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The impact of renewable energy on household electricity prices in liberalized electricity markets: A cross-national panel data analysis

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ABSTRACT

The main research questions addressed in this paper are: first, have electricity market reforms achieved lower household electricity prices and, second, has the introduction of renewable energy increased household electricity prices in deregulated markets Answers to the questions were derived using static and dynamic panel data analysis from 1991 to 2014 employing explanatory variables such as the extent of electricity market reform and the share of generation from renewable energy resources. The dynamic model suggests that a lower household electricity price is associated with the degree of electricity market reform, while the share of renewable energy in electricity generation is not statistically significant.

1. Introduction

The reform of electricity market has been prominent on the policy agenda in many developed countries aiming to create a more competitive market environment that makes the electrical industry operation more efficient and thus enables it to provide electricity at economically efficient prices for end-users. The United Kingdom initiated its electricity market reform in the late 1980's and other European countries, the United States, Canada, and Japan followed. Since the 1990s, climate change has been another major policy consideration requiring international efforts. It has become clear that reducing greenhouse gas emissions from electricity generation and use sector is needed in the ongoing context of the electricity market reform.

The effects of market reform and climate change policies on the actual electricity prices might be mixed. For example, an electricity distribution company in a deregulated market seeks inexpensive electricity from various sources. Such electricity may be sourced from fully depreciated older generation facilities, such as coal or nuclear, or from renewable energy sources such as photovoltaic (PV) and wind that have very low marginal cost in the near-term. The deregulated electricity exchange market allows participants to choose the least inexpensive generation source in order and match electricity supply and demand in the short-term. At the same time, however, the introduction of renewable energy has been financially supported by national governments through policy tools such as Feed-in-Tariffs (FITs) and Renewable Portfolio Standards (RPS) to cover high installation costs and reduce investment risks. These costs may be transferred more easily to the household (residential) electricity prices rather than to the industrial electricity price, partially due to the national government's political and economic concern for international competitiveness. An increase of electricity price has been observed in association with the increase in renewable energy in some countries in contrast with the original aims of electricity market reform is to provide lower cost electricity. Pollitt (2012) pointed out that the challenge for policy makers within a deregulated market context was that the costs of ambitious climate policy goals would be increasingly obvious to energy consumers.

In this study, the main research questions are: first, have electricity market reforms achieved lower household electricity prices and second, has the introduction of renewable energy increased household electricity prices in deregulated markets? To answer these questions, we model the effect of market reforms and renewable energy on household electricity prices. This paper is organized as follows. Section 2 gives an overview of the energy policy development related to electricity market reform and climate change that impacts electricity price. Based on prior empirical studies, both static and dynamic models are constructed to analyze the impact and significance of multiple explanatory variables such as extent of electricity market regulation and percentage of renewable energy in electricity generation with regard to the household electricity prices as a dependent variable. Data is prepared as internationally comparable panel data from 1991 to 2014 for seven selected OECD countries. Finally, empirical panel data analysis suggests that the household electricity prices have strong path dependency in the dynamic model and the evolution of regulatory reform on the electricity market is associated with lower household electricity prices. Increasing

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renewable energy market penetration with lower marginal generation costs can potentially lower electricity prices in the future in a deregulated electricity market that has a spot or dynamic electricity exchange market. However, the share of renewable energy in electricity generation was not statistically significant in this study. A EU derived dummy variable was introduced to examine the homogeneity of EU member countries and heterogeneity of non-EU countries, and it appears to be statistically significant.

2. Policy development

2.1. Deregulation of electricity markets

The policy objective of an electricity market reform[1] is to create a more competitive market environment that makes electric utility operations more efficient and provides electricity at economically efficient prices for end-users. Various measures have been taken into account to achieve the policy objective to reduce of government involvement in the management of electric power company and price control, encouraging new entrants to the wholesale and retail sales markets and unbundling of generation, transmission, and distribution. Creating an EU-wide single electricity market has also been a clear policy objective of the EU (Hyland, 2016).

One of the earliest movements of electricity market reform started in the late 1980's in the United Kingdom. Thomas (2005) analyzed forms and processes of electricity market reforms in a variety of countries and identified that a standard model for electricity liberalization is the “British model”, consisting of six reforms: (1) creation of a competitive wholesale spot market for electricity, (2) creation of retail sales market where each consumer can select his provider, (3) separation of electricity distribution network activities from other market-driven activities such as generation, (4) separation of retail sales from the generation of electricity, (5) creation of an incentive structure to set market prices originally in monopolistic competition, and (6) the privatization of formerly state-owned assets. In a country's process of electricity market reform, some of these elements are integrally implemented, some of the elements are not implemented in other cases, or implemented continuously in stages in a phased or step-by-step manner.

