Interval Effect During the Covid-19 Pandemic-Case of the Warsaw Stock Exchange

Efekt interwału w trakcie pandemii COVID-19 na przykładzie GPW w Warszawie

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ABSTRACT

Objective: Outbreak of the COVID-19 pandemic and significant destabilization of economic conditions, which caused, creates research motives that can be used to discover new dependencies in capital markets. Main aim of this study is to determine whether the occurrence of the interval effect of beta coefficients (β) occurred among shares in Warsaw Stock Exchange Index (WIG) during the COVID-19 pandemic.

Research design & Methods: The author of this article intends to check whether in the year of the spread of the COVID-19 pandemic (2020-20201) it was possible to observe other levels of the β of companies from the WIG in the situation of a different approach to estimating returns on their shares (daily, weekly, biweekly and monthly). β coefficients will be calculated by use the ordinary least squares method (OLS) on the research sample of 128 companies grouped in the three main WSE indices: WIG20, mWIG40 and sWIG80.

Findings: The values of the β coefficients, calculated on the basis of different time horizons of the returns (daily, weekly, biweekly and monthly), were characterized by significant differences. It is worth adding that these differences were statistically significant for pairs of β calculated on the basis of daily and weekly/biweekly/monthly returns, as well as for weekly and biweekly ones. Moreover, it was noted that the interval effect is invariably stronger in relation to companies with lower capitalization.

Implications: Obtained results indicate that the COVID-19 pandemic did not influence on the occurence of the interval effect observed on the polish capital market earlier, but only slightly changed some of its detailed characteristics.

Contribution: Conducting research on the occurrence of the interval effect during the COVID-19 pandemic on the Warsaw Stock Exchange (WSE) will allow to deepen the knowledge of capital market participants in the scope of the possibility of using the β to measure systematic risk in times of instability on capital markets.

Article type: original article.

Keywords: interval effect, beta coefficient, COVID-19, Warsaw Stock Exchange, shares.

JEL classification: C20, G11, G12, G17.

STRESZCZENIE

Cel: Głównym celem niniejszego opracowania jest weryfikacja występowania tzw. efektu interwału współczynnika beta (β) akcji spółek notowanych na GPW w Warszawie (GPW) w trakcie trwania pandemii COVID-19. Wybuch i rozprzestrzenianie pandemii zdestabilizowały funkcjonowanie wielu gałęzi gospodarki, w tym rynków kapitałowych, co może skłaniać do poszukiwania nowych, bądź potwierdzania wcześniej zauważonych zależności dotyczących ich funkcjonowania.

Metodyka badań: Zamierzeniem autora jest weryfikacja wartości β akcji spółek notowanych w indeksie WIG w trakcie trwania pandemii COVID-19 przy wykorzystaniu zróżnicowanego horyzontu czasowego stóp zwrotu (dziennych, tygodniowych, dwutygodniowych i miesięcznych). Współczynniki β zostaną obliczone przy wykorzystaniu klasycznej metody najmniejszych kwadratów (KMNK) na próbie badawczej 128 największych podmiotów zgrupowanych w indeksach: WIG20, mWIG40 oraz sWIG80.

Wyniki badań: Analizując wartości współczynników β szacowanych w oparciu o wskazane horyzonty czasowe stóp zwrotu w latach pandemii COVID-19 można dostrzec znaczne różnice między nimi. Co więcej, różnice te są istotne statystyczne. Wskazuje to na występowanie efektu interwału β w badanym okresie. Ponadto efekt ten jest silniejszy dla spółek o niższym poziomie kapitalizacji.

Wnioski: Bazując na uzyskanych rezultatach badawczych można wskazać, że pandemia COVID-19 nie zaburzyła występowania efektu interwału współczynników β. Miała wpływ na pewne szczegółowe jego charakterystyki, które w pewnej części różniły się od wcześniejszych obserwacji.
Wkład w rozwój dyscypliny: Przeprowadzone badania oraz uzyskane wyniki dotyczące występowania efektu interwału współczynników β akcji spółek notowanych na GPW pozwalają pogłębić wiedzę uczestników rynku kapitałowego w zakresie możliwego wykorzystania β do pomiaru ryzyka systematycznego akcji spółek w czasach podwyższonej zmienności.

Typ artykułu: oryginalny artykuł naukowy.
Słowa kluczowe: efekt interwału, współczynnik beta, COVID-19, GPW w Warszawie, akcje.

