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Methods of analysis and forecasting of the main indexes of  
the London Stock Exchange

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## Contents

Contents .....	2
Introduction.....	3
I. Stock exchange .....	3
II. Indexes .....	4
1. FTSE 100 .....	4
2. FTSE 350 Banks.....	4
3. FTSE 350 Financial Services .....	4
III. Analysis of the main indexes.....	5
<b>FTSE 100</b> .....	5
<b>FTSE 350 Banks</b> .....	6
<b>FTSE 350 Financial Services</b> .....	7
IV. Analysis of index values .....	9
A. Degree of process integration. ....	9
B. Long-term linking of indexes. ....	15
C. Has the crisis affected the degree of model integration? .....	19
D. Research hypothesis.....	19
V. Analysis of rates of return.....	20
A. Compatibility of the distribution of rates of return with the normal distribution. ....	20
B. Occurrence of group I effects. ....	21
C. Stationarity of processes. ....	25
D. Research question: .....	27
VI. AR, MA, ARMA or ARIMA modeling: .....	28
A. Analysis:.....	28
B. Research hypothesis.....	33
Ending.....	34

## Introduction

The aim of the study is to check whether political and economic changes in recent years have had an impact on the formation of stock market indices. The FTSE 100 index and two indices concerning the banking sector FTSE 350 and the financial services sector FTSE 350 were used for the study. The study will be conducted in the period from January 1, 2016 to October 25, 2023. The analysis will be carried out on daily and weekly data and taking into account sub-periods, i.e. the period of peace (from January 1, 2016 to March 8, 2020) and the period of crisis (from March 9, 2020 to October 25, 2023). Four hypotheses will be verified during the study:

- $H_0$ : The risk assumption guarantee in factoring programs is the provision of a guarantee and the assumption of part of the risk of insolvency of an entrepreneur, a client of a commercial bank or a domestic factoring company (factor) by BGK in connection with: increasing the factoring limit (commitment), or granting a new factoring limit (commitment).
- $H_1$ : Will the model classes change if time series aggregation is applied?
- $H_2$ : What effects characterize the primary index and how are they related to the class of models?
- $H_3$ : Which sector indices are related to the main index and thus the same classes of models can be correctly used?

### I. Stock exchange

The London Stock Exchange is a stock exchange located in the United Kingdom in the city of London. The regional stock exchanges that were established over 300 years ago were merged in 1973 to create the Stock Exchange of Great Britain and Ireland, later renamed the London Stock Exchange (LSE). As of August 2023, the total market value of all companies listed on this exchange was \$3.18 trillion. The exchange is physically located in London. In 2007, the London Stock Exchange merged with the Milan Stock Exchange, Borsa Italiana, to create the London Stock Exchange Group. The London Stock Exchange has been the most valuable stock exchange in Europe since 2023. The London Stock Exchange is a global stock exchange on which companies from outside the United Kingdom are also listed. The Main Market of the London Stock Exchange is one of the most diverse stock markets in the world, with companies from 40 different sectors operating on it. The Main Market is home to over 1,300 major companies from 60 countries. The FTSE 100 (the “footsie”) is the main index of shares of the 100 largest UK companies listed on the Main Market. The London Stock Exchange is the main stock exchange in the UK and one of the largest in the world. It has a long history dating back to the 17th century and has evolved over its lifetime. Many of the world’s largest companies are listed on the exchange, including Shell, HSBC and BP.

## II. Indexes

### 1. FTSE 100

The FTSE 100 is an index of shares of companies listed on the London Stock Exchange. FTSE is an abbreviation of the Financial Times Stock Exchange. The index includes 100 of the largest companies that meet a number of requirements regarding liquidity, capitalisation etc. The FTSE 100 is considered a barometer of the British economy. The index is run by the FTSE Group, now a wholly owned subsidiary of the London Stock Exchange, which was established as a joint venture between the Financial Times and the London Stock Exchange. It is calculated in real time and published every second the market is open. It is one of the largest indices in Europe. The companies in the index account for around 80% of the LSE's capitalisation. The total market value of a company is calculated by multiplying the company's share price by the total number of shares it has in issue. However, many of these companies are international in scope, so changes in the index are a fairly poor indicator of the health of the British economy and are heavily influenced by exchange rates for the pound sterling. In October 2022, the largest companies in the index by capitalization were: Shell plc (£164 billion), AstraZeneca plc (£152 billion), Unilever plc (£97 billion), HSBC Holdings plc (£92 billion), BP plc (£85 billion), Diageo plc (£82 billion), British American Tobacco plc (£73 billion). The composition of the index is revised every three months. Every year, several to a dozen or so companies enter and leave it.

### 2. FTSE 350 Banks

The FTSE 350 Banks is an index of shares of companies listed on the London Stock Exchange. FTSE is an abbreviation of the Financial Times Stock Exchange. The index includes the 350 largest companies that meet a number of requirements regarding liquidity, capitalization, etc. The FTSE 350 Index is a market capitalization-weighted stock market index, consisting of the components of the FTSE 100 and FTSE 250 indices. The FTSE 100 Index includes the 100 largest companies by capitalization whose main listings are on the London Stock Exchange, while the FTSE 250 Index includes mid-cap companies not included in the FTSE 100 Index, i.e. places 101st to 350th largest. In October 2023, the largest companies in the index in terms of capitalization were: Bank of Georgia Group, Barclays, HSBC, Lloyds Banking, Metro Bank, NatWest Group, Standard Chartered, Virgin Money UK.

### 3. FTSE 350 Financial Services

The FTSE 350 Financial Services is an index of shares of companies listed on the London Stock Exchange. FTSE is an abbreviation of the Financial Times Stock Exchange. The index includes the 350 largest companies that meet a number of requirements regarding liquidity, capitalization, etc. The FTSE 350 Index is a market capitalization-weighted stock market index, consisting of the components of the FTSE 100 and FTSE 250 indices. The FTSE 100 Index includes the 100 largest companies by capitalization whose main listings are on the London Stock Exchange, while the FTSE 250 Index includes mid-cap companies not included in the FTSE 100 Index, i.e. places 101st to 350th largest. In October 2023, the largest companies in the index in terms of capitalization were: 3i Group, Ashmore, Close Brothers, CMC Markets,

IG Group, Intermediate Capital, Intl Personal Finance, Investec, IP Group, Jupiter FM, London Stock Exchange Group PLC, Man Group, OSB Group, Paragon Banking Group, Rathbones, Schroders, TP ICAP, Vanquis Banking.

### III. Analysis of the main indexes

Shaping stock market indices

#### FTSE 100

Chart 1. Price formation of the FTSE100 index before the pandemic



Chart 1 Source: own study based on [www.stoog.pl](http://www.stoog.pl)

Calm period – a linear upward trend with cyclicity was used. Two random components were introduced: the first in the last quarter of 2018 – the trade war, and the second on 03/08/2020 – the outbreak of the pandemic. The periodogram confirmed a significant trend and medium-term fluctuations. It excluded the occurrence of seasonal fluctuations. The R2 coefficient of determination was 0.982711, which means that the linear trend reflects the volatility of the index price by as much as 94%.

Chart 2. FTSE100 index price formation during the pandemic



Chart 2 Source: own study based on [www.stooq.pl](http://www.stooq.pl)

Crisis period – a linear upward trend with cyclicity was used. The periodogram confirmed a significant trend and medium-term fluctuations. It excluded the occurrence of seasonal fluctuations. We can see a quick rebound and return to the upward trend. After the rebound, the growth dynamics slow down slightly and the next period of faster growth occurs in Q2 and Q3 2022. The  $R^2$  determination coefficient was 0.984119, which means that the linear trend reflects the volatility of the index price by as much as 98%.

### FTSE 350 Banks

Chart 3. FTSE 350 Banks Index Price Performance Before the Pandemic

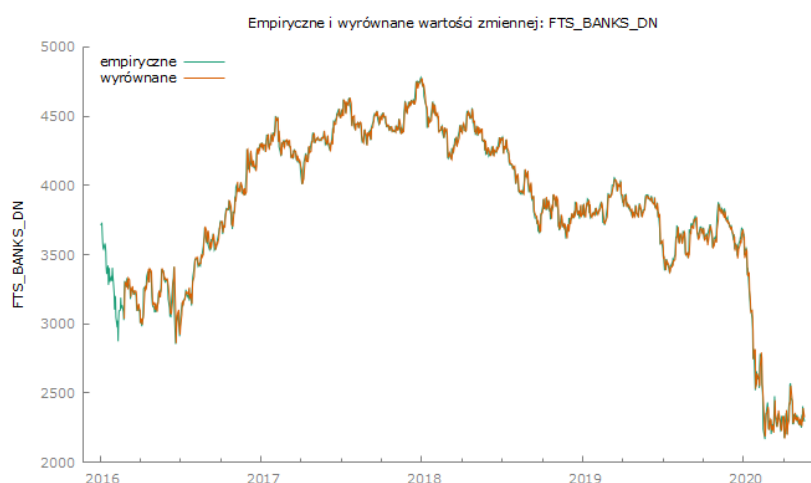


Chart 3 Source: own study based on [www.stooq.pl](http://www.stooq.pl)

Stability period – we observe dynamic growth and stabilization of the upward trend until the beginning of 2018, then the graph changes to a downward trend until the beginning of 2020, where a crisis breakdown occurs. A third-degree polynomial trend with cyclicity was used. In addition, a random component was introduced: 03/08/2020 - outbreak of the pandemic. The periodogram confirmed a significant trend and medium-term fluctuations. However, it excluded the occurrence of seasonal fluctuations. The  $R^2$  coefficient of determination was 0.993377, which means that the trend reflects the dynamics of the exchange rate by 99%.

Chart 4. FTSE 350 Banks Index Price Performance During the Pandemic

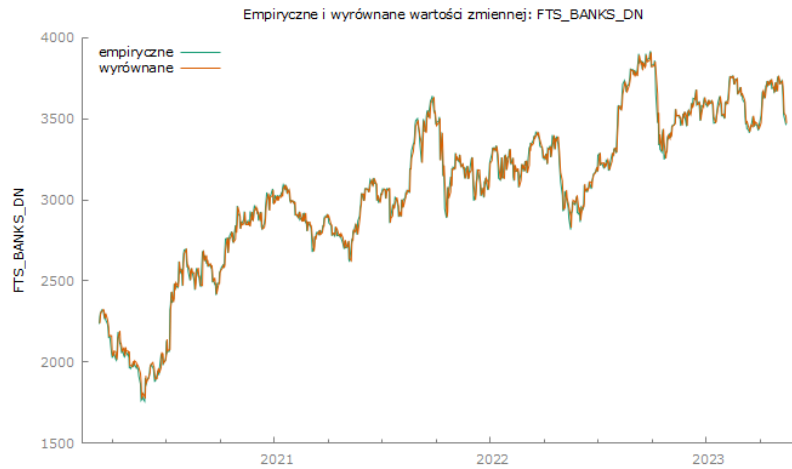


Chart 4 Source: own study based on [www.stoog.pl](http://www.stoog.pl)

Crisis period - a linear trend with cyclicalty was used. After the price bottom in Q2 2020, the index price recovered and a dynamic rebound occurred, which consolidated its upward trend. The periodogram confirmed a significant trend and medium-term fluctuations. The R2 determination coefficient was 0.989927, which means that the trend reflects the volatility of the exchange rate in almost 99%.

### FTSE 350 Financial Services

Chart 5. FTSE 350 Financial Services Index Price Performance Before the Pandemic

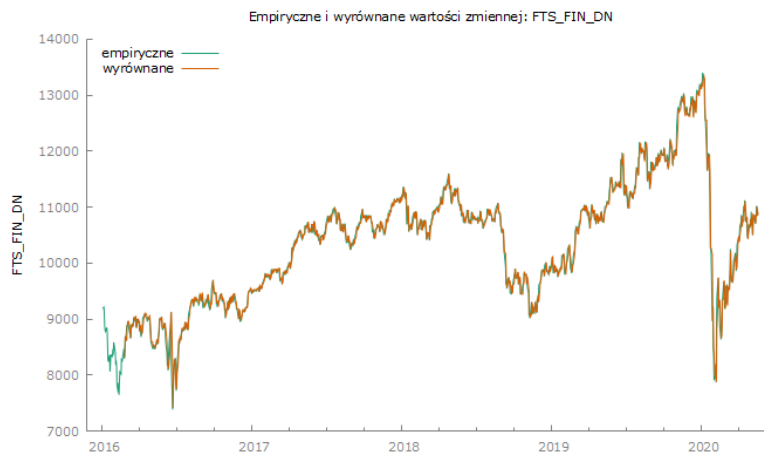


Chart 5 Source: own study based on [www.stoog.pl](http://www.stoog.pl)

Period of stability - we observe a stable increase in the index price, then a decrease in the second half of 2018. From the end of 2018, a stable increase is observed again, this time faster, which ends with a very strong decline at the turn of 2019/2020. A linear upward trend with cyclicalty was used. In addition, two random components were introduced: the first in the last quarter of 2018 - the trade war, and 03/08/2020 - the outbreak of the pandemic. The periodogram confirmed a significant trend and medium-term fluctuations. The R2

determination coefficient was 0.983997, which means that the linear trend reflects the dynamics (volatility) of the exchange rate by as much as 98%.

