

CHANGING RISK-RETURN CORRESPONDENCE DURING THE COVID-19 TURMOIL: EVIDENCE FROM POLISH STOCK MARKET

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Abstract

The article examines the impact of the shock induced by COVID-19 on the Polish stock market. As an object of research, 18 shares of companies included in the WIG20 index were taken. The impact of the shock is examined in the context of changing “risk-return” correspondence. Three-time intervals were used for the study: before the shock, shock, in fact, aftershock. For the shock in fact period, two parameters have been introduced, which in pairs describe the “reaction” of stocks to a shock. These are shock deepness and recovery rate parameters. A linear type of regression relationship between them is identified. In the periods “before shock” and “aftershock”, “risk-return” correspondence is considered in terms of two approaches: variability and Value-at-Risk. Both approaches show an increased risk in the post-shock period but to varying degrees. The first approach shows an increase to a greater extent than the second. An explanation of this observation is given. The dynamics of changes in liquidity in terms of the average daily trading volume is considered complementary. The investigated dynamics shows an increase in trading volumes directly in the shock and post-shock periods. The explanation for this is considered in the aspect of reformatting by investors of their portfolios.

Keywords: risk measurement, COVID-19, shock, portfolio management, investment, stock market.

JEL Classification: G20

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1. Introduction

The Turmoil induced by the pandemic COVID-19 has impacted almost every aspect of economic activity. Of course, this also affected the stock markets, which showed an unprecedented shock fall in mid-March 2020. This gave rise to great uncertainty among investors, they began to look for options to reconstruct their portfolios. In this case, one of the fundamental foundations of investment is the risk-return corresponding, which is expanded by correlation analysis in the case of portfolio investment (Just & Echaust, 2020), (Kaminskyi et al., 2020).

At the beginning of 2021, it is already possible to consider clearly defined structure of the turmoil into 3-time intervals. The first interval ends in mid-January 2020 (in our study, the interval is 07/01/2019–1/15/2020). It plays a basic role in analyzing further changes in the markets. Its risk parameters are taken as parameters of a “calm” market in which investors have implemented their strategies.

The next time interval is characterized by a shock fall that occurred in the middle of March 2020. Taking into account the shock fall, in our opinion, it is not correct to apply classical risk measures. Therefore, we have proposed two indicators that characterize the ratio under consideration. They are the depth of the fall and the percentage of recovery to the level of the base period.

From the beginning of April, recovery from the shock began, which had different dynamics for different investment assets. One of the interesting approaches in this direction is the classification of recovery types: (Girard, 2020), (Narayan, 2020). V-shaped, U-shaped, W-shaped, L-shaped and italicized V-shaped. In our study, we compared the risk-return correspondence between the recovery period and the baseline period.

The object of our research was the shares included in the Polish WIG-20. WIG-20 is a capitalization-weighted stock market index of the 20 largest companies on the Warsaw Stock Exchange. The interest in this study is that The Warsaw Stock Exchange is the largest stock exchange in Central Europe. Moreover, according to a study (Undervalued shares, 2020). The stock investment market is undervalued (in comparison with “Old Economy” markets). Therefore, naturally, potential investors may be interested in how the Polish market “goes” through the crisis caused by COVID-19.

2. Materials and Methods

2.1. Risk measurement approaches

Risk measurement one of the pillars for investors’ decision-making. Formalization of risk measurement is based on introducing risk measures which are formally represent random variable by figures. Random variable typically reflects the return of some asset for some period. So, the return of asset (in our research con-

stituents of polish index WIG20) over a period $[t; t + 1]$ will be presented through the formula:

$$R_{t,t+1} = (P_{t+1} - P_t) / P_t \quad (1)$$

There are very many risk measures were introduced during investment risk development (Szegö, 2004). From our point of view, structuring into 4 groups of measures is quite presentable (Kaminskyi et al., 2019):

- measures of variability,
- quantile measures,
- measures of sensitivity,
- risk premium.

Although, of course, this is far from exhausting modern approaches.

Consideration and analysis in our study of the four presented approaches led us to focus on the first two groups.

Also, to assess the direct shock of the market fall, we have proposed special indicators.

The first group of risk measures is based on variability as an expression of riskiness. This group includes basic metrics such as range and inter-quantile range, which show the general framework in which the values are “scattered”. After H. Markowitz’s work in the investment risk assessment system, there were imposed variation and standard deviation, which are classical risk measures in Modern Portfolio Theory. Their definite disadvantage is that they estimate the deviation from the mean in both directions. Semivariations (upper and lower) correct this defect. One of the widely used coherent risk measures, the Fisher measure (Fischer, 2003), is built on this approach.

Also, this group includes such risk measures as skewness, which reflects the asymmetry of the distribution of returns, and kurtosis, which is an indicator of “heavy tails”. Expected utility theory shows that investors prefer to maximize the (positive) skew and minimize kurtosis (Scott & Horvath, 1980).

