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The co-movements between commodity and stock markets in the period of economy downturn on the example of the global financial crisis of 2008

Research Master's Thesis submitted by
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With a view of getting the degrees:
Master in Finance
Master 120 credits in Management, professional focus
Supervisor :
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Academic Year *2019-2020*

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Acknowledgements

Foremost, I would like to express gratitude to my supervisor Prof. dr. Kristina Levišauskaitė for her supervision, support, and constructive feedback throughout the process of writing this thesis. Her professional guidance and knowledge have helped me a lot to improve the content of this Master Thesis.

Many thanks to Assoc. Prof. Dr. Mindaugas Butkus for his valuable comments related to the Methodology part.

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ABSTRACT

Author of Final Master Thesis:	Bayan Akhmetova
Full title of Final Master Thesis	The co-movements between commodity and stock markets in the period of economy downturn on the example of the global financial crisis of 2008
Supervisor:	Prof. dr. Kristina Levišauskaitė
Presented at:	Vytautas Magnus University, Faculty of Economics and Management, Kaunas, 2020 ; Catholic University of Louvain, Louvain School of Management,2020.
Number of pages:	80
Number of tables:	19
Number of pictures:	15
Number of annexes:	3

The aim of this paper is to substantiate theoretically the development of the research methodology and to assess empirically the co-movement of commodity and stock markets in the period of global financial crises and in the post-crisis period. The research has been based on the examination of co-movements between crude oil, gold, soybeans, rough rice, wheat, and stock market indexes from different regions such as S&P500, Nasdaq, Euronext 100, FTSE100, BSE30, Nikkei225 and SSEC. The first part of the paper is devoted to the analysis of the previous researches have done in this field. The second part is designed for the methodology development and research hypothesis settlement. The research hypotheses are based on the assumption that there are co-movements and causality between commodity and stock markets. Hypotheses have been tested by using the correlation analysis, annualized standard deviation, and VAR model. The third part of the research provides the results and discussions. We did not find strong evidence of co-movements between the commodities and stock markets. However, our conclusion cannot be considered as a final statement since there are many more different approaches applicable to the examination of this problem.

Key words: commodity market, stock market, market co-movements, global financial crisis.

SANTRAUKA

Baigiamojo darbo autorius:	Bayn Akhmetova
Pilnas baigiamojo darbo pavadinimas:	Sąveika tarp prekių ir akcijų rinkų ekonominio nuosmūkio laikotarpiu 2008 m. globalios finansų krizės pavyzdžiu
Baigiamojo darbo vadovas:	Prof.dr. Kristina Levišauskaitė
Baigiamojo darbo atlikimo vieta ir metai:	Vytauto Didžiojo universitetas, Ekonomikos ir vadybos fakultetas, Kaunas, 2020; Katalikiškasis Luveno universitetas, Luveno vadybos mokykla, 2020.
Puslapių skaičius:	80
Lentelių skaičius:	19
Paveikslų skaičius:	15
Priedų skaičius:	3

Šio diplominio darbo tikslas yra teoriškai pagrįsti tyrimo metodologijos parengimą ir empiriškai įvertinti sąveiką tarp prekių ir akcijų rinkų globalios finansų krizės ir pokriziniu laikotarpiu. Tyrimas buvo pagrįstas sąveikos tarp žaliavinės naftos, aukso, sojos pupelių, neapdorotų ryžių, kukurūzų ir įvairių pasaulio regionų akcijų rinkų indeksų, tokių kaip S&P500, Nasdaq, Euronext 100, FTSE100, BSE30, Nikkei225 ir SSEC, analize. Pirmoji darbo dalis skirta ankstesnių tyrimų, atliktų šioje probleminėje srityje, analizei. Antroji dalis yra skirta tyrimo metodologijos parengimui ir tyrimo hipotezių pateikimui. Tyrimo hipotezės yra pagrįstos prielaida, kad tarp prekių ir akcijų rinkų yra priežastinis ryšys. Hipotezės testuojamos, naudojant koreliacinę analizę, standartinį nuokrypį ir VAR modelį. Trečioje darbo dalyje pateikiami empirinio tyrimo rezultatai ir diskusija. Tyrime nebuvo nustatyta reikšminga sąveika tarp pasirinktų tyrimui prekių ir akcijų rinkų. Tačiau ši tyrimo išvada negali būti vertinama kaip galutinė, kadangi šios problemos tyrimui galėtų būti pritaikyta ir daugiau skirtingų metodų bei išplėstas tyrimo objektas.

Raktiniai žodžiai: prekių rinka, akcijų rinka, rinkų sąveika, globali finansų krizė.

INTRODUCTION

Nowadays the commodity becomes more and more popular from investment perspectives. Last decade commodity markets start attracting more and more institutional investors such as different mutual, pension funds, insurance companies that allocate the decent part of their investment portfolio to the commodity futures or indexes attempting to reduce the risk. The popularity of such commodity indexes as Goldman Sachs commodity index, Dow Jones commodity index, and Tomson-Reuters commodity index increased dramatically since 2000 and provided access for the huge number of investors to the commodity market. (Bonatoa and Taschinic, 2016). The reason for the increasing popularity of commodity markets is that thanks to globalization the plenty of emerging countries like China, India, and BRICS countries which are the biggest suppliers of commodities appear on the world financial scene and start playing the significant role there. The continuous growth of the investment interest in the commodity market has led to its financialization and change its behavior. (Adams and Glück,2015). Financialization implies the integration of commodity markets with other financial markets and their mutual influence on each other and co-movement. The co-movement is a feature of the markets which is used by investors for diversification purposes. It becomes most popular especially in periods of economic turmoil and crisis. It is an undeniable fact that from the ancient ages and up to now the gold served as a safe haven where the investors look at to save their funds. The different financial crises have different reasons, but all of them have negative consequences for economic development such as unemployment, a decline of business activity, and financial losses. It is a well-known fact that commodity markets are dependent on supply and demand, weather and climate conditions, political situations, and as well as economic cycles. Those factors exaggerate the volatility of commodity markets in the downturn periods thereby influencing the changes of the equity markets movement. All of the above spark the great interest of scientists in this problem. Moreover, the globalization process makes this interdependence more complicated involving the financial and commodity markets of different countries.

Research contribution. A substantial amount of researches has been devoted to the co-movement between stock and commodity markets crude oil and stocks. Another big proportion of studies has been designed to the gold, other precious metals, and stock co-movement. At the same time, very few researches considered the examination of such commodities as rice, soybeans, and

wheat. Furthermore, most researches have been conducted based on commodity indexes, not individual commodity future or spot prices. This paper contributes to the development of this problem by examination of co-movements between stock market indexes and commodity spot prices not only of popular crude oil and gold but also agricultural commodities such as wheat, rice, and soybeans, including different commodity markets both in developed and developing countries, representing Europe, US, Japan, China, and India. We have chosen the main specific commodities for Asian and European regions to focus our attention on the effect of specific commodity markets on the regional stock markets and their co-movements during the last global financial crises period. From the Asian stock market, we will observe the Shanghai composite index (SSEC), BSE 30 Indian stock index, and Nikkei225. For the European market, the wheat spot prices are considered with the Euronext 100, FTSE 100 stock indexes co-movements. We also will examine the co-movement of gold and crude oil spot prices. Such stock indexes as S&P500, Nasdaq has been considered as a global market benchmark.

The research problem is how do the commodity and stock markets co-move in the period of global financial crises and in post-crises period.

The object of the research is the co-movement between commodity and stock markets.

The aim of this diploma paper is to substantiate theoretically the development of the research methodology and to assess empirically the co-movement of commodity and stock markets in the period of global financial crises and in post-crises period.

For the realization of this aim following tasks has been settled:

1. To discuss the peculiarities of the commodity market and its dependence on the economic cycle.
2. To disclose the influence of the economic cycle on the stock market.
3. To provide an overview of the existing studies related to the co-movements between commodity and stock markets.
4. To determine the influence of the financial crisis of 2008 on the commodity and stock market.
5. To develop the methodology for the assessment of the co-movement of commodities and stock markets in the period of global financial crises and in post-crises period.

6. To conduct the empirical research using the developed methodology and to test the research hypotheses disclosing the co-movement of the commodity and stock markets in the period of global financial crises and in post-crises period.
7. To analyze the obtained research results and to compare them with the previous researches.

The content of this paper is structured in three main parts. The first part is devoted to the overview of the existing scientific literature related to this field. There the peculiarities of commodity and stock markets and their interaction with the business cycles were disclosed and, also, the co-movements and behavior of those markets during the last financial crisis of 2008 are discussed. The second part has been designed for the research methodology. In this part, the research object, settled hypotheses, research logic, and methods are provided and explained. The data sample used in the empirical research and limitations of the research is also considered there. The third part is allocated to the presentation and discussion of the empirical research results as well as their comparison with the results obtained by the previous researchers. The results are accompanied by tables and graphs allocated both in this part and in the Annexes of the paper.

Research methods. The analysis of the existing scientific literature has become one of the employed methods while the implementation of this work. The results of previous researches are systematized in the tables providing the main outcomes and used research methodology. Also, the supplementary literature and internet resources related to this field have been used to obtain a more precise opinion. Further, several research hypotheses have been tested by using the econometric models. For the examination of the co-movement of the commodities and stock markets, the Granger causality test and VAR model along with the Impulse Response Function analysis have been employed.

Research data sources. The relevant scientific literature, using sources of different academic and research databases were used for theoretical analysis of the research problem. The empirical study has been conducted based on the data obtained from such free available sources as Investing com, Yahoo Finance, and Macrotrends. For data sample stock prices of such indexes as S&P500, Nasdaq, SSEC, BSE 30, Nikkei225, FTSE100, Euronext 100, and commodity spot prices as Rough Rice, Soybeans, Wheat, Crude oil and Gold were used from 2007 to 2018.

I. THE PECULIARITIES OF COMMODITIES AND STOCK MARKETS AND THEIR CO-MOVEMENT

1.1. Peculiarities of the commodity markets and their interaction with the economic cycle.

Commodities are the natural resources or raw materials obtained from mining, drilling, agriculture. They are used in the manufacturing process and have an intrinsic value (Sharma et.al., 2014). Commodities exist in the different from such as energy carriers, precious metals, agricultural products, and livestock. It is possible to divide commodities for several groups:

- Energy commodity includes crude oil, natural gas, coal.
- Industrial metals are presented by zinc, lead, copper, aluminum, etc.
- Precious metals contain gold, silver, platinum.
- The soft commodities group mostly consists of agricultural commodities (grains, sugar, coffee, cotton, etc.) and livestock.

The commodity market is a place to buy or sell real assets (Sharma et.al, 2013). The most famous commodity markets are the New York Mercantile Exchange (NYMEX), London Metal Exchange (LME), Chicago Board of Trade (CBOT), and Chicago Mercantile Exchange (CME). Nowadays the commodity market experiences a boom and starts to play a significant role in the world trade arena. The transactions on the commodity markets among 11 developed countries sharply increased from $1400 trillion in the period from 1998-2004 to $9000 trillion in the period from 2004-2007 (Yamori, 2011). Valiante (2013) states that the globalization and proliferation of international trade in scope with the liberalization of WTO rules facilitated the development of the commodity market. Also, on the global scene, the fast-growing countries-suppliers of commodities such as China, India, Brazil, and other fast-growing Asian countries have appeared. Their sharp manufacturing growth, construction, and automotive sector development required the continuous supply of raw materials. Such commodities as crude oil, copper, and aluminum are actively used in a construction field and the demand for them increases in the period of the economic expansion. The innovation development has led to the active usage of some raw materials to create biofuels from the corn or employ the soybeans oil in the pharmaceutical products. It also fuels the increasing demand for commodities. The next factor such as a low cost of financing and good

return on alternative assets fostered the storages of commodities, in particular, metals (Valentine, 2013). The rapid expansion of the commodity markets also can be explained by entering institutional investors to this market seeking diversification benefits (Yamori, 2011). Besides conventional way trading as physical goods, nowadays commodity markets are diverse and provide the opportunities to invest in the future contracts, plenty of exchange-traded funds (ETF) and mutual funds offer to investors the low mean access to the commodity through the future indexes.

The financialization of the commodity market has led to the development of the trend to invest in commodity indexes. A commodity index is a basket of the commodity futures combined the several commodity futures based on the weighted principals on economic significance, liquidity, and diversification. There are several well-known commodity indexes are used as a benchmark. These are Bloomberg commodity index (BCOM), Goldman Sachs Commodity Index (GSCI), and Jones-AIG Commodity Index (DJ-AIGCI). It is also worth noting that after the financial crisis of 2008 investors had to revise their investment strategies by actively including commodity futures in their investment portfolios as a diversification tool. Further, the technological progress enabled commodity trading by providing opportunities to trade on special platforms similar to the HFT. All the above has led to the fast development of the commodity market within the last decades.

Commodities are specific assets. The commodity prices depend on many different factors such as supply and demand, weather conditions, crop diseases, storage capacity, technological factors, and geopolitical status and trade tariffs. The supply is the main driver of commodity prices, in particular for energy commodities and industrial metals. The scarcity of such materials always leads to a rise in prices. In opposite, the price of the soft and agricultural commodities is formed mostly by demand. In regards to it worth noting the supply of some commodities like agricultural commodities can be cyclical due to the climate and weather conditions and permanent as in a case of energy and minerals. The demand for commodities can be also periodical. For example, in winter the demand for energy commodities increases, while metals can fall due to the slowdown of constructions in that season (Jégourel, 2018). This seasonality is the main peculiarity of the commodity market, which should be taken into account by supply management. Since commodities are storable assets it is inevitable to note another significant factor affecting the price of the commodity as a cost of the store. Some commodities have a high level of storability as

livestock and agricultural commodity. Moreover, livestock is needed to be fed, which is an additional factor influencing the price of the commodity. Furthermore, commodity prices are affected by financial factors like changes in the country interest rate level, which consequently will entail the alteration of working capital cost and investment activity. The expectations of the interest rate increasing negatively influence the commodity prices due to the rising of the storage cost and shifting investor's preferences to the bonds (Kurach,2012). This author in his study examined the relationship between business cycles and commodity and stock prices and have found that commodities showed a positive reaction to the release of the product during the economic downturn period, while in the period of growth this reaction is insignificant. From all examined groups of commodities, the industrial commodities are more affected by the macroeconomic cycles and showed the lowest diversification benefits due to the synchronic co-movement with S&P 500 index. In contrast, precious metals and livestock are not influenced by business cycle fluctuations. Furthermore, the commodities express the short term expectations of the investors, while the stock's valuation is mainly based on the long term forecast. Based on such indicators as Industrial production (IP- seasonality adjusted), Consumer price index (CPI), Producer Price index (PPI), the author has found that commodity prices matched to the business cycles better than stocks. This coincidence can be explained from the point of view of inflation because inflation triggers commodity prices upward and vice versa increasing commodity prices leads to the rise of the inflation rate. In turn, increased inflation expectations lead to the rise of the supply of stocks and bonds. Especially the agricultural commodities are subject to inflation. Investment in crude oil can also serve as a hedging tool against inflation since it is a key driver of inflation (Arfaoui and Rejeb, 2017). In those authors' opinion, such reaction differs from the reaction of stocks and bonds. The availability of the credit supply affects the commodity price formation too since credits are frequently used by farmers. Such factors determine the level of business activity (Shousha, 2016). Shousha (2016) also determined the channel of the transmission effect of the commodity prices changes and interest rate as the working capital channel since the investment activity, usage of the labor sources are dependent on the cost of capital. Also, the author infers that an increase in commodity prices can allow banks to borrow more from foreign sources, which will accelerate the financial and business activity. Therefore, the author called it a financial acceleration channel. Jégourel (2018) states that commodity prices are subject to cyclical fluctuations related to business activity and type of commodities. Some commodity prices can experience more cycles during the

same periods than others. The author divided the commodity price movements by super-cycle and cycle. According to him, the super-cycle period is characterized by increasing the price trend of several commodities mainly industrial metals and energy commodities because usually it is accompanied by innovations and urbanization in developed economies and as a consequence leads to increasing demand for raw materials. Super-cycle periods last over several decades (from ten to thirty years). Then this phase changes to depression and decreasing prices. In contrast, the short cycle lasts no longer than ten years and attributed to investment behavior.

From all the above, we should summarize that commodities are specific assets which prices are affected by many factors besides the supply and demand. They are also exposed to fluctuation during the different business cycles. The peculiarities of commodities and their different co-movements patterns with stock markets are actively used last decades by investors seeking the diversification benefits thereby leading to the financialization of the commodity market. This, in turn, has changed the co-movements pattern of commodities depriving some of them of the hedging features. Since industrial and energy commodities are highly involved in manufacturing processes they cannot serve for diversification purposes. In contrast, due to less involvement in the industrial process, agricultural commodities can be considered for this purpose.

1.2. Stock markets and their interaction with the economic cycle

The stock or equity market is a place where the shares of the corporations are issued and traded. Shares or securities represent the peace of the ownership of the company which can be easily bought and sold on the equity market. The stock market is a complex of institutions and economic mechanisms related to the circulations of securities. The main purpose of the existence of the stock market is to attract financing by issuing, selling, and buying stocks. The investors gain profit on the difference between buying and selling prices of shares. In addition, the investors can get benefits from the dividends which are the major peculiarity of the stock market. The dividends also can be used for reinvestment to increment the initial capital.

Therefore, it is possible to distinguish the main economic functions of the stock market. First of all, it is the attraction of the capital for the business. Second, it provides a wide range of investment opportunities by offering different financial instruments to invest in. Third, the redistribution of wealth. Forth, the stock market serves as an economic health indicator. Looking at the ups and downs of stock market prices and gained returns we can judge the level of business

activities and economic growth of slowdown (Ildırar and İşcan, 2015). Each country over the world has its own stock exchanges, but there are most famous stock exchanges: The New York Stock Exchange (NASDAQ), London Stock Exchange, Tokyo Stock Exchange, Euronext, Shanghai Stock Exchange.

There are several features of the stock market. First, capital growth is achieved by the difference between the buying and selling price of securities. The companies going public first time use the IPO mechanism to introduce themselves on the stock exchange. Second, the perfect pricing mechanism enables great liquidity for investors. As a commodity market, the stock market is also affected by the same factors such as supply and demand, political factors, inflation rate, and interest rate level. Moreover, as discussed above the equity market is exposed to the influence of the financial and political news. According to the theory of the stock market efficiency, all those factors affect the stock prices formation process and all available information is incorporated in the stock prices. It implies that stock prices change as fast as new emerging information or any action has been undertaken. Rise of equity prices can enhance the market capitalization of the company, providing additional liquidity thereby increasing its investment attractiveness. Third, the set of rules and laws ensure the transparency of all financial transactions on the stock market. All listed companies are required to provide a set of financial and non-financial reports for investor's observation. From that, the forth stock market feature follows. The investors participating in the stock exchange are protected by the oversight of the SEC, FINRA, and other regulatory bodies. The protection is implemented by setting the requirements for the financial and non- financial reports disclosure. Other functions of the SEC include the maintenance of the stock market efficiency and facilitate capital formation. The fifth peculiarity, that trading on the stock exchange is allowed only for the members of the exchange or through the stockbrokers who will open the individual accounts for investors. In this regard is worth noting that the size of the broker's commissions also affects the final investor's outcome. The most specificity of the stock market is a prediction of the price movement. That requires the strong fundamental financial knowledge of stock price formation and skills of technical analysis. Trading the stocks differentiate from commodity trading. While stocks represent company ownership, the commodity futures provide only the right to buy the commodity from the contract. (Ildırar and İşcan, 2015).

Since equity prices can affect the level of consumption, investment activity, and consequently the GDP level which is the main indicator characterizes the business cycles.

Therefore, the stock market movement can serve as a good prediction of future returns and GDP growth. For these reasons, some stock market indexes are used as the indicators of the business cycles and the health condition of the market. Such indexes as S&P500, Dow Jones, Nasdaq serve as a measure of the global finance condition and benchmark for the market participants because they include the risk-adjusted return of the largest US corporations across all industries. Stock indexes are the combination of the different weights of the stocks from the different economic sectors based on their market capitalization. Moreover, equity prices are included in the composite financial cycle indicator to measure the length of the financial cycle. Meanwhile, each country has its own famous stock market indexes serving as a benchmark for the given country or a region. For instance, the Euronext100, FTSE100, are the indexes of European stock markets, BSE30 is the index of Indian stock market, SSEC - the index of Chinees famous stock market, Nikkei 225 is an index of Japanese stock market.

Looking at the mentioned indexes investors usually estimate the current situation on the market and can set the justified expectations for the near future (up to one year). They also take into account such fact that stock markets become bearish before the economic distress and bullish when the economy is growing. Kurach (2012) states that equity prices are lowest before the recession and aspire to reach a peak in a period of economic expansion. Therefore, the stocks are deemed as a weak hedge instrument. According to Claessens, Kose and Terrones (2011) in periods of financial downturn the stock prices drop deeper by 28% and recover sharper by 25% in the recovery periods. This feature is more inherent to the emerging markets than in the developed markets. The emerging stock markets are more volatile since they are more exposed to the influence of the international financial markets changes. Thus, being aware of such behavior in the downturn periods investors can rearrange the structure of their investment portfolio in advance. Such indicators as the equity and housing prices, as well as the domestic interest and exchange rate, significantly affect the relationship between stock markets and subsequently business and financial cycles (Claessens et al., 2011).

To summarize the analysis above, we should conclude, that stocks being the most popular financial instruments among investors at the same time are riskier in comparison with commodities. Their prices change under the different factors not only supply and demand but also under the different financial and political circumstances. Stock indexes of each country accumulate risk-adjusted returns of the largest corporations from the different industries. Therefore, the stock

market movements are used as an unmistakable indicator of the business cycle and the economic condition.

1.3. Co-movements between commodity and stock markets

As discussed above the commodity and stock markets have many differences. For example, the stock market is distinguished by the dividend existence and possibility to reinvest them thereby obtaining the additional gain. The primary peculiarity of the commodity market was that trading always was accompanied by the physical processions of goods. Moreover, initially, commodity trading was not dedicated to attract and raise additional financing "but rather commodity futures are derivative securities that allow firms to obtain security for their future outputs and inputs."(Baran and Ranusa, 2010). It can be said that this peculiarity of the commodity market is diminishing steadily due to the commodity financialization phenomenon, and some commodities such as crude oil, coffee, and cocoa are deemed as speculative instruments. From the first sight, these two markets seem so different to affect each other, but they certainly have a relationship which determines their co-movement.

