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Environmental policy performance and its determinants: Application of a three-level random intercept model

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ABSTRACT

This paper contributes to the study of environmental and energy policy by using a three-level random intercept (TLRI) model to rank the performance of different countries. Inspired by the literature on Item Response Theory and multilevel latent models, the TLRI model treats policy commitment as a latent variable which is estimated conditional on the difficulty of the policy portfolio implemented by each country. This approach is characterized by three novel aspects. First, the model results in a ranking of countries which is conditional on the complexity of their chosen policy portfolio. Second, it provides a unified framework in which to construct a policy indicator and to study its determinants through a latent regression approach. The resulting country ranking can thus be cleaned from the effect of economic and institutional observables which affect policy design and implementation. Third, the model estimates parameters which can be used to describe and compare policy portfolios across countries. We apply this methodology to the case of energy efficiency policies in the industrial sectors of 29 EU countries between 2004 and 2011. In the conclusions we highlight the future possible applications of this approach, which are not confined to the realm of environmental and energy policy.

1. Introduction

The COP21 Conference in Paris gave new impetus to efforts towards limiting greenhouse gas emissions (GHGs). As testified by the national pledges and the signing of the Paris Treaty, many countries committed to implementing policies supporting sustainable development through the promotion of renewable energy sources and increased energy efficiency. Indeed, European countries have been at the forefront of fighting climate change. For instance, cleaner energy is one of the five objectives of Europe 2020, the sustainable growth strategy that EU member states launched in 2010 as a response to the recent global economic crisis.[1]

In light of this renewed commitment, a major challenge for researchers and policy makers alike is the assessment of past energy and environmental policies, and specifically how countries are performing in this respect. This question is important for both policy evaluation and for research purposes.

First, appropriately describing and understanding the past performance of countries with respect to energy and environmental policies, and their ability to commit to a more or less complex portfolios of policy instruments, is a crucial step in ensuring that future interventions are drafted in a sound and cost-effective way. An in-depth analysis in this respect is currently missing due to lack of appropriate data and to more complex conceptual problems linked with the creation of appropriate indicators.

Second, the availability of sound indicators of policy commitment and stringency would allow for more solid empirical research on the inducement effects of such policies for innovation, competitiveness and economic performance more in general. Indeed, the poor quality of available indicators is often cited as one of the major shortcomings of the empirical literature dealing with such research questions.

As pointed out in Brunel and Levinson (2013, 2016), assessments of

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[1] The Europe 2020 strategy includes five main objectives: ensuring 75% employment of 20/64-year-old; Getting 3% of the EUs GDP invested into research and development; limiting greenhouse gas emissions by 20% or even 30% compared to 1990 levels, creating 20% of EU energy needs from renewables and increasing energy efficiency by 20%; reducing school dropout rates to below 10%, with at least 40% of 30/34-year-old completing tertiary education; ensuring 20 million fewer people are at risk of poverty or social exclusion. The environment and energy objective summarizes the so-called 20-20 Climate and Energy Package approved in 2007 by the EC and subsequently translated into a set of five directives approved in 2009.

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environmental and energy policy are characterized by major challenges. First, to address climate and energy concerns countries can choose from a wide array of policy instruments, each of which is characterized by a different level of effectiveness, dynamic efficiency and political acceptability (Fisher and Newell, 2008). This "multidimensionality" translates into the challenge of building a policy indicator able to capture the different aspects of a country's policy portfolio. Second, the ability of countries to implement certain (lower cost) options might depend crucially on some "initial condition" or on some time varying characteristics. For instance, the complexity and stringency of a country's policy portfolio at any given point in time is likely higher for those countries which have been committed to sustainable energy for a longer period of time. While these countries may appear has having an overall higher score, their efforts over a given period of time may be lower than that of countries which only recently committed to GHG reductions and energy efficiency. On the one hand, latecomers to climate mitigations may be asked to bridge the gap in environmental protection very swiftly upon joining international organizations (such as the OECD or the EU). On the other hand, forerunners in environmental protection may have already reaped the low hanging fruits, and any increase in policy commitment and stringency may be particularly difficult due to higher marginal costs in terms of economic performance or political and social support.

This state of affairs makes it hard to build a comprehensive indicator to assess countries' performance in the realm of environmental and energy policy. In addition, the data available to the researcher is poor to begin with, as even collecting information on the stringency of all the different policy instruments put in place is challenging. Actually, data in this respect is scarce or imperfect. Most databases only provide a count of the different policy interventions implemented in any country, often categorizing them by policy instrument, as in MURE (2012) or IEA (2012). The few attempts to provide qualitative scores together with counts of policies have been criticized since they rest on assessments by experts, which are often perceived as arbitrary. Indeed, to date the efforts to produce environmental policy indexes for a large number of countries and for long time frames has been severely limited by lack of data.

