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NATIONAL COMPETITIVENESS AND RENEWABLE ENERGY SOURCES

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1. RESEARCH BACKGROUND

Energy expenses are one of the largest part of the costs of countries. It has doubled between 1990 and 2010, its share was 10% of the World GDP in 2011, meaning the first or second biggest expenditures of nations.

Besides of its economic significance, energy is an issue of politics, environment, security and safety, technics and wealths thus impacting operation of countries in a complex way. Despite of that, there are only few scientific publications in the topic of the relation of energy to competitiveness.

In Hungary, 43 doctoral dissertations were born in the topic of competitiveness in the branches of science of Economics and of Management & Business Administration since 2005. As a common point, all these dissertations contain theoretic background and summary about competitiveness and the development of this notion over the last decades. Out of the 43 dissertations, only 3 studies attempt to present authors of competitiveness in a systematic logic structure. Somogyi analyses 35 authors or institutions in a detail manner, nevertheless she refers only 8 authors from the international playing field. By building upon on the doctoral dissertations focusing on competitiveness, I aimes to make a self structure to present the theroretic background of competitiveness, from the principles of competition advantages towards the findings of sustainable competitiveness.

My dissertation makes difference among the above listed domestic dissertations back to 2005, due to its core topic as none of them have focused on the relations of renewable energy sources and national competitiveness.

I use as an indirect background the various analysises about the energy dependence and exposure of nations, renewable energy potentials, developments, and economic, societal, environmental impacts of the usage of renewable energy sources.

I use as a direct background a study on the recast of the National Renewable Energy Action Plan of Hungary, which document assessed Hungary's renewable energy potentials via a multi criterion decision model.. Furthermore, I lean also on the findings of a book chapter about the domestic energy intensive industries and their possibilities in the field of renewables.

2. RESEARCH OBJECTIVES

The main objective of my study is to display the development of the notion of economic competitiveness, furthermore I attempt to place the notion of national competitiveness into the theories on general competitiveness and I put renewable energy sources in the general energy context.

Concerning the development of the notion of competitiveness, I aimed to evaluate the scientific studies that have been already published, and additionally to assess the doctoral dissertations of this topic. When doing this, my goal was to learn and interpret international authors reading in English as most of the Hungarian authors doesn't refer to the original works of these authors.

I aimed to introduce whether natural resources, energy sources put any weight in the definition of competitiveness. Besides of that, I present basically used energy sources and their alternatives as well, based on scientific studies.

After introducing the relevant notions, I represent various indexes and their methods dealing with the measurement of national and corporate level competitiveness. The goal of this chapter is to show the principles and practices the ways how to measure the previously mentioned abstract theories of competitiveness. Institutions and councils dealing with competitiveness will be analysed as well, looking at their relations to sustainability in terms of energy and environment. Furthermore I assess, whether these institutions identify energy-related sustainability as a competitiveness factor.

My goal is to introduce the field of energy as well (after the theories an practices of competitiveness) in order to point out the sustainable competitiveness impacts of the usage of different energy sources. I close the energy chapter with introducing energy strategies of the largest economies and a detailed analysis on the European Union's renewable energy policy.

Statistical methods support me to find relations between the long-term values of different general and environmental complex competitiveness indexes. In order to point out deeper relations, I compare competitiveness indexes to other economic indicators as well. The planned statistical methods to be applied are correlation analysis, significance level definition, main component analysis, cluster analysis.

3. HYPOTHESES

During defining the hypotheses of my research, I leant on my experiences gained in the field of energy market over the last one decade and on all the challenges I met over this period of time. I have experienced the challanges of SMEs, by working for the state administration I took part at development projects of economy strategy for the European Union and for Hungary, furthermore I had the opportunity to be part of legislation making of state aid and other regulatory measures. Finally, by working for one of the largest company of Central-Eastern European region, I had the chance to follow the examination of the energy and climate related legislative package of the European Union, including the work on the strategy transition towards a sustainable growths of the corporate which has been rely on conventional energy sources.

All the above mentioned personal impacts inspired the following hypotheses of which I tried to find answers during my research:

(H1): The notion of competitiveness changes over the times due to the alterations of the political-economical environment, thus the determining factors of competitiveness are changing as well.

(H2): The level of renewable energy usage plays some role in the framing of national competitiveness.

(H3): Renewable energy sources are more sustainable than conventional energy sources, they are reasonable alternatives to conventional energy sources in terms of sustainability.

(H4): The utilisation of renewable energy sources contributes to the modernisation of the economy structure, furthermore it enhances the innovation capacities.