1. INTRODUCTION

Risk is one of the fundamental criteria taken into account by investors in the process of making decisions. It has prompted for many years to look for more effective methods of its measurement. Among the many methodological proposals, the single-index model proposed by William Sharpe (1963, pp. 278-281) is very popular.

One of the parameters of the Sharpe model is the beta coefficient (β). It reflects the non-diversifiable part of the volatility of returns. The β is a measure of risk associated with investing in company shares. Its level depends, among others, on the structure of assets, area of economic activity or available financing sources (Rydzewska, 2016, p. 49). It shows the average change (in percentage points) of the return that will occur as a result of an increase of the market return by one percentage point.

The process of its estimation is associated with numerous decision-making difficulties (Feder-Sempach, 2017, pp. 20-22). Among them, abovementioned author indicates: the selection of the appropriate length of the research sample, the need to specify the stock exchange index that adequately represents the market for the companies selected for the sample, or the indication of the interval for measuring the return necessary to calculate it. The last of these difficulties was often mentioned in scientific research. The authors wondered what is the most appropriate interval for measuring returns that will later be used to estimate the β.

When using different time intervals (from daily to several years) to calculate it, significant differences in estimates were noticed. The occurrence of these differences in the values of the β depending on the adopted period of used quotations of shares of companies was called the interval effect or the intervalling effect (Gray et. al., 2005).

The purpose of this article is to determine whether the interval effect also occurred among companies grouped in the Warsaw Stock Exchange Index (WIG) during the COVID-19 pandemic years. The significant destabilization of economic conditions led to strong turmoil on the capital markets, which was observed especially in the first half of

2020. According to some researchers, the increase in price volatility on the stock market during the current turmoil is higher than in the periods of the previous great crises of 1930, 1987 or 2008 (Thakur, 2020, p. 1182, Zhang et al., 2020).

Situation of increased volatility in capital markets creates new motives for researchers that can be used to discover new dependencies in capital markets. Researchers may also undertake the quantification of the occurrence of previously noticed dependencies, but in the other, pandemic circumstances (Wiśniewska-Kuźma, 2020, Ruiz Estrada, Koutronas & Minsoo, 2021, Jóźwicki, Trippner & Kłos, 2022). The realities observed since the first quarter of 2020 may call into question many previously market dependencies due to the possibility of a global slowdown of economies (unprecedented for many years) and the accompanying increased uncertainty about the future (Zhang et al., 2020).

Based on the abovementioned indicated assumptions it seems appropriate to make an attempt to verify the occurrence, in the present, pandemic reality, of the interval effect. The author of this study intends to check whether in the year of the spread of the COVID-19 pandemic (2020) and in the next year of its duration (2021) on the Warsaw Stock Exchange (WSE) it was possible to observe other levels of the β of issuers listed in the WIG in a situation of differentiated approaches to estimating the returns on their shares (daily, weekly, biweekly or monthly, respectively). The author's research on the occurrence of the interval effect in the time of the COVID-19 pandemic on the WSE will allow to deepen the knowledge of capital market participants in the scope of the possibility of using the β to measure systematic risk in times of instability on the capital markets.

2. INTERVALL EFFECT-LITERATURE REVIEW

Choosing the right time frame to measure the returns was of interest to researchers as early as the 1970's. The first empirical study showing differences in the β estimates depending on the change in the length of the interval for estimating returns was carried out by Gerald Pogue and Bruno Solnik (1974). They analyzed the coefficients on the American and seven European capital markets. In their study, they diagnosed the occurrence of a range effect (measured by the quotient of the monthly and daily β value) for the above-mentioned markets. Importantly, it was noticeable to a much greater extent on the then less developed Belgian and Dutch stock exchanges. In another study on the selection of the appropriate time horizon for the calculation of the β, the authors noticed that errors in the coefficient forecast resulting from the adopted different time intervals

can be reduced by applying the coefficient correction proposed by Marshall Blume (1975, p. 787), increasing the number of companies in the portfolio or extending the estimation period (Eubank & Zumwalt, 1979, p .770).

The authors came to interesting conclusions in subsequent studies. Gabriel Hawawini (1983, p. 73) and Puneet Handa, S.P. Kothari and Charles Wasley (1989, pp. 90-96) noticed the differentiation of the interval effect depending on the capitalization of companies. In the first of the above, the β was supposed to increase along with the shortening of the interval for measuring returns. However, this dependence was to apply only to companies with higher than average capitalization and trading volume.

