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Renewable Energy as a Luxury? A Qualitative Comparative Analysis of the Role of the Economy in the EU's Renewable Energy Transitions during the 'Double Crisis'

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Abstract:

The European Union (EU) faces a double crisis: both economic and environmental, which has brought into stark relief the question of whether climate change mitigation and economic growth are mutually exclusive. Is saving the environment a 'luxury' reserved for wealthy countries, with less affluent countries being too poor to be green? We seek to address this important and timely question using fuzzy-set Qualitative Comparative Analysis (fsQCA) to analyse the causal relationship between economic growth and stability, and the expansion of renewable electricity shares among the European Union's (EU) 28 member states during the recent economic recession (2008-2013). Our paper, analyses the recent economic and financial crisis and its effects on sustainability transitions, and establishes a new indicator for progress in renewable electricity transitions in the context of Europe's 2020 targets. It therefore extends the 'sustainability as a luxury' debate to include renewable energy. The analysis reveals an ambivalent picture of the role of wealth in renewable energy transitions (RET) in Europe. Indeed, driven by the EU's common renewable energy targets, the findings suggest that RETs are promoted both because, and in spite of the means.

Keywords: Austerity; Economic Crisis; EU; Double Crisis; Renewable Energy; Qualitative Comparative Analysis

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1. Introduction:

This paper analyses *whether the economic and financial struggles of some EU member states have resulted in slower renewable energy transitions*. More specifically, we investigate whether the economic crisis has led to a division in the progress in expanding renewable electricity generation between economically stable and affluent EU member states and the weaker peripheries.

Following the financial crash of 2007/8, the European Union's (EU) economy plunged into a recession that officially ended in 2013 (Eurostat, 2017).[2] Rising debt levels particularly in Eurozone states led to the widespread introduction of austerity measures. The EU further introduced its 2020 Strategy in 2010 that set binding emission, renewable and efficiency targets for governments on a path towards greener growth. The 2020 strategy thereby reflected the emerging narrative of a 'double crisis' that linked the economic and environmental crises (Bina, 2013; Bina and La Camera, 2011; Edenhofer and Stern, 2009; Everett et al., 2010; Foxon, 2013; Leichenko et al., 2010; Read, 2009; Reinhart and Rogoff, 2009; Tienhaara, 2010; UNEP, 2009). Measures to achieve sustainable development are, however, often perceived as costly and a potential drag on the economy (Skovgaard, 2014). A key question in this debate therefore concerns whether the protection of the environment has become a luxury. Crucially, can poorer countries afford to invest in renewable transitions when times are tough?

Drawing upon the literature on the relationship between wealth and sustainability we develop the following two hypotheses:

(i) Less wealthy EU countries have made poorer progress towards meeting their 2020 renewable electricity targets.

(ii) Wealthier EU countries have better progress towards meeting their 2020 renewable electricity targets.

These hypotheses are assessed through a fuzzy-Set Qualitative Comparative Analysis (fsQCA) approach as developed by Ragin (2008, 2000) that determines causal relationships between an

[2] A recession refers to two consecutive quarters of no or negative growth, with the recession for the EU based on its average growth rates of all 28 member states.

outcome and multiple qualitative and quantitative conditions. We seek to identify which economic conditions are minimally sufficient and minimally necessary for strong progress in the expansion of renewable electricity shares across EU member states. Progress in renewable electricity shares constitutes the outcome for our analysis and is represented through an innovative measure devised by the authors: the Progress of Renewable Electricity Transitions (POET) indicator. The timeframe of the analysis, the economic recession in the EU (2008-2013), constitutes an important moment. Crises represent severe disruptions that test existing institutions and norms, providing opportunity for change, but also catalysing and unveiling underlying trends, dynamics and behaviours (Claessens and Kose, 2013; Habermas, 1975). We chose the focus on renewable electricity due to the decisive role played by the electricity sector in global environmental degradation and pollution (Heede, 2013).

Our paper enriches the existing debate in three main ways. Empirically, it provides a timely analysis set within the context of the recent economic and financial crisis and thereby contributes to the growing literature on how the crisis is affecting European climate and energy policies (Slominski, 2016). The focus on renewable electricity further provides a valuable new facet within the wider debate on 'sustainability as a luxury', due to energy's position at the critical junction of the economy (as its fundamental fuel) and the environment (as its primary polluter). We further provide a new way of conceptualising progress in renewable energy transitions (RETs) within the context of Europe's 2020 targets by establishing the novel POET indicator. Finally, methodologically, the application of QCA adds to a small but growing number of publications in the field of energy policy and environmental economics (Crawford, 2012; Muench, 2015; Wright and Schaffer Boudet, 2012; Yamasaki, 2009). This article represents the first application of QCA for testing a specific hypothesis surrounding the effect of economic conditions on renewable energy policies in times of economic crisis. To the best of our knowledge, ours is also the first study that explicitly addresses the issue of model ambiguities in QCA, a problem that has only recently been brought into focus by Thiem (2014a) and Baumgartner and Thiem (2015).

Below we briefly review the debates on the role of wealth in sustainability transitions; before providing a detailed outline of the use of QCA; in section four we present the results of the analysis before discussing them in section five. Section six provides some final remarks and conclusions. The analysis suggests an ambivalent relationship between wealth and renewable energy transitions in Europe: no significant gap emerged between wealthy and less wealthy EU countries' renewable energy transitions. As both indicators of wealthy and less wealthy European economies are identified as causes for POET, the overall findings suggest that RETs are promoted both because, and in spite of the means. As such, the role of differing national, political contexts and the EU's common renewable energy targets as a fundamental driver of RETs should not be underestimated.