(H5): Energy sources and especially renewable energy sources will determine competitiveness at a more crucial level in the future.

4. METHODS

The base method of my study is the analysis of scientific studies published in the field of competitiveness and renewable energy sources. This analysis shows and methodise different approaches of best known authors and institutions about competitiveness, and describes renewable energy sources from various angles.

My research consists of international publications typically. Its first cause is that literature of renewables freshens quickly due to the technology development and market trends, namely the most comprehensive, latest data, statistics and and findings are more available in the international publications compared to the Hungarian studies.

Most significant researches on competitiveness take place primarily at international scenes, therefore I studied this topic basically on the international level as well. (Hungarian authors refers many times to another Hungarian authors when interpreting international authors in an indirect way, consequently original essence distorts frequently. Therefore I preferred to learn original authors.)

Another main method is the collection, summary and analysis of secunder data of competitiveness rankings. The broader context of energy is introduced based on secunder data as well, touching upon on the results, trends of the renewable energy policies of the European Union.

Leaning on the data of World Bank and Eurostat, I completed analysises with correlation, significance, main component and cluster analysis methods for the economic and renewable energy performance the EU 28 countries.

Finally my aim is – in line with the hypotheses – to provide better identification and development of determinate factors of competitiveness, thus to contribute tot he sustainability of our living standard, even at the expense of higher efforts.

5. NEW AND NOVEL SCIENTIFIC RESULTS

I summarise new and novel scientific results of my research as follows:

R_1: Based on scientific studies wrote by 30 acknowledged authors and delivered by 5 worldwide known economy institutions my finding is that there is need to interpret competitiveness at national level as well, furthermore that the determinant factors of ecompetitiveness are well identifiable and recognisable. These determinant factors alter however, due to the political, economical and environmental circumstances. This change means varying weights on factors and extension of them as well. I found that the debates around the notion of competitiveness are mainly due to the different mission of corporates and countries, their interpretion differs about competition: the final goal of a competitive corporates is to raise profit while the goal of national competitiveness is to improve the living standard and well-being of its citizens, furthermore to ensure sustainability in terms of economy, society, environment.

R_2: Based on the analysis of national cometitiveness institutions and six multidimensional indexes, furthermore based on my research examinated with the use of statistical methods I conclude that utilisation of renewable energy sources has

impact on national competitiveness. National competitiveness councils set targets and measures related to renewable energy sources. Three complex indexes point out direct impact on a quantitative manner, besides of the direct impact the indirect impacts are also appreciated in the method of the analysed indexes. My finding is after the assessment of ten-years data (applying statistical methods) that GDP is not appropriate device to show how renewables impact on national competitiveness, on the other hand, complex composit-indexes can justify this impact.

R_3: Renewable energy sources are real alternatives to conventional sources, renewables are more sustainable than conventionals - I justified this thesis with detailed analysis of sustainability criteria. My finding is not true for all the renewable energy sources. Only those energy sources qualifies are sustainable sources which don't run out of reserves and the use of which don't emit harmful emissions (or this emission can be neutralised) and don't result large environmental risks. Based on all the aboves my finding is that currently renewable energy sources are environmentally sustainable but biomass firing.

R_4: Analysing the filed innovation patents and the macroeconomic impacts of renewable energies I concluded that utilisation of renewable energies contributes tot he modernisation of economy structure and enhances innovation capacities. A lot of other technologies are linked to renewable energy sources being a targeted field of innovations. The modernisation of economy structure is backed both in direct and indirect way – in terms of positive impacts on trade balance due to avoided import energy or in terms of the development of local green economy and green industry.

R_5: Based on energy outlooks, renewable energy sources have place both in current and future energy systems: bigger an bigger share of constantly growing energy demand will be supplied by renewable energy sources. The high level acceptance of global climate protection policies, growing commitment level of corporates and investment trends show that renewable energies will be significant factor of competitiveness as the sustainable substitution possibility of conventional energy sources.

6. CONCLUSIONS AND PROPOSALS

Based on energy outlooks, renewable energy sources have place both in current and future energy systems: bigger an bigger share of constantly growing energy demand will be supplied by renewable energy sources. It has more reasons, the most adequate cause is that renewable energies fit for all three criteria of sustainability (economy, environment, society) out of currently known energy sources. Obviously the first alternative should be the non-consumption, or the withhold of overconsumption and energy efficiency, increase of energy productivity. Utilisation of renewables is sustainable only if that doesn't serve wasting demands and operation of devices at bad efficiency.