The second group of risk measures is based on a quantile approach. The basic measure of risk is Value-at-Risk, which was introduced at the middle 1970 (Holton, 2003). The essence of this measure of risk is to determine the quantile of the distribution function of income / loss within a certain time interval. The economic essence (in the simple understanding) in this case consists in the coverage of losses by capital to the level of VaR. VaR in a certain sense is a universal measure of risk that integrates 3 elements: losses, time interval and investor’s attitude to risk. The main disadvantage of this risk measure is the lack of coherency for a large class of distributions.

A generalization of VaR is the Conditional Value-at-Risk (CVaR) measure of risk. This measure is the notional average of losses beyond the quantile correspond-

ing to VaR. This risk measure is more adequate to sharp falls in crisis conditions and is coherent.

2.2. The proposed methodology of risk-return correspondence

The basic methodological point is to separate the whole time period into three sub-intervals. The first interval, which was indicated in our research as 07/01/2019 – 01/15/2020 corresponds to the period “before shock”. At this period world markets (including the Polish market) were relatively stable and it may be considered as a starting point for following a risk assessment.

The second interval was indicated as 16/01/2020–03/31/2020. This period includes explicitly shock induced by COVID-19. At the beginning of this period, markets got the jitters and crashed in mid-March 2020 (WIG20 decreased significantly 03/12/2020).

The third interval was identified as a recovery period. It was indicating as 04/01/2020 to 10/14/2020.

One point of our methodology focuses on comparative analysis of risk-return correspondence in the first above-mentioned period and third. The logic involves estimates changes upon completion shock. This estimation was considered by applying risk measures from the variation approach and quantile approach.

Another point of our methodology concerned direct shock. We introduced two indicators. The first indicator, which is the risk indicator, was defined as the deepness of shock. It indicates the maximum negative return from the average price in the first period. A second indicator named recovery rate was defined as the average price for third-time intervals divided by the average price in the first period.

It is necessary to note, that the nature of introduced indicators attached conditions to the length of first and third intervals. The consideration of simply average price though interval be contrary to possible increased or decreased dynamic. So, the starting point of the first interval and ending point was grounded by a balance between “too short” and “too long” periods

2.3. Sample and Source Data

Research was conducted on the sample of stocks which are constituents of index WIG20. WIG20 is basic index of Warsaw Stock Exchange. There are two reasonable arguments for grounding this sample. First argument is capitalization criteria for including into the index. Second argument devoted to relatively wide covering of Polish capital market. According to rules for index creation there is not possible to include into the index more than 5 companies from each sector. Last fact provides good covering of market.

Allegro.eu SA (ALEP) is a Luxemburg-based shopping platform. The Company shopping platform in Poland and e-commerce website in Europe. The Company offers products in all key categories including Automotive, Fashion, Home&Garden, Electronics, Books and Collectibles, Kids or Health and Beauty. The Company provides deliveries. The company has been present on the Stock Exchange since October 1, 2020. Therefore, in a further study, we do not consider this company.

Alior Bank (ALRR) is a universal bank that provides services to both private and business clients. It serves almost 3 million private clients and 126 thousand companies. It has an extensive network of branches that provides easy access to a wide range of banking services.

Asseco Poland (ACPP) is the largest Polish IT company that provides state-of-the-art IT solutions in Central and Eastern Europe. Asseco is one of the largest software vendors in Europe. It is present in 60 countries worldwide and employs approximately 27,500 people.

Bank Polska Kasa Opieki SA – Bank Pekao SA (PEO) offers services to both private and business clients. The Bank's business has four segments: retail banking, private banking, corporate and investment banking, assets, and liabilities management, and others, covering supervision and monitoring of fund transfers.

CCC SA (CCCP) produces and sells various models and brands of shoes, including sports footwear, children, female and male shoes. It offers also accessories and garments. The Company's activity is divided into two operating segments: the retail segment and the franchise.

CD Projekt SA (CDR) is a player in the global digital entertainment market. The Company is active in four operating segments. The distribution and publishing in Poland segment, and Blu-ray storage devices in the domestic market. The Production of Games segment, through CD Project Red. The Global Digital Distribution of Games segment and the Others segment focuses on the holding activities.

Cyfrowy Polsat SA (CPS) is a pay digital television platform operator. It is composed of Cyfrowy Polsat, a direct-to-home (DTH) platform, and Telewizja Polsat, commercial television (TV) broadcaster.

Dino Polska SA (DNP) focuses on operating a supermarket chain under the Dino brand name. Its offer includes dairy and bakery products, chocolate and non-chocolate confectionery, fruits and vegetables, alcoholic and non-alcoholic beverages, as well as pet food, among others.

Polskie Gornictwo Naftowe i Gazownictwo SA (PGN) operating in the oil and natural gas market. Its business is divided into three segments: Exploration and Production; Trade and Storage and Distribution; and Others. The core activity of the Company

covers the exploration and production of natural gas and crude oil as well as import, storage, trade, and distribution of gas and liquid fuels.