This paper is a methodological contribution aimed at showing the potential of a model, which has been largely applied in statistics, for the field of energy and environmental policy assessment. We propose a novel approach to score countries with respect to their commitment to environmental and energy policy. Recognizing the fundamental challenges characterizing data on energy and environmental policy (Brunel and Levinson, 2013; Nesta et al., 2014; Galeotti et al., 2017), we show how a three level random intercept (TLRI) model inspired by Item Response Theory (IRT) can be of help to score the policy performance of different countries in a given sector. This model allows using the count of policy instruments by type, active in a given country in a given year, to characterize the complexity of a country's policy portfolio and its level of policy commitment.

To illustrate the potential of this approach, as well as its limitations, we estimate the model using data on policies promoting energy efficiency in the industrial sector in a sample of 29 European countries over the years 2004–2011. The contribution of our analysis to the literature is fourfold. First, our approach has relatively few data requirements and allows exploring the scarce information available on environmental and energy policies to the fullest. Second, the TLRI model allows building an index to assess and compare countries' environmental policy portfolios and performance addressing the aforementioned issue multidimensionality. The score we build accounts for the type, number and complexity of the policy instruments implemented in each of the countries in our sample. Third, the TLRI model can be augmented with a latent regression. This allows to condition the "raw" country score on specific observables at the beginning and during our sample period, thus addressing the problem of "initial conditions" noted above. Fourth, our methodology provides a unified framework to rate policy commitment and stringency (through a three level random intercept model) and to study its determinants (through a latent regression). It is therefore of potential relevance also for applications on a variety of research questions where a key requirement is the creation of a policy indicator cleaned from reverse causality and from the effect of covariates.

The rest of this paper is organized as follows. Section 2 provides a review of the available literature and highlights the contributions of this paper. Section 3 presents the proposed statistical model. Its empirical application, which focuses on energy efficiency policies in Europe, is presented in Section 4. We describe therein the data and report the empirical results, which include country rankings which account for (a) the complexity of the policy mix put into place and (b) the effect of economic and institutional observables. Section 5 concludes with a summary of main results, policy implications and a list of future research avenues.

2. Literature review

Assessing the economic impact of policy decisions is of central interest to Economics. As environmental and energy policy has become increasingly active worldwide in the last decades, several efforts were undertaken to ascertain the consequences of decisions concerning energy efficiency, renewable energy sources, emission reductions, and the like, on key variables such as innovation activity, economic growth or overall economic performance. A critical issue is of course the definition of an appropriate indicator of policy commitment and stringency. This is a topic that has received recently increasing attention. Brunel and Levinson (2013) provide a comprehensive review of the literature in this respect.

Popular proxies for regulatory stringency are data on private sector abatement expenditures (Pollution Abatement Costs, or PACs). Such data inform on the level of financial effort a given firm/sector has to face to comply with given standards (Lanjouw and Mody, 1996; Jaffe and Palmer, 1997; Berman and Bui, 2001; Hamamoto, 2006; Rubashkina et al., 2014).[2] Reductions in emissions or pollutants or indicators based on energy use are other popular indicators of choice (Cole and Elliot, 2003; Gollop and Roberts, 1983). Changes in regulation-based measures have also been used to judge the level of policy stringency (Popp, 2003, 2010). A different tack has been taken by the numerous papers which made use of general composite indexes through the use of aggregation techniques. The data used to that end include information on the presence or absence of a given policy (0–1 indicators) or on scores from surveys of government officials or business leaders (Tobey, 1990; Kellenberg, 2009). Finally, many have resorted to *ad hoc* data sets which are tailored to answering a specific research question (Jeppsen and Folmer, 2001).

Brunel and Levinson (2013) nicely describe the main conceptual issues that plague almost all previous efforts to create an index of energy and environmental policy stringency.

First, creating a reliable indicator is challenging due to the issue of "multidimensionality". Governments regulate various aspects of energy production and environmental protection, namely air, water, toxic chemicals, but also energy efficiency and renewable energy production. Moreover, policy instruments can be aimed at regulating pollution directly, through either a command-and-control or a market-based approach. In addition, environmental and energy policies *per se* can be combined with policies aimed at addressing the knowledge market failure and can stimulate the creation and diffusion of less polluting technologies.[3] Such heterogeneity in policy responses and in the sectors

[2] The use of this indicator is based on the assumption that profit maximizing firms typically face marginal abatement costs that are increasing in pollution abatement.

[3] Environmental (and energy) policy directly targets the environmental externality by regulating pollutants or emissions. On the one hand, command-and-control policy instruments include mandates and standards, which set a minimum requirement for firms to