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SUSTAINABLE DEVELOPMENT: METHODOLOGICAL APPROACHES TOWARD ISSUES

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Abstract. Aim of the paper is to outline a research methodology, which would ultimately allow predicting and enhancing competitiveness of less developed economies, which encounter energy security issues. The following theoretical questions are to be discussed. The first, what we mean by sustainable development in countries, which are in different economic development phases, i.e. if emphasis on different facets of sustainability (particularly economic environmental, related to energy consumption patterns) changes as country develops. The second research question raised in the paper deals with energy security issues. Authors tackle the following questions of methodological character: if/what natural consistent patterns of economies development exist; and how to indicate efficient ways of economic restructuring. Answer to the indicated questions would allow formulating policy implications directed towards energetically secure and sustainable development.

Keywords: Economic growth, sustainable development, energy security, economic structure, industrial structure.

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1. Introduction

Sustainable development concept is being widely discussed and a numerous definitions have been provided (e.g. Vosylius *et al.* 2013; Dudzevičiūtė 2012; Tvaronavičienė *et al.* 2013). Nevertheless a question, what sustainable development means for countries at different stages of development remains open. This question obtains its special urgency when sustainable development aims are considered in energetically dependent country (Tvaronavičienė 2012; Vosylius *et al.* 2013; Smaliukienė *et al.* 2012; Korsakienė *et al.* 2014). We aim to clarify if sustainable development targets shift as a country follows its development path. To put it into another ways, we wonder if priorities change as a country develops. If we find that priorities do change, then the second question would follow: if any similarities in countries behavior could be found. The ultimate aim is to ground methodological approaches letting to indicate what criteria should be used for restructuring of economic (and especial industrial) sectors having an ultimate goal to accelerate sustainable development of less developed energetically dependent country.

2. Methodological approaches towards sustainable development taking into account energy issues

In order to find out how various countries approach contemporary sustainable development issues, methodologies published in the latest articles are going to be reviewed. We will start from the most relevant and the newest papers found in Science Direct. One of the most recent papers "Evaluating the relationships among economic growth, energy consumption, air

emissions and air environmental protection investment in China" (Zhang *et al*. 2013b) analyses China's economic growth linked to its energy consumption, air emissions and air environmental protection investment during 2000-2007. In their analysis authors emphasize threat of increasing energy use (Figure 1) (Zhang *et al*. 2013b). In order to estimate energy dimension, the following five indicators are used: a ratio of nonrenewable energy to renewable energy (RNR), energy use per unit GDP (EUPG), environmental cost per unit GDP (ECPG), impact of emissions per unit energy consumption (IEPEC), and environmental benefit per unit environmental protection investment (EBPEI) (Zhang *et al*. 2013b).