Grupa Lotos SA (LTSP) active in the energy sector. The Company's business consists of the extraction and processing of crude oil, as well as the wholesale and retail sale of petroleum products. The Company produces and markets such products as unleaded gasoline, diesel oil, diesel oil for heating purposes, aviation fuel, and heavy fuel oil. It also specializes in the production and sale of lubricant oils and bitumens.

Jastrzebska Spolka Weglowa SA (JSW) is a coking coal producer. The Company's activities are divided into two sectors: Coal, including extraction and sales of black coal; and Coke, including production and sales of coke and coal derivatives. Additionally, the Company is engaged in natural gas mining and generation, transmission, and distribution of electricity.

KGHM Polska Miedz SA (KGH) involved in copper ore mining, copper production, and the production of precious metals and other non-ferrous metals. The Company also produces salt and provides casting of light metals. It deals with geological and exploratory activities, as well as waste management.

LPP SA (LPPP) engaged in the apparel and accessories industry. The Company specializes in the design and distribution of clothing, such as sweatshirts, shirts, jumpers, coats, trousers, and dresses, as well as underwear, and accessories, such as shoes, gloves, scarves, and caps, among others.

Orange Polska SA (OPL) active in the telecommunication sector, formed as a result of a merger among Telekomunikacja Polska SA, Polska Telefonia Komorkowa-Centertel Sp. z o.o., and Orange Polska Sp. z o.o. The Company is organized into two segments: Fixed line which includes entities offering telecom services based on fixed-line technology and other companies offering services for those entities; and Mobile which includes entities offering telecom services based on mobile technology and other companies offering services for those entities.

Polski Koncern Naftowy Orlen SA (PKN) active in the oil and gas sector. It specializes in the manufacture, distribution, wholesale and retail sale of refined petrochemical products. The Company's business is divided into three segments: Refining, including refinery products processing and wholesale, oil productions and sale as well as supporting production; Retail segment, including sales at petrol stations; and Petrochemical segment, including production and wholesale of petrochemicals and production and sale of chemicals.

PGE Polska Grupa Energetyczna SA (PGE) active in the power sector. The Company is involved in the production, sale, and distribution of electricity. The main areas of

the Company's activity comprise six business lines: Conventional Power Generation, Wholesale, Retail, Distribution, Renewable power generation, and Nuclear power generation.

Powszechna Kasa Oszczednosci Bank Polski SA (PKO) is a commercial bank that operations comprise cash deposits, maintenance of accounts, granting loans and cash advances, granting and confirming bank guarantees, clearing cash transactions, issuance of cards, and conducting transactions with the use of cards, as well as conducting forward transactions. At the same time, the Bank conducts brokerage activities through its brokerage house. It also provides specialist financial services relating to leasing, factoring, investment funds, pension funds, and Internet banking.

Powszechny Zaklad Ubezpieczen SA (PZU) is a joint-stock company operating in the sectors of property and casualty insurance. PZU SA is the parent company for numerous entities comprising the PZU Group. The Company provides property and casualty insurance in terms of gross written premiums, with motor insurance for retail and corporate customers as its principal product.

Santander Bank Polska SA (SPL1), formerly Bank Zachodni WBK SA, is a Poland-based commercial bank. It offers a range of banking services for private and business entities. The Bank operates through a network of retail branches in Poland, as well as automatic teller machines (ATM). Its operations are supported by mobile sellers, who can reach its clients in smaller cities. It also offers such services as securities intermediation, leasing, factoring, asset and fund management, insurance, and shares trading. The Bank issues payment cards and credit cards.

Tauron Polska Energia SA (TPE) is a company active in the energy sector. The company's business is divided into five operating segments: mining, including coal mining; generation, including generation of electricity using conventional sources, such as combined heat and power generation, and generation of electricity using joint combustion of biomass and other energy acquired thermally; renewable sources of energy, including generation of electricity using renewable sources; sale of energy and other energy market products, including wholesale trading in electricity, trading in emission allowances and energy certificates and sale of electricity to domestic end-users or entities which further resell electricity; and distribution.

Average prices (in Zloty) through first and third sub-intervals and minimum prices through second sub-interval are presented in Table 1. The daily trading value are given by similar logic.

