


# Similarity and Granger Causality in Polish and Spanish Stock Market Sectors During the COVID-19 Pandemic

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## Abstract

Capital markets react almost immediately to crises. Such relationships can be both international and local. The research focuses on the stock markets of two countries: Spain and Poland. These countries are often compared in terms of various economic and social criteria. The research covers the period from March 3, 2019, to March 31, 2021. The aim is to identify sectors and indices similar to each other at the local level and to identify, among pairs of similar indices, those that provide a boost to another sector. The research uses the hierarchical cluster analysis method (Ward's method) and the Granger causality test. This work presents a novel approach to sectoral comparison at the local level.

**Keywords:** coronavirus, economic sectors, financial volatility, similarity

**JEL:** C32, C38, G01, G14



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## Introduction

Situations related to economic crises are a frequent topic of research in the literature. The penultimate crisis, which took place between 2007 and 2009, was largely caused by the turbulence of the US economy. Since March 2020, the global economy has been facing a new crisis that was triggered by a completely different, non-financial determinant, i.e. the SARS-Cov-2 virus, which causes the extremely infectious COVID-19 disease.

Financial markets, especially currency and capital markets, react to crises almost immediately, discounting the future economic and social consequences of changes in the environment (Pražák and Stavárek 2017, pp. 7–9; Pera 2019, pp. 124–125; Šimáková and Rusková 2019, p. 119). Capital markets, as connected vessels, are particularly interdependent during crises (Syllignakis and Kouretas 2011, pp. 719–729). These dependencies may be inter- or intraregional (Gębka and Serwa 2007, p. 203). An interesting study in this context was presented by Akhtaruzzaman, Boubaker, and Sensoy (2021, p. 16), who, examining the interdependence of China and G7 countries, showed that Chinese and Japanese financial and non-financial firms are net transmitters of the spread of returns and volatility to other G7 countries during the COVID-19 period, indicating that financial contagion follows the same path as COVID-19.

Just a few months after the outbreak of the pandemic, numerous studies appeared in the literature on this period. It became clear to everyone that the consequences of the new pathogen would be felt not only in the area of medicine and public safety, but also in social and economic life. In terms of capital markets, research has focused primarily on the reactions of stock market indices to information on the number of cases of the disease (Ashraf 2020; Harjoto et al. 2020; Heyden and Heyden 2021) or increased stock market volatility (Ali, Alam, and Rizvi 2020; Baek, Mohanty, and Glam-bosky 2020; Onali 2020; Ramelli and Wagner 2020; Souza de Souza and Augusto 2020; Zaremba et al. 2020; Adnan and Hasan 2021; Albulescu 2021; Mazur, Dang, and Vega 2021; Narayan, Gong, and Ali Ahmed 2021). They often cover short series, which may not always reliably verify hypotheses. Moreover, studies focus on entire markets represented by major stock indices showing aggregate values (Żebrowska-Suchodolska, Karpio, and Kompa 2021). Such a study assumes homogeneous effects on sectoral performance, meaning that COVID-19 has the same effect on all sectors. Narayan and Sharma (2011, p. 3262) argued that sectors are heterogeneous and, therefore, likely to respond differently to market shocks. Since little attention has been paid in the literature to individual market sectors, their similarities, or causality, there is a need to address this issue more broadly. The paper fills a research gap in the context of a sectoral comparison of the stock markets of Poland and Spain during the pandemic.

Poland and Spain are often compared on various economic and social criteria. Both countries are among the largest countries in the European Union – Spain is the fourth

and Poland the fifth-largest economy in the EU – and they are classified as developed markets. However, the way stock trading is organised, as well as the size of the markets, are markedly different. In Spain, assets are traded on four regional stock exchanges, with the Bolsa de Madrid being the largest. At the end of 2020, a total of 2738 companies were listed on the Spanish market, while the total capitalisation amounted to USD 797.3 billion, which was 4.8% lower than the previous year (World Federation of Exchanges). Meanwhile, trading of assets in Poland takes place on a single exchange, the Warsaw Stock Exchange. At the end of 2020, the total number of companies listed on the Polish market was more than three times lower than on Spanish exchanges, at 806. However, capitalisation increased by 17.1%, reaching USD 177.5 billion at the end of 2020 (World Federation of Exchanges).

Despite this large divergence in market size, the MSCI country indices (Morgan Stanley Capital International Indices, the oldest and most widely used stock market index by portfolio investors) for the two markets have recently shown significant similarity (Figure 1).

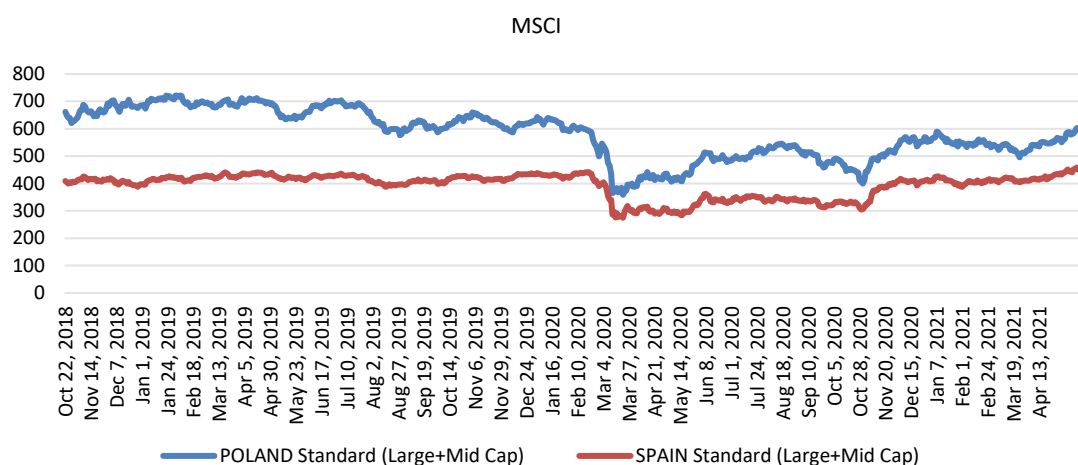


Figure 1. MSCI Poland and MSCI Spain indices

Source: based on MSCI Indexes (n.d.).

