Research on the Dependence of the Level of Economic Growth on the Consumption of Materials and Energy in Selected European Union Countries

ANNA BLUSZCZ[1]), ANNA MANOWSKA[2)]

[1)] dr inż.; Silesian University of Technology, Faculty of Mining, Safety Engineering and Industrial Automation; email: anna.bluszcz@polsl.pl
[2)] dr inż.; Silesian University of Technology, Faculty of Mining, Safety Engineering and Industrial Automation; email: anna.manowska@polsl.pl

Abstract

The article investigates the problem of decoupling the economic growth from the level of materials consumption DMC (Domestic Material Consumption) and from the level of FEC (Final Energy Consumption [million tonnes of oil equivalent TOE]). The research on the problem of decoupling the economic growth from the level of consumption of DMC materials and from the level of FEC and import was carried out using panel data techniques. The analysis was carried out for selected countries, i.e. Germany, France, the Czech Republic and Poland in the years 2006–2015 and the data were collected from the Eurostat database. The data from 2006 were assumed in the analysis as the base year and subsequent years are a reference to the base year. Reducing consumption of raw materials and energy while maintaining a stable level of economic growth is a strategic priority of the European Union, because in this way it is possible to lower the costs of functioning of the future economy, but it also lowers the pressure on the natural environment. The aim of the article is to examine the dependencies that occur between the GDP growth rate and the growth rate of imports of goods and services, while reducing energy consumption and a steady increase in the consumption of materials. The study of the relationship between the above-mentioned macroeconomic indicators is based on determining whether one variable is the cause of the other variable in Granger's sense. The study was based on data concerning the economies of Germany, France, the Czech Republic and Poland. The influence of foreign trade on economic growth can take place on many levels – indirect impact using scientific and technical knowledge, transfer of modern technologies and finally with the help of foreign direct investment. This work will describe the mechanism of impact of imports on GDP, while analyzing energy and materials consumption.

Keywords: decoupling, domestic material consumption, final energy consumption

Introduction

Nature conservation, or the preservation of the natural capital, is an important factor in ensuring prosperity for present and future generations. The essence of the concept of sustainable development is to ensure the use of natural resources in such a way that society's needs can be met most effectively while maintaining the possibility of biological regeneration of the environment. This concept does not mean abandoning the production and consumption of goods but indicates the need for a number of structural and technological changes that will allow for the relatively smallest depreciation of natural capital. An effective tool for monitoring progress in this area can be the continuously developed material flow account. Studies indicate that in highly developed countries GDP growth is possible with a relatively smaller increase in material demand. This may be affected by structural changes in highly developed economies (including an increase in the share of the services sector), as well as technological changes, implementation of recycling, as well as the use of appropriate incentives, among others in the form of environmental taxes and fees. Undoubtedly, further research is needed on the factors determining the amount of material demand.

The aim of the article is to examine the dependencies that occur between the GDP growth rate and the growth rate of imports of goods and services, while reducing energy consumption and a steady increase in the consumption of materials.

The study of the relationship between the above-mentioned macroeconomic indicators is based on determining whether one variable is the cause of the other variable in Granger's sense [Charezma, Deadman 1997]. The study was based on data concerning the economies of Germany, France, the Czech Republic and Poland. The influence of foreign trade on economic growth can take place on many levels - indirect impact using scientific and technical knowledge [McNeil 2006], transfer of modern technologies [Schmieder 2013] and finally with the help of foreign direct investment [Makki, Somwaru 2013]. This work will describe the mechanism of impact of imports on GDP, while analyzing energy and materials consumption. The benefits of international trade are broadly understood relations with other countries (including trade relations), so these benefits should be considered comparing the situation of an open economy in relation to the situation of a closed economy (autarky). In the case of a closed economy, manufacturers only produce for the domestic market of a country, therefore the entire production is dependent on domestic demand, and it is more difficult to obtain the benefits of the production scale. A different situation happens in the open economy, but these are not the only advantages of "openness". The article presents the method of modeling the decoupling phenomenon using the panel data technique. These models cause many problems related to the conditions that must be met by independent variables and the rests of the model. Despite all these problems, they are a good tool to
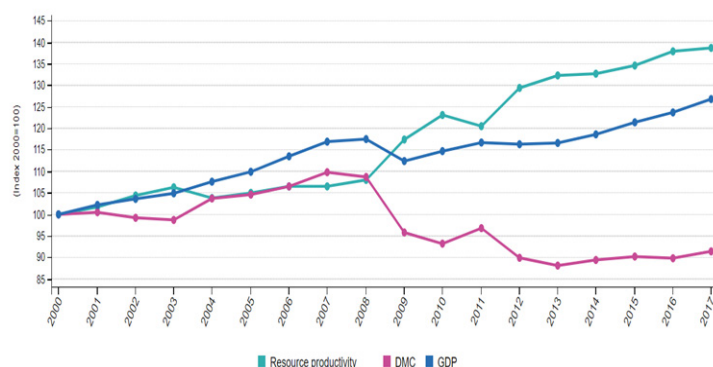
Fig. 1. EU-28 resource productivity in comparison to GDP and DMC, 2000–2017.
Source: https://ec.europa.eu/eurostat/statistics-explained/index.php/Resource_productivity_statistics

