Effects of the energy and mining industry on management of national competitiveness

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This study examines relationships between progress in the energy and mining industry and competitiveness of selected countries. The focus of the study was determined by reviewing the expert literature on the topic, which showed that not many approaches appreciate the correlations between these two areas and pay closer attention to their historical relations. The study works with historical data on the energy and mining industry in selected countries and also data on the competitiveness of those countries. Correlations were examined using bivariate correlation analysis of respective time series. This research identified historically strong correlations, for instance, between electric power consumption, land area, or forest rent and indicators of national competitiveness. The results show that the influence of energy and mining industry on competitiveness over the last 40 years has increased, particularly in the case of countries with low or medium economic development, and it has decreased in developed countries. The resulting information about the intensity of the mutual relations might be useful for management of competitiveness and planning of strategic economic tools.

Key words: *management, national competitiveness, indicators, energy industry, mining industry*

Introduction

The need to increase national competitiveness has become more and more important not only at the national, but also at the international level. In 2010, European leaders introduced the 'Europe 2020 Strategy' - a strategic document which focuses on European development. This document also encourages individual countries to increase their national competitiveness (EC, 2012). In 2012 and 2014, the World Economic Forum published reports that evaluate Europe's competitiveness progress. These reports maintain that European countries should not 'be complacent' and that it is necessary to implement measures for increasing the competitiveness of Europe as a broader economic unit (WEF, 2014). National competitiveness belongs to the most often discussed economic topics (Cipollina, 2012) and is the main focus of a large number of prestigious scientific magazines. 'National competitiveness' is usually understood as the 'measure of a country's advantage or disadvantage in selling its products in international markets' (EC, 2012). Competitiveness of organizations is defined in a similar manner (Mikuš, 2006) (Daňková, 2005), making this overall definition appropriate.

Competitiveness management policies in individual countries consist of a series of sector focused strategic tools (Fosu, 2013). However, the same structure of such tools, applied within the frameworks of different countries, would not automatically lead to similar economic results (i.e., competitiveness) (Bye, 2009), mainly because these sets of mechanisms are part of a broader global system. Relationships between elements of the system and their intensity affect the overall results of a particular country. It is therefore very difficult to isolate and generalize specific sources of competitive advantage (Eschenbach, 2006). The concept of competitiveness is often coupled with various levels of competitiveness and various sources of competitiveness in academic sources. Studies on organization competitiveness often discuss sources such as creativity (Williams, 2010) (Cropley, 2006), attitude towards change (Musteen, 2010), productivity (Ball, 2010) (Tauš, 2015), or CSR (Diačiková, 2013) while studies on national competitiveness are rather concerned with sources related to a broader macro-environment, such as technological intensity (Christou, 2008) (Šipikal, 2010), local infrastructure (Fuchs, 2010), or R&D intensity (Matsumura, 2013). However, generally speaking, each and every 'asset' which leads to the desired effect – in this case to advantages in selling products in international markets – may be considered a source of competitiveness. This principle is implemented into economic theories under the headings of 'international trade', 'economic growth', or ' general macro economic theory' (Hong, 2012) (Rice, 2012), but also into practically oriented methodologies concerned with quality management, such as CAF or EFQM (Grauzeľ, 2003).

The impact of particular macroeconomic factors on national competitiveness differs according to a broader context, but current economic theories see agricultural land and natural resources as important sources of competitiveness (Libman, 2013) (Cavalcanti, 2011). However, it is not the existence of natural resources as such that becomes the source of competitive advantage, but their efficient exploitation (James, 2011). Efficient

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exploitation of natural resources, in a broader context of their efficient transportation (Ambriško, 2015) (Andrejiová, 2015) (Rosová, 2013) (Rosová, 2015), or strategic orientation of the energy and mining industry (Pawliczek, 2015), may become a source of competitive advantage over other countries. On the national level, the efficiency of natural resource exploitation is often indicated by specific national indicators, usually environmental indicators (Su, 2014), and is assessed on an annual basis. National competitiveness is also measured or evaluated using a set of economic, sector or social indicators (Bowen, 2011). The amount of data collected by various international statistical and economic institutions offers many possibilities for complex examination of the effect of natural resources and their exploitation (i.e., the energy and mining industry) on particular attributes of national competitiveness.