Table 1. Source data

Stocks	Before shock		Shock		Post-shock	
	Price	Daily trading volume	Price	Daily trading volume	Price	Daily trading volume
ALRR	37,79	548764	22,42	627675	14,93	774073
ACPP	55,53	73229	62,99	99133	68,52	72694
PEO	102,99	649013	86,56	789691	53,06	1223604
CCCP	127,56	144229	73,97	550639	53,15	675141
CDR	246,10	224404	288,42	532663	389,10	366229
CPS	28,30	439495	26,16	689288	26,76	535303
DNP	145,08	171077	156,25	238701	201,04	197781
PGN	4,82	5474254	3,37	7678889	4,60	5652847
LTSP	86,95	272878	65,43	429191	52,25	451532
JSW	27,55	850609	16,16	1310222	18,00	1138216
KGH	87,60	589365	79,71	869191	104,02	711072
LPPP	8074,74	2103	7197,00	3366	6611,71	3038
OPL	6,37	1451463	6,73	2568912	6,83	1636895
PKN	94,53	842571	66,29	1613110	57,65	1363628
PGE	8,41	1671753	5,40	3708230	5,90	3876273
PKO	38,53	2667835	30,86	3185493	22,15	3226350
PZU	39,08	1724432	36,18	2317040	28,49	2031373
SPL1	310,53	61152	258,44	86099	159,12	96728
TPE	1,65	4219429	1,30	6682037	1,99	8153942

Source: own elaboration based on Investing.com (2020) <https://www.investing.com/> 12/20/2020.

The source data demonstrate big changes in prices through shock pipeline.

3. Results and Discussion

3.1. Measurement impact of shock and recovery rate

Financial shock induced by Covid-19 was realized in the middle of March. This shock has spread to nearly every stock market. It concerns traditional financial instruments as an alternative. The uncertainties relating to the impact on the world economy were suddenly raised. Economic Policy Uncertainty Index has grown in May 2020 two times in comparison January 2020 (Economic Policy Uncertainty, 2020). (Baker, et al., 2020) structured this uncertainty for different components, one of which is stock

market volatility. But at a short time recovering was starting. This process is quite different for companies from various spheres. Stocks of Boeing Co, for example, demonstrated very slow price recovering but stocks of Apple Inc. demonstrated recovery which moved to high speed increasing price (Investing.com, 2020).

We introduced two measures for characterizing “risk-return” correspondence in shock.

The first indicator is “shock deepness” which is defined as:

$$\text{Shock deepness} = \frac{\text{Minimum price at second sub-interval}}{\text{Average price at first sub-interval}} - 1, \text{ briefly } (SD)$$

$$\text{Recovery rate} = \frac{\text{Average price at third sub-interval}}{\text{Average price at first sub-interval}}, \text{ briefly } (RR)$$

First can be interpreted as “risk measure” and second as “return measure” (this is not classical return).

SD has the nature of classical return with some specification which is linked to average price through first sub-interval. It was due to exclusion from consideration price volatility before fallen. RR concern with corresponding after-shock price to before shock price. The logic of using such a form of RR is to desire estimate comparison with before shock period, not with the “bottom price”.

The application of this estimation to WIG20 constituents is presenting in Figure 1.

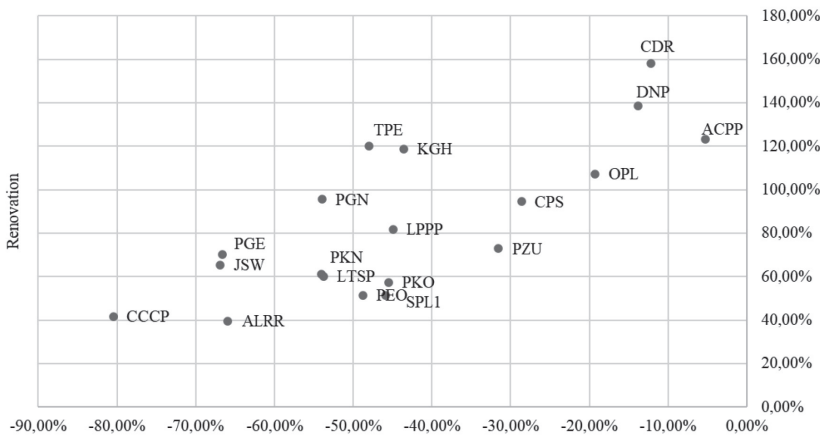


Fig. 1. Deepness of Fallen – Recovery Rate for WIG20 constituents

Source: own elaboration based on Investing.com (2020) <https://www.investing.com/> 12/20/2020.

The analysis of this diagram can detect the close to the linear dependency between RR and SD. Namely:

$$RR = 1,43DS + 1,29 \text{ (R-squared} = 0,61)$$

Inherently this indicates that recovery approximately equals 1,4 of fallen.

3.2. Changing risk-return correspondence from variability approach

The estimations of basic variability risk measures were applied for the first- and third- time sub-intervals. All returns were calculated on the daily basis. The results are presented in Table 2.