2. Renewable Energy: A Question of Means?

Debates about the relationship between economic development and environmental protection are long-standing. In the EU context, analysts have sought to determine if there is a '(rich) north - (poor) south divide' in environmental policy (Börzel, 2002, 2000; Lekakis, 2000). Martinez-Alier (1994) suggests that wealthier states are more sustainable, for three principal reasons. More extensive sustainability measures in wealthier states may be (i) based on the need to counteract growing resource dependence associated with increasing wealth, (ii) an attempt to benefit from the positive economic effects of sustainability, and (iii) due to the greater availability of means to invest in the environment (*ibid*.) – a prominent argument also related to the intra-European 'north-south divide' (Börzel, 2002, 2000). These analyses suggest three general motivators for government action, namely (i) the acknowledgment of a need for greater sustainability that leads to the willingness to act, (ii) a benefit from such action (motivation), and (iii) the means to act.

We can see willingness and motivation directly translated in the EU's 2020 Strategy that seeks to counteract anthropogenic climate change (willingness) and claims benefits of green and sustainable growth through innovation and efficiency (motivation). European countries are further 'motivated' to act by the threat of penalties if targets are missed (European Commission, 2013). It is important to note that some countries that have historically been more supportive of sustainability measures, or in this case renewable energy, such as Denmark, Germany, the Netherlands and Sweden, might have a greater willingness and motivation than other EU member states (Cohen, 2000; Dryzek, 2005; Requier-Desjardins et al., 1999). Nevertheless, with the basic targets set and National Renewable Energy Action Plans (NREAP) created by individual governments, a common, basic level of willingness and motivation can be considered a given, however, significant differences in the means available to facilitate greater sustainability remain. Therefore our question is how do these differences in the means (wealth) affect member states' RETs?

The existence of the double crisis and the two binding targets in the form of austerity and the 2020 strategy represent a significant challenge to policy-makers. The propagated fiscal consolidation is based on the belief that unsustainable government debt levels undermine the economic and financial stability of the Union (Checherita and Rother, 2010). Austerity measures thereby represent the enforcement of the European Monetary Union's (EMU) convergence criteria that require state government deficits to remain below 3 percent of Gross Domestic Product (GDP) and government debt below 60 percent of GDP. At the same time, the 2020 strategy seeks to address issues of environmental degradation, pollution and anthropogenic climate change through setting binding targets that seek a 20 percent reduction of greenhouse gas (GHG) emissions (based on 1990 levels), a 20 percent increase in renewable energy and a 20 percent improved energy efficiency (European Commission, 2010). For the renewable sector these targets are based on the 2009 Renewable Energy Directive that followed the 2008 climate change and energy package.[3]

[3] The Commission sought to increase these targets during the crisis (Skovgaard, 2014). In October 2014 the European Council introduced the framework for climate and energy that set a target of 27% renewables in final energy consumption by 2030. A proposal by the Commission from November 2016 calls for member states to combine their actions to ensure the meeting of these targets and envisaged a greater coordinating role for the EU and was aimed at complementing the Energy Union Governance (European Commission, 2016b). The Energy Union itself was identified as a priority project by the Juncker Commission and seeks to establish a fully integrated European energy market to improve energy security and efficiency, decrease prices and carbon emissions, and improve competitiveness and research and innovation (European Commission, 2017b).

While RETs are an important tool in mitigating the effects of anthropogenic climate change, considering the polluting effects of conventional energy sources (Heede, 2013), RETs are neither the cheapest nor the most effective way to do so (Apergis and Payne, 2012; Darwall, 2015). Replacing existing conventional power plants with renewables requires government support to create a favourable policy and investment environment that could be undermined through extensive fiscal consolidation programmes (Alesina and Ardagna, 2012; Busch et al., 2013). Although RETs do not necessarily impose an additional burden on the state budget, as many renewable policies transfer costs onto end-consumers, they are seen to increase electricity prices (Klessmann et al., 2008; Sáenz de Miera et al., 2008; Sensfuß et al., 2008). The installation of renewables has also been associated with a decrease in a country's wealth in the form of GDP per capita (Silva et al., 2012). Renewable electricity sources are therefore considered expensive *vis-à-vis* fossil fuels if the further societal and environmental benefits from renewables are not internalised. Hence, the economic effects of RETs fail to align with, and may even seem to directly contradict, the need to overcome the economic recession.

Sustainability transitions have therefore often been considered the preserve of wealthier, developed countries that can afford to carry the financial and economic burden of being green. Yet the literature assessing environmental quality in terms of being either a 'normal' or a 'luxury' economic good shows an ambivalent picture: it has been identified both as a normal (Aldy et al., 1999; Kristrom and Riera, 1996; Ready et al., 2002) and luxury good (Irene Lai and Yang, 2010; Martini and Tiezzi, 2014; Pearce and Palmer, 2001).[4] It, therefore, does not seem a given that the richer a country, the greater the willingness to pay for environmental quality, or in turn, that poorer countries are necessarily less sustainable.

As the role of means in driving sustainability transitions, therefore, appears to be inconclusive, this paper seeks to test the two fundamental assumptions of the current debates that are represented through our hypotheses.

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[4] Luxury goods in private consumption present an income elasticity of demand that is greater than unity, or put differently, a good for which demand increases more than proportionally as income rises.

3. Methodology and Data

QCA is a method of causal inference based on a difference-making theory of causation, and has been applied in a growing number of papers across many disciplines (Baumgartner, 2014; Baumgartner and Thiem, 2015; Ragin, 2008, 1989; Schneider and Wagemann, 2012).[5] QCA focuses on the causes of an outcome (B is caused by A) rather than the outcomes of a cause (A leads to B) (Baumgartner, 2014; Katz et al., 2005), which makes it "a powerful tool [in] testing hypotheses or existing theories" (Berg-Schlosser et al., 2009, p. 16). One of QCA's advantages is the ability to establish equifinality by identifying multiple causes and causal paths affecting an outcome, which is crucial as causal structures in social sciences are highly complex (Ragin, 2000, p. 222).

