers in which stock prices move in the stock market.
Source: Authors' own elaboration.

Figure 1 shows that equity price equilibrium can be placed under different zones. Deviation of the equity prices from their intrinsic value in the range of 0 to 100% is considered the equilibrium area or green zone. The deviation 0 to 100% is justified by the fact that the model possesses assumptions regarding the growth rate, discount rate, and the level of future cash flows. Moreover, some companies are characterized by liquidity issues where prices for some of them remain unchangeable for a certain period. The lack of liquidity associated with some firms stands as one of the limitations of the work. Competition is an additional dimension of stock price equilibrium where stock markets do not fulfill the criteria of being close to perfect competition. Equity stocks are not homogenous products since companies are diverse and they operate in different industries. Moreover, there are barriers to entry related to the listing requirements from stock exchanges. Consequently, stock exchanges tend to ensure that only high-quality firms are listed, which prevents the achievement of a perfectly competitive environment. Price deviation from 100% to 300% indicates moderate equilibrium or yellow zone, and deviation higher than >300% are considered speculative prices or red zone. The 100 to 300% deviation is justified by the fact that there must be a certain level of speculation to attract market participants. The authors suggest an innovative conceptual framework for testing the efficiency of equity stocks. Prices between 0 to 100% might fulfill the strong-form EMH condition while stocks in the range 100% to 300% and more than >300% reject the strong-form EMH. Zones associates with traffic light colors where green inform investors that prices are balanced. In contrast, yellow and red zones give signals to the investors for extra cautions.

The authors consider that measuring solely stock market efficiency is not enough to give reliable signals for market participants if the prices are not compared with the intrinsic value. Furthermore, the equilibrium of equity prices can only be achieved by the continuous valuation of firms. Since firms listed on the stock exchanges publish their financial statements quarterly, these valuations can be made in line with published statements.

3.2. Data collection and processing

The study estimates the fundamental value of the firms listed on Czech, Polish, Hungarian, and Slovak stock exchanges and compares them with their market prices. The DCF model was used to identify the estimated intrinsic value of the companies in the V4 stock markets from 2008 to 2019. Audited financial statements of the firms listed on the PSE, WIG20, BUX, and SAX were collected on an annual basis, to define components

used in the DCF model. Valuation was conducted only in those years when firms possess positive FCFF. Moreover, periods, when firms have negative FCFF, are not involved in the simulation.

Figure 2 shows the complete research process including the parameters used in the model. The process begins with the selection of companies where 10 firms were selected from PSE, 20 firms from WIG20, 16 firms from BUX, and 6 firms from SAX. Components used in the DCF model, such as WACC, CAPM, FCFF, and cost of debt were adjusted to the individual characteristics of the firms.

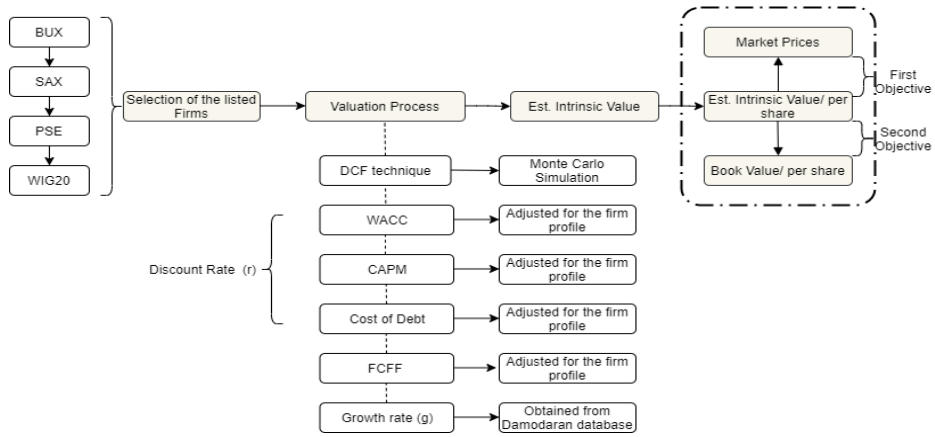


Figure 2: Schematic diagram of the research process and parameters used in the model.

Source: Authors' own elaboration.

