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STATISTICAL ANALYSIS OF SHARE PRICE VOLATILITY OF SELECTED COMPANIES BELONGING TO WIG-INDEX IN 2015-2020

Introduction

Stock exchange, as organized sales of precisely defined goods, operated already as early as in ancient times. Stock markets and trading in the present meaning started in the Netherlands in the 17th century[1]. The idea was mainly to separate capital trading from commodity training and to have transactions in a particular place in town[2]

The beginning of stock exchange in Poland dates back to 1817 when stock and money exchange (also referred to as the Warsaw Merchants Stock Exchange – Warszawska Giełda Kupiecka) was opened in Warsaw[3]. Initially, the trading included such goods as wheat, honey or even herrings. Shares, as they are known today, appeared as late as in 1826. They included covered or mortgage bonds issued by the Land Credit Society (Towarzystwo Kredytowe Ziemskie) [4]. As trading of securities was started, in1872 new regulations were adopted and the name was changed to the Warsaw Stock Exchange[5]. The stock exchange operated in its form until the outbreak of the First World War. It resumed activities in 1921 in independent Poland. The Warsaw Stock Exchange was the greatest stock exchange in the interwar period. There were also stock exchanges in Poznań, Lwów, Krakow and Wilno; they operated in compliance with the President of the Republic of Poland decree of 28 December 1924 on stock exchange organization (Journal of Laws 1924, No. 114, item 1020) [6]. The outbreak of the Second World War put an end to the functioning of the Warsaw Stock Exchange which was reactivated after over 50 years in 1991[7].

[1] Z. Dobosiewicz, *Giełda. Zasady działania. Inwestorzy. Rynki giełdowe*, Polskie Wydawnictwo Ekonomiczne S.A., Warszawa 2013, p. 9.
[2] A. Sopoćko, *Giełda papierów wartościowych*, AW i M MEDIABANK S.A., Warszawa 1993, p. 75.
[3] www.dsa.pl/poczatki-gieldy-w-polsce/ (accessed: 12.03.2020).
[4] www.forbes.pl/wiadomosci/historia-gieldy-w-polsce-200-lecie-pierwszej-sesji/xsts5l3 (accessed: 12.03.2020).
[5] Z. Dobosiewicz, *op. cit.*, p. 28.
[6] Ibidem, p. 28; www.dsa.pl/poczatki-gieldy-w-polsce/ (accessed: 12.03.2020).
[7] Ibidem.

On 22 March 1991 the act on Public Trading and Trust Funds was passed (Journal of Laws 1991, No.58, item 239) in compliance of which the Warsaw Stock Exchange (WSE) started operating[8]. Initially, it was not big but it developed quickly until 1994 when a sudden 13-month slump slowed the development. At that time, the Warsaw Stock Exchange Index (WIG) lost as much as 72% of its value[9]. Soon afterwards, there was a long-term recovery in the stock market. Another significant slump occurred in Warsaw in 2007. This was mainly the result of the crisis in global financial markets. It was obviously also caused by dangerously high prices of shares that occurred in the periods of stock market prosperity[10]. The latest years of the WSE operations involved significant volatility and fluctuation of prices. This was related mainly to substantial trading in Polish shares by foreign investors[11].

The rules that govern the operations of the WSE operations are included in the Act of 29 July 2005 on Trading in Financial Instruments (Journal of Laws 2005, No.183, item 1538), the Act on Public Offering, Conditions Governing the Introduction of Financial Instruments to Organized Trading and Public Companies (Journal of Laws 2005, No.184, item 1539), and also result from the Act on Financial Market Supervision (Journal of Laws 2006, No.157, item 1119)[12]. Moreover, everyday operations on the Stock Exchange are governed by its Statute, which – among other things – specifies the competencies and roles of particular bodies constituting the Stock Exchange authorities, i.e. the General Meeting of Shareholders, the Board of the Stock Exchange and its Management[13].

Trading in financial instruments – there were 3000 of them in 2017 – is conducted in three markets[14]. 90% of the stock exchange turnover accounts for Main Market (Rynek Główny) (which until 2007 was the only market in WSE), which has the strictest norms of listing. In 2007, the New Connect market was developed for companies with a high growth dynamics and ones that belong to such innovative sectors as IT, biotechnology or alternative sources of energy. The Catalyst market is the third market which was founded in 2009 to concentrate trading in debt instruments and mortgage bonds[15].

In order to present the situation in the whole market or its particular segments, various indices are used. In the Warsaw Stock Exchange (WSE), WIG is the official stock market index.

[8] Z. Dobosiewicz, *op. cit.*, p. 28.
[9] viem.viennalife.pl/pl/artykuly/najwieksze-bessy-w-historii (accessed: 12.03.2020).
[10] Z. Dobosiewicz, *op. cit.*, p. 29.
[11] Ibidem.
[12] www.infor.pl/prawo/encyklopedia-prawa/g/290645,Gielda-Papierow-Wartosciowych-w-Warszawie-SA-GPW.html (accessed: 12.03.2020).
[13] Z. Dobosiewicz, *op. cit.*, p. 38.
[14] www.gpw.pl/o-spolce (accessed: 12.03.2020).
[15] www.forbes.pl/gielda/catalyst-rynek-obligacji-gpw-w-pigulce/0vqrlb0 (accessed: 12.03.2020).

The index expresses the total value of all companies listed in WSE in relation to the value when they were first listed. Thus, WIG is a sort of a measure of profitability of investing in all shares[16]. Apart from WIG, the WSE uses WIG20, WIG30, sector indices such as WIGenergia, WIGleki, WIGmotoryzacja, as well as national indices: WIGPoland and WIGUkraine[17].