Rys. 1. Wydajność zasobów w UE-28 w porównaniu do PKB i DMC, 2000–2017.
Źródło: https://ec.europa.eu/eurostat/statistics-explained/index.php/Resource_productivity_statistics

identify relationships between variables and that is why they find a wide application.

The world's economic growth has long been coupled with declining resource prices – until recently. In the last decade, the increasing affluence and size of the world's population appears to have reversed the trend of falling resource prices. An ongoing path of ever greater consumption of resources is meeting constraints in stable, secure availability of some resources. We see unsustainable over-use of environmental resources and increased price volatility in several markets. Already, many countries and businesses have responded to these megatrends. The European Union countries has recognised the essential role in economic stability and growth played by both mineral and environmental resources - including rare earth metals, water, climate, fish, biomass, fertile soils, clean air and ecosystem services. So as an over-arching goal – set in the Europe 2020 Strategy - the EU has chosen to move to an economic system that is efficient in the way that it uses all resources. We now face choices on the pace of change and how to best manage transition. Good policy offers short and long term economic, social and environmental benefits from efficiency gains. Global demand for resources is increasing, driven by population growth and improving standards of living. In the 20th Century, the world experienced a 4 fold growth in population and a 23 fold increase in economic output. We increased our fossil fuel use by 12 times, our fishing catches by 35, and our water use by 9. globally, extraction of material resources grew by a factor of 8, ores and minerals by 23 times. Materials are now harvested at a rate of 47–59 billion metric tonnes a year. This result is the unsustainable depletion of environmental resources (fish, timber, water, fertile soils, clean air, biomass, biodiversity) and the environmental systems of which they form part. Some resources are already beyond their global sustainable limits or tipping points [EU Commission 2011].

Increases in economic activity have long been associated with growing resource and energy consumption. To allow for a continued improvement of living standards and quality of life without sacrificing the natural resource base they depend on, the EU strives to become a resource-efficient, green, and competitive low carbon economy. Focus has therefore shifted to improving the efficiency of resource and energy use by restructuring economies towards producing more from the same resource and energy input. This is of particular relevance in view of a growing population and rising per/capita wealth, which may result in more overall resource consumption, despite an increase in resource efficiency. Such decoupling of economic growth from the consumption of natural resources should also go along with minimising harmful impacts on human health and the environment [SD Report 2018].

Resource productivity indicator is estimated by GDP/DMC (euro/tonne), energy productivity (GDP per unit of GIC). Resource productivity and energy productivity directly monitor how much output (in terms of GDP) an economy produces per unit of used materials or energy. Over the past 15 years, the EU has increased its resource productivity by 32.9% (referring to the period 2002 to 2017), reaching EUR 2.04 per kg in 2017, and its energy productivity by 29.2% (2001 to 2016), reaching EUR 8.4 per kgoe in 2016. These trends can be attributed to the growth of the EU economy, alongside reductions in domestic material consumption (DMC) and gross inland energy consumption (GIC). The EU economy grew (in terms of GDP) by 21.2% and by 22.4% over the periods 2001 to 2016 and 2002 to 2017, respectively (4). Over the same time spans, GIC fell by 7.2% (from 2001 to 2016) (5) and DMC fell by 7.8% (from 2002 to 2017). The consumed materials can be classified into two types: renewable materials, such as biomass, and non-renewable materials, such as fossil fuels, metals and non-metallic minerals. Non-metallic minerals (for example, marble, granite, sand, salt) is the largest category of minerals, with a share of 47.7% in total DMC in 2017. They are mainly used for building infrastructure such as roads, homes, schools and hospitals, and for producing many industrial and consumer products such as cars, computers, medicines and household appliances. Biomass is the second largest category (24.9% in 2017), followed by fossil energy materials/carriers (22.3%) and metal ores (4.9%) (10). Consumption of non-metallic minerals decreased by 8.4% over the long-term period (2002 to 2017), but has increased by 4.6% in the short-term period since 2012. In contrast, consumption of fossil energy materials (including coal, natural gas and oil) has fallen both in the long- and short term periods, with an especially noteworthy 18.5% decrease between 2002 and 2017. This decline might have been driven in part by a decrease in overall economic activity from 2008 onwards due to the economic crisis, but

