HOW DO INVESTMENTS IN HEAT PUMPS AFFECT HOUSEHOLD ELECTRICITY CONSUMPTION?

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Overview

Increased energy efficiency is often seen as a cheep and effective way to combat the climate problem. Many of the efforts aimed at increasing the energy efficiency is focused on household production. In particular, this is true when it comes to heating and cooling of private residences.

It is often assumed that increased energy efficiency will reduce total energy consumption. This will be true under the assumption that consumers (or producers) do not change their behaviour when new and more energy efficient technology is applied. Based on economic theory, we will not expect this assumption to be fulfilled, as increased energy efficiency will reduce the cost of producing a particular service. We thus expect to see both substitution and income effects from the price reduction in the production resulting from the energy efficiency measures. Several studies have also shown such rebound effects of energy efficiency to be prominent in several cases (Frondell mfl. 2008).

In Norway, one of the largest sources of energy use in household production is space heating. Depending on how long and cold the winter is, energy use for heating may vary from around 35 to 50 percent of household energy consumption (Dalen and Larsen, 2009). One of the major sources of energy efficiency measures in household space heating has been the tremendous increase in the use of heat pumps in Norwegian homes during the last decade. In 2000 virtually nobody owned a heat pump. Now, in 2012, almost a quarter of Norwegian households own a heat pump, most of which are air-to-air heat pumps. The question is how this large change in heating technology has affected the mix of energy consumed in Norwegian households. It is also interesting to know what changes in behaviour this energy efficiency has resulted in. E.g. do households hold a higher indoor temperature, or has it affected the use of firewood for space heating, which is the most commonly used alternative to electricity in Norwegian homes?

Method

We use a micro econometric approach to examine if heat pump ownership in households has reduced electricity consumption ceteris paribus, or if the energy savings potential embedded in the energy efficiency increase is eaten away by rebound effects.

When estimating the effects of owning a heat pump on electricity consumption in an ordinary demand model, it results in insignificant coefficients. This is because the positive behavioural effects and the negative energy efficiency effects cancel each other out. Thus, we apply a conditional demand model (Halvorsen et al., 2010), in combination with a household production approach (Halvorsen and Larsen, 2001). The structural model enables us to separate the indirect behavioural effects, through changes in heating behaviour and changes in the consumption of other energy goods, from the direct effects of owning a heat pump on electricity consumption.

The model is estimated applying micro data from the Norwegian Survey of Consumer Expenditures from the year 2009, supplemented with an additional questionnaire mapping energy related behaviour. This data contains information about the consumption of all energy carriers, ownership of electric appliances and heating equipment, detailed information about the household and residence, prices on all energy carriers for each individual household, as well as some information on stated behavioural changes after investing in a heat pump. The data is drawn randomly across the Norwegian population, and consist of 1115 individual households.

We apply Maximum Likelihood estimations of the equation in the structural model, and correct the estimation for heterogeneity with respect to characteristics of the household and residence. Thus, we can correct the estimation of the heat pump effect for other factors which are highly correlated with heat pump ownership, such as household size and type and ownership of the residence.

Results

We find significant evidence that, households who own a heat pump holds a higher indoor temperature than others. They also use less of other heating sources. In particular, they use significantly less firewood for space

heating after investing in a heat pump. All these changes in heating behaviour result in an increase in electricity consumption.

In addition, owning a heat pump has several direct effects on electricity consumption. For instance, households who use the heat pump for cooling during the summer months use more electricity than those who do not. Furthermore, households who may use heat pumps to heat the entire residence, and households who admit that they use less fuel oil after investing in the heat pump, use significantly more electricity than those who do not. Finally, we find that the more opportunities the household has for switching between energy carriers, the larger the negative effect of the heat pump coefficient on electricity consumption is.

If we summarize all the estimated effects of owning a heat pump on household electricity consumption in our estimation, including the effects on indoor temperature, firewood and fuel oil consumption, we find a small but negative effect on household electricity consumption.

Conclusions

In this study, we find evidence of significant behavioural changes as a result of owning a heat pump, and the total effect, both behavioural and energy efficiency effects, is much less than the energy saving potential that is embedded in the heat pump. Subsidizing energy efficiency measures is thus not always a cheap and effective way to combat the climate problem. Furthermore, these unwanted behavioural changes will increase in magnitude if investments in more energy efficient equipment are subsidised, as this will increase the unwanted income effects.

In the case of the use of heat pumps to heat Norwegian residences, these behavioural responses almost eliminate any energy saving potential embedded in the heat pump. This is also found to be the case in other studies, even if the rebound effects in the Norwegian case is even higher than e.g. in the Danish case (Gram-Hanssen et al, 2011a and b). This is probably due to the fact that Norwegian winters are longer and colder, reducing the energy efficiency of the heat pumps.

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