Wig20 seems to be the flagship index in the WSE. It launched officially on 16 April 1994 (exactly three years after the first session in the Stock Exchange) and the assumption is that it covers the 20 largest corporations that are selected in line with precisely defined rules. The main criteria are market capitalisation and share-trading volume. However, the WIG20 index cannot include more than 5 companies from the same stock market sector and it does not list investment funds. As a result, it covers only 5 banks although there should be many more[18].

In the initial list of WIG20, Bank Śląski (now ING) had the greatest share (11.88%) and it was followed by Elektrim and Bank Zachodni (now Santander). At present, from the top 20 corporations that were covered by WIG20 at the beginning, there are fewer than half of them left on the stock market. Currently, the WIG20 index is influenced mainly by PKO BP, PZU and PKN Orlen[19]. One should also mention here the WIG30 index which was launched in 2013. Similarly to WIG20, it includes 30 greatest corporations listed on WSE. The objective of the introduction of new companies to the main index was to increase liquidity and turnover. However, the popularity of WIG30 is completely insignificant[20].

At first, only immediate cash transactions were conducted in WSE. As late as in 1998 derivative instruments were introduced and the first ones included the WIG20 index contracts. The launch of the first option contacts was also related to the WIG20 index. The experience in this area made it possible to have option transactions for other shares[21].

1. Share prices of selected WIG companies in February 2015 – January 2020

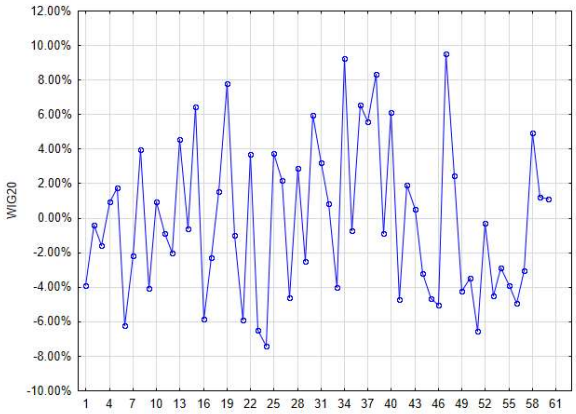
For the requirements of the article, the authors analysed the volatility of share prices of companies that were listed by WIG20 in the period of 5 years: February 2015 – January 2020. The following abbreviation were used:

[16] W. Tarczyński, *Rynki Kapitałowe. Metody ilościowe*, Agencja Wydawnicza „PLACET", Warszawa 1997, p. 134.
[17] www.gpw.pl/opisy-indeksow (accessed: 12.03.2020).
[18] www.bankier.pl/wiadomosc/WIG20-konczy-25-lat-Poznaj-historie-flagowego-indeksu-GPW-7653726.html (accessed: 12.03.2020).
[19] www.gpw.pl/indeks?isin=PL9999999987 (accessed: 12.03.2020).
[20] W. Panfil, A. Szablewski, *Wycena spółek z WIG30. Specyfika. Metody. Przykłady*, Wydawnictwo Poltext, Warszawa 2014.
[21] W. Bień, *Rynek papierów wartościowych*, Difin, Warszawa 2008, p. 255.

ALRR – Alior Bank S.A.
CCCP – CCC S.A.
CDR – CD Projekt S.A.
CPS – Cyfrowy Polsat S.A.
DNP – Dino Polska S.A.
JSW – Jastrzębska Spółka Węglowa S.A.
KGH – KGHM Polska Miedź S.A.
LPPP – LPP S.A.
LTSP – Grupa Lotos S.A.
MBK – mBank S.A.
OPL – Orange Polska S.A.
PEO – Bank Polska Kasa Opieki S.A.
PGE – PGE Polska Grupa Energetyczna S.A.
PGN – Polskie Górnictwo Naftowe i Gazownictwo S.A.
PKN – Polski Koncern Naftowy Orlen S.A.
PKO – Polska Kasa Oszczędności Bank Polski S.A.
PLY – Play Communications S.A.
PZU – Powszechny Zakład Ubezpieczeń S.A.
SPL1 – Santander Bank Polska S.A.
TPE – Tauron Polska Energia S.A.

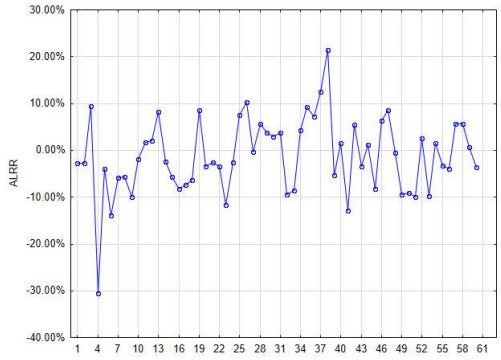
The graphs below (Graphs 1-21) present percentage volatility of the WIG20 index and particular companies listed by it. Tick marks on the x axis represent months, where 1 is February 2015 and 60 stands for January 2020. It is clearly visible that in the majority of graphs the volatility fluctuates significantly and the average monthly amplitude exceeds 10%. This confirms the opinion that investing in shares should be preceded by an adequate analysis although the risk involved is inevitable. That is why an analysis should be conducted of both share price volatility and the WIG20 index with the application of a linear correlation analysis and regression analysis.

Graph 1. WIG index volatility in February 2015 – January 2020



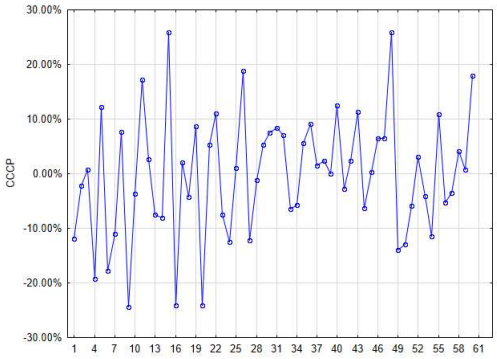
Source: Authors' research based on: www.stooq.pl (accessed: 12.03.2020).