Chart 6. FTSE 350 Financial Services Index Price Performance During the Pandemic

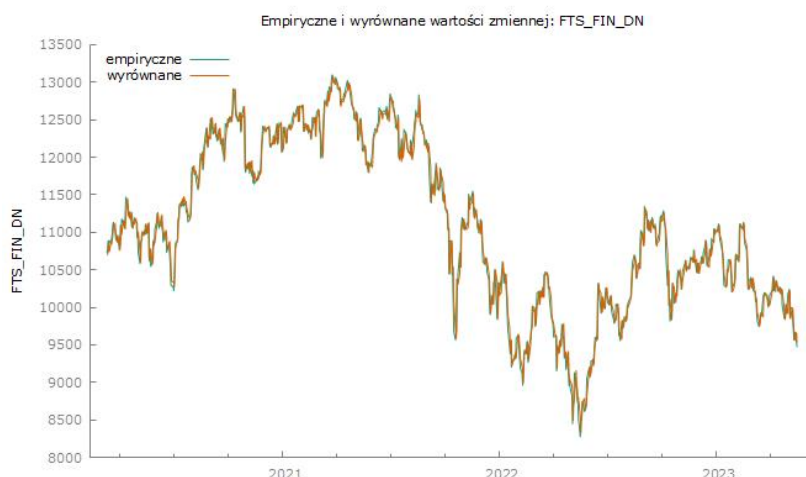


Chart 6 Source: own study based on [www.stooq.pl](http://www.stooq.pl)

Crisis period - A fourth-degree polynomial trend with cyclicity was applied. We can see a slight rebound after the pandemic, which stabilizes and then turns into a downward trend in mid-2021. In the second quarter of 2022, there is a rebound lasting a quarter and a half, only to turn into a decline again. The periodogram confirmed a significant trend and medium-term fluctuations. The R2 determination coefficient was 0.981971, which means that the trend reflects the dynamics of the exchange rate by as much as 98%.

In summary, in almost all indices, both before and after the pandemic, similarities can be observed, such as: a significant price drop accompanying the announcement of the pandemic, a price drop related to the trade war, or a post-pandemic recovery in index prices. Most models achieved a very good fit (94-99%).

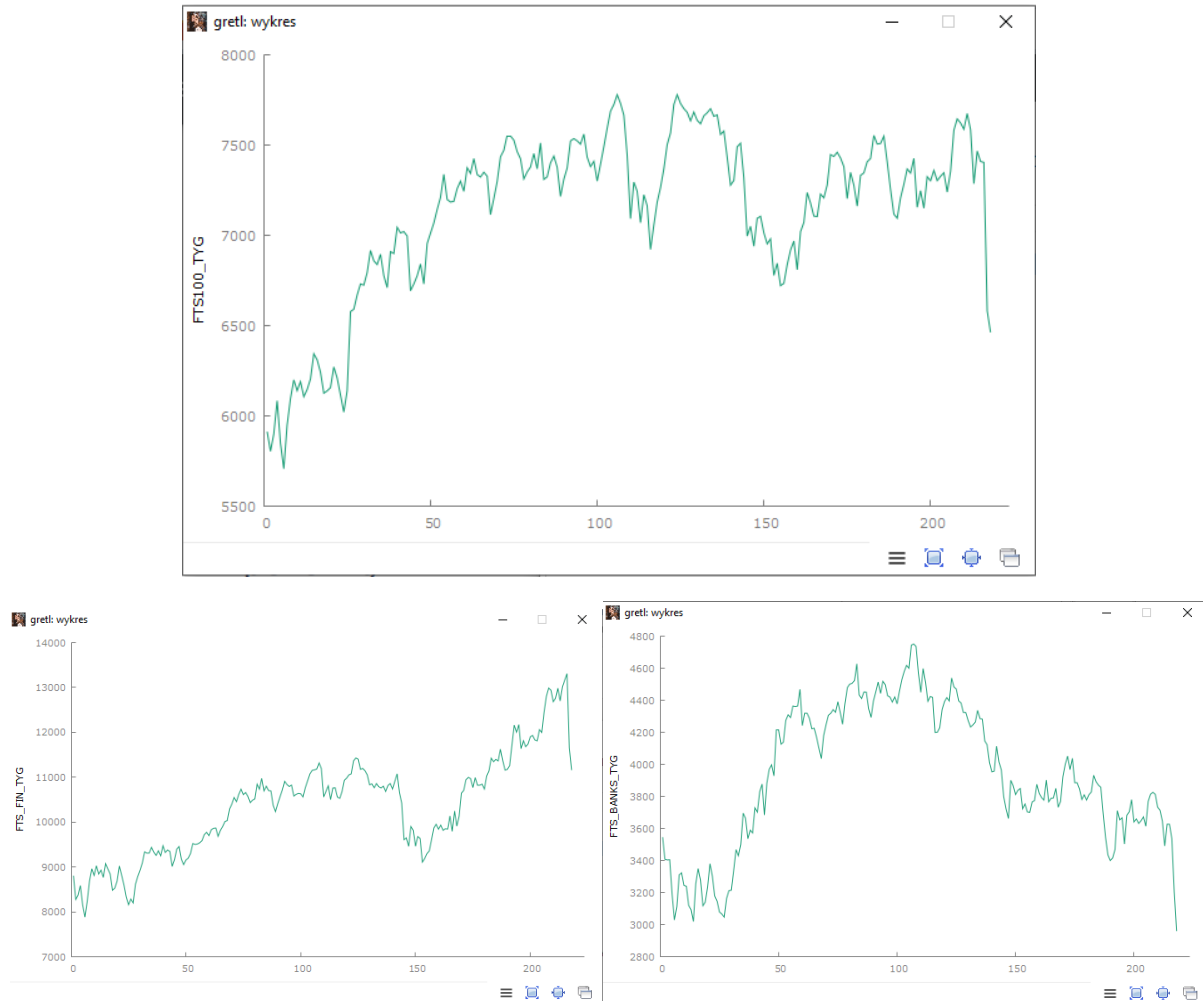


## IV. Analysis of index values

### A. Degree of process integration.

First, it is necessary to determine whether the process of the studied indices has a trend. In order to examine the occurrence of a process trend, it is necessary to look at the time series graphs before and during the crisis.

Figure 7. Peacetime time series charts for the FTSE 100, FTSE 350 Banks and FTSE 350 Financial Services.



Source: own study based on historical data from [www.investing.com](http://www.investing.com) FTSE 100, FTSE 350 Financial Services and FTSE 350 Banks.

In the case of the main index, there is a development process before the crisis, which means that a trend is present. In the case of sectoral indices, there is also a clear trend in the period before the crisis.

Figure 8. Time series graphs during the crisis period for the FTSE 100, FTSE 350 Banks and FTSE 350 Financial Services.



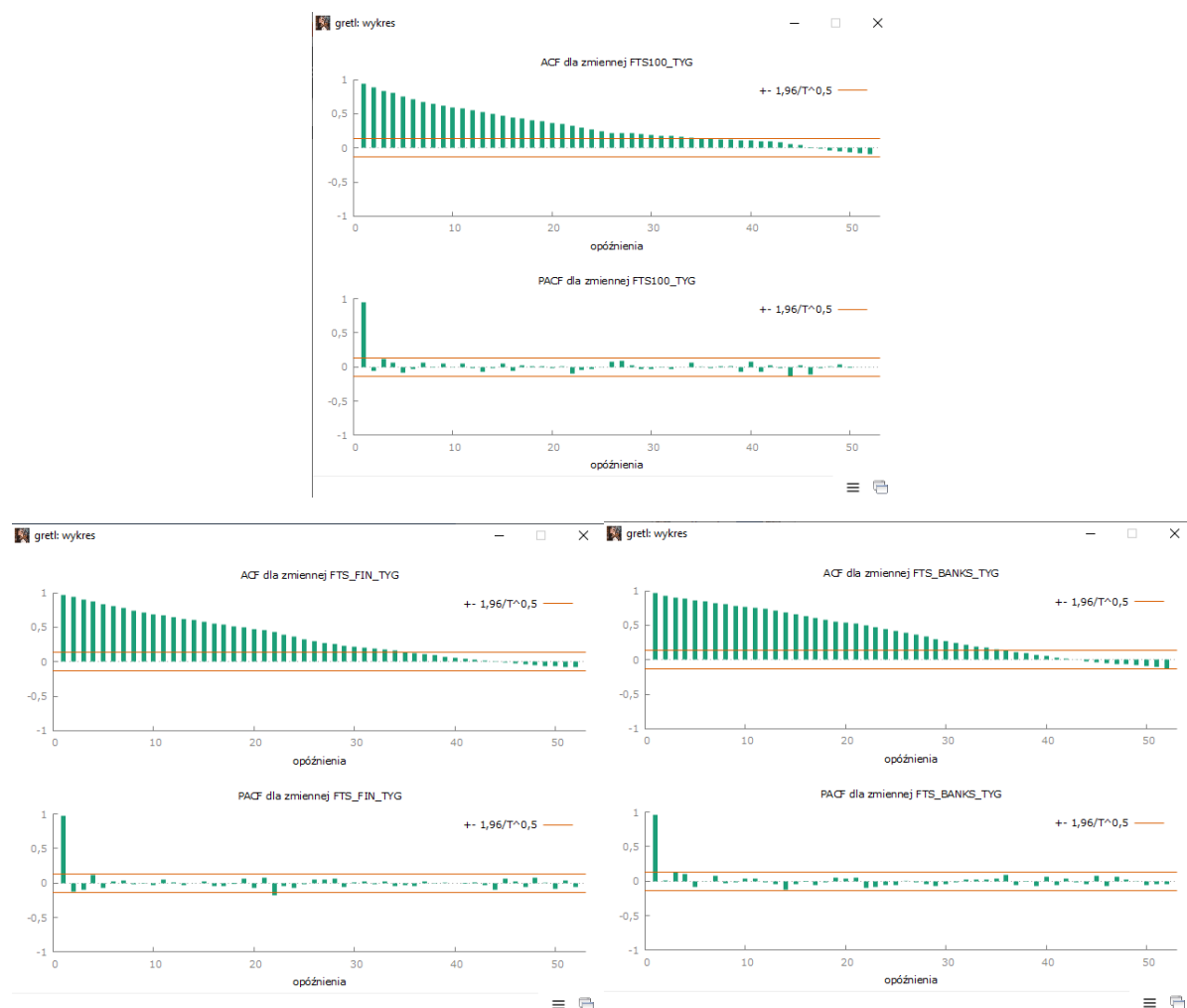
Source: own study based on historical data from [www.investing.com](http://www.investing.com) FTSE 100, FTSE 350 Financial Services and FTSE 350 Banks.

In the case of the crisis, the time series graph of the main index shows the occurrence of a trend. The graphs of the sectoral indices also indicate the occurrence of trends. Now we need to perform the ADF test with the intercept and the trend to check whether the processes are stationary. To proceed to the ADF test, we first need to look at the ACF and PACF graphs. We need to verify the research hypotheses for the pre-crisis period.

$$H_0: \alpha = 1 \ (\delta = 0)$$

$$H_1: \alpha < 1 \ (\delta < 0)$$

Figure 8. Peacetime ACF and PACF charts for the FTSE 100, FTSE 350 Banks and FTSE 350 Financial Services.



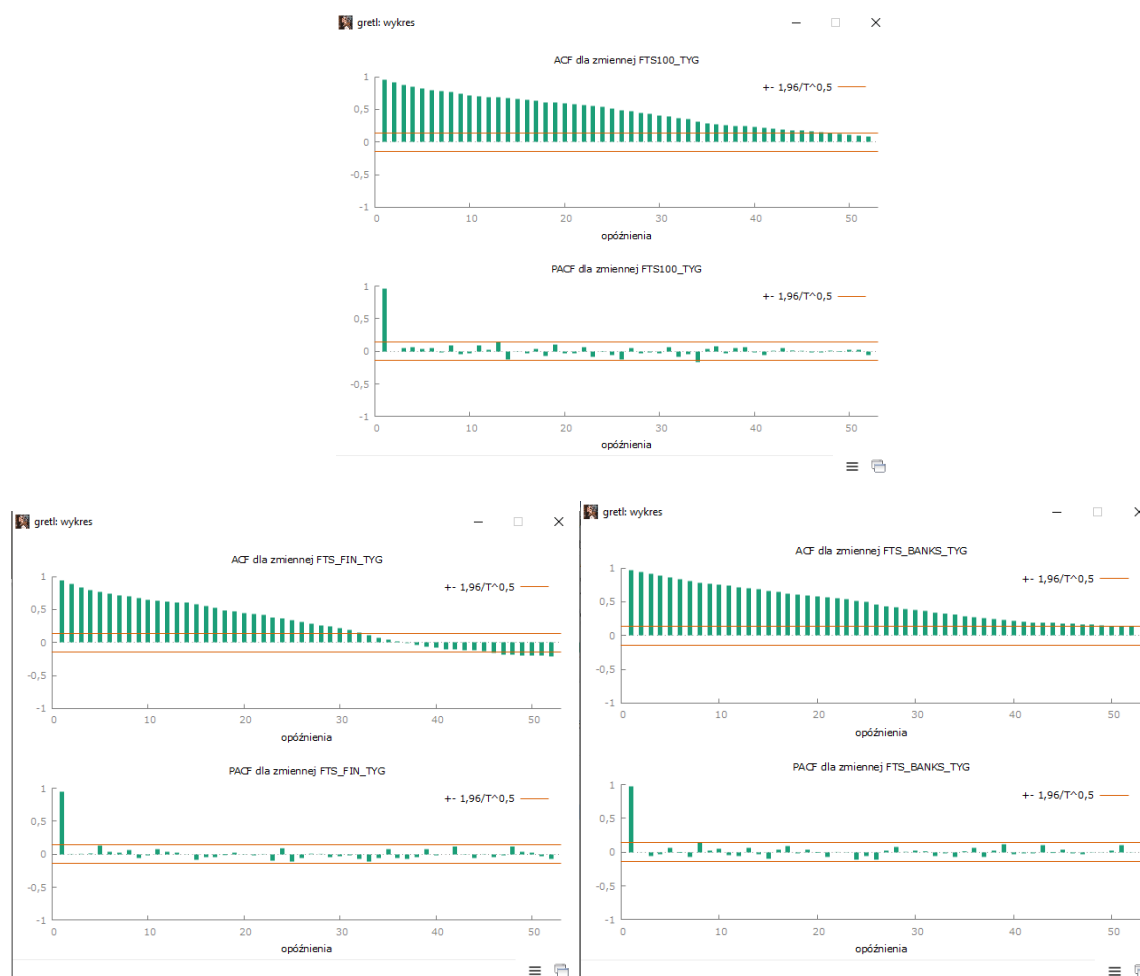
Source: own study based on historical data from [www.investing.com](http://www.investing.com) FTSE 100, FTSE 350 Financial Services and FTSE 350 Banks.

