DO BUILDING ENERGY RETROFITS DELIVER SAVINGS? A META-ANALYSIS

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Overview

Residential energy consumption represents around 30% of world final energy consumption and 26% of total Green House Gas emissions. Investment in the energy retrofit of dwellings is identified as a key strategy to reduce both. However, these investments are made at a slow pace, with household decisions hampered by multiple factors grouped together in the so-called energy efficiency gap phenomenon. To address this phenomenon, financial support programs for retrofitting have been set up in developed countries. Studies assessing the effectiveness of these programs highlight a great deal of heterogeneity. In order to help define effective programs, this paper therefore carries out a meta-analysis which reduces the uncertainty as to their real impact, which allows us to understand the determinants of these impacts and which corrects possible biases in the publication of the evaluation results.

Methods

The present paper aims to provide an estimate of the synthetic effect size, in terms of percentage of energy savings, that can be expected from programs supporting the energy retrofit of residential dwellings and to inform on the biases and determinants of energy savings reached. It builds on the now well established methodology of meta-analysis and, more specifically, meta-regressions. Meta-analysis refers to the statistical synthesis of results from a series of studies that have been collected systematically, all of these studies aiming to assess the size of a common effect or treatment. Meta-regressions are a further step of Meta-analysis that attemps to control for observed and unoberserved heterogeneity between studies for estimating the synthetic effect size.

The paper proceeds as follows. A first section presents the meta-data. The choice of the variable of interest, the collection strategy of the studies covered by the meta-analysis and, then, the general description of these studies are detailed. The second section deals with the publication bias, a bias that appears quite recurrently in meta-analyses and whose correction is often essential to calculate a robust synthetic effect size. A graphical approach based on the funnel plot, completed by a first series of meta-regressions (PET and PEESE tests) confirms the importance of this bias in our meta-data. A third section follows which aims to control for various sources of observed or unobserved heterogeneity between studies. The resulting meta-regressions models are estimated by using Weigted Least Squares (observed heterogeneity) or Restricted Maximum Likelihood (both observed and unobserved heterogeneity) to account for the intrinsic heteroscedasticity in the effect size reported by the different studies. The meta-regressions correcting for these different elements are finally mobilized in order to estimate a robust synthetic effect size around which the uncertainty is greatly reduced with regard to what a rudimentary preliminary examination of the meta-data could suggest. A last section concludes by examining the policy implications of the results of the meta-analysis.

Results

The meta-analysis carried out in this paper confirms the importance of correcting for publication bias on the one hand, and of taking into account the heterogeneity of studies including (and especially) unobserved heterogeneity, on the other hand. The correction of the publication bias leads to reducing the energy savings rate by at most 2% compared to a basic average of the rates reported in the studies. In return, and under the joint effect of taking into account the observed or unobserved heterogeneity and a correct treatment of heteroscedasticity, a substantial reduction in the uncertainty around the measurement of the synthetic energy savings rate is obtained. In view of the initial uncertainty surrounding this measurement, the gain is appreciable and offers greater visibility as to the effects to be expected from public policies promoting the retrofitting of household housing. Based on the mean point of the observations for the smallest sample, knowing that the observed and estimated values differ little when considering a sample enlarged to different versions of the results per study, and using the PEESE version of the most complete meta-regression model, the energy saving rate of 11.5% estimated for the synthetic effect amounts to an annual saving of 3024 KWh if an energy other than natural gas is used by the dwelling. The energy saving rate increases to

14.27% if natural gas is the main energy source, i.e. an annual saving of 3754 KWh. All of these figures result from an average retrofit cost of 3970 Euros or, at the average exchange rate for the year 2023, 4386 US dollars.

Conclusions

A first lesson in terms of policy recommendations, consistent with the motivations of the retrofit programs evaluated during the first decade of the period covered by our meta-analysis, concerns the profitability of the investments thus made. We consider four cases by crossing the case of gas *versus* electricity and the case of the European Union *versus* the United States for the year 2023. The lapse time to recover the average retrofit cost seems quite reasonable in both geographical areas. When natural gas is considered as the primary source of energy we compute that yearly energy savings are 1112.67€ in the European Union and 196.62$ in the US, which implies that respectively 3.56 years and 22.31 years are required to recover the retrofit cost. Retrofit of dwellings with gas as the primary source of energy is thus much more attractive in the European Union compared to the US, due to the gap in the price of gas for residential use between the two sides of the Atlantic. We also find that retrofit of dwellings using gas is more profitable than retrofit using electricity in Europe and conversely in the US.

A second lesson in terms of policy recommendations can be drawn, inspired by the focus of the second wave of studies mostly concentrated on the last decade of the period covered by our meta-analysis: is retrofit of dwellings a low cost strategy to reduce Green House Gas emissions? We consider a lifespan of 16 years and a 3% interest rate. It follows on that the yearly avoided GHG emissions resulting from the retrofit of a dwelling using mainly electricity as the source of energy amount to 10.27t and costs -67.76€/t in Europe whereas the corresponding figures in the US are 19.28t and -127$/t. The negative costs are due to energy savings offsetting the gross cost of the retrofit. It is consistent with the Enkvist et al. (2007) abatement cost of emissions in buildings but sharply contrasts with the high positive net cost obtained by Fowlie et al. (2018). Actually, the rate of energy savings obtained by the latter is similar to that estimated in our meta-analysis, but Fowlie et al. (2018) stress the particularly, not to say abnormal, high average cost of retrofit in their study which lead to a positive and high net cost per ton of avoided GHG emissions. When it comes to natural gas as the main source of energy for dwellings, the net cost per tonne of avoided GHG emissions is -1014.09€/t in Europe and 156.90$/t in the US. Again, the sharp difference between the highly negative abatement cost in Europe and the high positive abatement cost in the US stems from the price gap of natural gas for residential use in the two geographical zones. We conclude from these calculations that prioritizing the retrofit of dwellings to abate GHG emissions based on he argument that there are associated to low, or even negative, abatement costs crucially depends on what is the main source of energy used in these dwellings and what is the price of this source of energy in the geographical zone under consideration.

References

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