Co-movement or cointegration is characterized by a similar trend in the financial markets and increased correlation over the long-run period (Gulzar et al., 2019). This phenomenon emerged relatively recently in 1988 when the mutual funds started actively invest in a commodity by using so-called "style investing - the investment strategy shifting form one type of investment to the completely different" (The Free Dictionary by Farlex, 2020). Adams and Gluck (2015) argued that the relationship between commodity and stock markets exist in the two forms: co-movements and spillover. In the author's opinion, co-movement can have bi-directional causality. Furthermore, the spillover effect has a steady character, when a shock is transmitted from one group of assets to another. As discussed above in the 1.1. paragraph, an increase in commodity prices will lead to the rise of the inflation rate. Consequently, central banks should raise the interest rate to combat inflation. This will lead to economic slowdown due to the high cost of borrowing. As it is known the slowdown of the economy is accompanied by the fall of the stock market prices. This is also consistent with Öztek and Öcal (2017), who stated that such co-movement between stock and commodity markets can be explained through the "information discovery role of the commodity. Looking at the negative signal from the commodity market which is always the indicator of global economic stress, investors become pessimistic and can decrease their risk appetite and close their

position on the commodity market. This will lead to an increase in volatility and correlation between the two markets. Many scientists investigated that problem to determine the consistent patterns of their co-movement. For instance, Azar and Chopurian (2018) have found that all commodities can be used as diversification tools since they showed a negative correlation with stock indexes. In contrast, Abdullah, Saiti and Masih (2016) infer that in a short period the commodity and stock prices move in the same direction. De Boyrie and Pavlova (2018) stated that co-movement between commodities and stocks in Asia region lower than in developed countries. Moreover, those authors have found low co-movements between stock indexes and agricultural commodities and precious metals. According to them, the energy commodities experienced grate fluctuations and a high level of cointegration with stocks during the Financial crisis of 2008. This result is consistent with Ildırar and İşcan (2015) who investigated the interaction between stock prices and commodity prices of rubber, iron, wheat, and crude oil. Authors have not found co-movements between those assets.

There is a common belief that gold as an asset has a safe haven property in the turmoil period. The safe haven is a property of an asset that has a negative or zero correlation with other assets, which is used for diversification purposes to reduce the investment portfolio risk. Therefore, plenty of authors have investigated the relationship between gold and stock prices. Mensi (2019) examined the behavior of gold and stated that the stock market negatively influences on the gold prices. Some researchers infer that such a feature of gold as a safe haven disappeared during the

The financial crisis of 2008 due to the global market integration process (Batten, Szilagyi and Wagner, 2015). Meanwhile, not only precious metals possess a safe haven property. Investors also try to use other commodities for hedging purposes. As has been noticed by Tuna and Tuna (2019) the agricultural commodities in the Islamic market possess the safe haven feature due to the low volatility especially in the financial crisis period. In regards to other commodity groups in other regions, it can be said that during the financial crisis the co-movement between stock and commodity prices increased, which excludes the commodity from hedging instruments. However, the level of co-movements in the Asia region was much lower than in developed countries (Batten, Szilagyi and Wagner, 2015). Hoque and Farhan (2017) after examination stock prices and gold have concluded that there is bidirectional causality between stock and gold prices. Many authors have devoted their researches to the co-movement of crude oil and stock prices. For example, Huang, An, Gao and Sun (2017) conducted the Granger causality test which confirmed that

fluctuations of crude oil prices can cause the oscillations of the stock market. Hamma, Jarboui and Ghorbel (2013) also confirmed the unidirectional movement of the stock prices and crude oil. On the contrary, Arfaoui and Rejeb (2017) have found that the oil market has bi-directional positive causality with stock and gold market, which means that the rise of stock prices leads to an increase in stock prices and gold and vice versa. Moreover, there is an indirect influence on the stock prices based on the market expectations reflecting the speculative and herding behavior of the market participants. Youssef and Mokni (2019) investigated the relationship between oil and stock prices of the six oil importer and exporter countries in order to determine whether the different co-movement patterns between them. Those authors concluded that before 2006 the correlation between these types of assets was negative, but became positive after the Financial crisis of 2008 in all examined oil exporter and importer countries. This pattern continues over the last decade which was the reaction of both markets to the different political events and economic conditions. Moreover, Mensi (2019) has found that stocks from such industries as petrochemical and tourism were most affected by the changes in oil prices. Food, media, and telecommunication industries were less affected by the oil price fluctuations. According to Silvennoinen and Thorp (2013) agricultural commodities, grains and some metals have not illustrated nexus to the stock market. Similar results have been achieved by Kirithiga, Naresh, and Thiyagarajan (2018) who have not found the nexus between stock prices and such agricultural commodities as the seed of Chana, Cotton seed oilcake, Jeera and Mustard seed, Wheat and Kapaskhali raw cotton. Authors attributed such a result to the less involvement of those industries where mentioned commodities are used in the stock market in India. In contrast, since India is a great importer of soy oil, its price is affected by the global market and then have been found as a unidirectional cause of the Indian stock market. Special attention scientists paid to the co-movement patterns during the last Financial crisis. Many authors have come to the conclusion that during the turmoil period the increased volatility on the markets has led to the rise of correlation between commodity and stock returns. This consequently enabled the synchronized trend of those markets (Roy and Roy, 2017). Some scientists stated that increased correlation and co-movements during the distress period is a result of the financialization of commodities (Adams and Gluck, 2015).

Analyzing the previous studies the special attention should be paid to the consideration of the empirical methods applied by the scientists to examine the co-movements between commodity and stock markets in different periods. It worth noting that scientists used a wide range of methods

starting from the simple correlation and regression analysis. For example, Caballero, Farchi, and Gourinchas (2008) investigated the interaction between crude oil prices and other asset prices during the financial crises of 2008 by using the OLS regression and found that the correlation during the crisis period was different depends on the stage of the crises. They notice that in the first stage of the crisis the correlation was negative and then it increased when prices on both markets dropped. The correlation between commodity and stock markets has been investigated by exploiting different econometric tools. Among them, the Dynamic conditional correlation (DCC) model is very popular. This model is an extension of the well-known GARCH model and allows us to observe the correlation among assets in dynamic. The observation is made on the analysis of the variance. This model was used by De Boyrie and Pavlova (2018) in order to investigate the correlation between commodities and stocks in the Latin and Asian countries. By using that model they proved that precious metals and agricultural commodities have a low level of correlation, and observing this correlation in dynamic they found out that in general, the correlation between commodities and stocks increased during the turmoil period. From our analyses of the previous literature, it is seen that a significant proportion of researchers used the VAR model which allows determining the presence of cointegration of these markets (Table 2 in Annex 2). By deploying the VAR model and Impulse Response Function Shousha (2016) has found that commodity prices shock has a stronger impact on the macroeconomic indicators such as interest rate, output, and credit in emerging countries than in developed countries. The results of another part of the studies have been based on the Granger causality test which is useful to indicate the causality between the mentioned markets. For instance, Hoque and Farhan (2017) by using that test have found out the bi-directional causality between gold, crude oil, and stocks, which means that those markets can cause the changes of each other. Many researchers investigated the problem of the market co-movements during the financial crisis by observing the volatility in both markets. Such an approach requires the application of the GARCH model, which analyzes the volatility based on the variance indicators. The GARCH model has been employed by Öztek and Öcal (2017) in their study and it was concluded that that co-movements between commodity and stock markets started before the crisis. The authors showed that the precious metals and agricultural commodities experienced high volatility during the financial crisis period. The important aspects of previous researches regarding the problem of stock and commodity market co-movements are presented in Table1 below. The analysis of the variety of exploited empirical models, data frequency and

examined regions is presented in Table 2. Also, extended results of the previous studies are presented in Tables1, 2 of Annex 2.

Table1

Overview of findings in previous researches of co-movements between commodities and stock markets

Author	Aim	Findings
Creti et al. (2013)	To investigate the relationship between commodity and stock market.	Correlation between stock and commodity market got stronger over time. Both commodity and S&P prices have dropped during the 2007-2008 financial crisis.
Yamori (2011)	To find out whether the correlation between commodity and equity market during last financial crisis.	Japanese equity market showed the same behavior as a commodity market during the 2008, but it was the temporary phenomenon.
Gulzar et al. (2019)	To investigate is there the cointegration between Asian emerging and the US equity markets during the financial crisis 2008.	The spillover effect as well the cointegration between Asian and the US stock markets were confirmed during the pre-, crisis and post-crisis periods.
Roy and Roy (2017)	To examine the contagion between commodity derivative, stock, bond, foreign exchange markets in India	Increase of volatility has led to the rise of correlation during the crisis period. Mostly contagion was observed between stock and gold, in particular the stock market transmit volatility to the commodity market.
Jakpar et al. (2013)	To measure volatility of stock markets between China and 5 ASEAN countries.	The globalization has increased co-movement between China's and ASEAN stock markets. After the Financial crises those markets have become completely integrated.
De Boyrie and Pavlova (2018)	To examine the commodity and equity co-movements in the Latin America and Asia	1 Precious metals, agricultural commodities and stocks showed the low co- movements. 2.The stock and energy commodities showed the high level of integration . 3. The high and positive correlation and volatility has been found in the Financial crisis period.
Abdullah et al.(2016)	To determine causality between crude oil prices and Islamic stock prices.	There is a clear co-movements between commodity and Islamic stock prices in a short-time period. Gold has been confirmed as a good diversification tool.
Azar and Chopurian (2018)	To define the relationship between commodity and stock market of the GCC countries.	The correlation between stocks and commodities was negative, thereby proving the diversification opportunities for investors.
Hoque and Farhan (2017)	To examine the causality between gold, crude oil and stock markets in Thailand.	The bi-directional causality has been found between gold, crude oil and stocks.
Batten, Szilagyi and Wagner (2015)	To investigate the level of the relationship between commodities and stocks in the different regions of Asia	The Asia Pacific region demonstrated the low level of co-movements between stocks and commodity market. Co-movements between two markets increased in the last Financial crises of 2008.
Silvennoinen and Thorp (2013)	To determine the correlation between commodity and stock markets	1. Investigated commodities showed the strong correlation with stock indexes. The food and grain commodities and some metals have not illustrated the relationship with stocks. 2.The correlation enhancement has been noticed in the last financial crisis period.

Table 1continued

Huang et al. (2017)	To investigate whether the crude oil price have influence on the stock market.	The crude oil price fluctuation can cause the changes of the stock markets in short and long periods. Increase of the crude oil price can lead to the boom of the stock market.
Hamma et al. (2013).	To examine causality between stock and crude oil prices in Thunisia.	The Crude oil prices had direct and indirect impact in the different sectors of economy. There is unidirectional causality between crude oil and stock prices.
Kirithiga et al. (2018)	To examine the spillover between commodity and stock market in India.	The spillover between such agricultural commodities as seed of Chana, Cotton seed oilcake, Jeera and Mustard seed, Wheat and Kapaskhali raw cotton has not been identified.
Kurach (2012)	To estimate the interrelation between macroeconomic factors and equity, commodity prices in the different periods of the business cycle.	The correlation between commodity and stock indexes was low except the industrial metals prices. S&P has led the macroeconomic variables (CPI and PPI) earlier than commodity indexes however, the industrial metals behaved similar the S&P500. Precious metals, agricultural commodities and live-stock have not affected by the business cycle fluctuations.
Jégourel (2018)	To determine is there any cyclical movement of commodity prices.	There were a three super-cycles since last 19th century.1865-2010.The different commodities have the different cycle longitude. The cycles are usually characterized by increasing prices of industrial commodities as a main component of innovative technologies.
Mensi (2019)	To study the co-movements between crude oil and stock markets (sectoral analysis) in Saudi Arabia	The co-movements increased in the period from 2008-2009. The stocks of petrochemical and tourism industries were most affected by oil prices. Food, media and telecommunication industries were less affected by oil price fluctuations.

Note: the table has been compiled by the author based on the previous empirical researches presented in Table 1.

From Table 1 is clear that globalization has led to an increase of co-movements between commodity and stock markets. The vast majority of researchers investigated the co-movements patterns in different regions and have found that there was low co-movement between commodity and stock markets in the developing regions. In particular, this attributes to the Asian market before the last global financial crisis period due to the less involvement of it to the global interaction. All researchers have noticed the fact of increased volatility and correlation between commodity and stock market which started from the financial crisis. The influence of crude oil on the stock market movement is also a common opinion of all researchers. Moreover, there is no consensus about causality between crude oil and the stock market. Some authors find out the bi-lateral causality between crude oil and stock market indexes, other scientists think that there is only uni-lateral causality. From the analysis, it is clear that most scientists have come to the conclusion that

precious metals and agricultural commodities are weakly correlated with the stock markets. In contrast, the energy and industrial commodities behaved as the stock indexes.

Table 2

The overview of empirical models and data exploited in the previous studies on co-movements between commodity and stock markets

The key elements of empirical research	Criteria for evaluation of key elements in the empirical researches	Authors (list of the authors which follow under each element criteria)
The area covered by research	One country	Yamori (2011); Huang et al. (2017); Roy and Roy (2017); Hamma et al.(2013); Kirithiga, et al.(2018); Sharma et al.(2014); Bonato and Taschini (2016) ; Mensi (2019).
	Several countries	Youssef and Mokni (2019); Shousha (2016); Claessens et al. (2011); Childs and Kiawu (2009);
	One region	Jakpar et al. (2013); Abdullah et al.(2016); Batten, Szilagyi and Wagner (2015); Azar and Chopurian (2018).
	Several regions	Gulzar et al.(2019); Ildırar and İşcan (2015); Silvennoinen, Thorp (2013).
	Global	Creti et al. (2013); Öztek and Öcal (2017); De Boyrie and Pavlova (2018); Hoque and Farhan (2017); Kurach (2012); Baran and Ranusa (2010); Tuna and Tuna (2019); Arfaoui and Rejeb (2017);
Period covered by research	< 10 years	Ildırar and İşcan (2015); Abdullah et al. (2016); Huang et al. (2017); Hamma et al.(2013);
	10 years	Jakpar et.al. (2013); Kirithiga, et al. (2018); Sharma et al. (2014).
	>10 years	Creti et al.(2013); Yamori (2011); Gulzar et al.(2019); Roy and Roy(2017); Öztek and Öcal (2017); Adams and Glück (2015); De Boyrie Pavlova(2018); Azar and Chopurian (2018); Hoque and Farhan (2017); Batten, Szilagyi and Wagner(2015); Silvennoinen and Thorp (2013); Baran and Ranusa (2010); Kurach (2012); Bonato and Taschini (2016); Shousha (2016); Claessens et al.(2011); Jégourel (2018); Youssef and Mokni (2019); Mensi (2019); Arfaoui and Rejeb (2017); Tuna and Tuna (2019); Ravazzolo (2013); Caballero, Farchi and Gourinchas (2008); Childs and Kiawu (2009); Kang, Ratti and Vespignani (2017).
	up to 2015	Creti et al. (2013); Yamori (2011); Gulzar et al.(2019); Öztek and Öcal (2017); Adams and Glück (2015); Jakpar et al. (2013); Abdullah et al. (2016);Hoque and Farhan (2017); Batten et al.(2015); Silvennoinen and Thorp(2013); Huang et al. (2017); Hamma et al.(2013); Kirithiga et al. (2018); Baran and Ranusa (2010); Kurach (2012); Bonato and Taschini (2016); Shousha (2016); Claessens et al.(2011); Sharma et al. (2014); Jégourel (2018); Arfaoui and Rejeb (2017); Ravazzolo (2013); Caballero, Farchi and Gourinchas (2008); Childs and Kiawu (2009); Kang, Ratti and Vespignani (2017);
	later than 2015	Roy and Roy (2017); De Boyrie and Pavlova (2018); Azar and Chopurian (2018); Youssef and Mokni (2019); Mensi (2019); Tuna and Tuna, (2019);

Table 2 continued

Data used for commodities	Indexes of commodities	Yamori, (2011); Öztek and Öcal (2017); Roy and Roy(2017); Adams and Glück (2015); De Boyrie and Pavlova (2018); Azar and Chopurian (2018); Kirithiga et al.(2018); Kurach (2012); Youssef and Mokni (2019); Tuna and Tuna (2019); Ravazzolo (2013); Kang, Ratti and Vespignani (2017)
	Market prices of commodities	Creti et al. (2013); Ildırar and İşcan, (2015); Abdullah et al. (2016); Hoque and Farhan (2017); Batten, Szilagyi and Wagner (2015); Huang et.al. (2017); Hamma, et al.(2013); Shousha, (2016); Sharma et al. (2014); Mensi (2019); Arfaoui and Rejeb (2017); Caballero Farchi and Gourinchas (2008); Sharma et al. (2014)
	Future commodity price	Bonato and Taschini (2016); Silvennoinen and Thorp (2013);
Data frequency	Daily	Creti et al.(2013); Yamori (2011); Gulzar et al.(2019); Roy and Roy (2017); Adams and Glück (2015); De Boyrie and Pavlova (2018); Abdullah et al.(2016); Huang et al. (2017); Kirithiga et al. (2018); Mensi (2019); Tuna and Tuna (2019); Caballero et al. (2008);
	Weekly	Öztek and Öcal (2017); Azar and Chopurian, (2018); Silvennoinen, Thorp (2013); Hamma et al. (2013); Ravazzolo (2013);
	Monthly	Ildırar and İşcan (2015); Jakpar et al. (2013); Hoque and Farhan (2017); Batten, Szilagyi and Wagner (2015); Kurach (2012); Arfaoui and Rejeb (2017); Kanga et al. (2017)
	Quaterly	Shousha (2016); Claessens, et al. (2011);
	Yearly	Baran, Ranusa (2010); Jégourel (2018); Childs and Kiawu (2009);
Research models and methods	GARCH and DCC	Creti et al. (2013); Gulzar et al.(2019); Roy and Roy (2017); Öztek and Öcal (2017); De Boyrie and Pavlova (2018); Azar and Chopurian (2018); Silvennoinen, Thorp (2013); Hamma et al. (2013); Youssef and Mokni (2019); Ravazzolo (2013);
	VAR and its variations,	Gulzar et al.(2019); Jakpar et al.(2013); Abdullah et al.(2016); Hoque and Farhan (2017); Huang et al.(2017); Kirithiga et al.(2018); Shousha (2016); Kanga et al. (2017).
	OLS regression	Batten, Szilagyi and Wagner (2015); Bonato and Taschini (2016); Caballero et al. (2008);
	Unit root test	Ildırar and İşcan (2015); Jakpar et al.(2013); Azar and Chopurian (2018); Kurach (2012);
	Cointegration tests	Ildırar and İşcan (2015)
	Correlation (Excel)	Yamori (2011); Kurach (2012).
	Others (VaR, BB algorithm, Strategic asset allocation, Momentum strategy, Simultaneous equation approach.	Adams and Glück (2015); Claessens et al. (2011); Sharma et al. (2014); Mensi (2019); Tuna and Tuna (2019).

Note: the table has been compiled by the author based on the previous empirical researches presented in Table 2.

From Table 2 it is clear that scientists applied the different approaches to developing their methodology. Among reviewed studies, the equal portions belong to the co-movements examinations on a global scale and within one country. Very few researches have been dedicated to the co-movements investigation in one region and least examinations (only 3 cases) have been devoted to the relationship between commodities and stock market indexes in several regions.

Talking about the variety of employed by researchers methodology it is obvious that there is a diversity of methods and models applied by the scientists. Moreover, from Table 2 in Annex 2, it is seen that scientists were not limited by only one econometric model. Most of them have been used two models for robustness. From our analysis, it is seen that most of the researches used the GARCH model to investigate the volatility and DCC model. Another significant portion of researches has been done by applying the VAR model and Granger causality test. Also, limited researches have been done by applying such methods as VaR, momentum strategy, and correlation calculation by employing the Excel functionality. In the vast majority of cases, the scientists investigated the period of more than 10 years up to 2015. Fewer studies have been dedicated to the period that lasts after 2015. Commodity index prices have been used more frequently than the spot and futures prices. Among the reviewed scope of the literature, we also have noticed only two studies with commodity future prices. The daily data has been used in the vast majority of cases basis because it provides more reliable results than other frequency. However, monthly data has been also used by many authors. The weekly and quarterly frequency of data is represented in an insignificant portion of researches.

1.4. Global financial crisis of 2008 and its influence on the stock and commodity markets.

It is a well-known fact that economic development has a cyclical character. The economic cycle is an alteration period of recession and recovery (Market Business News, 2020). These periods are caused by changes in consumption and trade or in other words business activity. As discussed above, the main measure of such fluctuations is GDP growth. There are four phases to distinguish during the economic cycle. The first phase is characterized by economic slowdown and called the contraction. Then contraction reaches the trough. This is a very bottom point of the cycle with the lowest GDP indicator. This period is characterized by a high unemployment rate, a decrease in consumption and production manufacturing, and the overall decline of the wellbeing of the population. At the same time, it is a turning point from which the economy starts to recover or expand. During this period the business activity revives and reaches the highest peak which is the last point of the business cycle. Then the cycle repeats. Thus, the business cycle looks like waves. In more developed countries these waves are smoothly however, before the last crises the

expansion stage was rapid which had led to steeper waves. Thus, the stagnation and recession always follow after the economic boom.

The last great boom has been observed since 2000. It accompanied by industrialization and development of the new technologies, the rise of commodity and stock prices. In that period the appearance of fast-growing emerging countries has been observed on the international scene. The industrial boom needed the commodities and China, India, and Brazil being the great suppliers of them facilitated that boom. In turn, it resulted in the even greater economic growth of those counties. The steady GDP growth was observed in many developed and emerging countries. There were some noticeable features of the economy in the last pre-crisis period. First of all, the industrial boom accompanied by developing construction and technology increased demand for commodities, in particular for industrial metals and energy commodities. The commodity prices experienced an unprecedented rise. Prices for energy and industrial metals soared more than twice while food commodity prices increased up to 75%. (Roy and Roy, 2017). It worth noting that before the last crisis at the beginning of 2008 the price of crude oil exceeded the $100 per Barrel. Second, as it is known the periods of economic growth is characterized by increased demand for household and their prices. Third, that demand was fueled by excessive lending, which exaggerated the level of household leverage. Before the last crisis, most central banks over the world kept the low-interest rate which fostered the credit boom and accompanied by deterioration of the lending standards. This afterward has led to bad loans. Forth, relying on deposits, banks issued credits actively, which allowed investors to leverage more and in turn have led to the increase of asset prices and bubble formation. It means that assets were trading considerably higher than their intrinsic value which represents the real value of assets or property different from its book value. This is often based on the investor's unjustified positive expectations about the future perspectives and speculations. When no more investors are willing to pay such an unreasonable price, the bubble collapsed, the asset prices started to drop dramatically and the crisis began.