There is a controversial risk of overconsumption when renewables or energy efficiency comes into the picture. Based on the Jevons-paradox, energy efficiency measures of economic interests are driving consumption of energy rather than decrease of it. Studies make difference between direct rebound effect and indirect rebound effect. Direct effect is when someone switches to a more fuel-efficient car –

but drives and consumes finally much more than before because thinking on the efficiency of the new car. Indirect effect is when savings of energy efficiency are spent to another goods, resulting energy consumption on an other side. Jevon examplified rebound effect on coal efficiency measures in 1865, but thi principle was justified many times since then. These rebound effects can not be limited ultimately. Promising vision is that energy savings could finance further energy innovations, enabling much higher energy and cost savings in the future.

CONCLUSIONS

The findings of my research are the followings:

1. **I examined scientific studies first to identify the determinant factors of national economy and to assess whether these factors are the same or is there any change in the factors over the time?**

   Competitiveness is understood first at the level of corporates in the schientific studies. However Krugman opposed to consider competitiveness at country level, the notion of productivity used by Smith és Ricardo was already predecessor of our current definitions for national competitiveness. The World Economy Forum - making country rankings since 1979 - considers national competitiveness as all of the factors of institutions, policies which determinate the productivity of the economy (and productivity is determinant factor for prosperity). The Harvard Business School approaches national competitiveness also from the productivity. Other authors emphasise that competitiveness based on production factors is not sustainable, furthermore they say that the factors needed for competitiveness are in change (Graham, Clugston, Bogár – Vass, Czakó). Sustainability of competitiveness is in the focus point of some other authors (European Commission, Aiginger-Landesmann), and there are complex definitions interpreting competitiveness as its aim is to reach high living standard (and well-being) and sustainability in terms of economy, society, environment. These authors put weight on soft factors like human capital as well (Széchenyi, Porter, Csath).

   Determinant factors of competitiveness change due to the circumstances of economy, policy, environment. This change is shown both in the altering weights of factors and the broading of the determinant factors as well.

2. **Is there any role of the usage level of renewable energies in the shaping of national competitiveness?**

   The latest competitiveness theories include environmental sustainability, coupling economic activites to environmental performance (WEF, IMD, Csath, Graham, Clugston, Bogár - Vass, Káposzta). Porter (and Fogarassy as well) interprets environmental sustainability not only as requirement (cost issue) but as the root of innovation, thus as competitive advance. (Porter considers pollutions as wasted resources; efforts to decrease its volume are increasing productivity. Environmental policies are incentivising innovation, consequently enabling the avoidance of compliance expenses.)

   Based on the scientific studies analysed during my research, my finding is that one condition of competitiveness is sustainability. The desired triangle of sustainability

(economic, society, environment) is not achievable with the use of energy sources which are run out of reserves, are more polluter than their alternatives (both in local and global terms), and their usage might cause high environmental risks. Teller alarmed already back in 1959 that the "energy sources of the past" will run out of reserves, they pollute the atmosphere due to their greenhouse gas emissions resulting warming thus flooding of costal areas.

Concluding the analysis of relevant scientific studies my finding is the sustainable use of renewable energy sources can contribute to national competitiveness.

3. **Are renewable energy resources more sustainable than conventional ones? Are renewable energy sources alternatives to conventional energy sources in terms of sustainability?**

The run out of fossil reserves of the World is a challenging question since a long while. Proven oil and natural gas reserves have increased by 50% over the last 20 years ensuring to cover energy needs for another 50 years (based on production data of 2016). Coal reserves have decreased by 10% over the last 20 years, nevertheless they would enable to cover energy needs for 150 years (assuming production data of 2016). Looking at these trends, probable another new reserves will be extracted in case of attractive energy prices. Concerning environmental sustainability, run out is not the primary argument against of fossil energy resources.

However energy efficiency should take a significant role in easening of sustainable responsibility of energy usage, it is not expected to avoid the push on mitigation of negative impacts of fossil sources. Measures taken in order to mitigate negative impacts didn't reach breakthrough yet (e.g. CCS, CCU), thus the only alternatives are nuclear energy and renewable energy sources so far besides of energy efficiency technologies.

In terms of pollutions, furnace technologies emit greenhouse gases and particulate matters. Firing of biomass results greenhouse gas emission as well as fossil fuels, its environmental benefit is only the shorter lifecycle compared to fossil resources. (Based on data of Intergovernmental Panel on Climate Change, emission factor of energy sources is the following measured in CO_2 emission per 1 TJ energy yield: solid biomass / wood 112 t, lignite, coal 101 t, heating oil 74,1 t, natural gas 56,1 t, biogases 54,6 t.