The firm's growth rate (g) is determined based on the industry averages while estimations were obtained from Damodaran online database (DOD, 2020). Valuation was not performed for the periods when firms FCFF were negative. However, seasonality in cash flow can explain sometimes negative FCFF-s. Market prices of the selected companies are collected from the Thomson Reuters Eikon database (TRE, 2020) while book value from the publicly available financial statements. Statutory tax rate is used instead of the effective tax rate as we consider that in long run these two types of taxes converge. Calculating effective tax rate is a difficult task as some firms pay higher effective tax than others.

4. Results and discussions

The results of the study are separated into four parts where *section 4.1* is focused on the Prague Stock Exchange (PSE), *section 4.2* on the Warsaw Stock Exchange (WIG20), *section 4.3* on the Budapest Stock Exchange (BUX), and *section 4.4* on the Bratislava Stock Exchange (SAX).

4.1. Estimated intrinsic value of the firms listed on the Prague Stock Exchange (PSE)

The section analyses the intrinsic value of the firms listed on the PSE by comparing it with accounting value and their market prices. From the 13 companies selected in the PSE, only 10 of them possessed sufficient data for our study. The reason

why 3 of the 13 selected companies were not part of our study lies in the fact that they had negative FCFF over years. The results indicate that on average the deviation between intrinsic value per share and market prices of the firms from 2009 to 2019 was 103.1%. The market prices of the firms listed on the PSE stand in the red zone and reject the strong form efficiency since prices deviate in the range of 30% from the intrinsic value per share. The deviation of the market prices from the intrinsic value per share of the 4 domestic companies from 2009 to 2019 was 188.5%. In contrast, 6 international companies hold a deviation of 46.2% within market prices and intrinsic value per share. Book value per share has been measured by dividing total equity by the number of shares outstanding. The deviation of the book value per share with intrinsic value per share of the 10 companies listed on the PSE was 518.7%. International companies deviated in the range of 289% while domestic ones on the level of 891%.

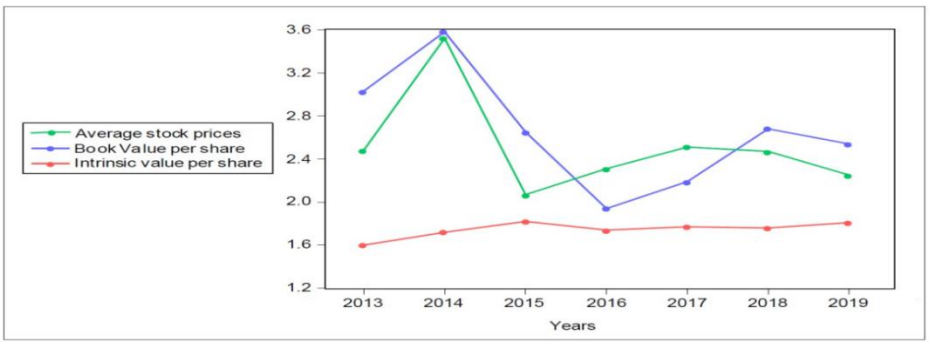


Figure 3: Book value per share, the intrinsic value per share, and market prices of the Stock Spirit PLC.

Source: Authors' calculations based on the Thomson Reuters Eikon database.

Figure 3 indicates the book value per share, estimated intrinsic value per share, and market prices of the Stock Spirit PLC. The reason why the results are from 2013 till 2019 lies in the fact the Stock Spirit PLC was listed on the PSE for the first time in 2013. The average deviation between market prices and intrinsic value per share from 2013 to 2019 was 15%. According to the model proposed by us, market prices of the Stock Spirit PLC meet the moderate equilibrium criterion or the yellow zone. In contrast, the average deviation between intrinsic value per share and book value per share from 2013 to 2019 was 45%. Based on the level of efficiency, the market prices of the Stock Spirit PLC from 2013 to 2019 reject the strong form EMH.

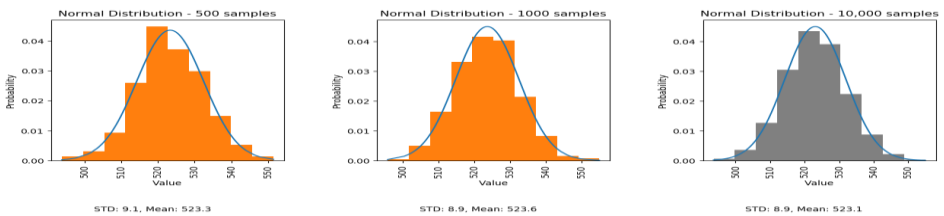


Figure 4: The normal distribution with 500, 1000, and 10000 trials for the Stock Spirit PLC.

