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Decoupling Analysis of Energy Consumption and Economic Growth of V4 Countries

Analiza rozprzężenia relacji pomiędzy poziomem konsumpcji energii a wzrostem ekonomicznym krajów grupy V4

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Abstract
Energy is a sector that has a direct impact on citizens' quality of life and the economic growth of the countries. The production and use of energy satisfies human needs, but also gives rise to a host of adverse environmental pressures, such as greenhouse gas emissions, air pollution and the generation of nuclear waste. Energy use leads to noise, water pollution, and ecosystem degradation. Energy-related air pollution also has significant negative effects on human health. To avoid these problems, many countries are closely monitoring their energy intensity and implement the politics and tools to its improvement. The aim of the paper is to perform quantitative evaluation on the relationship between economic development and energy consumption based on decoupling model theory. The paper focuses on the case of V4 countries in the period of 1991-2015. Throughout the more than 20 years examined, the countries spread out into many different forms of decoupling. The results of analysis suggest that in most observed partial variables occurs the strong decoupling of economic growth and energy consumption, what can be considered as positive trend. Though decoupling elasticity convey a positive message, the V4 countries will need to accelerate their implementation of new policies, while restructuring the ways how they meet their demand for energy.

Key words: energy consumption, economic growth, decoupling, decoupling elasticity, V4 countries

Streszczenie
Sektor energetyczny wywiera bezpośredni wpływ na jakość życia ludzi i wzrost ekonomiczny krajów. Produkcja i wykorzystywanie energii zaspokaja ludzie potrzeby, ale wywiera także silną negatywną presję na środowisko, związaną z emisją gazów cieplarnianych, zanieczyszczeniem środowiska, czy wytwarzaniem odpadów jądrowych. Użytkowanie energii powiązane jest z hałasem, zanieczyszczeniami wód i degradacją ekosystemów. Zanieczyszczenia powietrza z sektora energetycznego mają ponadto znaczący negatywny wpływ na ludzkie zdrowie. Aby zmniejszyć skalę tych zagrożeń, wiele krajów szczegółowo monitoruje energochłonność i wdraża polityki i narzędzia mające poprawić obecną sytuację. W tym artykule dokonano ilościowej oceny relacji pomiędzy rozwojem ekonomicznym a poziomem konsumpcji energii, w oparciu o koncepcję rozprzężenia (decoupling, odnoszącej się do odłączenia tempu wzrostu gospodarczego od tempa zużywania surowców). Omówiono przypadek krajów grupy V4, wykorzystując dane za lata 1991-2015. W ciągu ponad 20 lat kraje te realizowały wiele różnych form rozprzężenia. Wyniki analizy sugerują, że w przypadku większości obserwowanych zmiennych cząstkowych występuje silne rozprzężenie wzrostu ekonomicznego i zużycia energii, co można uznać za trend pozytywny. Jednak kraje grupy V4 i tak będą musiały przyspieszyć wdrażanie nowych polityk, jednocześnie starając się zaspokoić ich zapotrzebowanie na energię.

Słowa kluczowe: konsumpcja energii, wzrost gospodarczy, rozprzężenie, elastyczność rozprzężenia, kraje V4

Introduction

Energy and power industry are among the most important strategic policies of the European Union. Forming a common EU energy policy and cross-border cooperation with neighbors at governmental, non-governmental and business levels creates a key framework for decision-making and consideration of further development of the energy sector (e.g. Stoenoiu, 2018; Velkin and Shcheklein, 2017,Zelazna and Golebiowska, 2015).Regarding sustainable development of energy production and use, the term of energy efficiency is frequently used.

The emergence of resource and energy efficiency as well as the low-carbon economy as European policy priorities is grounded in a recognition that the prevailing model of economic development – based on steadily growing energy and material consumption is not sustainable from the long term point of view. That is the reason why these issues have emerged as central themes in global discussions on the transition to a green economy (OECD, 2014; UNEP, 2014b). The fundamental importance of these issues to future prosperity is likewise reflected in Europe's medium- and long-term planning. For example, one of the priority objectives of the 7th Environment Action Programme emphasizes the need to *turn the Union into a resource-efficient, green, and competitive low-carbon economy* (EU, 2013).