Better understanding of the relationship between the energy and mining industry of a country and its national competitiveness has been the subject of several studies in the past (Salamon, 1976) (Holloway, 1978) as well as recently (Čulková, 2015) (Sadorsky, 2013) (Campbell, 2012) (Hamann, 2003) (Watanabe, 1999). These studies, focused either on the national or the international level, usually examine only the current or short-term effect of developments in the energy and mining industry on the attributes of competitiveness of a country. However, the above-mentioned data offers much analytic potential for a closer examination of the relationship between the two areas.

The aim of this study is to identify correlations between indicators of the energy and mining industry in the examined countries and indicators of their national competitiveness, from a long-term perspective. The merit of the study lies in the examination of the correlations over a long period of time. This might foster academic discussion of the appropriateness and the potential for tangible results of strategic tools implemented in the energy and mining industry.

Material and methods

This is an empirical study. To obtain sources of our secondary data, we searched several international databases that summarize national indicators for various areas – the OECD, the Eurostat, the World Bank, Cedefop, and the World Economic Forum. Examination of the scope and quality of the available data led to the conclusion that the World Bank database best meets the needs of this study. For several decades, the World Bank has been collecting and processing a dataset called 'World development indicators' – WDI. The dataset consists of a total of 1343 indicators (some of them added later as a result of global developments). The indicators of 249 countries and international communities have been recorded for statistical purposes on an annual basis since 1960. The 1343 aggregate indicators exactly characterize a total of 20 key areas of countries' development. For the purposes of this study, we selected indicators which describe (a) the competitiveness of a country, and (b) the energy and mining industry. These indicators are the main empirical material of the study. They were processed using several statistical procedures in order to identify their mutual relationships. Figure 1 shows the research design of the study.

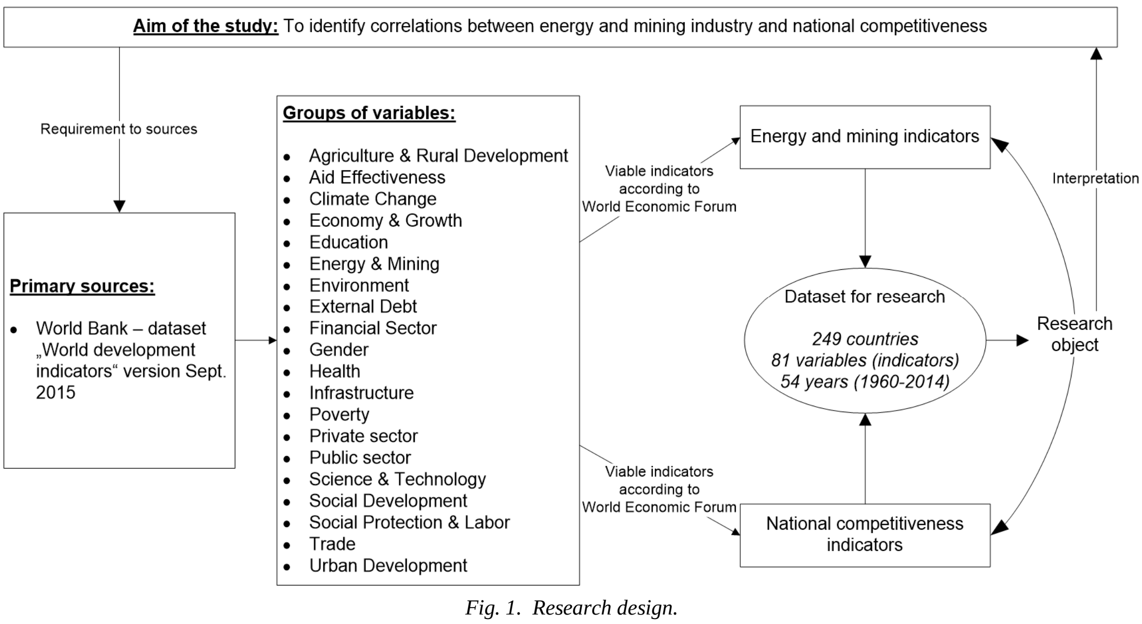

Fig. 1. Research design.