Based on the above results, in peacetime,  $H_0$  should be accepted, which means that a random walk occurs. This situation indicates the non-stationarity of processes caused by the existence of a unit root. First-order integrated variables should be used. Now, the research hypotheses for the crisis period should be verified.

$$H_0: \alpha = 1 \ (\delta = 0)$$

$$H_1: \alpha < 1 \ (\delta < 0)$$

Figure 9. ACF and PACF charts during the crisis period for the FTSE 100, FTSE 350 Banks and FTSE 350 Financial Services.



Source: own study based on historical data from [www.investing.com](http://www.investing.com) FTSE 100, FTSE 350 Financial Services and FTSE 350 Banks.

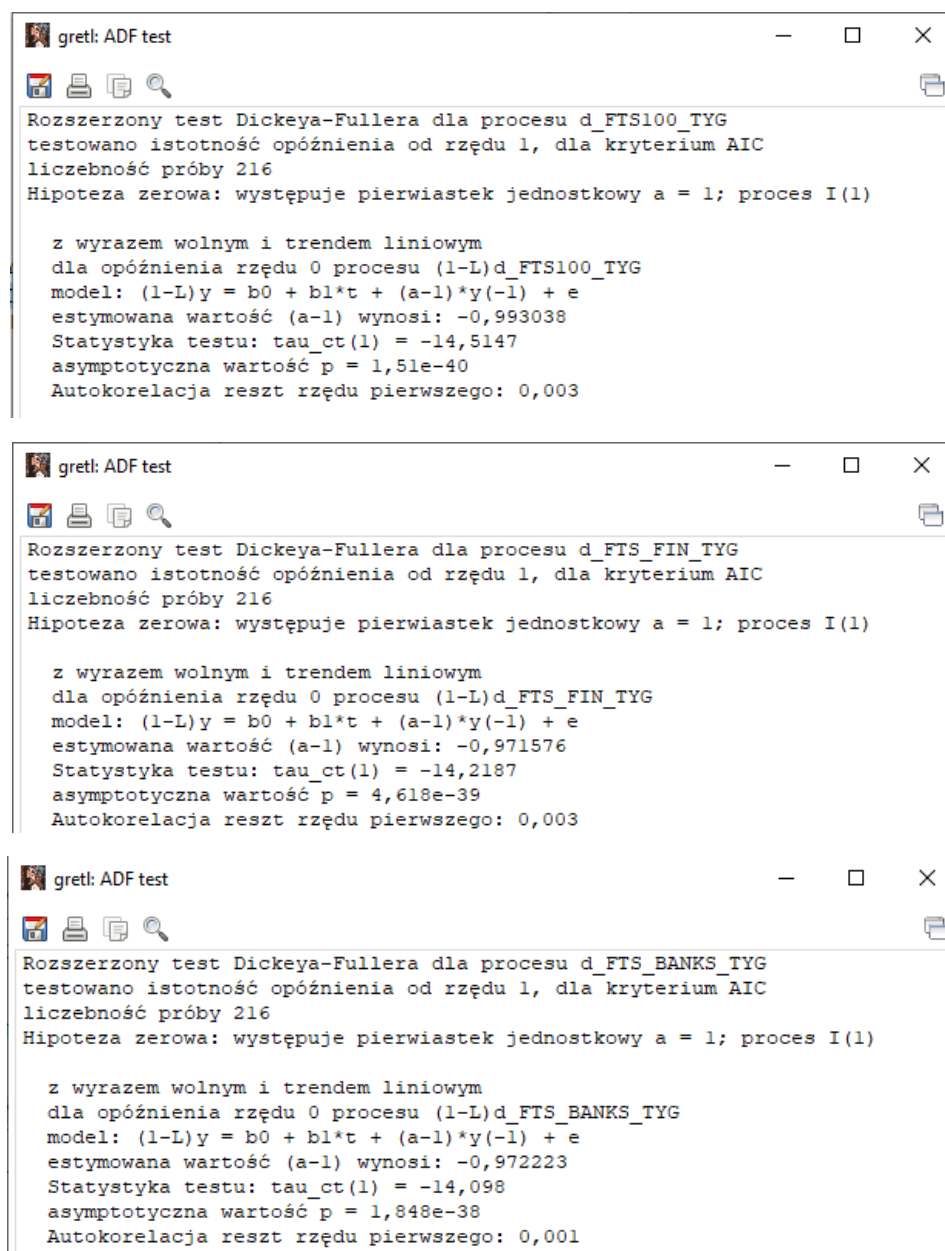
Based on the above results, during the crisis period,  $H_0$  should be accepted, which means that a random walk occurs. This situation indicates the non-stationarity of the processes caused by the existence of a unit root. Integrated variables of the first order should be used.

After using the first-order integrated variables for the pre-crisis period. It is necessary to proceed to the ADF test with the intercept and linear trend to verify the hypotheses.

$$H_0: \alpha = 1 \ (\delta = 0)$$

$$H_1: \alpha < 1 \ (\delta < 0)$$

Figure 10. Peacetime ADF test results for the FTSE 100, FTSE 350 Banks and FTSE 350 Financial Services.



Source: own study based on historical data from [www.investing.com](http://www.investing.com) FTSE 100, FTSE 350 Financial Services and FTSE 350 Banks.

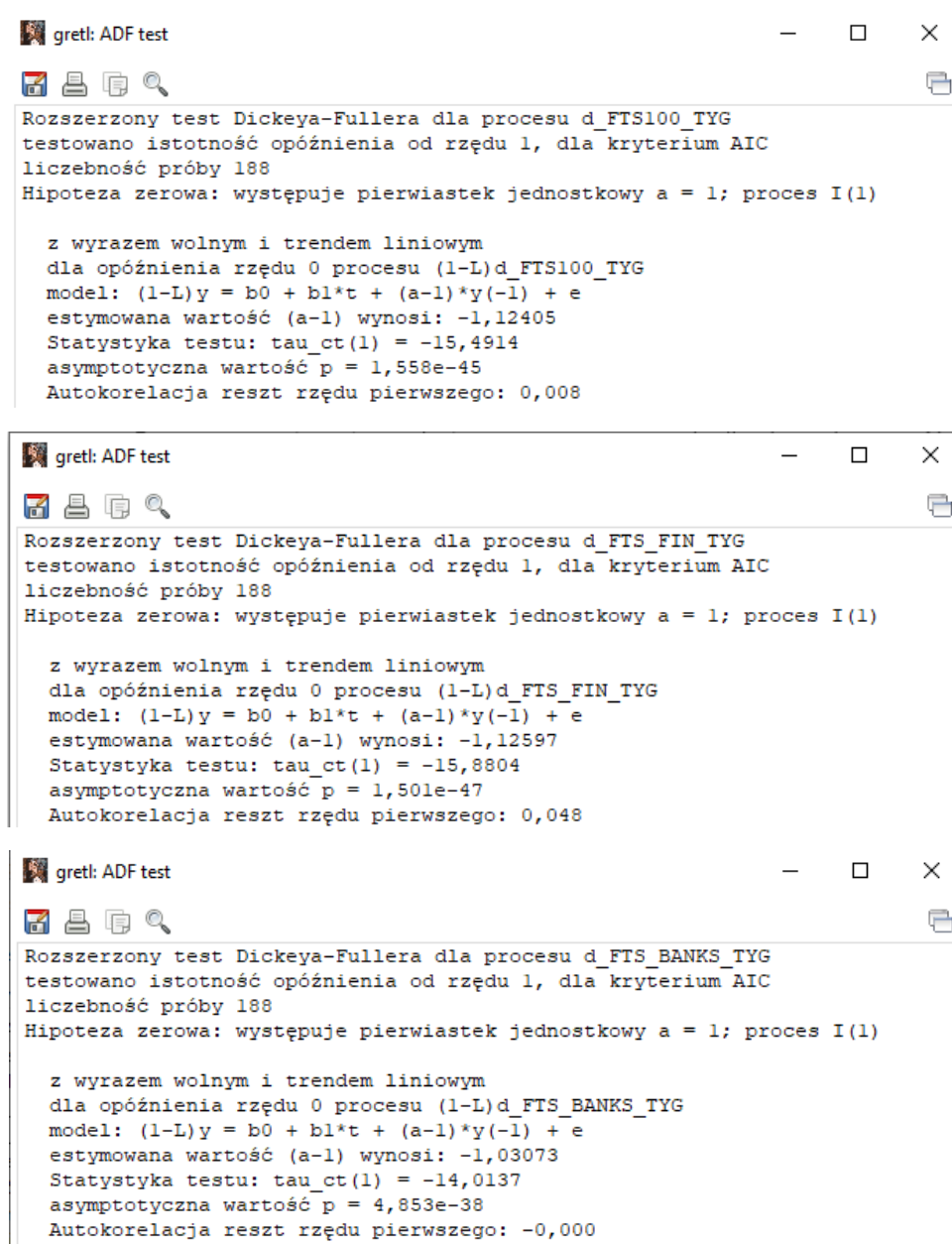
The above results indicate that the value of  $p < 0.05$  indicates the existence of stationarity of the process and  $H_1$  should be accepted.

After using the first-order integrated variables for the crisis period. It is necessary to proceed to the ADF test with the intercept and linear trend to verify the hypotheses.

$$H_0: \alpha = 1 \ (\delta = 0)$$

$$H_1: \alpha < 1 \ (\delta < 0)$$

Figure 10. ADF test results during the crisis for the FTSE 100, FTSE 350 Banks and FTSE 350 Financial Services.



Source: own study based on historical data from [www.investing.com](http://www.investing.com) FTSE 100, FTSE 350 Financial Services and FTSE 350 Banks.

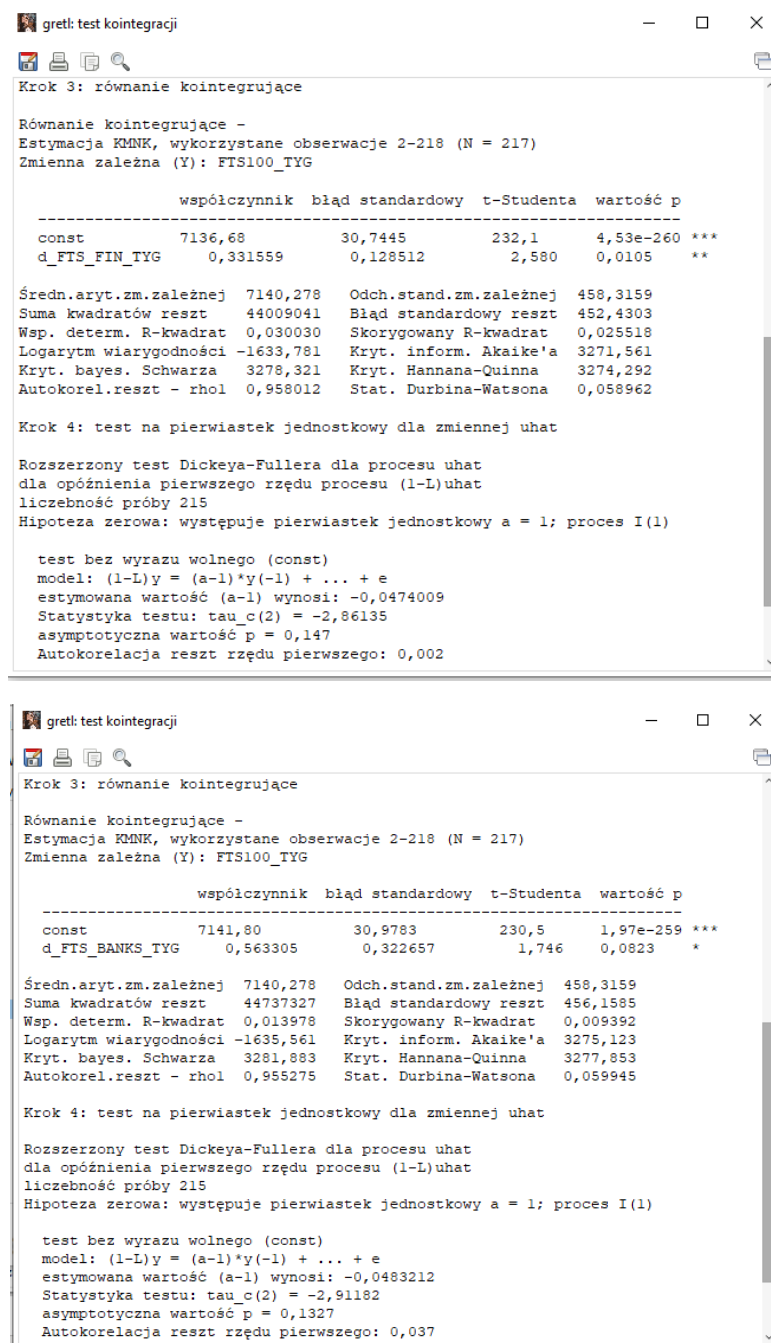
The above results indicate that the value of  $p < 0.05$  indicates the existence of stationarity of the process and  $H_1$  should be accepted.