Source: Authors' calculations based on the audited financial statements.

Figure 4 represents the normal distribution with 500, 1000, and 10000 samples for the Stock Spirit PLC. The company based on our estimates, was considered as the best performing compared to other firms listed on PSE. For this purpose, Stock Spirit PLC holds the lowest deviation between market prices and estimated intrinsic value per share.

4.2. Estimated intrinsic value of the firms listed on the Warsaw Stock Exchange (WIG20)

Section 4.2 defines the estimated intrinsic value of 20 companies listed on the Warsaw Stock Exchange (WIG20), from 2009 till 2019. The average deviation between intrinsic value per share of the firms and their market prices from 2009 to 2019 was 213.6%. The market prices of the listed firms in the WIG20 during this period were 2.1 times higher than their estimated intrinsic value per share and stand within the red zone and reject the strong form EMH. The deviation of the market prices of domestic companies from their intrinsic value per share was 239.8% while that of international ones were in the range of 108.8%. In contrast, the percentage gap between book value per share and intrinsic value per share was 508% where domestic companies deviate with 362% while international ones with 1093%.

According to our estimates, the best performing company with the lowest deviation on the WIG20 was Bank Polska Opieki SA. The average deviation between the estimated intrinsic value per share and market prices of the Bank Polska Opieki SA was 23%. The company with this level of deviation meets the criteria to be within the red zone and prices to be considered as speculative.

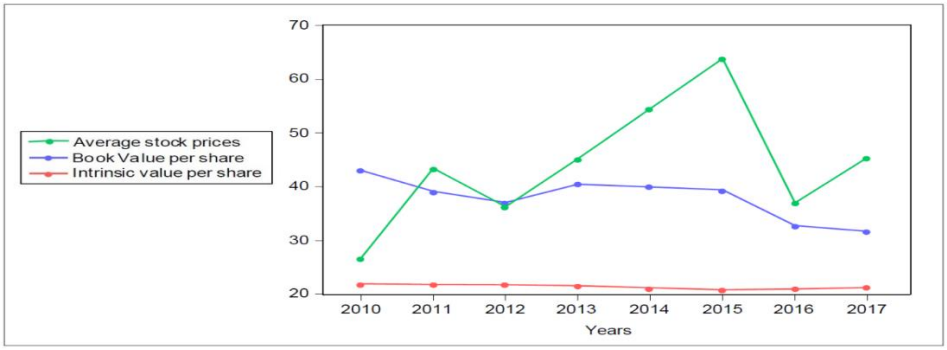


Figure 5: Book value per share, the intrinsic value per share, and market prices of the Bank Polska Opieki SA.

Source: Authors' elaboration based on the Thomson Reuters Eikon database.

Figure 5 shows that intrinsic value per share and market prices were converging and prices remained within the moderate equilibrium for the period from 2010 to 2017.

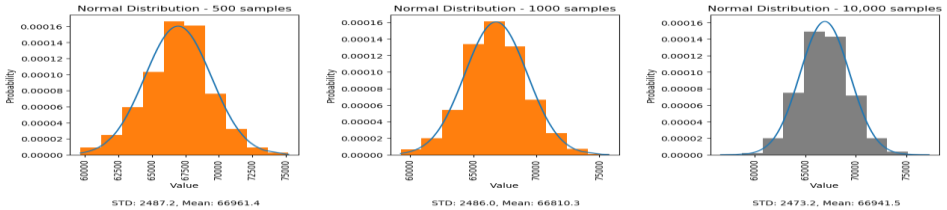


Figure 6: The normal distribution with 500, 1000, and 10000 trials for the Bank Polska Opieki SA.

Source: Authors' calculations based on the audited financial statements.

Figure 6 shows the normal distribution with 500, 1000, and 10000 samples for the best performing company in the WIG20. Shares of the company Bank Polska Opieki SA were traded with the lowest deviation from their estimated intrinsic value compared to other listed firms in WIG20.