Graph 2. Analysis of share price volatility of Allior Bank S.A. in February 2015 – January 2020



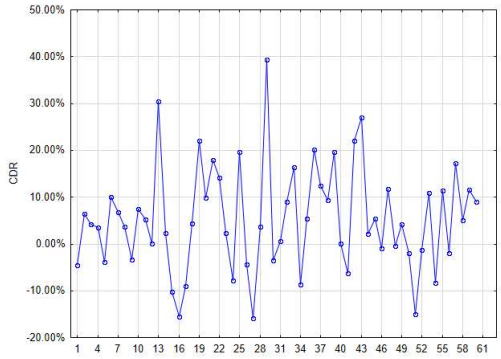
Source: Authors' research based on: www.stooq.pl (accessed: 12.03.2020).

Graph 3. Analysis of share price volatility of CCC S.A. in February 2015 – January 2020



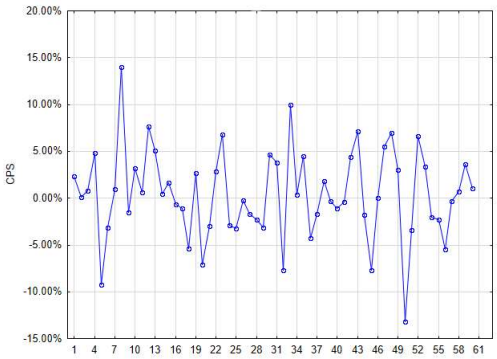
Source: Authors' research based on: www.stooq.pl (accessed: 12.03.2020).

Graph 4. Analysis of share price volatility of CD Projekt S.A. in February 2015 – January 2020



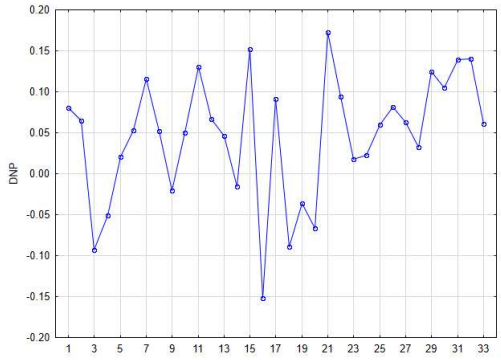
Source: Authors' research based on: www.stooq.pl (accessed: 12.03.2020).

Graph 5. Analysis of share price volatility of Cyfrowy Polsat S.A. in February 2015 – January 2020



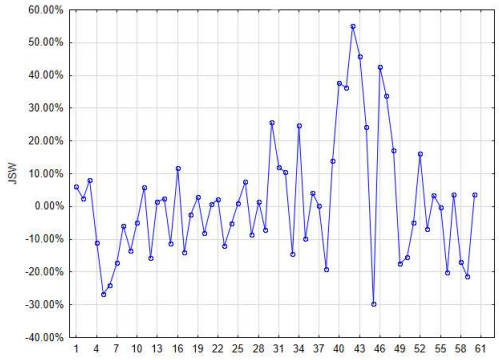
Source: Authors' research based on: www.stooq.pl (accessed: 12.03.2020).

Graph 6. Analysis of share price volatility of Dino Polska S.A. in May 2017 – January 2020



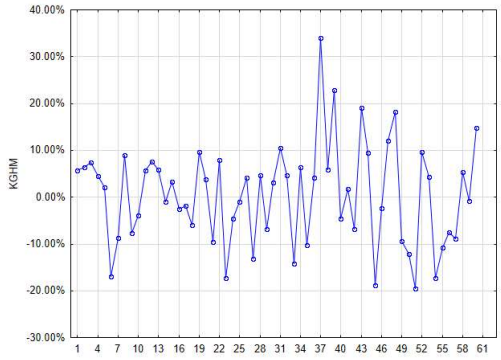
Source: Authors' research based on: www.stooq.pl (accessed: 12.03.2020).

Graph 7. Analysis of share price volatility of JSW S.A. in February 2015 – January 2020



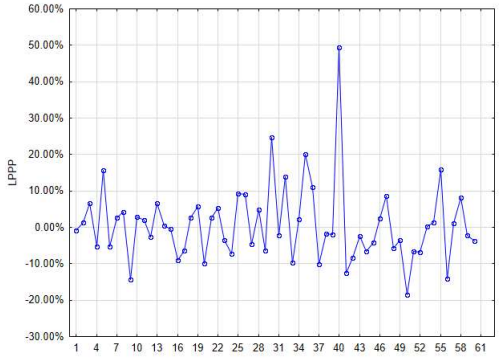
Source: Authors' research based on: www.stooq.pl (accessed: 12.03.2020).

Graph 8. Analysis of share price volatility of KGHM Polska Miedź S.A. in February 2015 – January 2020



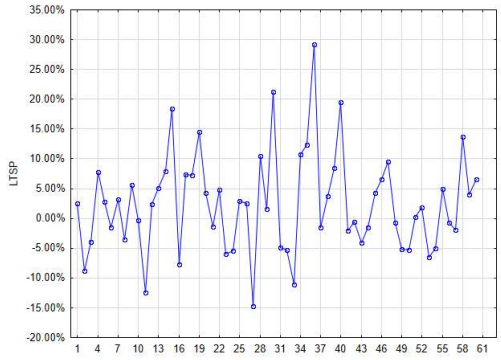
Source: Authors' research based on: www.stooq.pl (accessed: 12.03.2020).