These emissions degrade environmental sustainability while health issues caused by air pollution degrade societal sustainability. Sustainability of the economy is hampered by all redemption costs resulted by the previous mentioned issues.

IEA counts on the usage of nuclear energy to reach global climate goals as it doesn't emit any harmful materials. Nevertheles nuclear energy is critised concerning sustainability frequently. The most important objection is linked to the time-scale: it is the most expensive technology in terms of investment costs, return on investment takes long time despite of low operation costs (and longterm forecasts of energy prices is highly uncertain).

Nuclear heating materials are limited by technologies and by geopolitical factors meaning economical critics against the use of nuclear energy. Societal-environmental

critics are related to risks of accidental failures, natural disasters, terror attacks, and handling of nuclear waste.

Consequently, all energy sources qualify as environmently sustainable energy sources, which doesn't run shorts, doesn't cause emissions and it doesn't mean high risk on environment. All these justify that renewable energy sources are environmently sustainable (but biomass being used in furnaces).

4. **Impacts of renewables on modernisation of economy structure and innoation capacities**

Domestic energy offset import energy so improving trade balance might result modernisation of economy structure – indirect impact can be assumed this way. Development of local green economy is a direct impact in those countries who focus on renewable energy related technology development and technology production as well.

Renewable energies are outstanding fields of innovations. Helm (2014) justified that number of patents of renewable energies have grown at higher level than the average growths of patents (average annual growths is 6% from 2006 while 24% at renewables; 182.000 patents were filed concerning renewables in 2011). Number of patents started to increase at the late 1990's and jumped rapidly further in the 2000's worldwide.

Furthermore, the utilisation of renewable energy sources is linked to many other innovation areas, so impacting spill-over effects on other technologies and applications as well. Most typical fields are those areas where renewables face some disadvantages against fossil resources: energy storage, system integration, intelligent system solutions, energy digitisation. All these listed fields are rich in innovation activities as well.

With my study I find justified that renewable energies contribute to the modernisation of the economy and that the utilisation of renewable energy sources increase innovation capacities.

5. Assessing of future impact of (renewable) energy sources in competitiveness

Current opinions on renewable energy sources might change from the point of view of competitiveness and sustainability. On one side general approaches could turn on a more supportive direction while other factors might decrease the renewable energy's relative importance on competitiveness. The best scenario would be a strong increase in resource-efficiency but forecasts don't lay on this assumption. More realistic is the danger of overconsumption of clean energy sources or the appearance of new industrial trends taking over the experiences flagship-role of renewable energies (in terms of economy development, innovation, employment impacts) over the last one-two decades (such technologies might be industry 4.0, digitisation, blockchains, electric and self-driving vehicles, shared economy).

Most of all, the global climate agreements (backed by broad political and scientific arguments) justify my assumption that role of renewable energies will increase in the shaping of competitiveness in the future. Once the 'carbon budget' of the World would rich high level and broad acceptance, significance of renewables would be

valorised at high extent, becoming a basic need. This trend could be backed by the pricing of ’stranded assets’ meaning constant withdrawal of investments from fossil companies.

PROPOSALS

Based on my researches on publications, strategies, forecasts, country and company assessments it is ascertainable that the role of renewable energies is overweighted or underevaluated sometimes.

I guess, one kind of overweighting is the positive judgement of renewable development resulted by attractive subsidy schemes without taking into consideration impacts on environment, related parts of the systems and finance.

I find as an underevaluation when factors of macroeconomic impacts, innovation environment, potential for technology development, sustainability are not taken into consideration.

My proposal is to analyse renewable energy performance of countries taking into consideration the followig aspects:

- macroeconomic impact (triggered energy import amd its infrastructure)
- environmental impacts of manufacturing electric devices
- impact on energy prices
- environmental footprint (besides of operation) of manufacturing, installation and dismantling
- financial burden of subsidy schemes
- development impact on local/domestic green economy
- impact on related infrastructures
- direct and indirect impact on employment
- operation conditions of manufacturing devices
- innovation level of installed technologies
- innovation potential of technologies
- impact on competitiveness

7. SUMMARY

In my thesis, I aimed to present the positive impacts of the usage of renewable energy sources on national competitiveness by building upon on the scientific studies that have been already published and my personal experiences gained in the energy industry over the past decade.