The above results show that all processes in both peacetime and crisis are integrated at level 1.

## B. Long-term linking of indexes.

To check whether the indices are cointegrated, the Engle-Granger procedure should be performed. From the previous study, it is known that the processes after applying the variables are stationary and are integrated at level 1.

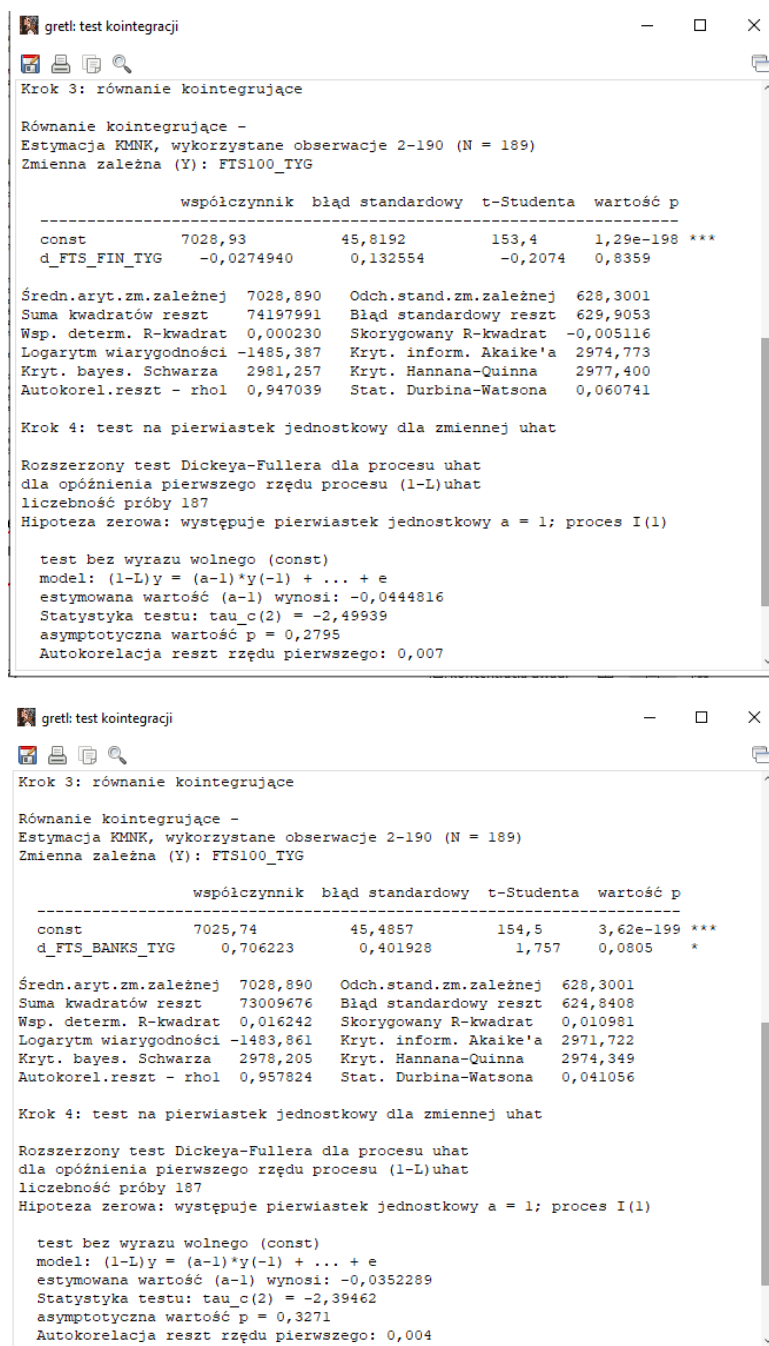
Figure 11. Peacetime cointegration test results for the FTSE 100, FTSE 350 Banks and FTSE 350 Financial Services.



Source: own study based on historical data from [www.investing.com](http://www.investing.com) FTSE 100, FTSE 350 Financial Services and FTSE 350 Banks.

The result of the Engel-Granger procedure indicates the occurrence of cointegration of sectoral indices with the main index in peacetime. Because the integrated indicators are important for the cointegration test.

Figure 12. Cointegration test results during the crisis period for the FTSE 100, FTSE 350 Banks and FTSE 350 Financial Services.



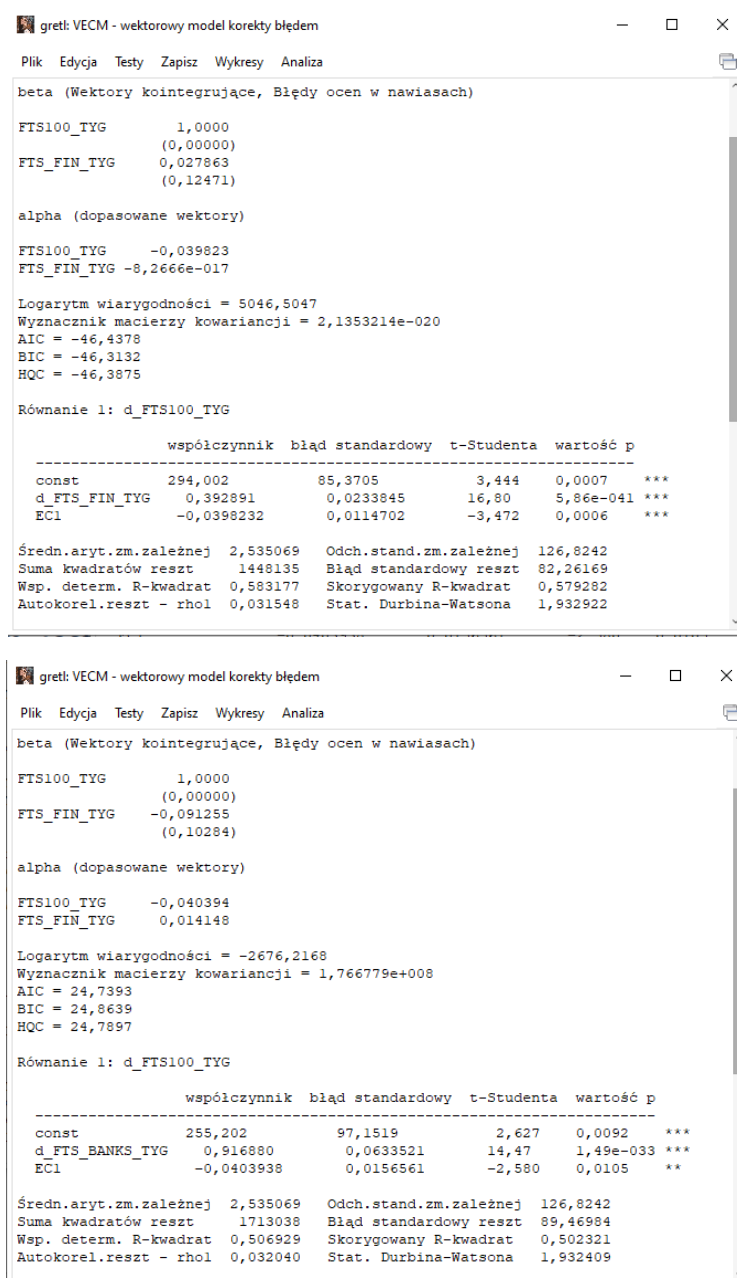
Source: own study based on historical data from [www.investing.com](http://www.investing.com) FTSE 100, FTSE 350 Financial Services and FTSE 350 Banks.



The result of the Engel-Granger procedure indicates the occurrence of only cointegration of the banking index with the main index during the crisis. The significance of the integrated banking index in the context of the main index occurs, while such a relationship does not appear in the case of the integrated financial index.

It is now necessary to apply the error correction mechanism to all peacetime and crisis indices.

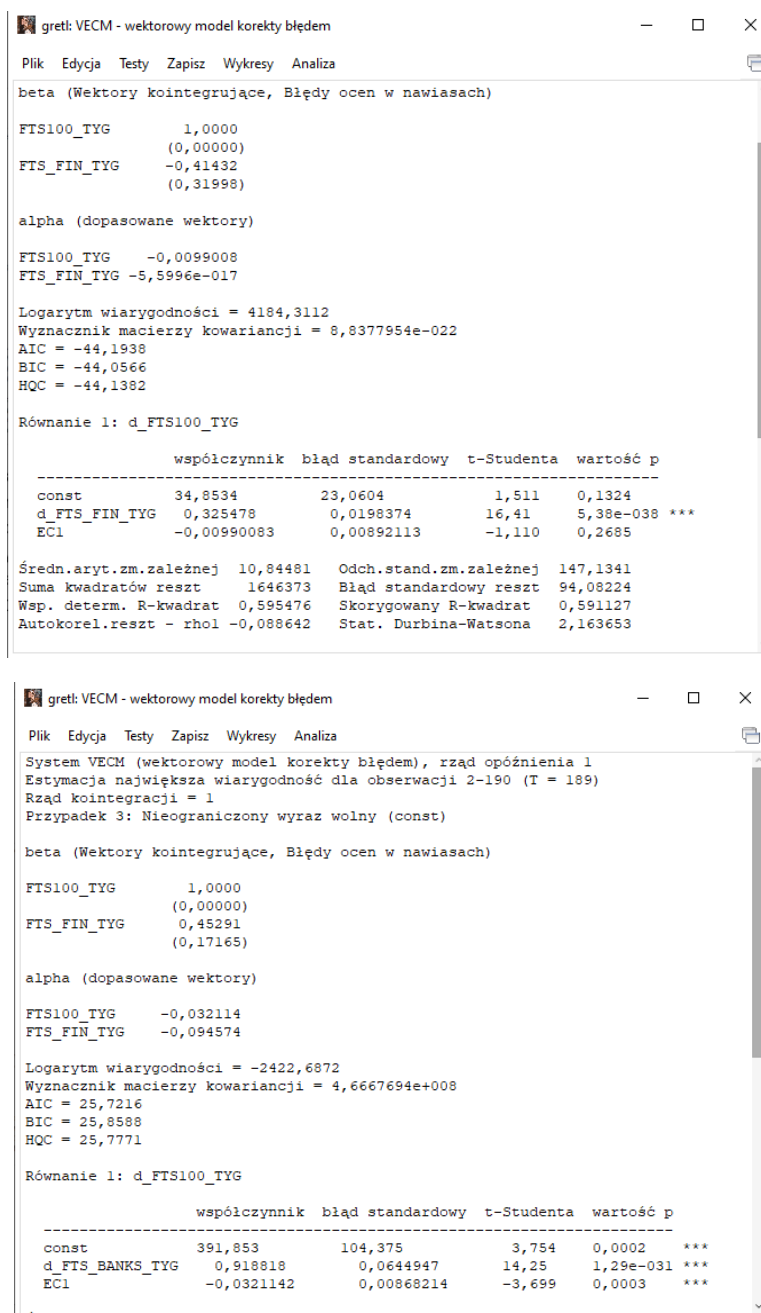
Figure 13. Peacetime VECM performance for the FTSE 100, FTSE 350 Banks and FTSE 350 Financial Services.



Source: own study based on historical data from [www.investing.com](http://www.investing.com) FTSE 100, FTSE 350 Financial Services and FTSE 350 Banks.

In the peacetime period there was a long-term relationship between the main index and the financial sector index. In this model all parameters were significant. The beta coefficient of the sector index was also positive, which indicates cointegration in the long run. The situation was similar in the case of the banking sector, here too all parameters were significant. Also in this case the beta coefficient was positive and equal to 0.9161880, which means that the main index explained it to this extent.

Figure 14. VECM performance during the crisis period for the FTSE 100, FTSE 350 Banks and FTSE 350 Financial Services.



Source: own study based on historical data from [www.investing.com](http://www.investing.com) FTSE 100, FTSE 350 Financial Services and FTSE 350 Banks.

During the crisis, there was also a long-term relationship between the main index and the banking sector index. In this model, only the finance index was a significant parameter. The beta coefficient of the sector index was also positive, which indicates cointegration in the long term. In the case of the banking sector, however, all parameters were significant, which indicates the occurrence of a long-term relationship. The beta coefficient was positive and equal to 0.9181818, which means that the main index explained it to this extent.

