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Differentiation of Beta Coefficients during COVID-19 Pandemic – the Example of Stocks of the Largest Companies Listed on the Warsaw Stock Exchange

Zróżnicowanie wartości współczynników beta w dobie pandemii COVID-19 na przykładzie akcji największych spółek notowanych na Giełdzie Papierów Wartościowych w Warszawie

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ABSTRACT

Objective: The article seeks to determine whether the occurrence of the interval effect of beta coefficients (β) occurred among chosen shares in Warsaw Stock Exchange Index (WIG) during the COVID-19 pandemic.

Research Design & Methods: The article seeks to determine whether in 2020 and 2021 (when the COVID-19 pandemic was spreading globally) it was possible to observe other levels of the β for chosen companies traded on the WIG. It examines a different approach to estimating returns of the companies' shares (daily, weekly, biweekly and monthly). β coefficients are calculated with the ordinary least squares method (OLS) on the research sample of issuers traded on the three main Warsaw Stock Exchange (WSE) indices: WIG20, mWIG40 and sWIG80.

Findings: The values of the β coefficients, calculated for different time horizons of returns (daily, weekly, biweekly and monthly) showed significant differences. These differences were statistically significant for pairs of β calculated for 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 for companies with lower capitalisation. The β increased for companies with the highest level of capitalisation as the time interval of returns was extended, which the literature has to this point reported only for Asian markets in crisis years.
Implications/Recommendations: The results indicate that the COVID-19 pandemic did not influence the occurrence of the interval effect observed on the Polish capital market earlier, and only slightly changed some of its detailed characteristics. However, the differentiation of the β (depending on the time horizon of returns used to calculate it) does not make it an effective measure of the risk of investing in securities.
Contribution: Conducting research on the occurrence of the interval effect on the WSE during the COVID-19 pandemic will contribute to the knowledge base of capital market participants, particularly on the use of β to measure systematic risk in times of instability on capital markets. Understanding this issue in the context of investing funds on the WSE will be useful for those seeking to adjust investment portfolios to the changing realities of the Polish capital market.

Article type: original article.

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

JEL Classification: C20, G11, G12, G17.

STRESZCZENIE

Cel: Celem artykułu jest weryfikacja występowania tzw. efektu interwału współczynnika beta (β) akcji spółek notowanych na Giełdzie Papierów Wartościowych w Warszawie (GPW) w trakcie pandemii COVID-19. Wybuch i rozprzestrzenianie się pandemii zdestabilizowały funkcjonowanie wielu gałęzi gospodarki, w tym rynków kapitałowych, co może skłaniać do poszukiwania nowych zależności dotyczących ich funkcjonowania bądź potwierdzania tych, które zostały zauważone wcześniej.
Metodyka badań: Zweryfikowano wartości β akcji wybranych spółek notowanych w indeksie WIG podczas pandemii COVID-19 z wykorzystaniem zróżnicowanego horyzontu czasowego stóp zwrotu (dziennych, tygodniowych, dwutygodniowych i miesięcznych). Współczynniki β zostały obliczone za pomocą klasycznej metody najmniejszych kwadratów (KMNK) na próbie badawczej składającej się z wybranych emitentów z GPW zgrupowanych w indeksach: WIG20, mWIG40 oraz sWIG80.
Wyniki badań: Analizując wartości współczynników β szacowanych na podstawie wskazanych horyzontów czasowych stóp zwrotu podczas pandemii COVID-19, można dostrzec między nimi znaczne różnice. Co więcej, w większości przypadków są one istotne statystycznie. Wskazuje to na występowanie efektu interwału β w badanym okresie. Efekt ten jest silniejszy dla spółek o niższym poziomie kapitalizacji, co stanowi potwierdzenie wyników wcześniejszych badań przeprowadzonych dla zagranicznych rynków kapitałowych. Za interesujące należy uznać to, że wraz z wydłużaniem horyzontu czasowego stóp zwrotu wartość współczynników β rośnie również dla spółek o najwyższym poziomie kapitalizacji, co dotychczas znalazło odzwierciedlenie w literaturze przedmiotu wyłącznie w przypadku rynków azjatyckich w latach kryzysowych.

