HOW MUCH ENERGY DO HOME RETROFITTING ACTIVITIES ACTUALLY SAVE? EVIDENCE FROM CANADA

Samuel Gamtessa, University of Alberta, Phone: +1 780 492-3406, E-mail: gamtessa@ualberta.ca
David L. Ryan, University of Alberta, Phone: +1 780 492-5942, E-mail: David.Ryan@ualberta.ca

Overview

Energy-saving home retrofitting has long been touted as "low-hanging fruit" in the drive to increase energy efficiency and reduce both energy consumption and greenhouse gas emissions. Technological improvements that have occurred in recent years have meant that houses built and equipped in the last decade are generally much more energy efficient than those that were built earlier. While it is unrealistic to expect rapid replacement of this older energy-inefficient housing, there are many changes that can be made in existing residential construction for which the associated capital costs appear to have relatively short payback periods in terms of the energy savings that they will elicit.

Despite this apparent cost-effectiveness of many home retrofitting activities, homeowners appear generally to have been relatively reticent to embrace the concept of home retrofitting in a major way. As a result, governments in many jurisdictions have introduced measures that are designed to encourage such activities. In Canada, the federal government introduced the EnerGuide for Houses (EGH) program, which provides a home energy-use evaluation service to homeowners along with recommendations on energy-efficiency improvements that could be made to their homes. This home energy audit typically costs the homeowner between $300 and $350, although the effective cost varies across regions because some provinces subsidize this service. Although it is believed that this cost as well as the costs of undertaking the recommended retrofit activities are recoverable through energy savings, as an incentive for undertaking the recommended retrofit actions, beginning in Fall 2003 (although discontinued in 2006 following a change in government, but recently reintroduced) grants were provided to homeowners who completed energy efficiency retrofits based on EGH advisor recommendations. The grant amount depended on the difference between the pre- and post-retrofit EGH ratings of the houses, and thus required homeowners to request an initial home-energy audit and undertake sufficient energy-savings retrofits that would be revealed in a second follow-up audit that had to be completed within a specified time limit.

The EGH audit reports have resulted in a very rich data set which contains information compiled during both the first and the second audits. By the end of 2005, over 180,000 homeowners across Canada had ordered first time EGH audits, and approximately 18% of these had undertaken sufficient retrofits to justify them following up with a second energy audit. This second audit process provides similar information to the first audit, as well as a description of the specific upgrades that were undertaken along with estimates of post-retrofit energy consumption and energy efficiency. These estimates can be compared to the pre-retrofit case as well as to what would have been expected based on adoption of each of the recommended upgrades.

In this paper we utilize data collected in these two rounds of audits to model and empirically investigate the energy savings that have been achieved by homeowners who have participated in this program, and the factors affecting the extent of these savings. Given that there are a variety of types of possible upgrade scenarios – depending upon the types and number of upgrades chosen by homeowners – evaluation of how various factors affect these choices, and in turn their energy-saving impacts, would be expected to provide important information for policy makers and households planning to undertake retrofit upgrades.

Methods

Without using information on the actual energy changes that were observed, or the specific changes that were made to various aspects of household equipment and characteristics, in the first part of our empirical analysis we employ the treatment evaluation approach to trace the average effects of conservation measures undertaken by homeowners in the EGH program. Hence, our method takes the effects of sample selection into account – that is, the fact that households that are treated (make retrofits) are not randomly chosen. Typically, after taking this selection effect into account and estimating the energy saved due to the undertaken upgrades, the observed difference between the actual savings and these estimates in general should be attributable to the rebound effect. However, the energy consumption data available in the EGH dataset are based solely on engineering calculations. Thus, details of the major energy-using equipment in the home (space heating, water heating, etc.), together with other energy efficiency characteristics of the house (insulation, windows, etc.), and some basic assumptions regarding household size and thermostat settings (weather) are used to infer energy consumption at the time of the first and second audits. This means that changes in household behaviour resulting from the retrofits which may act to increase energy consumption (rebound effects) are not captured and cannot be examined using these data. However, for households that undertook both energy audits, the EGH dataset contains information on the retrofits that were made and on the change in the amount of energy consumption that resulted from those retrofits. Thus, the amount of energy savings that resulted from the program is already available as part of the dataset and can be compared to estimates of average treatment effects on the treated to assess how well studies that lack this information are likely to be able to evaluate the average effect of retrofits on energy consumption for those households that retrofit.