Whether a condition or a set of conditions is a difference-maker is established through patterns, called configurations. QCA configurations follow notions of sufficiency and necessity in relation to the outcome (Schneider and Wagemann, 2012). A sufficient condition is a condition that whenever it is present, so is the outcome. However the outcome can also be present in the absence of the condition, indicating the possibility for the outcome to occur for reasons other than the condition. The condition is therefore sufficient (every time it is present, the outcome is) but not necessary, since not every time the outcome is present, the condition is too. It is important to stress that an effect cannot occur without any of its causes, meaning that the union (or disjunction) of all causes is necessary for the outcome.

In order to identify the difference-maker(s) of the outcome and, hence, its causes, necessary and sufficient conditions need to be freed of all redundancies (Baumgartner, 2014; Thiem and Baumgartner, 2016). Redundancies are factors that can be removed from conditions without altering a condition's sufficiency or necessity through a two-phase minimisation process using the Quine-McCluskey optimisation using Boolean algebra (*ibid*.). During this minimization process, the method generates prime implicants of the Boolean function, which is based on the concept of implication:

[5] "[D]ifference-making theories stipulate—as their name suggests—that causes are characterized by their property of making some sort of difference to their effects, where the relevant sort of difference-making is variably specified in different theories" (Baumgartner, 2014, p. 3)

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"[a] Boolean expression is said to imply another if the membership of the second term is a subset of the membership of the first" (Ragin et al., 2008, p. 39). A prime implicant (PI) of a function cannot be covered by a more general implicant, and therefore is minimal. If a PI covers an output of the function not covered by any other combination of PIs, this PI is called essential. One therefore differentiates between essential and inessential PIs.

The overall minimization process is inhibited by limited diversity, which refers to a situation in which not every logically possible configuration of conditions is observed. To address the issue of limited diversity, the number of conditions should be kept low relative to the number of cases through not exceeding its root (√number of cases) (Berg-Schlosser and De Meur, 2009). This rule allows for results that may be tested, and thereby corroborated or falsified, which is essential for the scientific quality of the method.

For this analysis of 28 EU states, we chose five conditions to measure 'means' as a maximum. Using Thiem's (2016) QCApro extension package for the R environment, we built the parsimonious solution as it is the only reliably causally interpretable solution (Baumgartner, 2014). The minimisation process as a whole follows indicators of coverage and inclusion. Coverage refers to the degree to which cases exhibiting the outcome agree in exhibiting at least one combination of conditions and provides a sense of empirical relevance (Legewie, 2013; Ragin, 2000; Schneider and Wagemann, 2012). Inclusion refers to "the degree to which cases sharing a given combination of conditions agree in displaying the outcome in question" (Ragin, 2008, p. 44). It thereby represents the strength of the set-relationship. In cases of configurations of multiple sufficient causal paths to an outcome, the causal configuration with the highest unique coverage can be considered most important, when the inclusion score is high (Ragin, 2008, pp. 63–68). As real-world examples render full inclusion levels of 1 rare, the inclusion rate can be lowered as low as 0.75 (Ragin, 2008), yet other minimum levels have been identified as well, such as 0.8 and 0.9 (Ragin et al., 2008; Thygeson et al., 2012). Furthermore, Ragin *et al.* (2008) claim that the coverage should not be below 0.75 (p.78). While there is a common trade-off between a higher inclusion and a higher coverage, no indicator exists on

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what constitutes the right balance for the solution to be empirically and theoretically compelling. The general strength of a causal model is calculated through the product of the inclusion and the coverage. To accommodate the above differences in approach and ensure the strongest possible result, we sought causal configurations that would show both the highest possible inclusion and coverage. As such, we ran the analysis from the top, with a cut-off of 1.0 and gradually lowered the inclusion score until the coverage score in the consequent model reached at least 0.8. It is important to note that during fsQCA analyses, the final inclusion score of a model can be below the initial cut-off and such models have not been considered in our analysis, as they do not adhere to the requirements initially set through the cut-off.[6]

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In fsQCA, each condition is assigned a membership score between 0 (non-membership) and 1 (full membership) by decimal place. It can thereby express data in relative terms to other data and with respect to a given context or a designated benchmark. The notion of 'fuzzy' in fuzzy-set therefore refers to unclear conceptual boundaries of, for example, wealth that is a matter of degree (one can be more or less wealthy), and relative depending on its context (Schneider and Wagemann, 2012). The point of indifference, 0.5, represents the cross-over between membership and non-membership and acts as a qualitative anchor (Schneider and Wagemann, 2012; Thiem, 2014b). It should be stressed that this calibration may require and can be enhanced through a high degree of qualitative knowledge of the matter at hand (Kent, 2008). The choice in conditions for the analysis is therefore impacted by the limitations of data and the focus of the analysis. Based on these factors, we identified the following five conditions: Eurozone membership, GDP per capita, real GDP growth, government debt, and governmental deficit.

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We drew the data for the analyses were from Eurostat (2017) and the Worldbank (2016), with each country's 2020 target considered according to its NREAP (European Commission, 2016a). Based on these data, we consider renewable electricity to include small and large hydropower, as

[6] To our knowledge, there has been no solution for this issue so far, and although not common practice in current fsQCA applications, to circumvent current problems in the QCA protocol, we only consider models with an inclusion score that meets the initial cut-off.

well as biomass, geothermal, solar and wind. An overview of the calibration of conditions can be seen in Table 1 and is further explained in the following to enhance replicability.

[Table 1 About Here]

3.*1 The Outcome*

The POET indicator consists of two variables; each member states' renewable electricity share progress (RESP) over the period of analysis, and the share achieved of each member states' 2020 renewable electricity target as of 2013 (RESA).[7] The final calibration score of the outcome is the average of the two separate variables' calibration scores.

We calibrated RESP around the rounded-down mean of the data, with double the mean necessary to reach full membership. The mean of 7.6 translated into calibration scores of 0, 7, and 14. In the context of membership, they imply that countries with a renewable electricity share increase of 14 percent or more are a full-member, showing very strong growth, while those between 7.1 percent and 13.9 percent show strong growth receiving membership scores of 0.51-0.99. Countries with renewable electricity share increases between 0.1 and 6.9 percent show weak growth, indicating their non-membership through scores of 0.01-0.49, and those at 7 percent show neither strong nor weak growth (0.5). As it cannot reasonably be expected that a country met more than its 2020 target by 2013, the thresholds for the RESA were set at 0, 50 and 100, meaning every country that already achieved its 2020 target in 2013 received a full-membership score.