Wnioski: Na podstawie uzyskanych wyników badań można stwierdzić, że pandemia COVID-19 nie zaburzyła występowania efektu interwału współczynników β. Miała wpływ na pewne szczegółowe jego charakterystyki, które do pewnego stopnia (aczkolwiek nieznacznie) różniły się od wcześniejszych obserwacji. Istotne do odnotowania jest to, że zróżnicowanie współczynnika β (w zależności od przyjętego do jego obliczenia horyzontu czasowego zwrotów) w dalszym ciągu nie pozwala na jednoznaczne wykorzystanie go jako efektywnej miary ryzyka inwestycji w papiery wartościowe.
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. Wiedza ta wydaje się ważna w kontekście lokowania środków na GPW ze względu na konieczność dostosowania portfeli inwestycyjnych do zmieniających się realiów funkcjonowania polskiego rynku kapitałowego.

Typ artykułu: oryginalny artykuł naukowy.

Słowa kluczowe: efekt interwału, współczynnik beta, COVID-19, GPW w Warszawie, akcje.

1. Introduction*

Among the many methodological proposals for measuring risk, the single-index model proposed by Sharpe (1963, pp. 278–281) is very popular. One of the parameters of the Sharpe model is the beta coefficient (β), which reflects the systematic part of the volatility of returns. β is a measure of risk associated with investing in the shares of publicly traded companies. It is affected by the structure of assets, the area of economic activity involved and available financing sources, among other factors (Rydzewska 2016, p. 49).

Finding the proper interval for measuring the return is among the difficulties with calculating β (Feder-Sempach 2017, pp. 20–22). This problem is frequently cited in scientific research, with numerous authors seeking to determine the most appropriate interval for measuring returns that will later be used to estimate β.

When using different time intervals (from daily to several years) to calculate β, significant differences in estimates have been observed. The occurrence of these

* This paper contains an extended and in-depth analysis of the research presented at conference proceedings from the 6th FEB International Scientific Conference in Maribor, Slovenia, 16–20 May 2022, "Challenges in Economics and Business in Post-COVID Times" (Lisicki 2022, pp. 57–66). This paper presents a detailed analysis of the preliminary research results presented in the above proceedings. The occurrence of the interval effect during the COVID-19 pandemic has been verified for individual indices (WIG20, mWIG40, sWIG80) included in the research sample. Also, detailed characteristics of β have been added in the context of individual issuers grouped in these indices. The development of β for differentiated returns has also been presented and the occurrence of statistical significance between individual pairs of β have been verified.

differences, which depend on the period adopted for the quotations of company shares, has been called the interval, or intervalling, effect (Gray *et al*. 2005).

The main purpose of this article is to verify whether the interval effect occurred among the selected issuers listed in the Warsaw Stock Exchange Index (WIG) during the COVID-19 pandemic years (WHO 2020). The destabilisation of economic and social conditions during those years led to strong turmoil on the capital markets, increasing price volatility on the stock market (especially in the first half of 2020). According to some researchers, it was higher during the year 2020 than during the major crises of 1930, 1987 and 2008 (Thakur 2020, p. 1182; Zhang, Hu & Ji 2020).

Increased volatility in capital markets creates new motives for researchers that can be used to discover new dependencies. Researchers may also undertake to quantify the occurrence of ones observed in other pandemic circumstances (Wiśniewska-Kuźma 2020, Ruiz Estrada, Koutronas & Lee 2021, Jóźwicki, Trippner & Kłos 2021). The realities observed since the first quarter of 2020 – a screeching global economic slowdown and increased uncertainty about the future (Zhang, Hu & Ji 2020) – may prompt questions about numerous previous market dependencies. The prices of securities listed on capital markets and their differentiation in response to the outbreak and spread of the COVID-19 pandemic are also being reviewed (Żebrowska-Suchodolska, Karpio & Kompa 2021).

Increased volatility of securities prices could have led to differences in β coefficients of companies listed on the Warsaw Stock Exchange (WSE) in relation to previous years. Such has been the case in other capital markets, including those of the US (Cao *et al*. 2022), Mexico (López Herrera, González Maiz Jiménez & Reyes Santiago 2022), India (Jain 2022) or on Islamic markets (Haroon *et al*. 2021). Gaining a similar knowledge in the context of investing on the WSE is important insofar as it provides the ability to adjust investor portfolios to the changing realities of the Polish capital market.

