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The determinants of residential gas demand in Ireland

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ABSTRACT

This paper examines the determinants of residential gas demand in Ireland using a micro-econometric analysis of the daily gas consumption panel data from Ireland's Smart Metering Gas Consumer Behavioural Trial. It also investigates the effectiveness of the demand side management stimuli that were tested during the Smart Metering Trial. The analysis is based on a sample of 1181 households over 539 days in the period from 1st December 2009 to 30th May 2011. The results provide evidence that weather, together with the structural characteristics of the dwellings and the socio-economic characteristics of the households, are significant factors in explaining residential gas demand. More specifically, weather is found to be the most influential factor on household's daily gas consumption. Finally, the demand side management stimuli employed in the Smart Metering Trial were found to reduce daily household gas use on average.

1. Introduction

Residential natural gas consumption in Ireland has grown considerably in recent years. According to the Sustainable Energy Authority of Ireland, natural gas as a share of total residential energy consumption increased from 5.2% to 20.1% over the period 1990–2011 (SEAI, 2012), while the penetration of natural gas fired central heating systems into Irish houses has grown from 4% in 1987 to 28% in 2005 (SEI, 2008). In 2011, the residential sector in Ireland used 569 kilo tonnes of oil equivalent (ktoe) of natural gas compared to just 117 ktoe in 1990 (SEAI, 2012). The remarkable growth in residential natural gas consumption in Ireland has been attributed to a number of factors including the large increase in the Irish housing stock since 1990, expansion of the gas network and a preference for natural gas on the part of residential users.

A better understanding of residential demand for natural gas can be of assistance to suppliers, policymakers and ultimately customers. Suppliers need accurate forecasting models of residential gas demand to support efficient purchasing of gas supplies and to plan future investment in the face of changing demographics, fuel prices, macroeconomic conditions and energy policy measures. Such models exist, but they tend to be based on the analysis of annual micro-data and there is a scope to improve these models using micro-data linking detailed household and socio-economic characteristics to daily gas use. Policymakers also have an interest in domestic fuel demand, because it contributes a significant proportion to national energy use and greenhouse gas emissions. The residential sector in Ireland emitted 1359 kilo tonnes of CO_2 from natural gas consumption alone in 2011, a 13% share of the overall energy-related household CO_2 emissions for that year (SEAI, 2012). Residential heating, apart from that contributed by electricity, also falls outside the boundaries of the Europe's Emission Trading Scheme, in a segment where there is not (yet) a common, consistent set of economic measures to provide incentives for carbon abatement across Europe. Overlapping policies towards carbon abatement, energy efficiency and encouragement of renewable fuels complicate the policy space in this area.

To curb carbon emissions and increase energy efficiency, policymakers employ a range of measures intended to change aspects of consumer behaviour. This may include encouragement of fuel switching, increased energy efficiency or changes in other aspects of behaviour that lead to lower fuel use. Better understanding the determinants of gas demand should help with the development of more effective and efficient policy measures. Information about consumer behaviour is particularly important when designing demand side programmes. These are used in some jurisdictions to bring about behavioural change among consumers, aiming to reduce fuel consumption by either improving the information available to households on potential energy efficiency opportunities or by giving them a financial incentive to decrease their overall household gas use. It is important for energy policy to investigate the usefulness of such programmes in reducing household gas consumption and to incorporate the factors affecting daily gas demand into programme design in order to maximise the potential impact on consumer behaviour.

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In this paper, the determinants of residential gas demand in Ireland are examined using a micro-econometric analysis of the gas consumption panel data from Ireland's Smart Metering Gas Consumer Behavioural Trial (CER, 2011). It is unusual for studies of gas demand to have access to such high frequency usage data combined with socioeconomic micro-data. With the majority of residential gas consumption in Ireland used for space and water heating, gas demand is expected to be determined to a large extent by the energy efficiency of gas using appliances and dwellings, as well as the socio-economic characteristics of the household. It is also anticipated that weather will have a significant role in determining household gas demand. For example, gas consumption reportedly experienced an unusual increase in 2010 as a result of two exceptionally cold spells at the beginning and end of the year.

This paper aims to provide evidence that the energy efficiency of the dwellings, together with the socio-economic characteristics of the households and the weather are indeed important factors in determining daily residential gas demand and should, for that reason, be taken into account in gas demand forecasting. In addition, this paper explores the impact of socio-economic factors on household consumption of gas and investigates the demand side management stimuli tested during the Smart Metering trial, demonstrating their effectiveness in reducing household gas consumption through the implementation of a differences in differences estimation of the gas savings.

The paper proceeds as follows: the related literature is reviewed in Section 2, the data and variables used are described in Section 3, details of the models used for estimation are specified in Section 4, results are presented in Section 5, and Section 6 provides a conclusion.