We focus on renewable electricity 'shares', rather than capacity or generation levels, since the 2020 targets are expressed this way. As RESP also stands relative to the total electricity produced, possible general declines in total electricity generation (and consumption) due to the economic downturn are taken into account. Combining RESP and RESA allows for the representation of change in renewable electricity shares relative to other member states' progress, as well as to

[7] As aforementioned, we chose the timeframe of 2008-2013 as it was the time from the beginning of the financial crisis until the official end of economic recession.

each member states’ own capabilities and ambitions. We joined the two variables, therefore, due to each individual one’s explanatory shortcomings. For RESP, the share increase relative to other countries can be impacted by the differing sizes of countries’ electricity markets as well as already installed base levels of renewable electricity as of 2008. Installing, for example, one wind farm on a smaller energy markets can make a significant difference for the renewable electricity share, unlike in countries of larger electricity markets. Also, a higher base level can affect the pace in which significant changes can take place over the period of study, considering different levels of market saturation under current technological conditions. RESA, while only representing a single point in time, puts progress in renewable electricity share in a solely domestic context, based on national endowment, investment and ambition. Indeed, the combination of the achievement condition with the general progress in renewable electricity compared to other EU states also provides an idea of how ambitious the state’s targets are (for example, when a state has shown strong progress compared to EU members but very little regarding its targets, the latter might have been too ambitious). Jointly, the two variables balance some of the interpretational pitfalls and provide a more comprehensive picture of the outcome (POET) in each EU member state.

3.2 The Five Conditions

Eurozone membership focuses on the potential impacts of austerity on RETs, as officially, only its member states are required to adhere to the EMU’s convergence criteria. Its calibration provided every Eurozone state with a score of 1, and the remaining EU members with a 0. Denmark, although part of the Exchange Rate Mechanism II, under which the national currency is allowed to float against the euro, is also given a non-membership score, as factually, Denmark does not have the Euro and hence is not part of the Eurozone. The condition’s abbreviation during the analysis is EURO.

GDP per capita captures the central aspect of the hypothesis that a sustainable electricity generation is costly and reserved for wealthy countries. GDP is the standard measure of economic performance at the national level. It represents the market value of all final goods and services produced within a country over a given period of time, usually a year. GDP per capita aims to represent the income and expenditure of the average person in the economy. Although GDP has several known shortcomings as it ignores, for example, the economic activities placed outside the market (e.g. home production, volunteer work and recreation) and social inequalities in wealth distribution (Stiglitz et al., 2010), we use it in our analysis as it represents the most widely used indicator about the economic conditions in a country. This is due to the fact that production is related to a country's wealth-related issues, such as standard of living, wages, and unemployment. The calibration was based on the average annual GDP per capita of each EU member state between 2008 and 2013 that enables the representation of a country's change in GDP per capita over the course of the crisis. We calibrated the condition based on the rounded-down mean, as before with RESP. With a mean of 33,285, the condition's thresholds were set at 0, 33,000 and 66,000. The condition's initialism is GDPPC.

Real GDP growth sheds light on the role of the wealth of a state in the context of RETs from a slightly different angle. It serves as an indicator for the change in size of a country's economy, representing the welfare and stability of an economy. Using real instead of nominal GDP accounts for inflation, thereby adjusting GDP rates for different price levels at different years, enabling a better judgment about improved or worsened conditions in a country relative to others. With a minimum value of -4.95, a mean of -0.14, and a maximum value of 3.02, our calibration of this condition was unable to follow the computational approach used with RESP and GDPPC. Consequently, the spread of the data from a rounded -5 to 3 was taken and divided by 2. By setting the cross-over at the centre, the thresholds were set at -2, 0, 2. The division by two set the thresholds below the minimum and maximum values in order for countries to be able to reach a full and a full non-membership score. It should be noted that with the cross-over at zero, countries below this threshold have negative growth. The condition's initialism is GDPG.

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The fourth and fifth conditions on deficit and debt are closely related, and refer to two EMU convergence criteria that are the basis for the implementation of austerity across the Eurozone. The size of government debt and deficit can therefore hint at the severity of imposed austerity measures, and thereby at the financial means available to a government, providing another perspective for testing the hypotheses. While a large-sized government deficit could also represent a government that is not austere, by January 2012, every EU member state had officially embarked on a path of austerity (Melchiorre, 2013; Šonje, 2012). To reiterate, the convergence criteria require that the annual governmental deficit relative to the country's GDP does not exceed 3 percent, and the overall gross government debt relative to GDP at market prices does not exceed 60 percent (European Commission, 2015). It should be noted that both criteria are closely linked to the GDP growth of a country, since they are connoted in portion to overall GDP; potential slumps in the economy could therefore lead to an expansion of government debt to GDP ratio, despite reduced government spending (Alesina et al., 2014; Pedroso, 2014). We calibrated the conditions by their aggregate average over the five-year period of analysis according to each condition's target as set in the convergence criteria. For debt, thresholds were identified as 0, 60, 120. The acronym for this condition is DEB. For governmental deficit the calibration had to take into account a budget surplus as well as deficit. The condition's thresholds, in accordance to the criteria, were hence set at 0 (making every state with a balanced budget or a surplus a full non-member), -3 (representing the criterion's 3 percent deficit) and -6. The acronym for this condition is DEF.