also by a long-term trend of increased use of energy from renewable sources, as well as the improved overall energy efficiency of the EU economies. The consumption of biomass has increased by 3.2% in the short term (since 2012), while it has remained nearly unchanged in the long term (since 2002). Only the consumption of metal ores increased significantly in both the short and the long term, by 25.5% and 17.0%, respectively [SD Report 2018].

The EU members are considerably diversified with regard to the levels of economic development, advanced technologies, economic innovativeness and accessibility to natural resources deposits, including energy resources, which causes a situation when actions for sustainable development and environment protection are on mixed levels [Kijewska and Bluszcz 2016; Bluszcz 2016; 2017].

Using energy more efficiently and increasing the share of renewables allows for further growth while reducing environmental impacts, dependencies and costs linked to energy supply and use. Therefore the EU seeks to boost its energy efficiency by 20% and to increase its share of renewable energy to 20% of energy consumption by 2020. This indicator has some shortcomings: for example it measures resources by weight, whilst the economic value, scarcity and environmental impact of some natural resources is only not strongly correlated to their weight. It also takes a national production perspective, which implies that it is insensitive to changes in environmental pressures that occur outside the national borders. In addition, Resource Efficiency covers many different uses of different resources with different economic and environmental impacts. In order to measure progress with regards to the energy efficiency target, it has been translated into absolute target values for primary energy consumption (1 483 Mtoe) and final energy consumption (1 086 Mtoe) for 2020. In 2016, 1 542.7 Mtoe of primary and 1 107.7 Mtoe of final energy were consumed. Overall, the consumption of primary and final energy fell in the long term (between 2001 and 2016) by 7.0% and 4.2%, respectively. In the short term (since 2011), the decrease has been lower for both primary and final energy consumption. As primary and final energy consumption have been rising again since 2014, the 2020. Energy-efficiency targets, particularly for final energy consumption, may be beyond reach. In contrast, the share of renewable energy in energy consumption shows a clearly favourable trend. The EU steadily increased its share, from 8.5% in 2004 to 17.0% in 2016, and is well on track to meet its 2020 target [SD Report 2018].

In Poland dominant role in the energy sector is played by hard coal and lignite thats why the share of renewable sources energy in electrical energy production in Poland still remains on a relatively lower level compared to the EU average, which amounted to 15.5% in 2007. [Jonek-Kowalska I. 2017; Stecuła and Brodny 2017; Palka and Brodny 2017; Kowal and Kustra 2016; Bąk and Sukiennik 2017].

Decoupling is an essential component of the path to sustainable consumption and production. Decoupling can be relative or absolute: relative decoupling is where an environmental pressure is still growing but at a slower rate than economic output (or in the consumption perspective: expenditure). Absolute decoupling occurs if environmental pressures are decreasing despite economic growth. Decoupling

in consumption-activated pressures to be broken down into two factors. These are: - shifts in the national consumption mix; - improvements in eco-efficiency within product group production chains. The first of these — changes in the consumption mix — is concerned with changes in the types of products consumed domestically (i.e. by government, households and gross capital formation). When consumption expenditure shifts from pressure-intensive product groups to less intensive product groups this has a positive decoupling effect. The second factor contributing to decoupling is concerned with improvements within production chains i.e. reductions in pressure intensity along the production chains of a given product group. This second development would lead to decoupling even where the actual types of products being consumed remained the same over time [EEA Report 2011].

Methodology and Data

Research on the problem of the decoupling of economic growth from the level of consumption of DMC materials and from the level of FEC and import was carried out using panel data techniques. The analysis was carried out for selected EU countries - Germany, France, Czech Republic and Poland.