In the development of the last financial crisis, the contagion phenomena played an important role. The term contagion can be explained as a transmission of the shock in one market to other asset markets as inside of one country as well as over the world. However, the contagion effect influenced mostly the countries with significant current account balance deficit and great involvement in the subprime mortgage activity. For instance, several fast-developing Asian countries were not affected severely by contagion phenomena. (Gulzar et al., 2019). The crisis in

one country served as an alarm calling the investors to revise their international portfolio in order to reduce the risk. It has led to the withdrawal the investments from different regions and that exaggerated the situation globally. The higher the integration level between markets, the more noticeable the contagion phenomenon will be.

Although all financial crises always have the common characteristics such as decline of economic activity, decrease of consumption, increase of unemployment rate, lowering the investment expectations and revenue, significant slowdown or negative GDP growth, the last financial crises of 2008 became the most severe after the Great depression of 1930 due to the global scale and coverage of countries. During this recession the purchasing power of the population dropped sharply, many projects were frozen, dramatically decreased the volume of transactions on the real estate markets, many entrepreneurs got bankruptcy. Real GDP of the USA in that period shanked by the (-4,3%), the GDP of the UK fall by (-2,6%), the S&P500 index dropped by 57% since October 2007-March 2009. The S&P500 index is another important indicator of the economy since it combines the stocks of 500 noticeable companies of the US. During the economic distress of 2008, the US stock market lost 40% of the market capitalization, its financial sector fall by 60%. In comparison, the Russian market capitalization dropped by 52% (Gulzar et al., 2019).

That crisis harmed both equity and commodity markets. Initially, the excessive demand and low-interest rate provoked the bubble appearance. As discussed above the WTI crude oil price soared by 100% from July 2007 to June 2008 and then dived by 53%. Seeking the hedging instruments investors restructured their portfolios by adding to them commodity futures or indexes thereby, encouraging commodity financialization. That in turn also has led to the excessive demand and sharp rise of commodity prices. Then the commodity market experiences the same mechanism of collapse as the stock market. Investors were not willing to pay the unreasonable price and prices considerably dropped making the commodity producers poorer and reduced the asset demand (Caballero, Farchi and Gourinchas, 2008). By employing the OLS regression these authors illustrated that in the first stage of the crisis correlation between oil prices and the stock was negative. In the second phase correlation between two types of assets increased, therefore the oil prices experienced a similar drop as the stocks. Moreover, from the causality perspectives, the authors concluded that the increase in oil prices increases the likelihood of the recession. All studies devoted to this topic have agreed that commodity and stock prices experienced great volatility during the last crisis period. From the review of existing studies, it is seen that there is

no clear consensus between scientists about causality. Some authors have found that the influence of commodity prices on the volatility on the stock market was more noticeable during the last crises than whenever else (Kanga, Rattibd, and Vespignanicde, 2017). However, Roy and Roy (2017) have come to the opposite opinion. They infer, that the stock market causes fluctuation in the commodity market. It worth noting that the rise of volatility and correlation mostly were observed among energy and industrial commodities which can be explained by their great involvement in the industrialization processes and decline of demand and manufacturing inevitably affected their prices. In regards to the soft commodities, it should be said that such agricultural commodities as grain have not illustrated the great oscillation during the crisis and could be exploited as a safe haven (Tuna and Tuna, 2019). The same can be attributed to the food and precious metals since their price did not highly fluctuate during the turmoil period (De Boyrie and Pavlova, 2018). Some authors noticed the interesting fact, that during the financial crisis prices of some agricultural commodities rose. For example, Childs and Kiawu (2009) explained in their study that due to the crisis and appreciating the US dollar major suppliers of the rise got panic, which immediately spiked the rice prices and subsequently prices of the wheat, corn, and soybeans. Situation exaggerated by the fact that rice is a base of the diet of half of the world population and pessimistic sentiments from one country transmitted to another by the contagion phenomena. That situation clear evidence of the negative crisis impact on the international commodity trade. The necessity to refinance made the investors withdraw from the commodity market which leads to the dramatic decline of commodity prices. The increase in the import finance cost has led to the reduction of the import demand which exaggerated the decline of prices.

The results of many studies implemented by researchers provide evidence of the tough interrelation between commodity and stock markets. The amplifying oscillation of prices increased the correlation between commodity and stock prices during the last crises and further up to now demonstrate the fact that co-movement between those markets is present. However, some issues regarding specific developing markets and types of commodities are still needed to be investigated.

To generalize the first part of our study we should say that despite the commodity and stock markets are different by nature and have own influencing factors they are toughly interrelated. This was fostered by globalization and the sharp growth of developing countries such as India and China the biggest world suppliers of commodities. Many investors turned to the commodity markets trying to diversify the investment portfolios last decades. It has led to the

evolution of commodity assets from the form of goods to the commodity futures and indexes. In brief, the commodity market has been financialized and started traded like stocks through ETF and mutual funds providing the investors with access to the commodity market. The stock market movement serves as a good prediction of the economic condition. It is possible to trace the business cycles by observing the price levels of the stock market. The financial crisis of 2008 negatively affected both markets and changed their relationship. The main findings from previous researches are:

1. The periods of economic growth is accompanied by the increasing prices of industrial commodity as a main part of innovation technologies.
2. Stock prices have an upward trend in the periods of economic growth and a downward trend before the recession.
3. The volatility in the crisis period on both markets increased thereby enhancing the correlation between commodity and stock markets even though it was low before the crisis.
4. The crude oil, gold, and stock markets showed the bi-lateral causality meaning that they cause the movements of each other.
5. The precious metals and agricultural commodities have been found as less affected by the business cycles with a low level of co-movements with the stock markets.

The co-movements of these markets have been investigated during the last two decades through correlation, volatility, and cointegration by using different econometric models. In order to investigate the co-movements, the vast majority of scientists employed the VAR, GARCH models, and Granger causality tests. Also, the different frequency data of the stock and commodity indexes, spot, and futures prices have been used to determine whether these two markets co-move together or not.

II. RESEARCH METHODOLOGY FOR THE ASSESSMENT OF THE CO-MOVEMENT BETWEEN COMMODITY AND STOCK MARKETS IN THE PERIOD OF GLOBAL FINANCIAL CRISIS AND POST-CRISIS PERIOD.

This part of the diploma paper is devoted to the development of the research methodology. It has been organized as follows. First, we will discuss the research object and explain the reasons for our choice. Then, the research hypotheses with their justification will be presented. Further, the description of the logic of the research and econometric models used for the research as well as the criteria for the assessment of our hypotheses will be presented. After that, the generalized information of the data sample employed for the empirical study will be presented. Also, we will discuss the limitations of this research at the end of this part.

2.1. Empirical research object

This chapter is dedicated to the characteristic of the complex research object chosen for this study - commodities and stock markets. As was discussed in the previous part, the commodity market plays an important role in the economic development in each separate country and on a global scale as well. In connection with this is worth mentioning the fact that some commodities are very specific or strategic for some regions due to diet habits or due to the fact that climate conditions facilitate the cultivation of them. Therefore, the price fluctuations of those commodities can influence the stock markets of the specific region or globally in a case that such commodities have constant demand over the world.

2.1.1. Characteristic of commodities for selection

In this subchapter, we will explain the main criteria for the selection of the commodities and stock markets which were included in our research object. First of all, the choice of the commodity has been made based on the frequency of involvement of these types of commodities in the previous researches presented in Part 1, Table 2. Secondly, while analyzing the previous studies of this problem we have found out that very few studies investigated the relationship of such commodities as soybeans and rough rice markets with the stock market. Therefore, our study will contribute to this gap by examining those commodities behavior. Thirdly, we also selected

commodities in accordance with their strategic importance for certain regions to understand whether the fluctuation of such commodities' prices affects the relevant stock markets. We have grounded our opinion of the commodity importance to the specific country or region on the statistic data about the production volume of commodity and its export-import volume. Bellow, we provide some statistical information to justify our choice of the commodities in our research: rough rice, soybeans, wheat, crude oil, and gold.

Routh rice. As it is known that rough rice is a popular component of the diet of half of the planet and daily used in the Asian region. Moreover, due to climate-specific, rice is grown mostly in the Asian region. From 2008 to 2019 the world rice consumption increased from 437,179 MMT to 493,126MMT (Statista.com 2020). Meanwhile, the main producer and consumer of the rough rice is China which share of rice production reaches 30% of world rice production volume. (WorldAtlas,2020). China is also the main importer of rice and has a 6,5% share of world rice imports. The major supplier of rice in the world is India which global rice export share is 30%. (World's top exports,2020). Since 2008 to 2018 overall world supply of rough rice increased significantly from 587.5MMT to 738,75 MMT relatively (Statista,2020). In general to the Asian region belongs approximately 80% of the global rice trade (United States Department of Agriculture Economic Research Service, 2020).

Soybeans. Soybeans are used not only as a meal. Some species of soybeans are used for the production of protein fibers that can be mixed with cotton, wool, or chemical fibers. The result is a high-quality fabric with a soft texture. Such versatile qualities of soybeans are actively used in manufacturing processes. The major producers of soybeans in the world are the USA and Brazil which possess 36% and 34% shares of world soybeans production relatively (CLALNews, 2018). The main soybeans importing country in the world is China (Observatory of Economic Complexity: OEC,2018). It's import increased substantially from 2008 to 2019 from 40 MMT to 95 MMT relatively and China's import share in the world constitutes (AgriUpdate, 2020). The major suppliers of soybeans in the world are Brazil and the USA which possesses 45% and 38% of the world soybeans export relatively (Observatory of Economic Complexity: OEC, 2018). The production of soybeans grew significantly from 2008 to 2018 from 200.000 MT to 350.000 MT relatively (IHS Markit, 2020). As a response to increasing demand, the volume of soybean export from the USA increased from 40 to 100 MMT from 2008 to 2018 and is expected to increase in

the near future by 120 MMT. (The Fence Post,2019) According to the WTO data, the overall world supply of soybeans from 2008-2018 increased by 5,5% (World Trade Statistical Review, 2019).

Wheat. Wheat is an important component of the world population's diet. It provides up to 20% of proteins for the human body and also it is a source of useful vitamins and minerals. The wheat is cultivated almost in every country in the world. At the same time, the major producer of wheat in the world is the EU produced the 153,5 MMT in 2019 which is about 50% of world wheat production (Statista, 2020). Overall wheat production in the world increased from 680 to 745 MMT from 2008 to 2018 (U.S. Wheat Associates, 2020). The main exporter of wheat is Russia which possesses 19% of world wheat export volume. The second and third places belong to the EU and the USA. From 2008 to 2018 the Russian wheat export was increased from 18,39 MMT to 19,93 MMT. The EU decreased their supply of wheat from 25,43 to 19,29 MMT for the same period. The USA also lowered the export from the 27,64 to 25,86 MMT from the 2008-2018 (Ag Update, 2020). The main importer of wheat in the world is Egypt which import share achieves about 9,8% of world wheat imports (Observatory of Economic Complexity: OEC, 2017).

The trends of selected agricultural commodity prices since 2008-2018 are illustrated in Figure 1. From it is clear that their prices have not changed a lot since 2008. They only experienced significant oscillation during the period of the financial crisis of 2008 but in the post-crisis period, it fluctuated within the same range. In general, it is not possible to distinguish downward or upward trends.

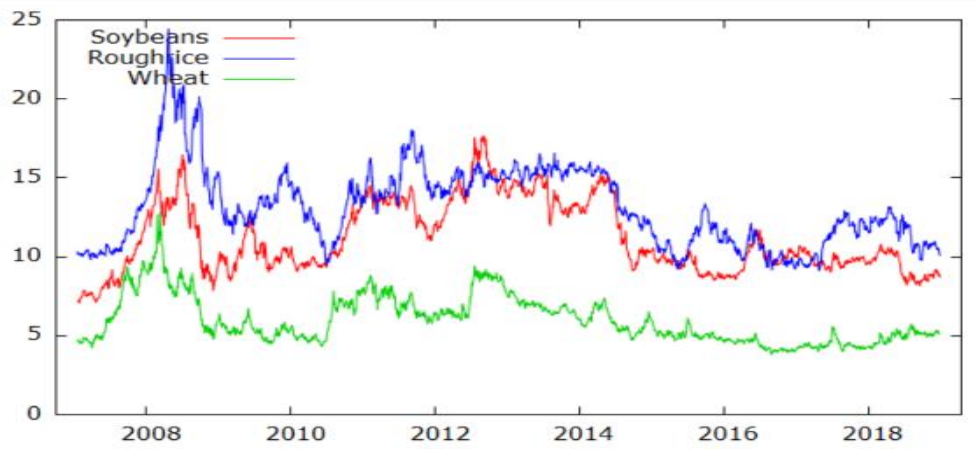

Figure 1. The trends of different commodities in the period of 2008-2018.

Note: developed by the author based on the collected data from Macrotrends.net.

*Wheat and soybeans price is given in USD per bushel, price of rough rice is given in USD per cwt.

Crude oil. Also, we could not avoid the consideration of crude oil due to its undeniable direct and indirect impact on the global economy. The importance of that product is obvious. Crude oil is a highly demanded product. It constitutes about 6% of globally exported products. The major supplier of crude oil is Saudi Arabia which possesses 16% of the world crude oil exports. At the same time, the main producer of crude oil in the USA which produces 18% of all of the crude oil volume (Investopedia, 2020). The demand for crude oil increases over time. From 2005 to 2018 the crude oil production increased by 14%. and it is expected to grow up to 107 million b/d in 2050. The largest importer of crude oil is China which consumption proportion in the world is 20% and the USA which have 13,8% from the world crude oil consumption. (World Oil Review, 2019). Despite the crude oil is highly investigated commodity, it is also a subject of influence different external factors, in particular political. This has led to the high volatility of crude oil. As it is seen in Figure 2 crude oil price experienced the huge ups and downs since 2008. Therefore, it would be good to follow the changes in its behavior in regards to the stock market one more time.

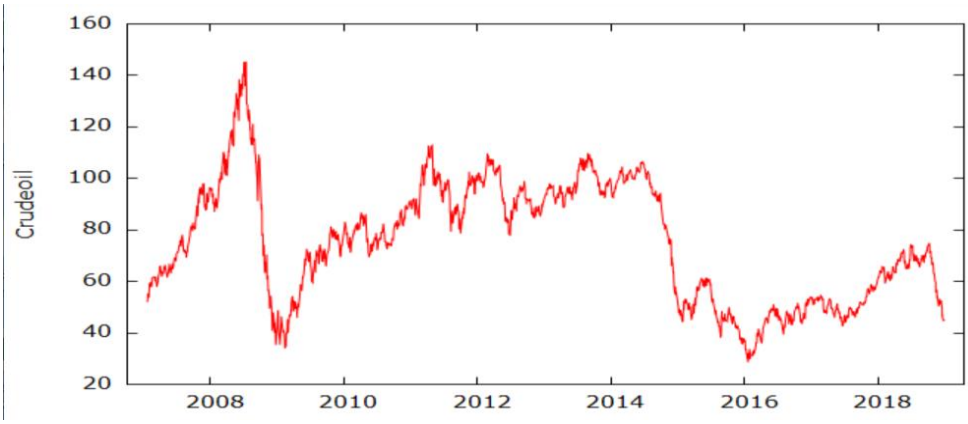

Figure 2. The trend of price of crude oil WTI* in the period of 2007-2018 (in USD/barrel).

Note: developed by the author based on MarketsInsider.com data.
*- West Texas Intermediate brand of oil

Gold. The importance of the gold is in its safe haven peculiarity. Due to this feature, gold does not lose popularity. It is used by investors for diversification benefits. The price of gold is taken into account while setting the monetary and fiscal policies by the government. As a metal, it's durable and easy to use. Therefore, gold is actively used in such industries as jewelry and medicine. The main gold producer in the world is China. It accounts for 11,5% of the world's gold production (IndexMundi, 2020). China's production of gold increased by 40% from 2008 to 2018 (CEIC, 2020). The largest importer and exporter of gold is Switzerland which possesses 21% of

the global import and 22% for export. The second and third places belong to China 12% and India with 11%. As an example, we provided Figure 3 below with trends of gold and S&P500 index. From Figure 3 it is seen that there is a different pattern of co-movements between these assets. In some periods these assets move together, in other periods do not. Therefore, to clarify this matter we decided to add the gold to our examination.

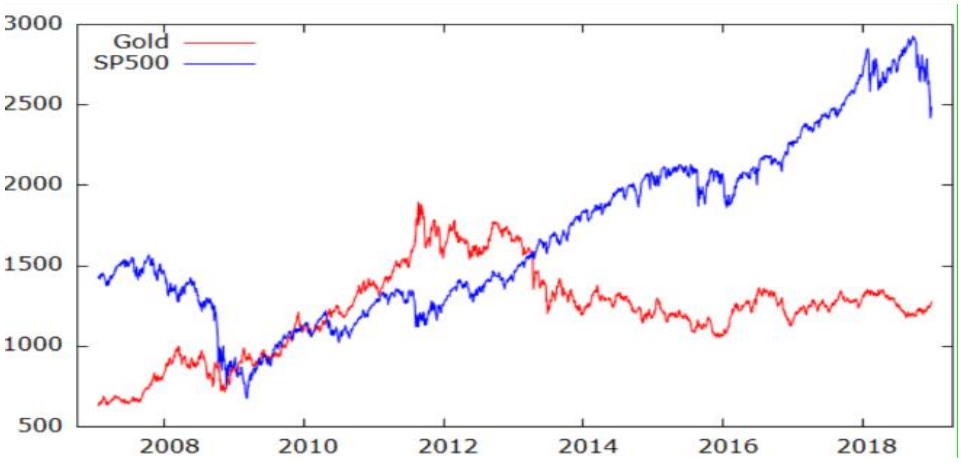

Figure 3. The trend of gold (USD/Troy Ounce) and S&P500 index in the period of 2007-2018.

Note: developed by the author based on MarketInsider.com data.

In order to draw a clear picture of the commodities characterized above and substantiate our choice we generalized all information and present it in Table 3 below. There we stressed the fields of application of selected commodities and which country or region is a famous exporter or importer of it. From it becomes clear how important are chosen commodities for examined countries. As is seen from Table 3 the largest shares of selected commodities in the world belong to China, India, the EU, and the USA. Therefore, we think that there is might be cross regions relationship between commodity and stock markets or co-movements between commodities and stock markets within the entire region. This assumption has determined our decision to examine the Asian region, the EU, and the benchmark in the USA. Moreover, based on the literature analysis we have taken into account how often the previous researchers of commodities and stock markets relationship examined the particular regions and what data frequency they employed. From it is obvious, that a significant proportion of studies have been dedicated to the investigation of the co-movements of Asian region commodities and the stock market. Therefore, it would be purposive to compare our results obtained related to the Asian region using our methodological assumptions with previous studies.

Table 3

Generalized information of examined commodities

Commodity	Field of application	Main producer (country/region), world share %	Main exporter (country/region), world share %	Main importer (country/region, world share %
Rough rice	Meal	China (30)	India (30)	China (6,5)
Soybeans	Meal, textile, chemical industry	USA (36), Brazil (34)	Brazil (45)	China (93)
Wheat	Basic meal product	EU (50)	USA (23), Russia(19), EU (13)	Egypt (9,8)
Crude oil	Chemical industry, oil refining industry	USA (18)	Saudi Arabia (16)	China (20), USA (13,8)
Gold	Jewelry, medicine, hedging purposes	China (11)	Switzerland (21)	Switzerland (22)

Note: developed by the author, based on the Statista.com, USDA. gov,WorldAtlas.com, World's Top Export.com websites data.

2.1.2. Stock markets selection

Since we investigate the co-movements between commodity and stock markets it is logical that the selection of stock markets is inextricably linked with countries- producers, importers, and exporters of commodities which we discussed in chapter 2.1.1. Therefore, we should focus on the US, Chinese, Indian and European markets. In addition, we decided to include the Japanese stock market to our research because it plays an important role in the Asian region, has close economic ties with the other countries in this region. We also took into account the fact that the consumption of rough rice and soy products in Japan is also high. Selected for the research stock markets are the largest in the world. Also, we based our choice of stock market indexes on the fact of how well those indexes represent the region's market. In Table 4 we have collected the main stock market indexes by selected stock exchanges.

Table 4

Largest stock exchanges in the world by market capitalization as of May 2019

Country/ region	Stock exchanges	Market capitalization (trillion US dollars)	Main Indexes
USA	NYSE	23,21	S&P 500 Index, NASDAQ Composite, Dow Jones Industrial Average
	Nasdaq	11,22	
Europe	Euronext	4,27	Euronext 100—pan-European blue-chip index, AEX in Amsterdam, BEL 20 in Brussels, CAC 40 in Paris .PSI 20 in Lisbon
	London stock exchange	3,97	FTSE100, FTSE250, FTSE350, FTSE ALL share
Asia	Japan Exchange group (Tokyo stock exchange, Osaka stock exchange	5.61	Nikkei 225, TOPIX, JPX-Nikkei 400, Mothers Index, JASDAQ INDEX .REIT Index
	Shanghai Stock Exchange, China	5,01	Shanghai Stock Exchange Composite Index(SSEC), Shanghai Shenzhen CSI 300 Index,
	Shenzhen Stock Exchange, China	3,36	SZSE Composite Index, Taiwan Capitalization Weighted Stock Index
	Bombay Stock Exchange, India	2.18	BSE SENSEX; S&P BSE SmallCap; S&P BSE Mid Cap; S&P BSE Large Cap; S&P BSE 500

Note: developed by the author based of the Statista.com data

The S&P500 is widely employed as a market benchmark serving as an indicator of global economic health. It includes stock prices of 500 US leading companies. The Nasdaq composite index contains the common stock securities of more than 3000 American's and foreign corporations listed on the Nasdaq stock market. Nasdaq Composite Index is considered an important indicator of the dynamics of securities prices of high-tech and rapidly growing companies. In our study, it has been included as an American representative and can be used for robustness purposes.