At the strategic level, EU policy sets out a broad framework for resource efficiency and climate change policy, including a variety of long-term (non-binding) objectives. For example, the Roadmap to a Resource Efficient Europe (EC, 2011) includes a vision for 2050, wherein the EU's economy has grown in a way that respects resource constraints and planetary boundaries, thus contributing to global economic transformation. These are complemented by policies addressing specific pressures and sectors. The EU's 2020 targets on greenhouse gas emissions and energy consumption (EC, 2010) are prominent examples. These and other policies share similar goals and in different ways seek to balancesocial, economic and environmental considerations. Implementing andstrengthening them can help to push science and technologicalfrontiers, create jobs, improve the quality of the environment and enhance competitiveness.

The issue of energy efficiency resonates in the V4 countries also in the context of the 20-20-20 commitments. While the Union as a whole is doing well in reducing emissions as well as in increasing the share of renewables, unfortunately, there are countries still far from their goal. This means that in the coming years, energy efficiency has to get to prominent positions in programs and major projects. This concerns not only the EU and the Member States, but also regions, industries, businesses, housing and households.

Material and Method

There is a long-standing debate on the relationship between economic growth and the state of the environment. It has been widely discussed since the second half of last century. Many authors argue that continued economic expansion in a finite world is not possible, therefore the use of material resources to produce economic growth cannot go on forever and there has been a growing concern that such a grow will cause irreparable damage to our planet (e.g. Daly, 1997; Stern, 2004; Anderson, 2010; Drastichova, 2017; Hronec, Huttmanová and Chovancová, 2009; Huttmanová, Adamišin and Chovancová, 2013).

Different indicators have been used for measuring both the economic and environmental variables (Huttmanová, 2011; Adamišin and Vavrek, 2015; Chovancová andRusko, 2008). The economic variable is usually GDP, either in absolute or per capita form, though many authors has noted, that GDP has some shortcomings, as it clusters diverse resources by weight, obscuring huge differences in scarcity, value and associated environmental impacts. It also provides a distorted picture of resource demands from overseas, because it includes only net imports of resources, rather than encompassing the raw materials consumed in producing imports (Anderson, 2010; Kotulič and Adamišin, 2012).

Many different environmental indicators have been used, and the results depend on the chosen indicator. Among environmental indicators related to energy sector can include energy productivity, CO_2 productivity, Energy intensity in different sectors of the economy, share of energy from renewable sources in gross final energy consumption etc.

The dilemma of expanding economic activities while attempting to stabilize the rate of resource use and reduce environmental impacts poses an unprecedented opportunity and challenge to society. Since most of the world's economies are striving towards economic growth, ways to achieve it with less environmental harm are being sought for. There have been several concepts proposed for this. These include increased eco-efficiency, de-materialisation, immaterialisation, de-linking and decoupling. The drawback in these approaches is to get more from less, which means using resources more efficiently to produce the same value with less material. The environmental impact remains the same, but only the economy grows faster. This is called the rebound effect (e.g. Binswanger, 2001).

Within environmental research these approaches has been applied to several areas, e.g. de-linking of material resources from economic growth (Vehmas, Luukkanen and Kaivo-oja, 2007), decoupling of GDP from traffic volume and CO_2 emissions from transport (Tapio, 2005), decoupling of carbon dioxide emissions per capita from income per capita in developed countries (Marzio, 2003), etc.

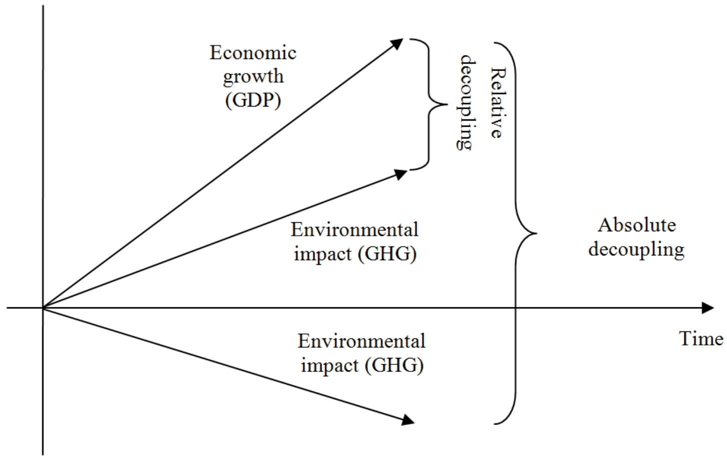

Figure 1. Relative and absolute decoupling (modified from UNEP, 2011)

