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Electricity inequality in Canada: Should pricing reforms eliminate subsidies to encourage efficient usage?

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ABSTRACT

Using household expenditure data from 10,811 Canadian families, this research analyses consumption of electricity, natural gas, and other fuels to investigate the extent to which higher income families have higher energy consumption. Lorenz curves show that although inequality in electricity consumption exists, its distribution is fairer than income distribution. Knowing that electricity is fairly accessible in Canada, high electricity consumption raises environmental issues. This paper discusses how different pricing in provinces results in different consumption levels when weather and environmental conditions are comparable. It means that in a subsidized electricity market, the high-income families use more energy resources, which can be considered as a "second order" inequality in provinces with lower prices due to market structures and effective subsidies based on access to low-cost hydropower. To address this issue, the paper suggests that local governments move toward an integrated market-based pricing structure that includes royalties on public natural resources to encourage efficient energy usage.

1. Introduction

According to the International Energy Agency (IEA, 2013), Canada is the world's fifth-largest electricity producer (the third-largest hydroelectricity producer) and the third-largest electricity net exporter. In other words, electricity is an important resource both for internal consumption and revenue purposes in the form of exports. Canada is also ranked among the countries with high electricity consumption: in 2011, consumption reached 16,406 kWh per capita, five times greater than the world average.

Considering the importance of the electricity industry in Canada, different aspects should be considered in order to determine whether optimal decisions about production and consumption are being made. Affordable and reliable access to energy is essential from a policy perspective. In addition, climate change and other environmental issues are increasingly important in public debate, especially in developed countries. According to the World Energy Council (WEC, 2014), achieving sustainability in the energy sector requires the following:

- Energy security: the effective management of a primary energy supply from domestic and external sources, the reliability of energy infrastructure, and the ability of participating energy companies to meet current and future demand.
- Energy equity[1]: the accessibility and affordability of an energy supply across the population.
- Environmental sustainability: achieving supply- and demand-side energy efficiencies and the development of energy supplies from renewable and other low-carbon sources.

Regarding the first component, it is important for policy-makers to ensure that electricity is affordable and accessible for all citizens. From a technical standpoint, electricity is distributed via a complex and interconnected network of high- and low-voltage transmission lines that connect consumers to power generation facilities. According to Amin (2003), these networks have the required degree of penetration and continuity of services with acceptable power quality across North America.

Regarding climate change, the inefficient use of energy may result in increased pollution and depletion of natural resources. Canada has 0.5% of the world's population and 3% of the world's energy production. Although "overconsumption" may be a

[1] There is a slight difference between the concepts of equity and equality: equity refers to fairness while equality means two things that are equal to each other. Making an investigation on a fair distribution and consumption of energy may be done in a multidisciplinary study but from an economics standpoint, this research only looks at energy equality for which there is adequate and available data.

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simplistic description (especially because Canada is colder than many parts of the world), assessing electricity consumption and efficiency is worthwhile.

This paper focuses on energy consumption equality among households. For such purposes, the Lorenz curves and Gini coefficients are effective tools with which to investigate the joint distribution of energy expenditure and consumption. These tools consider the joint distribution of variables determining whether the target variable (electricity) is consumed or distributed equally among the population. The fact that energy consumption by high-income households is higher than for low-income households is not a novel or unexpected finding. However, this paper contributes to the literature by comparing the levels of inequality across Canadian provinces by income, electricity, gas, and other fuels. In addition, the paper also discusses whether such inequalities impact the fair use of public natural resources, which is also relevant to the sustainability debate.

Electricity consumption has different determinants. Among others factors, price is an especially important incentive with regard to electricity consumption. A second goal of this paper is to analyse the effect of price on end-use electricity efficiency in Canada. Because the market structure of electricity falls under the provincial authorities in Canada, the important question is whether electricity consumption under the current subsidy regime represents an inefficient pattern compared to unsubsidized electricity markets that have quite same weather and peripheral conditions. In particular, if energy prices embed effective subsidies, high-income households that consume more electricity have increased access to public resources, implying implicit or second-order inequality. In addition, the paper confirms that higher-income individuals consume more electricity but it also investigates whether those individuals pay as much as their willingness to pay. Paying the lower price means to benefit public natural resources in an un-fair way, which is called second-order inequality in this article.

The rest of the paper is as follows: Section 2 explains the method and framework by reviewing the literature and proposes a framework for further analysis. Section 3 describes the data and presents the results, which is followed by discussion and a review of policy implications.