4. Results

Table 2 shows the results of the calibration and includes the RESP and RESA scores used to estimate the POET index to provide a better understanding of the underlying dynamics of the outcome. Considering the results, the two variables are similar (within 0.1 points of each other) in only nine countries (Belgium, Germany, Spain, Italy, Cyprus, Latvia, Lithuania, Malta, Netherlands) that therefore show an aligned progress in renewable energy shares towards national targets domestically and compared to other member-states. The remaining cases in which RESP and RESA scores diverge by more than 0.1 scores can be further divided into the five with a better RESP than

RESA score (Denmark, Ireland, Greece, Portugal, United Kingdom) and the remaining 14 that scored better in the RESA (Bulgaria, Czech Republic, Estonia, France, Croatia, Luxembourg, Hungary, Austria, Poland, Romania, Slovenia, Slovakia, Finland, Sweden). For the five countries with better RESP score, this hints at overly ambitious 2020 targets, while for the other 14, the opposite is true. It should be noted that none of these scores are making any statement about whether countries are more or less likely to reach their 2020 targets, as they are merely comparing progress levels between 2008 and 2013.

[TABLE 2 ABOUT HERE]

Overall, four countries made extremely strong progress (0.90-1.0), eight countries showed very strong progress (0.65-0.89), eight countries showed strong progress (0.51-0.64), one country showed neither strong nor weak progress (0.50), three countries showed weak progress (0.34-0.49), and three countries showed very weak progress (<0.35), with the lowest score being 0.12 (Malta). It is therefore also noteworthy that only France, Cyprus, Luxembourg, Hungary, Malta and the Netherlands received a 'weak' POET score of below 0.5, of which France and Hungary had at least a partial score above 0.5. Poland is the only country that received an overall score of 0.5, rendering it a country that neither showed strong nor weak progress in its RET. This means that 21 out of 28 cases show strong progress in RETs. This group includes five of the six European Debt Crisis states (Portugal, Italy, Greece, Spain, Ireland, yet not Cyprus), with Italy, indeed, receiving the highest score among the EU-28. Since Italy achieved full membership in both variables, meaning its increase in renewable electricity share has been one of the strongest among EU countries, this success seems to be authentic and not due to an unambitious 2020 target. A first look at the calibration scores in light of the hypotheses already indicates that there is no clear gap among more affluent states and poorer states regarding a weaker progress in RETs in the latter; several countries with low scores in GDPPC and GDPG, such as Croatia, Latvia, and Slovenia, received POET scores of above 0.5.

[TABLE 3 ABOUT HERE]

The analysis identified six different models at seven different cut-offs in which the final inclusion score was equal to, or higher than the initial cut-off. The models are shown in Table 3, with the inessential PIs in brackets. The highest cut-off that resulted in a model was at 0.97, while the model crossing the 0.8 coverage threshold was achieved at a cut-off of 0.89. As expected, the various models depict a gradual trade-off between the inclusion and coverage scores. Considering the unique coverage of each causal path, the highest score of 0.394 is assigned to the PI 'EURO*gdppc*gdpg' in Model 1 and 2. However, M1 and M2 have a low coverage of around 0.7, meaning that there exist several cases featuring the outcome that cannot be explained by the model, which is reflected in an overall strength of the models below 0.7. As such, the model of fit of M1 and M2 is less than with the other four models at the low cut-off of 0.89. Indeed, model three to six have a high coverage of 0.87/0.88 and a strength of between 0.77 and 0.79.

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5. Discussion

It is important to highlight that through the calibration, we identified 21 out of 28 EU member states with a strong POET (score above 0.5). This result indicates that there has been a solid support and achievement in promoting the expansion of renewable electricity in the EU, with only a few laggards since the economic downturn. However, the model ambiguity – represented through the six different models – shows that the data is insufficient to determine the data-generating causal structure. As such, the data underdetermines its own causal modelling, as technically, only one of the models can represent a causal path. Consequently, we focus our analysis, firstly, on the four strongest models (M3, M4, M5, and M6) that are all included due to the fact they are all generated from the same cut-off, and, secondly, on the common elements shared across these four models, as their causal relevance can be argued to be supported by the data, and they, therefore, constitute a sufficiently informative result. Indeed, we can only causally interpret these common paths, as elements appearing only in some models are not clearly identifiable as causes, as the data is indeterminate in their regard. There are four common elements across M3-6 (compare Table 3): (i) def*deb, (ii) euro*GDPPC, (iii) EURO*gdppc, and (iv) GDPPC*gdpg. Although with the exception of the first path, all elements are inessential PIs, their repeated occurrence as causes for strong progress in RETs across the models renders them highly noteworthy.

Considering the first element of (i) a low deficit and high debt, 'def*DEB' is the essential PI in all four models at the cut-off of 0.89. A low deficit and a high debt could indicate a case in which fiscal consolidation is taking place following prior fiscal expansion that supported the progress in RETs. As capacity expansions of renewable energy can take up to five years from the securing of funding until entering the market, the strong POET may be the result of a more favourable investment environment prior to the introduction of austerity that is generally associated with increased investment uncertainty (Alesina et al., 2014; Busch et al., 2013; Corsetti et al., 2012). The introduction of austerity and the therefore potentially worsening investment environment, however, could also mean that the progress in renewable energy transitions will be slowing in future years, though the result makes no claim about this.

The second and third elements both relate to Eurozone membership and GDP per capita, in opposite contexts, meaning one path (ii) refers to non-Eurozone membership and a high GDP per capita (euro*GDPPC), and the other (iii) to Eurozone membership and a low GDP per capita (EURO*gdppc). These elements also partly appear in M1 and M2. Crucially, 'euro*GDPPC' seems to affirm the second hypothesis that a wealthy country that is not required to adhere to the Eurozone's convergence criteria (and hence austerity) can afford to invest in renewable energy. Furthermore, considering the observed cases meeting this path, such as Denmark and Sweden, both are well-known for their wealthy, stable economies, and their pioneering role in sustainability efforts and renewable energy (Jänicke, 2008; Mathiesen et al., 2011).