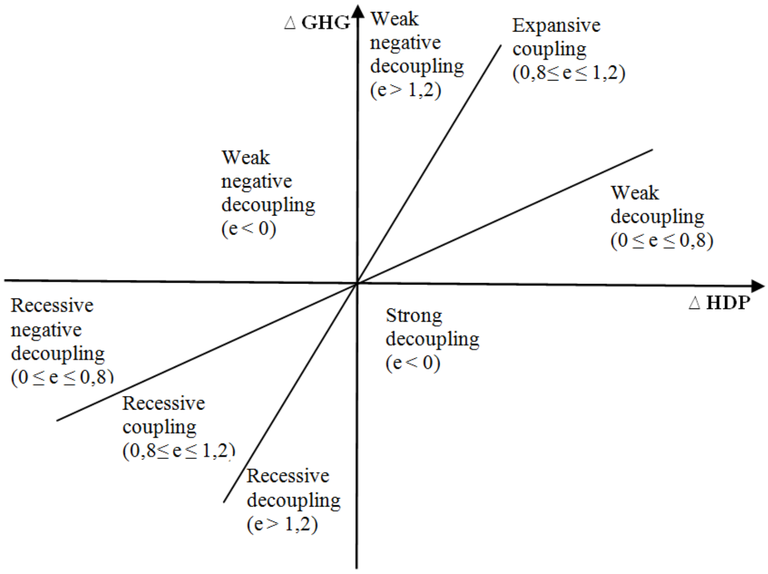

Figure. 2. Decoupling model (modified from Finel and Tapio, 2012)

There are two basic forms of decoupling: absolute and relative decoupling (e.g. Ballingall, Steel and Briggs, 2003; UNEP, 2011). Relative decoupling of resources or impacts means that the growth rate of the environmentally relevant parameter (resources used or some measure of environmental impact) is lower than the growth rate of a relevant economic indicator (for example GDP). The association is still positive, but the elasticity of this relation is below 1 (Mudgal et al., 2010). Such relative decoupling seems to be fairly common. With absolute decoupling, in contrast, resource use declines, irrespective of the growth rate of the economic driver. This latter relation is shown by the Environmental Kuznets Curve that claims that if prosperity rises beyond a certain point, the environmental impact of production and consumption decreases. Absolute reductions in resource use are rare (De Bruyn et al., 2009; Steger and Bleischwitz, 2009); they can occur only when the growth rate of resource productivity exceeds the growth rate of the economy. Graphically is this distinction illustrated in fig. 1.

The aim of this paper is to quantitatively assess the relationship between economic growth and energy consumption in the V4 countries using decoupling method. The ratio between the gross inland consumption of energy and the gross domestic product (GDP) can be referred as energy intensity. This indicator measures the energy consumption of an economy and its overall energy efficiency. The gross inland consumption of energy is calculated as the sum of the gross inland consumption of five energy types: coal, electricity, oil, natural gas and renewables.

The used data we obtained from the databases of the World Bank (GDP in mil. USD in current prices) and the Eurostat (Energy intensity of the economy – Gross inland consumption of energy divided by GDP (kg of oil equivalent per 1 000 EUR).

To compare countries and time periods it is necessary to set the levels, respectively subcategories of decoupling. A similar method used in his research (Tapio, 2005) and (Finel, and Tapio, 2012), which distinguishes 8 subcategories of decoupling, as illustrated in fig. 2.