Table 2. Statistical analysis for risk measures

Stocks	min		max		mean		Std		skewness		kurtosis	
	Before shock	Post-shock	Before shock	Post-shock	Before shock	Post-shock	Before shock	Post-shock	Before shock	Post-shock	Before shock	Post-shock
ALRR	-0,1499	-0,0785	0,0916	0,1593	-0,0039	0,0012	0,0272	0,0360	-0,7359	1,3716	6,3324	3,6639
ACPP	-0,0417	-0,0479	0,0675	0,1013	0,0014	0,0014	0,0166	0,0239	0,2658	0,8098	1,3800	1,6073
PEO	-0,0477	-0,0949	0,0420	0,0754	-0,0006	-0,0004	0,0144	0,0259	0,1721	0,3200	1,4826	1,2865
CCCP	-0,0927	-0,1238	0,0536	0,3277	-0,0040	0,0048	0,0253	0,0556	-0,5076	2,1975	1,1155	8,8214
CDR	-0,0612	-0,0856	0,0499	0,0714	0,0022	0,0025	0,0167	0,0270	-0,3460	-0,1639	0,9486	0,7266
CPS	-0,0415	-0,0640	0,0463	0,0581	-0,0003	0,0010	0,0154	0,0194	-0,1009	0,0599	0,3528	0,6832
DNP	-0,1027	-0,0736	0,0996	0,1003	0,0014	0,0024	0,0239	0,0256	-0,0035	0,6555	3,9460	2,8023
PGN	-0,0545	-0,0528	0,0511	0,0831	-0,0013	0,0026	0,0213	0,0206	0,2002	0,2736	-0,1657	1,3225
LTSP	-0,0467	-0,0507	0,0629	0,0982	0,0004	-0,0028	0,0191	0,0290	0,3698	1,0249	0,6101	1,1929
JSW	-0,0966	-0,1181	0,1634	0,3395	-0,0042	0,0061	0,0391	0,0522	1,0516	1,8741	3,0788	10,9278
KGH	-0,0552	-0,0627	0,0631	0,1149	-0,0002	0,0058	0,0213	0,0292	0,1960	0,7370	0,4403	1,5558
LPPP	-0,0479	-0,0654	0,0582	0,1251	0,0010	0,0020	0,0150	0,0268	0,3001	0,6888	2,4175	2,7463
OPL	-0,0684	-0,0451	0,0708	0,0959	0,0009	0,0014	0,0206	0,0206	0,0937	1,2604	1,3834	3,8360
PKN	-0,0630	-0,0573	0,0599	0,0831	-0,0003	-0,0015	0,0182	0,0250	-0,0035	0,3558	1,2879	0,6787
PGE	-0,0738	-0,0857	0,0549	0,1958	-0,0011	0,0038	0,0216	0,0459	-0,0527	1,3702	0,4114	3,0937
PKO	-0,0567	-0,0641	0,0440	0,0840	-0,0014	-0,0001	0,0160	0,0237	-0,1854	0,5498	0,9920	1,1571
PZU	-0,0523	-0,0590	0,0357	0,0653	-0,0003	-0,0017	0,0143	0,0197	-0,4624	0,2981	1,3249	0,6352
SPL1	-0,0693	-0,0718	0,0693	0,1338	-0,0016	-0,0012	0,0192	0,0301	0,1707	0,9950	1,8980	3,1764
TPE	-0,0506	-0,0852	0,0649	0,1998	-0,0003	0,0054	0,0220	0,0456	0,0399	1,4021	-0,1054	3,8798
Average	-0,0668	-0,0730	0,0655	0,1321	-0,00059	0,001883	0,020444	0,03065	0,016183	0,838067	1,51295	2,812056
Rate of increasing		9%		102%		-419%		50%		5079%		86%

Source: own elaboration based on Investing.com (2020) <https://www.investing.com/> 12/20/2020.

Moreover, risk-return correspondence on the base of the classical H. Markowitz approach is given in Figure 2.

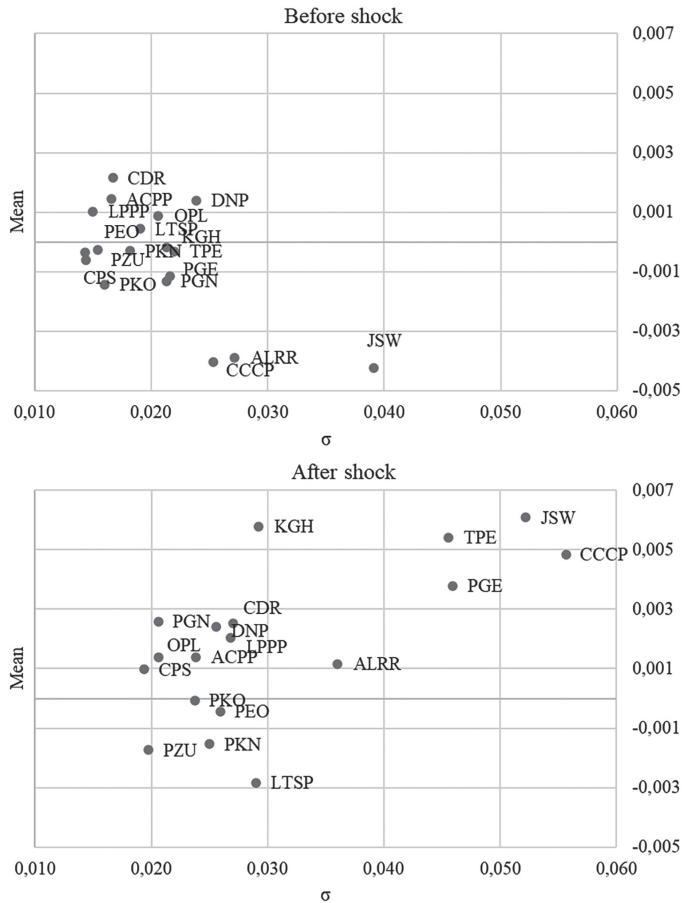


Fig. 2. Risk-return correspondence comparison from variability point of view
 Source: own elaboration based on Investing.com (2020) <https://www.investing.com/> 12/20/2020.