MSCI indices are often a benchmark of investment portfolio composition for global and regional investors, and especially for investment funds. We have therefore compared the returns of national MSCI indices calculated for European stock exchanges over the one-year period following the announcement of the COVID-19 pandemic by the World Health Organisation (WHO) (Table 1). This comparison gave a very different picture of the market from what was observed at the very beginning of the pandemic (March 2020). Only 1 of the 28 indices generated a negative return, and the vast majority gave a higher return than before the outbreak.

Table 1. Annual return of the MSCI European stock exchange indices (11.03.2020–11.03.2021)

Rank	Country	Price return (%)	Rank	Country	Price return (%)
1	SWEDEN	64.08	15	SPAIN	23.38
2	NETHERLANDS	58.28	16	PORTUGAL	22.27
3	AUSTRIA	54.87	17	UNITED KINGDOM	22.10
4	NORWAY	51.71	18	CROATIA	21.46
5	IRELAND	49.46	19	CZECH REPUBLIC	21.05
6	DENMARK	49.06	20	BELGIUM	19.31
7	FINLAND	43.76	21	SWITZERLAND	18.62
8	GERMANY	41.99	22	LITHUANIA	17.99
9	ITALY	38.46	23	HUNGARY	15.32
10	SLOVENIA	38.03	24	GREECE	10.32
11	FRANCE	37.93	25	BULGARIA	7.41
12	ROMANIA	27.85	26	BOSNIA AND HERZEGOVINA	5.41
13	UKRAINE	27.12	27	TURKEY	2.74
14	POLAND	24.67	28	ESTONIA	-6.71

Source: calculations based on MSCI (n.d.).

Poland and Spain were ranked 14<sup>th</sup> and 15<sup>th</sup> in this comparison, respectively, achieving similar rates of return despite having radically different epidemiological and economic conditions. Poland was one of the countries that coped best with the spread of the pandemic in the initial period, while Spain was one of the countries worst affected, especially in the first and second waves. The first case of COVID-19 infection in Spain was recorded on 1.02.2020, and at the beginning of March, the number of infected exceeded 100. On 28.03.2020, it already exceeded 100,000. One day later, the total number of deaths exceeded 5 thousand. For comparison, in Poland, on 26.03.2020, the total number of infections exceeded 1000, and on 7.04.2020, the total number of deaths exceeded 100 (Phan and Narayan 2020, pp. 2141–2142). By March 15 2021, more than 3.2 million cases had been reported in Spain, with just over 2 million in Poland (World Health Organization n.d.).

Given these differences and similarities, the subject of this research is the market sectors of the Spanish and Polish stock exchanges. The research covers the period from March 3, 2019, to March 31, 2021. The objective of the research is to identify sectors and indices similar to each other at the local level and to identify, among pairs of similar indices, those that provide a boost to another sector. The research used the hierarchical cluster analysis method (Ward's method) and the Granger causality test.

## Stock markets during the COVID-19 pandemic

When COVID-19 was spreading in China (as of 17.11.2019), becoming a growing problem not only for the province of Hubei, where it appeared, but for a growing area of China, the reactions of the capital markets did not foreshadow such serious consequences. However, with each passing month, the public health situation worsened, with negative economic and social consequences. This culminated in March 2020, when the World Health Organization (11.03.2020) declared a global pandemic (World Health Organization 2020), thus causing an unprecedented shock to global financial markets. As demonstrated by Baker et al. (2020, pp. 744–746), no previous infectious disease pandemic has affected stock markets as much as COVID-19. The Dow Jones Industrial Average (DJIA) index fell by 6400 points in just four trading days, the equivalent of about 26%. By comparison, the DJIA fell 24.5% on 28–29 October 1929 and 22.6% on October 19 1987 (Mazur, Dang, and Vega 2021, pp. 1, 3).

The study by Nguyen shows that the COVID-19 pandemic negatively affected stock markets around the world, although the onset varied across countries. The first signs of significant volatility in Asia appeared just before the end of December 2019, when rumours of a strange disease started to emerge. Next, right at the beginning of 2020, stock markets in Europe experienced a slowdown, but large declines appeared starting from week 7 of 2020. In the US and Canadian stock markets, there was no volatility until week 8. From February 24, the situation began to change dramatically. Stock markets entered another phase, called by some the fever phase (Ramelli and Wagner 2020, p. 662; Wagner 2020, p. 440). In the US, in the month between February 24 and March 24, there were 18 price spikes ( $\pm 2.5\%$ ) during 22 trading days – more than ever before in history. The frequency of such price spikes was 20 times higher than the average since 1900, and, it should be noted, the large daily movements in stock prices were bidirectional (Baker et al. 2020, p. 746).

The Chicago Board Option Exchange Volatility Index (known as the VIX), often referred to as the “fear index”, showed a significant increase. Compared to previous high-risk cases, such as the September 11, 2001, terrorist attack (41.75), the 2008 global financial crisis (46.72), the 2011 US debt crisis (48) or the 2018 US-China trade conflict, COVID-19 with a VIX score of 84.57 is seen as a critical challenge for capital markets (Nguyen 2020). “Coronavirus has emerged as a bane for the financial markets with unexpected levels of uncertainty and high volatility. Within 100 days, nearly 30% of wealth has eroded off the bourses globally” (Ali, Alam, and Rizvi 2020, p. 6).

As shown by Zaremba et al. (2020, p. 2), conducted on data from 67 countries, the increase in volatility is not only the result of factors directly related to the pandemic, but also policy responses to COVID-19. Government interventions significantly and decisively increase volatility in international equity markets. Similar conclusions were

reached by Aharon and Siev (2021), who studied emerging markets. Heyden and Heyden (2021) demonstrated that only the first information about the number of deaths negatively impacted equity markets, and that policy responses (isolation, travel bans, stimulus packages) did not calm equity markets. Instead, they worsened the situation by fuelling investor uncertainty and increasing volatility. Interventions, particularly closures, disrupt economic activity, which is reflected in negative returns in financial capital markets. Most of these interventions appear to be associated with the creation of additional economic uncertainty (Aharon and Siev 2021).