Hence an attempt has been made to verify the existence of the interval effect during the COVID-19 pandemic. The goal of the research reported herein was to determine whether, in the years 2020 and 2021, on the WSE, other levels of β of selected issuers listed in the WIG could be observed with differentiated approaches to estimating the returns on their shares. The main hypothesis of the paper is the following: The explosion and spread of the COVID-19 pandemic did not disturb the occurrence of the interval effect for issuers listed on the WSE.

The author's research about the interval effect on the WSE during the COVID-19 pandemic will deepen the knowledge of capital market in terms of how β can be used to measure market risk in times of increased volatility of securities on the capital markets. This will enable investors and researchers of Polish capital markets to see whether β can be used to measure the systematic risk level of securities during periods of increased volatility of prices on the capital markets.

2. The Interval Effect – Literature Review

Choosing the appropriate time horizon to measure returns was a matter of interest to researchers as early as the 1970's. In 1974, Pogue and Solnik did the first empirical study showing differences in the β estimates. They analysed the abovementioned 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 markets. Notably, this effect was visible much more on the then less-developed Belgian and Dutch stock exchanges (Pogue & Solnik 1974).

Other studies have revealed a further range of curious conclusions. Hawawini (1983, p. 73) and Handa, Kothari and Wasley (1989, pp. 90–96) observed that the interval effect differed depending on companies' market capitalisation. In the first study, β was supposed to increase as the interval for measuring returns shortened. However, this was expected to apply only to companies with higher--than-average capitalisation and trading volume.

The interval effect was also tested in non-US markets. Corhay (1992) observed that the interval effect is inversely proportional to the market value of the companies. Observations regarding the occurrence of the interval effect have been confirmed in the Australian (Brailsford & Josev 1997, p. 372) and Greek markets (Diacogiannis & Makri 2008, p. 109). Those studies pointed out that the β of companies with the highest (lowest) capitalisation decreased (increased) as the time horizon adopted for its estimation was extended.

Another study indicates the optimal period of returns used to estimate β for emerging markets (Damodaran 1999, p. 16). There were differences between the values of β, indicating the occurrence of the interval effect, though Damodaran's recommendation for which time intervals should be used in the calculations should be noted. According to this calculation, monthly returns should be used when estimating β for research periods longer than three years. For calculations for shorter research periods, daily or weekly returns should be applied.

Research on the interval effect has also been done on the Polish capital market. Interesting publications on the interval effect on the WSE have been done by Brzeszczyński, Gajdka and Schabek (2011), who, using heteroscedastic ARCH autoregressive models, estimated the effect of the interval for short-term returns on stocks. Other noteworthy studies have been carried out on the interval effect of β and the determination coefficients of the market model (Olbryś 2014a, 2014b), which showed changes in the sensitivity of the abovementioned elements to changes in the length of the time interval for measuring returns. Comparative analyses of the interval effect on shares of companies from the Polish WIG20 index and the German DAX (Feder-Sempach 2017) and also another carried out on the 33 largest issuers listed on the WSE (Dębski, Feder-Sempach & Świderski 2015, p. 279) have also each reported curious results. A paper about interval effect on the RESPECT Index was done in 2019 (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 different securities (Hong 2016, pp. 40–42). The degree of autocorrelation of returns on securities with the market return determines the existence and direction of the interval effect. That the interval effect also applies to ETFs was another important conclusion (Milonas & Rompotis 2013).

Authors have also recently attempted to assess the diversified value of β in individual phases of the economic cycle for Islamic and European/American capital markets (Rizvi & Arshad 2018, p. 563). Meanwhile, during the COVID-19 pandemic, repeated attempts have been made to quantify β in order to come to grips with the systematic risk of securities listed on many global capital markets (e.g. Cakici & Zaremba 2021). As with analyses of β in other crisis periods, the values of this coefficient increased for most time intervals of returns during the COVID-19 pandemic, especially in its first phase (Jain 2022). In their paper, López Herrera, González Maiz Jiménez and Reyes Santiago (2022) showed that during crises (indeed such as the pandemic), it is necessary to precisely define the β specification, which in turn may suggest a volatility of systematic risk far exceeding typical market risk.