2. Method and framework

In investigating consumer access to energy, two concepts are discussed in the literature: energy equality and energy poverty. Energy poverty is related to a lack of access to modern energy services or the high burden of energy service in terms of cost (IEA, 2014). Energy equity is related to the distribution of energy consumption and energy price (WEC, 2014). Although similar to energy equity, energy equality considers the distribution of energy consumption among individuals. As discussed earlier, energy poverty is not an important issue in developed countries such as Canada; however, researchers are still investigating fair access to energy and public natural resources generally.

Pachauri et al. (2004) classify the methods for measuring energy poverty into three main categories: (1) defining an energy poverty line or fuel poverty line, (2) an estimation of direct energy required to satisfy basic needs, and (3) access to energy services. They also introduce a novel method with a two-dimensional measure that combines the elements of access to different energy types and the quantity of energy consumed. Using this method, the authors conduct the following tasks: (1) estimating basic energy needs for an average household, (2) correcting for household-size economies of scale, (3) grouping households by the amount of consumed energy, (4) grouping households with respect to access to different energy services, and (5) putting all this information into one matrix. The matrix provides a temporal analysis of energy poverty conditions that controls for family size and energy access.

The above methodologies used for assessing energy poverty are mostly suitable for developing countries in which the main focus is to ensure accessible energy for all. In developed countries, more suitable methods of assessment focus on the distribution of energy consumption or expenditure among individuals to assess energy equality. For this purpose, the Lorenz curve and Gini coefficient can be used to measure and trace inequality for one specific variable. In the Lorenz curve, the X-axis is the normalized number of cases, sorted from min to max while the Y-axis is the cumulative measure of the goal variable. With a population sorted based on one specific variable, the Lorenz curve shows the point at which the Y-axis variable represents a portion of the population.

Assuming that the X-variable is income and the Y-variable is energy expenditure, it is also possible to build a variable to measure cumulative energy expenditure at each percentage level of cumulative income. The curve is expected to have a concave trend. Fig. 1 is an example of the Lorenz curve and the Gini coefficient as defined as the ratio score of (A/A + B): the lower the slope of curve, the more equal the society in terms of that variable. In terms of mathematical modelling, if the function of the Lorenz curve is $Y = L(x)$, the value of B can be calculated by $B = \int_0^1 L(x)\mathrm{d}x$.

Using the concept of the Gini coefficient and the Lorenz curve, Jacobson et al. (2005) map the distribution of energy consumption in some developing and developed countries and report that country-specific, energy-conversion efficiency and climate situation are significant determinants for these curves. In another study, Wu et al. (2010) conduct a Lorenz curve and Gini analysis for per-capita energy consumption around the world. Their analysis is not only based on sorted income, but also sorted variables of the human development index (HDI), energy production, and energy consumption. The Gini coefficients of different energy services have been investigated in the case of Mexico by Rosas-Flores et al. (2010), in which the authors show that different fuels have different distribution. In the first group (electricity, gas, gasoline), the Gini coefficients are positive because these items are mainly consumed by households with higher income, while in the second group there are negative Gini coefficients (firewood and kerosene), consumed mainly by lower-income families.

Canada has a well-penetrated electricity network and a sufficient amount of electricity supply. Electricity inequality is investigated in the next section by drawing a Lorenz curve and calculating Gini coefficients for different provinces and different energy services, which will also be compared with income inequality by province to identify energy inequality in Canada.

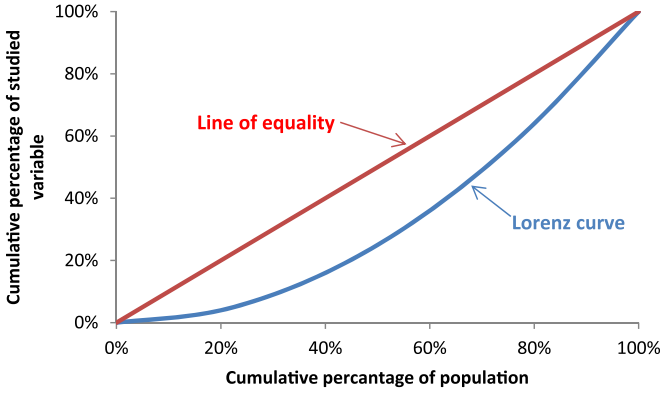

Fig. 1. A schematic description of a Gini analysis in which the Gini coefficient is the ratio of (A/A + B).