The interval effect was also tested in non-US markets. Examining companies listed on the Brussels stock exchange, it was noticed that the values of β converge to their asymptotic values and are depending on the day adopted for the first day of verification of the interval effect (Corhay, 1992, pp. 65-66). The same author also noticed that the existence of the interval effect is inversely proportional to the market value of the companies. The observations regarding the occurrence of the interval effect have been confirmed in the Australian (Brailsford & Josev, 1997, p. 372) or Greek market (Diacogiannis & Makri, 2008, p. 109). In those study have been noticed that the β of companies with the highest (lowest) capitalization decreased (increased) along with the extension of the time horizon adopted for its estimation.

One can also find a study that indicates the selection of the optimal period of returns used to estimate the β for emerging markets (Damodaran, 2012, p. 16). There are differences between the values of the β indicating the occurrence of the interval effect, but seems important the author's recommendation indicating which time intervals should be used in the calculations. According to it, monthly returns should be used when estimating the β for research periods longer than 3 years. In the case of a calculation for a research period shorter than the above-mentioned one, daily or weekly returns should be apply.

The interval effect was also confirmed on the Bucharest Stock Exchange (Oprea, 2015, p. 16). Using the standard market model, this article found that β estimates for the same stocks vary significantly when using daily and monthly returns. Furthermore, using a linear regression model, this article shows that the differences between monthly and daily β estimates are negatively related to some stock characteristics such as market capitalization and transaction intensity.

The research on the interval effect also did not avoid the Polish capital market. With regard to the WSE, there were also some really interesting publications on the interval effect. One of the first were the studies by Janusz Brzeszczyński, Jerzy Gajdka and Tomasz Schabek (2010, 2011). The authors estimated the effect of the interval for 1-, 5-, 10-, and 21-day returns on stocks. The estimation was performed with the use of heteroscedastic ARCH autoregressive models. Noteworthy are also studies on the effect of the interval effect of β or determination coefficients of the market model (Olbryś, 2014a, 2014b), which shows changes in the sensitivity of the above-mentioned elements to changes in the length of the time interval for measuring returns. The comparative analysis of the interval effect on the example of shares of companies from the WIG20 index and the German DAX (Feder-Sempach, 2017) or the one carried out for the 33 largest companies listed on the Warsaw Stock Exchange (Dębski & Feder-Sempach, 2015, p. 279) is also interesting. In recent years can also be found a paper about interval effect on the example of RESPECT Index (Lisicki, 2019, pp. 130-131).

In recent years, it has been possible to notice the emergence of new conclusions about the interval effect. Among them, first of all, it should be pointed out that the occurrence of the interval effect is related to the autocorrelation of returns on securities (Hong, 2016, pp. 40-42). The degree of autocorrelation of returns on securities with the market return determines the occurrence and direction of the interval effect. This effect disappears as the time horizon used to calculate returns increases. A revealing issue was to verify the existence of the interval effect on the ETFs market (Milonas & Rompotis, 2013). When examining 40 ETFs listed on the NASDAQ Stock Exchange, the authors found that the average β increased as the time horizon of returns increased.

Importantly, in the literature review from recent years, the author did not reach a study, which verified the occurrence of the interval effect in the time of the COVID-19 pandemic, especially in relation to the Polish capital market. Filling this research gap is the main goal of the study. Thanks to it, investors or researchers of the Polish capital market can see whether the previously discovered dependence is still unchanged or whether the β may be used to measure of level of systematic risk of securities in times of instability on the capital markets.

To achieve the main goal of this paper is necessary to formulate the main hypothesis, which is following: Explosion and the spread of the COVID-19 pandemic did not disturb the occurrence of differentiation β levels depending on the time horizon used

to calculate returns. In connection with above, it is still possible to observe an interval effect on case of issuers listed on the WSE.

3. METHODOLOGY AND DATA

As mentioned in the introduction, the main goal of this study is to obtain knowledge on the interval effect of shares of companies listed in the WIG in the time of the COVID-19 pandemic. The author intends to verify whether the uncertainty of the economic situation, which caused the increase in the volatility of the market valuation of issuers, is reflected in the levels of the aforementioned β coefficients when it is calculated on the basis of returns that differ in the period of their estimation (daily, weekly, biweekly and monthly).