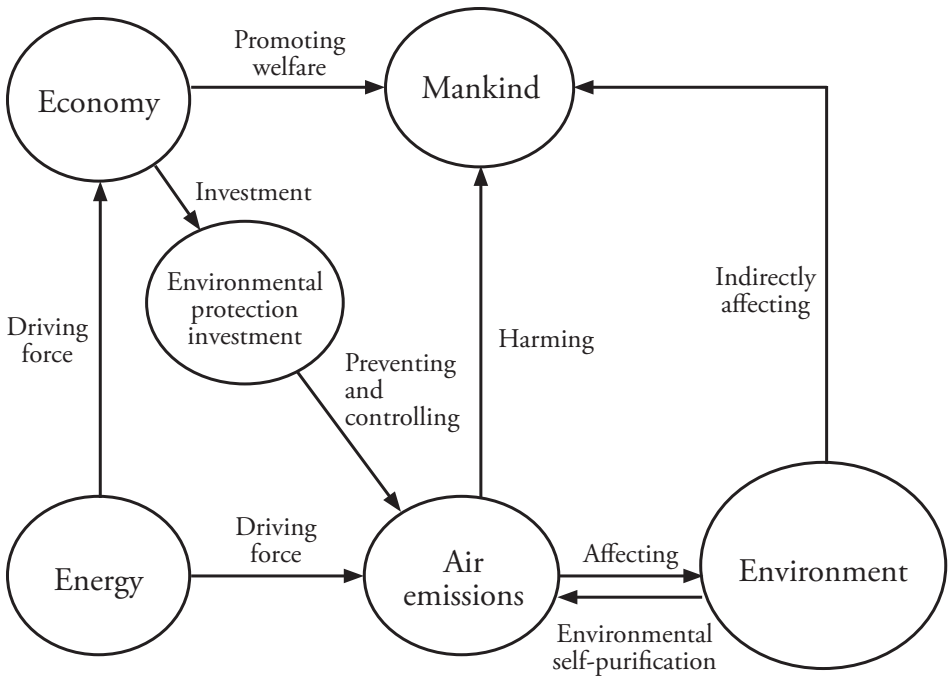

Fig.1. The relationships among economy, energy, air emissions and environment

Source: Zhang *et al*. (2013b)

Authors state that fast growing economy brings rapid increase of energy consumption. They admit that energy efficiency improves as country develops. On the other hand, article claims, that the performance of air environmental protection investment was obviously reduced during analyzed period (Zhang *et al*. 2013b), what points to incompatibility of sustainable development goals: to enhance economic growth, reduce energy use and preserve environment.

The article overview above supports our hypothesis about different strategies of countries at different stages of their development. In case of China, it appears, the country tried to employ different strategies to deal with the relationship between environmental protection and economic growth during its 10th Five-Year Plan and the 11th Five-Year Plan period (Zhang *et al*. 2013b). Nevertheless the tensions between the growth imperative and sustainability have been in evidence throughout those two five-year plans (Zhang *et al*. 2013b). As authors claim, no fundamental change in the inappropriate industrial structure was achieved and extensive economic growth mode has not been changed. There are also such problems as environmental protection lagging behind economic growth, poor or inflexible mechanism, insufficient input and capacity (Zhang *et al*. 2013b). Authors have no doubts that a conflict between energy based growth and environmental protection exists. They point out, that it is necessary to synchronize environmental protection and economic development. Alas, the task is complicated and there are no simple solutions allowing implementing general direction towards transformation from mainly employing administrative methods to protect the environment into comprehensive application of legal, economic, technical and necessary administrative methods to address environmental problems (Zhang *et al*. 2013b).

To generalize, China's experience verifies, that country at the lower level of its development experiences difficulties in overcoming conflict programmed in aim to develop sustainably. Its case evidences that less developed country trade-offs its environmental health for faster economic growth. Methodology suggested by authors' tackles efficiency of governmental policy considering environment protection. Recall, that the following indicators for development direction monitoring are being suggested: the indicator RNR reflecting the energy mix, the EUPG giving the energy intensity of economic activity, the ECPG measuring environmental cost per unit economic output, the IEPEC reflecting environmental loading intensity of energy consumption, and the EBPEI embodying the performance of environmental protection investment (Zhang *et al*. 2013b). Let us discuss economic meaning of each indicator. Ratio of nonrenewable energy to renewable energy (RNR) refers to the ratio of energy of nonrenewable resources to that of renewable energy resources. This indicator reflects the energy mix. The bigger the indicator, the greater dependence on nonrenewable energy resources the economic activity has, which most likely lead to the more emissions when all other conditions keep the same (Zhang *et al*. 2013a,b). That approach seems to be logical and uncontentious.

Energy use per unit GDP (EUPG, J/$): EUPG equals the energy (J) of total energy consumption divided by GDP. The higher the indicator, the lower the energy efficiency of economic activity is. The indicator is mainly affected by energy mix, industrial structure and technical progress. The authors claim that high share of renewable energy and/or advanced technology mean high energy efficiency of economic activity. They argue, that compared to those traditional energy intensity indicators for measuring economic activity, such as tonne of standard coal equivalents per unit GDP, tonne of oil equivalent per unit GDP, etc., this indicator is more convenient when comparing and tracing the energy efficiency of different countries or regions in different years (Zhang *et al*. 2013a,b). Our comment here is, that despite high share of renewable energy lead to pollution diminishing, from economic point of view that composition does not proxy high energy efficiency. Since economic approach suggests adopting cost-benefit analysis, expensive renewable energy does not lead to high energy efficiency of economic activity. That is we express opinion, which do not comply with one provided by authors of commented paper. Environmental cost per unit GDP (ECPG, sej/$): it is the ratio of the total energy loss caused by emissions to GDP. This indicator measures environmental cost of emissions in terms of energy. The bigger the indicator, the higher the environmental cost of economic activity is. The indicator is mainly affected by industrial structure, technical progress and environmental protection measures. High share of high-polluted enterprises, backward technology and environmental protection measures can lead to big ECPG values (Zhang *et al*. 2013a,b).