The overall number of statistically processed indicators is 81, with 49 indicators describing competitiveness of a country, and 32 indicators describing the energy and mining industry (or the respective government's policy in that industry). The correlations were examined using bivariate correlation analysis, as well as time series analysis with autocorrelation and partial autocorrelation, and they were quantified using Pearson's correlation coefficient (*r*) as explained in Equation 1, with X and Y as variables, and *n* as the number of cases with no missing values for either of the two variables (Lysá, 2012).

$$r = \frac{\sum XY - \frac{(\sum X)(\sum Y)}{n}}{\sqrt{\left(\sum X^2 - \frac{(\sum X)^2}{n}\right)\left(\sum Y^2 - \frac{(\sum Y)^2}{n}\right)}} \quad (1)$$

The variables were merged into two factors – factor 'Energy and mining industry', and factor 'Competitiveness'. We also carried out cluster analysis, which allowed us to widen interpretation options using analogies of countries with similar features. Time series analysis was carried out using the standard procedure of linear regression, which is among the generally accepted approaches to the examination of historical development (Dunis, 2002).

Results

The fact that some indicators entered the database at a later time, and that data for other indicators were not collected in some countries, means that, in these cases, the data show a "missing value". This is a natural occurrence, implemented directly into the respective statistical procedures, and so presents no problem for the analytical processing. The following results of the statistical procedures were obtained by processing 472 732 numerical values. For purposes of clarity, in front of every indicator we added a short string according to the character of the indicator – 'COM' for the competitiveness indicators, and 'E&M' for the energy and mining industry indicators, respectively.

Relations between energy and mining industry and countries' competitiveness

The data sample was stratified according to the years, which means the bivariate correlation analysis resulted in 54 correlation matrices (54 examined years).

Tab. 1. Characteristics of correlation between individual E&M indicators.

Indicator of energy & mining industry	Pearson's Coefficient characteristics			
	Average	Standard deviation	Skewness	Kurtosis
E&M01_Electric power consumption (kWh per capita)	**0,272**	0,208	1,154	0,648
E&M02_Access to non-solid fuel (% of population)	**0,267**	0,196	0,931	0,293
E&M03_Energy use (kg of oil equivalent per capita)	**0,267**	0,200	0,955	-0,050
E&M04_Adjusted savings: particulate emission damage (% of GNI)	**0,251**	0,156	0,588	-0,089
E&M05_Access to electricity (% of population)	**0,244**	0,178	1,021	1,059
E&M06_Fossil fuel energy consumption (% of total)	**0,205**	0,136	0,912	0,608
E&M07_Land area (sq. km)	**0,199**	0,281	1,666	1,258
E&M08_Forest rents (% of GDP)	**0,190**	0,122	0,699	0,246
E&M09_Adjusted savings: natural resources depletion (% of GNI)	**0,184**	0,106	0,659	-0,127
E&M10_Electricity production from nuclear sources (% of total)	**0,175**	0,125	0,635	-0,805
E&M11_Electricity production from hydroelectric sources (% of total)	**0,170**	0,085	0,103	-0,348
E&M12_Oil rents (% of GDP)	**0,161**	0,127	0,922	0,406
E&M13_Adjusted savings: net forest depletion (% of GNI)	**0,156**	0,102	0,574	-0,297
E&M14_Fuel exports (% of merchandise exports)	**0,147**	0,126	0,997	0,087
E&M15_Adjusted savings: energy depletion (% of GNI)	**0,146**	0,116	1,005	0,841
E&M16_Electricity production from coal sources (% of total)	**0,135**	0,075	0,279	-0,043
E&M17_Energy imports, net (% of energy use)	**0,129**	0,108	0,768	-0,579
E&M18_Electricity production from oil sources (% of total)	**0,128**	0,096	0,460	-0,858
E&M19_Alternative and nuclear energy (% of total energy use)	**0,128**	0,121	1,121	0,250
E&M20_Electricity production from oil, gas and coal sources (% of total)	**0,125**	0,078	0,460	-0,791
E&M21_Adjusted savings: carbon dioxide damage (% of GNI)	**0,125**	0,099	1,545	2,780
E&M22_Agricultural land (% of land area)	**0,118**	0,089	1,167	1,407
E&M23_CO2 emissions (kg per PPP $ of GDP)	**0,111**	0,084	1,688	4,520
E&M24_CO2 emissions from manufacturing industries and construction (% of total fuel combustion)	**0,104**	0,086	1,286	1,367
E&M25_Electricity production from natural gas sources (% of total)	**0,102**	0,091	1,425	1,399
E&M26_Electricity production from renewable sources, excluding hydroelectric (% of total)	**0,099**	0,090	1,545	2,455
E&M27_Annual freshwater withdrawals, total (% of internal resources)	**0,098**	0,071	1,263	2,206
E&M28_Arable land (hectares per person)	**0,089**	0,065	0,893	0,436
E&M29_Fuel imports (% of merchandise imports)	**0,088**	0,058	0,826	0,056
E&M30_Adjusted savings: mineral depletion (% of GNI)	**0,083**	0,056	0,952	0,238
E&M31_Mineral rents (% of GDP)	**0,083**	0,055	0,988	0,425
E&M32_Forest area (% of land area)	**0,080**	0,112	2,973	9,966