In the first part of my thesis I emphasise the importance and validity of the correlation between renewable energy sources and national competitiveness, furthermore I provide an overview of their general scientific background. I attempt to place the notion of national competitiveness into the theories on general competitiveness and I put renewable energy sources in the general energy context.

After the general introduction, I completed broad and in-depth research to find answers to my questions and to justify my hipothesis.

I have ascertained the reasonability to define competitiveness at the level of national economy, furthermore I have justified that the factors of competitiveness are identifiable and determinable. Nevertheless I have highlighted that definitive factors of competitiveness may change depending on various cirumstances in terms of aspects as geography, resources, time, economy development.

I have brought the conclusion that the utilisation of renewable energy sources is able to shape competitiveness of a nations economy. The impact is proportional to the level of energy import-dependency and physical-economical possibility to replace import energy with domestically produced clean energy sources.

I have pointed out that renewable energy sources are more sustainable than conventional energy sources and they are real alternatives to conventional energies in terms of sustainability. On the other hand I had to point out the sustainability challenges of biomass firing and the need to prioritise technologies bearing higher innovation potential and emitting fewer greenhouse-gases over their life-cycle.

I have declared that the innovation potential of renewable energy technologies is high thus they enhance innovation capabilities. They contribute to the modernisation of the economy structure via their positive impacts on innovation, trade balance, employment, industry development, enabling economies to be more multifold and more resistant to criseses.

Global climate agreements are based on broad scientific and political consensus, the justify my assumption that energy - and escpecially renewable energy - will play an even more crucial role in the future of competitiveness. In case of worldwide adoption of carbon budget (meaning limitation in use of fossil reserves so capping greenhouse-gas emissions), renewables will be more appreciated, their use will become a basic necessity. This progress may be supported by the phenomen of ’stranded assets’ and the gradual disinvestments from companies engaged in fossil energy sources.

I present the significance of renewable energy sources (based on the analysed scientific studies), the methods of statistical examination of available data and my main findings in the next table:

Table 1: Renewable energy source in competitiveness theories and measurement methods applied in my study

Analysis of published studies	Measurement and analysis
• Ownership of natural capital • Productivity, effectivity • Impact on trade: - Decrease of import exposure - Opportunities to export technology • Innovation content: - Developing techs have higher innovation potential than matured ones - Related fields of innovation are system integration, electrification and decarbonisation (which has impact on innovations related fossil technologies as well) • Target area and device of politics • Theory of changing competitiveness factors • Apperance of sustainability barriers: - Natural phenomenons - Policy efforts - Regulatory measures - Impact of shaping public awareness	• Import offsetting impact on international trade balance • Composite indexes and analysis of their methodical background • GDP is not capable indices to measure relation of renewables and competitiveness • Analysis of long time data with statistical methods • Measurement factors are cnostantlx changing: more and more weight might be on various aspects of sustainability, methods of composite indecees may change as well.

Source: own editing, based on own research, 2018

With this thesis I had the aim to contribute to the better identification of determining factors of national competitiveness and to stand up for more efficient development of it, in order to be able to do more - even if it requires higher efforts - for our sustainable quality of life.

During the finalisation of this thesis, my focus shifted from the use of renewable energy sources to the necessity of complex interpretation of sustainability and sustainable competitiveness. In this context, we shall also analyse further crucial issues of our present and future life from the point of view of sustainability. Neither my thesis nor the studied multi-criteria indecees could cover all of this future-shaping issues. One of these issues is robotification showing already the need to dedicate efforts on educational-development in order to excell and to maintain life quality of labour. Material and energy demand of robotification should also be analysed through sustainability criteria. Similarly, dissemination of electric vehicles also raises the question of material and energy requirements, furthermore it highights the sustainability challenge of supply chains and employment of the automotive industry. Digitalisation could easily mean unprecedented challenges in data security, data protection and data management.

All the above issues may create new dependency issues at the international level. Natural resources such as rare earth materials deemed to be one bottleneck in this

new dependency landscape while data may become a new resource of our economies and societies.

Consequently new dependencies could emerge both in the physical and virtual reality, forcing the presence of widely different competitive strategies.

As a further aspect, model of circular economy is beginning to influence more and more our daily life via mainly environmental damages caused by use of plastics and regulatory restrictions brought by above reasons.

I am convinced that the above issues will bring new interrelations to be the subject of scientific researches, and studies of competitiveness and competitiveness indecees will also analyse them.

8. AUTHOR'S PUBLICATIONS ON THE TOPIC

Full papers in scientific journals

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