4.3. Estimated intrinsic value of the firms listed on the Budapest Stock Exchange (BUX)

Section 4.3 identifies the level of deviation between the intrinsic value per share and market prices of the companies listed on the Budapest Stock Exchange (BUX). Of the 16 selected companies, all possessed the parameters set to be usable in the study. From 2009 to 2019, market prices of the BUX companies deviate from their intrinsic value per share at the level of 261.2%, known to us as red zone or speculative prices (rejection of the strong-form EMH). However, 11 domestic companies hold a deviation in the level of 343.4% while 5 international companies are exposed to a deviation of 80.3%. Domestic companies on BUX during this period possess higher speculative prices than international companies. Considering the accounting data, the deviation between intrinsic value per share and book value per share for 16 companies is at the level of 1113.6%. Among them, 11 domestic companies have a deviation at the level of 1120% while the international ones in the range of 1100%. Based on our estimates the company with the lowest deviation between intrinsic value per share and market prices was Zwack Unicum Likoripari es Kereskedelmi Nyrt. The deviation of the intrinsic value per share from market prices during this period was in the range of 59%.

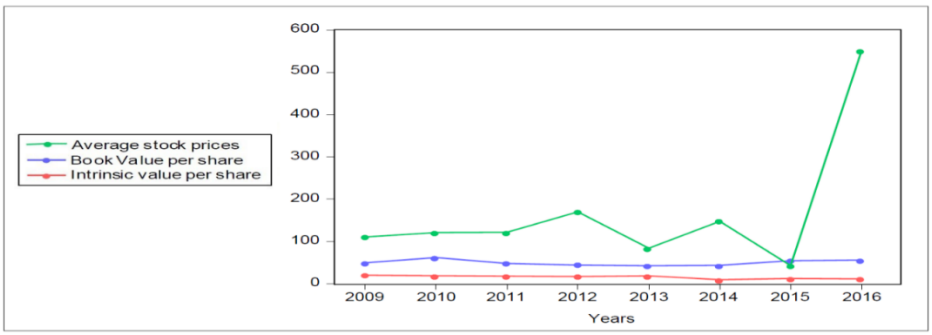


Figure 7: Book value per share, the intrinsic value per share, and market prices of the Zwack Unicum Likoripari es Kereskedelmi Nyrt.

Source: Authors' elaboration based on the Thomson Reuters Eikon database.

From Figure 7 it can be seen that the market prices were constantly above intrinsic value per share and the company was undervalued during this period. Movements of the book value per share stand closer to the market prices than those of the intrinsic value per share.

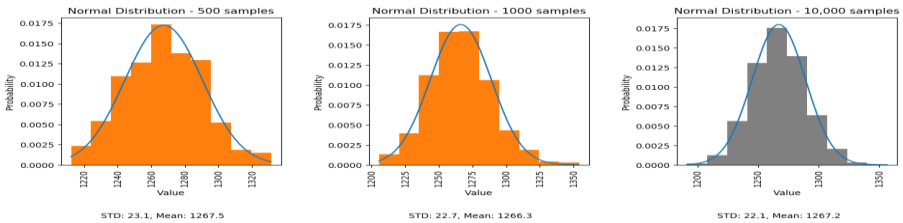


Figure 8: The normal distribution with 500, 1000, and 10000 trails for the Zwack Unicum Likoripari es Kereskedelmi Nyrt.

Source: Authors' calculations based on the audited financial statements.

Figure 8 shows the simulated samples with 500, 1000, and 1000 trials for the Zwack Unicum Likoripari es Kereskedelmi Nyrt, considered as the best performing firm on the Budapest Stock Exchange (BUX). Moreover, the figures presents the mean and standard deviation of the cumulative DCF-s on different trials.

4.4. Estimated intrinsic value of the firms listed on the Bratislava Stock Exchange (SAX)

Bratislava Stock Exchange has the lowest level of trade volume and a limited number of listed companies, compared to other Visegrad Stock Exchanges. The average deviation between stock prices and intrinsic value per share for the SAX companies was in the range of 80.2%, which stands in the red zone and reject the strong-form EMH. However, 3 international companies hold a deviation in the range of 75.7% while 3 domestic ones in the range of 84.7%. The average book value per share of the 6 selected companies deviates from the intrinsic value per share in the range of 567.7%. In addition, domestic companies deviate at the level 685% while international ones at the level of 450%.

In terms of the Bratislava Stock Exchange, our best estimates indicate that the Tatry Mountain indicates the lowest deviation between stock prices and estimated intrinsic value per share. The average deviation between stock prices and intrinsic value per share for the Tatry Mountain was 62% and stand in the red zone (reject strong-form EMH). Figure 9 shows that after 2011 intrinsic value per share were permanently above-market prices which indicate that the company was undervalued. However, the deviation between book value per share and intrinsic value per share for the company was in the range of 390%.