In principle, it is possible to estimate time series for each case or cross-sectional regressions for each time unit by using the expressions (1) and (2) correspondingly [Gil-Garcí et al. 2013]:

$$y_{it} = x_{it}\beta + v_{it} \tag{1}$$

$$y_{it} = x_{it}\beta + u_{it} + \varepsilon_{it} \tag{2}$$

where:
y_{it} – explained variable,
x_{it} – explanatory variable (vector of variables),
β – vector with the N dimension of the structural parameters of the model
v_{it} – random error,
u_{it} – individual effect,
ε_{it} – pure random error,

where (1) is a model with fixed effects, while 2 is a model with random effects. The importance of panel models is emphasized by articles [Griliches et al. 2007]. Wide range of panel models for econometric analysis is also presented by other articles [Baltag 2003]. They undoubtedly apply in the analysis of economic phenomena.

Results

The aim of the article is to examine the dependencies that occur between the GDP growth rate and the growth rate of imports of goods and services, while reducing energy consumption and a steady increase in the consumption of materials. The study of the relationship between the above-mentioned macroeconomic indicators is based on determining whether one variable is the cause of the other variable in Granger's sense [Charezma, Deadman 1997]. The study was based on data concerning the economies of Germany, France, the Czech Republic and Poland. The influence of foreign trade on economic growth can take place on many levels – indirect impact using scientific and technical knowledge [McNeil 2006],

Tab. 1. Fixed Effects Model – France. Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1. Source: own study

Tab. 1. Model efektów stałych – Francja

Coefficients	Estimate	Std.Error	t-value	p-value
Const	0,7751	0,1513	5,1250	0,0022**
FEC	-0,0695	0,1519	-0,4580	0,6634
DMC	-0,0814	0,0667	-1,2210	0,2679
Import	0,338	0,0516	6,4670	0,0006***
Multiple R2	0,95			
Adjusted R2	0,93			
F-statistic (3,6)	40,94,87			0,0002
Residual standards error	2,265			

Tab. 2. Fixed Effects Model – Germany. Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1. Source: own study

Tab. 2. Model z efektami stałymi – Niemcy

Coefficients	Estimate	Std.Error	t-value	p-value
Const	1,1958	0,2404	4,975	0,0025**
FEC	-0,4556	0,1706	-2,670	0,0370*
DMC	-0,5087	0,1835	-2,772	0,0323*
Import	0,6952	0,0520	13,370	0,0000***
Multiple R2	0,97			
Adjusted R2	0,96			
F-statistic (3,6)	77,53			0,0000
Residual standards error	0,013			

Tab. 3. Fixed Effects Model – Poland. Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1. Source: own study

Tab. 3. Model z efektami stałymi – Polska

Coefficients	Estimate	Std.Error	t-value	p-value
Const	0,0586	0,2177	4,975	0,7970
FEC	0,2187	0,2675	-2,670	0,4450
DMC	-0,0352	0,1008	-2,772	0,7390
Import	0,8050	0,0513	13,370	0,0000***
Multiple R2	0,98			
Adjusted R2	0,97			
F-statistic (3,6)	115,40			0,0000
Residual standards error	0,017			

transfer of modern technologies [Schmieder 2013] and finally with the help of foreign direct investment [Makki, Somwaru 2013]. This work will describe the mechanism of impact of imports on GDP, while analyzing energy and materials consumption. The benefits of international trade are broadly understood relations with other countries (including trade relations), so these benefits should be considered comparing the situation of an open economy in relation to the situation of a closed economy (autarky). In the case of a closed economy, manufacturers only produce for the domestic market of a country, therefore the entire production is dependent on domestic demand, and it is more difficult to obtain the benefits of the production scale. A different situation happens in the open economy, but these are not the only advantages of "openness".

Analyzes were carried out on panel data techniques and panel models were constructed with a generalized least squares method, a panel model with fixed effects. The statistics such as R2, standard error of residuals and sum of residual squares, statistics F were used to verify the models. The Gross Domestic Product was used as the explanatory variable, the explanatory variables were: FEC, DMC, import.

Table 1–4 contains the numbers characterizing the results of panel estimation using the least squares method.