The COVID-19 pandemic and related policy responses triggered a historically large wave of capital reallocations between markets toward safe assets, amplifying volatility (ElFayoumi and Hengge 2020, p. A1: 3). During the initial phase of the pandemic (Q1 2020), investors' herding behaviour was evident in international equity markets, amplifying uncertainty (Kizys, Tzouvanas, and Donadelli 2021, p. 9). In the current world, market sentiment in response to an outbreak can be quickly amplified through social media, which then stimulates trading activity and causes extreme price movements (Zhang, Hu, and Ji 2020, p. 2). As demonstrated by Liu et al. (2020, p. 4), investor sentiment is a transmission channel for the impact of the COVID-19 outbreak on stock markets.

The Spanish economy has been hit hard by the pandemic. From the beginning of January 2020 to March 16, 2020, the main index of the Spanish stock exchange (IBEX35) lost nearly 37%, with drops of more than 14% on the day after the WHO announced the pandemic (March 12, 2020) and nearly 8% on the day after the lockdown was introduced (March 16, 2020). The service sector, subject to the greatest government restrictions, suffered the most. On March 12, 16 and 23, the sector index fell -14.84, -18.23, and -12.67%, respectively (based on Refinitiv data). In the second quarter of 2020, Spain's GDP contracted by 18.5%, and the unemployment rate rose to 15.5% (Henríquez et al. 2020). Since then, the situation has slowly started to improve.

The situation was different in Poland, where the pandemic was just beginning to spread. Nevertheless, stock market reactions were similar. Between the beginning of January and March 16, 2020, the main index (WIG20) lost over 31%, and the worst day was also the day after the pandemic was announced (down 13.28%). At the same time, the broad market index (WIG) lost 36% (World Federation of Exchanges 2021). In the second quarter, Poland's GDP contracted by 8.2% (GUS 2020a), and the unemployment rate was 3% (GUS 2020b). Here, too, the situation began to improve.



## Research data and methodology

The research for the Spanish stock exchange covered the following sectors: petrol and power, basic material industry and construction, consumer foods, consumer services, financial services and real estate, and technology and telecommunications. The data were comprehensive, i.e. they included listings for sectors that included companies from the Madrid, Barcelona, Bilbao and Valencia stock exchanges.

In order to compare the results, the following sectors of the Warsaw Stock Exchange were taken into account in the research: energy, mining, fuels, construction, chemicals, food, clothing, automotive, pharmaceuticals, media, games, banks, telecommunications, IT, and real estate. Abbreviations for sectors and indices of particular stock exchanges were also introduced (Table 2).

Table 2. Introduced assays for testing

Index/sub-index Spanish Stock Exchange	Designation	Index/sub-index Polish Stock Exchange	Designation
petrol	H1	energy	P1
materials	H2	mining	P2
goods	H3	oil & gas	P3
services	H4	construction	P4
financial	H5	chemicals	P5
technology	H6	food	P6
IBEX	H7	clothes	P7
		moto	P8
		medicine	P9
		media	P10
		games	P11
		banks	P12
		telecommunications	P13
		IT	P14
		developers	P15
		WIG	P16

Source: own study.

The data concerned daily closing prices for the period 3.03.2019–31.03.2021. The whole period was divided into two sub-periods, where the date of the division was the lowest value of the closing price of the main stock exchange indices. In this way, periods

of similar length were adopted for the study. Furthermore, quotations of the IBEX35 and WIG indices were adopted for the research. Both indices are seen as images of the condition of individual stock exchanges. They gave a picture related to the situation on the Spanish and Polish markets. They were also the basis for setting the split date for the sectoral indices. For the Spanish stock exchange, the split date was March 16, 2020, and for the Warsaw stock exchange, it was March 12, 2020.

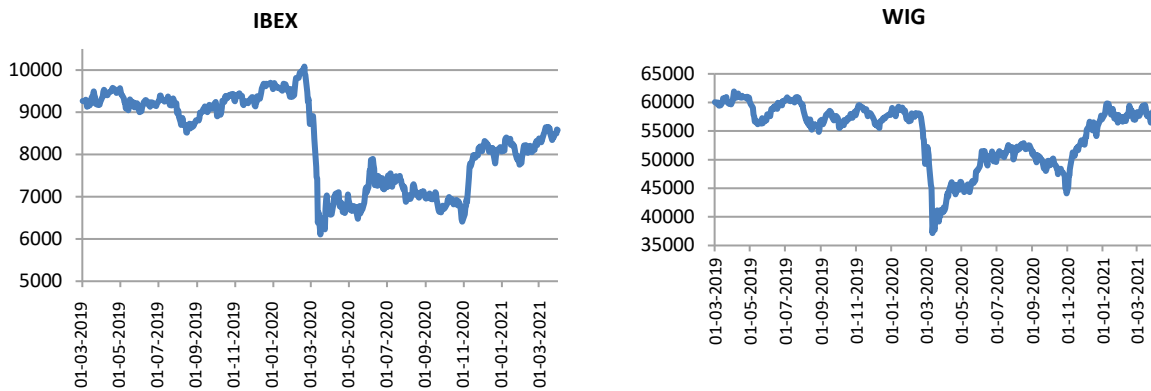


Figure 2. Quotations of the IBEX35 and WIG indices

Source: own study.

The research was conducted within each stock exchange separately and consisted of several stages. The first stage involved determining basic descriptive statistics for the index and stock sub-indices. They gave the basic knowledge about the behaviour of quotations in individual periods separately for each stock exchange. Characteristics such as mean, median, standard deviation, skewness and kurtosis, and rate of return (in %) were determined here.

The second step was to find sectors and indices that were similar in terms of price performance and volatility. However, due to the differences in scales between the sectors or between a sector and a country's market index, it became impossible to compare the indices among themselves. Therefore, a normalization transformation of the form had to be applied:

$$z_{ij} = \frac{p_{ij} - \min_i p_{ij}}{R_j} \quad (1)$$

where  $p_{ij}$  is the value of the  $j$ -th variable for object  $i$ ;  $\min_i p_{ij}$  ( $i = 1, 2, \dots, n$ ) is the smallest value of the  $j$ -th variable;  $R_j$  is the range of the  $j$ -th variable;  $j = 1, 2, \dots, m$ .