C. Has the crisis affected the degree of model integration?

Yes, the crisis affected the degree of integration of the models. In the case of the degree of explanation of the main index by the financial services sector index, this value decreased from 0.392891 to 0.325478. This model also ceased to be cointegrated in the long run. On the other hand, in the case of the degree of explanation of the main index by the banking sector index, this relationship increased from 0.9161880 to 0.9181818, and the significance of the parameters increased.

D. Research hypothesis.

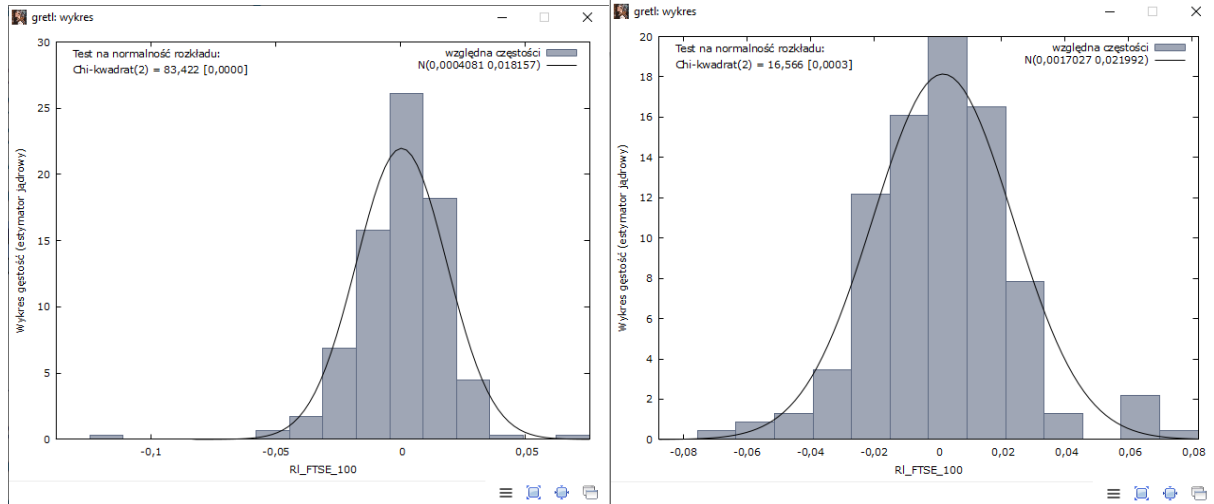
H<sub>4</sub>: Which sector indices are related to the main index and thus the same classes of models can be correctly used?

Depending on the sub-period under study, the relationship between sector indices and the main index changes, which means that the classes of models that should be used also change. During the crisis, both sector indices are related to the main index, but during the crisis, only the banking index remains in a full relationship with the main index. For both indices in the pre-crisis period, ARIMA modeling should be used. However, during the crisis, ARMA should be used for the financial sector index, and ARiMA for the banking sector.

## V. Analysis of rates of return.

### A. Compatibility of the distribution of rates of return with the normal distribution.

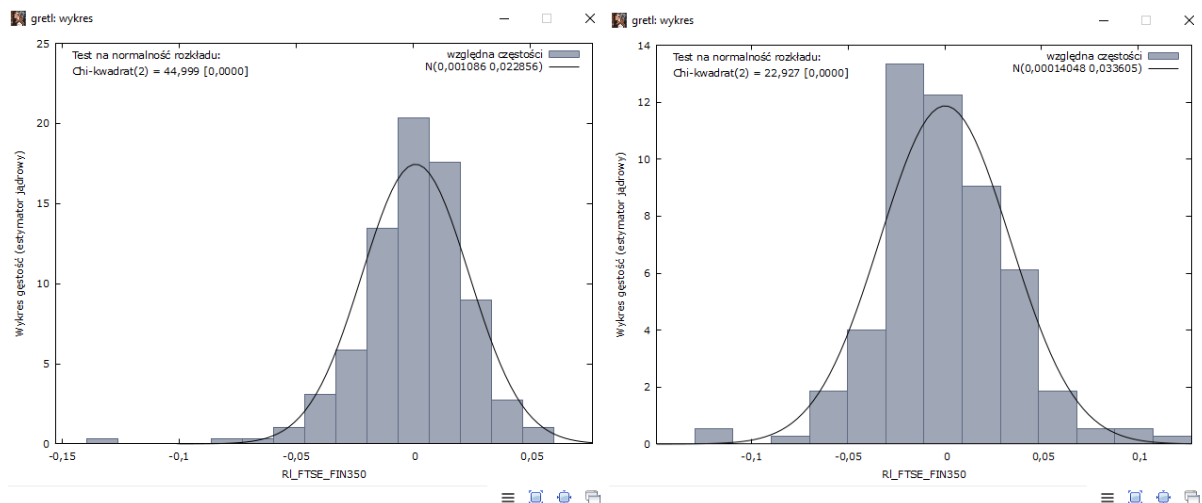
Figure 15. Graph of the distribution of peacetime and crisis rates of return for the FTSE 100.



Source: own study based on historical data from [www.investing.com](http://www.investing.com) FTSE 100, FTSE 350 Financial Services and FTSE 350 Banks.

In the case of the main index, both in the peacetime period (left figure) and the crisis period (right figure), the distribution of rates of return did not follow the normal distribution. The results of the above test clearly show that the p-value in both cases was less than 0.05.

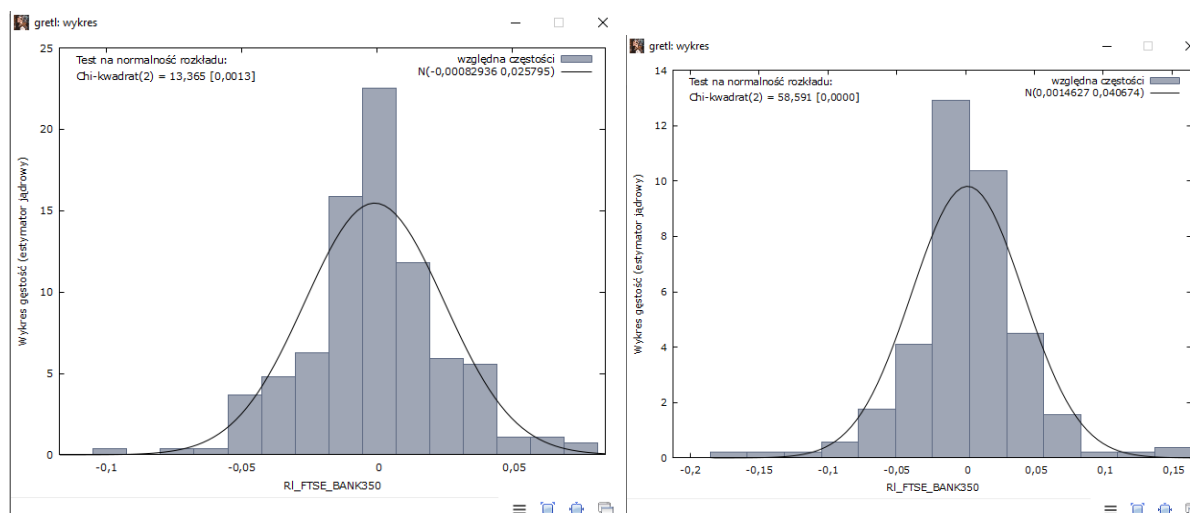
Figure 16. Peacetime and crisis rate of return distribution graph for the FTSE 350 Financial Services



Source: own study based on historical data from [www.investing.com](http://www.investing.com) FTSE 100, FTSE 350 Financial Services and FTSE 350 Banks.

Also, the distribution of financial sector returns both in the peacetime (left figure) and in the crisis period (right figure) did not follow the normal distribution. The results of the above test clearly show that the p-value in both cases was less than 0.05.

Figure 17. Graph of the distribution of peacetime and crisis rates of return for the FTSE 350 Banks.



Source: own study based on historical data from [www.investing.com](http://www.investing.com) FTSE 100, FTSE 350 Financial Services and FTSE 350 Banks.

Also, the distribution of banking sector returns both in the peacetime (left figure) and in the crisis period (right figure) did not follow the normal distribution. The results of the above test clearly show that the p-value in both cases was less than 0.05.

## B. Occurrence of group I effects.

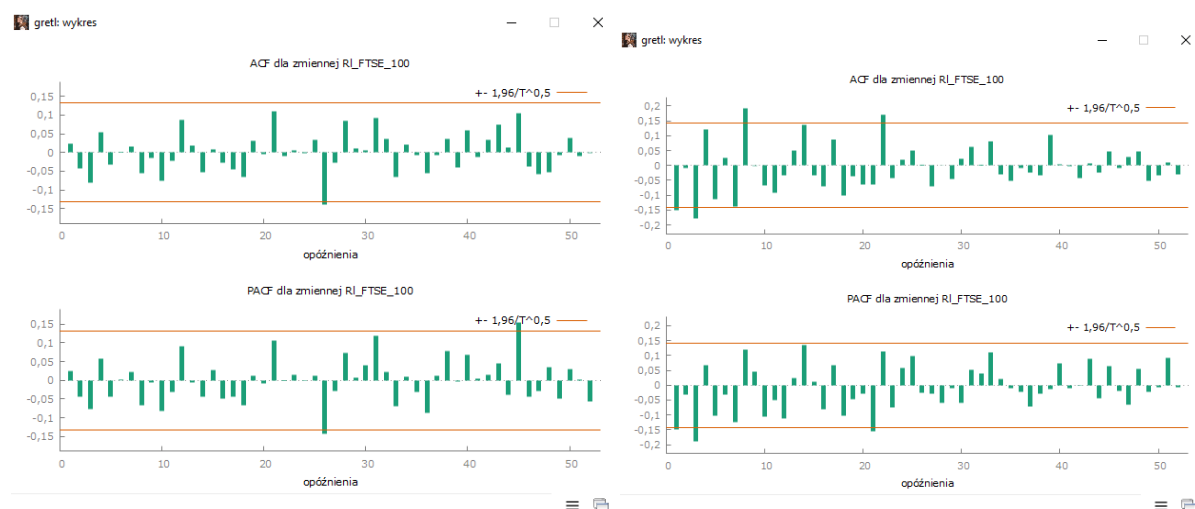
Figure 18. Descriptive statistics of peacetime and crisis returns for the FTSE 100.

Statystyki opisowe, wykorzystane obserwacje 1 - 218 dla zmiennej 'Rl_FTSE_100' (218 prawidłowych obserwacji)		Statystyki opisowe, wykorzystane obserwacje 1 - 190 dla zmiennej 'Rl_FTSE_100' (190 prawidłowych obserwacji)	
Średnia	0,00040810	Średnia	0,0017027
Mediana	0,0020165	Mediana	0,0017565
Minimalna	-0,11788	Minimalna	-0,069425
Maksymalna	0,069094	Maksymalna	0,075921
Odchylenie standardowe	0,018157	Odchylenie standardowe	0,021992
Wsp. zmienności	44,492	Wsp. zmienności	12,916
Skośność	-1,2958	Skośność	0,17638
Kurtoza	8,1423	Kurtoza	1,5011
Percentyl 5%	-0,029386	Percentyl 5%	-0,034203
Percentyl 95%	0,024219	Percentyl 95%	0,033449
Zakres Q3-Q1	0,019440	Zakres Q3-Q1	0,024769
Brakujące obs.	0	Brakujące obs.	0

Source: own study based on historical data from [www.investing.com](http://www.investing.com) FTSE 100, FTSE 350 Financial Services and FTSE 350 Banks.

In the case of the main index returns, both in the peace period (left figure) and the crisis period (right figure), left-side skewness is visible. Both the above descriptive data and the previous graphs indicate the occurrence of leptokurtosis, because there is a large amount of data deviating from the normal distribution, i.e. high kurtosis, a lot of data in the tails and in the center of the distribution above the normal distribution line. It should be noted that the phenomenon intensifies in the crisis period. As for the occurrence of heavy tails, the previous graphs show a moderate occurrence of extreme data in the peace period, while the tails increase in the crisis period.

Figure 19. ACF and PACF chart of peacetime and crisis returns for the FTSE 100.



Source: own study based on historical data from [www.investing.com](http://www.investing.com) FTSE 100, FTSE 350 Financial Services and FTSE 350 Banks.

Both in times of peace and crisis, autocorrelation of rates of return is visible.