Analysis of received results makes it clear that all risk measures have grown. Range and standard deviation increased by approximately 50% and kurtosis by 86%. This indicates the increased volatility of aftershock, which is natural. Also, we can see an extremely high growth of skewness. As was noted investors prefer positive skewness. The explanation of this effect that stocks of many companies leaped up after shock.

3.3. Changing risk-return correspondence within the Value-at-Risk approach

Consideration of the risk-return correspondence within the VaR approach shows certain differences from the previous approach. The main difference is that risk measures do not indicate so much increase as in the variability approach. The increase has averages 10%–20%. Table 3. Present changes in the values of risk measures.

Table 3. Risk measurement by VaR and CVaR

Stocks	VaR		CVaR		CVaR/VaR	
	Before shock	Post-shock	Before shock	Post-shock	Before shock	Post-shock
ALRR	-0,0503	-0,0400	-0,0661	-0,0591	1,3141	1,4775
ACPP	-0,0240	-0,0312	-0,0345	-0,0385	1,4375	1,2340
PEO	-0,0230	-0,0398	-0,0318	-0,0496	1,3826	1,2462
CCCP	-0,0484	-0,0368	-0,0616	-0,0796	1,2727	2,1630
CDR	-0,0265	-0,0426	-0,0343	-0,0579	1,2943	1,3592
CPS	-0,0258	-0,0302	-0,0351	-0,0383	1,3605	1,2682
DNP	-0,0358	-0,0331	-0,0512	-0,0511	1,4302	1,5438
PGN	-0,0350	-0,0290	-0,0407	-0,0404	1,1629	1,3931
LTSP	-0,0285	-0,0406	-0,0370	-0,0461	1,2982	1,1355
JSW	-0,0534	-0,0369	-0,0777	-0,0863	1,4551	2,3388
KGH	-0,0337	-0,0348	-0,0432	-0,0468	1,2819	1,3448
LPPP	-0,0215	-0,0350	-0,0319	-0,0496	1,4837	1,4171
OPL	-0,0318	-0,0228	-0,0431	-0,0347	1,3553	1,5219
PKN	-0,0296	-0,0396	-0,0408	-0,0508	1,3784	1,2828
PGE	-0,0367	-0,0492	-0,0469	-0,0683	1,2779	1,3882
PKO	-0,0282	-0,0346	-0,0380	-0,0453	1,3475	1,3092
PZU	-0,0252	-0,0321	-0,0349	-0,0422	1,3849	1,3146
SPL1	-0,0313	-0,0396	-0,0425	-0,0560	1,3563	1,4163
TPE	-0,0362	-0,0459	-0,0448	-0,0718	1,2376	1,5643
Average	-0,0330	-0,0363	-0,0441	-0,0531	1,3420	1,4612
Rate of increase		+10%		+20%		+9%

Source: own elaboration based on Investing.com (2020) <https://www.investing.com/> 12/20/2020.