For the European region, we selected the FTSE 100 and Euronext 100 indexes. FTSE100 (Financial Times Stock Exchange) index contains the 100 UK companies with the highest market capitalization listed on the London stock exchange. The Euronext 100 is a blue-chip index. It consists of the 100 largest and most traded stocks on the five European stock exchanges in Amsterdam, Lisbon, Paris, and London.

From the Asian region the BSE30, SSEC (Shanghai composite index), and Nikkei 225 have been chosen. The BSE Sensex index is composed of the 30 well established Indian companies stocks traded on the Bombay stock exchange and represents the Indian equity market. The SSEC is a Shanghai Stock Exchange Composite index that includes all A- and B -shares of companies listed

on the Shanghai stock exchange and serves as an indicator of China's economic health. Nikkei 225 is one of the most important indexes of Japan. It is an average of the 225 actively traded companies on the Tokyo stock exchange.

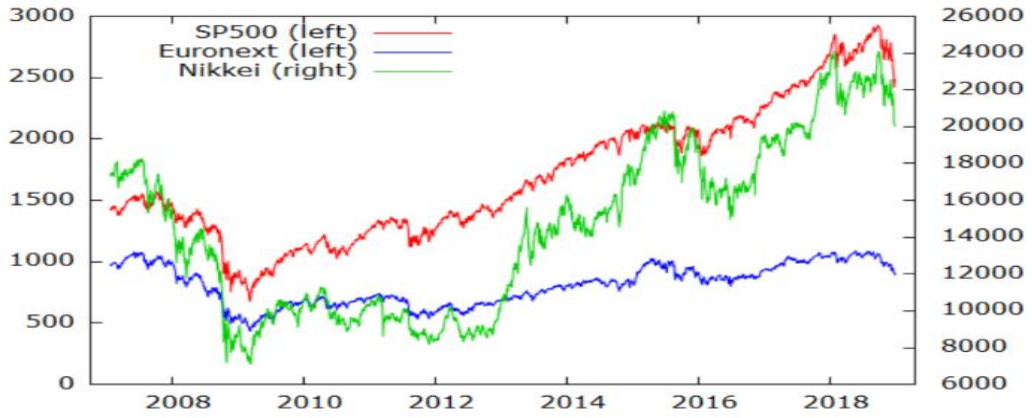

Figure 4. The trends of stock market indexes in the period of 2008-2019.

Note: developed by the author based on the data collected from YahooFinance.com, Investing.com .

Looking at the trends of some of selected stock market indexes (Figure 4) we should say that all of them experienced the huge drop during the last financial crisis of 2008. However, in post-crisis period they have risen substantially. Comparing the trends of agricultural commodities and stock market indexes on the Figures 3 and 4 we see that those trends vary very much**.** Commodity prices had not increased significantly since last financial crisis of 2008 while the stock market indexes have risen dramatically. Therefore, it is an important reason to test what was the co-movements between these markets in the financial crisis of 2008 and post-crisis periods.

2.1.3. The selection of the econometric model

In regards to the econometric model, from the literature overview we have found out that VAR model and Granger causality test very frequently applied for the examination of co-movements between commodity and stock markets. The big advantage of the VAR model is the possibility to test the large number of variables. Therefore, the investigation of the half of our empirical study will be also based on the VAR econometric model. Like some of scientists form our literature review we will also employ the Excel functionality (CORREL and STEV functions) to test the other part of our research. We have chosen it due to the clarity and simplicity of implementation.

2.2. Empirical research hypotheses

In this chapter, we will set the hypotheses which we will test. The main point of our research is to show how the commodity and stock markets were interrelated in the period of the last global financial crisis and after it. Plenty of researchers, such as Azar, Chopurian (2018), Kurach (2012) for the investigation of co-movements between commodities and stock markets have used the correlation method and demonstrated that correlation between those assets types was different in different periods of economic development. Such results of the research are very important from the practical perspective because it is likely that patterns of relationship between commodity and stock markets are repeatable. Therefore, it can be used for forecasting purposes. Many scientists (Roy and Roy, 2017; Creti, et.al., 2013) also noted that oscillation on the commodity and stock markets in the last financial crisis was huge which accompanied by the increasing correlation even between assets which were believed as a hedge. Youssef and Mokni (2019) also emphasized that volatility on the different markets differs and depends on time and region Therefore, we will also examine this phenomenon of selected assets. So, our hypothesis

H1 is: *The co-movement between commodity and stock markets during the global financial crisis and post crises period (in the period from 2007 until 2018) was significant and increased.*

Gold as one type of commodity is an interesting asset for examination because it is believed by investors as a safe haven. Some researchers (Tuna and Tuna, 2019) noticed that gold has proved its hedging feature during the last global financial crisis, in contrast, other scientists (Arfaoui and Rejeb, 2017) have found the positive interdependence between gold and the stock market. Thus, there is no consensus regarding the safe-haven feature of gold. Therefore, in this study, we will also examine this feature of gold through its correlation with stock market indexes. Thus, our hypothesis

H2 is*: During the global financial crisis of 2008 gold has proved its safe-haven feature.*

There is a significant scope of researches, such as Mensi (2019), Bonato & Taschini (2016) and others designed to investigate how the commodity and stock markets influence each other and co-move. The scientists used different stock and commodity indexes from different countries. Unfortunately, there is no consensus about the types and levels of influence. The interrelation between the crude oil prices and stock markets is highly investigated and many researchers have concluded that there is a bilateral causality. Hoque and Farhan (2017) investigated this relationship

using the Stock market index (MSCITH) and oil price index on the monthly data basis for quite a long period (1993-2013). However, Hamma et al. (2013) have found only uni-directional causality between crude oil and stock market movements within a single country Tunisia by employing the weekly prices since 2006-2012. The difference in their results could occur due to these differences in their approaches and data frequency. Therefore, we think that we could contribute to the investigation of this problem by adding the examination of causality between crude oil and stock market indexes in different regions taking the long period after the global financial crisis of 2008.

Thus, our hypothesis *H3 : There was the bi-lateral causality between crude oil and stock markets in the period of global financial crisis and post-crisis period.*

From the review of previous studies on the relationship between commodities and stock markets, it is clear that the character of the relationship between stock indexes and such soft commodities as rough rice, soybeans, and wheat is not investigated that much. Moreover, some authors, such as Batten, et al. (2015), infer that in particular Asian markets are not strongly affected by the changes in a global scene and since agricultural commodities do not integrate into industrial processes they cannot affect the stock markets. Thus, there is not a clear picture of the link between some soft commodities and the stock market. Therefore, our hypothesis H4 is targeted to find out whether the fluctuation of the prices of agricultural commodities influences the changes in the stock market indexes.

Thus, our hypothesis *H4* is: *In the period of global financial crisis and post-crisis period the agricultural commodity market prices cause the movement of the stock markets indexes.*

To implement the investigation of Hypothesis 1-2 we will examine the correlation between selected commodities and stock market indexes. To prove or reject the Hypothesis 3-4 we will test the presence of causality between selected assets, then we will observe the degree of the impulse response of rough rice, soybeans, wheat, crude oil and gold to the changes in Asian, European, and American stock indexes and vise versa.

2.3 Logic and stages of the empirical research

Stages of our research disclosing the logical consequence, actions undertaken and assessment criteria for research hypotheses testing are presented in Table 5.

Table 5

The logic and the stages of the empirical research

Research stage	Hypothesis	Action to undertake	Criteria of assessment
For the Stages 1-2 the returns of all assets are calculated			
Stage 1	Hypothesis 1: The co-movement between commodity and stock markets during global financial crisis and post crises period (in the period from 2007 until 2018) was significant and increased.	1.Calculation of the Pearson correlation between each commodity and stock market index returns by using the CORREL function of Excel.	1.1. Accept this part of H1 if ratio >0,5 and increased over time. 1.2. Reject this part of H1 if ratio <0,5 or has not increased over time.
		2. Calculation the annualized standard deviation of each asset by employing the Excel functionality.(STEV function)	1.3 Accept this part of H1 If annualized SD in crisis period > than in post crisis period. Otherwise-reject it.
		3. Compare the obtained result with statistical significance criteria.	Accept the H1 as a whole if points 1.1 and 1.3 are true.
Stage 2	Hypothesis 2: During the global financial crisis of 2008 gold has proved its safe-haven feature.	1.Calculate the Pearson correlation between gold and each stock market index returns by using the Excel CORREL function.	1. If correlation value is < 0,5 during the 2008-2009 accept the hypothesis. Otherwise reject it.
		2. Compare the obtained result with the significance criteria	
For Stages 3-4 the initial data of commodity and stock market indexes are used			
Stage 3	Hypothesis 3: There was the bi-lateral causality between crude oil and stock markets in the period of global financial crisis and post-crisis period.	1.ADF test for unit root. a. If data are not stationary test for cointegration by using the Johansen cointegration test. b. If data are stationary implement the VAR model and Granger causality test.	Reject the H0 if p-value < 0,05 and if tau-statistic < than specified value state that data are stationary: 1% level of significance (-3,96) 5% level of significance (-3,41)
		2. Determine the lag order (AIC) for cointegration test.	In the Gretl software an appropriate order is indicated by asterisk. *
		3.Run the Johansen cointegration test a. If there is no cointegration apply log differencing procedure and run the VAR and Granger causality test. b. If cointegration exists implement the VECM.	1.Do not reject the H0 if p-value > 0,05 (cointegration does not exist)
		4. Determine the lag order (AIC) for VAR	An appropriate order is indicated by asterisk. *
		5.Determine the lags order and implement the VAR and Granger causality test by using the crude oil as a dependent then as an independent variable.	If p-value <0,05 accept Hypothesis 3.
		6.Conduct the Impulse response analysis.	Observe whether the impulse response positive or negative. If value is If value is > 0,005 response is strong. (*log scale taken into account)

Table 5 continued

Stage 4	Hypothesis 4: In the period of global financial crisis and post-crisis period the agricultural commodity market prices cause the movement of the stock markets indexes.	1.ADF test for unit root. a.If data are stationary implement the VAR model and Granger causality test b.If data are not stationary test for cointegration.	Reject the H0 and state that data are stationary if 1.p-value < 0,05 2. tau-statistic < than specified value: 1% level of significance (-3,96) 5% level of significance (-3,41)
		2.Determine the lag order (AIC) for cointegration test.	An appropriate order is indicated by asterisk. *
		3. Run the Johansen cointegration test a. If there is no cointegration apply the log differencing procedure and run the VAR and Granger causality test. b. If there is a cointegration implement the VECM.	Do not reject the H0 if p-value >0,05
		4. Determine the lag order (AIC) for VAR	An appropriate order is indicated by asterisk. *
		5.Implement the VAR and Granger causality test by using the agricultural commodities as independent variable.	If p-value <0,05 accept Hypothesis 4.
		6.Conduct the Impulse response analysis.	Observe whether response positive or negative. If value is > 0,005 response is strong. (*log scale taken into account)

2.4. Methods of the empirical research

Test of the Hypotheses 1 -2.

2.4.1 Log return

Before testing our Hypotheses 1 and 2, we need to transform our initial data to the log return. Using the log of return of data we can reduce the heteroscedasticity and exclude some negative outliers which can help to make the data more normally distributed. The calculation of it has been made by taking the natural logarithm of dividing the price at the time t $P_{(t)}$ by the preceding price $P_{(t-1)}$.

$$r = \ln \frac{P_t}{P(t-1)} \quad (1)$$

2.4.2 Correlation

To test our first hypothesis we are going to calculate the correlation between returns of commodities and stock market indexes for each year during the examined period. The observation

of the correlation patterns will give us an understanding of how the relationship between the two markets changed during the investigated period. Moreover, we propose the result of the annualized standard deviation of all variables which is the measure of volatility in order to compare and link the volatility of assets and changes of their correlation. The correlation is a linear relationship between variables and statistical measure which shows the degree of the relationship between variables. It is also known as a Person correlation or Pearson product-moment correlation coefficient (PPMCC). It is determined as the covariance between two variables divided by their standard deviation.

$$\rho(_{xy})=\underline{COV_{xy}/}\ \sigma_x\sigma_y, \qquad (2)$$

where: COV is a covariance between two variable,
σ is a standard deviation of the variable.

The correlation also can be determined as a sample correlation coefficient.

$$r_{xy} = \frac{\sum(x_i-\bar{x})(y_i-\bar{y})}{\sqrt{\sum(x_i-\bar{x})^2\Sigma(y_i-\bar{y})^2}} \quad , \qquad (3)$$

where: **rxy** is a sample correlation coefficient,
x and **y** are the individual variable,
$\bar{x}$ and $\bar{y}$ are the sample means of relevant variables.

From the geometrical point of view, the correlation can be determined as an angle φ between two regression lines y = g X(X) and x = g Y(Y). The correlation coefficient is varied from (-1) to 1. The strength of the relationship depends on the value of the coefficient. The higher the value of the coefficient the relationship between variables. The value of the correlation which is close to zero implies that there is no relationship between variables is stronger. The low value of the coefficient denotes an insignificant relationship. The sign before the coefficient is evidence about a positive or negative relationship. The analysts think that the relationship is moderate when the value of the coefficient is 0,5 and strong when its value is more than 0,8 and aspire to1. The coefficient (-1) is an indicator of the perfect negative correlation meaning that the variables move in opposite directions. In this case, while the value of one variable increases, the value of the second variable drops. The coefficient is equal to 1 denotes perfect positive correlation and it means that variables move together in the same direction. Investors always observe the correlation coefficients between assets to diversify the investment portfolio and decrease the risk.

For the purpose of this study, we calculated the correlation between log-returns of each commodity and stocks for each year by using the CORREL function in the Excel during all investigated period. Then we analyzed the obtained result by comparing the correlation value in crisis period and postcrisis period and make a decision to accept or reject the first part of Hypothesis1. If the coefficient of correlation is larger than 0,5 and increased in the post-crisis period we will accept the first part of Hypothesis 1, otherwise, it will be rejected.

2.4.3. Volatility (Annualized Standard deviation of log return)

For the second part of testing our Hypothesis1, we need to assess the volatility level in different years during the investigated period. The volatility is a measure that determines how far the variables are spread from their average value. The volatility can be measured by *variance and standard deviation*. Both of them give a sense of how far the variables are from their mean. However, the variance shows the distribution of data that is not bounded to a certain time period and it is a key point of the asset allocation of the portfolio, while the standard deviation is a measure of such dispersion and calculated for a certain period of time. The *standard deviation* is the statistical term which denotes the dispersion of variables around the mean. In other words, it shows the difference between the actual value of the variable and their average among the sample. The larger that difference means the greater the standard deviation. The greater standard deviation implies a higher risk for investors. The security with volatility higher than 1% is believed as volatile. The standard deviation is denoted as σ and calculated as a square root of the variance, using the formula (4).

$$\boldsymbol{\sigma_r} = \sqrt{\frac{\sum_{\boldsymbol{i=1}}^{\boldsymbol{n}} (\boldsymbol{r_i} - \bar{\boldsymbol{r}})^2}{\boldsymbol{n}}}, \qquad (4)$$

where $\boldsymbol{r_i}$ is a value of $\boldsymbol{i}$ point of data sample,
$\bar{\boldsymbol{r}}$ is a mean value of the data sample,
$\boldsymbol{n}$ is a number of points in the data sample.

In finance, this measure is used by investors to assess the risk of securities. For financial purposes usually, the annualized standard deviation of log return is used (Duan, Härdle, Gentle, 2012). This measure evaluates the risk of the securities and compares the deviation of the return in different periods of time. The higher the annualized volatility of assets implies the riskier the securities are.

In order to estimate the volatility level in different points during the investigated periods and compare them, we should compute the annualized standard deviation of the log return. For that:

- first, we calculated the average σ daily within each year period by using the STDEV function of Excel;
- then, the annualized standard deviation for each year is calculated by using the formula:

$$\sigma_{an} = \sigma_d \sqrt{252} \quad , \qquad (5)$$

where: 252 is a number of trading days per year.

To reject or accept this part of our Hypothesis 1 we need to compare the obtained value of the annualized standard deviation for each year during the examined period to understand whether the volatility in the crisis period was significant and increased over time. We will accept this part of our hypothesis in a case of increase of the annualized standard deviation in 2008 in comparison with other years.

Test of Hypothesis 2

To test Hypothesis 2 we also employed the correlation analysis. We applied the same procedure as for Hypothesis 1 but only for the gold by using the CORREL function of Excel. Then we will assess the calculated result of the correlation between gold and stock market indexes for significance. If the correlation value is smaller than 0,5 in the mentioned period of time Hypothesis 2 will be accepted.

Test of Hypotheses 3-4

We will test the Hypothesis 3 and Hypothesis 4 following the same procedure by employing the Gretl software.

2.4.4. ADF test

Following the logic of our research first, we need to test the data for unit root by running the ADF test. For that first, we need to determine the lag length which is calculated by taking the cube root from the sample size.

The *null hypothesis* of the ADF test sounds that *unit root is present* in the autoregressive model.

$$\Delta y_t = \alpha + \beta t + \gamma y_{t-1} + \delta_1 \Delta y_{t-1} + \cdots + \delta_{p-1} \Delta y_{t-p+1} + \varepsilon_t \quad (6)$$

where: α and β are trend coefficients,
yt-1 is a lag 1 in a first difference,
Δ yt-1 is a first difference of the time series at (t-1) time.

From that, it follows that if γ=1, the unit root is present and the null hypothesis is accepted. If γ=0 we reject the null hypothesis meaning that there is no unit root. The assumption of this hypothesis that if time series contains the unit root then the lagged value of yt-1 will not provide the relevant information of yt changes. If the results of ADF test are less than the specified value of tau statistics and p-value is less than 0,05 we should reject the null hypothesis stating that there is no unit root and our variables are stationary. For the test of our sample size with constant and trend we have to apply the critical value for the 1% level of significance (-3,96), for the 5% level of significance is (-3,41) (Statistics How To, 2020). If our time series is not stationary we need to test them for cointegration.

2.4.5. AIC

Before running the cointegration test we need to determine the lag order according to AIC. AIC is a statistical tool that is widely used for the estimation of the quality of the model relative to each of the other models by providing the means for the model selection. Generally, the AIC is based on the assumption that the less information the model has lost the higher the quality of the model. In relation to autoregressive models, the AIC is useful to define the length of lags. The Gretl software indicates the appropriate lag order by an asterisk.

2.4.6. Johansen co-integration test

The cointegration is a property of non-stationary time-series variables which implies that despite random changes (random walk) in some individual variables they have a stable long term relationship between each other. The cointegration is a linear stationary combination of the individually non-stationary time series variable. Xt and yt are said to be cointegrated if there exists a parameter α such that ut = yt – αxt, where is α is a long-run component of Yt and Xt a stationary process. In a case of many variables in the empirical study the Johansen cointegration test is exploited. This test implies that there can be more than one cointegration relations between several variables and determines the number of cointegrating relationships. For example, for N variables

it is possible to have N-1 relationships. It means that the VECM will be estimated by using N-1 cointegrated residuals. The Null hypothesis of the Johansen test for cointegration infers that **r=0** or there is no cointegration. The **r** denotes the rank. The r>0 indicates the cointegration relationship between two or more variables.

$$\Delta \vec{Y}_t = \vec{\mu}_t + \Pi \vec{Y}_{t-1} + \Gamma_1 \Delta \vec{Y}_{t-1} + \ldots + \Gamma_{p-1} \Delta \vec{Y}_{t-p+1} + \vec{\epsilon}_t \quad (7)$$

In equation 7 the Π denotes the number of long-run impact matrix. If Π=0 there is no cointegration. If Π has reduced rank, 0<r<p, there are cointegration relations among variables. The cointegrating vectors are given as $\Pi=\alpha\beta'$, where βi represents the i-th cointegration vectors, and αj represents the effect of each cointegrating vector on the $\Delta Y_{p,t}$, variables in the model.

The Johansen cointegration test is estimated according to the Trace statistic. If p-value of it is greater than 0,05 we cannot reject the Null hypothesis meaning that there is no cointegration relationship. In a case, if our data are not cointegrated we will transform the data to the log differences and implement the VAR model for two reasons. First, according to Hyndman, Athanasopoulos (2018), "differencing can help stabilize the mean of the time series by removing changes in the level of a time series, and so eliminating (or reducing) trend and seasonality"(p.215). Second, applying the log differencing helps to bring the data to the approximate return. This procedure is made automatically by Gretl software. Then, the differenced data are applied to the VAR model.

2.4.7. Vector autoregression model (VAR)

The Vector autoregressive model (VAR) which is an extension of the AR(p) autoregression model. It was proposed by Christopher Sims in 1980. The VAR represents the time-varying linear function of the several time-series variables where their current values depend on their own previous values. This model is believed as one of the most successful and useful tools to analyze different factors of the economy such as GDP, unemployment, money supply, and very useful for the future stock prices forecast as well as the future foreign exchange rates. In finance this model is used to observe the behavior of the time series variables in dynamic. The biggest advantages of this model are that it allows implementing the analysis of the complex relationship among a large number of variables. The VAR model is a system of several equations. Each equation includes its own endogenous (dependent) variable. The right side of the equation is a lagged value of the dependent variable.

$$y_t = c + A_1 y_{t-1} + A_2 y_{t-2} + \cdots + A_p y_{t-p} + e_t, \tag{8}$$

where: yt is a vector of time series variables,
yt−i (yt-1, yt-2 yt-p) , where the **i** is a period of lags,
c- is an intercept,
Ai (A1,A2, Ap) –a matrix autoregression coefficient, where is ***p*** is a length of lags,
p is determined by the AIC information,
et- is an error term or white noise or the response for the external factors.