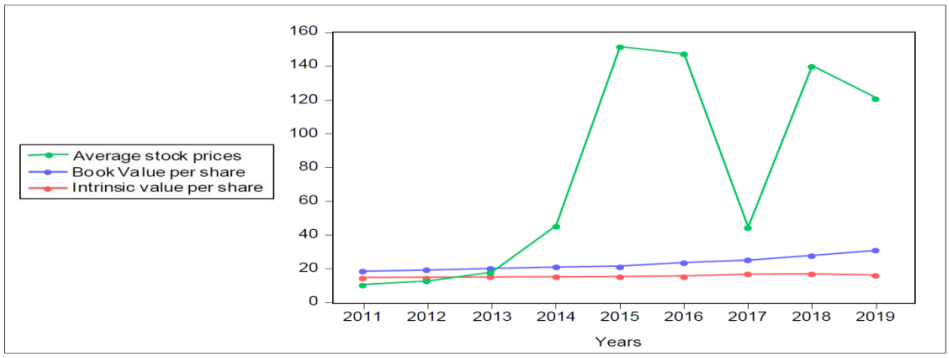


Figure 9: Intrinsic value per share, book value per share, and market prices of the Tatry Mountain.

Source: Authors' calculations based on the Thomson Reuters Eikon database.

Figure 10 indicates the normal distribution of the company Tatry Mountain with 500, 1000, and 10000 trails. The company is listed on the Bratislava Stock Exchange (SAX) and holds the lowest deviation between market prices and intrinsic value per share.

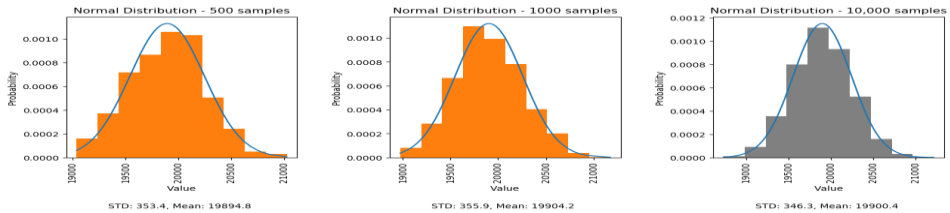


Figure 10: The normal distribution with 500, 1000, and 10000 trails for the Tatry Mountain.

Source: Authors' calculations based on the audited financial statements.

The company contains the lowest gap between stock prices and the intrinsic value compared to other listed companies in SAX *(the same simulations were performed for all V4 selected firms and are available on request)*.

4.5. Discussion and comparison of the cross-country valuation results

The section explores percentage differences linked with the Visegrad Stock Exchanges within the book value per share, the intrinsic value per share, and market prices. Figure 8 shows the aggregate percentage deviation of the intrinsic value per share compared to the market prices of the four Visegrad Stock Exchanges. On average from 2009 to 2019, the index with the lowest gap within market prices and intrinsic value per share was SAX with 82% deviation, followed by PSE with 116%, WIG20 with 207%, and BUX with 246%. The fact that the SAX index has the lowest level of deviation or is closer to the moderate equilibrium, oppose the findings of Aliu et al. (2019) who consider that BUX is the most diversified stock exchange compared to BUX, WIG20, and PSE. However, diversification in itself does not necessarily reflect the speculation level that stock prices hold. Market prices on the V4 stock exchanges from 2009 to 2019 were permanently located in the red zone and reject the strong-form EMH. Moreover, the

inefficiency of the V4 stock exchanges is also confirmed by other authors who have used other techniques to measure this phenomenon (Miloş et al., 2020; Dragotă and Ţilică, 2014; Guidi et al., 2011; Todea and Zoicas-Ienciu, 2008).

