

Szczecin, 7th of June 2022

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DISSERTATION REVIEW

MSc Patrick Rausch

pt.: **THE DETERMINANTS OF THE RISE OF PV PROSUMERS IN GERMANY
FROM THE PERSPECTIVE OF TRANSACTION COST ECONOMICS**

PhD dissertation prepared under supervision

of

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I. Formal basis of the review

This review of the doctoral dissertation has been written according to the resolution of the Economic and Finance Discipline Council of the University of Gdańsk of March 24, 2022.

II. Characteristics of the formal side of the dissertation

Doctoral dissertation by Patrick Raush, M.Sc. entitled: „The determinants of the rise of PV prosumers in Germany from the perspective of transaction cost economics” contains a total of 273 numbered pages including the title page, acknowledgements by the author, list of publications, table of contents, list of abbreviations, references, lists of tables, figures and

appendices. The substantive part of the work includes: introduction, six chapters and conclusion. The References list includes 338 entries, including of 144 items supplemented with 89 studies and 105 Internet sources. Legal References list consist of 24 normative acts. Their selection testifies to a comprehensive approach to the subject matter, with particular consideration of statistical data for the area and field under study, although some of the references have become outdated and are presented in a different form. The number of bibliographical items proves a very good substantial basis of the researched subject supplemented with detailed studies from the scope of the dissertation subject undertaken by the author.

The scientific argument of the author is interwoven in a coherent way with graphic forms, which include: 38 tables and 46 figures.

The dissertation submitted for review is written in competent scientific language, appropriate for scientific research papers in the social sciences.

III. Assessment of the substantive correctness of the dissertation

The title of the dissertation adequately reflects the content of the dissertation, which allows to conclude that it was formulated in an appropriate manner. The dissertation has the character of an empirical study built on a grounded theoretical approach to the topic under study. The beginning of the dissertation presents its layout in a structural form, and each chapter begins by showing its embedding in the whole. A summary of the considerations contained in the work is provided at the end of the dissertation.

The subject of research related to the development of prosumer photovoltaic generation is topical and important in the context of the development of the European electricity market and the standard of living of societies in the European Union countries. The research analyses carried out by the author bear the features of a creative and thorough search for scientific solutions to current problems.

The author formulated 7 main objectives of the accomplished work, which in fact reflect the logical sequence of the realization of the analytical process of the dissertation. The main one

refers to the use of transaction cost theory as a starting point to explain the mechanisms of photovoltaic generation prosumers and their propensity to invest. In the further part of the research, the influence of macroeconomic factors on the above prosumer behaviour was examined.

All the objectives set by the author have been formulated correctly and are consistent with the substantive foundations of the work.

To verify the undertaken subject matter, the author used the implementation of transaction cost theory in combination with the methodology of Williamson's scheme, verifying the empirical part of the work by means of exploratory factor analysis (EFA). The research methods adopted by the author should be considered as correctly applied to the undertaken research topic.

IV. Characteristics of the contents of the dissertation

The first chapter of the paper is a review of classical and neoclassical theories of energy economics. In addition, the author reviewed the literature related to the issue of transfer cost theory (TCT) and selected features of world electricity markets in the dimension of renewable energy sources implementation with special reference to the European Union policy.

The second chapter discusses in detail energy markets (in particular with regard to market design, energy transition) in Germany, state of California (the USA) and China. Each of these examples is supported by literature and case studies and local characteristics in the context of the energy mix, the impact of local government and the operation of renewable energy sources. In addition, a synthetic comparative analysis of the aspects presented was also carried out. The analysis as a whole is characterised by the thoroughness and depth of the areas examined.

The third chapter is an overview and description of photovoltaic power generation systems. It also considers the concept and role of the electricity prosumer in a complex electricity system. The author quotes the general principle of operation and reviews the latest developments and theoretical and practical applications of prosumer installations of this type. Nevertheless, the

characterisation of operation and genesis of photovoltaic technologies would be worth extending.

The fourth chapter provides a detailed and in-depth description of selected factors for 16 administrative units in Germany from 2009 to 2019 for the analyses in the next chapter. The author describes and indicates the level of 20 indicators assigned to four groups. Additionally summarises the annual added capacity of solar PV per state.

The fifth chapter undertakes an exploratory factor analysis (EFA) based on the data contained in the fourth chapter of the dissertation. After the implementation of the preliminary analysis, the author undertook the construction of a model that tested the influence of the identified factors on the variable related to the development of photovoltaics in the German market between 2009 and 2019.

