Working Paper No. 533

May 2016

An Examination of the Abandonment of Applications for Energy Efficiency Retrofit Grants in Ireland

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Subsequently published in "An examination of the abandonment of applications for energy efficiency retrofit grants in Ireland", *Energy Policy*, Vol. 100, January, 2017, pp. 260-270, http://dx.doi.org/10.1016/j.enpol.2016.10.030

Abstract: The Sustainable Energy Authority of Ireland (SEAI) operates the Better Energy Homes (BEH) grant scheme to incentivise residential energy efficient retrofits, an ongoing scheme which was implemented in 2009. This scheme provides a financial incentive for home owners to engage in energy efficient retrofits, provided the upgrades meet appropriate energy efficiency standards. This study analyses the BEH data, which is comprised of all applications from March 2009 to October 2015, in order to examine the extent to which applications are abandoned and the determinants thereof. We find that more complicated retrofits are more likely to be abandoned, with variation across certain retrofit measure combinations. We find lower probabilities of abandonment among certain obligated parties, who are energy retailers obliged by the State to reduce energy consumption in Ireland, while others possess greater likelihoods of abandonment, relative to private retrofits. We find that newer homes are less likely to abandon an application than older homes, as are applications made for apartments, relative to houses. Regional variations exist in abandonment, with rural households more likely to abandon than urban households. A seasonal trend in abandonment is also present, with higher likelihoods of abandonment among applications made during winter.

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Keywords: energy efficiency, abandonment, energy retrofits

Acknowledgements: We acknowledge the Sustainable Energy Authority of Ireland for access to the anonymous dataset of Better Energy Homes scheme applications. This research has been financially supported by Sustainable Energy Authority of Ireland and the Energy Policy Research Centre. We thank contributors at SEAI, participants to the Irish Economic Association annual conference and others for helpful comments and suggestions.

1 Introduction

Under the European Union's Energy Efficiency Directives, Ireland is obliged to promote energy efficiency and achieve a targeted reduction in energy consumption of 20% by 2020 (European Parliament and the Council of the European Union, 2012). Improving the energy efficiency of the nation's building stock is one policy aim of the Irish government (DCENR, 2014). Nearly 40% of final energy consumption in the EU occurs in buildings, with two thirds of residential consumption used for space heating (European Commission, 2011), providing a significant opportunity for policy to improve residential energy efficiency. Many European governments offer financial incentives for residential retrofit measures. Examples include the UK's recently concluded green deal, providing up-front finance for retrofit measures, to be paid back through savings on energy bills, and France's *crédit d'impôt développement durable*, a tax credit available for heating and energy conservation works on the home. Grant aid is offered by the Sustainable Energy Authority of Ireland (SEAI) to homeowners who wish to undertake retrofit measures to improve the energy efficiency of their home. This scheme has been successful in aiding the completion of over 160,000 retrofit installations since the introduction of the scheme in 2009, but achieving the national target of energy savings equivalent to a 20% reduction on historic energy demand is ambitious and ultimately will require either more homes to improve or for homes to engage in more comprehensive retrofits. With a view to engaging more homes in energy efficiency retrofits, of all households applying to the Better Energy Homes (BEH) scheme to date, 15% abandon their application. To help drive residential retrofitting activity, it is therefore important to gain a greater understanding of why some homes are disengaging from the BEH scheme subsequent to submitting their applications.

This research aims to gain an understanding of the characteristics of households who make a decision to engage in an energy efficient retrofit but, after applying for grant aid, abandon their application. This abandonment could be either through cancellation or by allowing an application to expire and not making any subsequent applications. This research also explores the role of obligated parties in engaging households through the BEH scheme. Obligated parties are energy distributors and retailers who are obliged by the Irish government to achieve energy savings of 1.5% each year through energy efficient measures, and contribute to Energy Efficiency Directive targets (DCENR, 2014). This process is described in more detail in section 2. Given the heterogeneity in household characteristics and behaviours, it is unclear which households are less likely to follow through with the installation of energy efficient measures (EEMs). By gaining such an insight, it may be possible to identify households which may require greater support following application to the scheme, thus helping to achieve more energy efficiency savings.

