Do energy retrofits work? Evidence from commercial and residential buildings in Phoenix

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Introduction

Buildings are a major component of energy use, accounting for 60% of electrical use in developed nations [1]. To date, there have been numerous energy-efficiency upgrade programs. However, discrepancies exist between realized energy savings and the estimated savings predicted by engineering models [2,3].

Our study adds to the existing literature in several respects. First, we were able to test the efficacy of energy retrofits to low-income residents. Second, we were able to assess the efficacy of energy retrofits to buildings in Phoenix, a city where energy bills are higher than the national average [4]. Third, we were able to assess the efficacy of energy retrofits to middle-income homeowners while existing economic studies on energy savings following retrofits in commercial buildings. Finally, this study is among the first to assess the efficacy of energy retrofits to low-income homeowners.

Our study adds to the existing literature in several respects: 1) Empirical assessment of energy savings in commercial buildings; 2) Moderate- and high-income homeowners for residential buildings besides low-income families; 3) Energy retrofits in arid cities.

Energize Phoenix program and data

The Energize Phoenix program

The program was a three-year (2010-2013) energy efficiency program, and it targeted buildings located in the light rail corridor. It was managed by contractors working directly with participants.

Data

The collected billing data spanned January 2008 through April 2013. The data in this study include: 1) monthly electricity billing data; 2) retrofit information; 3) information on physical attributes; records of CDD and HDD; and electricity rates from APS [4].

Model specification

We ran fixed effects regression with a dummy variable indicating whether a building has received a retrofit:

\[ \ln(Energy_{it}) = \alpha + \beta_1 T_{it} + \delta_1 CD_{it} + \delta_2 HH_{it} + \eta_i + \xi_t + \epsilon_{it} \]  

To disentangle the effects by each type of retrofit, the model specification was modified:

\[ \ln(Energy_{it}) = \alpha + \beta_1 T_{it} + \gamma_1 CD_{it} + \gamma_2 HH_{it} + \eta_i + \xi_t + \epsilon_{it} \]  

Effects of retrofits on EU;

Effects of typical retrofit bundles;

Impacts of building attributes by adding interaction terms;

Individual-year fixed effects \( \eta_i \);

Impacts by season;

Learning effects analysis by adding interaction terms;

\[ \ln(Energy_{it}) = \alpha + \beta_1 T_{it} + \gamma_1 CD_{it} + \gamma_2 HH_{it} + \delta_1 CD_{it} + \delta_2 HH_{it} + \eta_i + \xi_t + \epsilon_{it} \]  

Analysis with control buildings.

Effects of different types of retrofit bundles on energy use for commercial buildings

Effects of different types of retrofit bundles on energy use for residential buildings

Effects of different types of retrofit bundles on energy use for residential buildings

1) The negative sign of coefficients on the interaction terms suggests retrofits work more efficiently with poorer initial building conditions; 2) There is evidence of a “learning effect”, which means there is improved learning and control of energy use; 3) It is easier to save energy during winter than summer; low-income family (Energy Assist 100% program) can save during summer; 4) Energy savings are less for both commercial buildings and Energy Assist 60/40 buildings with control buildings included.

Conclusion

The realized energy savings are 30-50% lower than those predicted by engineering models; Among residential buildings, middle-income households exhibit the largest energy savings; Individual retrofits and retrofit bundles and building attributes should be considered when making energy efficiency decisions.

References