The interval effect will be verified by calculating β systematic risk factors for the shares of selected issuers listed on the WSE, grouped in the WIG. For this purpose, it was decided to narrow down the research sample to 140 (finally 128, because 12 issuers had to be rejected from the research sample) largest and most liquid companies grouped in three main WSE indices: WIG20, mWIG40 and sWIG80. It was decided to use the historical portfolios of these indices as of the first quarter of 2020 (WSE, 2020), which was a period of significant spread of the pandemic.

β will be calculated by use the ordinary least squares method (OLS) separately for the daily, weekly, biweekly and monthly returns. It is worth pointing out that for the calculation of the weekly, biweekly and monthly returns was used the quotations of last day of market operation in which the trade took place in a given period. The index used to indicate the market return will be the WIG (broad market index on the WSE). Quotations of shares of the indicated issuers have been downloaded from the stooq.com quotation database (2022). They have been used to calculate the β. Due to the large number of β estimated for several time horizons of returns, in the next part presenting the results of the study, it was decided to present only their descriptive statistics.

In order to better compare the calculated β for different intervals of measuring the returns, it was also decided to estimate the value of the coefficient of determination R^2 for each of the results. Its value informs what part of the volatility of returns was explained by the calculated β (Kornacki & Wesołowska-Janczarek, 2008, p. 8).

Detailed relationships between the values of β calculated on the basis of various returns will be also examined. More information on them is included in the explanations to Table 1, which can be found in the next section of the study.

The obtained differences between the values of β will be statistically verified in terms of their significance. For this purpose, a test will be used to check the significance of differences between two dependent groups, which will be the *t-test for dependent groups* (Kyun, 2015, p. 52). It, assumes the normality of the distribution of variability (verified later in the article), seems to be the most appropriate to verify the occurrence of the interval effect in the COVID-19 pandemic period on the WSE.

4. ESTIMATED BETA PARAMETERS OF WIG INDEX COMPANIES DURING COVID-19 PANDEMIC- RESULTS

The averaged values of β calculated during the COVID-19 pandemic for different time horizons of returns (daily, weekly, biweekly and monthly) are presented in Table 1. Moreover It also includes R^2 and descriptive statistics of the coefficients (mean and standard deviation, random error). It includes "Detailed Characteristics" too, which are designed to determine the beta relationships that occur during the COVID-19 pandemic.

At this point, it would be necessary to explain what these notations mean:

• A / D - the possibility of unequivocally classifying companies to aggressive (β> 1) or defensive (β <1) based on the calculated β (in all time intervals). This is to help determine whether the shares of the indicated company will react appropriately stronger (weaker) than changes in the market[1].

• Rising β - dependence consisting the increase in the value of β along with the extension of the time horizon of measuring the returns.

•Decreasing β - dependence consisting the decrease in the value of β together with extending the time horizon for measuring returns.

• Increasing R^2 - recording the increase in the β of determination R^2 (proving better adjusting of the beta coefficient to the model) along with the extension of the time horizon for measuring the returns.

In order to look more precisely at the values of β, during the COVID-19 pandemic years, it was decided also to indicate detailed shaping of their values calculated for various time horizons of returns (daily, weekly, biweekly, monthly) for whole research sample. They are presented in Figure 1.

[1] Depending on the values of the β, it may be distinguished (Michalak, 2020, pp. 341-342).:
• aggressive shares with β >1 - the change in the company's return is higher than the change in the market return,
• defensive shares with β<1 - the change in the company's return is lower than the change in the market return,
• shares with β <0 - the change in the company's return moves in the opposite direction than the change in the market return.
There are also assets with β=1 and β=0. As for the first, the change in the return is identical with the change in the market return. In case of the other, the change in the market return does not imply changes in the company's return

Table 1. Values of beta coefficients for a varied horizon of the estimated returns for selected WSE companies for the years 2020-2021 (128 cases)

