Utilities Policy 51 (2018) 12–17

Contents lists available at ScienceDirect

Utilities Policy

journal homepage: www.elsevier.com/locate/jup

The long-run price elasticity of residential demand for electricity: Results from a natural experiment☆

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ARTICLE INFO

Keywords:
Residential demand for electricity
Price elasticity
Difference-in-differences

ABSTRACT

In one of two otherwise similar adjacent regions in a Canadian province, the price of electricity changed abruptly, substantially, and permanently. That natural experiment allows for a simple differences-in-differences calculation of the long-run price elasticity of residential demand for electricity. This analysis is of interest for two reasons. First, it is a rare circumstance when such a methodology can be used. Secondly, the magnitude of the elasticity estimate has substantial implications for utilities, regulators, and policymakers.

1. Introduction

Decisions about the electricity usage, pricing, and infrastructure investment depend on many considerations. Among them, the price elasticity of demand for electricity is especially crucial. The focus herein is on residential demand for electricity in the long run. Estimates of its price elasticity are plentiful and diverse, and reflect both differences in space and time but also in estimation techniques. In a frequently cited contribution, Espey and Espey (2004) carried out a meta-analysis of price and income elasticity estimates from 36 studies published over the period 1947 to 1997. From the 123 estimates that they analysed, short-run price elasticities ran from −2.01 to −0.004 with a mean of −0.35; and 125 estimates of long-run price elasticity fell in the range from −2.25 to −0.04 with a mean of −0.85.[1] Differences in econometric techniques may explain some of the variation, but even with the same methodology, a wide range of estimates can be obtained. For example Krishnamurthy and Kristöm (2015), using a common methodology, obtained a range of price elasticities between −0.27 and −1.4 for a set of 11 OECD countries.[2]

In more recent years, the feasibility of real-time pricing has sparked interest in determining near-immediate price elasticities when consumers have informational feedback. A great deal of this research is based on experiments (see Faruqui and Sergici (2010) and Jessoe and Rapson (2014) for experimental evidence with respect to residential demand). That is in contrast to econometric studies focusing on short-run and long-run price elasticities, which use either time series, cross-sectional, or panel data sets that are typically from surveys rather than from experiments. One exception is the study by Battalio et al. (1979), which dealt with short-run rather than real-time elasticity. Using a system of rebates and information, the researchers conducted a field experiment on a sample of residential customers in College Station, Texas, over a three-month period. By offering cash payments to a subset of customers for each percentage reduction in their electricity consumption compared to a year earlier, they obtained an estimate of short-run price elasticity of demand. While interesting, experiments of that type have severe limitations. The participants know that they are in an experiment and the experiment is for a short period of time, so there is no incentive for them to invest in changing heating and cooling systems or electrical appliances. Thus, such experiments give no insight into long-run price elasticity.

The findings reported in this paper are based on a very rare set of circumstances that yields a long-run elasticity via a natural experiment.[3] Among other things, the subjects involved do not perceive that they are in an experiment, nor was an experiment even intended. It is based on a homogeneous area in the Canadian province of Newfoundland and Labrador, where all residential customers initially faced the same price schedule, but then those in a geographic subset were switched to a different price regime. The change in price was abrupt,

☆ I am very grateful to two anonymous referees, whose thorough and constructive comments led to substantial improvements. I remain solely responsible for any errors.
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[1] Boogen et al. (2017) offer a very recent review of studies on the price elasticity of residential demand for electricity.

[2] Those differences are not surprising since the countries likely have numerous differences in terms of price-setting, housing stock, incomes, climates, demographics, and other factors that would influence the nature of their respective demand curves.

[3] Two recent applications of natural experiment data to electricity issues are reported in Choi et al. (2017) and Deryugina et al. (2017). However, the former is concerned with the impact of daylight-savings time, not price, on electricity demand. The latter's focus is on price elasticity but, because it involves many communities over a wide area of Illinois, a more sophisticated analysis was appropriately undertaken. By contrast, in this paper, the similarity of the two groups supports a common-trends assumption and therefore a direct calculation of price elasticity.

https://doi.org/10.1016/j.jup.2018.02.003
Received 21 May 2017; Received in revised form 18 February 2018; Accepted 18 February 2018
Available online 08 March 2018