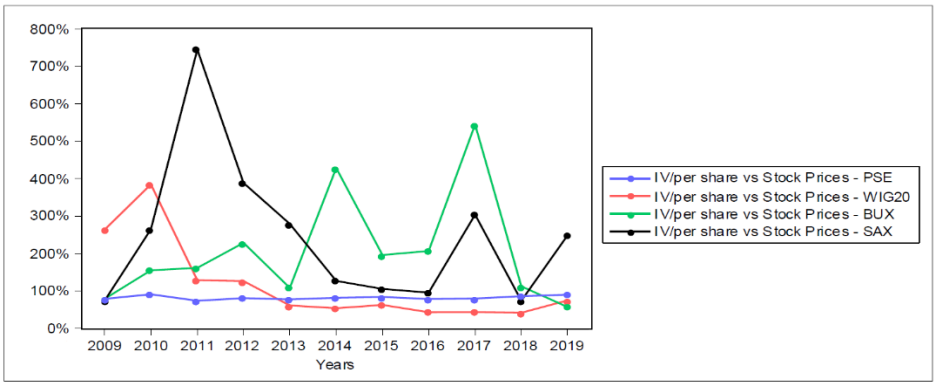


Figure 11: The deviation between aggregate intrinsic value (IV) per share and stock prices of the Visegrad Stock Markets.

Source: Authors' calculations based on the Thomson Reuters Eikon database.

According to Figure 11, SAX and BUX percentage deviation of the intrinsic value per share (IV/share) and stock prices were moving almost in the same line except during 2010 and 2011. Regarding WIG20, from 2009 to 2014 stock prices had a higher level of speculations and then tends toward a more representative price level *(the intrinsic value results of all other firms listed on V4 stock exchanges are available on request)*.

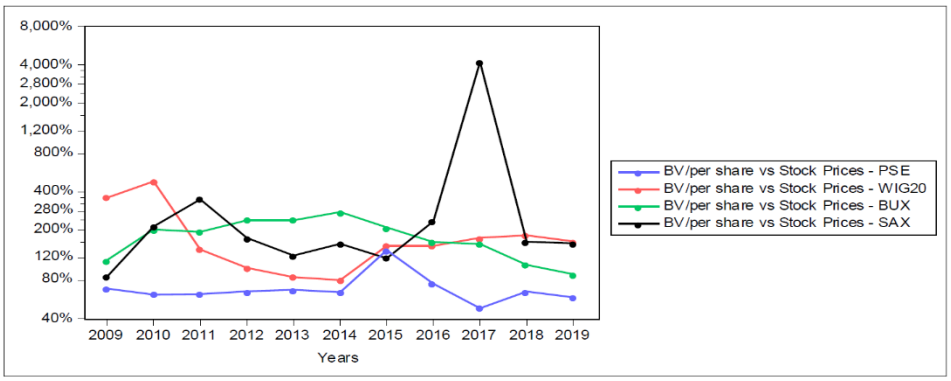


Figure 12: The deviation between book value (BV) per share and stock prices of the Visegrad Stock Exchanges.

Source: Authors' calculations based on the Thomson Reuters Eikon database.

Figure 12 shows the difference between the book value per share (BV/per share) and stock prices of the major equity indexes of the Visegrad countries. The equity index with the lowest differences between BV/per share and market prices was SAX with 71% deviation, followed by WIG20 with 181%, PSE with 188%, and BUX with 545%. Gornik-Tomaszewski and Jermakowicz (2001) investigated from 1996 to 1998, the gap

between book value and the market value of the 77 Polish listed firms. Their results indicate that the MV/BV ratio was 0.61 (61%) while our study indicates that the deviation stands in the range of 181%. In the case of the Czech Republic, Hellström (2006) identified an MV/BV ratio of 61% for the period 1994-1997, while a deviation of 57% for the period 1998-2001. In contrast to Hellström (2006), our results for the Czech Republic show that the average deviation between stock prices and book value from 2009 to 2019 was 188%. Korányi (2008) by analyzing the Budapest Stock Exchange detected a deviation at the level of 150% of the MV/BV ratio while the results of our stand in the range of 545%.

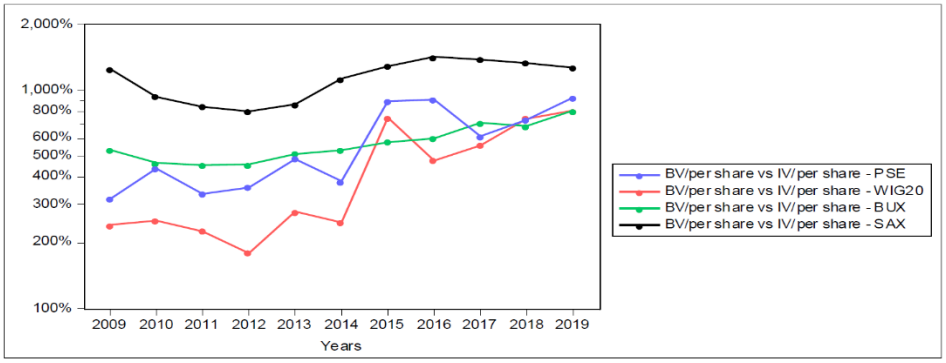


Figure 13: The difference between book value (BV) per share and intrinsic value (IV) per share of the Visegrad Equity Exchanges.