Entire research sample (128 cases)/returns	**Mean**	**Average R^2**	**Standard deviation**	**Random error**	**Highest R^2**	**Lowest β**	**Highest β**	**Detailed characteristics**	
					Number of cases in sample				
Daily	0,873	0,204	0,387	44,32%	5	54	19	A/D	86
Weekly	0,958	0,289	0,479	50,06%	31	23	26	Decreasing β	24
Biweekly	1,013	0,325	0,557	54,97%	29	17	23	Rising β	68
Monthly	1,015	0,360	0,701	69,05%	63	34	60	Increasing R^2	79
WIG20 (19 cases)/returns	**Mean**	**Average R^2**	**Standard deviation**	**Random error**	**Highest R^2**	**Lowest β**	**Highest β**	**Detailed characteristics**	
					Number of cases in sample				
Daily	1,216	0,381	0,380	31,23%	2	6	4	A/D	17
Weekly	1,242	0,457	0,427	34,37%	5	5	5	Decreasing β	3
Biweekly	1,282	0,443	0,562	43,86%	4	4	2	Rising β	10
Monthly	1,331	0,477	0,646	48,57%	8	4	8	Increasing R^2	8
mWIG40 (39 cases)/returns	**Mean**	**Average R^2**	**Standard deviation**	**Random error**	**Highest R^2**	**Lowest β**	**Highest β**	**Detailed characteristics**	
					Number of cases in sample				
Daily	0,854	0,207	0,303	35,50%	0	19	6	A/D	21
Weekly	0,941	0,301	0,408	43,32%	10	6	7	Decreasing β	8
Biweekly	1,010	0,344	0,483	47,78%	11	4	8	Rising β	21
Monthly	1,003	0,366	0,666	66,38%	18	10	18	Increasing R^2	25
sWIG80 (70 cases)/returns	**Mean**	**Average R^2**	**Standard deviation**	**Random error**	**Highest R^2**	**Lowest β**	**Highest β**	**Detailed characteristics**	
					Number of cases in sample				
Daily	0,790	0,156	0,384	48,63%	3	29	9	A/D	48
Weekly	0,890	0,238	0,507	56,95%	16	12	14	Decreasing β	13
Biweekly	0,941	0,281	0,578	61,45%	14	9	13	Rising β	37
Monthly	0,936	0,324	0,719	76,82%	37	20	34	Increasing R^2	46

Source: Author's calculation.

Ultimately, 128 entities grouped in the three main indexes of the WSE were finally qualified for the final research sample. Due to the withdrawal from the stock exchange in the analyzed period, it was necessary to disqualify 12 entities (1 company from WIG20, 1 from mWIG40 and 10 from sWIG80). The author assumed that in order to properly verify the differences between the β, it is necessary to make a note in the whole research period (2020-2021), not only in its part.

When analyzing the data contained in Table 1, it can be observed that the averaged values of β were characterized by the highest value for monthly returns, while the lowest were recorded for daily returns. This is also confirmed by the total number of cases indicating that β was the lowest for daily returns (54 out of 128) and the highest for monthly returns (60 out of 128). This relationship is also visible in each of the subgroups. It can be seen that in the case of WIG20 issuers, where the highest number of cases of the lowest β value was recorded for daily returns, while the highest was for monthly returns. The same is for companies from the mWIG40 index and for those listed in the sWIG80 index. Based on the results of the study, it cannot be ruled out that, in fact, with the extension of the time horizon of the returns, the estimated β do not increase, but converge to 1, which would emphasize their tendency estimated by Marshall Blume (1975, pp. 790-791). However, this is contradicted by the behavior of the β calculated for the companies from the WIG20 index. In this case, it can be clearly noticed that their values are growing and moving away from level 1. This confirms the observation that values of the β increase along with the extension of the horizon of returns for issuers from the WIG index during the COVID-19 pandemic, which is consistent with the research authors from previous years (i.a. Diacogiannis & Makri, 2008).

