



How Selected Energy Commodity Prices Volatility Impacts Gross Domestic Product (GDP) Fluctuation with Respect to Selected European Countries

Robert RANOSZ¹⁾, Barbara KOWAL²⁾

¹⁾ Ph.D., DSc, Eng.; AGH University of Science and Technology, Faculty of Mining and Geoengineering, Cracow, Poland; email: rranosz@agh.edu.pl

²⁾ Ph.D., Eng.; AGH University of Science and Technology, Faculty of Mining and Geoengineering, Cracow, Poland; email: bkowal@agh.edu.pl

<http://doi.org/10.29227/IM-2020-01-15>

Submission date: 01-12-2019 | Review date: 12-01-2020

Abstract

The article examines price volatility of the following energy raw materials: uranium, coal, crude oil and natural gas, and its influence on GDP fluctuation with regard to selected European countries. The study was carried out using linear regression approach, in which the volatility of raw materials prices was determined as independent variables and GDP fluctuation as a dependent variable. The article examines 33 European countries and the examined period covered 28 years (from 1990 to 2018). As demonstrated in the study, energy raw materials prices volatility influences GDP fluctuation, especially in the countries involved in their extraction and processing. Attention was also drawn to the fact that uranium and coal are the most significant energy raw materials for the European countries. In the case of crude oil, its volatility turned out to be significant only for two countries, i.e. Norway and the Russian Federation. It was a surprise that natural gas prices volatility slightly affects GDP fluctuation in selected European countries.

Keywords: gross domestic product, energy raw materials, price volatility, GDP

Introduction

The article discusses the study on the influence of energy raw materials prices volatility on GDP fluctuation with regard to selected European countries. As it can be assumed, the prices (their volatility, to be precise) of raw materials such as: uranium, coal, crude oil or natural gas, can positively or negatively influence the economic growth of the European countries. There are many factors influencing the economic development of individual countries of course, like demand for consumer goods, investments or the amount of taxes. Nevertheless the authors focused on the previously mentioned energy resources in the article. The energy raw materials prices may have direct or indirect impact on the aforementioned economic factor. The direct impact relates to the extraction and processing of a particular energy raw material by a selected country, while indirect impact may affect GDP of a selected country through its influence on prices of, e.g. of consumer goods, production or inflation. This thesis is confirmed by the research conducted by A. Geis, who states that influence of crude oil prices on such parameters as production and inflation can be observed both in the long and short term in the European Union countries [1]. Within the framework of the research carried out by Hamilton J.D., the author claims that economic activity and crude oil prices have negative correlation [2]. Nevertheless, it should be pointed out that crude oil prices – being the main focus of the majority of scientific publications – are continuously losing importance with respect to GDP development in selected countries [3]. It results, among other things, from the fact that the majority of developed economies have significantly improved the efficiency of the raw material's consumption [4]. An upturn in the consumption of crude oil is related to implementation of a worldwide trend aimed at reducing CO₂ emissions to atmosphere, and

the crude oil itself has an essential meaning in this respect. In terms of significance, the coal is second and natural gas is third in the classification [5]. As opposed to crude oil, in the case of coal, reduction of its consumption may result in decline of GDP indicator in particular countries, especially the countries outside the Organisation for Economic Co-operation and Development (OECD) [6]. The prices of the energy raw materials in question directly translate into energy prices, which in turn affects GDP development in selected countries. As it has been shown, the significance of the aforementioned relationship depends on the country [7]. It has also been stated that energy prices affect GDP to a greater extent in the developed countries than in the developing countries [8].

The first part of the article presents the methodology of the study and data taken into account in the analysis conducted. The second part of the article contains study results for particular raw materials. The whole article ends with a summary which discusses the study results presented in the previous chapter and the references.

Methodology and data for analysis

The aim of this article is to examine to what extent energy raw materials prices volatility impacts GDP fluctuation with regard to selected European countries [9]. In order to determine the aforementioned relationship, the linear regression was used. It was carried out using Excel and data analysis function (linear regression).