Table 1 summarizes basic statistical characteristics of the correlation between the indicators of the energy and mining industry and the indicators of national competitiveness. All of the examined E&M indicators show, on the average, a positive correlation with the other group of COM indicators. "Electric power consumption", "Access to non-solid fuel", and "Energy use" show the biggest effects on competitiveness. These indicators affect, or are affected by, the economic progress of particular countries. On the other hand, "Adjusted savings: mineral depletion", "Mineral rents", and, paradoxically, "Forest area" are the indicators which show low correlation with competitiveness.

The most intensive relations

This overview of overall effects of E&M indicators on national competitiveness may give us a rough idea of the problem, but aggregate data cannot broadly speak, identify closer mutual relationships. For this reason, we synthesized correlation coefficients for the whole examined period. This synthetization took the form of an overall correlation matrix with the COM indicators in the lines and the E&M indicators in the columns. Table 2 shows 10 coefficients with the largest and 10 coefficients with the smallest correlation.

Tab. 2. The strongest relations between E&M and COM indicators.

Indicator of energy & mining industry/Indicator of countries' competitiveness	E&M05_Access to electricity (% of population)	E&M02_Access to non-solid fuel (% of population)	E&M04_Adjusted savings: particulate emission damage (% of GNI)	E&M01_Electric power consumption (kWh per capita)	E&M03_Energy use (kg of oil equivalent per capita)	E&M08_Forest rents (% of GDP)	E&M07_Land area (sq. km)
COM01_Adjusted net national income per capita (current US$)				0,810 (R1)			
COM02_Cost to import (US$ per container)	-0,431 (R2)						
COM03_Final consumption expenditure, etc. (% of GDP)					-0,463 (R9)		
COM04_GDP per capita (current US$)				0,759 (R10)			
COM05_Gross national expenditure (% of GDP)					-0,468 (R3)		
COM06_Gross value added at factor cost (current US$)							0,795 (R11)
COM07_Internet users (per 100 people)			-0,457 (R12)				
COM08_Exports of goods, services and primary income (BoP, current US$)							0,791 (R13)
COM09_Labor force, total							0,914 (R7)
COM10_Life expectancy at birth, total (years)	0,837 (R4)	0,806 (R5)	-0,694 (R6)			-0,561 (R8)	
COM11_Logistics performance index: Overall (1=low to 5=high)			-0,482 (R14)				
COM12_Patent applications, nonresidents							0,811 (R15)
COM13_Population, total							0,924 (R16)
COM14_Research and development expenditure (% of GDP)			-0,437 (R17)				
COM15_Researchers in R&D (per million people)				0,763 (R18)			
COM16_Urban population (% of total)			-0,588 (R19)			-0,461 (R20)	

For further processing, these relations are designated 'R1' to 'R20'. One of the interesting results is the strong correlation between "E&M01_Electric power consumption" and "Adjusted net national income per capita" (the R1 relation) or "GDP per capita" (the R10 relation). On the other hand, "Adjusted savings: particulate emission damage" shows a very negative effect on several competitiveness indicators (COM07, 10, 11, 14, 16). All these correlation coefficients were examined, and their development is presented in graphs – Figure 2 and Figure 3. Only relations with a sufficient number of correlation coefficients (at least half of all examined years) are presented in the graphs. Figure 2 shows the historical development of correlations from 1960 up to now (2013). The data enabled a deeper analysis of 9 of the 20 above-mentioned correlations (5 positive and 4 negative). As seen in the figure, there is one quite stable correlation – the "Land area" vs. "Total population" (R16). This finding is logical since the data describe a relatively peaceful period. Fluctuations in this relation would be visible in case of a global armed conflict, which was shown in some demographic studies in the past (Boyce, 2006). The R11 relation is also rather stable, except the 1960's, when "Gross value added at factor cost" contributed less to national competitiveness. Several authors have paid closer attention to this development in relation to the 1970's energy crisis (Richman, 1979).