Table 1. Decoupling elasticity of the V4 countries in the period 1991-2012

		S1 (1991-1995)	S2 (1995-1999)	S3 (1999-2003)	S4 (2003-2007)	S5 (2007-2011)	S6 (2011-2015)
Czech Republic (CZ)	%ΔGIC	-8,47	-6,86	12,42	3,62	-6,21	-3,17
	%ΔGDP	50,36	7,85	34,89	47,35	16,99	-22,01
	e	-0,17	-0,87	0,36	0,08	-0,37	0,14
Hungary (HU)	%ΔGIC	-5,34	-0,90	1,76	1,53	-2,99	-3,36
	%ΔGDP	25,14	5,60	42,37	38,99	0,66	-14,57
	e	-0,21	-0,16	0,04	0,04	-4,52	0,23
Poland (PL)	%ΔGIC	-2,13	-6,51	-1,65	5,70	3,98	-5,64
	%ΔGDP	39,85	16,25	21,98	49,33	18,81	-10,78
	e	-0,05	-0,40	-0,08	0,12	0,21	0,52
Slovakia (SK)	%ΔGIC	-10,27	1,51	4,19	-5,17	-2,66	-5,88
	%ΔGDP	44,77	15,39	34,92	45,85	12,10	-12,21
	e	-0,23	0,10	0,12	-0,11	-0,22	0,48
EU (current composition)	%ΔGIC	0,23	2,54	4,79	0,27	-6,53	-4,39
	%ΔGDP	18,28	18,22	14,96	18,60	1,54	10,79
	e	0,01	0,14	0,32	0,01	-4,24	-0,41