For the linear regression analysis - showing the relation between dependent variable and independent variables - to be carried out properly, data for the study should be selected appropriately in the first place. This article analyses the influence of particular energy raw materials (their prices volatility) on GDP fluctuation with respect to selected European

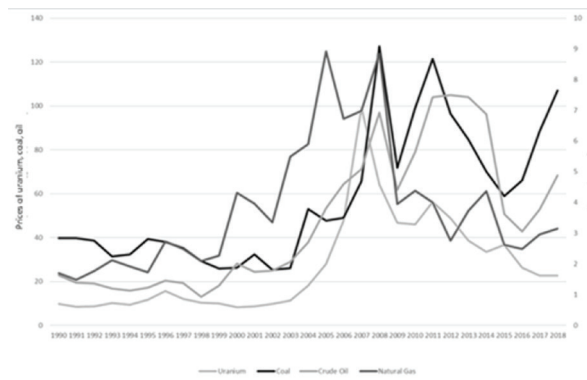


Fig. 1. Energy raw material prices. Source: own elaboration based on [11]

Rys. 1. Ceny surowców energetycznych. Źródło: opracowanie własne na podstawie [11]

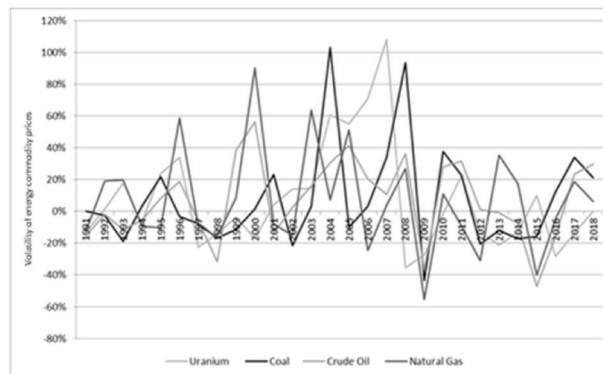


Fig. 2. Volatility of energy raw materials prices taken into account for the analysis. Source: own elaboration based on [11]

Rys. 2. Zmienność cen surowców energetycznych wzięty pod uwagę w analizie. Źródło: opracowanie własne na podstawie [11]

countries. Taking the above into consideration, raw materials prices (historical data) and GDP values for the selected countries are fundamental data. Figure 1 shows the prices of energy raw materials. The prices of the following raw materials were taken into account for the analysis: coal, crude oil, natural gas and uranium. The aforementioned raw materials are the base for electricity generation. It should also be stressed that they constitute more than 85% of the energy sources in the EU [10].

Figure 2 shows energy raw material prices volatility in the analysed period, i.e. in the years 1991–2018, as it is the main focus of the study.

As shown in Table 1, the correlation between the volatility of particular energy raw material prices is not significant. Taking the above into consideration, data considered as independent variables were taken into account in the analysis.

Within European countries, 46 countries can be distinguished. For the purpose of the analysis, 33 countries were taken into account. The remaining 13 countries were not analysed due to a lack of data. The following countries were not analysed: Bosnia and Herzegovina, Croatia, Montenegro, Estonia, Liechtenstein, Lithuania, North Macedonia, Moldova, Monaco, San Marino, Serbia and the Vatican City.

The analysis covered the period between 1990 and 2018.

Study results

Based on the assumptions presented in the previous chapter, an appropriate study of the relationship between energy

raw material prices volatility and GDP fluctuation with regard to selected European countries was carried out. Firstly, the coefficient of determination of independent variables to dependent variable (R squared) was determined. This coefficient value determines to what extent the independent variables describe the dependent variable. The study results are presented in Table 2.

Based on the results obtained, it can be generally stated that energy raw material prices volatility describes GDP fluctuation with regard to selected European countries within the range of nearly 14% to 70%. As it can be readily seen from Table 2 – Norway and the Russian Federation are the countries where GDP fluctuation depends on raw materials prices volatility to the greatest extent. In the case of the first of the aforementioned countries, GDP fluctuation depends on raw material prices volatility in 70%, and in the case of the second one this value slightly exceeds 64%. In the case of Poland, this value is at the level of nearly 45%, and for all the EU countries it is close to 40%. This means that energy raw materials prices volatility describes GDP fluctuation in 40%, thus the raw materials prices shape the level of dependent variable in 40%. As it can also be seen, the countries that mainly depend on energy raw materials prices volatility, rely on extraction and processing of these resources.