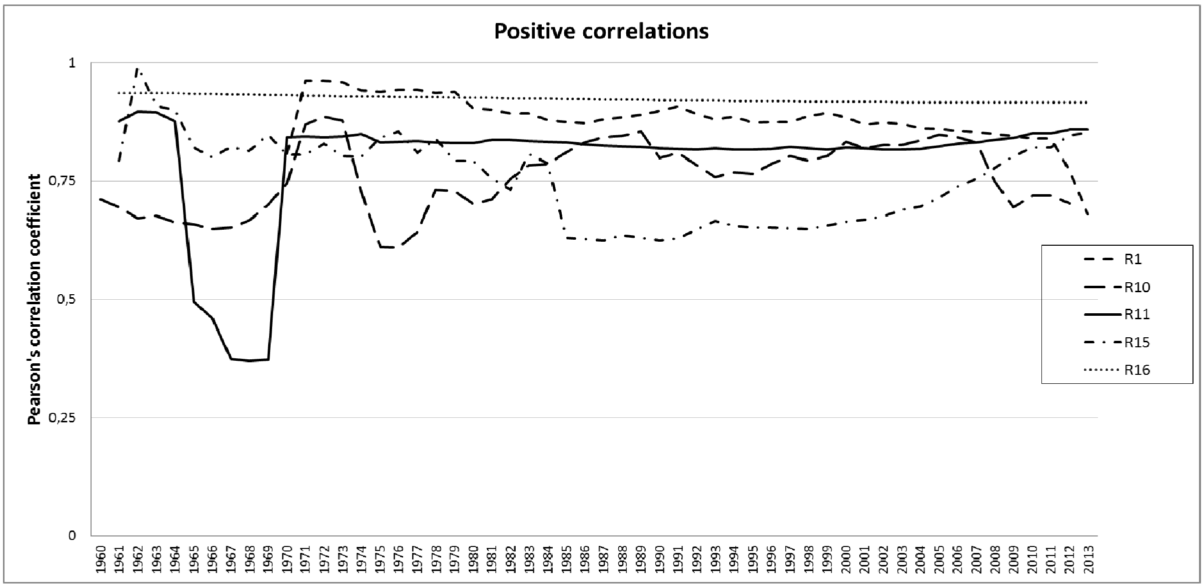

Fig. 2. Intensity of examined relations – positive correlations.

"Patent applications" (in the R15 relation) were an important factor of national competitiveness until about the first half of the 1980's. After that period, the effect of patents shows a significant decrease, but then gradually increases again due to developments in information and communication technology (Cropley, 2006). The "Electric power consumption" vs. "GDP per capita" relation (R10) is similar to the R11. In this case, we again see a rapid increase followed by a rapid decrease in the intensity of the relation in the 1970's due to the effects of the energy crisis. This relation shows a stable intensity, but nowadays the intensity is decreasing, which might be the result of national political pressures to save energy and protect the environment. The decrease in the R1 relation – the correlation between "Electric power consumption" and "Adjusted national income per capita" – might also be partly explained by environmental policies.