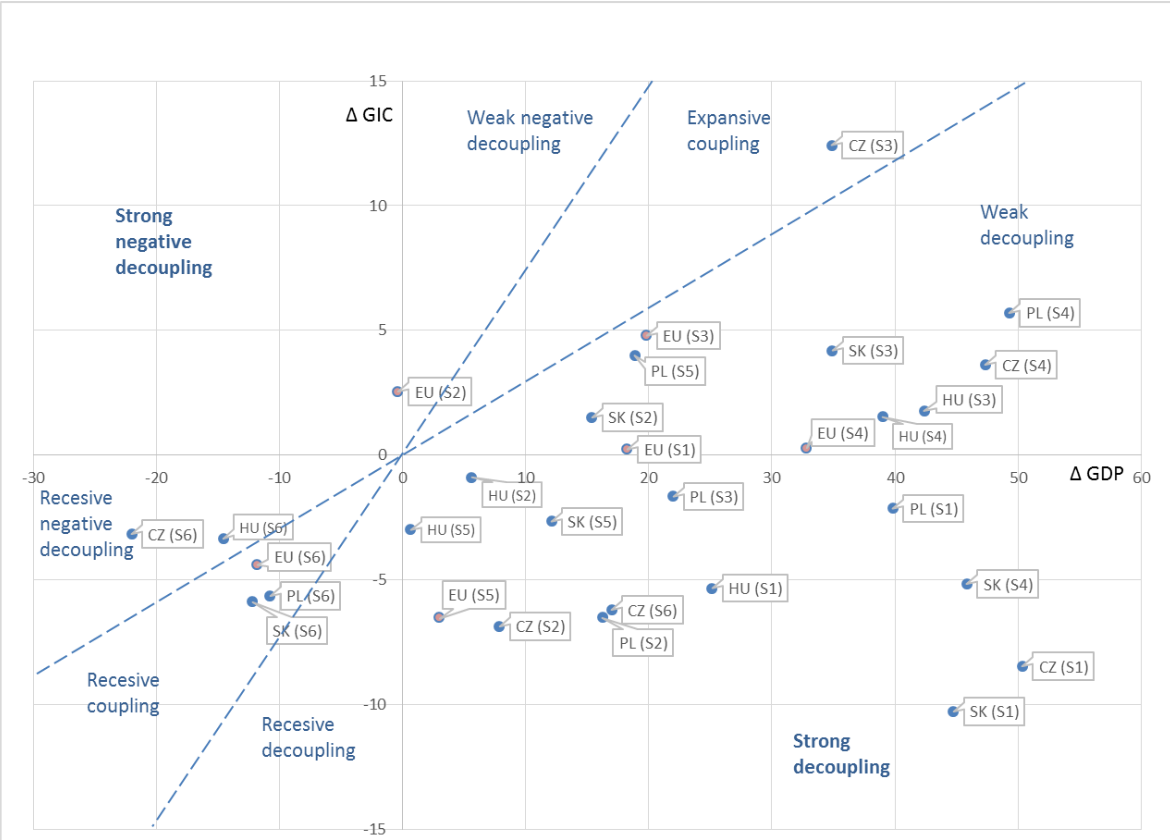

Figure 3. The distribution of the V4 countries into sub-categories of decoupling

Decoupling of energy intensity and economic growth can be calculated as the ratio of percentage units of changes of gross inland consumption of energy and percentage units of changes in GDP in the analysed period of time. The result will be decoupling elasticity e:

$$e = \%\Delta GIC / \%\Delta GDP$$

The ration of changes in gross inland consumption of energy (ΔGIC) and GDP (ΔGDP) can be represented according to (Finel and Tapio, 2012) as strong decoupling, weak decoupling, coupling, or expansive negative decoupling.

In order to better interpretation of the results, the elasticity value was divided into eight subcategories as recorded in the decoupling model illustrated at fig. 2.

Results and discussion

In this study, we will analyse the relationship between Gross Domestic Production (GDP) and Gross

Inland Consumption (GIC) of energy in V4 countries (Czech Republic, Hungary, Poland and Slovakia) in the period of 1991 – 2015. For comparison, the EU average is added in table 1. The analysed period is divided into six sections S1 – S6 (see tab. 1). Values %ΔGIC and %ΔGDP were calculated using data from available databases of the World Bank (GDP) and Eurostat (GIC). Subsequently the value of decoupling elasticity was calculated using the equation.

Based on the results of the analysis, we have created a model of decoupling (Fig.3) in which countries are divided within each period in the following sub-categories:

Expansive coupling: in this sub-category both energy consumption and GDP grew at a similar rate. There is only one case represented in this subcategory – Czech Republic in the period of 1999-2003.

Weak decoupling: in this sub-category, GDP and gross inland consumption of energy both increase, but the GDP grows faster than the energy consumption. Decoupling occurs to some extent, because energy consumption grows more slowly than the GDP, but it is weak, since the absolute amount of consumed energy nevertheless continues to grow. This sub-category includes Czech Republic in the period of years 2003-2007, Hungary in the period 1999-2003 and 2003-2007, Poland in the period of 2003-2007 and 2007-2011 and Slovakia in the period of 1995-1999 and 1999-2003. The development in European Union shows weak decoupling in three out of six periods under review; particularly in years 1991-1995 and 1999-2007.

Strong decoupling: in this sub-category the GDP increases and gross inland consumption of energy decrease. Thus the GDP elasticity of gross inland consumption of energy is below 0. This is the case of absolute decoupling and the best case for both the economy and the environment. This sub-category is in our survey the most frequent – exactly 50% of analysed cases belong to this group, which can be considered as a positive fact.

Recessive decoupling: in this sub-category both GDP and gross inland consumption of energy decrease, but the energy consumption decrease more rapidly than the GDP. The GDP elasticity of gross inland consumption of energy is over 1.2. In this sub-category we have no representatives.

Recessive coupling: in this sub-category both energy consumption and GDP have decreased at a similar rate. There are two cases present in this subcategory – Poland and Slovak Republic in the period of 2011-2015, but as can be seen in the fig. 3, the average of EU countries belongs to this subcategory in this period.

Recessive negative decoupling: In this sub-category GDP and gross inland consumption of energy both decrease but GDP decreases faster than the emissions. Decoupling elasticity is over 0.8. There are two cases present in this subcategory – the Czech Republic and Poland in the period of 2011-2015.

Strong negative decoupling: In this sub-category GDP decreases and gross inland consumption of energy increase and $e < 0$. Strong negative decoupling might be characterized as the worst case of development. In this subcategory there is only one representative: the European Union in the period 1995-1999. In this period the economic growth of the Union decreased slightly but energy consumption increased.

In category of **weak negative decoupling** we have no representatives, which can be considered as a positive finding.