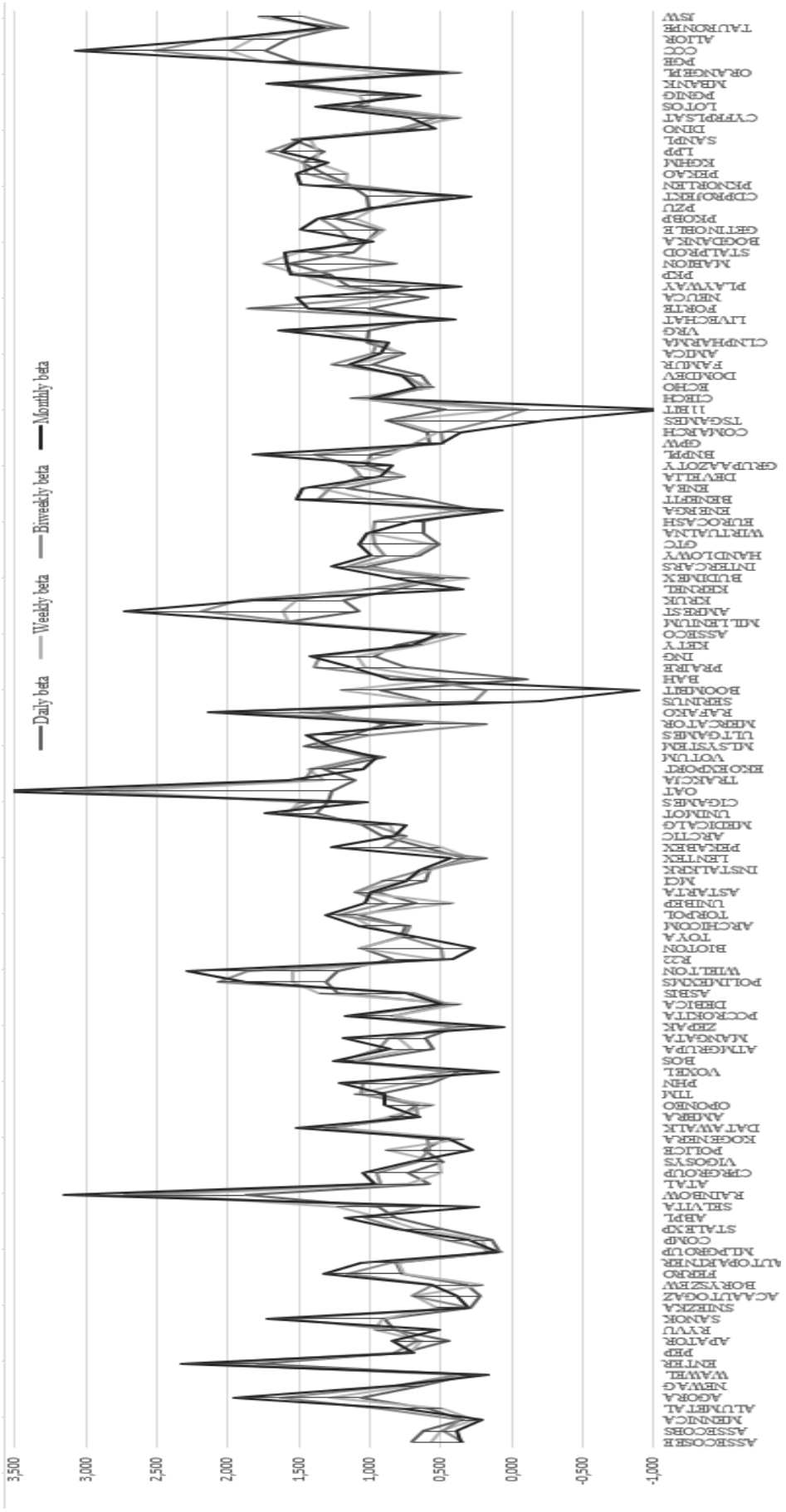

Figure 1. Shaping of beta coefficients values for selected WSE companies for the years 2020-2021 (128 cases) – own calculations

Averaged values of β were characterized by the highest value for monthly returns, while the lowest were recorded for daily returns were noticed both in the case of the entire research sample (128 cases) and in relation to the companies grouped in the WIG20 and mWIG40 indices. There is some difference in the case of companies from the sWIG80 index - the averaged β were the lowest when used to calculate the daily returns, and the highest with the biweekly returns.

Interestingly, it can be seen the increasing in the differences between the β along with the decreasing in the capitalization of companies (inverse relationship). The highest differences in estimation concern the companies grouped in the sWIG80 index. These results confirm the dependencies indicating a stronger occurrence of the interval effect in relation to companies with lower capitalization (Corhay, 1992, p. 68). The author of this study can also confirm the relationship noticed on the Greek market (Diacogiannis & Makri, 2008, p. 120). These researchers, when studying the interval effect, proved that the average value of β increases in all groups along with the extension of the interval for estimating the returns.