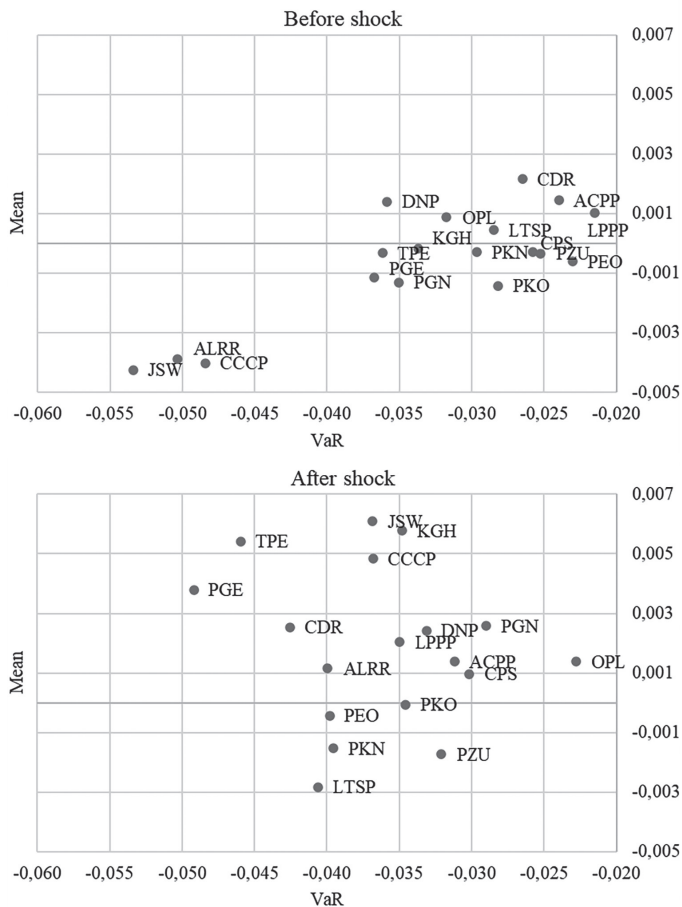


Fig. 3. Stocks Value-at-Risk

Source: own elaboration based on Investing.com (2020) <https://www.investing.com/12/20/2020>.

The difference in displaying risk between the two approaches is as follows. After the shock, a relatively quick recovery began. The upward bursts of profitability were more than downward. At the same time, VaR and CVaR evaluate the quantiles of the left end of the distribution.

3.4. Changing in liquidity and correlation: complimentary estimations

Liquidity and correlations can be considered as additional parameters that complement risk measuring. The basic logic of using a liquidity frame can be explained no less than two factors. The first factor focuses on possible problem of low liquidity. As liquidity shows a very low level it may impact essentially to price and, correspondingly, to return. Each large trading will affect for returns of assets.

So, it may be not correct in this situation to apply measures of market risk (because “market risk” is distorted). The second factor reflects the interdependency between risk-return correspondence and liquidity changing. When risk will grow and will return growth (or reverse) investors will reconstruct their portfolios which tends to higher liquidity.

Liquidity was considered by using such indicators as an average daily trading volume for components of index WIG20. Our consideration of risk-return changing supports the assumption about changing daily trading activity through this. This presents in Fig. 4. The average trading volume was increased at the second sub-interval in comparison with the first sub-interval standing at 69%. Also, the average trading volume aftershock was higher than this indicator at the period before shock on 61%.

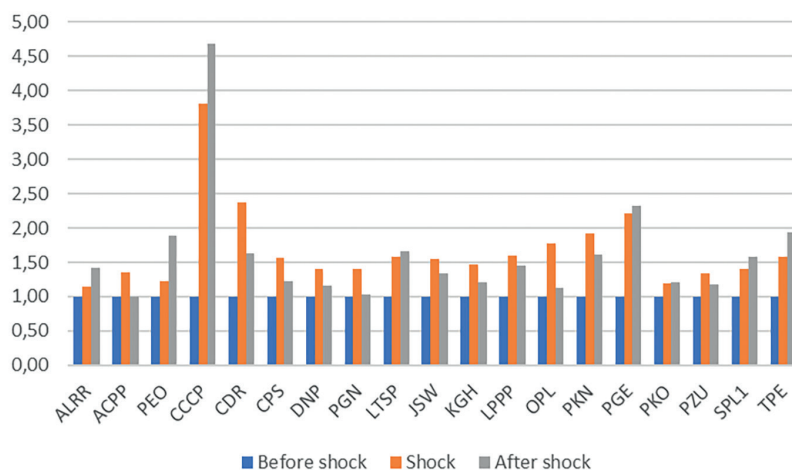


Fig. 4. Daily trading volume for components of index WIG20

Source: own elaboration based on Investing.com (2020) <https://www.investing.com/> 12/20/2020.

Correlation is one of the crucial elements for portfolio construction. Low correlations offer opportunities for portfolio construction. In general, the correlation between returns of WIG20 constituents not so much as before shock (average correlation is 22%) as after (28%). Most likely it can be explained through different returns behavior of companies from various spheres.

Conclusions

The shock generated by COVID-19 hit the global financial markets. This shock gave rise of turmoil and a high level of uncertainty. The phenomenon of this shock, using the terminology of Nassim Nicolas Taleb, can be fully described as “black swan”. The Polish market is no exception. In March 2020, the stocks of many

Polish companies fell in value, and investors began to look for the right solutions. The aim of our research was to analyze the “passage” of the Polish stock market through this shock. The analysis of the risk-return correspondence was chosen as the main methodological approach for investors. The relevance of this approach is explained by the fact that the risk-return correspondence is in many ways key for both direct and portfolio investors.

The analysis of risk-return correspondence dynamics led to the thought use comparative based study. It was proposed to construct special 3-time intervals: before the shock, during the shock and after the shock. The logic of comparative based study led to the matching of risk-return correspondence for 3 intervals. During the pre-shock and post-shock periods, two classical approaches to measuring risk were applied: variability and Value-at-Risk techniques. Two special indicators were proposed for estimation falling down and recovery. They are together characterize the passage of the shock in a complex manner.