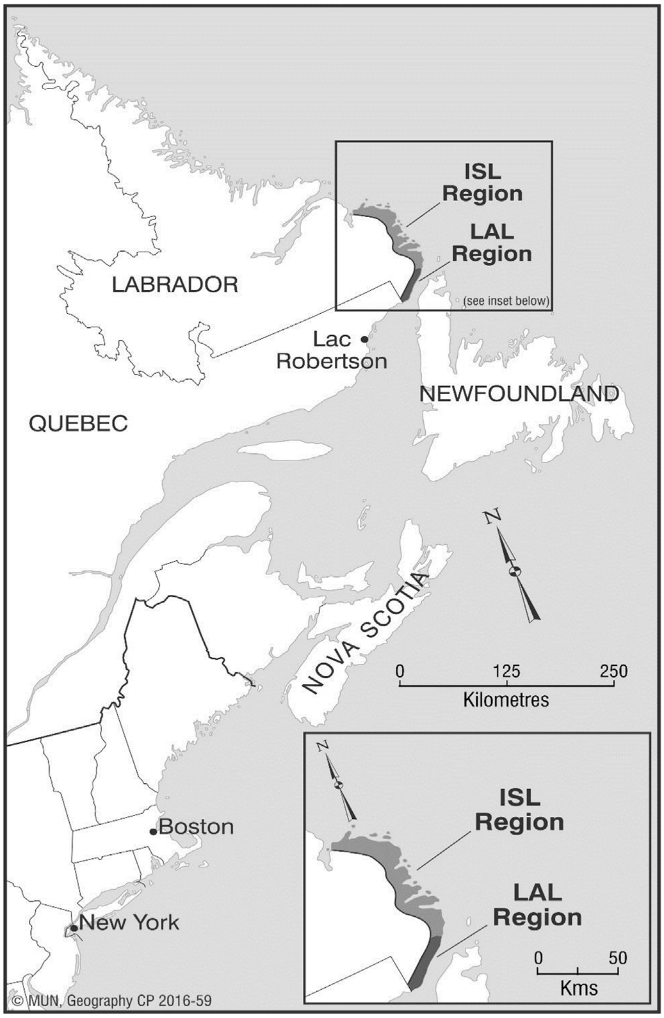

Fig. 1. Northeastern North America and the ISL and LAL regions.

substantial, and long lasting. Data on electricity consumption for both groups is available and provides insight into consumer adjustment. In particular, the similarity of the two groups allows for a simple differences-in-differences approach to estimating the long-run impact of the price change.

The next section provides the background on the natural experiment. Section 3 illustrates the magnitude of the price shock and how electricity consumption patterns changed in its aftermath. In Section 4, the long-run price elasticity is determined. Section 5 briefly discusses that result and policy implications, the latter of which are substantial if a similar elasticity value applies to residential customers elsewhere in the same province.

2. The setting

The focus is on residential demand in communities located on the south coast of the Labrador area of the province. That coastal area and the two regions of interest there are identified in the map of northeastern North America in Fig. 1. One of the two regions is L'Anse au Loup (LAL), named for the largest community within it. The other region will be referred to herein as the Isolated Southern Labrador (ISL) one.

Until late in 1996 all of their electricity demand was met by diesel turbines operated by the government-owned utility, Newfoundland and Labrador Hydro Corporation (NL Hydro). Diesel generation is expensive and, despite charging higher rates in isolated areas serviced in this way, NL Hydro incurred operating losses there. Full recovery was not possible because of provincial government policy that constrains NL Hydro in its rate design. The entire area's residential customers faced increasing-block pricing but subject to the government directive that the basic customer charge and per-kilowatt hour (KWh) rate for the first block of energy both be the same as those approved by the regulator for the residential customers on the interconnected grid in the Newfoundland area of the province. For illustration, as of July 1, 1996, all LAL and ISL residential customers faced the following monthly charges, in Canadian currency [4]:

Basic Customer Charge	$16.72
First Block (up to 700 KWh)	6.6 cents per KWh
Second Block (in excess of 700 KWh to 1000 KWh)	9.6 cents per KWh
Third Block (in excess of 1000 KWh)	13.0 cents per KWh

These rates also applied to other isolated communities that were served by diesel generators. Those communities were mostly further north on the Labrador coast but also included a small number on the island of Newfoundland. However, importantly, the pricing differed for the island interconnected residential customers. Those customers were charged the same basic charge but the 6.6 cent per KWh rate was a flat rate, regardless of consumption. The island basic charge and per kWh rate were set by the regulator but, as a policy, also automatically applied to the isolated systems up to the limit of those systems' first block. The higher second and third block rates applied only to the isolated customers and, while below the marginal cost of diesel generation, served to deter higher consumption in order to limit NL Hydro's cross-subsidization of diesel service.

In late 1996, there was a price shock. Residential customers in the LAL region were removed from the block-pricing scheme. NL Hydro entered into an agreement by which it would import electricity from Quebec. That province's utility, Hydro-Quebec, agreed to sell surplus electricity from its new small 22-MW hydro-electric plant at Lac Robertson, located on the Quebec side of the provincial border near the LAL system, to NL Hydro. [5] That amount of energy was sufficient to displace NL Hydro's diesel plants supplying the LAL system and was less expensive. Following that agreement, the government of Newfoundland and Labrador, through an order to the province's regulator, the Board of Commissioners of Public Utilities (the PUB), directed that once the connection was in place NL Hydro would charge the same residential rates in the LAL system as applied to interconnected customers on the island of Newfoundland.[6] NL Hydro had wanted to maintain separate rates for L'Anse au Loup ratepayers because the unit cost in the area, even with cost savings from connection to Lac Robertson, would still be much higher than the unit cost on the interconnected system; see PUB (1996, 32). However, the government order prevailed and the LAL residential customers were removed from having to pay the second and third block rates. This change did not apply to the ISL system, which was not connected to the Lac Robertson plant and continued under the block-rate regime. This policy remains in effect to the present. Hence, there was a marked, immediate and sustained deviation of the prices in the two neighbouring Labrador systems, where customers had previously faced exactly the same prices.

The price change set the stage for a natural experiment with the ISL region serving as the control group and the LAL region being the test

[4] These rates were provided by NL Hydro on request. For recent details of this pricing, see https://www.nlhydro.com/wp-content/uploads/2014/04/Schedule-of-Rates-and-Regulations.pdf.

[5] That plant was commissioned in 1995 (http://www.hydroquebec.com/generation/centrale-hydroelectrique.html).

[6] PUB, 1996/97 Order P.U.5 set this policy and it refers to Government order MC 96–0567 as the basis for doing so; see http://pub.nl.ca/orders/pu97.htm.