Emissions' impact per unit energy consumption (EIPEC, sej/J): EIPEC is the ratio of the emergy of emissions' impact to the energy of total energy consumption. It reflects environmental loading intensity of energy consumption. The bigger the ratio, the larger the environmental loading intensity energy consumption brings about. This indicator is mostly affected by technical process, energy structure and environmental protection measures. Advanced technology and environmental protection measures and high share of renewable energy resources can lead to low EIPEC values (Zhang *et al*. 2013a). Here we needed to provide and insight that the authors are bias about renewable energy in terms that do not take into account the cost of it, what is important factors, and, actually makes all the relation between economic growth and environment that complicated. Avoiding indicating issues hinders prospecting of unconventional smart solutions. Raising right questions even without providing right answers is more valuable than compromising in indicating issues, which needs to be resolved.

Anyway the paper we are commenting on is of scientific interest. In order relate above indicated indexes authors devise a complex indicator, so called Structural coordination degree (SCD) indicator, which integrates indicators provided above: (Zhang *et al.* 2013a). Structural coordination degree (SCD): this index is defined as follows:

$$(SCD)_i = \frac{(RNR)_o}{(RNR)_i} \times \frac{(EUPG)_o}{(EUPG)_i} \times \frac{(ECPG)_o}{(ECPG)_i} \times \frac{(EIPEC)_o}{(EIPEC)_i}$$

here (SCD)*i* means relative coordination degree in *i* year; (RNR)*i*, (EUPG)*i*, (ECPG)*i* and (EIPEC) *i* mean ratio of nonrenewable energy to renewable energy, energy use per unit GDP, environmental cost per unit GDP and emissions' impact per unit energy consumption in *i* year respectively; $(RNR)_0$, $(EUPG)_0$, $(ECPG)_0$ and $(EIPEC)_0$ refer to ratio of nonrenewable energy to renewable energy, energy use per unit GDP, environmental cost per unit GDP and emissions' impact per unit energy consumption in reference year (authors in their paper refer to year 1978) respectively (Zhang *et al*. 2013a). On the base of reference year, the bigger value of the SCD means that the economic structure is more reasonable, and this can promote sustainable development of economy. Scale coordination index (SCI): According to Zhang *et al.* (2013a), economic development can keep sustainable only when economic scale and resources and environmental capacity are in coordination due to limited resources and environmental capacity. Based on different impacts of GDP, population, nonrenewable resources and emissions on economic sustainability, the index SCI was constructed to reflect the relative sustainability of economic development in different years for one country or region based on reference year. This index is defined as follows:

$$SCI_j = \left(\frac{GDP_j GDP_o}{(P_j/P_o) \times (N_j/N_o) \times (IE_j/IE_o)} \right)$$

Here, SCI*j* means scale coordination index in *j* year; GDP*j*, *Pj*, *Nj* and IE*j* mean the gross domestic product, the population, the non-renewable energy consumption and the impact of emissions in *j* year respectively; GDP_0, P_0, N_0 and IE_0 mean the gross domestic product, the population, the non-renewable energy consumption and the impact of emissions in reference year (authors in their paper refer to year 1978) respectively. On the base of reference year, the increasing value of the SCI means the relationships among economic aggregate, population, energy consumption and environment become more harmonious, and the sustainability of economy is being improved.