Graph 9. Analysis of share price volatility of LPP ka S.A. in February 2015 – January 2020



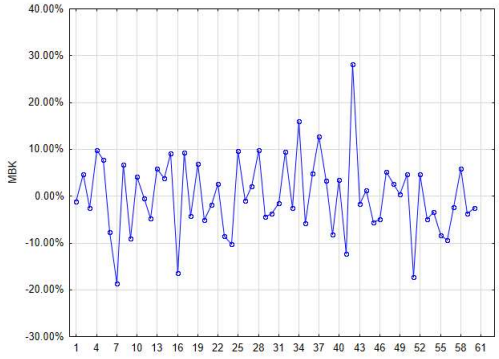
Source: Authors' research based on: www.stooq.pl (accessed: 12.03.2020).

Graph 10. Analysis of share price volatility of Grupa Lotos S.A. in February 2015 – January 2020



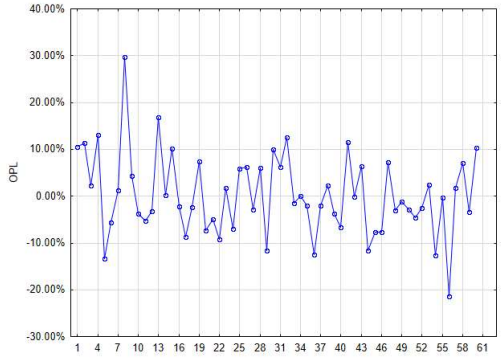
Source: Authors' research based on: www.stooq.pl (accessed: 12.03.2020).

Graph 11. Analysis of share price volatility of mBank S.A. in February 2015 – January 2020



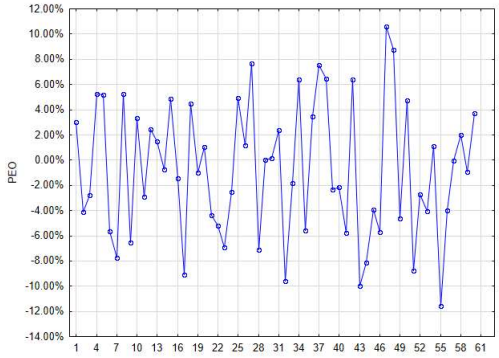
Source: Authors' research based on: www.stooq.pl (accessed: 12.03.2020).

Graph 12. Analysis of share price volatility of Orange Polska S.A. in February 2015 – January 2020



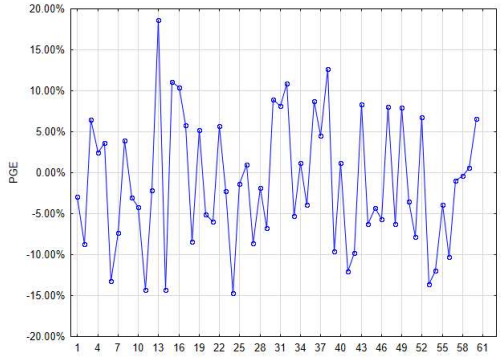
Source: Authors' research based on: www.stooq.pl (accessed: 12.03.2020).

Graph 13. Analysis of share price volatility of Bank Polska Kasa Opieki S.A. in February 2015 – January 2020



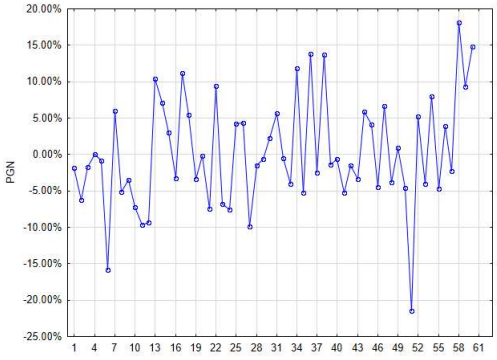
Source: Authors' research based on: www.stooq.pl (accessed: 12.03.2020).

Graph 14. Analysis of share price volatility of Polska Grupa Energetyczna S.A. in February 2015 – January 2020



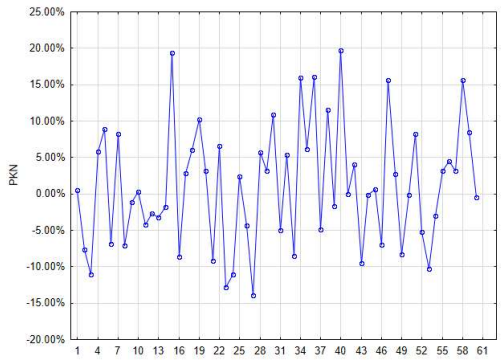
Source: Authors' research based on: www.stooq.pl (accessed: 12.03.2020).

Graph 15. Analysis of share price volatility of Polskie Górnictwo Naftowe i Gazownictwo S.A. in February 2015 – January 2020



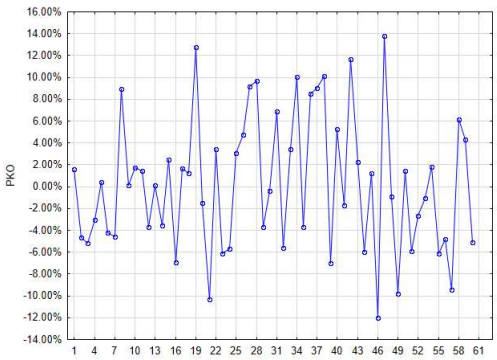
Source: Authors' research based on: www.stooq.pl (accessed: 12.03.2020).

Graph 16. Analysis of share price volatility of Polski Koncern Naftowy Orlen S.A. in February 2015 – January 2020



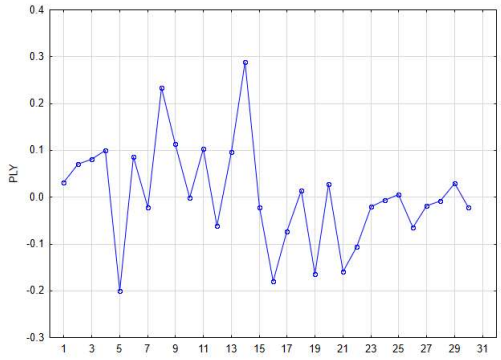
Source: Authors' research based on:www.stooq.pl (accessed: 12.03.2020).