The chosen unitisation transformation brought the quotations of the indices down to a spread of 1, but left proportional variation in the quotations of the stock indices



in terms of standard deviation. This is particularly important for further research on determining similar groups in terms of volatility.

For the data of each sector in each sub-period after the unitisation transformation, the mean and standard deviation were determined. The variables would not be correlated with each other, which allowed us to proceed to the cluster analysis. Ward's method (Ward 1963) was used to find industries and indices similar to each other. It is a hierarchical method that groups objects into homogeneous clusters characterised by minimum variance. Its implementation starts by marking an index treated as an object as a one-element cluster. Then, by determining the distances between the clusters, objects are combined to form a new two-element cluster. Next, a new distance matrix is determined, in which the distances of objects from the resulting cluster are calculated according to the adopted binding rule. In Ward's method, the binding involves minimising the sum of squares of deviations inside the clusters. The procedure is continued until all objects are collected in one cluster. The distance in Ward's method is understood as the Euclidean distance. The cut-off point was determined using a graph showing the distances between clusters at the moment they merge. The visible flattening gave information about the distant clusters and thus about the corresponding cut-off point.

Finding industries and indices similar to each other allows us to proceed to step three. For pairwise similar industries and indices, one-way dependence was examined using the Granger causality test. It aims to identify the indices that cause changes in the indices from a given pair taken for the study.

This step started by determining the daily logarithmic rate of return according to the formula:

$$r_t = \ln \frac{p_t}{p_{t-1}} \quad (2)$$

where  $p_t, p_{t-1}$  – quotations of indices at time  $t$  and  $t-1$ .

The stage of testing unidirectional dependencies is preceded by the test of non-stationarity of the series of returns, as such an assumption is required in the Granger causality test. The Dickey-Fuller test (ADF) was used here, in which the null hypothesis of non-stationarity of these tested series is put forward against the alternative hypothesis of its stationarity (Dickey and Fuller 1979; 1981).

The starting point is the following equations (Granger 1981):

$$y_t = \alpha_0 + \sum_{i=1}^k \alpha_i y_{t-i} + \varepsilon_t \quad (3)$$

$$y_t = \beta_0 + \sum_{i=1}^k \beta_i y_{t-i} + \sum_{i=1}^k \gamma_i x_{t-i} + \eta_t \quad (4)$$

where  $y_t, x_t$  – time series representing the realisation of stationary stochastic processes;  $\alpha_0, \alpha_i, \beta_0, \beta_i, \gamma_i$  for  $i = 1, 2, \dots, k$  – structural coefficients of both models estimated by the classical least squares method;  $\varepsilon_t$  i  $\eta_t$  – random components;  $k$  – order of delays.

Since the dependence is examined here unidirectionally, lagged variables  $x_t$  and  $y_t$  are taken as explanatory variables in the models. In order to ascertain the effect of variable  $x_t$  on  $y_t$ , the coefficients  $\gamma_i$  are tested, posing the null hypothesis regarding the variance of the random components that  $H_0 : \sigma^2(\varepsilon_t) = \sigma^2(\eta_t)$ , against the alternative hypothesis that  $H_0 : \sigma^2(\varepsilon_t) \neq \sigma^2(\eta_t)$ .

The Wald version of the test statistic is of the form:

$$G = \frac{N(S^2(\varepsilon_t) - S^2(\eta_t))}{S^2(\varepsilon_t)} \quad (5)$$

where  $S^2(\varepsilon_t), S^2(\eta_t)$  – estimators of respective residual components in (3) and (4);  $N$  – sample size.

The value of Ward's version statistic is compared with the critical value of the  $\chi^2(k)$  distribution, where  $k$  is the lag order of the  $y$  and  $x$  variables. The research was conducted at significance levels of 0.1, 0.05 and 0.01 and lag row  $k = 5$ .

The research based on the methods mentioned above will verify the following research hypotheses:

H<sub>1</sub>: There is a similarity between industries (H1 and H3), (H4 and H5) for the Spanish stock market.

H<sub>2</sub>: The fuel sector is driving changes in the food sector, and the financial sector is driving changes in the services sector for the Spanish stock exchange.

H<sub>3</sub>: There is a similarity between sectors P11 and P14 for the Warsaw Stock Exchange.

H<sub>4</sub>: In the second sub-period, there is less correlation between sectors.

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## Empirical results

The successive stages described in Chapter 3 will help realize the research objective and verify the research hypotheses.

The first stage is implemented by descriptive statistics for price quotations of the IBEX35 index and individual sectors of the Spanish stock exchange. When comparing the basic characteristics of the index quotations in both periods, it is possible to see both lower average and median values in period two. After a sharp decline, sectors were unable to catch up despite the upward trend. Volatility, as measured by standard deviation, outside the sectors of industry and construction and technology and telecommunications was higher in period two.

For the Warsaw Stock Exchange, the situation is slightly different. In the second period, there are sectors for which the average and median values are higher than in the first period: construction, chemicals, moto, games, and IT. Except for the chemical industry, these sectors, which were in an upward trend in period one after a sharp downturn, achieved higher results than in period one. In these cases, the pandemic period did not harm these industries, and one might be tempted to say that these industries benefited from the pandemic.

In the next step, the variables were unitised, and Ward’s method was applied, taking into account the mean and standard deviation of the indices. As a result, the clusters shown in Figures 3 and 4 were distinguished for the Spanish stock exchange.