Four countries were selected for the analysis: Germany, France, and the Czech Republic, which is economically close to Poland. The analysis for Poland shows that the phenomenon of decoupling economic growth from the level of materials consumption DMC and from the level of FEC is hardly visible (the so-called apparent decoupling). A further increase in energy consumption is observed with a reduction in material consumption and a significant share of imports. The relationship is like the Czech Republic. However, for France and Germany, the separation phenomenon is visible, there is both a reduction in energy consumption and materials, but with an increase in imports. Statistical analysis of the separation phenomenon using the panel data technique proves that there is an increase in gross domestic product, with a decrease in the use of materials, and the reduction in energy only occurs in highly developed countries. GDP growth is positively correlated with imports, which proves that the analyzed economies are open. An additional aspect that is included in the analysis is the level of imports to EU countries, which indicates a steady upward trend, which can be a justification for the declining trend in Germany and France in terms of consumption of materials and energy. Reducing consumption of raw materials and energy while maintaining a stable level of economic growth is a strategic priority of the European Union, because in this way it is

Tab. 4. Fixed Effects Model – Czech Republic. Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1. Source: own study

Tab. 4. Model z efektami stałymi – Czechy

Coefficients	Estimate	Std.Error	t-value	p-value
Const	0,4475	0,9667	0,463	0,660
FEC	0,0326	0,1706	-0,004	0,997
DMC	-0,0015	0,4010	0,029	0,978
Import	0,4516	0,2377	1,900	0,106
Multiple R2	0,67			
Adjusted R2	0,50			
F-statistic (3,6)	4,006			0,0699
Residual standars error	0,046			

possible to reduce the operating costs of the economy in the future, but also to reduce the pressure on all components of the environment.

Discussion and Conclusions

The article presents the method of modeling the decoupling phenomenon using the panel data technique. These models cause many problems related to the conditions that must be met by independent variables and the rests of the model. Despite all these problems, they are a good tool to identify relationships between variables and that is why they find a wide application.

The article shows the causality of the growth of gross domestic product. For this purpose, energy consumption, material consumption and import were used as variables explaining. It was shown in this way that international cooperation has a significant influence on the implementation of the principles of sustainable development. Imports are positively correlated with the increase in gross domestic product for all analyzed economies, and this proves that the reduction in the consumption of raw materials and energy is apparent.

Acknowledgements

Literatura – References

1. European Commission Report: Roadmap to a Resource Efficient Europe. Brussels 2011. http://ec.europa.eu/environment/resource_efficiency/pdf/working_paper_part1.pdf [accessed 20.06.2019]

2. Sustainable development in the European Union. Monitoring report of the EU sustainable development strategy 2018, Publications Office of the European Union, European Commission, Luxembourg. https://ec.europa.eu/eurostat/documents/3217494/9237449/KS-01-18-656-EN-N.pdf/2b2a096b-3bd6-4939-8ef3-11cfc14b9329

3. European Environment Agency. Environmental pressures from European consumption and production. A study in integrated environmental and economic analysis 2013, EEA Technical Report, no. 2, Publications Office of the European Union, Luxembourg. Progress in Sustainable Consumption and production in Europe. Indicator-based Report 2011

4. Gil-García, R., Puron-Cid, G. (2013): Using Panel Data Techniques for Social Science Research: an Illustrative Case and Some Guidelines, Using Panel Data Techniques for Social Science Research, pp. 203-216

5. Griliches Z., M.D. Intriligator, (2007): Handbook of econometrics, V2, Elsevier North Holland, Spain, pp. 1248-3018

6. Baltag,I B.H.. (2003): Econometric Analysis of Panel Data, John Wiley & Sons, LTD, England, pp. 1-297

7. Manowska , A.(2018): Practical application of selected panel data techniques in analyzing sales capabilities of coal assortments. Enterprise and competitive environment. 21st Annual International Conference, March 22-23, 2018, Brno, Czech Republic. Conference proceedings. Eds. Svatopluk Kapounek, Veronika Kocis Krutilova. Mendel University in Brno. Faculty of Business and Economics. Brno : Mendel University, pp. 415-423

8. Charezma W., Deadman D. (1997): Nowa ekonometria , PWE, Warszawa.

9. McNeil L., International trade and economic growth: A methodology for estimating corss-border R&D spillovers, [on-line] http://faculty.arts.ubc.ca/nmalhotra/490/Articles/mcneil_example%20of%20li terature%20search.pdf,

10. Makki S., Somwaru A., Impact of Foreign Direct Investment and Trade on Economic Growth, [on-line] https://www.gtap.agecon.purdue.edu/resources/download/2595

11. The relevance of foreign trade in explaining growth – a look at East Asia, [on-line] http://willmann.com/~gerald/awsem/schmieder.pdf