The VAR model for two variables looks like :

$$\begin{aligned} y_{1,t} &= c_1 + a_{1,1} y_{1,t-1} + a_{1,2} y_{2,t-1} + e_{1,t} \\ y_{2,t} &= c_2 + a_{2,1} y_{1,t-1} + a_{2,2} y_{2,t-1} + e_{2,t}. \end{aligned} \tag{9}$$

or can be transformed as a matrix:

$$\begin{bmatrix} y_{1,t} \\ y_{2,t} \end{bmatrix} = \begin{bmatrix} c_1 \\ c_2 \end{bmatrix} + \begin{bmatrix} a_{1,1} & a_{1,2} \\ a_{2,1} & a_{2,2} \end{bmatrix} \begin{bmatrix} y_{1,t-1} \\ y_{2,t-1} \end{bmatrix} + \begin{bmatrix} e_{1,t} \\ e_{2,t} \end{bmatrix}, \tag{10}$$

where: $e_{1,t}$ and $e_{2,t}$ two white noise variables that may be correlated.

2.4.8. Engle -Granger causality test

Granger causality is an econometric method that implies that changes of one-time series variable happens can cause the movements of another. This hypothesis is investigated by the regression model. The idea of these methods that if the past value of X variable has explanatory power of the current value of Y variable, it means that X Granger causes Y. This relationship can be expressed by the following equation:

$$y_t = a_0 + a_1 y_{t-1} + a_2 y_{t-2} + \cdots + a_m y_{t-m} + b_p x_{t-p} + \cdots + b_q x_{t-q} + \text{error}_t, \tag{11}$$

where: *y* and *x* are the stationary time series,
b is beta coefficient,
a is an autoregressive coefficient,
p and *q* are the shortest and longest length of lags.

The lags are determined according to the AIC information (1974). The *b* coefficient is the measure of the influence of the past value of x_{t-p} *on the* y_t. *The Null hypothesis states that X does not cause Y*, if $b_i = 0$ .When it is statistically insignificant (ρ-value is>0,05), then X has no explanatory power of Y, which means that X does not Granger cause the Y. The null hypothesis of Granger causality

test is accepted if F-statistic value is a grater of the 0,05 meaning that there is no explanatory power of all X's.

To test the Hypothesis 3 first, we will take the crude oil as a dependent variable and stock market indexes as an independent variable. Then we will do the same for the stock market indexes as a dependent variables and stock market indexes as independent variables.

For the estimation of the Hypothesis 4 we will take the rough rice, soybeans and wheat as the independent variables and stock market as indexes as the dependent variables.

The assessment of both models will be made looking at the p-value coefficient. If p-value will be smaller than 0,05 we will accept the Hypothesis 3 and 4. In a case if examined variables are cointegrated the Vector Error Correction (VECM) model will be implemented.

2.4.9. Vector Error Correction model (VECM)

If cointegration is proved the cointegrating residuals is included in the Vector error correction model (VECM). It is a special case of the VAR model. The VECM reflects the short-term dependence between changes in variables and the correction of the dynamics of these series depending on the magnitude of the deviation (error) from the long-term dependence and can be written as follows (Zou, 2018):

$$\triangle y_t = \alpha\beta' y_{t-1} + \sum_{i=1}^{p-1} \Gamma_i \triangle y_{t-i} + \mu_t \tag{12}$$

where, $\Delta y = yt - yt\text{-}1$ is a deviation of short run dynamic of y, α is an adjustment coefficient,
$\beta' yt\text{-}1 = ecmt\text{-}1 \neq 0$ is an error correction term which represents the long run relationships,
Γi -are matrices for each differencing lags.

By multiplying the α and $\beta' y_{t-1}$ we will have the error correction. Thus, $\alpha\beta' y_{t-1}$ determines the Δy_t to move in a correct direction to return the system to the equilibrium.

2.4.10. Impulse response analysis

At the end of our research we will conduct the Impulse Response Analysis to determine how the time series react to the shocks in each other. The Impulse Response is a reaction of a certain dynamic system to the external (exogenous) factors in a period of time. For the economic purposes that function is used to investigate how does the economy react to the exogenous impulses such as changes in tax, monetary policies, consumption rate, etc. In finance, the Impulse response function is employed to investigate the reaction of financial markets to different shocks

such as some news, changes in supply and demand, and so on. Those exogenous impulses are called shocks and modeled within the vector autoregression The main idea of this function is to observe the evolution of examined variables in one or multiple variables. It is a useful tool to trace the shock transmission through the system of the equations. In the following equation 13, the y is the evolution vector and e denotes the shock.

$$y_t = Ay_{t-1} + e_t, \tag{13}$$

The shock of a variable ***j*** at time ***t0*** affects the values of variable ***i*** and other endogenous variables at this and subsequent periods of time.

$$y_{t-1} = Ay_{t-2} + e_{t-1} \tag{14}$$

.

The equation 14 denotes the one lagged period. After the transformation of the original equation the twice lagged equation appears (equation15):

$$y_t = A^2 y_{t-2} + Ae_{t-1} + e_t \tag{15}$$

.

$$y_t = A^3 y_{t-3} + A^2 e_{t-2} + Ae_{t-1} + e_t \tag{16}$$

The equation (16) denotes the effect of $\boldsymbol{e_{t-2}}$ component of ***j*** variable of the matrix $\boldsymbol{A^2}$ to the ***i*** component of the $\boldsymbol{y_t}$.The shock will affect the all components of $\boldsymbol{y_t}$ in subsequent periods of time. However, this process will steadily fade out because the VAR implies that variables are stationary. The Impulse Response Function measures the reaction which is denoted as **R** for every variable in the equation. The result of the IRF is provided in a form of the Choleski decomposition variance-covariance matrix

$$\Sigma = PP^{-1}, \tag{17}$$

where : P is a lower triangular matrix,
P^{-1} is upper triangular matrix.

It implies that the first variable is “the most exogenous” (it affects all subsequent changes, but it is not affected by the rest of the variables). The last variable is the most endogenous. Its shock

does not affect other variables but it is influenced by other variables.

While testing the VAR model for Hypothesis 3 and Hypothesis 4 we implemented the Impulse response analysis to find out the strength of the response of examined variables to the shocks in other examined variables. Looking at the results of the IRF analysis provided numerically and graphically, it is possible to evaluate whether there is positive or negative response is and how long does it last. Normally, it is counted the response is stronger if the numerical value of response will exceed 0,5 but taking into account that we used the log we will compare with threshold 0,005.

2.5. Empirical research data sample

This study used commodity spot prices, not futures for some reasons. First of all, the spot prices more clearly reflect the situation in the market in each given period of examination. In contrast, the future prices being derivatives also take into account some investor's expectations, risks, and sentiments which could affect the purity of the investigation. Moreover, it is difficult to find future prices for each instrument with the same future contract duration.

From the stock market side, we employed the stock market indexes instead of stock prices. As it is already discussed the stock market indexes accumulate the prices of the most powerful companies stocks within the region and reflect the economic conditions of the country and region. Therefore, we think that usage of the stock market indexes in the research could ensure a better reflection of the relationship between the commodity and the stock market. Due to the limited access to the free data of commodities we had to appeal to the different internet sources. To get information about commodity prices we mostly used the Macrotrends and Markets Insider websites. The data of stock indexes have been obtained from the Yahoo finance, WSJ Markets (Wall Street Journal Markets), and Investing.com sites. Like most of the authors from our literature review, we use the daily frequency data because it leads to a more accurate result. Our research covers the period from 19 January 2007 to 28 December 2018. Such interval allows us to trace not only the period of the last financial crises (2007-2008) but also the post-crisis period. The information about the data used in this research is generalized in the Table 6.

Table 6

Generalized data used in the research

Type of assets	Markets represented in the research	Regions and countries	Measure of data	Frequency of data used	Data source
Commo-dities	Crude oil WTI	Global	Spot price	Daily quotations	Markets Insider.com
	Gold	Global	Spot price	Daily quotations	MarketsInsider.com
	Wheat	Europe	Spot price	Daily quotations	Macrotrends.net
	Rough rice	Asia	Spot priced	Daily quotations	Markets Insider
	Soybeans	Asia	Spot price	Daily quotations	Macrotrends.net
Stocks	NYSE	USA	S&P500	Daily quotations	Market Insider
	NASDAQ	USA	Nasdaq	Daily quotations	Investing .com
	Euronext	Europe	Euronext100	Daily quotations	Yahoo Finance
	London stock exchange	Europe, UK	FTSE100	Daily quotations	WSJ Markets
	Bombey Stock Exchange	Asia, India	BSE30	Daily quotations	Yahoo Finance
	Tokyo Stock Exchange	Asia, Japan	Nikkei225	Daily quotations	Yahoo Finance
	Shanghai Stock Exchange	Asia, China	SSEC	Daily quotations	Investing.com

2.6. Research limitations

As this study focuses on the investigation of the co-movement between commodity and stock markets in the period of the global financial crisis and post-crisis period, the research period was limited and includes 12 years (from 2007 to 2018). We were limited by freely available data for some commodities for the defined period. For example, it was not possible to use the spot prices of rubber for the mentioned period. However, it would be interesting to include it in the examination as an Asian commodity.

In this research, we considered the co-movements of commodities and stock markets in the Asian, European regions, and the USA. However, only indexes of stock markets representing three Asian region countries have been selected and examination of the European region was based on the two European stock markets indexes as well as for the US. It means that the result received in this research may not be applicable to the other countries and their markets in the investigated and other regions. In addition, only five types of commodities and seven stock indexes have been employed in this research which could be the limitation to make a broader conclusion about the co-movements between commodities and stock markets for the whole region.

Also, in this research for testing the four research hypotheses, we used only three tests: unit root test (ADF), Granger causality, and Impulse response analysis within the VAR framework. However, many other tests could be used to reject or prove our hypotheses.

III. EMPIRICAL RESULTS OF THE ASSESSMENT OF CO-MOVEMENT BETWEEN COMMODITY AND STOCK MARKETS IN THE PERIOD OF GLOBAL FINANCIAL CRISES AND POST-CRISIS PERIOD

3.1. Summary statistics of the stock market indexes and commodity prices data sample

We start our empirical part with simple observation of the Figure 5 which provides the imagine of behavior of investigated variables. The diagrams reflect the movements of selected variable spot prices over the 12 years period. It has been made by using the Gretl software.

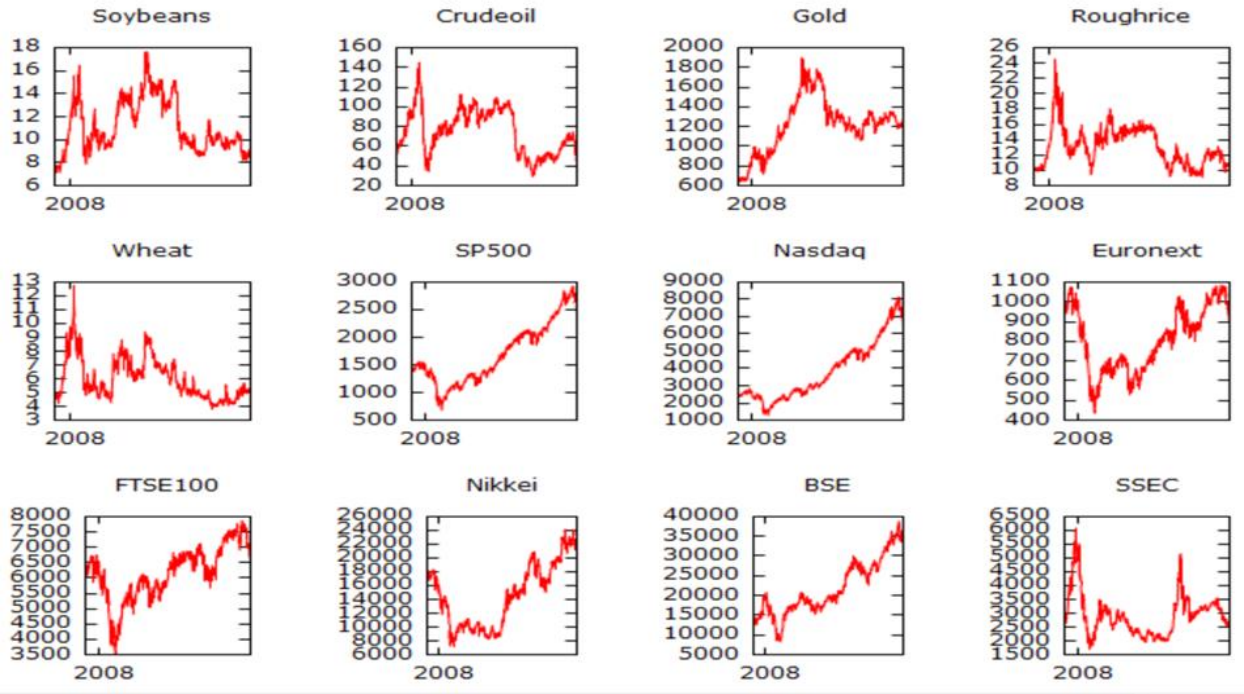

Figure 5. The commodity and stock indexes trends in the period of 2007-2018.

Note: developed by the author using the Gretl software based on the data from the Yahoo Finance.com, Investing.com, Market Insider and Macrotrends.ne

From Figure 5 is clear that most stock indexes have an upward trend over the years after a significant drop in 2008. An exception is only the Chinese SSEC composite index which does not show certain trends experiencing the sharp ups and downs in the considered period. The examined commodity prices also do not have clear trends during the investigated period. From

Figure 5 it is not possible to define the common trend between commodities as stock market indexes. There is only one common point that both commodity and stock markets experienced a huge drop in 2008. It worth noting that there is no cyclicality among selected assets neither a commodity nor stock indexes. It is notably, that among examined assets only gold prices showed an increase in 2008 but after the crisis period it also has similar ups and downs as other commodity prices.

The examined sample of data contains 2409 observations. The short description of the examined variables is presented in the Summary statistics in Table 7. From it can be concluded that there are widespread prices from the minimum to maximum. It is the first sign of the volatility of series. All variables are not normally distributed because the kurtosis of all assets is far from the normal value which is equal to three. In this case, we have the leptokurtic data which means that samples have outliers. Such outliers could occur as a consequence of the high volatility of the time series. Concerning the standard deviation, it is also clear, that assets are volatile because all variables have a standard deviation larger than1. The higher value of the standard deviation means the larger distance of data points from the mean. In other words, it also indicates not normally distributed data. All data in our sample are skewed to right or to the left side.

Table 7

Summary statistics of assets selected for research

	Mean	Median	Minimum	Maximum	Std. Dev.	Skewness	Ex. kurtosis
Soybeans	11.248	10.365	7.0950	17.683	2.2879	0.51795	-0.79230
Crude oil	75.630	74.990	28.630	145.29	23.348	0.15027	-0.78075
Gold	1223.6	1242.7	632.90	1898.1	274.26	-0.097695	-0.26193
Rough rice	13.193	12.823	9.1300	24.460	2.5319	0.75176	0.80035
Wheat	6.0044	5.5525	3.8065	12.825	1.4971	0.94307	0.61246
S&P500	1710.2	1539.9	676.53	2929.7	549.71	0.41550	-0.84227
SSEC	2932.2	2871.2	1706.7	6092.1	764.74	1.3378	2.3057
Nasdaq	3886.5	3162.0	1268.6	8109.7	1729.9	0.70560	-0.56831
Euronext100	811.87	823.72	434.61	1087.4	164.39	-0.076921	-1.1636
FTSE100	6202.6	6284.5	3512.1	7877.4	881.44	-0.53934	0.039587
Nikkei	14641.	14732.	7086.0	24124.	4613.2	0.17903	-1.2274
BSE	21981.	19675.	8160.4	7063.8	7063.8	0.43564	-0.71038

Note: developed by the author by using the Gretl software

3.2. Results of testing the Hypothesis 1

In this chapter we present the results of tested hypothesis H1: The co-movement between commodity and stock markets during global financial crisis and post crises period (in the period

from 2007 until 2018) was significant and increased. For the examination the correlation and standard deviation are used which have been calculated by using the Excel CORREL function.

3.2.1 Correlation examination results

In order to test this hypothesis, we calculated the correlation between each commodity and all examined stock index prices for each year separately within the 12 years. Based on the obtained results we have built the graphs which are presented in Figures 1-4 of Annex 2. From these results, it is obvious that the correlation between all commodities and stock index returns was high from 2008 to 2009 and became positive even though in 2007 some of the assets had a negative correlation between each other. In most cases, it was higher more than twice than in the pre-crisis and post-crisis periods.

Concerning the crude oil, it can be said that its return demonstrated a strong positive correlation from 2008-2010 with most considered stock market indexes. In some cases, it had a value of 0,85 with S&P500 and FTSE100. With Nikkei225 and Euronext100 before the global financial crisis crude oil correlated negatively then it became strong positive exceeding the value 0,75 and then decreased after the crisis period. Regarding the correlation with BSE30, Nasdaq, and Euronext 100 we see the same situation of strong correlation in the crisis period. In 2013-2014 it started declining and became very low and even negative in SSEC and BSE30 cases. Since 2017 it again turned to increase **(**see Table 8).

Table 8

Correlation of crude oil and stock market indexes

Years	Crude oil/ S&P500	Crude oil / Nasdaq	Crude oil / Euronext100	Crude oil/ FTSE 100	Crude oil/ Nikkei225	Crude oil/ BSE30	Crude oil/ SSEC
2007	0,2884	0,748198	-0,02318	0,108931	-0,70013	0,932272	0,854326
2008	**0,807001**	**0,859118**	**0,712347**	**0,739907**	**0,855077**	**0,589306**	**0,318324**
2009	**0,871069**	**0,913639**	**0,830115**	**0,813233**	**0,878149**	**0,952243**	**0,877603**
2010	**0,898986**	**0,879944**	**0,815016**	**0,886327**	**0,346828**	**0,618154**	**0,482347**
2011	0,657014	0,577194	0,45767	0,553564	0,153911	0,403739	0,44204
2012	0,046462	0,241567	0,123551	0,399999	0,495469	-0,15613	0,546663
2013	0,31204	0,347851	0,292753	0,23548	0,313001	-0,12407	-0,55276
2014	-0,61149	-0,71301	0,209987	0,551831	-0,83326	-0,5837	-0,95002
2015	0,485993	0,209532	0,478453	0,745483	0,334841	0,398155	0,706989
2016	0,830581	0,738203	0,573928	0,693223	0,287404	0,637961	0,39245
2017	0,44167	0,354389	0,164716	0,070188	0,589076	0,200442	0,414833
2018	0,5568	0,64173	0,761097	0,671502	0,501817	0,140439	0,173928

Note: author's calculations.

The correlation between agricultural commodities and stock market indexes is provided in Tables 9-11.The Soybeans had the very low correlation with stock market indexes in 2007 which increased significantly by the value of 0,4 and dropped again in period from 2013-2015 (Table 9).

Table 9

Correlation of Soybeans and stock market indexes returns

Years	Soybeans/ S&P500	Soybeans/ Nasdaq	Soybeans/ Euronext100	Soybeans/ FTSE100	Soybeans/Nikkei225	Soybeans/BSE30	Soybeans/ SSEC
2007	0,0924335	0,0619847	0,273929	0,2896379	0,15288	0,1292627	-0,021078
2008	**0,3215427**	**0,3181428**	**0,393133**	**0,4244043**	**0,301891**	**0,2108295**	**0,116045**
2009	**0,4471669**	**0,3802156**	**0,467701**	**0,439254**	**0,214635**	**0,3618117**	**0,303525**
2010	0,3625466	0,3879021	0,343987	0,3965077	0,274136	0,3524448	0,313263
2011	0,3344291	0,3651381	0,297843	0,2926398	0,302477	0,1772762	0,173723
2012	0,1869859	0,1994331	0,226586	0,2516124	0,146014	0,2251139	0,088658
2013	-0,138415	-0,144331	-0,09073	-0,066355	-0,039516	-0,072443	0,064359
2014	0,2012115	0,1560126	0,074766	0,0706821	-0,007399	0,0212044	0,022863
2015	0,0470934	0,0429137	0,075581	0,0855385	-0,021596	0,0371338	0,237063
2016	0,1569445	0,0545958	0,198637	0,132532	0,171665	0,0712275	0,078783
2017	0,0067351	0,0135433	0,077	0,1026784	0,06509	-0,010517	0,027135
2018	0,1180419	0,0969226	0,17969	0,1593991	0,011968	0,0685345	0,121093

Note: author's calculation.

The Rough rice also showed the very low correlation level with stock market indexes in 2007 which increased by the value of 0,2 from 2008-2009, then started declining since 2011 becoming negative in most cases by 2018 (Table 10).

Table 10

Correlation of Rough rice and stock market indexes returns

Years	Rough rice/ S&P500	Rough rice/ Nasdaq	Rough rice/ Euronext 100	Rough rice/ FTSE100	Rough rice/ Nikkei225	Rough rice/ BSE30	Rough rice/ SSEC
2007	0,0047792	-0,000815	0,097093	0,1055763	0,024833	-0,000366	-0,0362528
2008	**0,2273025**	**0,188745**	**0,221625**	**0,2520041**	**0,144717**	**0,203166**	**0,0377923**
2009	**0,2394036**	**0,2234684**	**0,162472**	**0,1679868**	**0,098893**	**0,1322094**	**0,0786092**
2010	0,3263506	0,3221217	0,323231	0,3048381	0,218215	0,2203762	0,2617209
2011	0,1831567	0,2031053	0,193512	0,2341585	0,075981	0,1020017	0,0083009
2012	0,1591271	0,1552947	0,044677	0,1016863	0,038005	-0,024149	0,0348784
2013	0,074588	0,0168824	-0,07226	-0,021521	-0,052597	-0,151715	-0,0054884
2014	0,0596867	0,0995285	0,103972	0,1044637	0,066607	-0,006707	-0,0628725
2015	0,1486287	0,1202819	0,076111	0,0990384	0,094132	0,0464843	0,0183302
2016	-0,108295	-0,178037	-0,00551	-0,019498	0,052049	0,0222837	0,0381154
2017	-0,017236	-0,009516	-0,01037	0,0188055	0,06883	0,032336	-0,019533
2018	-0,064203	-0,107001	0,002442	-0,044671	-0,090006	-0,053756	-0,0648467

Note: author's calculations.

The negative correlation between Wheat and stock market indexes in 2007 reached the average

value of 0,3 by 2009 and then dropped by 2018 becoming very low or even negative (Table11).