In contrast however, (iii) 'EURO*gdppc' directly contradicts our first hypothesis that less wealthy states are too poor to be green. It is, however, also similar to the results of Hess and Mai (2014), who find that poorer Asian countries have higher levels of renewable electricity. In the European context, there are several potential explanations for this. Four (Greece, Spain, Cyprus, Portugal) of the seven observed cases meeting the path received bailout packages from the 'Troika' of the European Commission, European Central Bank, and International Monetary Fund (European Commission, 2017a, 2014). While, therefore, these crisis-ridden countries had to adhere to strict austerity measures as part of the packages' requirements, the international support reassured investors and allowed a supportive renewable energy policy aimed at meeting the countries' 2020 targets. The renewables sector may also have profited from the necessary re-structuring and reforming of these countries' economies encouraged through the concept of 'green growth' embedded in the 2020 strategy that aims to achieve economic growth without the large and irreversible negative effects on the environment by redirecting the economy from dirty to clean(er) sectors and processes (Jacobs, 2012; OECD, 2014; Van Der Ploeg and Withagen, 2013). The path also exists in combination with low GDP growth in M1 and M2 as both models' essential PI. In this combination it represents the highest unique coverage of 0.394, and can thereby explains almost 40% of cases with the outcome.

The fourth element, of (iv) high GDP per capita and low GDP growth, again appears to affirm our second hypothesis about wealthier states showing better progress in renewable energy transitions, as they may hint at developed countries, or high-income countries, that achieved a high standard of living while economic growth rates fall to lower levels; cases include Denmark, Ireland, Italy, the Netherlands, and Finland. At the same time, as aforementioned, there is also the ongoing debate on the effects of RETs on the economy, suggesting they undermine economic growth since policies impose costs on the private sector (Alesina et al., 2014; Busch et al., 2013; Darwall, 2015; Silva et al., 2012). As such, the two elements (iii), 'EURO*gdppc', and (iv), 'GDPPC*gdpg', could hint at this inverse relationship that indeed, the expansive RETs have an adverse effect on the economy.

However, this argument does not hold when considering the other causal paths identified by the analysis. A case in point is that both a low and a high GDP per capita are identified as difference-makers in conjunction with either being in the Eurozone or not. Particularly the argument that renewable energy may also decrease GDP per capita (Silva et al., 2012) appears therefore questionable.

Jan-Justus Andreas 5/5/17 13:02
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Conclusion

The analysis depicted an ambivalent picture of the role of wealth in RETs in Europe. Crucially, the causal paths identified across the four strongest models, both reaffirmed our second hypothesis that wealthy states show a strong progress in renewable energy transitions (euro*GDPPC, GDPPC*gdpg), and invalidated our first hypothesis that less wealthy states are too poor to be green (EURO*gdppc). The fourth causal path that we identified, of a low government deficit and high government debt as cause for strong progress in renewable energy transitions (def*DEB) could mean that a more favourable investment environment prior to the introduction of austerity drove a strong progress in renewable energy transitions. In turn, however, this finding leads to the question whether current policies under an austerity regime will be sufficient to drive renewable growth in the future; something that calls for in-depth research on the effects of the economic crisis on contemporary renewable energy policy.

Jan-Justus Andreas 8/5/17 11:29
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Overall, the results of the calibration showed that 75 percent of EU member states showed strong progress in expanding their renewable electricity share between 2008 and 2013, including most of the debt-ridden states (with the exception of Cyprus), as well as several states with low real GDP growth/ GDP per capita. As such, and considering the identified causal paths, no growing division between wealthy and less wealthy EU countries could yet be identified. As differing conditions of means seem to explain a strong RET equally well, other factors, for example within the national political context, may be playing a role in driving the expansion of renewable energy. This outcome is supported by the fact that Eurozone membership or non-membership was identified as a difference-maker in opposite wealth contexts.

Concerning the debate on ‘sustainability as a luxury’, the analysis demonstrated that of the three factors crucial to sustainability – motivation, willingness and means – the role of means is highly ambiguous. Indeed, the result of the QCA analysis suggests that RETs are promoted both because, and in spite of the means. Here, the power of the binding Europe 2020 targets in encouraging countries to ensure the expansion of renewable energy despite potential economic reservations should not be underestimated. By establishing a target framework across EU member states, the 2020 Strategy provided a common driver for the expansion of renewables. It remains to be seen whether more significant divisions in reaching the targets will emerge over time. However, for the time being, our analysis indicates that ‘where there is a will, there is a way’.

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Tables and Figures

Table 1

Outcome and Conditions Calibration Patterns

Outcome	Measures	Anchor Points[8]
Renewable Energy Share Progress	Change in Renewable Electricity Share, 2008-2013.	Calculated around mean of data. (1.00 = strong progress; 0.5 = neither weak nor strong progress; 0.0 = no progress)
Renewable Energy Share Achieved	Share of renewable electricity achieved of 2020 target in 2013.	Full achievement means full membership, other anchors set accordingly. (1.00 = Achieved 2020 target; 0.50 = half way towards achievement; 0.00 = no achievement)
Conditions		
Eurozone Membership	Full accession to the Eurozone	(1.00 = yes, 0.00= no)
GDP per Capita	Average GDP per capita between 2008-2013.	Calculated around mean of data. (1.00 = wealthy EU member state; 0.50 = neither wealthy nor poor EU member state; 0.00 = poor EU member state)
Real GDP growth	Average real GDP growth between 2008-2013.	Calculated based on spread of data set, around no growth (0). (1.00 = strong GDP growth; 0.50 = neither positive nor negative growth; 0.00 = strong negative growth)
Government Debt	Average government debt between 2008-2013.	Calculated according to Maastricht convergence criteria, with threshold set at 60 percent of GDP. (1.00 = Very high debt; 0.50 = Meeting convergence criteria; 0.00 = Less debt than convergence criteria)
Governmental Deficit	Average governmental deficit between 2008-2013.	Calculated according to Maastricht convergence criteria, with threshold set a 3 percent of GDP. (1.00 = Very high governmental deficit; 0.50 = Meeting convergence criteria; 0.00 = Lower governmental deficit than convergence criteria)

[8] *The anchor points of non-membership (0.00), indifference (0.50) and full-membership (1,00) are set based on qualitative knowledge or calculated based on the data. The latter implies the rounded down mean of the condition's data as threshold, with double of the mean set as full membership. All otherwise informed anchor points are explained specifically.*

Table 2.