In the European context, the V4 countries are among *the richer out of poor* EU countries and GDP ranges between 66% (Hungary) to 82% (Czech Republic) of the EU-28 average. Energy intensity have fallen since 1991, mainly due to the collapse of inefficient industries, increasing energy efficiency and the launch of new carbon-free energy sources. Though energy intensity of V4 countries remains significantly above the EU average – Czech republic in 2015 had the third highest energy intensity, Poland was in fourth place, Hungary had sixth highest energy intensity and Slovakia had seventh highest energy intensity in the EU 28. The main reason is the high share of energy consumption by industry on gross inland consumption. For evidence, in Slovakia, the steel industry, which is the biggest energy consumer, has been mainly responsible for this development.

Here comes up a question, how could the V4 countries support new political and technological solutions towards new energy efficient economy. It has to be mentioned that increasing energy efficiency in the long term is considered to be economically beneficial but in the short and medium term is expensive. Therefore part of the investments should go to research and development, in order to launch a wave of progressive innovation.

Throughout almost 25 year examined period, countries spread out into different forms of decoupling. The largest group of examined periods falls under the subcategory of strong decoupling, which can be seen as a very positive. But as with all studies, this study has limitations. First, the decoupling elasticity does not reveal the environment's capacity to sustain, absorb or resist pressures of various kinds. Elasticity values cannot convey the message of whether the economic growth is sufficiently decoupled from negative environmental impacts. Constant environmental impacts or decreased environmental impacts over time do not guarantee that human economic activity is within the physical limits of biosphere. Even if strong decoupling could be achieved, this would not necessarily ameliorate the environmental impacts of economic growth.

We also have to state that even absolute decoupling at the individual country level, may not indicate that energy use is actually decreasing with increasing GDP. It may just indicate that more energy intensive operations has been off-shored (Wiedmann, 2013). Developed nations experience an increase in imports of semifinished and finished products and a change in economic structure toward service economies, which add high value to the GDP. These trends make developed countries look more resource-efficient, but they actually remain deeply anchored to a material foundation underneath.
Though using this method can bring a lot of advantages. The quantification of the extent of decoupling makes it possible to assess if decoupling strategies are sufficient to reach the goal of environmental sustainability. We can track the trends; compare the extent of decoupling among countries and set future decoupling targets. Results of decoupling analysis can facilitate environmental policy making processes.

Conclusion

The issue of reduction of energy consumption directly affects all European Union member states, whose vision is to reduce energy consumption by 20% relative to business-as-usual projections. In this study, we focused on the V4 countries which have several common features – historical, political, economic or geographic. Also in energy sector we can determine some common features, such as (1) high dependence on imports of primary energy sources, (2) high energy intensity of the economies and (3) relatively low share of renewable energy sources in energy mix.
Using the method of decoupling, we determined the rate of decoupling elasticity, thus disengaging economic growth and gross inland consumption of energy in the individual V4 countries within the monitored periods. On the basis of the analysis can be concluded prevailing strong decoupling, which means that the economies of these countries grow, while production of energy consumption is declining. Despite this positive finding of this study and quite a number of reforms within energy sector implemented in V4 countries, these countries belong to the EU countries with higher energy intensity.
Ensuring a cost-efficient transformation of the energy system of V4 countries necessitates a diverse mixture of actions addressing both supply and demand at the continental scale. On the supply side, breaking the continuing dominance of fossil fuels will require a strong commitment to improving energy efficiency, deploying renewable energy, and continuous climate and environment proofing of energy projects. Substantial investments and regulatory change will be needed to integrate networks and facilitate the growth of renewables. On the demand side, there is a need for fundamental changes in society's energy use. Smart meters, appropriate market incentives, access to finance for households, energy saving appliances, and high performance standards for industrial companies can all contribute.
Reducing energy consumption and switching to alternative energy sources in V4 countries is essential to cutting reliance of on fossil fuels and achieving the EU's 2050 climate policy goals. It would also deliver substantial additional economic, environmental and social benefits, such as balanced economic growth, price stability, a highly competitive social market economy, green-jobs opportunities and overall improvement of the quality of the environment.

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