2. Literature

Much of the literature on residential gas demand focuses on estimating elasticities of demand using time-series data. For example, Bernstein & Madlener (2011) analyse residential natural gas demand in 12 OECD countries including Ireland from 1980 to 2008 and find that the long run price elasticity for Ireland is −1.62, while the long run income elasticity is 1.72. On average across all the countries, the long run elasticities with regard to price and income are found to be −0.51 and 0.94 respectively, with Ireland being the most elastic of the 12 countries in this analysis. Asche et al. (2008) report that the own-price elasticity of natural gas is very inelastic in the short run, though it does demonstrate greater responsiveness in the longer run. This is most likely due to the limited substitution possibilities between different fuels in the short run. In considering the ownership of energy-using durables and the demand by individual households in the UK for gas and electricity, Baker & Blundell (1991) use data pooled from the family expenditure survey (FES) over the period 1972 to 1988. They also report demand for natural gas to be generally price inelastic.

While there is a limited body of research which specifically examines the determinants of residential gas demand, some important related research has been conducted in the area. For example, Brounen et al. (2012) examine the extent to which gas and electricity use in the Netherlands is determined by household and individual characteristics. They found that residential gas consumption was driven largely by dwelling characteristics, with older and bigger homes found to consume more gas. They also note that insulation had a significant effect on gas consumption by households and that "residents living in a well-maintained and insulated home consume about 12% less natural gas compared to the same home with a lower level of maintenance and insulation" (Brounen et al., 2012). Interestingly, it was found that each additional person in a household decreases the per capita gas consumption by roughly 26%. According to the authors, "this reaffirms the well documented economies of scale in residential energy consumption" (Brounen et al., 2012). On the other hand, single-parent and elderly households were found to use more natural gas per capita. This is consistent with findings from a study of demand for space and water heating by older households in the United States. In particular, Liao & Chang (2002) reported that most elderly households spend a significant amount of their income on space heating energy and as the household head becomes older more heating energy is required.

In another study, Leth-Peterson (2002) conducted a micro-econometric analysis of household demand for natural gas for a cross-section of 2885 Danish households. The year in which the house was built as well as the house type were found to be important determinants of gas demand. The consumption of natural gas in non-detached houses was found to be 4% lower than in detached houses. In an analysis of residential heating consumption in the Netherlands, Guerra-Santin & Itard (2010) found that the frequency of use of the heating system was a much stronger determinant than temperature settings in explaining energy consumption by households. Interestingly, they found that "households with a programmable thermostat were more likely to keep the radiators turned on for more hours than households with a manual thermostat or manual valves on radiators." Karjalainen (2007) found significant gender differences in thermal comfort, with females preferring a higher room temperature than males. However, males tend to use thermostats more often than females in their sample.

In contrast to residential natural gas demand, there is a larger literature on energy demand for residential space and water heating more generally. For example, Rehdanz (2007) studies the determinants of household expenditure on space heating and hot water supply in Germany in an attempt to establish if different types of households respond differently to changes in energy prices. The analysis covers more than 12,000 households for the years 1998 and 2003. The author points out that energy price increases lead to higher expenditures for households in rented accommodation compared to households in owner occupied accommodation with the difference becoming smaller over time. This suggests that home owners are more likely to have invested in energy efficient heating and hot water systems and, furthermore, that landlords have very little incentive to improve the energy efficiency of rented accommodation as their tenants pay the energy bills. In a replica study for Great Britain, Meier & Rehdanz (2010) utilise panel data over 15 years from 1991–2006 on over 5000 households and discover the opposite result. The study finds that heating expenditure for home owners tend to be higher than for renters. Heating expenditures are lowest for flats compared with households living in other house types and as the majority of rented accommodations in Britain are flats, this explains the contradicting result.

In examining residential energy consumption for space heating in Norwegian households, Nesbakken (2001) confirms that house type, dwelling size and temperature (degree days) are important in explaining energy demand in households. Furthermore, Druckman & Jackson (2008) explore patterns of UK household energy use at high levels of socio-economic and geographical disaggregation. Their results show that rural/urban location is also an important factor in household energy consumption. In a study examining the effect of a major energy efficiency refurbishment programme on domestic space heating fuel consumption in English dwellings, Hong et al. (2006), using data collected from 1372 households participating in the "Warm Front" energy efficiency scheme, found that attic and cavity wall insulation appeared to reduce space heating fuel consumption by 10–17%.

Another strand of literature in this area investigates the impact of weather on demand for energy. For example, Conniffe (1996) developed a model to help explain how daily demand for fuel by the domestic and commercial sectors in Ireland varies from day to day in response to different factors including meteorological variables. The author estimates the model for natural gas and establishes that temperature measured as degree days is non-linear in the demand for gas. He also found that wind speed and sunshine hours have substantial effects on gas demand, while the significance of rainfall is much less pronounced in the model. Tol et al. (2012) also find that energy use is non-linear in temperature and that it declines with rising temperatures due to the decreased demand for heating.