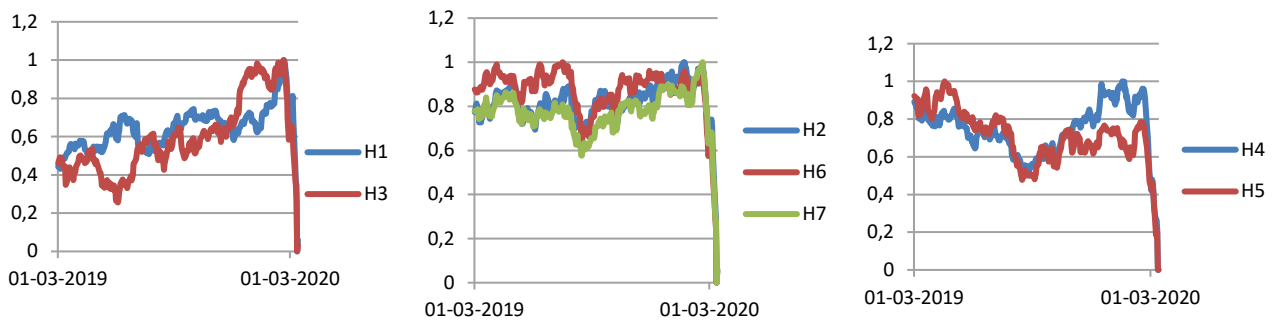


Figure 3. Clusters in the 1<sup>st</sup> sub-period for the Spanish stock exchange

Source: own study.

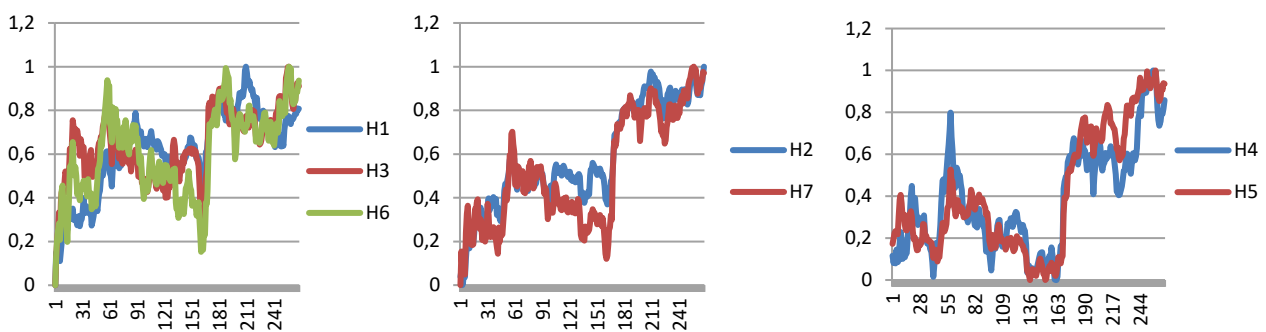


Figure 4. Clusters in the second sub-period for the Spanish stock exchange

Source: own study.

Cluster one included the energy and fuel industries, which were in an upward trend during period one. Cluster two included industry and construction, technology and telecommunications and the IBEX35 index. These sectors thus largely influenced the quotations of the IBEX25 index itself. Cluster three, which included the financial and consumer services industries, was in a downtrend in period one.

In sub-period two, the technology and telecommunications sector moved from cluster two to cluster one. Focus three remained identical. Thus, in both sub-periods, one may notice the similarity of the same sectors.

A similar procedure was carried out for the Polish stock exchange. The resulting clusters are presented in Figures 5 and 6.

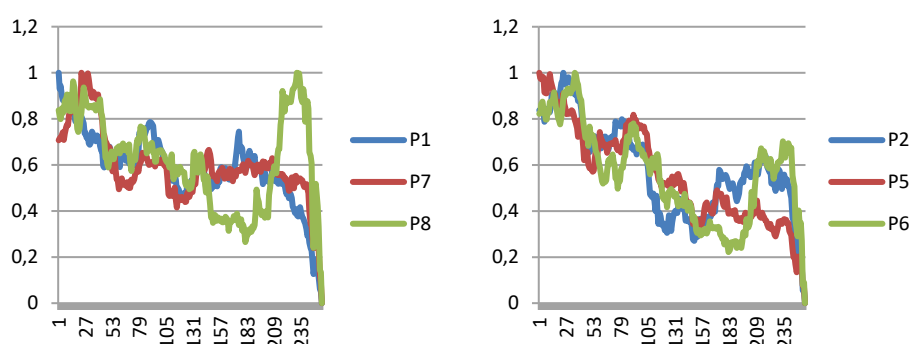


Figure 5. Clusters in the first sub-period for the Polish stock exchange

Source: own study.

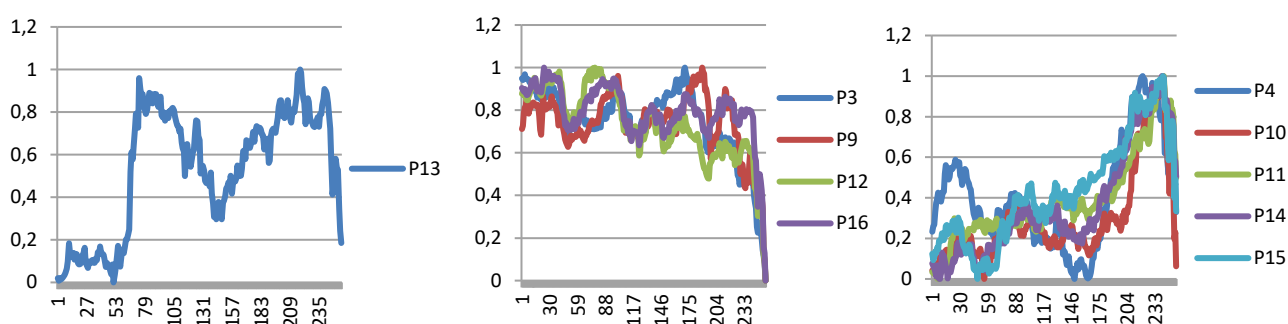


Figure 6. Clusters in the second sub-period for the Polish stock exchange

Source: own study.

For the Warsaw Stock Exchange, since more sub-indices were taken into account, more clusters appeared. The first cluster included the energy, moto and clothing industries. Apart from moto, which saw an increase before a sharp fall in value, the others were in a downward trend. Cluster two included the mining, chemical and food industries. Here, too, there was a downward trend. Cluster three included only the telecommunications sector. It differed from the others; hence it was the only one in this cluster. The fourth cluster, including the fuel

sector, pharmaceuticals, banks and the WIG index, tended to remain at a similar level with a downward trend at the end of the period. The last cluster included construction, media, games, IT and developers, which were in an upward trend in period one.