Table 11

Correlation of Wheat and stock market indexes

	Wheat/ S&P500	Wheat/ Nasdaq	Wheat/ Euronext100	Wheat/ FTSE100	Wheat/ Nikkei225	Wheat/ BSE30	Wheat/ SSEC
2007	-0,07926	-0,085154	-0,03943	-0,060832	-0,110873	-0,096194	-0,1520037
2008	**0,2164368**	**0,2348781**	**0,255124**	**0,2780124**	**0,286966**	**0,1658289**	**0,0800345**
2009	**0,4029561**	**0,3580667**	**0,380649**	**0,4028749**	**0,153841**	**0,3170002**	**0,1962988**
2010	0,2038898	0,1607518	0,169381	0,1719168	0,227511	0,1368956	0,1365888
2011	0,3149453	0,3190405	0,267513	0,2958835	0,206077	0,1074427	0,0637528
2012	0,1437084	0,1364056	0,201446	0,166981	0,132955	0,1214956	-0,0380326
2013	-0,100689	-0,086532	-0,11551	-0,122482	0,092019	-0,028958	0,204102
2014	-0,011725	-0,039367	-0,10214	-0,068463	-0,187861	-0,086872	0,0593265
2015	0,006132	-0,040948	-0,05605	-0,047888	-0,04734	-0,051743	-0,0136254
2016	0,0947661	0,053458	0,155306	0,0980989	0,089013	0,1232121	-0,0087246
2017	0,0677944	0,0307661	-0,06128	-0,03521	0,075545	-0,01464	0,122654
2018	-0,012764	0,0061531	0,117926	0,0871813	0,16043	0,1539502	0,086398

Note: author's calculations.

When it comes to the gold we see how the correlation between gold and all considered stock market indexes decreased in the financial crisis period.

Table 12

Correlation of Gold- Stock market indexes returns

Years	Gold/ S&P500	Gold/ Nasdaq	Gold/ Euronext100	Gold/ FTSE100	Gold/ Nikkei225	Gold/BSE30	Gold/SSEC
2007	0,3380628	0,3110875	0,2795234	0,2425704	0,213268	0,198398947	0,105270379
2008	**0,0572866**	**0,0108078**	**0,1179061**	**0,1392412**	**0,132459**	**0,005162158**	**0,053171708**
2009	**0,1108209**	**0,0915407**	**0,0911466**	**0,1326764**	**-0,055738**	**0,053442778**	**0,243137706**
2010	0,2590784	0,2555675	0,1680967	0,2385898	0,151761	0,362572929	0,189813798
2011	-0,020967	-0,01287	0,0718854	0,0952207	0,143777	0,195516086	0,075304506
2012	0,2687464	0,283848	0,1644053	0,1942199	0,042427	0,104728748	0,103061752
2013	0,1629122	0,132185	-0,035841	-0,054593	0,004416	0,046721816	0,127493021
2014	-0,217215	-0,220267	-0,188141	-0,133822	-0,198557	-0,21139657	-0,25583298
2015	-0,048143	-0,070942	-0,161402	-0,043735	-0,140161	0,045340642	0,062945841
2016	-0,312447	-0,347295	-0,354317	-0,259907	-0,272932	-0,2351955	-0,15113859
2017	-0,22009	-0,120475	-0,374268	-0,107218	-0,148183	-0,00355169	0,166214277
2018	0,0488481	0,0630291	-0,037487	-0,005211	-0,055227	0,067827672	0,11286681

Note: author's calculations.

From the Table 12 it is seen that correlation between gold and stock market indexes decreased substantially in some cases more than two times falling from 0,338 in 2007 to 0,05 in 2008 (S&P500 case) or even became negative as in a case of (Nikke225). In post crisis period starting from 2010 the correlation level did not returned to the level of 2007 being negative since 2013 in all cases.

From all analysis above, we can conclude that correlation between considered commodities increased in the period of the global financial crisis of 2008 but weakened in post crisis period. Thus, we *have to reject the first part of Hypothesis 1* because correlation level was not significant in whole examined period keeping the value of 0,3- 0,2 in most cases except the crude oil. Only crude oil since 2008-2010 showed the significant correlation level having the value of 0,8- 0,9 but it also dropped dramatically to the value of 0,3-0,2 in the post crisis period.

3.2.2 Results of Volatility (Annualized Standard deviation) calculation

The annualized standard deviation has been calculated also in order to show similar patterns of increased volatility on both commodity and stock markets during the examined period. In order to investigate the volatility, we calculated the annualized standard deviation of each examined financial instrument for each year during the examined period. We followed the steps described in the second part of our research. All calculations have been made in the Excel sheet. The obtained results of the volatility (annualized standard deviation) graphically are presented in Figure 6 below and provided in Table 1 in Annex 3. From those graphs, it is obvious that both commodities and stock markets experienced great volatility in 2008. From our graphs, it is turned out that among examined commodities the soybeans commodity is the least volatile asset. It was only one splash in volatility in 2008-2009. In contrast, the rough rice, crude oil, and wheat showed a high level of volatility during the whole period of the study. As it is seen from the Figure 6 the amplitude of volatility of crude oil, gold, and rough rice increased more than two times in that period. Slightly less fluctuated the wheat and rough rice. The volatility spikes in all examined markets continued until 2009 and then faded out. The different volatility patterns demonstrated the SSEC index which annualized standard deviation was higher than 30% earlier in 2007 and characterized by several splashes of fluctuations during the whole examined period. It is notable, that the S&P500 index is the least volatile asset among examined stock market indexes. Its annualized standard deviation was equal to 44% in 2008. In other years it was less than 20%. It worth noting that the period of 2013- 2014 was distinguished by the least fluctuations in both

commodity and stock markets in all examined regions. If we compare our obtained correlation results and volatility we will see those periods of increased fluctuation in both markets and increase the correlation between commodities and stock market coincidences. From all the above, we can infer that during the last financial crisis the volatility was significant, but at the same time, it decreases substantially in the post-crisis period.

Summarizing outcomes of the first and second part of the Hypothesis1 we should conclude, that co-movements between commodity and stock markets was not proved. Although correlation and volatility increased in 2008, then it substantially decreased in a post crisis period. The same is attributed to the volatility. Thus, we cannot accept our Hypothesis 1 stating that in most cases the correlation between commodity and stock market was insignificant during all examined period while volatility increased only in the period of the global financial crisis of 2008.

Figure 6. Volatility of the commodity and stock indexes in the period of 2007-2018.
Note: developed by the author.

3.3. Results of testing the Hypothesis 2.

In this chapter, we present the results of testing hypothesis H2: During the last financial crisis of 2008, the gold proved its safe-haven feature. We have made our examination of Hypothesis 2 based on the correlation calculation between gold and stock market indexes for each year during the examined period. From Table 12 above and Figure 7, it is seen that in 2007 the correlation between gold and stock markets was low (lower than the critical value of 0,5). Since 2008 level of correlation between gold and stock market indexes experienced periodical ups and downs.

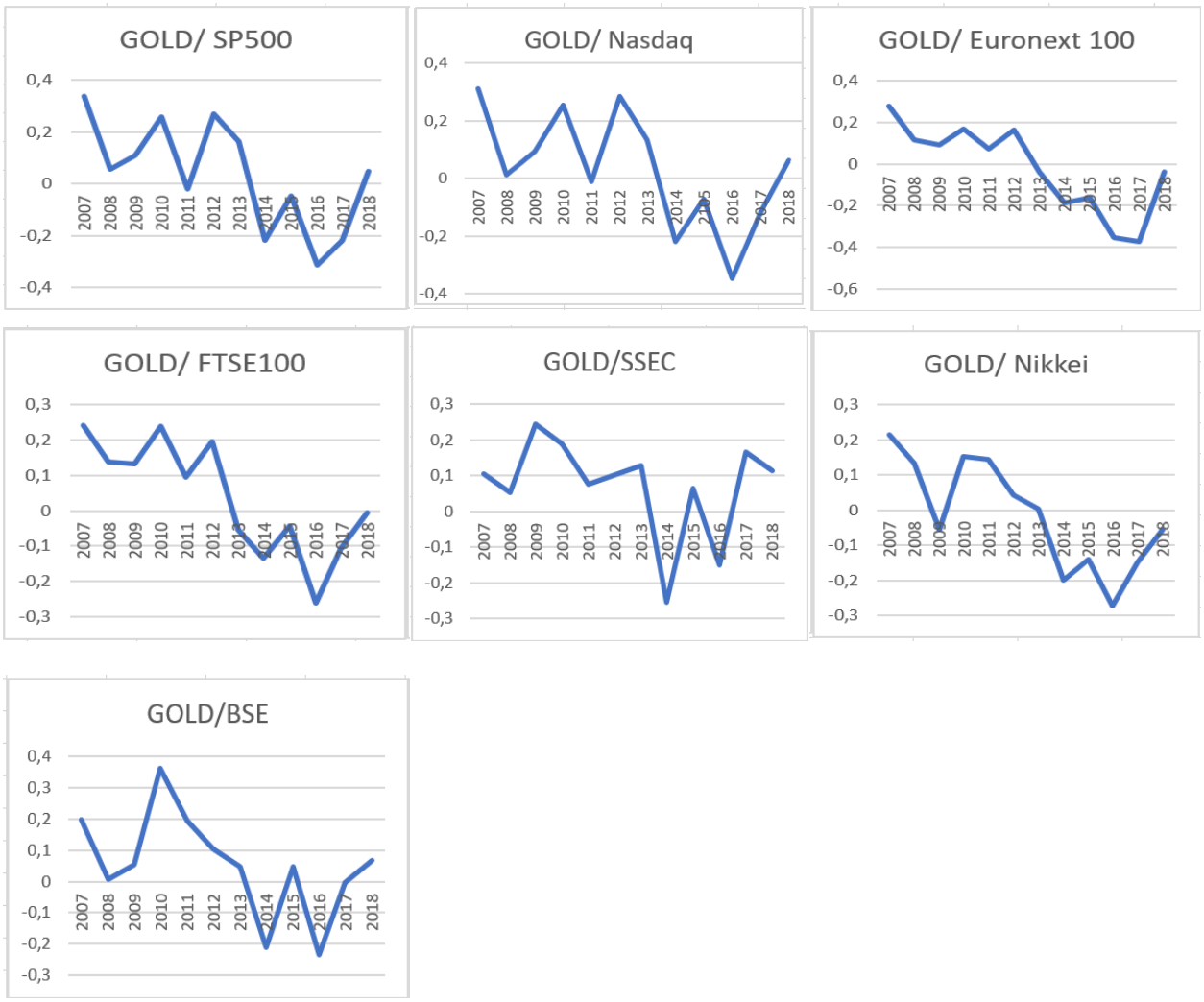

Figure 7. Correlation between gold and stock market indexes returns.
Note: developed by the author**.**

In 2008 the level of correlation between gold and stock indexes decreased substantially reaching the value 0,05-0,1 depends on assets, which means that trends of those assets moved differently which gave the hedging possibilities to investors. In 2010 it rose and then again dropped significantly becoming negative from 2013 to 2104. It means that the trend of gold and stock market indexes in that period moved in the opposite direction. From our observations, it is clear that in overall correlation level between gold and stock market indexes during the whole examined period was lower than the critical value 0,5 mentioned in the assessment criteria in Part II. Therefore, it can be concluded that we accept our Hypothesis H2 meaning that gold has kept the safe-haven property during the last financial crisis of 2008 and in the post-crisis period.

3.4. Results of testing the Hypothesis 3

In this chapter, we present the results of testing hypothesis H3: There was the bilateral causality between crude oil and stock markets in the period of the global financial crisis and post-crisis period. For testing this hypothesis ADF test, Johansen cointegration test, VAR, Granger causality test and impulse response analysis were used.

3.4.1. ADF test results

In order to test our hypothesis, we need to check our variables for unit root by running the ADF test. For that first the lag length is calculated. Since the number of our observations is 2409, the lag length is approximate 13. The results of the ADF test are reported in Table 13.

Table 13

ADF test results

	Results for the initial data		
	tau_c(1)	**Asymptotic p-value**	**Null hypothesis**
Soybeans	-2.82639	0.1876	Not rejected
Crude oil	-2.45908	0.3488	Not rejected
Gold	-1.831	0.6895	Not rejected
Rough rice	-3.22165	0.08012	Not rejected
Wheat	-3.66519	0.02466	Not rejected
S&P500	-2.39888	0.3801	Not rejected
SSEC	-2.30447	0.4309	Not rejected
Nasdaq	2.32936	0.4173	Not rejected
Euronext100	-2.37696	0.3917	Not rejected
FTSE100	-2.88603	0.167	Not rejected
BSE	-2.58801	0.2859	Not rejected
Nikkei	-2.52565	0.3155	Not rejected
Critical value for 1% level of significance	-3,96		
Critical value for 5% level of significance	-3,41		

Note: author's calculations.

We tested the data for the constant and trend. The critical value for our sample size is (-3,96) for a 1% level of significance. *The Null hypothesis for ADF test states that there is a Unit root.* From Table 13 it is seen that p-values of tested variables are large, therefore at a 1% level of significance *we cannot reject the Null hypothesis* stating that there is a unit root and our variables are non-stationary.

Thus, since our variables are non -stationary, we need to test them for cointegration relationship. In this case we need to run Johansen cointegration test.

3.4.2 AIC lag order selection

To conduct the Johansen cointegration test first it is needed to determine the lag order. According to the AIC criteria we have to use the *lag order 2* indicated by asterisk (Table 2 of Annex 3).

3.4.3. Johansen cointegration test

The result of the Johansen cointegration test is reported in the Table 14**.** *The Null hypothesis of the Johansen test states that there is no cointegration.* According to the obtained result of this Rank Trace test (p-value is greater than 0,05) ***we do not reject*** the Null *hypothesis* and conclude that our variables are not cointegrated.

Table 14

Johansen cointegration Rank Trace test

Rank	Trace test / p-value	Null hypothesis
0	335.56 [0.0560]	Not rejected
1	275.24 [0.1250]	Not rejected
2	218.71 [0.2932]	Not rejected
3	174.21 [0.3906]	Not rejected
4	131.96 [0.5721]	Not rejected
5	91.890 [0.8293]	Not rejected
6	66.133 [0.8372]	Not rejected
7	45.966 [0.7985]	Not rejected
8	30.480 [0.6974]	Not rejected
9	17.414 [0.6153]	Not rejected
10	8.2361 [0.4481]	Not rejected
11	0.077124 [0.7818]	Not rejected

Note: author's calculations.

3.4.4. ADF test for variables with log differences

Since all our variables have been found as not cointegrated to test our hypothesis we need to transform all of them to the log differences and check them again for the unit root (ADF test).

Application of log differencing allows us to bring the initial data closer to the return of selected assets. Differencing procedure and transformation to the log are made automatically by the Gretl software. From Table 15 it is seen that after applying the log differencing procedure the asymptomatic p-value became less than 0,05 and tau statistic is less than a critical value. Thus, we *should reject the Null hypothesis* stating that there is no unit root and our variables are stationary.

Table 15

ADF test for variables with log differences

	Results for log differenced variables		
	tau_c(1)	**asymptotic p-value**	**Null hypothesis**
ld_Soybeans	-18.7047	7.981e-045	Reject
ld_Crudeoil	-11.4665	5.758e-024	Reject
ld_Gold	-33.5659	6.894e-041	Reject
ld_Roughrice	-47.6547	1.126e-082	Reject
ld_Wheat	-49.496	1.068e-075	Reject
ld_SP500	-14.8619	2.632e-042	Reject
ld_Nasdaq	-37.4667	1.896e-136	Reject
ld_Euronext100	-24.6804	2.015e-093	Reject
ld_FTSE100	-13.971	7.901e-038	Reject
ld_BSE	-13.6642	2.58e-036	Reject
ld_Nikkei	-18.4509	3.878e-061	Reject
ld_SSEC	-11.5218	3.797e-024	Reject

Note: author's calculations.

The next step is to run the VAR and Granger causality test for the log differences.

3.4.5. VAR and Granger causality test

First, we determined the number of lags which is reported in the Table 3 (Annex 3). Result of AIC suggests us to apply the *lag4*. To examine the bi-lateral causality between crude oil and stock market indexes first, we have to run the VAR for crude oils as an independent and then as a dependent variable.

a. Crude oil as a dependent variable

In the Table 16 the result of the test of Crude oil as a dependent variable is presented. The insignificance of the obtained p-values in most cases evidences that no one examined stock market indexes can affect the crude oil movement. Only Nasdaq composite index demonstrated significance in the second lag and Nikkei 225 in the fourth lag. The F test of zero restrictions also shows that jointly results are insignificant. Thus, we should state that stock market indexes cannot Granger cause the crude oil prices movement.

Table 16

Crude oil as a dependent variable

Variables	p-value	F-test [p-value]
ld_SP500_1	0.9303	1.319 [0.2605]
ld_SP500_2	0.0603*	
ld_SP500_3	0.1922	
ld_SP500_4	0.4306	
ld_Nasdaq_1	0.5912	2.2734 [0.0591]
ld_Nasdaq_2	0.0182**	
ld_Nasdaq_3	0.1110	
ld_Nasdaq_4	0.3354	
ld_Euronext_1	0.0747*	1.1298 [0.3405]
ld_Euronext_2	0.9741	
ld_Euronext_3	0.5196	
ld_Euronext_4	0.3383	
ld_FTSE100_1	0.3453	1.1426 [0.3346]
ld_FTSE100_2	0.2106	
ld_FTSE100_3	0.4407	
ld_FTSE100_4	0.4218	
ld_Nikkei_1	0.9442	1.6331 [0.1632]
ld_Nikkei_2	0.4810	
ld_Nikkei_3	0.7532	
ld_Nikkei_4	0.0159**	
ld_BSE_1	0.1505	1.2789 [0.2760]
ld_BSE_2	0.8094*	
ld_BSE_3	0.6436	
ld_BSE_4	0.0798	
ld_SSEC_1	0.1983	0.45373 [0.7697]
ld_SSEC_2	0.7808	
ld_SSEC_3	0.8907	
ld_SSEC_4	0.8692	

Note: author's calculations.

b. Crude oil as an independent variable

From Table 17 below it is clear that Crude oil as an independent variable showed the significance only regarding the Nikkei 225 index in the first order. The F- test of zero restriction also confirms the joint significance of this result. In all other cases, we have got the insignificant results. The F-test of zero restrictions also evidences that results are jointly insignificant. Therefore we cannot infer that crude oil Granger causes the stock market indexes movement.

The result of our test of crude oil as a dependent and the independent variable demonstrates that there is no causality neither unilateral nor bi-lateral between crude oil and selected stock market indexes. From all the above, we should reject Hypothesis 3 and conclude that there is no bilateral causality between crude oil and stock market indexes.

Table 17

Crude oil as an independent variable

	ld_S&P500 p-value	ld_Nasdaq p-value	ld_Euronext 100 p-value	ld_FTSE 100 p-value	ld_Nikkei 225 p-value	ld_BSE30 p-value	ld_SSEC p-value
ld_Crudeoil_1	0.4310	0.1543	0.4444	0.2490	0.0154**	0.4022	0.6127
ld_Crudeoil_2	0.8190	0.9710	0.2430	0.7455	0.0712*	0.1117	0.2796
ld_Crudeoil_3	0.2886	0.7736	0.2423	0.5391	0.7954	0.3168	0.9211
ld_Crudeoil_4	0.9192	0.9710	0.7422	0.7851	0.4373	0.6345	0.2341
F-tests of zero restrictions	0.40726 [0.8035]	0.093815 [0.9844]	0.88619 [0.4713]	0.54608 [0.7019]	**2.6224 [0.0332]**	1.4911 [0.2022]	0.73781 [0.5661]

Note: author's calculations.

3.4.6 Impulse response analysis

a. Response of stock market indexes in a shock in Crude oil

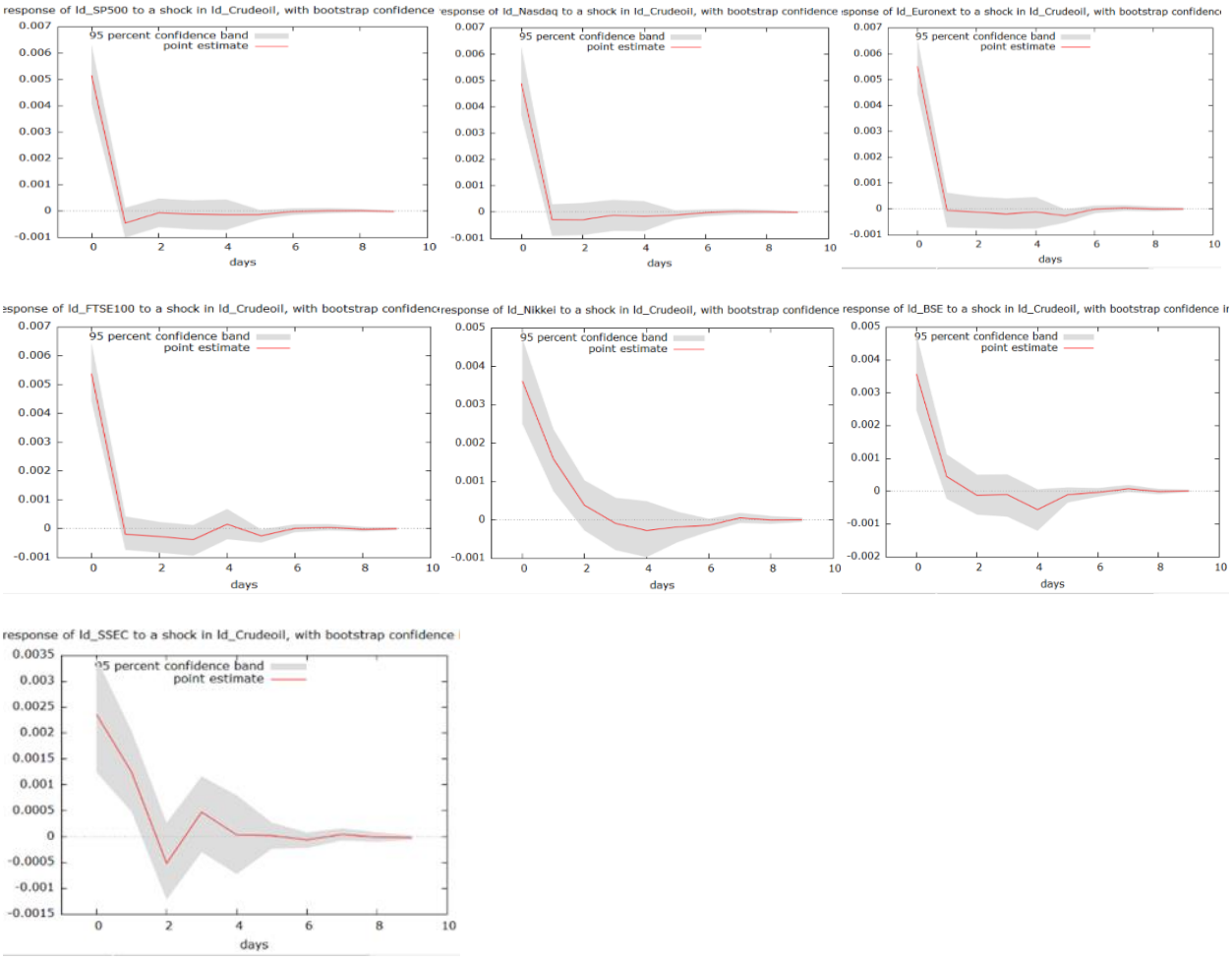

Figure 8. Response of the stock market indexes to the shock in crude oil.
Note: developed by the author.