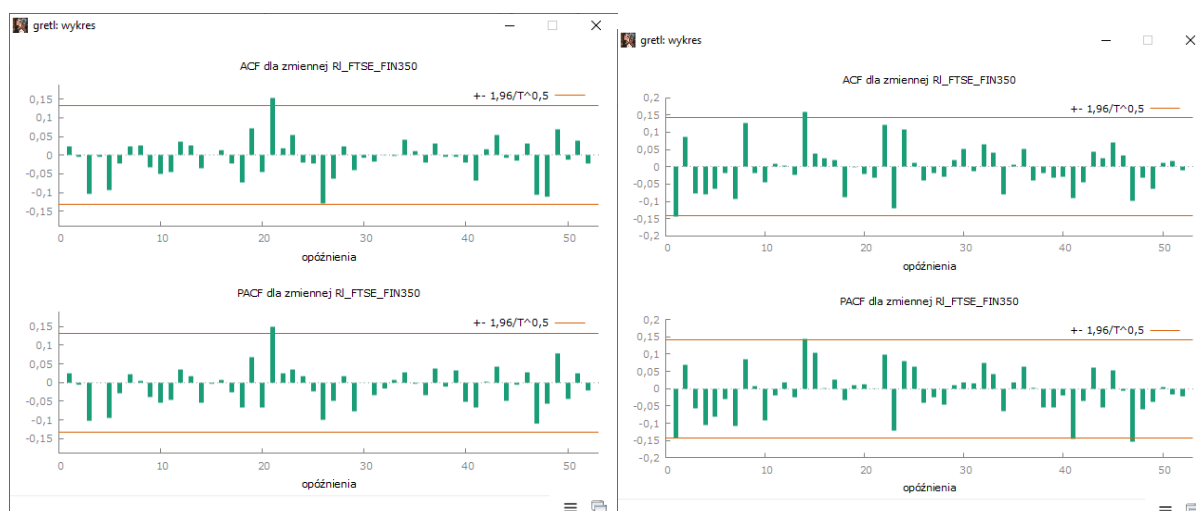
Figure 20. Descriptive statistics of peacetime and crisis returns for the FTSE 350 Financial Services.

Statystyki opisowe, wykorzystane obserwacje 1 - 218 dla zmiennej 'Rl_FTSE_FIN350' (218 prawidłowych obserwacji)		Statystyki opisowe, wykorzystane obserwacje 1 - 190 dla zmiennej 'Rl_FTSE_FIN350' (190 prawidłowych obserwacji)	
Średnia	0,0010860	Średnia	0,00014048
Mediana	0,0035925	Mediana	0,00026783
Minimalna	-0,13259	Minimalna	-0,11934
Maksymalna	0,053445	Maksymalna	0,11762
Odchylenie standardowe	0,022856	Odchylenie standardowe	0,033605
Wsp. zmienności	21,046	Wsp. zmienności	239,22
Skośność	-1,2986	Skośność	0,0027758
Kurtoza	5,3698	Kurtoza	1,8160
Percentyl 5%	-0,037220	Percentyl 5%	-0,053040
Percentyl 95%	0,034510	Percentyl 95%	0,051037
Zakres Q3-Q1	0,025164	Zakres Q3-Q1	0,040136
Brakujące obs.	0	Brakujące obs.	0

Source: own study based on historical data from [www.investing.com](http://www.investing.com) FTSE 100, FTSE 350 Financial Services and FTSE 350 Banks.

In the case of the financial sector index returns, left-side skewness is visible in the peace period (left figure), while in the crisis period (right figure), low right-side skewness is visible. Both the above descriptive data and the previous graphs indicate the occurrence of leptokurtosis, because there is a large amount of data deviating from the normal distribution, i.e. high kurtosis, a lot of data in the tails and in the center of the distribution above the normal distribution line. It should be noted that the phenomenon intensifies in the crisis period. As for the occurrence of heavy tails, the previous graphs show a moderate occurrence of extreme data in the peace period, while the tails increase in the crisis period.

Figure 21. ACF and PACF chart of peacetime and crisis returns for the FTSE 350 Financial Services.



Source: own study based on historical data from [www.investing.com](http://www.investing.com) FTSE 100, FTSE 350 Financial Services and FTSE 350 Banks.

Both in times of peace and crisis, autocorrelation of rates of return is visible.

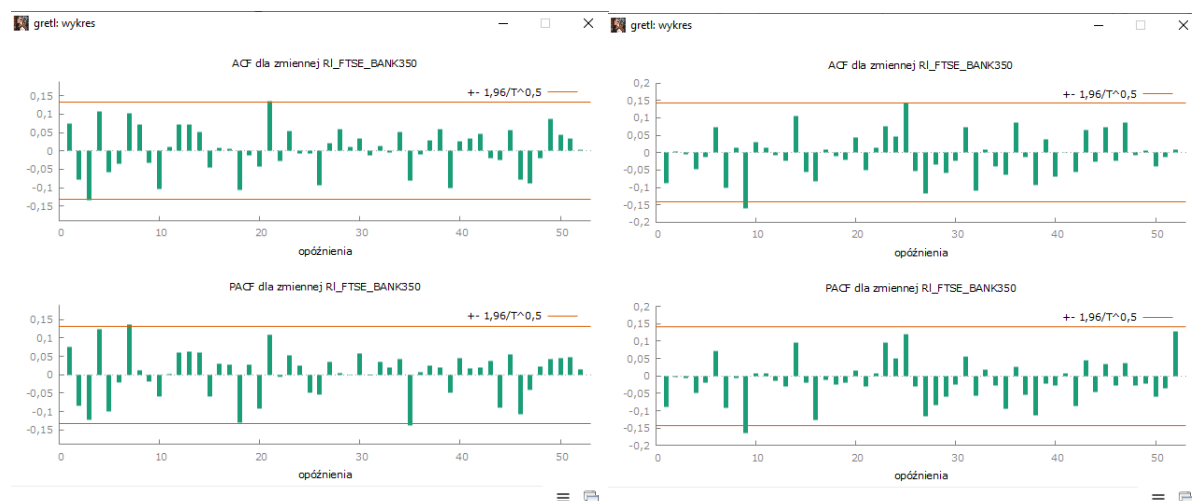
Figure 22. Descriptive statistics of peacetime and crisis returns for the FTSE 350 Banks.

Statystyki opisowe, wykorzystane obserwacje 1 - 218 dla zmiennej 'Rl_FTSE_BANK350' (218 prawidłowych obserwacji)		Statystyki opisowe, wykorzystane obserwacje 1 - 190 dla zmiennej 'Rl_FTSE_BANK350' (190 prawidłowych obserwacji)	
Średnia	-0,00082936	Średnia	0,0014627
Mediana	-0,00015073	Mediana	0,0015180
Minimalna	-0,098537	Minimalna	-0,17204
Maksymalna	0,075403	Maksymalna	0,15108
Odchylenie standardowe	0,025795	Odchylenie standardowe	0,040674
Wsp. zmienności	31,102	Wsp. zmienności	27,807
Skośność	-0,063723	Skośność	-0,20373
Kurtoza	1,2011	Kurtoza	3,5481
Percentyl 5%	-0,043447	Percentyl 5%	-0,057667
Percentyl 95%	0,042052	Percentyl 95%	0,065467
Zakres Q3-Q1	0,029258	Zakres Q3-Q1	0,038942
Brakujące obs.	0	Brakujące obs.	0

Source: own study based on historical data from [www.investing.com](http://www.investing.com) FTSE 100, FTSE 350 Financial Services and FTSE 350 Banks.

In the case of the banking sector index returns, both in the peacetime period (left figure) and the crisis period (right figure), left-side skewness is visible. Both the above descriptive data and the previous graphs indicate the occurrence of leptokurtosis, because there is a large amount of data deviating from the normal distribution, i.e. high kurtosis, a lot of data in the tails and in the center of the distribution above the normal distribution line. As for the occurrence of heavy tails, the previous graphs show a low occurrence of extreme data in the peacetime period, while an increase and a decrease in the crisis period.

Figure 23. ACF and PACF chart of peacetime and crisis returns for FTSE 350 Banks.



Source: own study based on historical data from [www.investing.com](http://www.investing.com) FTSE 100, FTSE 350 Financial Services and FTSE 350 Banks.

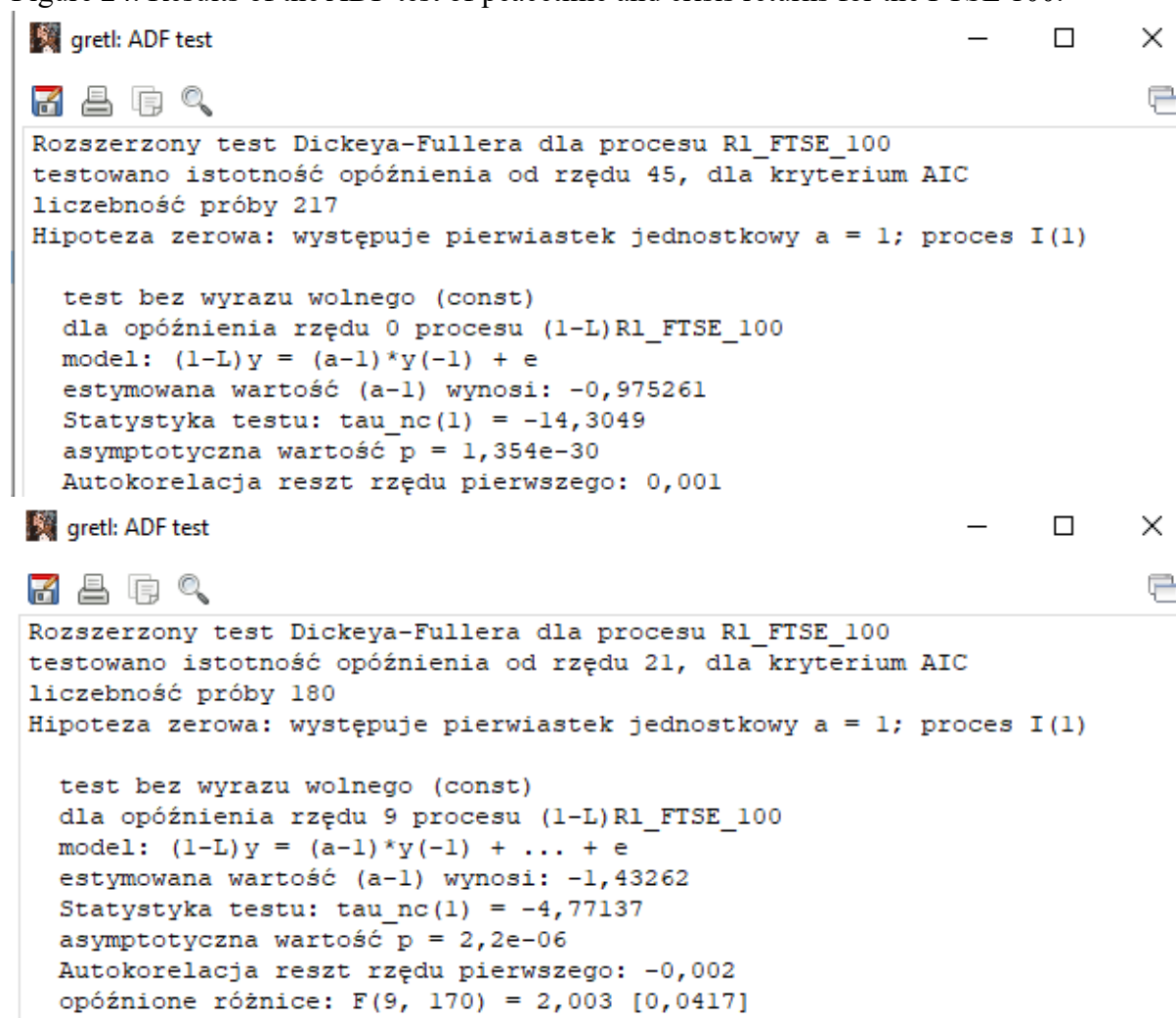
Both in times of peace and crisis, autocorrelation of rates of return is visible.



### C. Stationarity of processes.

To check whether stationarity occurs in the studied return rate processes, the ADF test should be performed.

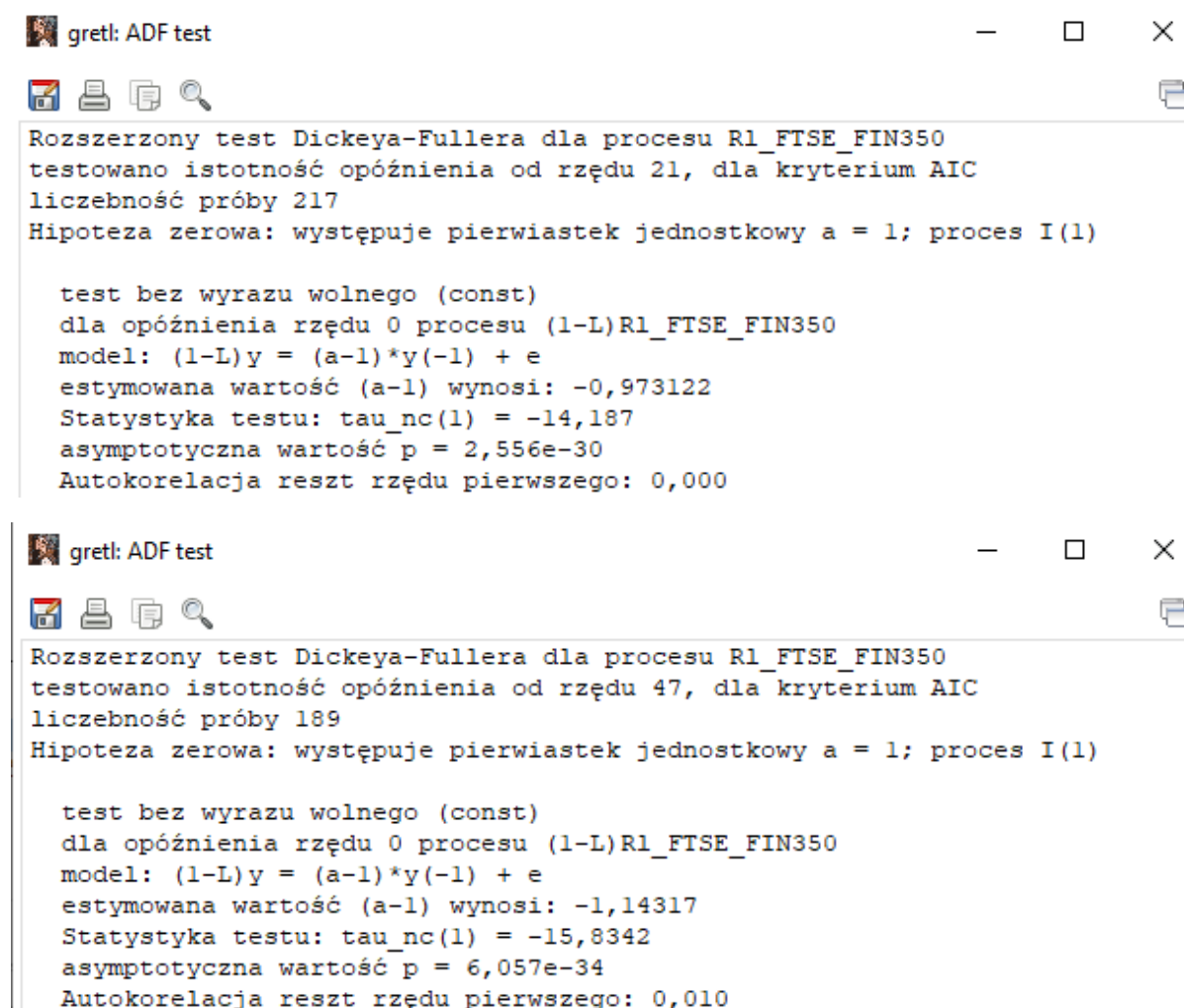
Figure 24. Results of the ADF test of peacetime and crisis returns for the FTSE 100.