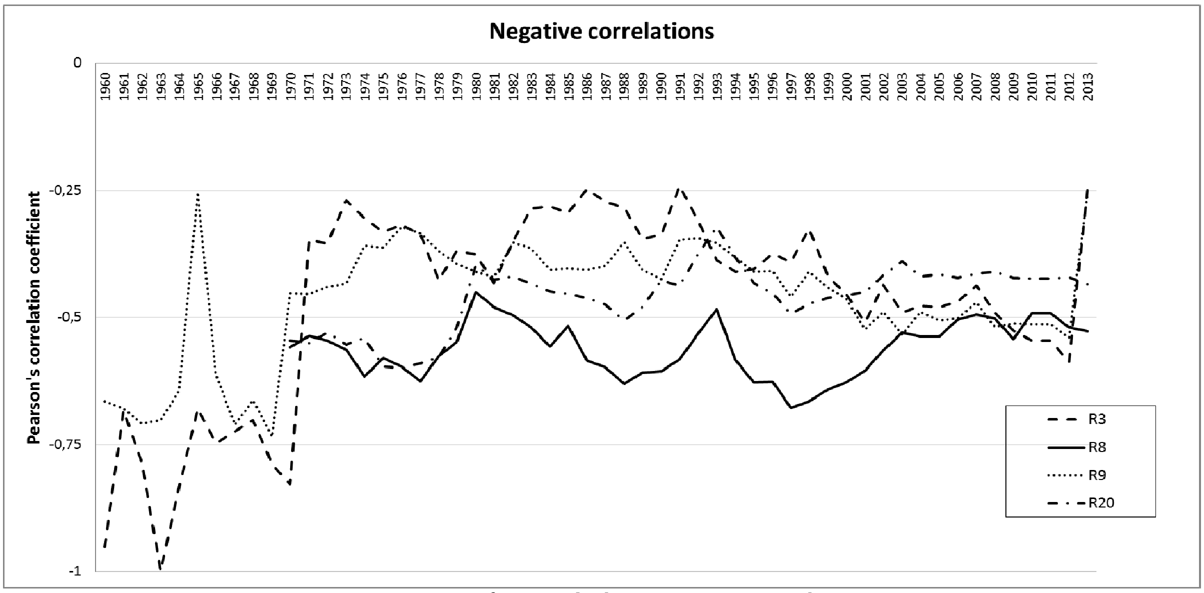

Fig. 3. Intensity of examined relations – negative correlations.

Figure 3 shows a similar graph, this time with negative correlation coefficients. One can see that the intensity of negative correlations between the energy and mining industry and national competitiveness has been decreasing in the long term. The reason for this might be the reduction of negative effects of this sector brought about by research and development. The most striking negative correlation – the R3 ("Energy use" vs. "Gross national expenditure") – has been significantly reduced since the beginning of measuring in the 1960's, but it is demonstrably prone to interval (seasonal) fluctuations caused by changes in the markets or political strategies (Gordon, 1986). The R9 relation shows similar characteristics to the R3, and so the same interpretation applies to it. The negative correlation of R8 ("Forest rents" vs. "Life expectancy at birth") is an interesting finding, and since academic sources have not paid much attention to explaining this phenomenon, it carries potential for further research. It would be interesting to see whether this intensity is the result of a systematic effect or mere coincidence. The R20 ("Forest rents" vs. "Urban population") is also a potential topic for further research. In this case, again, literature offers no interpretation of the results.

Historical changes in the effect of the energy and mining industry on national competitiveness

Because the data has been synthesized for more than five decades, it enabled us to delineate the changes in the competitiveness of individual countries. To assess the historical changes, we applied factor analysis with 2 predefined factors. One factor consisted of variables, mainly from the energy and mining industry and the other factor consisted of variables from national competitiveness. Variables that showed less than 20 % variability in an algorithmic mathematical model were excluded from the correlation analysis. At the same time, 2-factor score valuables were computed for each case (particular country). One value represents the factor "Energy and mining industry", the other value represents the factor "Competitiveness". This enabled us to represent graphically the location of individual countries in a two-dimensional space – Figure 4.

The left side of Figure 4 shows the actual, momentary state for 2013 of the examined countries, which are stratified according to their GDP per capita. We chose this stratification because of studies that show how various accelerators of economic growth differ according to the current economic performance of the country (Šipikal, 2010). The graph on the left side consists of four quadrants (Q1 to Q4). Quadrant Q1 shows countries with a strong orientation in the energy and mining industry, but with no significant effect of this industry on their competitiveness (countries such as the United Arab Emirates (ARE) or Switzerland (CHE)). Quadrant Q2 is occupied by countries with a strong orientation in the energy and mining industry which is also a significant source of their competitive advantage (United States of America (USA) or European Union (EUU)). Quadrant Q3 is occupied by developing countries with no significant energy and mining industry (Equatorial Guinea (GNQ), Congo (CON), or Liberia (LBR)). Quadrant Q4 is occupied by countries that are relatively competitive at the regional level, but their competitiveness is not due to the energy and mining industry (South Asia (SAS), Sub-Saharan Africa (SSF), or the so-called Lower middle income (LMC) economies). The graph also shows a markedly bigger symbol of the average value (arithmetic mean, centroid) for the respective groups (according to Economic Wealth). The position of this symbol characterizes the groups according to progress in their energy and mining industry and their overall competitiveness for that year (2013 in this case). The data, however, allowed us to compute the average values of the groups for every recorded year. To show historical changes in the effects between the two examined areas, we devised a graph (the right side of Figure 4) that shows only the centroids of these five groups of countries.