The further part of the article examines, which of the energy raw materials prices volatilities are of particular significance for development of GDP fluctuation with regard to selected European countries. The significance of particular

Tab. 1. Correlation matrix showing relation between the energy raw material prices taken into account for the analysis. Source: own elaboration
 Tab. 1. Macierz korelacji pomiędzy zmiennością cen surowców wziętych pod uwagę w analizie. Źródło: opracowanie własne

	Uranium	Coal	Crude Oil	Natural Gas
Uranium	1			
Coal	0.223376	1		
Crude Oil	0.263144	0.489415	1	
Natural Gas	0.056714	0.181226	0.640421	1

Tab. 2. R squared for selected European countries. Source: own elaboration
 Tab. 2. R kwadrat dla poszczególnych krajów Europy. Źródło: opracowanie własne

	R	R-square	Adjusted R2
Norway	0.837701335	0.7017435	0.649872836
Russian Federation	0.803203622	0.6451361	0.583420591
Kazakhstan	0.739889213	0.547436	0.468729273
Ukraine	0.739135325	0.546321	0.467420339
Romania	0.717212237	0.5143934	0.42994007
Belarus	0.704794402	0.4967351	0.409210828
Poland	0.667659168	0.4457688	0.349380724
Hungary	0.644451231	0.4153174	0.313633457
European Union	0.63242485	0.3999612	0.295606615
Czech Republic	0.631245168	0.3984705	0.293856629
Slovak Republic	0.624343211	0.3898044	0.283683479
Luxembourg	0.618838512	0.3829611	0.275649991
Denmark	0.609045378	0.3709363	0.261533885
France	0.608565234	0.3703516	0.260847582
Sweden	0.598647339	0.3583786	0.246792313
Spain	0.59780066	0.3573656	0.245603129
Andorra	0.592256535	0.3507678	0.237857856
Greece	0.591566743	0.3499512	0.236899248
Switzerland	0.588275624	0.3460682	0.232340942
Netherlands	0.587448363	0.3450956	0.231199159
Belgium	0.587039351	0.3446152	0.230635235
Italy	0.584439958	0.3415701	0.22706051
Austria	0.581491561	0.3381324	0.223025033
United Kingdom	0.557481255	0.3107853	0.190921932
Finland	0.555799621	0.3089132	0.188724213
Malta	0.55180396	0.3044876	0.183528934
Germany	0.548700211	0.3010719	0.179519212
Iceland	0.530408473	0.2813331	0.156347609
Ireland	0.524784914	0.2753992	0.149381676
Slovenia	0.522713007	0.2732289	0.146833912
Portugal	0.505472037	0.255502	0.126024064
Turkey	0.468249248	0.2192574	0.08347603
Bulgaria	0.4043057	0.1634631	0.017978421
Albania	0.375867211	0.1412762	-0.008067116

independent variables for the formation of a dependent variable is determined by the value „p”. If this value is below 0.05, then it can be assumed that the influence of a particular energy raw material (its volatility) affects development of GDP fluctuation of a selected country (bearing in mind importance of development of GDP fluctuation depended on energy raw materials prices volatility presented in Table 2).

Firstly, it was examined whether uranium prices volatility affects GDP fluctuation with regard to selected European countries. In the case of this energy raw material, it can be stated that it affects GDP fluctuation in the following countries: Norway, Kazakhstan, the Czech Republic, Slovakia, Luxembourg, Greece, Great Britain, Iceland and Ireland. The results are presented in Table 3.

With regard to all the aforementioned countries, an increase of the raw material price results in raise of GDP value in particular countries. Nevertheless, it should be remem-

bered that with regard to all these countries (despite of Norway) the influence is not significant. As shown in Table 3, Polish GDP fluctuation does not depend on the volatility of uranium prices. However, with regard to all European countries, there is such relation and similarly as in the case of the countries where GDP fluctuation depends on volatility of uranium prices, an increase of this raw material price results in raise of European GDP value.