Moreover, it can be seen that in as many as 79 out of 128 cases can observe an increase in the value of the R^2 coefficient along with the extension of the time horizon of returns used to calculate the β. These results are consistent with those of previous researchers verifying the existence of the interval effect on the WSE (Olbryś, 2014, Feder-Sempach, 2017, pp. 29-30). Unfortunately, also in their cases the standard deviation of the β is the highest, which proves the greatest volatility in relation to the other horizons of returns. In this cross-section, the β calculated on the basis of daily returns show the lowest variability of estimation. Based on the abovementioned calculations, it is difficult to indicate the best time horizon that would be used to calculate the β in the next research (Lisicki, 2019, pp. 130-131). Those with the highest R^2 level also show the highest volatility, which prevents their preferential nature in the calculation of systematic risk of companies listed on the WSE. The increase in errors in estimating β along with the extension of the time horizon of returns has already been reflected in the literature on the subject (Podgórski, 2019, p. 13).

Results of this study were also obtained with regard to the first of the "Detailed characteristics" presented in Table 1. Despite the positive verification of as many as 86 cases (out of 128 in the entire sample), which, based on the calculation of the β for the four time horizons of returns, made it possible to unambiguously qualify companies included in the group of aggressive or defensive. Their averaged values in the case of

daily and weekly returns show a defensive nature of the analyzed entities, while in the case of using the biweekly and monthly returns should already be perceived as aggressive ones. The situation is different in the case of the cross-sectional results of the study. The averaged values of β make it possible to unambiguously qualify the aggressive issuers from the WIG20 index to the group of aggressive companies and the sWIG80 index companies to the group of defensive companies. As in the case of the entire research sample, it is not possible to qualify companies from the mWIG40 index to one of these groups. These results constitute another evidence of significant differentiation of the β values, which precludes an certain quantification of the systematic risk of shares of individual issuers (Lisicki, 2017, p. 43).

Interestingly, in the entire sample, 68 cases of increase in the β were recorded while extending the time horizon of measuring the returns used in its calculation (with only 24 cases of decrease). This increase was noticeable even in the case of companies with higher capitalization, but also for issuers with quite lower level of capitalization.

These results are surprising. Earlier discoveries exploring this issue showed a noticeable tendency to decrease the value of β along with the extension of the time horizon of their returns (e.g. Hawawini, 1983, p. 73, Corhay, 1992, pp. 65-68 Brailsford & Josev, 1997, p. 372) in relation to companies with higher capitalization. This tendency was not observed on the WSE during the COVID-19 pandemic. Moreover, it was possible to notice a slight increase in the value of the β. Thus, a certain dependence can be noticed that differs from those shown in previous studies.

In order to confirm the research results presented in Table 1, it was considered necessary to carry out their statistical verification. The existence of the interval effect among WSE-listed companies during the COVID-19 pandemic can be considered when the presented differences in the estimates of β using different returns are statistically significant. For this purpose, a parametric *t-test for dependent groups* was used (Gerald, 2018, p. 52). To carry it out, it is required to meet the assumption of the normality of the distribution of variables, which for the adopted research sample was positively verified after the D'Agostino-Pearson test (*D'Agostino-Pearson test for normality*) (D'Agostino, Belanger & D'Agostino Jr., 1990, p. 320).

Statistical verification was performed separately for each possible pair of coefficients estimated using a different time horizon for measuring the returns. Therefore, 6 pairs of coefficients were distinguished (daily-weekly; daily-biweekly, daily-monthly,

weekly-biweekly, week-monthly, biweekly-monthly) each time verified for differences in β estimates. The results of the verification are presented in Table 2.

By analyzing the results of statistical verification of the differences between β calculated on the basis of returns differing in the time horizon of the calculation, their significance can be observed in the case of pairs (in relation to whole research sample): β estimated on the basis of daily and weekly returns, daily and biweekly returns, and daily and monthly returns (all three pairs at significance level $p < 0.01$), as well as a β estimated from weekly and biweekly returns ($p < 0.05$). Only for pairs of β based on weekly and monthly, as well as biweekly and monthly returns, the calculated value of the *t-test* statistic does not indicate the significance of the calculated differences between them.