Graph 17. Analysis of share price volatility of Bank Powszechna Kasa Oszczędności Bank Polski S.A. in February 2015 – January 2020



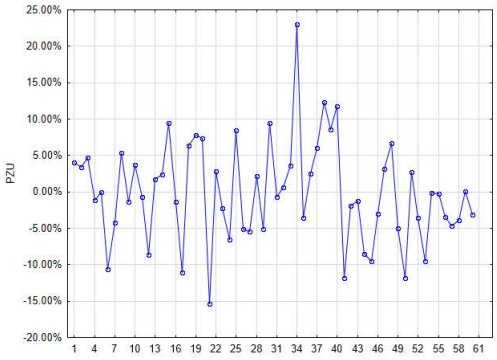
Source: Authors' research based on: www.stooq.pl (accessed: 12.03.2020).

Graph 18. Analysis of share price volatility of Play Communications S.A. in February 2015 – January 2020



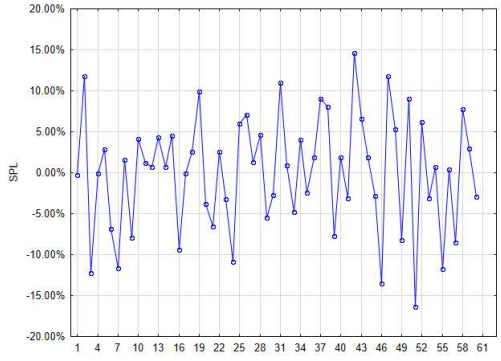
Source: Authors' research based on: www.stooq.pl (accessed: 12.03.2020).

Graph 19. Analysis of share price volatility of Powszechny Zakład Ubezpieczeń S.A. in February 2015 – January 2020



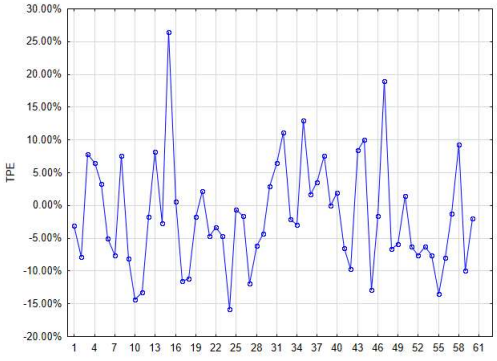
Source: Authors' research based on: www.stooq.pl (accessed: 12.03.2020).

Graph 20. Analysis of share price volatility of Santander Bank Polska S.A. in February 2015 – January 2020



Source: Authors' research based on: www.stooq.pl (accessed: 12.03.2020).

Graph 21. Analysis of share price volatility of Tauron Polska Energia S.A. in February 2015 – January 2020



Source: Authors' research based on: www.stooq.pl (accessed: 12.03.2020).

2. Correlation analysis of WIG20 companies

Table 1 presents the coefficients of partial correlations between all companies that were subject to research and the WIG20 index. Additionally, basic measures of descriptive statistics are given in the form of arithmetic average and standard deviation.

The correlation analysis of the WIG20 companies shows clearly a random character of the volatility of share prices. The correlation coefficients that were calculated for the data for

February 2015-January 2020 usually do not exceed the value of 0.5, which testifies to an insignificant connection between the volatility of share process of particular companies. This means that one should not be overly influenced by changes in the share price of one company in the context of changes in the other WIG20 companies. It can be noticed that from the companies under analysis the most significant impact on the change of the WIG20 index in the given period was exerted by ALRR, CCCP, KGH, LTSP, MBK, PEO, PGE, PGN, PKN, PKO, PZU, SPL1 and TPE. For all these companies, the value of the correlation coefficient between the volatility of their share prices and the change in the WIG20 index value was at least 0.5. The highest value was in the case of the PKO company: 0.71. Thus, it can be assumed that this company had relatively the highest impact on the WIG20 value.

Table 1. Correlation matrix for the WIG20 index volatility and the volatility of all the companies in February 2015 – January 2020