In period two, there was a complete shuffling of sectors in the various clusters. Only IT and games were still similar, as in period one. There was also one more cluster, which included the medicine industry. Such an unpredictable and sudden event, which affected the real economy of virtually the whole world with unprecedented speed, also caused significant changes in the functioning of sectors, with numerous restrictions and limitations affecting individual sectors to varying degrees. This was reflected in the quotations of listed companies, which resulted in a complete dislocation of sectors in particular clusters in the Warsaw Stock Exchange and significant movements in the Spanish stock exchanges.

The final stage of the research was a Granger causality test between indices within a cluster. It was based on the stationarity of the return series under study. If a cluster was single-element, it was not taken for further analysis. On the other hand, if the clusters contained more than two indices, the research was conducted in pairs, taking into account all possible combinations of those pairs. The results of verifying the Granger causality test can be seen in Tables 3 and 4.

**Table 3.** Delays at which causality occurs (Spanish stock exchange)

Period I	k	Period II	k
H1→H3	2,3,4,5	H1→H3	5
H3→H1	1	H6→H1	1,5
H6→H2	2,3,4	H7→H2	1,2,3,4,5
H2→H7	1,2,3,4,5	H5→H4	1,3,4,5
H6→H7	1,2		
H4→H5	1,2,3,4,5		
H5→H4	3,4,5		

Source: own study.

In the Spanish stock market, where the number of sectors was smaller, unidirectional relationships in both periods are more noticeable. In the first cluster, the fuel and energy sector appeared to be the cause of food changes. This occurred in both Period I and Period II. Industry and construction and technology and telecommunications were the cause of changes in the IBEX35 index in Period I. Consumer services were the cause of changes in financial services and real estate in Period I. The reverse relationship also occurred, and did so in both periods.

Table 4. Delays at which causality occurs (Polish stock exchange)

Period I	k	Period II	k
P7→P8	2,3,4	P3→P1	2
P2→P6	2	P1→P16	1
P5→P6	2,3,4,5	P16→P1	1,2
P3→P9	1,2,3,4,5	P3→P5	2
P3→P12	1,2,3,4,5	P3→P16	4,5
P3→P16	1,2,3	P16→P3	5
P12→P9	3,4,5	P13→P16	5
P16→P12	1	P14→P11	1,2
P16→P9	2,3,4,5	P12→P6	4,5
P4→P10	1,2,3,4,5	P8→P15	4,5
P11→P10	1,2,3,4,5	P15→P8	3,4,5
P10→P14	1,2,3,4,5		
P14→P10	1,2,3,4,5		
P10P15	1,2,3		
P15P10	3,4,5		
P11P14	2,3,4,5		
P11→P15	1		
P15→P11	3,4,5		
P14→P15	4,5		
P15→P14	1,2,3,4,5		

Source: own study.

In the Warsaw Stock Exchange, as the sectors were in different clusters in both periods, it is difficult to find the same relationships between pairs of sectors. There were far fewer relationships in Period II. This can be interpreted as other factors having a greater influence on the behaviour of the sectors in a period of such high uncertainty. Even similar industries such as games and IT behaved differently in the two periods. In period one, the games industry was the cause of the IT industry's changes, while in period two, the relationship was the other way around. It is important to remember that sectors are heterogeneous (Narayan and Sharma 2011, p. 3262) and are therefore likely to react differently to market shocks.

The results obtained for the Polish and Spanish stock markets are consistent with the results for the markets of other countries (Shen et al. 2020; Zarembo et al. 2020; Kizys, Tzouvanas, and Donadelli 2021) and sectors (Nguyen 2020; Hanif, Mensi, and Vo 2021; Narayan, Gong, and Ali Ahmed 2021). Hanif, Mensi, and Vo's (2021, p. 3) analysis



of the dependence structure and risk spillovers between US and Chinese listed sectors in the pre- and post-pandemic periods indicates that COVID-19 had an impact on changing the dependence structure of sectors. The differential impact of the pandemic on sectors is also confirmed by a few studies from other markets (Liu, Zhang, and Zhang 2020; Nguyen 2020; Narayan, Gong, and Ali Ahmed 2021). The results are thus in line with the mainstream, showing the asymmetry of the pandemic's impact on inter-sectoral dependencies.

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## Conclusions

The aim of the research was to investigate similarity and Granger causality between sectors within a stock exchange. The similarities found between sectors made it possible to indicate which sectors that are similar to each other were the cause of changes in other sectors and to verify the hypotheses. For the Spanish stock exchange, unidirectional relationships in both periods are more discernible. In the first cluster, the fuel and energy sector appeared to be the cause of food changes. The energy sector is often treated as a potential multiplier of change because of the links between oil prices and other sectors of the economy. The impact of shocks in this sector on other areas of economic activity varies depending on the sector's dependence on energy consumption (Laborda and Olmo 2021, p. 2). Industry and construction and technology and telecommunications were the cause of changes in the IBEX35 index in Period I. Consumer services drove changes in the financial and real estate sectors (confirming  $H_1$  and  $H_2$ ). The inverse relationship also occurred, and in both periods. It should be noted that the last three sectors distribute consumer income into spending, saving and investment; hence, it should be assumed that these sectors interact with each other.

In the Polish stock market, it is difficult to indicate such unidirectional dependencies. Only IT and games were still similar (confirming  $H_3$ ). The likely reason for this is the overly large number of sectors represented by a relatively small number of companies, which do not reflect the actual economic and financial state of a given sector. As a consequence, this may distort mutual relations and give ambiguous results.

In the second period, there was a complete reshuffling of the sectors in each cluster for both markets, which resulted in a lower correlation between sectors (confirming the last hypothesis). Both the pandemic and the administrative restrictions that changed the rules of the markets affected the similarities and causality of sectors. To what extent these changes are permanent will be possible to assess in the long term.