Calibration Scores for the Outcome (POET) and its sub-indicators (RESP, RESA), and the five conditions.

Country	Outcome			Conditions				
	RESP	RESA	POET	EURO	GDPPC	GDPG	DEF	DEB
Belgium	0.55	0.59	0.57	1.00	0.70	0.63	0.60	0.84
Bulgaria	0.64	0.92	0.78	0.00	0.11	0.69	0.25	0.13
Czech Republic	0.54	0.95	0.75	0.00	0.31	0.53	0.56	0.32
Denmark	1.00	0.83	0.92	0.00	0.91	0.33	0.26	0.35
Germany	0.75	0.66	0.71	1.00	0.67	0.67	0.25	0.63
Estonia	0.78	1.00	0.89	1.00	0.25	0.37	0.11	0.06
Ireland	0.69	0.49	0.59	1.00	0.79	0.37	1.00	0.75
Greece	0.83	0.53	0.68	1.00	0.40	0.00	1.00	1.00
Spain	0.91	0.91	0.91	1.00	0.48	0.18	1.00	0.56
France	0.19	0.63	0.41	1.00	0.64	0.60	0.87	0.69
Croatia	0.56	0.99	0.78	0.00	0.21	0.07	0.91	0.50
Italy	1.00	1.00	1.00	1.00	0.56	0.14	0.6	0.97
Cyprus	0.45	0.41	0.43	1.00	0.47	0.30	0.72	0.56
Latvia	0.72	0.82	0.77	1.00	0.21	0.15	0.75	0.31
Lithuania	0.59	0.62	0.6	1.00	0.21	0.61	0.94	0.27
Luxembourg	0.12	0.45	0.29	1.00	1.00	0.73	0.00	0.16
Hungary	0.09	0.61	0.35	0.00	0.21	0.37	0.64	0.65
Malta	0.11	0.12	0.12	1.00	0.32	0.98	0.54	0.56
Netherlands	0.19	0.27	0.23	1.00	0.79	0.48	0.58	0.51
Austria	0.21	0.96	0.59	1.00	0.75	0.65	0.48	0.66

Poland	0.45	0.56	0.50	0.00	0.2	1.00	0.86	0.44
Portugal	1.00	0.89	0.94	1.00	0.34	0.18	1.00	0.86
Romania	0.67	0.88	0.78	0.00	0.13	0.74	0.90	0.24
Slovenia	0.20	0.83	0.52	1.00	0.37	0.23	1.00	0.37
Slovakia	0.29	0.87	0.58	1.00	0.26	0.96	0.80	0.35
Finland	0.27	0.94	0.61	1.00	0.74	0.31	0.18	0.39
Sweden	0.59	0.98	0.78	0.00	0.84	0.66	0.03	0.32
United Kingdom	0.60	0.45	0.52	0.00	0.62	0.59	1.00	0.62

Table 3

Six identified models, their cut-offs, inclusion, coverage scores, overall strength and causal paths

	Cut off	Incl.	Cov.	Strength*	Model						
1	0.97	0.970	0.694	0.67318	EURO*gdppc*gdpg +	(euro*deb)					=> POET
Unique Coverage:				:	*0.394*	*0.035*					
2	0.95	0.959	0.723	0.693357	EURO*gdppc*gdpg +	(euro*deb +	euro*GDPPC)				
	0.94	0.959	0.723		EURO*gdppc*gdpg +	(euro*deb +	euro*GDPPC)				
Unique Coverage:					*0.394*	*0.028*	*0.01*				
3	0.89	0.893	0.883	0.7914	def*DEB +	(euro*GDPPC+	EURO*gdppc+	gdppc*deb+	GDPPC*gdpg)		=> POET
Unique Coverage:					*0.028*	*0*	*0*	*0*	*0*		
4	0.89	0.893	0.883	0.7914	def*DEB +	(euro*deb +	euro*GDPPC +	EURO*gdppc +	GDPPC*gdpg)		=> POET
Unique Coverage:				:	*0.028*	*0*	*0.01*	*0*	*0*		
5	0.89	0.896	0.874	0.7831	def*DEB +	(DEF*deb +	euro*GDPPC +	EURO*gdppc +	gdppc*def +	GDPPC*gdpg)	=> POET
Unique Coverage:					*0.028*	*0*	*0.01*	*0*	*0*	*0*	
6	0.89	0.890	0.874	0.77786	def*DEB +	(DEF*deb +	euro*def +	euro*GDPPC +	EURO*gdppc +	GDPPC*gdpg)	=> POET
Unique Coverage:					*0.028*	*0*	*0*	*0*	*0*	*0*	