We assume that indicators provide useful information, but not sufficient. The main target of criticism is related to the very assumption that renewable energy can stand for sustainability. We do not neglect importance of renewable energy, but indicate that in practice countries compromise environmental issues and go for economically efficient (in short-term) growth. Benchmarking here remains a grey zone. If we managed to find better argumented goalpost, we could have come to more efficient and prudent economic policies. Another argument, initiating search for different methodological approaches is related to the fact that renewable energy at current time comprises very tiny fraction in overall consumed energy structure. This feature of energy structure is characteristic not only to developing countries. E.g. even in Japan energy consumption structure renewable energy sources account for only 1% of both electricity and primary energy supply. While the share of renewable energy in global terms and Japan's energy mix will grow, this will happen at a very slow pace due to relative higher costs and other structural impediments (discussed below) that inhibit a fast uptake of renewables (Vlado 2012). At that point we could formulate answer to the first research question raised: what we mean by sustainable development in countries, which are in different economic development phases, i.e. if perception of sustainability changes as country develops. To our minds, sustainable development changes its meaning as country develops. We can conclude that countries sacrifice environmental goals at early stages of their development. We support an opinion that there is a conflict between economic growth and economic development and policymakers face a tradeoff between these two policy objectives (Wu *et al.* 2012), despite opposite opinion exist (e.g. Wangjiraniran *et al.* 2011).

2. Consistent patterns of economies development and economic restructuring

Reason, why an economic conflict between economic and sustainable development exists lies in the limitations of current level of technology, which does not allow cutting significantly costs of renewable energy. Energy intensity and cost of energy mixed remains urgent issues, enforcing to trade-off between sustainable development and economic growth. Hence, complex ways of energy intensity diminishing are being elaborated. International variations in energy intensity are well understood as the consequence of the different technologies used in separately taken countries. Besides technologies country's energy intensity is conditioned by economic structures. Alas, previous studies failed to take into account energy consumption structure and economic structure (Feng

et al. 2009). The lack of empirical evidence on the relationship between energy intensity, energy consumption and economic structure creates an obvious deficiency that may affect applied research and policy making in energy and economic development. Despite above expressed opinion, we need to contradict, that investigations, discussing relationship between secondary or tertiary industry and energy consumption could be found. The whole strand of scientific literature is devoted to analysis of relationship between energy intensity and economic structure. Let us recall that diminishing of economy's energy intensity would lead towards more energetically secure and, at the same time, more sustainable development of a country.

Considering economic structure and its relation to energy intensity authors usually raise a specific question about impact of agricultural, industrial and service sector on energy intensity. E.g. Feng *et al.* (2009) that China's gradual move away from secondary industry, which was generally energy intensive, to tertiary industry (service industry) contributed to China's declining energy intensity. Another study e.g. is devoted to finding out the relationship between energy intensity and tertiary industry instead of studying energy intensity and industrial structure. Indirectly, the purpose of the paper is the same: to re-examine a statement that secondary industry is the main factor that causes over-consumption in energy (Tianli *et al.* 2011; Chontanawat *et al.* 2008). Convincing methodology for revealing relationship between energy consumption and economic growth bases on calculation of elasticity coefficient of energy consumption**.** According the authors, Energy consumption elasticity coefficient is the index to measure the relationship between energy consumption and economy development, indicating the sensitivity of energy consumption to economic growth. Formula is:

Energy consumption elasticity coefficient = the growth rate of energy quantity/the growth rate of economy (GDP)

The authors calculated energy consumption elasticity coefficient for China during 1996-2009 year period. Results revealed, that energy consumption elasticity coefficient increases year by year. It was especially high in years 2003 and 2004, when the growth rate of energy consumption exceeded that of GDP; i.e. it was equal to 1.53 and 1.59 respectively. This reflects that China's economy has an increasing dependence on energy consumption. The following years, China made some adjustment in its energy policy, encouraging energy conservation and improving energy efficiency. There is a slight decrease of GDP dependence on the energy, and the cost of the economic growth declines, with the increasing energy efficiency. But the degree of energy consumption is still the obstacle to China's economic development. Then authors explore China's energy intensity. Recall, that Energy intensity is the ratio of energy use to the output of economic or material resources. At the national level, energy intensity is the ratio of the total amount of domestic primary energy use or final energy use to GDP. (In recent years China's energy intensity about 6 times that of EU 25 countries - comment from the article). The cost of China's GDP growth is far higher than the average level of the EU. The energy efficiency gap between China and developed countries is very obvious, with an economy growth depending on extensive energy consumption, rather than energy efficiency. Those tendencies could be found and in other developing countries (Miškinis *et al.* 2013). The main difference here is that in other countries the same development pattern is not that vivid. Authors generalize, and we completely agree, that energy efficiency and economic structure have to be changed in order to diminish energy consumption.