Source: own study based on historical data from [www.investing.com](http://www.investing.com) FTSE 100, FTSE 350 Financial Services and FTSE 350 Banks.

The ADF test for the main index showed that in the peace period (upper figure) and the crisis period (lower figure) the process of rates of return was stationary, because the p-value was less than 0.05. The stationarity of the process allows the use of AR models.

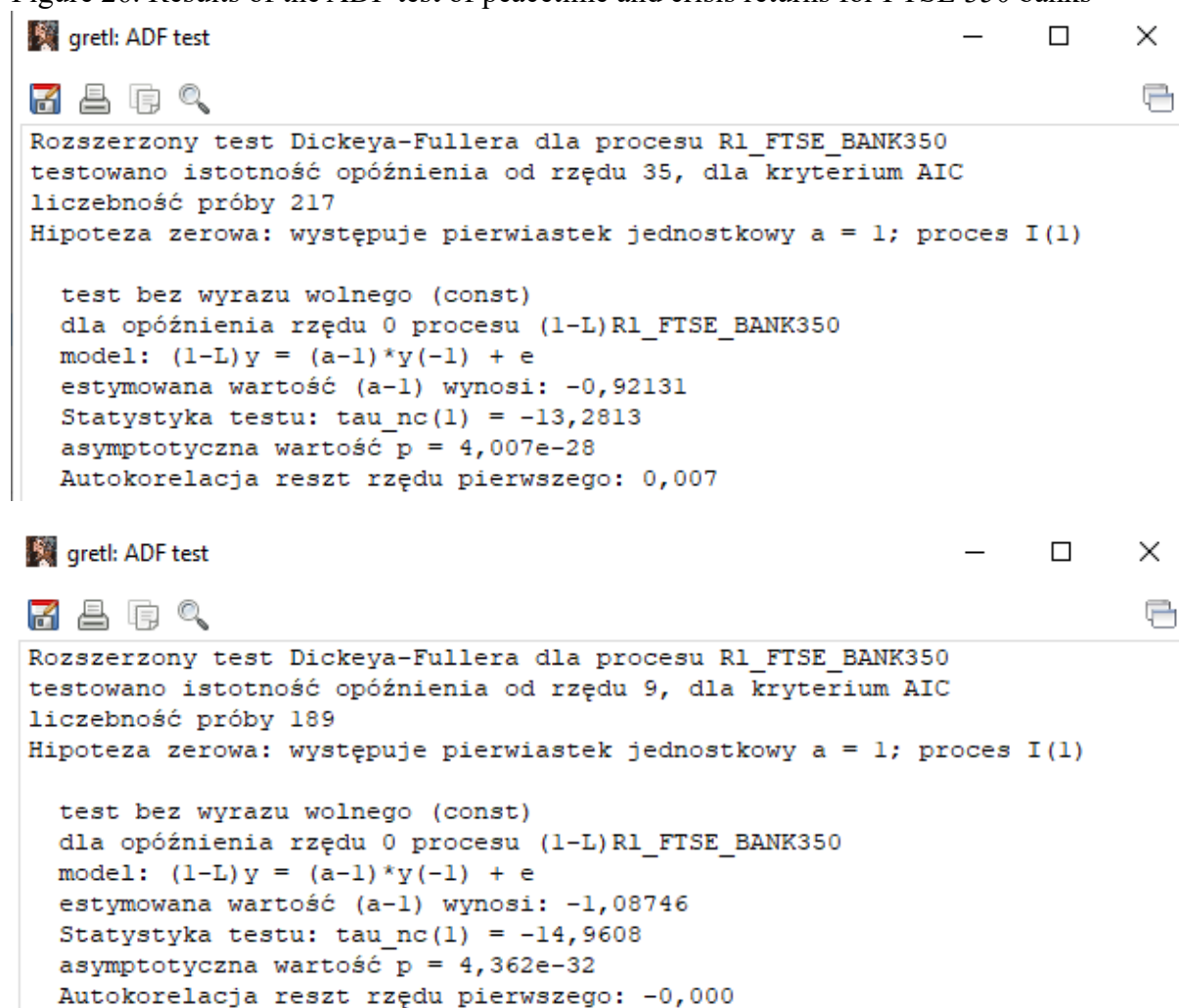
Figure 25. ADF test results of peacetime and crisis returns for the FTSE 350 Financial Services.



Source: own study based on historical data from [www.investing.com](http://www.investing.com) FTSE 100, FTSE 350 Financial Services and FTSE 350 Banks.

The ADF test for the financial sector index showed that in the peace period (upper figure) and the crisis period (lower figure) the process of rates of return was stationary, because the p-value was less than 0.05. The stationarity of the process allows the use of AR models.

Figure 26. Results of the ADF test of peacetime and crisis returns for FTSE 350 banks



Source: own study based on historical data from [www.investing.com](http://www.investing.com) FTSE 100, FTSE 350 Financial Services and FTSE 350 Banks.

The ADF test for the banking sector index showed that in the peace period (top figure) and the crisis period (bottom figure) the process of rates of return was stationary, because the p-value was less than 0.05. The stationarity of the process allows the use of AR models.

#### D. Research question:

H<sub>3</sub>: What effects characterize the primary index and how are they related to the class of models?

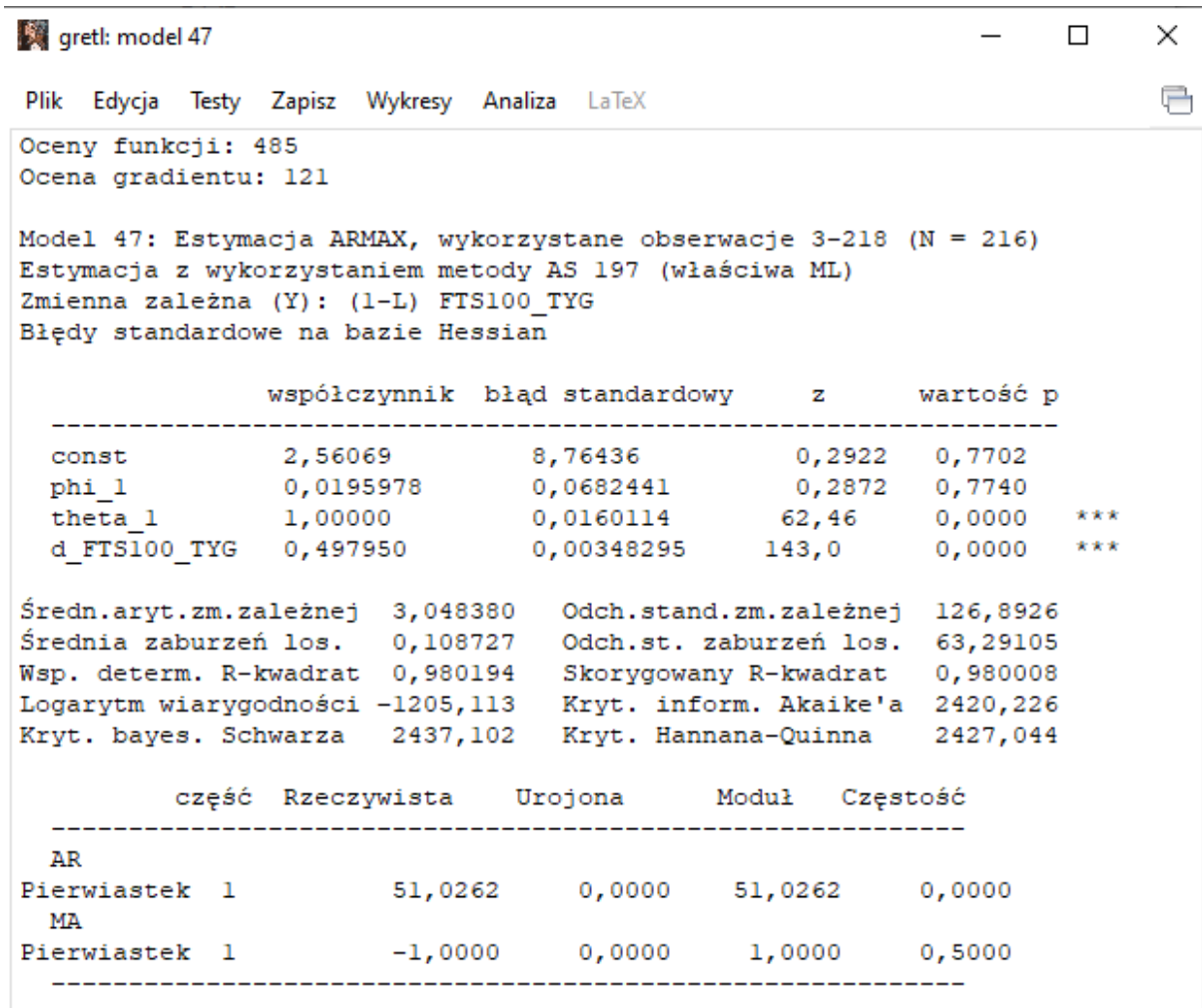
The main index is characterized by a lack of compliance with the normal distribution, the occurrence of left-sided skewness, the occurrence of leptokurtosis, heavy tails in the crisis period and autocorrelation. In the case of the main index, the class of models will not change because the ARiMA model should be used both in peacetime and in the crisis period.

## VI. AR, MA, ARMA or ARiMA modeling:

### A. Analysis:

The previous analyses show that ARiMA modeling should be used for the main index.

Figure 27. Peacetime and crisis price modelling results for the FTSE 100.



gretl: model 44					
Plik Edycja Testy Zapisz Wykresy Analiza LaTeX					
Oceny funkcji: 123					
Ocena gradientu: 42					
Model 44: Estymacja ARMAX, wykorzystane obserwacje 3-190 (N = 188)					
Estymacja z wykorzystaniem metody AS 197 (właściwa ML)					
Zmienna zależna (Y): (1-L) FTS100_TYG					
Błędy standardowe na bazie Outer Products matrix					
	współczynnik	błąd standardowy	z	wartość p	
const	10,7175	4,63713	2,311	0,0208	**
phi_1	0,785370	0,113948	6,892	5,49e-012	***
theta_1	0,0706676	0,0845208	0,8361	0,4031	
theta_2	-0,883922	0,0803875	-11,00	4,01e-028	***
d_FTS100_TYG	0,486945	0,00533579	91,26	0,0000	***
Średn. aryt. zm. zależnej	11,83511	Odch. stand. zm. zależnej	146,8941		
Średnia zaburzeń los.	1,154330	Odch. st. zaburzeń los.	70,38866		
Wsp. determ. R-kwadrat	0,987042	Skorygowany R-kwadrat	0,986830		
Logarytm wiarygodności	-1068,077	Kryt. inform. Akaike'a	2148,154		
Kryt. bayes. Schwarza	2167,573	Kryt. Hannana-Quinna	2156,022		
	część Rzeczywista	Urojona	Moduł	Częstość	
AR					
Pierwiastek 1	1,2733	0,0000	1,2733	0,0000	
MA					
Pierwiastek 1	-1,0244	0,0000	1,0244	0,5000	
Pierwiastek 2	1,1044	0,0000	1,1044	0,0000	

Source: own study based on historical data from [www.investing.com](http://www.investing.com) FTSE 100, FTSE 350 Financial Services and FTSE 350 Banks.

For the main index in peacetime, the ARiMA model was used with the lowest Akaike criterion, model 47. In the crisis period, however, the ARMA model was used, and model 44 had an Akaike criterion of 2148 and was the most parsimonious model.