Chapter six is an analysis of the results of the previous chapters presented in a structured way according to Williamson's model. The multidimensional analysis undertaken by the author is concluded with the author's recommendations and conclusions of the work.

The conclusion of the work is a synthetic summary of the assumptions made, the research carried out and proposing a holistic approach to the analysis of photovoltaic development in the German Federal Republic.

V. Editorial and stylistic notes

The dissertation submitted for review is characterised by careful and reliable editorial and stylistic preparation. Nevertheless, the author is not free of a few mistakes, the indication of which is intended to help in the case of a desire to publish this work.

The remarks should include:

- Errors of an editorial nature regarding the characters displayed in Figure 5, p. 30;
- On page 43 – Figure 8 - Minor missing borders of drawing components;
- No differences in the percentages levels adopted in Figure 9, suggesting they are equal, p.49;
- On page 61 – Figure 12 – no unit for “Utilities” element;

- On page 71 – Figure 18 – error in the unit of investment level adopted – values on the “Investment in billion EUR” axis indicate investment levels from 5 000 000 million € to 25 000 000 million €;
- On page 79 - paragraph 1 - Does the term "hydraulic power" refer to "hydraulic" power plants (there is nothing in the context quoted to indicate this). Suggest changing to 'hydroelectric' or 'hydro';
- On page 95, Figures 27, 28 and 29 - it is suggested to change the scale for the indications in Figure 28 and 29 for better resolution of growth or fluctuations or to start Figure 29 with 0 on the ordinate axis. Different (inappropriate) scales make it difficult to read the values correctly and to compare the graphs with each other;
- On page 136, Table 15 - it is suggested to correct the phrase “Crime in crime” to “Crime ratio” to reflect the title of Table 15 more precisely;
- Lack of page numbers 151, 152, 153
- Table no. 32 in the date of data acquisition contains a value relating to January 2009, while the date of the particular data itself refers elsewhere to 15.10.2009, whereas lower section of table refers to 12.01.2009, 14.01.2009, 15.01.2009. It is worth specifying in a clear and coherent way what exactly the given cells describes, p.151;
- Table no. 33, no units for data in the table, p.152;
- Table no. 34, in second column of the table – “Year” – values representing years are formatted wrongly, p.152;
- Table no. 34, lack of units in fifth column “Total added capacities <10 MWp”, p.152;
- List of References, starts from number 3, numbers 1 and 2 are missing, p.194;
- Chapter 5 – subsection 5.2 is missing;

The errors and shortcomings presented above do not in any way impinge on the substantive value of the work.

VI. **Critical and polemical remarks**

Some parts of the work contain entries that may be subject to polemic. Thus:

- on p. 26 it is written "The current electricity market design in Germany, Europe and in many other countries is highly regulated and bureaucratic Therefore, the classic economic theories don't seem to be suitable to analyze the market design and elaborate adjustments as this is highly unlikely to be realistic". It should be noted that

different sectors of the energy market are subject to bureaucratisation and regulation in different ways (vide distribution vs. trade vs. generation), so the lack of realistic conclusions in the context of considerations of classical economic theories is too far-fetched a statement.

- On p. 43, the drawing and description suggests an "outdated" approach to generation and transmission omitting MV generation and the increasingly important LV generation, which is one of the pillars discussed by the author - prosumer energy.
- On p. 45 and 46, it is written "The transition of the energy markets bears the chance for many countries to mitigate their dependency on energy imports. As an example, Germany, a country without appreciable gas or oil occurrence, the transition could help to abandon the prevailing supply chain of importing from Russia, Norway etc. (Federal Ministry for Economic Affairs and Energy, 2017). This is especially important in hindsight on political implications connected to energy exports, like in the case of Russia and Ukraine."

Considering:

- p. 34 - "As the grid has always balance supply and demand and electricity isn't storable on a huge scale, the time specificity is very important in regard of this thesis."
- p. 43 - "In order to have stable grids, supply and demand must be balanced at all time".
- p. 44 - "... until now, electricity isn't storable on a big scale, which means that supply and demand have to be matched at every time."
- p. 46 - "Especially photovoltaics and wind energy are highly depended on unchangeable weather conditions."

It is highly debatable to claim that the transition of energy markets (towards variable and non-dispatchable renewables) "could help to abandon" dependence on gas and oil.

- On p. 49, it is written "Despite the fact that renewable energies have become the cheapest source of energy generation within the last years, there is still a high level of policy attention in numerous countries (REN21, 2021)."