Table 2. Results of statistical verification of differences between beta coefficients for companies listed on the WSE during the COVID-19 pandemic

Research sample	**β daily**	**β weekly**	**β daily**	**β biweekly**	**β daily**	**β monthly**
Mean	0,873	0,958	0,873	1,013	0,873	1,015
Variance	0,150	0,230	0,150	0,310	0,150	0,491
Pearson R	0,888		0,739		0,668	
df (n-1)	127		127		127	
t Stat	-4,29369**		-4,21443**		-3,04585**	
Research sample	**β weekly**	**β biweekly**	**β weekly**	**β monthly**	**β biweekly**	**β monthly**
Mean	0,958	1,013	0,958	1,015	1,013	1,015
Variance	0,230	0,310	0,230	0,491	0,310	0,491
Pearson R	0,849		0,776		0,932	
df (n-1)	127		127		127	
t Stat	-2,11318*		-1,44719		-0,09113	

** p<0,01
* p<0,05
Source: Author's calculation.

Based on the above results of the statistical significance, it should be noted that in relation to companies listed on the WSE, during the COVID-19 pandemic, the interval effect can be still observed. It is especially noticeable in the case of issuers with lower level of capitalization (mWIG40, sWIG80) than these listed on the blue chips index (WIG20). Therefore, it can be assumed that the increased volatility in capital markets caused by the COVID-19 pandemic did not cause significant differences in the occurrence of the interval effect on the WSE. The only one (in relation to the studies of earlier researchers) is the observed increase in the value of the coefficients for companies with the highest level of capitalization, which previously did not take place on other stock exchanges.

5. CONCLUSIONS

The outbreak and spread of the COVID-19 pandemic should be treated in the category of the stock market "black swan" (Taleb, 2010, p. 42). It means an unpredictable event that causes panic on global financial markets. This situation created incentives to discover new dependencies existing on capital markets (Wiśniewska-Kuźma, 2020, Ruiz Estrada, Koutronas & Minsoo, 2021, Jóźwicki, Trippner & Kłos, 2022). These undoubtedly include the attempt to find an answer to the question concerning the β interval effect presented in this article.

The research hypothesis presented at the beginning of this study indicated that explosion and the spread of the COVID-19 pandemic did not disturb the occurrence of differentiation β levels depending on the time horizon used to calculate returns. Referring to this the presence of the interval effect among companies listed on the WSE during the COVID-19 pandemic years (2020-2021) may be observed.

The interval effect has been checked on a research sample of 128 companies grouped in the three main WSE indices: WIG20, mWIG40 and sWIG80. When calculating the β of the shares of these entities based on daily, weekly, biweekly and monthly returns, respectively, differences in their estimates were noticed. It is worth adding that these differences were statistically significant for pairs of β calculated on the basis of daily and weekly/biweekly/monthly returns, as well as for weekly and biweekly ones (in case of the whole research sample). Moreover, the statistical significance of differences in the estimates of β (based on daily and other returns) for companies with capitalization lower than the blue chips listed on the WSE confirms that the interval effect is invariably stronger in relation to companies with lower capitalization (Corhay, 1992, p. 68). Therefore, in the analyzed period, the interval effect can be noticed on the WSE. This is a premise for the adoption of the research hypothesis put forward at the beginning of the paper, which indicates that the occurrence of the interval effects of β of companies listed on the WSE has not been disturbed by the COVID-19 pandemic.

Interestingly, among the analyzed detailed relationships, it was noticed that along with the extension of the time interval of returns, the β increased for companies with higher capitalization. This result is quite different from the previous results, which showed an inverse relationship between the level of capitalization and the value of the β along with the extension of the time horizon for measuring returns.

The reasons for this state should be looked for in perceiving companies with lower capitalization during the COVID-19 pandemic as more risky than they actually could be.

On the other hand, companies with higher capitalization at times of increased volatility on the capital markets, due to their size and importance, may be perceived as less risky than they truly are. The paradox of such a situation was already noticed in previous studies analyzing the differentiation of the β depending on the time horizon of returns, which was used for its calculation (Scholes & Williams 1977, p. 323, Hawawini 1983, p. 73).

These results are an original contribution to the current area of capital market research during the COVID-19 pandemic on the example of WSE. They indicate that the COVID-19 pandemic did not influence on the occurence of the interval effect observed on the polish capital market earlier (Olbryś 2014a, Feder-Sempach, 2017, Lisicki 2019), but only slightly changed some of its detailed characteristics.

However, what can be noticed already at this stage of the research is the fact that the differentiation of the β (depending on the time horizon of returns used for its calculation) still does not allow to unambiguously use it as an effective measure the risk of investment in securities (Lisicki, 2017, p. 43). Therefore using the β to measure systematic risk in times of instability on the capital markets can be associated with significant errors.

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