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Do homes that are more energy efficient consume less energy?: A structural equation model of the English residential sector

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Scott Kelly

Energy consumption from the residential sector is a complex socio-technical problem. To be understood fully it must combine characteristics about the physical properties of the building, the economics of energy and technologies and the behavioural choices made by occupants. This paper presents the first known application of structural equation modelling (SEM) for the explanation of residential energy consumption in England. This powerful statistical technique allows for the calculation of both direct and indirect effects, including the magnitude and statistical significance these variables have for explaining residential energy consumption.

Buildings are a significant contributor to greenhouse gas emissions with space heating alone responsible for over half of all end use emissions from UK dwellings. Furthermore, the residential sector has been repeatedly identified by government departments; commercial organisations, non governmental organisations and by academia as having one of the lowest costs and largest impacts for reducing overall CO2 emissions. Still, there remains significant debate about the best strategy for meeting the ambitous CO2 reductions imminently required.

Using the English House Condition Survey (EHCS) consisting of 2531 unique cases, the main drivers behind residential energy consumption are found to be the number of household occupants, floor area, household income, dwelling efficiency (SAP), household heating patterns and living room temperature. While the number of occupants living in a dwelling is shown to have the largest magnitude of effect, floor area and household income are also substantial drivers. In addition, it is shown there is strong mediation between causal variables. For instance, household income and the number of occupants living in a dwelling are both strongly mediated by dwelling floor area. In other

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words, households occupied by more people or have higher incomes tend to live in larger houses and therefore consume more energy.

In the multivariate case, SAP explains very little of the variance of residential energy consumption. However, this procedure fails to account for simultaneity bias between energy consumption and SAP. Using SEM its shown that dwelling energy efficiency (SAP), has reciprocal causality with dwelling energy consumption and the magnitude of these two effects are calculable. When nonrecursivity between SAP and energy consumption is allowed for, SAP is shown to have a negative effect on energy consumption but conversely, homes with a propensity to consume more energy also have higher SAP. This confirms the existence of a rebound effect but also leads to important implications for policy makers.

This research shows that homes with a propensity to consume more energy already have relatively higher SAP values which therefore suggests the scope for additional savings through the implementation of energy efficiency technologies may be limited. What is more, this finding implies that homes with a propensity to consume more energy will be more expensive to decarbonise due to the law of diminishing returns. On the other hand, if we focus on homes with a propensity to consume less energy, it can be shown that these homes already have relatively lower SAP rates and are therefore less efficient. However, improving the energy performance of these homes through the implementation of energy efficiency technologies may contribute to the rebound effect acting to increase the average internal temperature rather than decrease energy consumption. These findings suggest the presence of a residential energy efficiency barrier that must be overcome before any real savings from the residential sector can start to accrue. This result may explain why several Government supported projects in the UK aimed at reducing residential energy consumption have not realised their anticipated targets. With this purpose in mind, a dual policy approach may have the most impact. Homes with a propensity to consume more energy should be targeted using behavioural campaigns combined with economic penalties and incentives associated with energy consumption. On the other hand, homes with low SAP values should be targeted for whole home efficiency upgrades in order for these homes to break through the energy efficiency barrier.

Contact sjk64@cam.ac.uk
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