	Correlations (stock market). Correlation coordinates are significant with p < .05000 N=60																						
	Average	Standard deviation	WIG20	ALRR	CCCP	CDR	CPS	DNP	JSW	KGH	LPPP	LTSP	MBK	OPL	PEO	PGE	PGN	PKN	PKO	PLY	PZU	SPL1	TPE
WIG20	0.00	0.04	1.00	0.52	0.49	0.23	0.23	0.06	0.25	0.57	0.46	0.58	0.63	0.34	0.55	0.57	0.54	0.65	0.71	0.00	0.68	0.67	0.50
ALRR	-0.01	0.08	0.52	1.00	0.40	0.25	0.08	0.04	0.26	0.32	0.31	0.24	0.29	-0.05	0.31	0.26	0.33	0.21	0.41	-0.11	0.33	0.37	0.21
CCCP	0.00	0.11	0.49	0.40	1.00	0.18	0.20	0.39	0.28	0.40	0.45	0.30	0.30	0.10	0.13	0.27	0.18	0.31	0.23	-0.19	0.18	0.34	0.26
CDR	0.05	0.11	0.23	0.25	0.18	1.00	0.14	0.11	0.09	0.21	0.09	0.10	0.20	0.07	-0.01	0.12	0.14	0.03	0.08	0.08	0.03	0.16	0.11
CPS	0.00	0.05	0.23	0.08	0.20	0.14	1.00	0.08	0.23	0.29	0.05	-0.04	0.10	0.48	0.12	0.23	0.00	-0.16	0.17	0.22	0.19	0.15	0.18
DNP	0.03	0.06	0.06	0.04	0.39	0.11	0.08	1.00	-0.09	-0.03	0.15	-0.07	0.13	0.12	-0.09	0.01	-0.05	0.01	0.03	-0.05	-0.15	0.12	0.04
JSW	0.02	0.18	0.25	0.26	0.28	0.09	0.23	-0.09	1.00	0.37	0.23	0.11	0.23	0.16	0.02	0.07	0.01	0.04	0.11	0.00	0.22	0.19	0.16
KGH	0.00	0.11	0.57	0.32	0.40	0.21	0.29	-0.03	0.37	1.00	0.04	0.17	0.36	0.32	0.30	0.39	0.29	0.08	0.28	0.03	0.36	0.44	0.40
LPPP	0.01	0.11	0.46	0.31	0.45	0.09	0.05	0.15	0.23	0.04	1.00	0.50	0.16	0.13	-0.03	0.27	0.15	0.43	0.14	-0.09	0.36	0.06	0.26
LTSP	0.02	0.08	0.58	0.24	0.30	0.10	-0.04	-0.07	0.11	0.17	0.50	1.00	0.20	0.03	0.13	0.33	0.46	0.77	0.25	-0.06	0.38	0.11	0.33
MBK	0.00	0.08	0.63	0.29	0.30	0.20	0.10	0.13	0.23	0.36	0.16	0.20	1.00	0.23	0.49	0.32	0.32	0.29	0.58	0.07	0.32	0.73	0.26
OPL	0.00	0.09	0.34	-0.05	0.10	0.07	0.48	0.12	0.16	0.32	0.13	0.03	0.23	1.00	0.16	0.38	0.03	-0.03	0.21	0.35	0.21	0.23	0.39
PEO	-0.01	0.05	0.55	0.31	0.13	-0.01	0.12	-0.09	0.02	0.30	-0.03	0.13	0.49	0.16	1.00	0.19	0.26	0.24	0.54	0.05	0.39	0.53	0.24
PGE	-0.01	0.08	0.57	0.26	0.27	0.12	0.23	0.01	0.07	0.39	0.27	0.33	0.32	0.38	0.19	1.00	0.45	0.28	0.26	-0.22	0.32	0.27	0.59
PGN	0.00	0.08	0.54	0.33	0.18	0.14	0.00	-0.05	0.01	0.29	0.15	0.46	0.32	0.03	0.26	0.45	1.00	0.45	0.32	-0.01	0.23	0.37	0.25
PKN	0.01	0.08	0.65	0.21	0.31	0.03	-0.16	0.01	0.04	0.08	0.43	0.77	0.29	-0.03	0.24	0.28	0.45	1.00	0.40	-0.14	0.46	0.27	0.34
PKO	0.00	0.06	0.71	0.41	0.23	0.08	0.17	0.03	0.11	0.28	0.14	0.25	0.58	0.21	0.54	0.26	0.32	0.40	1.00	-0.01	0.42	0.72	0.16
PLY	0.00	0.08	0.00	-0.11	-0.19	0.08	0.22	-0.05	0.00	0.03	-0.09	-0.06	0.07	0.35	0.05	-0.22	-0.01	-0.14	-0.01	1.00	0.14	-0.02	0.04
PZU	0.00	0.07	0.68	0.33	0.18	0.03	0.19	-0.15	0.22	0.36	0.36	0.38	0.32	0.21	0.39	0.32	0.23	0.46	0.42	0.14	1.00	0.24	0.27
SPL1	0.00	0.07	0.67	0.37	0.34	0.16	0.15	0.12	0.19	0.44	0.06	0.11	0.73	0.23	0.53	0.27	0.37	0.27	0.72	-0.02	0.24	1.00	0.26
TPE	-0.02	0.08	0.50	0.21	0.26	0.11	0.18	0.04	0.16	0.40	0.26	0.33	0.26	0.39	0.24	0.59	0.25	0.34	0.16	0.04	0.27	0.26	1.00

Source: Authors' research.

The analysis of mutual relations between the companies shows that relatively high connections between the percentage changes of the share prices of particular companies can be noticed for the following relations:

- ALRR – CCCP; r = 0.4
- ALRR – PKO; r = 0.41
- CPS-OPL; r = 0.48
- CCCP – KGH; r = 0.4
- JSW – KGH; r = 0.37
- KGH – PGE; r = 0.39
- KGH – SPL1; r = 0.44
- KGH – TPE; r = 0.4
- LPPP – LTSP; r = 0.5
- LPPP – PKN; r = 0.43
- LTSP – PGN; r = 0.46
- LTSP – PKN; r = 0.77
- MBK – PEO; r = 0.49
- MBK – PKO; r = 0.58
- MBK – SPL1; r =0.73
- OPL – PGE; r = 0.38
- OPL – PGN; r = 0.45
- OPL – TPE; r = 0.39
- PEO – PKO; r = 0.54
- PEO – SPL1; r = 0.53
- PGE – PGN; r = 0.45
- PGE – TPE; r = 0.59
- PGN – PKN; r = 0.45
- PGN – SPL1; r = 0.37
- PKN – PKO; r = 0.4
- PKN – PZU; r = 0.46
- PKO – PZU; r = 0.42
- PKO – SPL1; r = 0.72

The analysis of the above figures shows clearly sector connections of particular companies – e.g. the share prices of the banking institutions (such as MBK, SPL1, PEO or PKO) or the financial entities (PZU) are usually correlated. Thus, the above indicators can be used to develop statistical models that could – with a defined probability – help predict changes in share prices that were caused by changes in other companies from a similar sector. A similar trend is visible in the case of the mining and power engineering companies (such as LTSP, PGE, PGN, PKN or TPE). The highest correlation was observed for the LTSP-PKN relation (r = 0.77) as well as for MBK - SPL1 (r = 0.73) and PKO - SPL1 (r = 0.72). That leads to the conclusion that the SPL1 company is the most reliable information source about share price changes for banking and financial sector companies

The analysis helped develop regression models for relations where R>0.5. The results are given in tables 2-9 and the regression equations obtained are given in equations (2)-(8).

