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DOCTORAL DISSERTATION REVIEW

Title: **THE ROLE AND PERFORMANCE OF WIND AND SOLAR ENERGY POLICY IN ENERGY TRANSITION PROCESS IN GERMANY AND POLAND**

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The review is based on a letter from prof. Stanisław Popek, the Director of the Doctoral School at Kraków University of Economics.

Research objective

The main objective of the thesis, formulated on page 21, is: **The evaluation of comparative policy effectiveness and efficiency in terms of solar and wind energy in Germany and Poland.**

On page 22, mgr Oleh Ożarowski also formulates the following auxiliary theses:

T1: German wind and solar energy policies are more effective and efficient in comparison to those in Poland.

T2: Countries with FIT (feed-in tariff) and quota-based instruments deliver better results than the ones with tenders.

T3: Resource endowment has a positive impact on efficiency of wind and solar energy policies.

The results of the dissertation broadly confirm the above theses, as they show that:

R1. Wind and solar energy policy in Germany was more effective than in Poland.

R2. Feed-in tariffs and quotas contributed to the development of wind and solar energy in the early stages of their development. In turn, tenders are more effective mechanism to support their development in the maturity phase.

R3. There is a significant and positive relationship between weather conditions and the efficiency of renewable energy sources (RES) policy.

Structure and content of the dissertation

The thesis consists of the Introduction, four chapters and discussion. The Introduction outlines a general background and aims. Chapter 1 provides discussion about RES characteristics, presents theories of energy transition and reports the main facts about energy transition in Poland and Germany. Chapter 2 reviews the literature on the effectiveness of various RES energy policies. Chapter 3 presents the details of various methodologies used to measure the performance of RES policies, including the one applied in the empirical application of the thesis (DEA framework). Chapter 4 is the main part of the thesis, as it reports the empirical results of mgr Oleh Ożarowski investigation. It presents:

- policy effectiveness indicator calculations,
- the results of DEA model with two inputs (the value of policy support and installed capacity) and four outputs (power production, employment, as well as environmental and energy security indicators),
- regression analysis on RES policy effectiveness determinants.

The last chapter summarizes the thesis and provides ideas for further research.

Overall assessment

In my opinion, there are reasons to consider the dissertation as a contribution to the Economics and Finance discipline. The most important one is that it delivers new results on the efficiency of RES policies in Germany and Poland, in the context of all EU countries, using a well established and reliable DEA methodology extended for regression analysis. The additional reasons are as follows:

1. The thesis contains an original discussion on the energy transition process in Poland and Germany. For instance, chapter 1 provides an innovative description of the RES market as well as a transparent summary on main policy instruments supporting RES development.
2. Mgr Oleh Ożarowski delivers interesting argumentation on which RES policy works better or worse, hence contributes to the debate on various RES policies. Specifically, in chapter 2 there is an extensive and comprehensive literature review on RES policy effectiveness in the global context. This chapter also well summarizes the main results from the other studies, and explains why sound energy policy is crucial for the development of the RES market.
3. The thesis also delivers a comprehensive review on the main findings from selected DEA-based investigations on the efficiency of RES policies and provides a critical assessment of these findings.
4. Mgr Oleh Ożarowski constructed a new dataset from various sources, which he next transformed to calculate a set of indicators related to the functioning of the RES market. These indicators are presented in chapter 4 as well as in the appendices.

I also have several critical comments, which do not change my overall positive assessment of the dissertation.

1. In chapter 2 I was missing references to several studies that focus on policies supporting RES market development in Poland (e.g. Paska *et al.*, 2000¹, Jankowska *et al.*, 2021² or Pietrzak *et al* 2021³). In my opinion, this chapter would profit if it

¹ Paska et al. (2000). Electricity Generation from Renewable Energy Sources in Poland as a Part of Commitment to the Polish and EU Energy Policy. *Energies*.

² Jankowska et al. (2021), Public policy support and the competitiveness of the renewable energy sector – The case of Poland, *Renewable and Sustainable Energy Reviews*.

³ Pietrzak et al. (2021). Energy Transition in Poland—Assessment of the Renewable Energy Sector, *Energies*.

was extended for the discussion on which instruments are attractive in the context of energy transition in Poland.