Importantly, in a literature review I did in 2022, I did not come across a study that verified the interval effect during the COVID-19 pandemic time, either for foreign markets or the Polish capital market. Filling this research gap is the main goal of this study.

3. Methodology and Data

As mentioned in the introduction, the main goal of this study is to obtain knowledge on the interval effect of selected companies listed on the WSE 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 (Zhang, Hung & Ji 2020) is reflected in the levels of the β coefficients calculated on the returns differ in the period of their estimation (daily, weekly, biweekly and monthly).

The interval effect will be verified by calculating β coefficients for the shares of chosen issuers listed on the WSE, grouped in the WIG. To this end, the research sample was cut to the 140 (and ultimately to 128, as 12 issuers had to be rejected from the research sample) largest and most liquid companies grouped in WSE indices: the WIG20, mWIG40 and sWIG80. The historical portfolios of these indices were used as of the beginning of 2020 (Warsaw Stock Exchange 2020), when the pandemic was spreading rapidly.

β will be calculated with the ordinary least squares (OLS) separately for four types of returns: daily, weekly, biweekly and monthly. To calculate the weekly, biweekly and monthly returns, quotations from the last day of market operation in which the trade took place were used. The broad market index on the WSE-WIG is used to indicate the market return (Olbryś & Majewska 2017). Share quotations were downloaded from the stooq.com quotation database (Stooq 2022), and used to calculate β. Due to the large number of β estimated for several time horizons of returns, only their descriptive statistics are presented in the Results section of this paper.

To better compare the calculated β, the value of the R^2 was estimated for each of the results. It informs about part of the volatility of returns which has been explained by the calculated β (Kornacki & Wesołowska-Janczarek 2008, p. 8).

The detailed relationships between the values of β calculated on the various returns are also examined. More information on these relationships is included in the explanations to Table 1, which can be found in the next section of the study.

The significance in the differences between the values of β is statistically verified using a test – *t-test for dependent groups* – that checks the significance of differences between two dependent groups (Kyun 2015, p. 52). The test assumes the normality of the distribution of variability (verified later in the article), and appears to be the most appropriate means to verifying the existence of the interval effect in the COVID-19 period on the WSE.

4. Estimated Beta Coefficients of Issuers Listed on the WIG Index during the COVID-19 Pandemic – Results

Table 1 presents the averaged values of β calculated during the COVID-19 period for different time horizons of returns (daily, weekly, biweekly and monthly). It also includes R^2, statistics describing the coefficients (mean, standard deviation, random error), and "detailed characteristics" designed to determine the β relationships that occurred during the COVID-19 pandemic.

The following notations will be observed:

– 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 intended to help determine whether a company's shares will react correspondingly stronger or weaker than changes in the market[1];

– rising β – dependence consisting of an increase in the value of β as the time horizon of measuring the returns is extended;

[1] Depending on the values of β, the following may be distinguished (Michalak 2020, pp. 341–342): aggressive shares with β > 1, and defensive shares with β < 1.

– decreasing β – dependence consisting of a decrease in the value of β as the time horizon for measuring returns is extended;

– increasing R^2 – recording the increase in the β of determination R^2 (proving better adjustment of the β coefficient to the model) with extended time horizon for measuring the returns.

Table 1. Values of β Coefficients for a Differentiated Time Horizon of the Returns for Selected WSE Issuers in 2020–2021 (128 cases)

Time horizon of returns	Mean	Average R^2	Standard deviation	Random error (in %)	Highest R^2	Lowest β	Highest β	Detailed characteristics	
					Number of cases in sample				
Entire research sample (128 cases)/returns									
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									
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									
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									
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: the author.

To look more precisely at the values of β during the COVID-19 pandemic years, detailed shaping of their values calculated for various time horizons of returns (daily, weekly, biweekly, monthly) are indicated for the entire research sample. They are presented in Figure 1.