Coal is another energy raw material subject to analysis. From the point of view of Poland and its resources, this raw material's volatility seems to be important for development of Polish GDP fluctuation. It should be remembered that in the case of Poland, raw materials prices volatility is described by GDP fluctuation to the extent of 35%. The results with regard to this raw material are presented in Table 4.

Analyzing coal, it should be stated that its volatility – from the perspective of GDP development in particular countries –

Tab. 3. Uranium. Source: own elaboration
 Tab. 3. Uran. Źródło: opracowanie własne

	Coefficient	Standard error	t-stat	p-value
Norway	0.080798948	0.037019744	2.183	0.03953308
Russian Federation	0.156415905	0.084070475	1.861	0.0756441
Kazakhstan	0.221321121	0.083553753	2.649	0.01434619
Ukraine	0.168238325	0.089459194	1.881	0.07274665
Poland	0.103200273	0.05526958	1.867	0.07466886
European Union	0.092047291	0.042091504	2.187	0.03918428
Czech Republic	0.159416512	0.066748681	2.388	0.02552385
Slovak Republic	0.128176127	0.055924331	2.292	0.03139331
Luxembourg	0.106124325	0.047251593	2.246	0.03461126
Greece	0.123226289	0.057262678	2.152	0.04213404
United Kingdom	0.113531674	0.044862042	2.531	0.01868272
Iceland	0.157013225	0.067862082	2.314	0.02996924
Ireland	0.119645996	0.050018041	2.392	0.02531744

Tab. 4. Coal. Source: own elaboration
 Tab. 4. Węgiel. Źródło: opracowanie własne

	Coefficient	Standard error	t-stat	p-value
Norway	0.064237212	0.042684998	1.505	0.14595655
Russian Federation	0.215552221	0.096936059	2.224	0.03627551
Kazakhstan	0.188674173	0.096340262	1.958	0.06241738
Ukraine	0.245379708	0.103149432	2.379	0.02605036
Romania	0.182837934	0.087034116	2.101	0.04682431
Poland	0.17676199	0.063727668	2.774	0.01080227
Hungary	0.144004921	0.060068549	2.397	0.02502887
European Union	0.103543184	0.048532907	2.133	0.04377663
Slovak Republic	0.138605839	0.064482618	2.15	0.0423477
Denmark	0.109643216	0.050794667	2.159	0.04156027
France	0.110317463	0.051402283	2.146	0.04264239
Switzerland	0.113000685	0.048517842	2.329	0.02900068
Netherlands	0.110678409	0.052790872	2.097	0.0472309
Belgium	0.115090659	0.053699647	2.143	0.04290174
Austria	0.112380899	0.054151541	2.075	0.04932718
Germany	0.118710708	0.055234421	2.149	0.04237323

Tab. 5. Crude oil. Source: own elaboration
 Tab. 5. Ropa naftowa. Źródło: opracowanie własne

	Coefficient	Standard error	t-stat	p-value
Norway	0.253462306	0.07149273	3.545	0.00172633
Russian Federation	0.380692704	0.162357358	2.345	0.0280377
Kazakhstan	0.217617048	0.161359462	1.349	0.19058089
Ukraine	0.262289238	0.172764082	1.518	0.14259264
Poland	-0.031800496	0.106736914	-0.3	0.76842868
European Union	-0.012928238	0.081287341	-0.16	0.87502279

is much more important that changes in the uranium prices. As regards coal prices volatility, it is crucial for 13 countries, and in the case of uranium, the number of countries amounts to 9. As shown in Table 4, coal prices volatility is not of significant influence on GDP development only with regard to two countries, these are: Norway and Kazakhstan. It is also worth noting that in the case of Poland, coal prices in the context of GDP are the most important among the mentioned countries.

Crude oil is another energy raw material subject to analysis. The results obtained with regards to this variable are presented in Table 5.