Presented above approaches let us to generate related but novel approach. We suggest tackling not country's economic structure, i.e. proportion between agriculture, services and industry, but just industrial structure. The following argumentation would back this approach. The first argument is that agriculture plays a very important role in the context of increasing world population. Food security is already an agenda; hence energy intensity of economy has to be achieved not through diminishing role of agricultural sector; what was the case in the 5th and the 6th decade of 20th century. Besides, agricultural sector is very heavily affected by state policy, taken the EU or other regions. The second argument, grounding necessity of elaboration of industrial structure is related to general tendencies of industry-services ratio change. It is obvious that service sector has tendency to expand as countries develop. Service sector because of its nature, i.e. recourses used for value added generation is less energy intensive, if to compare to industry. Anyway, urges to adopt economic policies encouraging even faster service sector growth can appear to be detrimental to countries economic development,

since industrial export in majority of countries still prevails. Hence, we see that closer elaboration of industry sub-sectors would allow revealing directions of industry restructuring allowing diminishing energy consumption (and energy security at the same time) in medium and long-run. Search for efficient economic restructuring of industrial sub-sectors could be done by applying Long-range Energy Alternative Planning system (LEAP) (Heaps 2012; Pirlogea and Cicea 2012). Since the program allows to model a vide range of sustainable development indicators, we eliminate those, which are not relevant in the context of the research questions raised. To put it in another words, we make an assumption of *ceteris paribus* and simulate scenarios, in which industrial subsectors expand in accelerated ways. Acceleration mode or growth rate of selected industries would serve as modeling assumptions. Sub-industries, which have export potential, would be in a hub of scientific interest. Each scenario developed using LEAP software would result in energy balance, indicating what amount of energy energetically dependent country has to import. Comparison of scenarios would allow indicating direction of structural changes within industry that would let to increase value added created by industry by gradually diminishing energy intensity of overall industry sector. Suggested methodological approach is novel. Despite its scientific rigor, as we see it, research limitations have to be stressed. As it was already mention above, assumption is being made, that all other conditions remain the same. It means, beliefs, perceptions and mode of household behavior are the same, transport mode and institutions as well have not changed. One more moment has to be added: however grounded and rational methodologies are, all changes are "path dependent", what means that transitions are gradual and therefore slow enough.

Conclusions

The first conclusion answers the first research question, i.e. what we mean by sustainable development in countries, which are in different economic development phases, i.e. if emphasis on different facets of sustainability (particularly economic environmental, related to energy consumption patterns). We found, that sustainable development changes its meaning as country develops. We can conclude that countries sacrifice environmental goals at early stages of their development. We support an opinion that there is a conflict between economic growth and economic development and policymakers face a tradeoff between these two policy objectives (Wu *et al.* 2012), despite opposite opinion exist (e.g. Wangjiraniran *et al.* 2011). Trials to introduce goalpost of sustainable development related to renewable energy consumption do are not acceptable for practical use due to minor fraction of renewable energy used and comparatively high price. Another goalpost has to be suggested.

The second conclusion answers the second research question about existence of consistent patterns of economies development and ways to find efficient policies of economic restructuring. We conclude, due to natural tendencies of agricultural, industrial and service sectors development, it is more efficient to tackle industrial sub-sectors development, which, on one hand, are more energy intensive, and, on the other hand, remain main source of export. Sustainable development and energy security goals can became compatible if energy intensive industrial subsectors grow slower than less energy intensive sectors. Scenarios of industrial sector restructuring in the level of industry sub-sectors, resulting in respective energy balances for a country would let to indicate directions of efficient industrial restructuring.

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