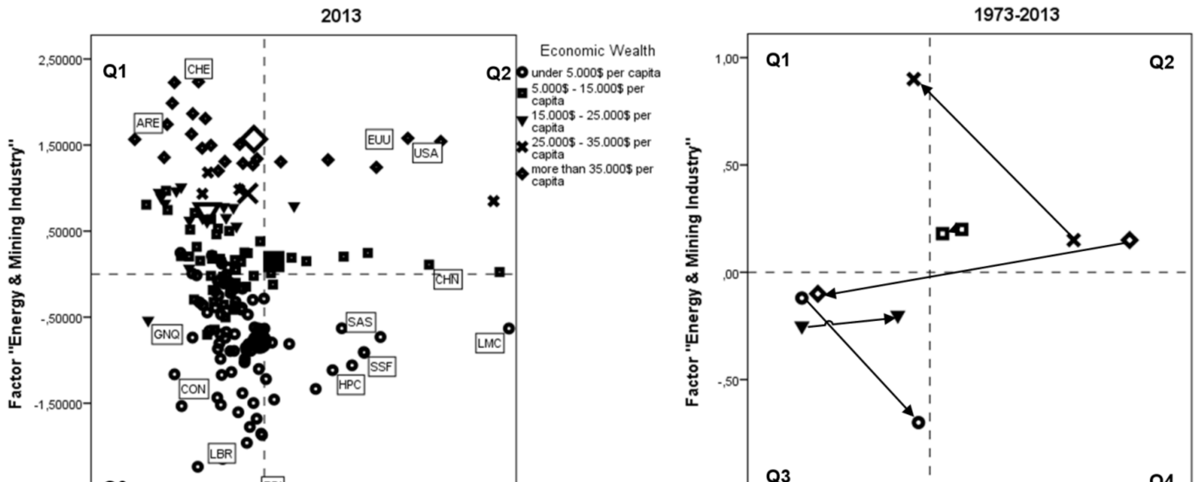

Fig. 4. Factor correlations – actual state in 2013 on the left; historical change in 1973-2013 on the right .

This graph shows in which quadrant the mean of the individual groups was in 1973, and where it gradually moved to until 2013 (indicated by the arrow). As can be seen, the effect of the energy and mining industry on national competitiveness shows a rapid decrease in the case of countries with the average income per capita higher than 25.000 $. This complex decrease in the effect of the energy and mining industry on competitiveness might be considered a natural consequence of rising standard-of-living among the population. The role of accelerators of the economy and competitiveness has been recently taken by information and communication technologies, developments of new materials, nanotechnologies, or other rapidly developing areas (Grauzeľ, 2003). Nevertheless, the energy and mining industry may still be considered as an accelerator of competitiveness in developing countries, which is also shown by positive changes in quadrant Q3.

Discussion and conclusion

The subject of this study – the relations between the energy and mining industry and national competitiveness – was also examined using a worldwide database of related indicators. Historical research showed that the exploitation of natural resources, with the energy and mining industry as its sub-group, might be considered as a source of competitiveness. The identification and quantification of 10 positive and 10 negative correlations between the examined areas are one of the main results of this study. By deeply analyzing some of these correlations, we assessed the effects of the energy and mining industry on national competitiveness. The examination of historical changes may also provide material for a broader discussion in the context of present global developments.

It is, of course, necessary to mention methodological or contextual risks connected with processing this type of data. The results are, to a great extent, influenced by the availability of the data (WDI). The missing values in the dataset may present a certain bias. The aggregate results interpreted using the factors in Figure 4 and the positions of the centroids of the groups might have been affected by not including some countries into the analysis due to lack of relevant data. Even though these risks were taken into account when creating the algorithms, they could not have been avoided altogether.

The merit of this study lies in its focus on the historical context of the relationship between the energy and mining industry and national competitiveness. Sources of competitiveness are often examined in the framework of a particular momentary state, which makes our approach based on examination of the long-term developments of correlations a useful contribution to the discussion of the focus and efficiency of national policies in the energy and mining industry.

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