Source: Authors' calculations based on the Thomson Reuters Eikon database.

The reason why MV/BV ratio was lower in the previous authors, may be related to the fact the Visegrad countries at that time were not part of the EU, their economy was still in the process of restructuring and stock market activity was limited. Moreover, previous authors cover the period mainly from 1994 to 2001 while our study focuses from 2009 to 2019. The end of transition for V4 countries was considered EU accession, which gave investors more confidence not only with the economy but also in terms of democracy.

Figure 13 presents the deviation outcomes between book value (BV) per share and intrinsic value (IV) per share concerning SAX, BUX, WIG20, and PSE. The lowest gap within BV/per share and IV/per share from 2009 to 2019 was shown on the PSE with 433% deviation, followed by WIG20 with 576%, SAX with 581%, and BUX with 1138%. Both indicators are generated from accounting inputs where BV/per share is determined by equity level and number of shares outstanding while IV/per share by the DCF model.

However, BV/share is an aggregate indicator and is based largely on the firm's historical records while IV/per share considers the firm's risks and opportunities to generate cash flows in the future. Since IV/per share is a comprehensive indicator, for this reason, it provides more realistic signals on the current situation of firms than BV/per share. Although the DCF model has its limitations, it still offers a realistic prospect of the firm's financial reality. To improve the efficiency of the stock exchanges, the authors consider that a firm valuation report should be carried out when interim reports are published. This will not allow stock prices to be out of balance and hold speculative elements over long periods.

5. Conclusion

Equity markets in the V4 countries stand on the different development phases and are covered with unique national characteristics. Past studies show sufficient evidence that capital markets in V4 countries are inefficient, and prices do not domestic reality. To this end, our work traces the differences between the intrinsic value per share and market prices of firms listed on V4 Stock Exchanges. The additional objective of the study was to explore the gap between book value per share and their market prices. The authors suggest a new form of measuring the efficiency level of equity exchanges and determining a possible equilibrium value for the listed shares. The results present only our estimates, while other scholars may provide different outcomes. Monte Carlo simulation with 500, 1000, and 10000 samples has been employed to generate the estimated results. Results of the study show that on average from 2009 to 2019, the Visegrad Stock Exchanges reject the strong form EMH and stand in the red zone. The stock market with the best performance which holds the lowest gap between market prices and intrinsic value per share was SAX with an 82% deviation. PSE was the second stock exchange with the best performance where the deviation between stock prices and intrinsic value per share was 116%, followed by WIG20 with 207% and BUX with 246%. The reality in terms of individual firms was different from the overall results of Visegrad Stock Exchanges. From the PSE, the company with the lowest deviation was Stock Spirit PLC with 15%, followed by Bank Polska Opieki SA from WIG20 with 23%, Zwack Unicum Likoripari es Kereskedelmi Nyrt from BUX with 59%, and Tatry Mountain from SAX with 62%. The Stock Spirit PLC was the only company from the Visegrad Stock Exchanges that met the criteria to be in the yellow zone or named as moderate equilibrium. The accounting indicators reflect the book value of the listed firms based on the historical registration of the assets and debts. The Visegrad Stock Market with the lowest level of deviation within book value per share and stock prices was SAX with 71%, followed by WIG20 with 181%, PSE with 188%, and BUX with 545%.

The DCF model used in our study does not consider potential mergers and acquisitions, future projects, lifespan of the firms, and possible bankruptcies. Financial and legal due diligence would enable a more comprehensive approach of the firm's risk characteristics which is an additional limitation of our work. The cash flow-based models can provide incomplete explanations of changes in stock prices while more sophisticated models are required to describe the complex reality of capital markets. Moreover, the firm's valuation based on the DCF techniques is built on several assumptions that make the model to some extent inaccurate. Future studies can compute the firm's market value using methods such as dividend-based model, relative valuation techniques, DCF based on free cash flow to equity etc. The equality of these two measures is disputable since DCF estimates the company's value from a controlling position perspective. To be comparable with the value based on DCF, market capitalization should be adjusted with a control premium which is another limitation of the work.

6. Acknowledgments

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