Table 2. Linear regression analysis for the LPPP-LTSP relation

N=60	Summary of the dependent variable regression: LPPP (stock market) R= .50412027 R^2= .25413725 Corrected R2= .24127755 F(1.58)=19.762 p<.00004 SEE: .09210					
	b*	Standard error for b*	b	Standard error for b	t(58)	p
Absolute term			-0.008115	0.012398	-0.654545	0.515348
LTSP	0.504120	0.113401	0.641199	0.144236	4.445480	0.000040

Key: R – correlation coefficient; R^2 – determination coefficient; Corrected R2 – corrected (standardized) determination coefficient; SEE – standard error of estimation; F – Snedecor's F-test results; p – significance level; N – sample size; b – value of regression equation coefficient; t – value of t-Student test; b* - standardized value of regression equation coefficient.

Source: Authors' research.

$$LPPP = 0.641LTSP - 0.008;\ R^2=25.41\% \quad (1)$$

Table 3. Linear regression analysis for the LTSP-PKN relation

N=60	Summary of the dependent variable regression: LTSP(stock market)) R= .77222502 R^2= .59633149 Corrected R2= .58937168 F(1.58)=85.682 p<.00000 SEE: .05327					
	b*	Standard error for b*	b	Standard error for b	t(58)	p
Absolute term			0.015937	0.006937	2.297408	0.025223
PKN	0.772225	0.083425	0.770779	0.083269	9.256471	0.000000

Source: Authors' research.

$$LTSP = 0.771PKN + 0.016;\ R^2=59.63\% \quad (2)$$

Table 4. Linear regression analysis for the MBK - PKO relation

N=60	Summary of the dependent variable regression: MBK (stock market)) R= .58207511 R^2= .33881143 Corrected R2= .32741163 F(1.58)=29.721 p<.00000 SEE: .06808					
	b*	Standard error for b*	b	Standard error for b	t(58)	p
Absolute term			-0.001633	0.008794	-0.185738	0.853298
PKO	0.582075	0.106770	0.779007	0.142893	5.451680	0.000001

Source: Authors' research.

$$MBK = 0.779PKO - 0.002;\ R^2=33.88\% \quad (3)$$

Table 5. Linear regression analysis for the MBK – SPL1 relation

N=60	Summary of the dependent variable regression: MBK (stock market) R= .72524627 R^2= .52598215 Corrected R2= .51780943 F(1.58)=64.358 p<.00000 SEE: .05764					
	b*	Standard error for b*	b	Standard error for b	t(58)	p
Absolute term			-0.000352	0.007442	-0.047323	0.962418
SPL1	0.725246	0.090403	0.858639	0.107031	8.022360	0.000000

Source: Authors' research.

$$MBK = 0.859SPL1 - 0.0003;\ R^2=52.60\% \quad (4)$$

Table 6. Linear regression analysis for the PEO - PKO relation

N=60	Summary of dependent variable regression: PEO (stock market) R= .54228056 R^2= .29406820 Corrected R2= .28189697 F(1.58)=24.161 p<.00001 SEE: .04541					
	b*	Standard error for b*	b	Standard error for b	t(58)	p
Absolute term			-0.008685	0.005867	-1.48032	0.144199
PKO	0.542281	0.110323	0.468556	0.095325	4.91538	0.000008

Source: Authors' research.

$$PEO = 0.469PKO - 0.009;\ R^2=29.41\% \quad (5)$$

Table 7. Linear regression analysis for the PEO – SPL1 relation

N=60	Summary of the dependent variable regression: PEO (stock market) R= ,53070010 R^2= ,28164260 Corrected R2= ,26925713 F(1,58)=22,740 p<,00001 SEE: ,04581					
	b*	Standard error for b*	b	Standard error for b	t(58)	p
Absolute term			-0.007859	0.005914	-1.32884	0.189104
SPL1	0.530700	0.111290	0.405648	0.085066	4.76862	0.000013

Source: Authors' research.

$$PEO = 0.406SPL1 - 0.008;\ R^2=28.16\% \quad (6)$$

Table 8. Linear regression analysis for the PGE - TPE relation

N=60	Summary of the dependent variable regression: PGE (stock market) R= .59039228 R^2= .34856304 Corrected R2= .33733137 F(1.58)=31.034 p<.00000 SEE: .06475					
	b*	Standard error for b*	b	Standard error for b	t(58)	p
Absolute term			-0.003447	0.008504	-0.405301	0.686747
TPE	0.590392	0.105980	0.559298	0.100398	5.570812	0.000001

Source: Authors' research.

$$PGE = 0.559TPE - 0.003;\ R^2=34.86\% \quad (7)$$

Table 9. Linear regression analysis for the LPPP - LTSP relation

N=60	Summary of the dependent variable regression: PKO (stock market) R= .72204179 R^2= .52134434 Corrected R2= .51309166 F(1.58)=63.173 p<.00000 SEE: .04328					
	b*	Standard error for b*	b	Standard error for b	t(58)	p
Absolute term			0.001873	0.005588	0.335141	0.738728
SPL1	0.722042	0.090844	0.638741	0.080364	7.948126	0.000000

Source: Authors' research.

$$PKO = 0.639SPL1 + 0.002;\ R^2=52.13\% \quad (8)$$

Having considered the crucial correlation coefficients for the relation between the changes in company share prices and the percentage change of the WIG20 index, the decision was made to look for possibly the best model that would make it possible to predict WIG20 values. To do this, the method of backward stepwise regression as applied. First, on the basis of the correlation matrix, the variables were selected. Due to a potential autocorrelation effect between the variables, the following variables were selected for the model: ALRR, PKO and

TPE. The results of the analysis are given in Table 10, and the form of the model is presented by equation (9).