The research results show several patterns. One of these patterns is the presence of a linear regression between the rate of recovery and the deepness of shock. At the same time, the regression coefficient shows a slightly higher level of recovery. The use of two approaches to measuring risk indisputably shows an increasing risk in the post-shock period and a change the risk-return correspondence. The variance-based approach shows a greater increase in risk than the VaR-based approach. This is because the measurement of risk in the first approach is based on the entire distribution and in second approach only according losses.

In addition, the dynamics of liquidity, expressed in daily trading volume, and the dynamics of correlation dependences were considered. It is very interestingly, that daily trading volume demonstrated increasing during the shock period shows. This is reflection of investor activity to reconstruct their investment portfolios. The correlation of returns did not show much changes.

Summing up, that analysis of risks induced by COVID-19 and their assessment pointed out several effects which have great potential for research.

Bibliography

1. Baker, S.R., Bloom, N., Davis, S.J., & Terry, S.J. (2020). *Covid-induced economic uncertainty* (No. w26983). National Bureau of Economic Research.
2. Economic Policy Uncertainty Index. <https://www.policyuncertainty.com/> 12/25/2020.
3. Fischer, T. (2003). Risk capital allocation by coherent risk measures based on one-sided moments. *Insurance: Mathematics and Economics*, 32(1), 135–146.
4. Girard, M. (2020). The 5 shapes of coronavirus economic recovery – which will it be. <https://ci.natwest.com/insights/articles/the-5-shapes-of-coronavirus-economic-recovery-and-why-our-base-case-is-a-swoosh/> 01/12/2021.
5. Holton, G.A. (2003). *Value-at-risk*. Acad. Press.
6. Investing.com (2020) <https://www.investing.com/> 12/20/2020.

7. Just, M., & Echaust, K. (2020). Stock market returns, volatility, correlation and liquidity during the COVID-19 crisis: Evidence from the Markov switching approach. *Finance Research Letters*, 37, 101775.
8. Kaminskyi, A., Motoryn, R., & Pysanets, K. (2019). Investment risks and their measurement. *Probability in Action*. – V3, 103–114
9. Kaminskyi, A., Nehrey, M., Rizun, N. (2020). The impact of COVID-induced shock on the risk-return correspondence of agricultural ETFs. *Machine Learning for Prediction of Emergent Economy Dynamics 2020*. Proceedings of the Selected Papers of the Special Edition of International Conference on Monitoring, Modeling & Management of Emergent Economy (M3E2-MLPEED 2020), Vol. 2713, 204–218.
10. Narayan, M. (2020). 3 key investment trends for a post-COVID world. <https://www.refinitiv.com/perspectives/future-of-investing-trading/3-key-investment-trends-for-a-post-covid-world/01/12/2021>.
11. Scott, R.C., & Horvath, P. A. (1980). On the direction of preference for moments of higher order than the variance. *The Journal of finance*, 35(4), 915–919.
12. Szegö, G.P. (Ed.). (2004). *Risk measures for the 21st century* (Vol. 1). New York: Wiley.
13. Undervalued shares (2020). Investing in Poland (part 1): Europe's overlooked growth champion. <https://www.undervalued-shares.com/weekly-dispatches/investing-in-poland-part-1-europes-overlooked-growth-champion/01/12/2021>.

ZMIANA WSPÓLZALEŻNOŚCI RYZYKO–ZWROT NA POLSKIM RYNKU GIEŁDOWYM W TRAKCIE WSTRZĄSU WYWOŁANEGO COVID-19

Streszczenie

W artykule przeanalizowano wpływ wstrząsu wywołanego przez COVID-19 na polski rynek akcji. Przedmiotem badań objęto 18 akcji spółek wchodzących w skład indeksu WIG20. Wpływ szoku zbadany został w kontekście zmieniającej się zależności „ryzyko–zwrot”. Do badań wykorzystano trzykrotne interwały: przed wstrząsem, w trakcie i po wstrząsie. Dla okresu szoku wprowadzono dwa parametry, które łącznie opisują „reakcję” akcji na szok. Są to parametry głębokości wstrząsu i szybkości regeneracji. Zidentyfikowano liniowy typ zależności regresji między nimi. W okresach „przed szokiem” i „po wstrząsie” zależność „ryzyko–zwrot” rozpatruje się w kategoriach dwóch podejść: zmienności i wartości narażonej na ryzyko. Oba podejścia wykazują zwiększone ryzyko w okresie po szoku, ale w różnym stopniu. Pierwsze podejście wykazuje wzrost w większym stopniu niż drugie. Podano wyjaśnienie tej obserwacji. Dynamikę zmian płynności w zakresie średniej dziennej wysokości obrotu uznaje się za komplementarną. Badana dynamika wskazuje na wzrost wysokości obrotów bezpośrednio w okresach szokowych i po szokach. Wyjaśnienie tego zjawiska rozważano w aspekcie ponownego formatowania portfeli przez inwestorów.

Słowa kluczowe: pomiar ryzyka, COVID-19, szok, zarządzanie portfelem, inwestycje, giełda.