## References

- Adnan, A.T.M., Hasan, M.M. (2021), *The emergence of COVID-19 and capital market reaction: An emerging market scenario analysis*, "Asian Academy of Management Journal of Accounting and Finance", 17 (1), pp. 35–62, <https://doi.org/10.21315/aamjaf2021.17.1.2>
- Aharon, D.Y., Siev, S. (2021), *COVID-19, government interventions and emerging capital markets performance*, "Research in International Business and Finance", 58, 101492, <https://doi.org/10.1016/j.ribaf.2021.101492>
- Akhtaruzzaman, M., Boubaker, S., Sensoy, A. (2021), *Financial contagion during COVID-19 crisis*, "Finance Research Letters", 38, 101604, <https://doi.org/10.1016/j.frl.2020.101604>
- Albulescu, C.T. (2021), *COVID-19 and the United States financial markets' volatility*, "Finance Research Letters", 38, 101699, <https://doi.org/10.1016/j.frl.2020.101699>
- Ali, M., Alam, N., Rizvi, S.A.R. (2020), *Coronavirus (COVID-19) – An epidemic or pandemic for financial markets*, "Journal of Behavioral and Experimental Finance", 27, 100341, <https://doi.org/10.1016/j.jbef.2020.100341>
- Ashraf, B.N. (2020), *Stock markets' reaction to COVID-19: Cases or fatalities?*, "Research in International Business and Finance", 54, 101249, <https://doi.org/10.1016/j.ribaf.2020.101249>
- Baek, S., Mohanty, S.K., Glambosky, M. (2020), *COVID-19 and stock market volatility: An industry level analysis*, "Finance Research Letters", 37, 101748, <https://doi.org/10.1016/j.frl.2020.101748>
- Baker, S.R., Bloom, N., Davis, S.J., Kost, K., Sammon, M., Viratyosin, T. (2020), *The Unprecedented Stock Market Reaction to COVID-19*, "The Review of Asset Pricing Studies", 10 (4), pp. 742–758, <https://doi.org/10.1093/rapstu/raaa008>
- Dickey, D.A., Fuller, W.A. (1979), *Distribution of the estimators for autoregressive time series with a unit root*, "Journal of the American Statistical Association", 74 (366a), pp. 427–431, <https://doi.org/10.1080/01621459.1979.10482531>
- Dickey, D.A., Fuller, W.A. (1981), *Likelihood ratio statistics for autoregressive time series with a unit root*, "Econometrica: Journal of the Econometric Society", 49 (4), pp. 1057–1072, <https://doi.org/10.2307/1912517>
- ElFayoumi, K., Hengge, M. (2021), *Capital Markets, COVID-19 and Policy Measures*, "IMF Working Paper", No. 2021 (033), <https://doi.org/10.2139/ssrn.3799625>
- Gębka, B., Serwa, D. (2007), *Intra- and inter-regional spillovers between emerging capital markets around the world*, "Research in International Business and Finance", 21 (2), pp. 203–221, <https://doi.org/10.1016/j.ribaf.2006.03.005>
- Granger, C.W.J. (1981), *Some properties of time series data and their use in econometric model specification*, "Journal of Econometrics", 16 (1), pp. 121–130, [https://doi.org/10.1016/0304-4076\(81\)90079-8](https://doi.org/10.1016/0304-4076(81)90079-8)
- GUS (2020a), *Wstępny szacunek produktu krajowego brutto w drugim kwartale 2020 r.*, Warszawa, <https://stat.gov.pl/obszary-tematyczne/rachunki-narodowe/kwartalne-rachunki-narodowe/wstepny-szacunek-produktu-krajowego-brutto-w-drugim-kwartale-2020-r,3,72.html> (accessed: 30.06.2021).

- GUS (2020b), *Bezrobocie rejestrowane. II kwartał 2020 r.*, Warszawa, <https://stat.gov.pl/obszary-tematyczne/rynek-pracy/bezrobocie-rejestrowane/bezrobocie-rejestrowane-ii-kwartal-2020-roku,3,41.html> (accessed: 30.06.2021).
- Hanif, W., Mensi, W., Vo, X.V. (2021), *Impacts of COVID-19 outbreak on the spillovers between US and Chinese stock sectors*, "Finance Research Letters", 40, 101922, <https://doi.org/10.1016/j.frl.2021.101922>
- Harjoto, M.A., Rossi, F., Lee, R., Sergi, B.S. (2020), *How do equity markets react to COVID-19? Evidence from emerging and developed countries*, "Journal of Economics and Business", 105966, <https://doi.org/10.1016/j.jeconbus.2020.105966>
- Henríquez, J., Gonzalo-Almorox, E., García-Goñi, M., Paolucci, F. (2020), *The first months of the COVID-19 pandemic in Spain*, "Health Policy and Technology", 9 (4), pp. 560–574, <https://doi.org/10.1016/j.hlpt.2020.08.013>
- Heyden, K.J., Heyden, T. (2021), *Market reactions to the arrival and containment of COVID-19: An event study*, "Finance Research Letters", 38, 101745, <https://doi.org/10.1016/j.frl.2020.101745>
- Kizys, R., Tzouvanas, P., Donadelli, M. (2021), *From COVID-19 herd immunity to investor herding in international stock markets: The role of government and regulatory restrictions*, "International Review of Financial Analysis", 74, 101663, <https://doi.org/10.1016/j.irfa.2021.101663>
- Laborda, R., Olmo, J. (2021), *Volatility spillover between economic sectors in financial crisis prediction: Evidence spanning the great financial crisis and Covid-19 pandemic*, "Research in International Business and Finance", 57, 101402, <https://doi.org/10.1016/j.ribaf.2021.101402>
- Liu, H., Manzoor, A., Wang, C., Zhang, L., Manzoor, Z. (2020), *The COVID-19 Outbreak and Affected Countries Stock Markets Response*, "International Journal Environmental Research Public Health", 17 (8), 2800, <https://doi.org/10.3390/ijerph17082800>
- Liu, Z., Zhang, T., Zhang, G. (2020), *Heterogeneous Stock Market Reactions to COVID-19: More Hidden Mechanisms*, <https://doi.org/10.2139/ssrn.3697622>
- Mazur, M., Dang, M., Vega, M. (2021), *COVID-19 and the march 2020 stock market crash. Evidence from S&P1500*, "Finance Research Letters", 38, 101690, <https://doi.org/10.1016/j.frl.2020.101690>
- MSCI (n.d.), <https://www.msci.com/end-of-day-data-country> (accessed: 31.06.2021).
- MSCI Indexes (n.d.), <https://app2.msci.com/products/indexes/performance?&size=30&scope=C&style=C&currency=15&priceLevel=0&indexId=95> (accessed: 31.06.2021).
- Narayan, P.K., Sharma, S.S. (2011), *New evidence on oil price and firm returns*, "Journal of Banking & Finance", 35 (12), pp. 3253–3262, <https://doi.org/10.1016/j.jbankfin.2011.05.010>
- Narayan, P.K., Gong, Q., Ali Ahmed, H.J. (2021), *Is there a pattern in how COVID-19 has affected Australia's stock returns?*, "Applied Economics Letters", 29 (3), pp. 179–182, <https://doi.org/10.1080/13504851.2020.1861190>
- Nguyen, K. (2020), *A coronavirus outbreak and sector stock returns: the tale from the first ten weeks of year 2020*, <https://doi.org/10.2139/ssrn.3559907>
- Onali, E. (2020), *COVID-19 and Stock Market Volatility*, <https://doi.org/10.2139/ssrn.3571453>