Table 10. Analysis of the multiple regression for the WIG20 index and the three selected companies

N=60	Summary of dependent variable regression: WIG20 (stock market) R= .83468051 R^2= .69669155 Corrected R2= .68044288 F(3.56)=42.877 p<.00000 SEE: .02504					
	b*	Standard error for b*	b	Standard error for b	t(56)	p
Absolute term			0.002355	0.003329	0.707354	0.482280
ALRR	0.214470	0.081826	0.116486	0.044443	2.621057	0.011265
PKO	0.563239	0.081129	0.402186	0.057931	6.942476	0.000000
TPE	0.364856	0.075553	0.192441	0.039850	4.829134	0.000011

Source: Authors' research.

$$WIG20 = 0.116ALRR + 0.402PKO + 0.192TPE + 0.002;\ R^2=69.67\% \qquad (9)$$

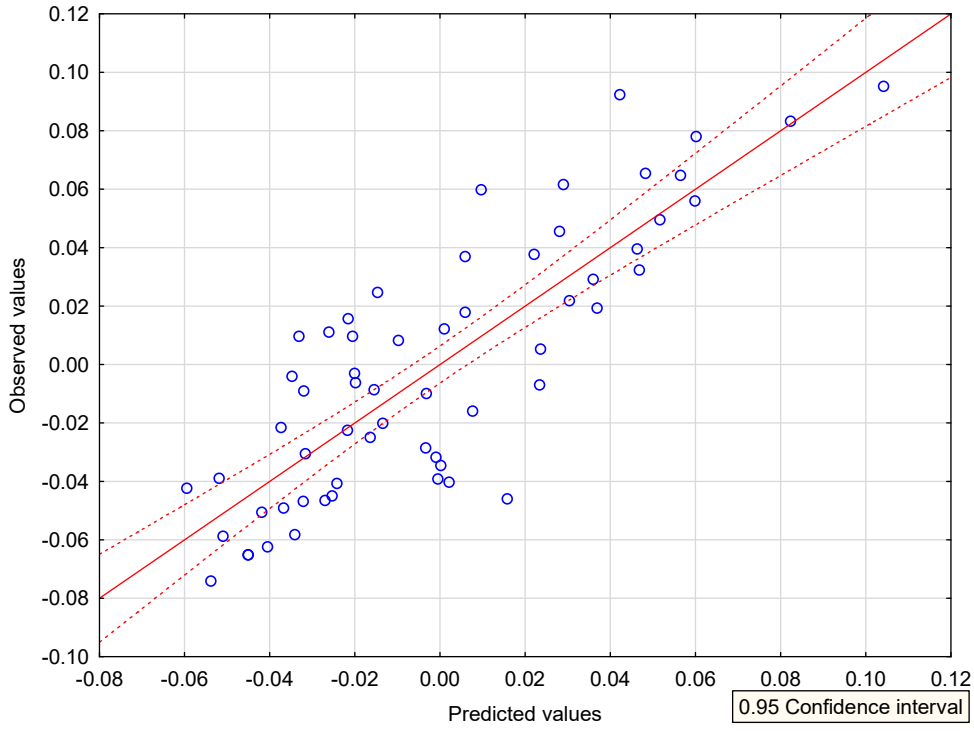
All the obtained coefficients of the multiple regression model appeared to be statistically significant, which means that the selection of variables to the model was adequate. The value of the coefficient of determination equals 69.67% , which leads to the conclusion that the model gives the chance of accuracy of 70% in the prediction of WIG20 on the basis of the share prices of the three selected companies. The results are also confirmed by the variance analysis, which is given in Table 11. The model is given in Graph 22.

Table 11. Variance analysis for the obtained multiple regression model

Result	Variance analysis ; DV: WIG20 (stock market)				
	Sum of squares	df	Average of squares	F	p
Regression	0.080628	3	0.026876	42.87684	0.000000
Remaining	0.035102	56	0.000627		
Total	0.115730				

Source: Authors' research.

Graph 22. Predicted values with reference to the observed values of the WIG20 index



Source: Authors' research.

Conclusions

The above analysis leads to the conclusions that share prices of companies that belong to WIG20 are difficult to describe and predict effectively. The search for dependencies in share prices volatility should mainly involve companies from similar sectors and of similar sizes. However, the predictions that are based on such relations are still encumbered with a significant error and, consequently, the risk of investing is substantial. The period under analysis (February 2015-January 2020) involved considerable fluctuation of share prices and as a result it is difficult to identify a volatility trend that would not be associated with a considerable error. The optimal model of multiple regression for the variation of the WIG20 index includes the volatility of share prices of such companies as ALRR, PKO and TPE as independent variables. Due to the correlation relations od the above companies with the other ones from a similar sector, they could be replaced in the model and its quality would not change significantly. However, the inclusion of a higher number of variables would result in autocorrelations, which would weaken the reliability of the equation obtained.

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Abstract

The aim of this article is to characterize the volatility of share prices of companies belonging to WIG20 and the WIG20 index itself using statistical methods. The share prices of the companies were subject to deep fluctuations in the selected time period. The correlation analysis shows a random nature of the changes. The analysis of the remaining indicators indicates sector connections of companies, i.e. share prices of companies with a similar profile are correlated with one other. The applied method of backward stepwise regression allowed to build a model to predict changes in the WIG20 index with 70% certainty.