Ultimately, 128 selected issuers grouped in the three indicated indices of the WSE qualified for the final research sample. Due to their withdrawal from the stock exchange in the period under analysis, 12 issuers were disqualified (1 of the WIG20, and mWIG40 index and 10 of the sWIG80 index). The author assumed that in order to properly verify the differences between β, it would be necessary to analyse it for the whole research period (2020–2021), not merely for a part of it.

Analysis of the data in Table 1 indicates that the mean of β was characterised by the greatest 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 also occurs in each of the subgroups (Jain 2022). In the case of the WIG20 issuers, the highest number of cases of the lowest β value was recorded for daily returns, and the highest for monthly returns. The same holds for companies from the mWIG40 index as well as those listed in the sWIG80 index. At the same time, it cannot be ruled out that, in fact, as the time horizon of the returns is extended, the estimated β does not increase but converges to 1. This would confirm the tendency estimated by Blume (1975, pp. 790–791). However, it is also contradicted by the behaviour of β calculated for companies listed on the WIG20 index, whose values are clearly growing and moving away from level 1. This confirms the observation that values of β increase along with the extended time horizon of returns for selected issuers from the WIG index during the COVID-19 pandemic. It is also consistent with what other authors have found (Diacogiannis & Makri 2008, Choudhry, Lu & Peng 2010), especially for periods of crisis (Slimane, Bellalah & Rijba 2017).

Mean values of β were characterised by the greatest value for monthly returns, while the lowest were recorded for daily returns both in the case of the entire research sample (128 cases) and in relation to the companies grouped in the WIG20 and mWIG40 indices. Companies from the sWIG80 index exhibited some difference – the averaged β was the lowest when used to calculate the daily returns and the highest with the biweekly ones.

Interestingly, the differences between β increased as the capitalisation of issuers fell (an inverse relationship). The highest differences in estimation occurred for the issuers grouped in the sWIG80 index. These results confirm the dependencies indicating a stronger occurrence of the interval effect for companies with lower capitalisation (Corhay 1992, p. 68). I can also confirm the relationship observed on the Greek market (Diacogiannis & Makri 2008, p. 120).