In the case of this raw material, crude oil prices volatility affects GDP fluctuation only with regard to the following two countries: Norway and the Russian Federation. The results obtained for these two countries should be beyond any

doubt, taking into consideration the fact that their economies are based on the extraction and processing of crude oil itself. Admittedly, in the case of Poland and EU countries crude oil prices volatility is not important (according to the study results), nevertheless, even if it is assumed that there is some relation with regard to this raw material, it should be stated that it is negative, i.e. the increase in crude oil prices causes the Polish GDP decrease, as well as for the EU in general.

Natural gas is the last energy raw material subject to analysis. The results obtained for this study are presented in Table 6.

According to the study results, presented in the table hereinabove, natural gas prices volatility has no significant impact on GDP fluctuation with regard to selected European countries. Even for countries like Norway and the Russian Federation. The study results concerning this scope can be in-

Tab. 6. Natural gas. Source: own elaboration
 Tab. 6. Gaz ziemny. Źródło: opracowanie własne

	Coefficient	Standard error	t-stat	p-value
Norway	-0.00838149	0.048773345	-0.17	0.86506189
Russian Federation	0.039479241	0.110762471	0.356	0.72476637
Kazakhstan	-0.002029172	0.110081693	-0.02	0.98545214
Ukraine	-0.015972689	0.117862085	-0.14	0.89337972
Romania	0.110692127	0.099448171	1.113	0.27717936
Belarus	0.102067051	0.101122094	1.009	0.32331074
Poland	0.072937569	0.072817423	1.002	0.32693501
European Union	0.043732748	0.055455367	0.789	0.43839253

terpreted in such a way that crude oil is much more important for the economic situation of these countries than natural gas.

Summary

According to the analysis conducted, raw materials prices volatility affects GDP fluctuation in selected European countries. This dependence is particularly evident in the case of countries that are involved in the extraction and processing of particular energy raw materials. It concerns the countries such as Norway and the Russian Federation. In the case of Norway, crude oil and uranium have the greatest impact on GDP fluctuation. With regard to the Russian Federation, crude oil and coal prices volatility are the most significant. According to the study carried out, countries within the con-

tinental in question, depend primarily on resources such as uranium and coal. In the case of Poland, only the volatility of coal prices has an impact on GDP fluctuation. It should also be noted that within the European countries in question, GDP of Poland depends on coal prices volatility to the greatest extent. Considering the European Union countries, these are uranium and coal prices volatilities that mainly influence GDP development. Summing up the study results, it should be stated that coal and uranium are still significant for GDP fluctuation development with regard to selected European countries.

This paper was supported by the AGH University of Science and Technology [No. 16.16.100.215]

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Wpływ zmienności cen surowców energetycznych na zmienności wartości produktu krajowego brutto dla poszczególnych krajów Europy

W artykule poddano badaniu zmienność cen surowców energetycznych, do których zaliczono: uran, węgiel, ropę naftową oraz gaz ziemny, na zmienność produktu krajowego brutto poszczególnych krajów Europy. Badanie przeprowadzono przy użyciu regresji liniowej, w której zmienność cen surowców określono jako zmienne niezależne a zmienność PKB jako zmienną zależną. W artykule wzięto pod uwagę 33 kraje Europy, a badany okres obejmował 28 lat (od roku 1990 do roku 2018). Jak wykazano w badaniu zmienność cen surowców energetycznych wpływa na zmienność PKB szczególnie dla krajów zajmujących się ich wydobyciem oraz przetwarzaniem. Zwrócono również uwagę na fakt, iż najistotniejszymi surowcami energetycznymi, które mają znaczenie dla krajów Europy to uran oraz węgiel. W przypadku ropy naftowej zmienność tego surowca okazała się być istotna tylko dla dwóch krajów tj. Norwegii oraz Federacji Rosyjskiej. Zaskoczeniem okazał się fakt, iż zmienność cen gazu ziemnego w nieznacznym stopniu wpływa na zmienność PKB poszczególnych krajów Europy.

Słowa kluczowe: produkt krajowy brutto, surowce energetyczne, zmienność cen