In order to find out how do the crude oil and stock markets react to the shock in each other the Impulse Response analysis has been applied. This function provides the results in different ways: numerically and graphically. The result of it is presented in Figure 8 and Table 4 of Annex 3. Figure 8 shows that stock market indexes react to the shock in crude oil immediately, positively. In most cases, the reaction becomes slightly negative by the second or third day and diminishes by the 4th day. Also from Table 4 (Annex 3), it is seen that the S&P500, FTSE100, and Euronext100 indexes showed the strongest response to shock in Crude oil.

b. Response from Crude oil to the shock in stock market indexes

From the Figure 9 and Table 5 of Annex 3 it is seen that impulse responses from the crude oil to shock in stock market indexes were week and positive in most cases. The strongest positive response was observed to the shock in S&P500 index. The negative insignificant response was observed to the shocks in SSEC and Euronext100 indexes.

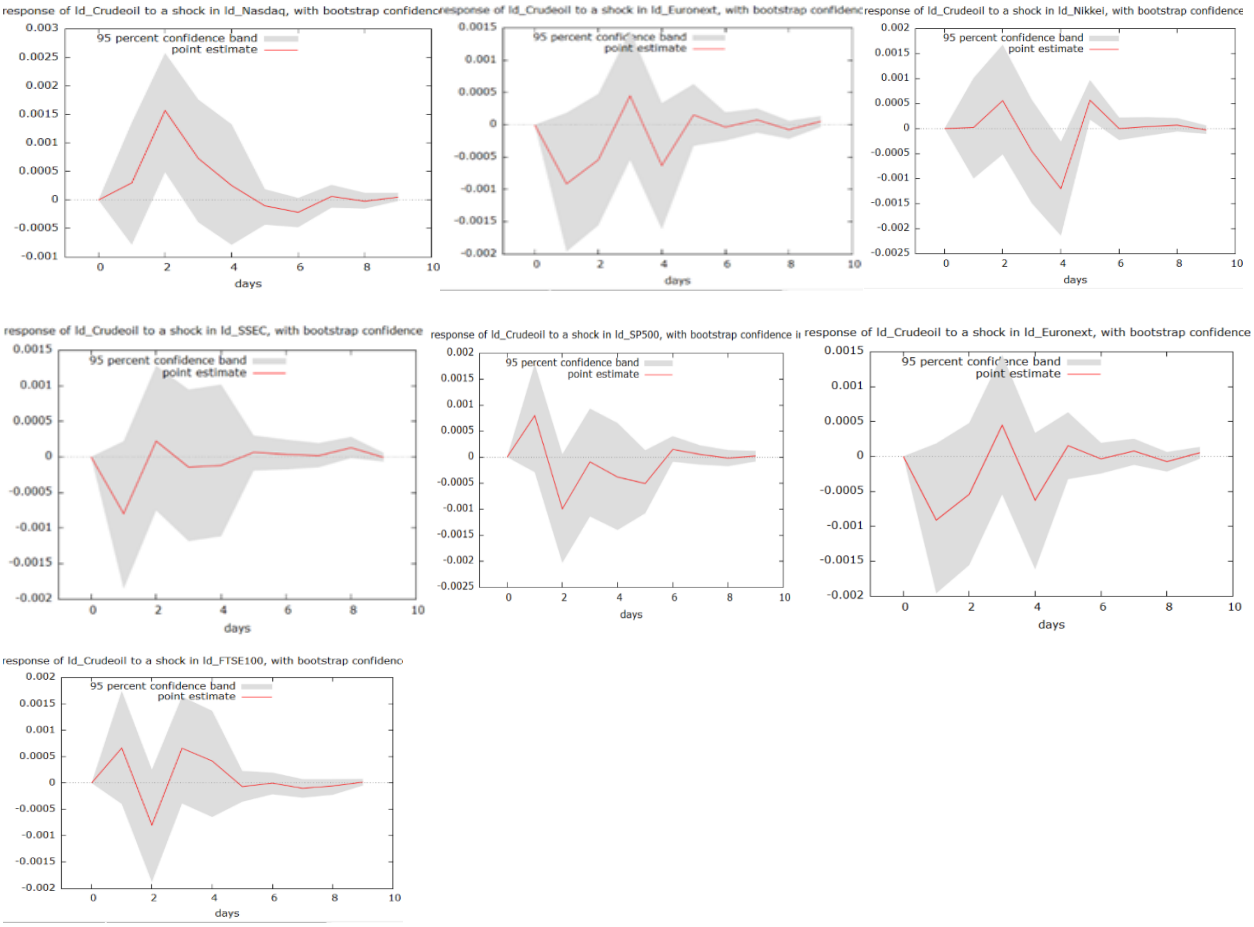

Figure 9. Response of the crude oil to the shock in stock market indexes.
Note: developed by the author.

3.5. Results of testing the Hypothesis 4.

In this chapter we present the results of testing hypothesis H4: In the period of global financial crisis and post-crisis period the agricultural commodity market prices cause the movement of the stock markets indexes. For testing of this hypotheses AIC, VAR models and the Impulse response analysis were used.

3.5.1. AIC

To examine the hypothesis 4 we have to determine the lag order for the VAR. According to the AIC we have to apply *the lag order2*. See the Table 6 in Annex 3.

3.5.2. VAR model

The next step is to run the VAR to determine whether the selected commodities cause changes in the stock market. For that, we took the stock market indexes as the dependent variables. It worth to remind that we use the log differenced data which are close to returns of selected assets. The obtained result of the examination is reported in Table 18. From it is seen that all p-values are insignificant except the BSE30 index in a second lag. The F-test also shows the insignificance of joint results. Thus, we *have to reject our Hypothesis 4* stating that agricultural commodities do not Granger cause the stock market movements in all examined period (since 2007-2018).

Table 18

Agricultural commodities as an independent variables

Independent / Dependent	**ld_Soybeans p-value**	**ld__Rough rice p-value**	**ld_Wheat p-value**
ld_SP500_1	0.9512	0.5732	0.3365
ld_SP500_2	0.4990	0.5210	0.3340
ld_Nasdaq_1	0.3063	0.8409	0.6359
ld_Nasdaq_2	0.4743	0.1978	0.3356
ld_Euronext100_1	0.1477	0.4622	0.7258
ld_Euronext100_2	0.7831	0.6214	0.1349
ld_FTSE100_1	0.8410	0.7701	0.9222
ld_FTSE100_2	0.5315	0.9128	0.1235
ld_Nikkei225_1	0.9673	0.7949	0.4639
ld_Nikkei225_2	0.6505	0.5830	0.6139
ld_BSE30_1	0.7239	0.1784	0.8202
ld_BSE30_2	0.2483	0.0214**	0.3726
ld_SSEC_1	0.2228	0.2821	0.9726
ld_SSEC_2	0.5018	0.5333	0.3448
F test for zero restrictions [p-value]	0.52816 [0.8714]	1.0711 [0.3810]	0.72379 [0.7027]

Note: author's calculations

3.5.3 Impulse response function for agricultural commodities

a. Response of Soybeans to the shocks in stock market indexes.

The Impulse response analysis has been applied to observe how the shock in one asset can be transmitted to others. The Figure 10 and Table 7 in Annex 3 show the obtained results. From it is seen that Soybeans has not responded immediately to the shocks in stock market indexes and the reactions were insignificant. The almost zero reaction is observed to the shock in FTSE100 and Nikkei225 stock market indexes. The strongest positive responses were observed in regard to the shocks in S&P500 and Nasdaq composite indexes. To the Euronext and SSEC Soybeans reacted negatively but the response to the shock in Euronext100 was stronger. All responses disappeared by the 4th day.

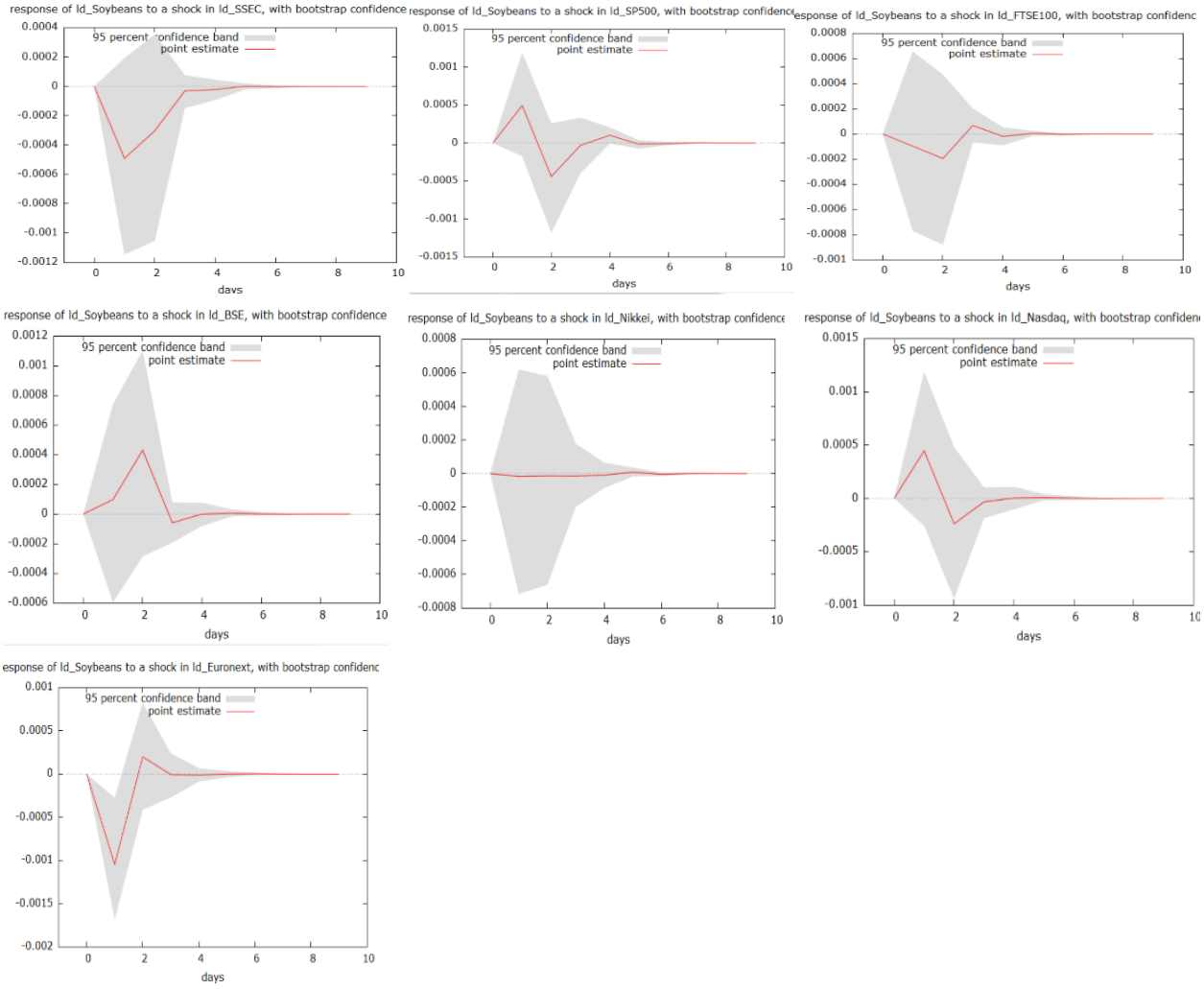

Figure 10. Response of Soybeans to the shock in stock market indexes.

Note: developed by the author.

b. Response from the stock market to the shock in soybeans

In regards to the response from the stock market indexes to the shock in soybeans, it should be said that reaction was immediate, positive, and insignificant in all cases. All responses had an approximate level of strength. According to Figure 11 and Table 8 in Annex 3 by the 4th day, most responses faded out.

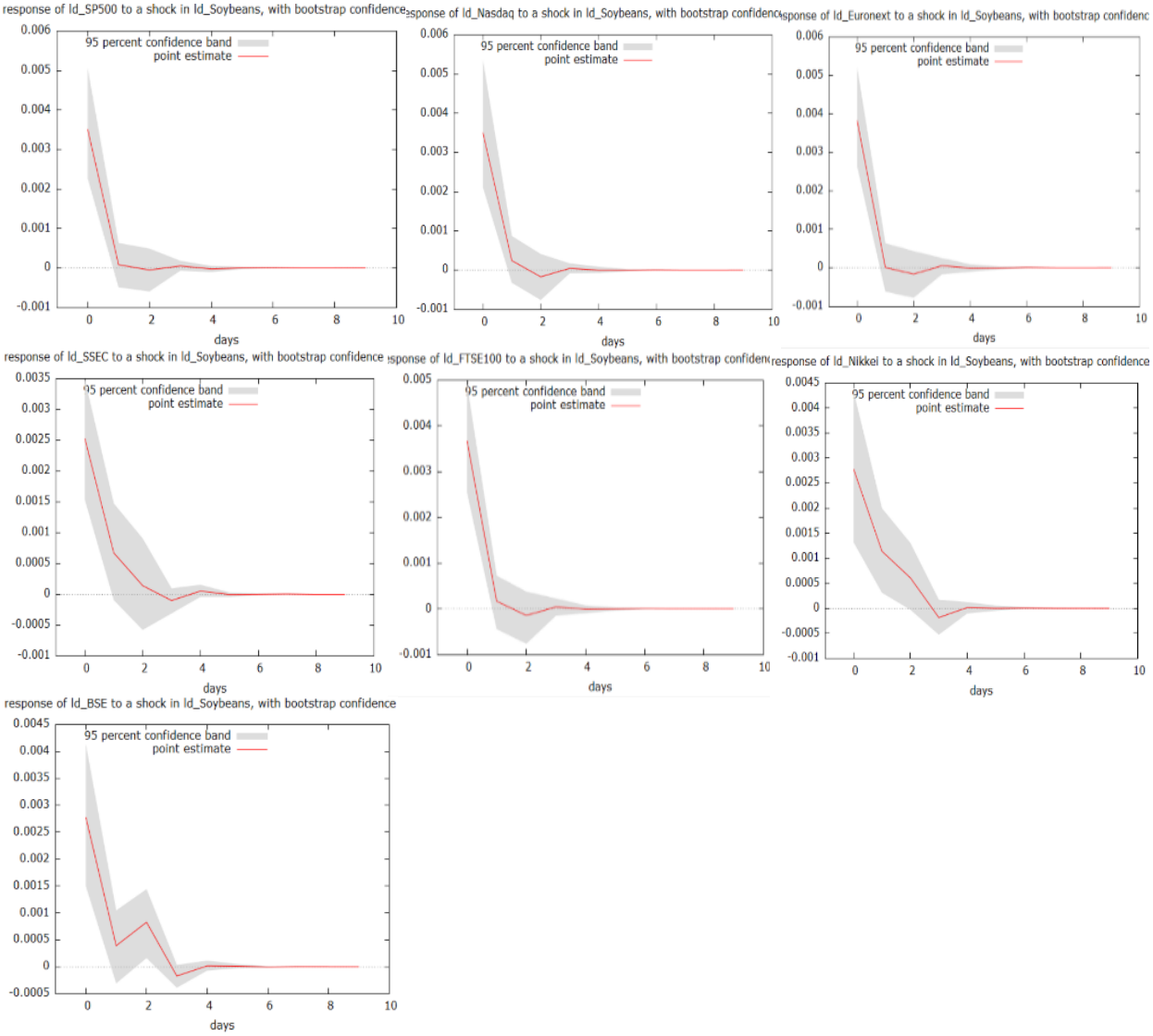

Figure 11. Response from the stock market indexes to the shocks in soybeans.
Note: developed by the author.

c. Impulse response of Rough rice to the shock in stock market indexes.

From the Figure 12 and Table 9 in Annex 3 is seen that the responses from the Rough rice to the shocks in stock market indexes were lagged, insignificant, and in most cases negative, except

the S&P500 and Nasdaq composite index cases. The weakest response was observed to the shock in Nasdaq composite index. All responses diminished by the 4th day.

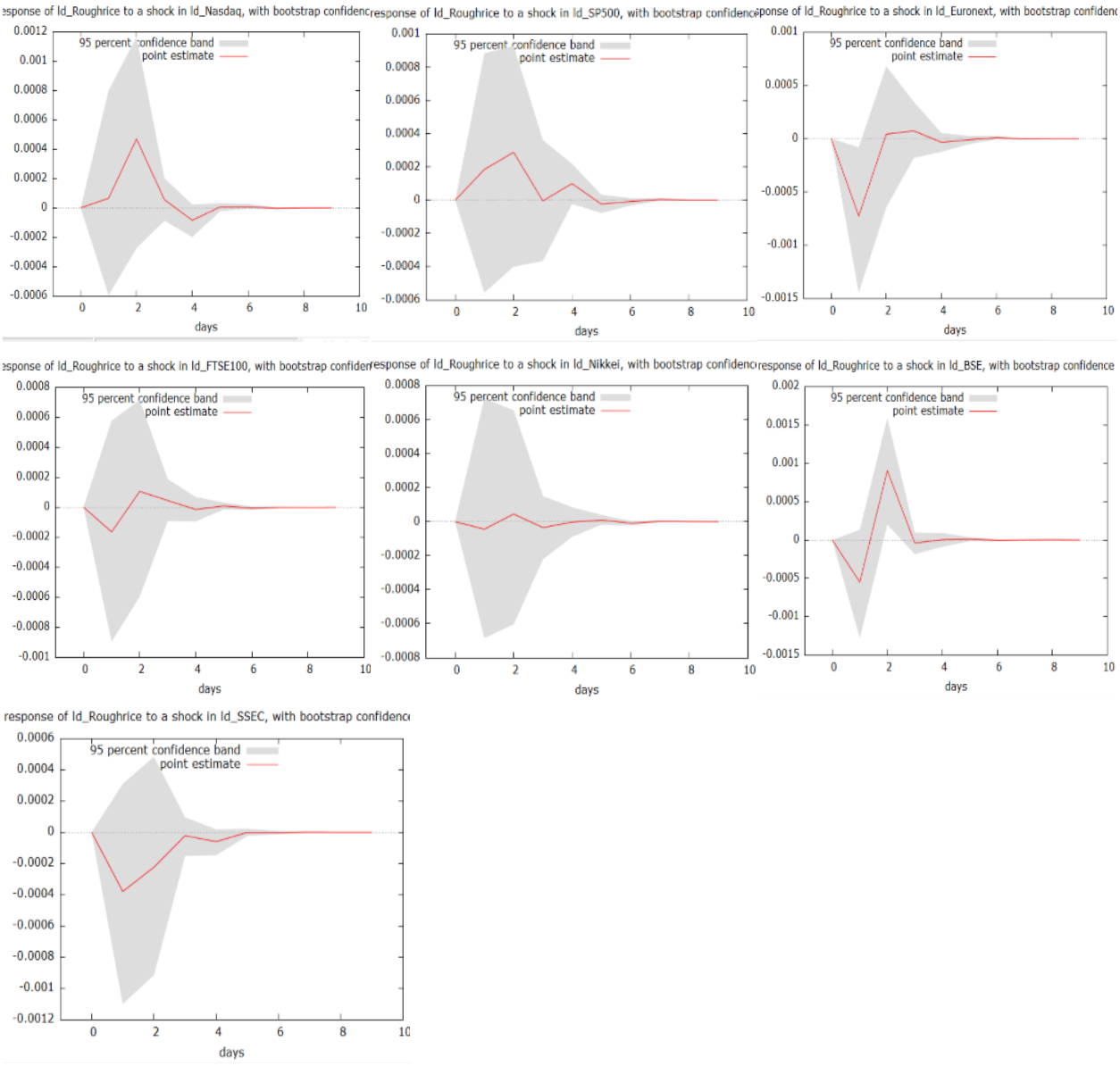

Figure12. Response of Rough rice to the shock in stock markets indexes.

Note: developed by the author.

d. Response from the stock market indexes to the Rough rice shock

From the Figure 13 and Table 10 in Annex 3 it is obvious that stock market reacted positively to the shock in Rough rice in vast majority of cases and insignificantly. The response from the SSEC index was negative and least noticeable in comparison with other stock indexes.