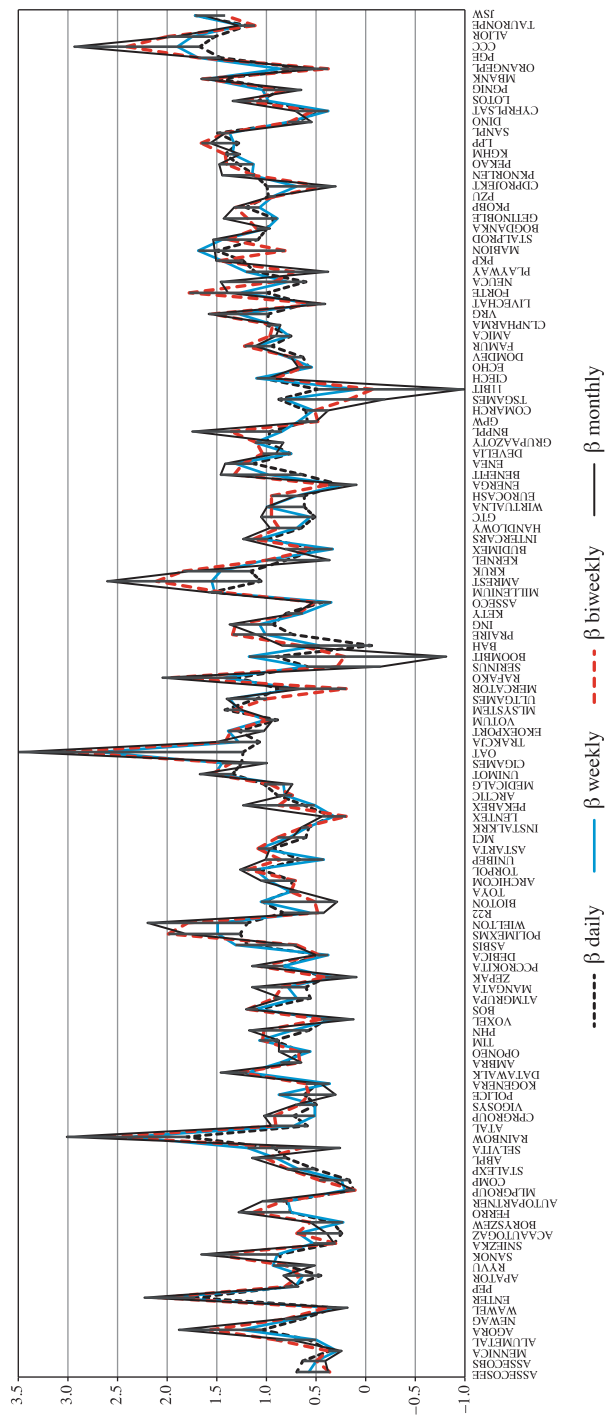

Fig. 1. Shaping of β Coefficients Values for Selected WSE Issuers for the Years 2020–2021 (128 cases)

Source: the author's own calculations.

Looking at the interval effect, these researchers proved that the average value of β increases in all groups as the interval for estimating the returns is extended, including during economic crises (Choudhry, Lu & Peng 2010, Slimane, Bellalah & Rijba 2017).

Moreover, in as many as 79 out of 128 cases, R^2 increased as the time horizon of returns used to calculate β was extended. These results are similar with previous studies conducted on the WSE (Olbryś 2014b). Unfortunately, the standard deviation and random error of β are also the highest in those cases. In this cross-section, β calculated on the basis of daily returns shows the lowest estimation variability. This could indicate that a shorter return interval, which is characterised by lower volatility (Daves, Ehrhardt & Kunkel 2000), should always be used to calculate β.

However, high-frequency data (daily returns) are considered more prone to heteroscedasticity, in turn reducing the efficiency of estimations based on them (Jacobsen & Dannenburg 2003). The risk of a single-index model (from which β is connected) appears too high for this coefficient (estimated for the selected time horizon of the returns) to be used as a universal measure of the systematic risk of shares. It is therefore difficult to indicate the best time horizon for calculating the β in subsequent studies (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 (Oprea 2015).

Results of this study were also obtained for the first of the "detailed characteristics" presented in Table 1. 86 cases out of the 128 in the entire sample were verified as either "aggressive" or "defensive" (based on the β values). This was based on the calculation of β for the four time horizons of returns, and made it possible to unambiguously qualify companies included in the groups labeled "aggressive" or "defensive" (Michalak 2020). Their mean values in the case of daily and weekly returns show the issuers analysed to have a defensive nature, while using the biweekly and monthly returns should be perceived as a sign of aggressiveness.

The situation is different for the study's cross-sectional results. The mean 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 for the entire research sample, it is not possible to place issuers from the mWIG40 index in one of these groups (Feder-Sempach & Szczepocki 2022). These results constitute further evidence of significant differentiation in the β values, thus making it impossible to quantify the systematic risk of shares of individual issuers (Lisicki 2017, p. 43).

Interestingly, in the entire sample, 68 cases of an increase in β were recorded when the time horizon used to measure the returns in its calculation was extended (with only 24 cases of decrease). This increase was noted for companies with a higher capitalisation as well as their lower-cap counterparts.

These results are surprising. Earlier discoveries exploring this issue showed a tendency for the value of β to decrease as the time horizon of their returns was extended (e.g. Corhay 1992, pp. 65–68; Brailsford & Josev 1997, p. 372) in relation to companies with higher level of market capitalisation. This tendency has been not observed on the WSE during the COVID-19 period. Moreover, it was possible to notice a slight increase in the value of β. Thus, a certain dependence can be noticed that differs from those shown in previous studies (Handa, Kothari & Wasley 1989). However, these results are partly in line with the results of research conducted on Asian markets during crisis periods, when the β values increased for companies with the largest capitalisation. However, they decreased for medium and small ones (Cao *et al*. 2022).

The research results presented in Table 1 were verified statistically. The existence of the interval effect among WSE-listed companies during the COVID-19 pandemic can be considered when the 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, the distribution of variables must be normal. The D'Agostino-Pearson test showed this to be the case for our research sample (*D'Agostino-Pearson test for normality*) (D'Agostino, Belanger & D'Agostino 1990, p. 320).