Considering:

- p. 55, "The memorandum also refers to the current problem that 90% of the variable renewable electricity sources are connected with the grid which causes several problems like the necessity for huge investments in the grid system and fluctuating feed-in."

- p. 173 and 174, "The distribution network is receiving fluctuating electricity from RES and often needs to transfer the surplus into the transmission grids. As a result of the missing grid infrastructure, the redispatch and the management of the supply increased significantly and caused costs up to 800 million euros in 2015 (Agora Energiewende, 2017 I). (...) The depressed network expansion is more and more a problem for the energy transition in Germany as the additional costs are fostering the price per kWh for private households and the economy"

Without clarifying the specific assumptions of initial claim, its veracity is questionable.

- On p. 75 "Based on these figures, production costs for one kWh solar PV electricity will fall to 4-6 Cent/kWh in Europe by 2025, and down to 2-4 Cent/kWh by 2050.". Do the proposed values take inflationary aspects into account?
- On p. 92 "This is even more important as the USA, under president Trump, announced to leave the global climate agreement negotiated in Paris 2015.". The author missed the fact that on January 20 2021, on his first day in office, President Biden signed the instrument to bring the United States back into the Paris Agreement. Per the terms of the Agreement, the United States officially becomes a Party again today.
- On p. 96, it is written "Objectives of network policy are: 1. Market access free of discrimination, 2. Low costs for end consumers 3. Long-time economic planning horizon for investments (Agora Energiewende, 2019)". Given the context of the political and economic system of the People's Republic of China, the pursuit of non-discriminatory market access there is polemic.
- On p. 103, Section 3.1.2 laconically captures photovoltaic technology by omitting a historical outline and new technologies for obtaining electricity from the sun and their economic efficiency.

- On p. 113, - paragraph 1. The author describes opex costs of solar plant: inverter lifetime, solar panel cleaning and insurance. It's worth including also solar panels lifetime and their efficiency degradation in time.
- General comment - the dissertation repeatedly states that in the near future baseload capacity (nuclear, coal) will be replaced by unstable RES sources and fast-starting (in this context flexible) gas sources. In the context of the current geopolitical situation, these assumptions need to be verified. It should be remembered that, as a rule, base load is met by the most stable (albeit not very flexible) sources of energy and RES have so far mostly been peak capacity.
- General comment - the author repeatedly mentions the use of electric vehicles and energy storage in the future of energetics. However, these statements do not find any detailed justification in the text regarding the outline of costs versus benefits of such installations. Current prices and availability of raw materials seem to call into question the economic viability and payback time of such investments.
- General comment - the paper omits the issue of technical constraints for unlimited connection of Renewable Energy Sources to transmission and distribution networks. Another aspect is problems with power quality parameters (especially high voltage levels causing them to be disconnected from the grid).

Selecting for discussion from the above statements those that are closely related to the topic and purpose of the dissertation, it would be interesting to know the Doctoral Student's opinion on the following questions:

1. How will the current geopolitical situation affect the development of prosumer energy on the German market?
2. Are there any models for liberalising the bureaucracy of individual energy sectors. If so, which ones.
3. What solutions could allow the replacement of baseloads by unstable Renewable Energy Sources.

VII. Conclusion

The dissertation submitted for review by Patrick Rausch, MSc, should be assessed as correct and useful. The research problem can be regarded as topical, relevant and interesting. The presented model and research bears the signs of possible adaptation also in other territorial areas apart from the one indicated in the dissertation concerning the Federal Republic of Germany. The solution cited by the author demonstrates the appropriate level of the Doctoral Student's scientific workshop, and the original approach to the application of research methods shows the ability to put theoretical knowledge into practice.

Taking into account all aspects included in the review, I conclude that the doctoral dissertation of Patrick Rausch, M.Sc. "The determinants of the rise of PV prosumers in Germany from the perspective of transaction cost economics" meets the requirements for doctoral dissertations as indicated in Article 13(1) of the Act of 14 March 2003 on degrees and academic title and degrees in art (consolidated text Dz. U. of 2017, item 1789), applied in connection with Articles 175-176 of the Act of 3 July 2018. - introductory provisions of the Act on Higher Education (Journal of Laws of 2018, item 1669 as amended), because: it constitutes an original solution to a scientific problem, it demonstrates the Doctoral Student's general theoretical knowledge in the field of social sciences, in the discipline: economics and finance, it demonstrates the Doctoral Student's ability to conduct independent scientific work.

Therefore, it is the basis for further proceedings in order to award the degree of Doctor of Social Sciences to Mr. Patrick Rausch, M.Sc.