12. Jonek-Kowalska I. (2017) The impact of renewables on Polish energy balance – opportunities and threats for green energy development. SGEM 2017 Vienna GREEN Conference Proceedings, vol. 17. Iss. 43, 797-804 pp. DOI: 10.5593/SGEM2017H/43/S29.100

13. Steculła K., Brodny J. (2017): Perspectives on renewable energy development as alternative to conventional energy in Poland. SGEM 2017 Vienna GREEN Conference Proceedings, Vol. 17, Issue 43, 717-724 pp; 2017. DOI: 10.5593/sgem2017H/43/S29.090

14. Steculła K., Brodny J. (2017): Renewable energy sources as an opportunity for global economic development. SGEMc2017 Vienna GREEN Conference Proceedings, Vol. 17, Issue 43, 749-756 pp; 2017. DOI: 10.5593/sgem2017H/43/S29.094

15. Palka D., Brodny J.(2017): The impact of the adaptation of conventional energy to the requirements of the new EU emission standards for energy costs and the state of the environment in Poland., [in]: 17th International Multidisciplinary Scientific GeoConference. SGEM 2017, 27-29 November 2017, Vienna, Austria. Conference proceedings. Vol. 17, Energy and clean technologies. Iss. 43, Recycling, air pollution and climate change, modern energy and power sources, 2017, pp. 805-812.

16. Bluszcz A. (2017): Ecological growth boundaries. Management Systems and Production Engineering. PANOVA. No 7 iss. 1, pp. 55-59.

17. Bluszcz A. (2016): A comparative analysis of the selected synthetic indicators of sustainability. Procedia - Social and Behavioral Sciences 220 40 – 50. doi:10.1016/j.sbspro.2016.05.467

18. Kijewska, A., Bluszcz, A. (2016). Research of varying levels of greenhouse gas emissions in European countries using the k-means method. Atmospheric Pollution Research. 7: 935-944. http://dx.doi.org/10.1016/j.apr.2016.05.010.

19. Bluszcz A. (2016): European Economies in terms of energy dependence. Quality and Quantity vol.51. no. 4 1531-1548, DOI: 10.1007/s11135-016-0350-1

20. Kowal B., Kustra A. (2016): Sustainability reporting in the energy sector, E3S Web of Conferences 10, 00129.

21. Bąk P., Sukiennik M. (2017): Impact of corporate culture on business goals of Energy Sector Companies. SEED 2017 International conference on the Sustainable Energy and Environment Development: Institute for Sustainable Energy, p. 3

Badanie zależności poziomu wzrostu gospodarczego od zużycia materiałów i energii w wybranych państwach Unii Europejskiej

W artykule podjęto badania nad problemem zjawiska rozdzielenia wzrostu gospodarczego od poziomu zużycia materiałów i energii przy wykorzystaniu analizy panelowej. Analiza została przeprowadzona dla wybranych państw Unii Europejskiej tj. Niemiec, Francji Czech oraz Polski w latach 2006–2015, dane pobrano z bazy Eurostat. Dane z roku 2006 zostały w analizie założone jako rok bazowy, lata następne stanowią odniesienie do roku bazowego. Ograniczenie zużycia surowców i energii przy zachowaniu stabilnego poziomu wzrostu gospodarczego stanowi priorytet strategiczny Unii Europejskiej, gdyż w ten sposób możliwe jest zmniejszenie kosztów funkcjonowania gospodarki w przyszłości, ale również skutkuje zmniejszeniem presji na środowisko naturalne.

Celem artykułu jest zbadanie zależności, jakie zachodzą między stopą wzrostu PKB a stopą wzrostu importu dóbr i usług, przy jednoczesnym zmniejszeniu zużycia energii i stabilnym wzroście zużycia materiałów. Badanie zależności pomiędzy wyżej wymienionymi wskaźnikami makroekonomicznymi opierać się ma na ustaleniu, czy jedna zmienna jest przyczyną drugiej zmiennej w rozumieniu Grangera. Badanie zostało oparte na danych dotyczących gospodarek Niemiec, Francji, Czech i Polski. Wpływ handlu zagranicznego na wzrost gospodarczy może odbywać się na wielu płaszczyznach – oddziaływanie pośrednie za pomocą wiedzy naukowo-technicznej, przenoszenia nowoczesnych technologii czy wreszcie za pomocą bezpośrednich inwestycji zagranicznych. W pracy opisano mechanizm wpływu importu na PKB, analizując zużycie energii i materiałów.

Słowa kluczowe: rozdzielenie, zużycie materiałów, zużycie energii