Statistical verification was performed separately for each possible pair of β coefficients estimated using a different time horizon for measuring the returns. Six pairs of coefficients were distinguished (daily-weekly, daily-biweekly, daily-monthly, weekly-biweekly, week-monthly, biweekly-monthly), each time verified for differences in the β estimates. Table 2 presents the results.

By analysing the results of the statistical verification of the differences between β calculated on the different returns, their significance can be observed for 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, does the calculated value of the *t-test* statistic not indicate the significance of the differences calculated between them.

Based on the above results, it can be concluded that the interval effect can still be observed for companies listed on the WSE during the COVID-19 pandemic. This is especially noticeable for issuers with a lower level of capitalisation (mWIG40, sWIG80) than those listed on the blue chips index (WIG20). It can therefore be assumed that the increased volatility of securities' prices in capital markets caused by the COVID-19 did not cause significant differences in the occurrence of the interval effect on the WSE. These research results are consistent with those obtained in research done on β differences in foreign capital markets during crises

Table 2. Results of Statistical Verification of the Differences between the β Coefficients for Companies Listed on the WSE during the COVID-19 Pandemic

Statistics	Time horizon of returns					
	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[a]		–4.21443[a]		–3.04585[a]	
Statistics	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[b]		–1.44719		–0.09113	

[a] $p < 0.01$, [b] $p < 0.05$.

Source: the author.

(Choudhry, Lu & Peng 2010, Liau 2016, Jain 2022). The only difference is that the value of the coefficients increased for companies with the highest level of capitalisation, a phenomenon that did not occur on other stock exchanges.

5. Conclusions

The outbreak and spread of the COVID-19 pandemic should be treated, in the parlance of the stock market, as a "black swan" event (Taleb 2010, p. 42). That is, an unpredictable event that causes panic on global financial markets. It created incentives to verify the dependencies at work on capital markets (Wiśniewska-Kuźma 2020, Ruiz Estrada, Koutronas & Lee 2021, Jóźwicki, Trippner & Kłos 2021). Discovering the influence of the β interval effect presented in this article is one such dependency to be verified.

The research hypothesis explored herein was that the outbreak and spread of the COVID-19 did not disturb the occurrence of differentiation β coefficients values depending on the time horizon used to estimate returns. Therefore, the interval effect among the WSE-listed companies examined here during the COVID-19 pandemic years (2020–2021) may be observed.

In the research done for this article, the interval effect was examined on a research sample of 128 issuers grouped in the 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 observed. 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 the 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 capitalisation lower than the blue chips listed on the WSE confirms that the interval effect is invariably stronger for companies with lower capitalisation (Corhay 1992, p. 68). Therefore, in the analysed period, the interval effect can be noticed to occur on the WSE. This is one premise for the hypothesis that the COVID-19 pandemic did not diminish the interval effects of the β of selected issuers listed on the WSE.

Among the detailed relationships analysed, β increased for companies with higher capitalisation as the time interval of returns was extended. This finding differs from previous results, which showed an inverse relationship between the level of capitalisation and the value of β as the time horizon for measuring returns was extended.

The reasons for this state of affairs should be sought in the perception that, during the COVID-19 pandemic, companies with lower capitalisation were riskier than they could actually have been. At the same time, companies with higher capitalisation at times of increased volatility in the capital markets, due to their size and importance, may be perceived as less risky than they truly are. This seeming paradox has been explored in studies analysing the differentiation of β depending on the time horizon of returns used for its calculation (Scholes & Williams 1977, p. 323; Hawawini 1983, p. 73).

Using the example of the WSE, these results are a contribution to the research about capital markets during the COVID-19 period. They indicate that the occurrence of the COVID-19 pandemic did not influence the interval effect observed on the Polish capital market earlier (Olbryś 2014a, Feder-Sempach 2017, Lisicki 2019), but only slightly changed some of its characteristics.

However, as is already evident at this stage of the research, the differentiation of the β (depending on the time horizon of returns used for its calculation) still does not allow us to unambiguously use it to effectively measure the risk of an investment in securities (Lisicki 2017, p. 43). Using β to measure market risk at times of instability may therefore lead to significant errors.

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