In the second part of our empirical analysis we focus on the change in energy consumption that resulted from the set of retrofits that the homeowner chose to implement, and examine the roles of various factors on this change. The nature of the EGH data means that there is no point trying to determine contributions to total energy saving of individual aspects of the overall energy-saving retrofits that were made to each home, as such analysis will only serve to provide an (imperfect) estimate of the engineering calculation that was used to compute the energy savings in the first place. Rather, the issue that can be examined with these data is the role of the pre-retrofit state of household energy-using equipment and other energy efficiency characteristics of the house, as well as various socio-economic variables, on the amount of energy-saving retrofitting that was undertaken. However, such analysis requires a method of aggregating the different kinds of retrofits that were undertaken (such as increased heating furnace efficiency, increased RSI values, etc.). We focus on the change in energy consumption that resulted from the chosen set of retrofits.

Results

In terms of average treatment effects on the treated, we find that overall and for various subgroups of the dataset, the estimates based on econometric analysis are very similar to the averages of the actual energy savings for houses that completed both audits. However, estimates for individual houses differ in many cases quite considerably from the values contained in the EGH dataset.

Estimation of the derived model of the change in energy consumption using data for the subsample of households that completed both audits shows that the pre-retrofit characteristics of the house, as well as household characteristics, have important roles. Of particular interest is the role of the household characteristics, since the dependent variable is calculated as the difference between two sets of engineering calculations of energy consumption, and thus depends only on changes made to the energy efficiency characteristics of the house given assumed values for a weather-related variable and average household size. These other household characteristics are found to have an important role through their effect the homeowners' decisions of how much energy-saving retrofitting to undertake.

Conclusions

Data collected in two rounds of energy audits under the Canadian EGH Program are used to model and empirically investigate the energy savings that have been achieved by homeowners who participated in this program, and the factors affecting the extent of these savings. Using only information on energy savings after the retrofits, and the characteristics of the house prior to the retrofits – as well as information on weather, household size and other homeowner characteristics, we find that using a treatment model approach we are able to derive a very accurate estimate of the average treatment effect on the treated – that is, the average energy savings for those who undertook retrofits – although estimates of these savings for individual houses often differed from their actual savings as reported in the EGH dataset.

We also derived a model of energy savings for those who participated in both audits and estimated this model including a sample selection correction. Generally we find that energy savings are larger for houses that were in a poorer energy efficiency state at the time of the first audit, and that household characteristics play an important role in these savings. This finding occurs despite the fact that the energy consumption savings are obtained as engineering measurements that depend only on the actual energy-savings upgrades that the homeowner undertook. This occurs because these upgrades are endogenous, and homeowner characteristics play an important role in the type and extent of upgrades that homeowners undertake.

A number of issues remain to be incorporated into subsequent analysis. First, selection into the first energy audit is non-random, and this sample selection issue needs to be taken into account. Unfortunately, corresponding data for houses that did not complete this first audit are not available, so alternative ways to deal with this issue need to be considered. Second, and perhaps most importantly, since the energy consumption data that are used are based solely on engineering calculations, they do not allow for the possibility of rebound effects. Ideally, data reflecting actual energy consumption would be used, and while these are not available in the EGH dataset, they are available in some much smaller datasets, which we plan to use these in future work to assess the extent and importance of possible rebound effects. Ideally this information might be utilized in further analysis with the more detailed EGH data to determine whether it is possible to adjust predictions of the energy saving potential – and hence the greenhouse gases emission reduction effects – made on the basis of the upgrades observed under the EGH program.