The rational selection of energy resources will change with the progress of market reform. Utilities traditionally utilize the least expensive generation source available. In a deregulated market with an electricity exchange market, renewable energy such as PV and wind are likely to be used in merit order. The merit order is a way of lining up available sources of energy purely from an economic viewpoint, especially electrical generation, based on ascending order of price together with the amount of energy that will be generated. The price reflects the short-term marginal costs of electricity generation. In an electricity exchange market with centralized management that matches grid-wide supply and demand within short periods (such as 30 min), the order is so that the power plants with the lowest marginal costs are the first ones to be brought on line to meet demand, and those with the highest marginal costs are the last to be brought on line. Dispatching generation in this way minimizes the cost of production of electricity. Implications of the merit order system to renewable energy in a liberalized electricity market are very clear. Energy from PV and wind are more likely to be brought on line first because of their very low marginal cost of production due to no fuel costs; they will thus be price competitive with electricity derived from fossil fuel derived electricity.

2.2. Economic and policy measures for climate change - FIT, RPS, ETS and carbon tax

The FIT is a fixed price measure that obliges electricity companies to purchase electricity generated by renewable energy such as PV, wind, and biomass at a fixed price for a certain period such as ten to twenty years. The tariff is set taking into account the profit and the generation costs.

RPS is a policy that forces an electricity company to introduce certain amounts of renewable energy by themselves or purchase it from others. Theoretically, renewable energy sources are developed from the point where the costs for generation are the least expensive. The FIT and RPS allow electricity companies to introduce renewable energy by lowering risks associated with renewable investment. Government policy plays an important role in setting an appropriate tariff and target level of renewable energy and communicating the price to electricity producers. These policies can also have distribution consequences for renewable energy generation facilities and consumers, which was originally unintended.

Emission Trading System (ETS) and carbon taxes are also economic measures for environmental protection aiming directly to control greenhouse gas (GHG) emissions rather than aiming to reduce CO_2 by shifting energy mix to renewable energy. ETS sets targets and rights for GHGs emission and allows a market participant to sell/buy the extra rights and thus makes entities that set emission rights to take actions to reduce GHGs such as to implement energy saving measures, to improve energy efficiency and to shift energy mix with lower GHGs emissions. Carbon, an environmental, or green taxes in some countries are levied based on the emission of carbon or use of fossil fuel aiming to internalize the external cost of environmental protection regarding the global warming issue.

The costs relating to FIT, RPS, ETS, and carbon taxes are eventually paid by the end-users through electricity prices in the same way as other costs for fuel, operation and maintenance, and capital investment by the electricity utilities.

2.3. Progress of electricity market reform and climate change policy measures in the selected countries

In the current study, static and dynamic panel data analysis models were developed to examine the impacts of electricity market reforms and the introduction of renewable energy on household electricity prices. Seven developed countries: Canada, France, Germany, Italy, Japan, the United Kingdom, and the United States were selected for the following reasons. First, these countries are OECD and Group of Seven countries, accounting for one-third of world electricity consumption in total. These countries also lead world energy policy to actively pursue electricity market reform and tackle climate changes. Second, the experiences of these countries have been well shared and analyzed through policy research by OECD/IEA and in the published literature. Third, reliable, internationally comparable data are readily available for these countries necessary for the panel data of this study from 1991 to 2014 under common metrics.

Table 1 summarizes the evolution of policy measures of electricity market reform and the introduction of renewable energy in the seven selected countries based on the database from the International Renewable Energy Agency (IRENA) of IEA (IEA IRENA), and publications for US electricity market reforms by the U.S. Department of Energy (U.S. Department of Energy, 2017).

[1] The wording “electricity market reform” is mainly used throughout this study to cover the following wording unless referring to published literature where the expression is used. Deregulation, liberalization and restructuring of electricity market are slightly different terminology concerning electricity market reform. Deregulation seems to cover privatization of government owned utility company. Some published literature uses the wording liberalization, assuming entry into the wholesale and/or retail sale market of non-conventional generators, removal of regulation on electricity prices or end-users' choice for price plan. Ensuring non-discriminatory access to grid system by non-conventional generators is important element of restructuring of electricity market for more efficient operation.