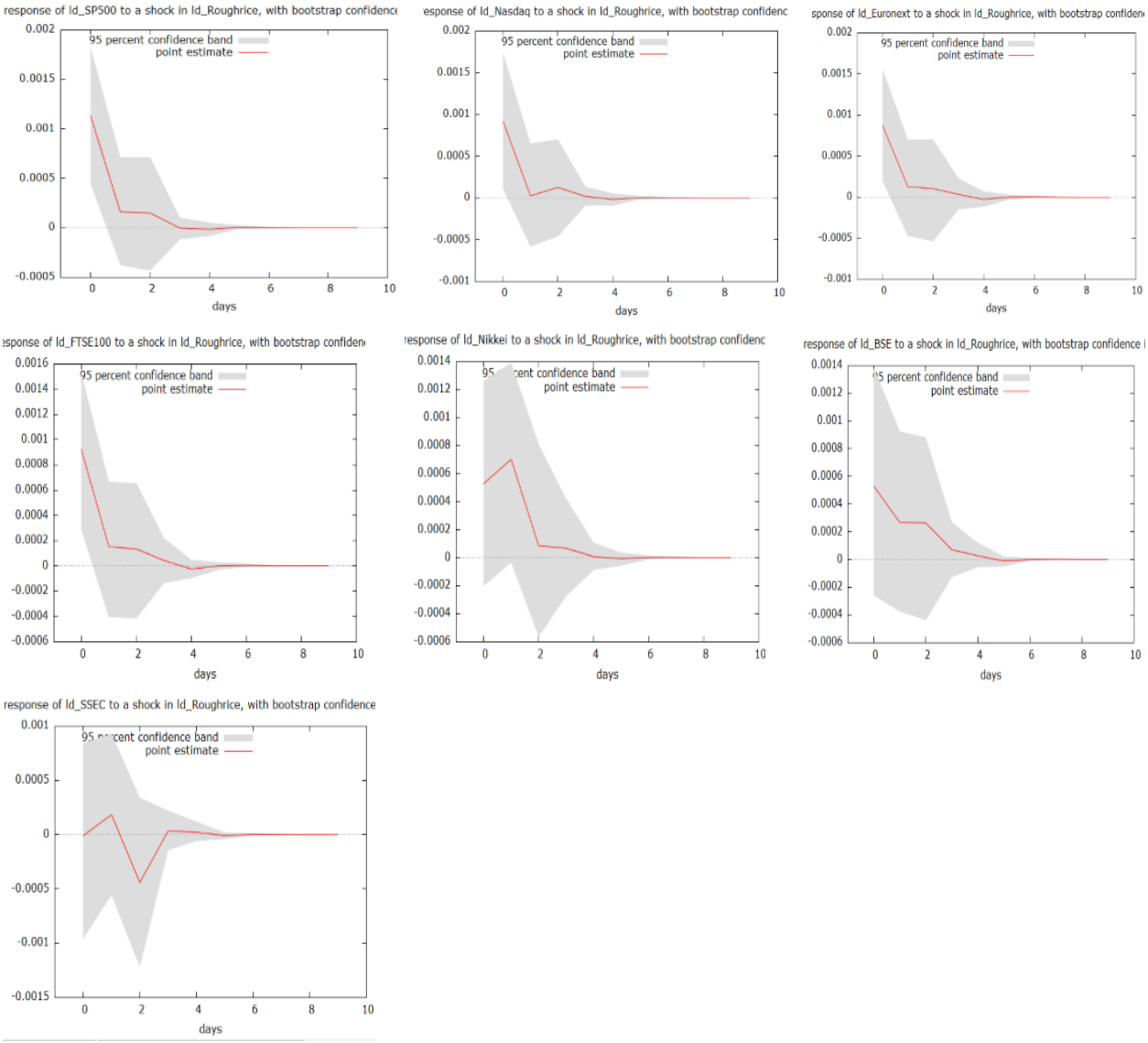

Figure 13. Response from the stock market indexes to the Rough rice shock.

Note: developed by the author.

e. The impulse response of the stock indexes to the shock in Wheat

The output from the Impulse response analysis of stock market indexes to the shock in Wheat is presented in Figure 14 and Table 11 in Annex 3. As it is seen from Figure 14 in all cases except the SSEC index the responses from the stock market indexes to the shock in Wheat were positive. The response amplitude differs depends on the stock index. The responses of Nikkei225, S&P500, and Nasdaq composite indexes were stronger among all stock indexes. Other stock market indexes showed minor results. All impulse responses faded out by the 4th day.

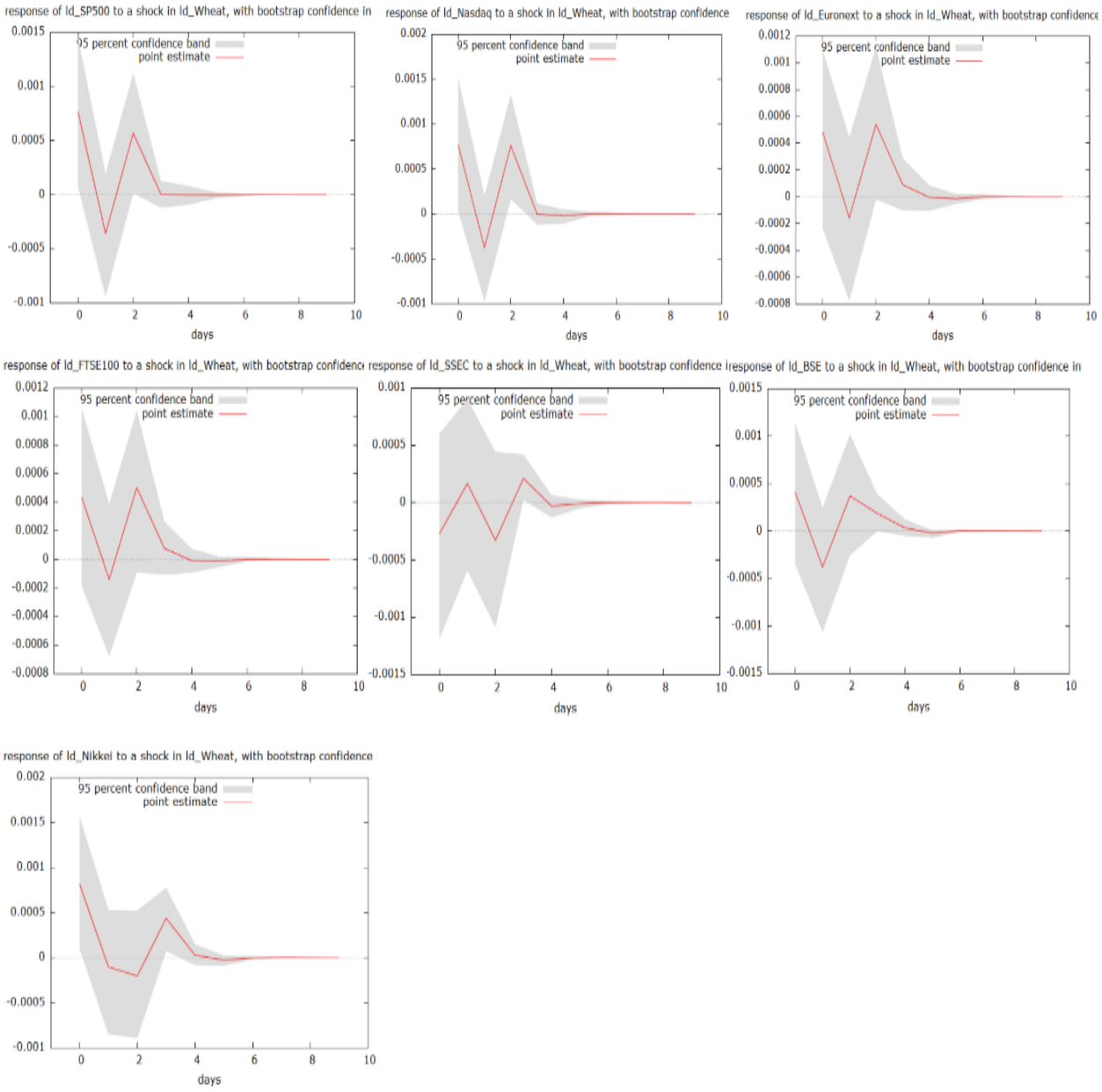

Figure 14. Response from the stock market indexes to the shock in Wheat.

Note: developed by the author.

f. The Impulse response from the Wheat to the shock of stock market indexes

From the Figure 15 and Table 12 in Annex 3 it is clear that responses from the Wheat to the shocks in stock market indexes were lagged and too minor. In most cases it was negative except the S&P500 index and disappeared by the 4th day.

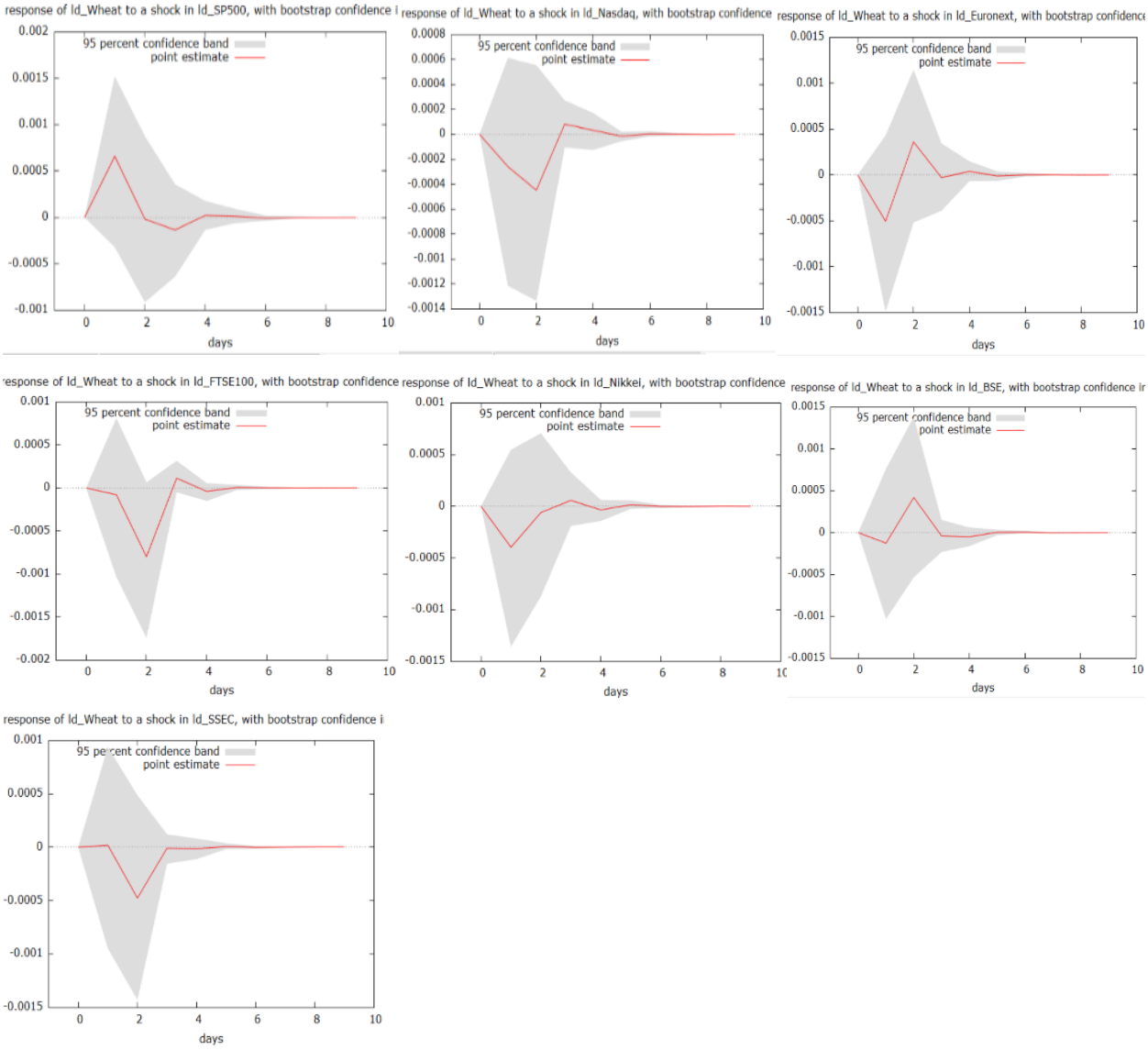

Figure 15. The Impulse response from the Wheat to the shock in stock market indexes.

Note: developed by the author.

From all the above we should conclude that obtained results contradicts the statement of our Hypothesis 4, that agricultural commodity market prices cause the stock market indexes movement. The impulse response analysis also confirmed the weak relationship between examined assets.

3.6. Generalization and discussion of the empirical research results

To sum up the results of our study, we should state the following. Hypothesis 1 is rejected due to the fact that despite the increasing correlation between commodities and stock market

indexes in the global financial crisis period in most examined cases it remained lower than the critical level of 0,5. Moreover, in the post-crisis period, the correlation between commodities and stock indexes decreased as well as volatility. Hypothesis 2 is accepted since we have found that the correlation level between gold and stock market indexes was low during the whole examined period. We have to reject Hypothesis 3 as we have not found strong evidence regarding causality between crude oil and selected stock market indexes. When it comes to causality between agricultural commodities and selected stock market indexes from our examination it is also clear that those commodities do not Granger cause the stock market indexes. Thus, we also have to reject Hypothesis 4. To sum up, all obtained results evidence the absence of co-movements between considered commodities and stock market indexes in the selected region in the period of the global financial crisis of 2008 and in the post-crisis period. The generalized results of tested hypotheses are provided in Table 19.

Table 19

Generalized results of tested hypotheses

Hypothesis	Result	Argumentation
H1:The co-movement between commodity and stock markets during global financial crisis and post-crises period was significant and increased.	Rejected	1) The insignificant correlation between most of commodities and stock market indexes (except of crude oil) during financial crisis. (level of significance is lower than 0,5) 2) In 2008-2009 the correlation level increased by value of 0,8-0,9, but in post-crisis period decreased by 0,3-0,2.
H2: During the last financial crisis of 2008 the gold proved its safe-haven feature.	Accepted	Low correlation level during the whole examined period
H3: There was the bi-lateral causality between crude oil and stock markets in the period of global financial crisis and post-crisis period.	Rejected	The insignificant result of the Granger causality test (p-value of higher than 0,05) showed that crude oil cannot cause the stock market indexes movement.
H4: In the period of global financial crisis and post-crisis period the agricultural commodity market prices cause the movement of the stock markets indexes.	Rejected	The insignificant result of the Granger causality test (p-value of higher than 0,05) showed that agricultural commodities cannot cause the stock market indexes movement.

The results of our study distinguished several common points with other researchers. While the examination of Hypothesis1 we have found out that our examined commodities and stock market indexes started showing the downward trend in the middle of the Financial crisis of 2008. (Figure1). This is consistent with the statement of Kurach (2012) who stated that the equity market becomes bearish before the economic downturn and bullish in the growth period. Our

examination showed that the annualized standard deviation (which is evidence of volatility) of Asian SSEC and BSE30 indexes is much higher than in other indexes cases. This supports the opinion of Claessens et al. (2011) about the higher volatility of emerging equity markets. In 2008 the annualized standard deviation of those indexes exceeded 50% while other stock market indexes were around 40%. It is also obvious from Figure 6 that regardless of regions volatility of all assets increased simultaneously in 2008 and started declining in 2009. When it comes to our investigated commodities it is seen that agricultural commodities were less volatile in comparison with stock market indexes. Such authors as Roy and Roy (2017), have come to the conclusion that increased volatility was the reason for the rise of correlation between commodity and stock markets in that period. In our case, it is also seen the coincidence of periods of risen volatility and the increasing correlation between commodity and stock markets. In regards to correlation, it should be said that from our calculations it is clear that in the period of financial crisis years 2008-2009 correlation between all examined commodities except the gold was higher than in the post-crisis period. It contradicts Creti et al. (2013) who stated that the correlation between commodity and the stock market gets stronger over time.

The result of Hypothesis 2 is consistent with many researchers who investigated the safe heaven property of gold in different periods. Our results are based on the calculation correlation between gold and the stock market. The significant drop of the correlation value which lasted during 2008-2009 allows inferring that gold is still a reliable asset for investors in the crisis periods. Tuna and Tuna (2019) and De Boyrie and Pavlova (2018) also stated that precious metals showed a low level of co-movement in the crisis period proving the hedging opportunities.

Our result of Hipothesis3 contradicts opinions of Arfaoui and Rejeb (2017) about bi-lateral causality between crude oil and stock market prices and the opinion of Hamma et al. (2013) about unidirectional causality between crude oil and stock market prices.

While testing Hypothesis 4 of causality between agricultural commodity market prices and stock market indexes because we found out that the market prices of selected agricultural commodities could not cause a change in stock market indexes. This result is supported by the study of De Boyrie and Pavlova (2018) as well as Silvennoinen and Thorp (2013). They have found that grain and other agricultural commodities showed low co-movement with the stock market. A similar opinion was expressed by Batten et al. (2015) who stated that the Asia Pacific region showed low co-movements between stock and commodity markets.

CONCLUSSIONS AND RECOMMENDATIONS

This study is devoted to the investigation of how do the commodity and stock markets co-move in the period of the financial crisis of 2008 and in the post-crisis period. To implement the research we worked on several objectives set for achieving the main aim of the diploma paper. The results of the realization of these objectives in the Master Thesis are presented below.

In the first part of our study, we considered the peculiarities of the commodity markets. Besides supply and demand commodity prices are affected by weather conditions, storage capacities, interest rates, and different business cycles. Business cycles are usually characterized by increasing prices of industrial commodities as the main component of innovative technologies (Jégourel, 2018). Moreover, last decades commodities became a subject of financialization which is also an additional price influencing factor.

The behavior of stock markets differs in the different periods of the economic cycle and in the period of the financial crisis of 2008. Many authors concluded that usually stock market indexes prices soar in the period of economic expansion and drop before the recession thereby serving as an unmistakable indicator of economic health (Kurach, 2012).

While analyzing the previous studied in the research problem area of co-movements between commodity and stock market the special attention has been paid to studies of such authors as De Boyrie and Pavlova (2018), Batten et al. (2015) and Hoque and Farhan (2017), because their researches covered approximately the same regions and examined commodities. Those authors have not found the co-movements between agricultural commodities and stock market indexes since the agricultural commodities are less involved in the industrial processes.

The financial crisis of 2008 negatively affected both commodity and stock markets and changed their relationship. Prices of stock and commodity markets dropped dramatically in 2008. Seeking the hedging instruments investors restructured their investment portfolios by adding the commodity futures to them and thereby encouraging the commodity financialization. Such researchers as Creti et al. (2013), Mensi (2019) and Silvennoinen and Thorp (2013) have noticed an enhanced correlation between commodity and stock markets during the period of the last financial crisis and changed co-movements pattern.

In the second part of our study while developing our research methodology and setting our research hypotheses we relied on the existing experience of scientists reflected in the reviewed papers. We used the ADF test, VAR model, Granger causality test, and Impulse response analysis

which were most often used in previous studies by employing the Gretl software to examine two of our research hypotheses. In addition, we have applied the Excel functionality to investigate the volatility and correlation between assets. The data for this research has been derived from such web sources as YahooFinance.com, Investing.com, and Market Insider. From the Asian region, we have investigated such indexes as the Shanghai composite index from China (SSEC), BSE30 index from India, and Nikkei225 from Japan. From Europe, we have used Euronext100 and FTSE100. For the benchmark, the S&P500 and Nasdaq composite stock market indexes as the US representative have been used. From the agricultural commodity side, we examined wheat, soybeans, and rough rice. Also, the relationship between crude oil and gold with stock markets have been investigated. For the study, the spot prices of mentioned assets on a daily basis in the period of global financial crises, and the post-crisis period (2007-2018) have been employed.

For the empirical research, four hypotheses disclosing the co-movement of the commodity and stock markets in the period of global financial crises and in the post-crisis period have been set. Based on the statements of many authors mentioned above about enhanced correlation between commodity and the stock market in the financial crises period of 2008 we set up H1: The co-movement between commodity and stock markets during the global financial crisis and post crises period (in the period from 2007 until 2018) was significant and increased. Some scientists (Tuna and Tuna, 2019) stated that during the financial crisis of 2008 gold proved its hedging feature. To examine this phenomenon we have set the H2: During the global financial crisis of 2008 gold has proved its safe-haven feature. Many studies examined whether causality or not between commodity and stock markets (Mensi, 2019; Bonato & Taschini, 2016). In this regard, it was purposive to investigate the relationship between crude oil and stock market indexes. This was reflected in H3: There was the bi-lateral causality between crude oil and stock markets in the period of the global financial crisis and post-crisis period. When it comes to agricultural commodities, some authors (Batten et al.2015), infer that since agricultural commodities are not integrated very much into industrial processes they cannot influence the stock markets. To examine the fairness of that statement we have set the H4: In the period of the global financial crisis and post-crisis period the agricultural commodity market prices cause the movement of the stock market indexes.

Testing of the research hypotheses empirically provides us with the following results:

- We had to reject H1 because the correlation between commodity and stock markets was not significant except for the crude oil case. It increased notably in the financial crisis period as well as volatility but not exceeded the value of 0,5 and in the post-crisis period, it decreased again. Thus, we cannot infer that co-movement is constant. That outcome is supported by the result of Ildırar and İşcan (2015).
- We accepted H2 about the safe haven peculiarity of gold because in the period of the financial crisis of 2008 the correlation between gold prices and stock market indexes decreased. Moreover, in the post-crisis period, we also observed the low correlation level between gold and stock market indexes. This corresponds with the results of many scientists such as Tuna and Tuna (2019) and De Boyrie, Pavlova (2018).
- Since the Granger causality test showed the low level of significance we had to reject Hypothesis 3 of bi-directional causality between crude oil and stock markets. This result contradicts some of the scientists, in particular Huang et al. (2017) and to Arfaoui and Rejeb (2017) who proved the bi-directional causality between crude oil and stock market index prices.
- Hypothesis 4 was rejected because examined commodities have not shown the causality towards the stock market indexes. The obtained result is supported by the result of Batten et al. (2015) who inferred that the Asian pacific region demonstrated the low co-movement between the commodity and the stock market.

To sum up, some results of our study can have a practical application. Since the safe haven feature of gold has been proved one more time it can be used for the diversification of the investment portfolio. The agricultural commodities can also be used for that purpose since they have a low correlation level with stock market indexes. The crude oil is a debatable commodity from the diversification perspective. It is influenced very much by political factors and should be examined by applying additional techniques and variables to get a more accurate result. Actually, in the current situation in the world markets, it is hard to predict the behavior of any assets because so many non- economic factors affect their movement. In our study, we also did not take into account political and weather conditions and were limited by freely available data. Moreover, we examined only three regions. Therefore, the obtained results may not be applicable to other regions and commodities. Thus, our recommendation for further investigation is to employ the data from all continents for a longer period by using a different econometric model.

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