*Product of Inclusion and Coverage

Justus Andreas 3/5/17 13:35
Comment [15]: Comment 22

Appendices

Appendix A: Aggregate Raw Data for outcome and conditions

Country	Renewable Electricity Share Difference, 2008-13	Renewable Electricity Share 2020 Target as per NREAP, in percent	Renewable Electricity Share of 2020 target achieved in 2013, in percent	Average GDP per capita, 2008-2013, in USD	Average real GDP growth, 2008-2013, in percent	Average government debt to GDP ratio, 2008-2013, in percent	Average government deficit to GDP ratio, 2008-2013, in percent
Belgium	8.8	20.9	64.1	46,292.09	0.63	101.41	-3.56
Bulgaria	8.9	20.6	91.7	7,370.85	0.87	16.91	-1.97
Czech Republic	8.7	13.5	103.0	20,389.43	0.51	39.06	-3.11
Denmark	22.6	51.9	93.4	60,121.03	-0.29	42.54	-1.07
Germany	13.1	38.6	73.1	44,647.82	0.84	75.44	-1.21
Estonia	12.5	17.6	83.0	17,387.17	-0.04	7.69	-0.46
Ireland	11.5	42.5	53.4	52,756.02	0.21	92.53	-11.89
Greece	12.3	39.8	55.0	25,750.72	-4.14	153.11	-10.31
Spain	14.1	40	94.5	31,174.18	-0.91	71.44	-8.23
France	3.9	27	67.8	42,501.93	0.40	84.49	-5.01
Croatia	11.5	39	116.2	14,056.28	-1.57	64.50	-5.56
Italy	16.8	26	128.5	36,737.46	-1.30	118.80	-3.50
Cyprus	7.1	16	46.3	30,417.49	-1.04	73.01	-4.96
Latvia	12.4	59.8	85.5	14,016.48	-0.87	38.13	-4.06
Lithuania	8.8	21	65.2	14,240.18	0.81	33.76	-4.91
Luxembourg	2.3	11.8	50.0	109,480.96	1.39	19.79	0.76
Hungary	2	10.9	67.0	13,723.85	0.09	77.47	-3.63
Malta	3.3	13.8	23.9	21,087.68	2.41	67.31	-3.06
Netherlands	2.5	37	27.0	52,249.45	0.16	62.03	-3.31
Austria	4.8	70.6	99.2	49,550.63	0.54	79.93	-2.84
Poland	8	19.13	64.8	13,298.73	3.11	52.09	-4.90
Portugal	18	55.3	94.2	22,562.12	-0.99	106.90	-7.13
Romania	13.6	42.62	97.8	9,144.26	1.26	30.81	-4.86
Slovenia	3.9	39.3	86.3	24,311.68	-0.50	49.61	-6.24
Slovakia	6	24	95.8	17,653.62	1.93	44.23	-4.50
Finland	4.1	33	95.2	49,202.77	-0.70	48.24	-1.41
Sweden	9.7	63	100.5	55,705.90	0.87	39.07	-0.39
United Kingdom	12.3	31	57.4	41,648.94	0.69	76.50	-7.50

Source: (Eurostat, 2017; The World Bank, 2016)

Appendix B: R-Script, Calibration and Analysis

```
library(QCApro)

#Poet Calibration
RESPdata<- read.csv("~/qca/resp.csv")
View(RESPdata)
summary(RESPdata)
RESP <- calibrate(RESPdata$RESP, type = "fuzzy", thresholds = c(0, 7, 14))

RESAdata<- read.csv("~/qca/resa.csv")
View(RESAdata)
summary(RESAdata)
RESA <- calibrate(RESAdata$RESA, type = "fuzzy", thresholds = c(0, 50, 100))

#Conditions Calibration
GDPPCdata<- read.csv("~/qca/gdppc.csv")
View(GDPPCdata)
summary(GDPPCdata)
GDPPC <- calibrate(GDPPCdata$GDPPC, type = "fuzzy", thresholds = c(0, 33000, 66000))

GDPGdata<- read.csv("~/qca/gdpg.csv")
View(GDPGdata)
summary(GDPGdata)
GDPG <- calibrate(GDPGdata$GDPG, type = "fuzzy", thresholds = c(-2, 0, 2))

DEFdata<- read.csv("~/qca/def.csv")
View(DEFdata)
summary(DEFdata)
DEF <- calibrate(DEFdata$DEF, type = "fuzzy", thresholds = c(0,-3, -6))

DEBdata<- read.csv("~/qca/deb.csv")
View(DEBdata)
summary(DEBdata)
DEB <- calibrate(DEBdata$DEB, type = "fuzzy", thresholds = c(0, 60, 120))

#Analysis
data <- read.csv("~/qca/data.csv")
View(data)
conditions <- c("EURO", "GDPPC","GDPG", "DEF", "DEB")

tt1 <- truthTable(data, outcome = "POET", exo.facs = conditions, incl.cut1 = 1.0,)
tt1
ana1 <- eQMC(tt1, details = TRUE)
ana1

tt2 <- truthTable(data, outcome = "POET", exo.facs = conditions, incl.cut1 = .99,)
tt2
ana2 <-eQMC(tt2, details = TRUE)
ana2

tt3 <- truthTable(data, outcome = "POET", exo.facs = conditions, incl.cut1 = .98,)
```

Justus Andreas 3/5/17 13:35
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```
tt3
ana3 <- eQMC(tt3, details = TRUE)
ana3

tt4 <- truthTable(data, outcome = "POET", exo.facs = conditions, incl.cut1 = .97,)
tt4
ana4 <- eQMC(tt4, details = TRUE)
ana4

tt5 <- truthTable(data, outcome = "POET", exo.facs = conditions, incl.cut1 = .96,)
tt5
ana5 <- eQMC(tt5, details = TRUE)
ana5

tt6 <- truthTable(data, outcome = "POET", exo.facs = conditions, incl.cut1 = .95,)
tt6
ana6 <- eQMC(tt6, details = TRUE)
ana6

tt7 <- truthTable(data, outcome = "POET", exo.facs = conditions, incl.cut1 = .94,)
tt7
ana7 <- eQMC(tt7, details = TRUE)
ana7

tt8 <- truthTable(data, outcome = "POET", exo.facs = conditions, incl.cut1 = .93,)
tt8
ana8 <- eQMC(tt8, details = TRUE)
ana8

tt9 <- truthTable(data, outcome = "POET", exo.facs = conditions, incl.cut1 = .92,)
tt9
ana9 <- eQMC(tt9, details = TRUE)
ana9

tt10 <- truthTable(data, outcome = "POET", exo.facs = conditions, incl.cut1 = .91,)
tt10
ana10 <- eQMC(tt10, details = TRUE)
ana10

tt11 <- truthTable(data, outcome = "POET", exo.facs = conditions, incl.cut1 = .9,)
tt11
ana11 <- eQMC(tt11, details = TRUE)
ana11


tt12 <- truthTable(data, outcome = "POET", exo.facs = conditions, incl.cut1 = .89,)
tt12
ana12 <- eQMC(tt12, details = TRUE)
ana12
```