2. I have found several statements that are in my opinion questionable. For instance, on page 94 it is written that “The effectiveness of RE policies of the EU member states were systematically assessed from around mid-2000’s until 2015. Not much empirical assessment has been carried out after 2015”. A quick review of the literature allows to find a number of relevant studies published after 2015, e.g. highly cited paper by Kilinc-Ata (2016)⁴ or a more recent study of Ceryova et al. (2020).⁵ In the same vein, the sentence “All relevant empirical works on this topic are summarized in Table 3.2.” on page 105 would indicate that the other investigations are not important, including studies published in highly ranked journals reviewed by Mardani et al. (2017).⁶
3. In Appendix B there is a table presenting the overview of studies on RES policy performance. Unfortunately, there is no parallel table presenting the selection of input and output variables in DEA studies analyzing the efficiency of RES policy. This would help to assess to what extent input and output variables described in Table 4.3 are similar or different from those used in the literature.

Finally, I would point that there are few minor issues. For instance, Figures 1.7 – 1.10 incorrectly indicate that energy production and capacity is much higher in Germany than in EU27. Next, indexing in equation (3.2) contain errors and information is not provided on what θ^* stands for. The problem with indexing is also present in equations (3.3) and (3.4) as well as in Table 4.7 -- why time dimension is present solely in the case of the depended variables? I am also confused why index i is only on the RHS in equations (3.5) and (3.6).

⁴ Kilinc-Ata, (2016), The evaluation of renewable energy policies across EU countries and US states: An econometric approach, *Energy for Sustainable Development*.

⁵ Ceryova et al., 2020. Assessment of the Renewable Energy Sector Performance Using Selected Indicators in European Union Countries. *Resources*.

⁶ Mardani et al., (2017). A comprehensive review of data envelopment analysis (DEA) approach in energy efficiency, *Renewable and Sustainable Energy Reviews*.

Questions

In this section I formulate several questions, which I would be happy to discuss during thesis defense.

Q1. The dissertation contains few sentences indicating that the literature is not providing reliable and comprehensive picture on the efficiency of RES policy.⁷ I would appreciate explicit explanation on what topics were unanswered in the academic literature or policy debate, and which of these questions have been addressed in the dissertation?

Q2. The main empirical result of the thesis is based on the bias-corrected input oriented BCC DEA approach. How exactly the bias is corrected and why the standards BCC DEA might be biased?

Q3. To what extent installed capacity could be treated as output rather input variable in the assessment of RES support policy? This question is related to my third comment from the previous page.

Q4. I wonder if there could be approximate collinearity among input and output variables from DEA and one explanatory variable from the second stage of the analysis, and what this would imply for the design of the study? In particular, what would be the estimate of the model, in which power production (PR) would be dependent on installed capacity (CAP) and wind speed of solar potential (POT): $\ln(PR_i) = \alpha_0 + \alpha_1 \ln(CAP_i) + \alpha_2 \ln(POT_i) + \epsilon_i$

Q5. I am slightly concerned that in standard DEA model M5 the efficiency of most countries is equal to unity (Figure 4.12), which decreases the empirical usefulness of this outcome. Appendix G shows that this result is partly explained by the fact that in M5 are four output variables. Why model M5 is chosen as the most reliable one?

⁷ Examples:

p. 3. "there is a need for reliable and up-to-date research in the mentioned area. This thesis aims to fill that gap by providing a comprehensive study on policy performance of wind and solar energy technologies."

p. 19 "While measuring performance of RE support is popular among scholars, there is a lack of comprehensive and structural research which provides policymakers with robust results [...] Overall, there is a consensus in the literature that indicates a lack of studies on the topic. These and other research gaps indicate that a need for comprehensive research in the area of RE economics and policy is very strong."

Q6. My last question is of more general nature. How the results from the thesis can be related to the debate on reaching net zero in the Polish, German and EU context? For instance, what kind of policy instruments enumerated in section 1.3. would be most effective in Poland?

Conclusion

My overall assessment of the thesis is positive, albeit with some reservations. In general, the thesis proves that mgr. Oleh Ozarowski has good understanding of energy policy topics. At the same time it contains valuable analysis on the effectiveness of RES policy and contributes to the Economics and Finance discipline. Consequently, it meets the requirements for doctoral theses as described in the Act of 20 July 2018 on Scientific Degrees and Academic Title. I thereby recommend to admit the thesis to the next stages of the doctoral dissertation proceedings.

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