For the financial sector index, ARIMA modeling should be used, this results from previously conducted analyses.

Figure 28. Peacetime and crisis price modelling results for the FTSE 350 financial services.

gretl: model 51

Plik Edycja Testy Zapisz Wykresy Analiza LaTeX

Oceny funkcji: 1011  
Ocena gradientu: 187

Model 51: Estymacja ARMAX, wykorzystane obserwacje 3-218 (N = 216)  
Estymacja z wykorzystaniem metody AS 197 (właściwa ML)  
Zmienna zależna (Y): (1-L) FTS\_FIN\_TYG  
Błędy standardowe na bazie Hessian

	współczynnik	błąd standardowy	z	wartość p	
const	13,2892	3,59409	3,698	0,0002	***
phi_1	0,942538	0,0248853	37,88	0,0000	***
theta_1	-1,67179e-07	0,0186496	-8,964e-06	1,0000	
theta_2	-1,00000	0,0186496	-53,62	0,0000	***
d_FTS_FIN_TYG	0,496909	0,00327059	151,9	0,0000	***

Średn. aryt. zm. zależnej	13,34245	Odch. stand. zm. zależnej	237,2378
Średnia zaburzeń los.	2,146908	Odch. st. zaburzeń los.	117,4966
Wsp. determ. R-kwadrat	0,988986	Skorygowany R-kwadrat	0,988830
Logarytm wiarygodności	-1339,698	Kryt. inform. Akaike'a	2691,396
Kryt. bayes. Schwarza	2711,647	Kryt. Hannana-Quinna	2699,578

	część	Rzeczywista	Urojona	Moduł	Częstość
AR					
Pierwiastek	1	1,0610	0,0000	1,0610	0,0000
MA					
Pierwiastek	1	-1,0000	0,0000	1,0000	0,5000
Pierwiastek	2	1,0000	0,0000	1,0000	0,0000

gretl: model 51					
Plik Edycja Testy Zapisz Wykresy Analiza LaTeX					
Oceny funkcji: 241					
Ocena gradientu: 68					
Model 51: Estymacja ARMAX, wykorzystane obserwacje 3-190 (N = 188)					
Estymacja z wykorzystaniem metody AS 197 (właściwa ML)					
Zmienna zależna (Y): (1-L) FTS_FIN_TYG					
Błędy standardowe na bazie Outer Products matrix					
	współczynnik	błąd standardowy	z	wartość p	
const	3,59936	19,0267	0,1892	0,8500	
phi_1	1,76702	0,0956400	18,48	3,24e-076	***
phi_2	-0,895196	0,0862731	-10,38	3,18e-025	***
theta_1	-0,862772	0,101011	-8,541	1,33e-017	***
theta_2	-0,800360	0,0624129	-12,82	1,21e-037	***
theta_3	0,864711	0,0892612	9,687	3,41e-022	***
d_FTS_FIN_TYG	0,485240	0,00717542	67,63	0,0000	***
Średn. aryt. zm. zależnej	6,843032	Odch. stand. zm. zależnej	339,0615		
Średnia zaburzeń los.	0,611593	Odch. st. zaburzeń los.	166,2233		
Wsp. determ. R-kwadrat	0,977643	Skorygowany R-kwadrat	0,977029		
Logarytm wiarygodności	-1229,334	Kryt. inform. Akaike'a	2474,668		
Kryt. bayes. Schwarza	2500,560	Kryt. Hannana-Quinna	2485,159		
	część Rzeczywista	Urojona	Moduł	Częstość	
AR					
Pierwiastek 1	0,9869	-0,3782	1,0569	-0,0582	
Pierwiastek 2	0,9869	0,3782	1,0569	0,0582	
MA					
Pierwiastek 1	0,9908	0,3366	1,0464	0,0521	
Pierwiastek 2	0,9908	-0,3366	1,0464	-0,0521	
Pierwiastek 3	-1,0561	0,0000	1,0561	0,5000	

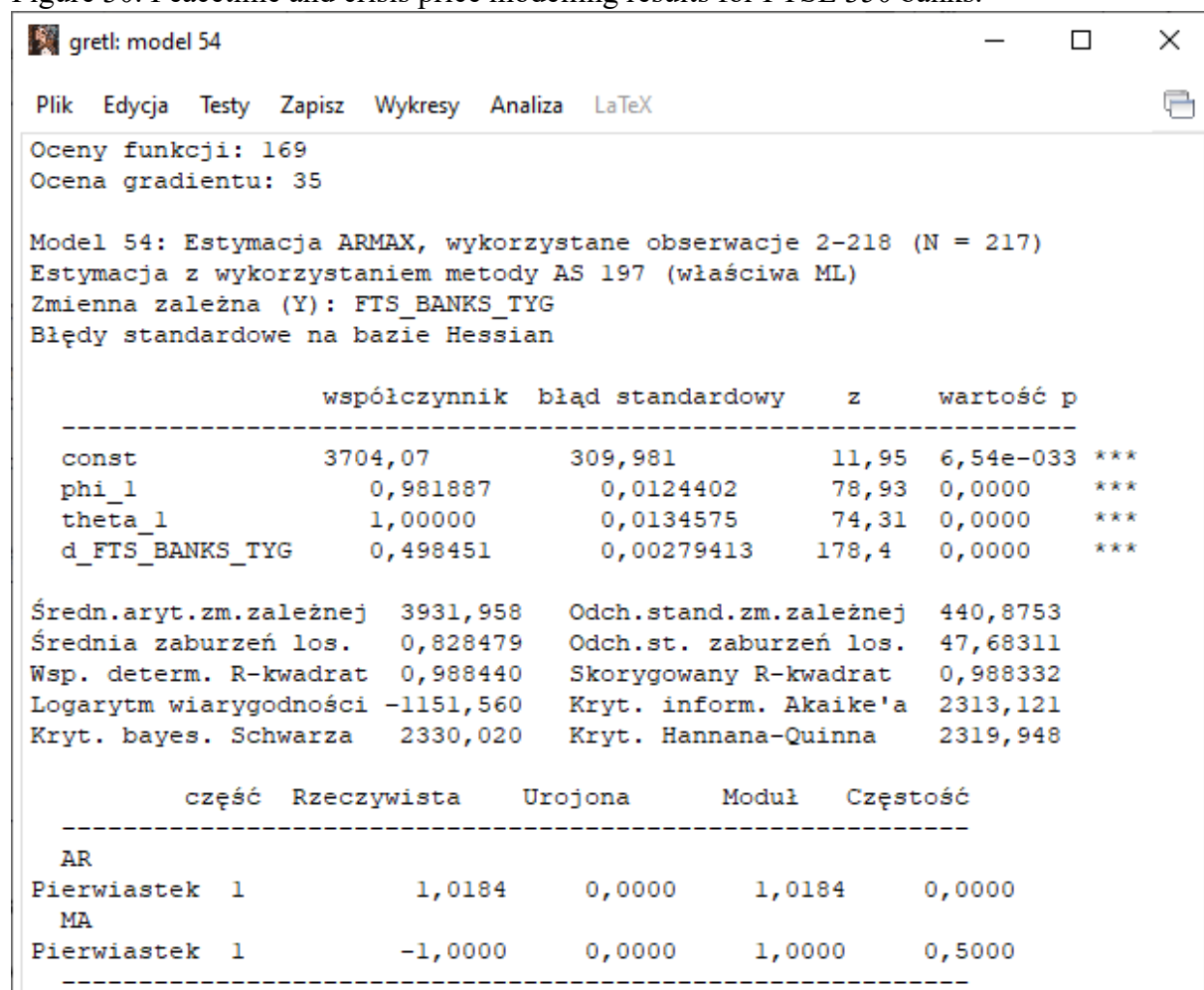
Source: own study based on historical data from [www.investing.com](http://www.investing.com) FTSE 100, FTSE 350 Financial Services and FTSE 350 Banks.

The above data shows that the class of models has not changed. Both of the above models are as economical as possible, as shown by the Akaike criterion.

Based on the results from Section 3, ARMA modeling should be used to model the peacetime banking sector index.



Figure 30. Peacetime and crisis price modelling results for FTSE 350 banks.





gretl: model 56

Plik Edycja Testy Zapisz Wykresy Analiza LaTeX

Oceny funkcji: 154  
Ocena gradientu: 48

Model 56: Estymacja ARMAX, wykorzystane obserwacje 3-190 (N = 188)  
Estymacja z wykorzystaniem metody AS 197 (właściwa ML)  
Zmienna zależna (Y): (1-L) FTS\_BANKS\_TYG  
Błędy standardowe na bazie Outer Products matrix

	współczynnik	błąd standardowy	z	wartość p	
const	7,59765	1,14963	6,609	3,88e-011	***
phi_1	0,964384	0,0766422	12,58	2,62e-036	***
phi_2	-0,0774600	0,0773390	-1,002	0,3166	
theta_1	-0,0550506	0,150368	-0,3661	0,7143	
theta_2	-0,944949	0,141285	-6,688	2,26e-011	***
d_FTS_BANKS_TYG	0,493769	0,00735703	67,12	0,0000	***

Średn. aryt. zm. zależnej	4,549894	Odch. stand. zm. zależnej	113,6768
Średnia zaburzeń los.	-1,137845	Odch. st. zaburzeń los.	55,11274
Wsp. determ. R-kwadrat	0,988496	Skorygowany R-kwadrat	0,988244
Logarytm wiarygodności	-1022,953	Kryt. inform. Akaike'a	2059,906
Kryt. bayes. Schwarza	2082,561	Kryt. Hannana-Quinna	2069,085

	część	Rzeczywista	Urojona	Moduł	Częstość
AR					
Pierwiastek	1	1,1416	0,0000	1,1416	0,0000
Pierwiastek	2	11,3085	0,0000	11,3085	0,0000
MA					
Pierwiastek	1	-1,0583	0,0000	1,0583	0,5000
Pierwiastek	2	1,0000	0,0000	1,0000	0,0000

Source: own study based on historical data from [www.investing.com](http://www.investing.com) FTSE 100, FTSE 350 Financial Services and FTSE 350 Banks.

The above data show that the class of models has changed. Because in the case of peacetime ARMA modeling was used, while in the crisis period it was ARiMA modeling. Both of the above models are as economical as possible, which is shown by the Akaike criterion.

#### B. Research hypothesis.

Has the COVID pandemic caused other mechanisms to determine the formation of stock market indices (e.g. the main index)? (i.e. another class is correct in modeling)

Yes, the factors shaping the course of the process have changed. This is most visible in the case of the banking sector index, where ARMA modeling has been replaced by ARiMA modeling.

## Ending

The crisis affected the formation of the main LSE stock exchange indices because it was mainly caused by the announcement of the COVID-19 pandemic. This event had its psychological and legal consequences in the British economy. The increase in uncertainty had an adverse effect on the local economy and the lockdown that superimposed it prevented it from operating effectively, which drastically reduced the profits of companies taken into account when constructing the indices presented above. We can see clear dips in places that constitute the beginning of the pandemic in Great Britain (early 2020). Then, most often in the case of the examined indices, there was a rebound and the indices tried to return to equilibrium, recording downward and upward trends at the same time.

The appropriate models were fitted to the index price charts. It was found that there were trends in the price charts of the main index and industry indices before and during the pandemic. After performing the ADF test with the intercept and trend to check stationarity (ACF and PACF charts were included), a result indicating non-stationarity was obtained. First-order integrated variables were used. And stationarity was tested again, which was confirmed this time. The results show that all processes in both the peacetime and crisis periods are integrated at level 1. The Engel-Granger procedure was used to check cointegration. It showed cointegration of all indices with the main index in the period before the pandemic and the banking index with the main index during the pandemic. Then, error correction was applied to all indices. In the peacetime period, there was a long-term relationship between the main index and the financial sector index. In this model, all parameters were significant. The beta coefficient of the sector index was also positive, which indicates cointegration in the long term. The situation was similar in the case of the banking sector, where all parameters were also significant. In this case, the beta coefficient was also positive and equal to 0.9161880, which means that the main index explained it to this extent.

The crisis affected the degree of integration of the models. In the case of the degree of explanation of the main index by the financial services sector index, this value decreased from 0.392891 to 0.325478. This model also ceased to be cointegrated in the long run. On the other hand, in the case of the degree of explanation of the main index by the banking sector index, this relationship increased from 0.9161880 to 0.9181818, and the significance of the parameters increased.

During the crisis, both sector indices are related to the main index, but during the crisis, only the banking index remains in full relation to the main index. For both indices in the pre-crisis period, ARIMA modeling should be used. However, during the crisis, ARMA should be used for the financial sector index, and ARiMA for the banking sector.

The distribution of returns for the main index did not follow a normal distribution in the period before or after the outbreak of the pandemic.

Both in peacetime and crisis periods, autocorrelation of return rates for all the above indices is visible, and their return rate processes were also characterized by the fact that they were stationary both in peacetime and crisis periods.

The main index was characterized by a lack of compliance with the normal distribution, the occurrence of left-sided skewness, the occurrence of leptokurtosis, heavy tails in the crisis period and autocorrelation. In the case of the main index, the class of models will not change because the ARiMA model should be used both in peacetime and in the crisis period. Moreover, the factors shaping the course of the process changed. This is most visible

in the case of the banking sector index, where ARMA modeling was replaced by ARiMA modeling.