- Pera, J. (2019), *The Effectiveness of Investing in Stock Exchange Markets in Central and Eastern European Countries with Regard to NYSE2-LSE-HKSE2. A Comparative Risk Analysis*, "Comparative Economic Research. Central and Eastern Europe", 22 (2), pp. 121–140, <https://doi.org/10.2478/cer-2019-0016>
- Phan, D.H., Narayan, P.K. (2020), *Country Responses and the Reaction of the Stock Market to COVID-19 – a Preliminary Exposition*, "Emerging Markets Finance and Trade", 56 (10), pp. 2138–2150, <https://doi.org/10.1080/1540496X.2020.1784719>
- Pražák, T., Stavárek, D. (2017), *The relationship between stock market development and macroeconomic fundamentals in the Visegrad group*, "Comparative Economic Research. Central and Eastern Europe", 20 (3), pp. 5–23, <https://doi.org/10.1515/cer-2017-0017>
- Ramelli, S., Wagner, A.F. (2020), *Feverish Stock Price Reactions to COVID-19*, "Review of Corporate Finance Studies", 9 (3), pp. 622–655, <https://doi.org/10.1093/rcfs/cfaa012>
- Shen, H., Fu, M., Pan, H., Yu, Z., Chen, Y. (2020), *The Impact of the COVID-19 Pandemic on Firm Performance*, "Emerging Markets Finance and Trade", 56 (10), pp. 2213–2230, <https://doi.org/10.1080/1540496X.2020.1785863>
- Souza de Souza, P.V., Augusto, C. (2020), *Effects of COVID-19 Pandemic on International Capital Markets*, "International Journal of Economics and Financial", 10 (6), pp. 163–171, <https://doi.org/10.32479/ijefi.10702>
- Syllignakis, M.N., Kouretas, G.P. (2011), *Dynamic correlation analysis of financial contagion: Evidence from the Central and Eastern European markets*, "International Review of Economics & Finance", 20 (4), pp. 717–732, <https://doi.org/10.1016/j.iref.2011.01.006>
- Šimáková, J., Rusková, N. (2019), *The Role of Exchange Rates in the Stock Price Development of Chemical Companies in the Visegrad Four Countries*, "Comparative Economic Research. Central and Eastern Europe", 22 (3), pp. 117–129, <https://doi.org/10.2478/cer-2019-0026>
- Wagner, A.F. (2020), *What the stock market tells us about the post-COVID-19 world*, "Nature Human Behaviour", 4 (5), 440, <https://doi.org/10.1038/s41562-020-0869-y>
- Ward, J.H. (1963), *Hierarchical grouping to optimize an objective function*, "Journal of American Statistical Association", 58 (301), pp. 236–244, <https://doi.org/10.1080/01621459.1963.10500845>
- World Federation of Exchanges (2021), *2020 Annual Statistics Guide*, <https://www.world-exchanges.org/our-work/articles/2020-annual-statistics-guide> (accessed: 30.06.2021).
- World Health Organization (2020), *Coronavirus disease 2019 (COVID-19): situation report, 51*, <https://apps.who.int/iris/handle/10665/331475> (accessed: 30.06.2021).
- World Health Organization (n.d.), *WHO Coronavirus (COVID-19) Dashboard*, <https://covid19.who.int/table> (accessed: 15.08.2021).
- Zaremba, A., Kizys, R., Aharon, D.Y., Demir, E. (2020), *Infected Markets: Novel Coronavirus, Government Interventions, and Stock Return Volatility around the Globe*, "Finance Research Letters", 35, 101597, <https://doi.org/10.1016/j.frl.2020.101597>

- Zhang, D., Hu, M., Ji, Q. (2020), *Financial markets under the global pandemic of COVID-19*, "Finance Research Letters", 36, 101528, <https://doi.org/10.1016/j.frl.2020.101528>
- Żebrowska-Suchodolska, D., Karpio, A., Kompa, K., (2021), *Covid-19 Pandemic: Stock Markets Situation in European Ex-Communist Countries*, "European Research Studies Journal", XXIV (3), pp. 1106–1128, <https://doi.org/10.35808/ersj/2408>

## Podobieństwo i przyczynowość w sensie Grangera sektorów rynku giełdowego Polski i Hiszpanii w okresie pandemii COVID-19

Rynki kapitałowe reagują prawie natychmiast na sytuacje kryzysowe. Zależności takie mogą mieć zarówno charakter międzynarodowy, jak i lokalny. Badania skupiają się na giełdach dwóch krajów: Hiszpanii i Polski. Kraje te są często porównywane do siebie pod względem różnych kryteriów gospodarczych i społecznych. Badania dotyczą okresu od 3 marca 2019 roku do 31 marca 2021 roku. Celem badań jest identyfikacja sektorów i indeksów podobnych do siebie na poziomie lokalnym oraz wskazanie wśród par indeksów podobnych tych, które stanowią impuls dla innego sektora. Do badań wykorzystano metodę hierarchiczną analizy skupień (metoda Warda) oraz test przyczynowości Grangera. W niniejszej pracy przedstawiono nowatorskie podejście do porównań sektorowych na poziomie lokalnym.

**Słowa kluczowe:** koronawirus, sektory gospodarki, zmienność finansowa, podobieństwo