There exist many benefits to engaging in retrofit measures in the home, most notably the reduction in energy costs, increased comfort, environmental benefits (Clinch and Healy, 2000; Gillingham et al., 2009), health benefits (Howden-Chapman et al., 2012) and in many cases, an increased sale value of the property (Hyland et al., 2013). Previous literature has explored the drivers of energy efficient retrofit behaviour. These include socio-economic conditions and specific household characteristics (Cameron, 1985), the cost and profitability of the home retrofit investment (Amstalden et al., 2007; Sadler, 2003) and the availability of financial subsidies (Neuhoff et al., 2012). Specifically in the Irish context, it has been found that the decision to invest in Energy Efficiency Measures (EEMs) is determined mainly by the cost of investment and gains in energy savings, followed by comfort gains. Moreover, environmental benefits were found to be of little concern (Aravena et al., 2016).

While a wider range of literature exists on the decision by households to engage in energy efficient retrofits, little exists with regard to those who are interested in retrofitting, but ultimately do not implement the desired measures. Many barriers to investing in energy efficient technology exist, both for households and organisations. Sorrell et al. (2000) discuss barriers to energy efficiency in public and private organisations, the findings of which may also be applied to households, dividing these barriers into three categories, being economic, behavioural and organisational barriers. Economic barriers include the neo-classical barriers to trade, such as imperfect information, access to capital and hidden costs. Organisational barriers include power-related and culture-related barriers. Power-related barriers, in the case of residential retrofits may be that those who would like to engage in retrofitting may not be the key household decision maker, or could be tenants in a rental property where the landlord or owner prevents investment. Culture also has a large effect. For example, if energy efficiency or environmental concerns are not seen as priorities, individuals will be less likely to invest. Behaviourally, bounded rationality and cognitive limitations may prevent a thorough understanding of the benefits of retrofit investments, leading to excessive discounting of future benefits. Inertia, lack of environmental awareness and lack of trust for a source of information may also inhibit energy efficient investments. Of these barriers, much research has underlined the importance of the lack of information and incentives as barriers to investment in residential energy efficiency (Henryson et al., 2000; Clinch and Healy, 2000; Caird et al., 2008; Jaffe and Stavins, 1994; Mills and Schleich, 2012). In the context of this research, these barriers have been either fully or partially overcome as homeowners have become engaged with the BEH scheme. Subsequent factors therefore lead to abandonment.

A narrow range of abandonment literature exists, spanning various domains, although common methods of analysis are used. Phillips and Zhao (1993) examine the abandonment of assistive technology for people with disabilities, using a logistic regression to investigate the determinants of abandonment. Volden (2007) also uses a logistic regression model to analyse the likelihood that a state will abandon a policy action depending on inherent state characteristics and the success or failure of similar policies in neighbouring states. In terms of application abandonment, Lemley and Sampat (2008) descriptively analyse the abandonment of patent applications, looking at the proportion of applications which were abandoned in the US across various applicant characteristics. Looking specifically at abandonment of energy efficient retrofit applications, Aravena et al. (2016) analysed survey data collected from participants in the BEH scheme in 2009. This research found that the main barriers to retrofit implementation were a lack of own funds, other priorities and the perception that a retrofit investment would not provide value for money. It was also shown, using a probit regression model, that those who noted environmental benefits as a reason for pursuing a retrofit were slightly more likely to abandon. One key difference between this work and Aravena et al. (2016) is that we examine the actual behaviour of the population of BEH applications, as opposed to a stated preferences approach which examined a subset of BEH applicant households.

The remainder of the paper is organised as follows: Section 2. provides a description of the BEH data. Section 3. contains a discussion of modelling and estimation issues. This is followed by the presentation and discussion of the estimation results in Section 4., while Section 5. concludes.

2 Descriptive Analysis

The Better Energy Homes scheme, originally known as the Home Energy Savings scheme, was developed by the Sustainable Energy Authority of Ireland (SEAI) and, following a pilot in 2008, began in March 2009. It is a grant aid scheme for households to engage in energy efficiency improvements, with grants available for various EEMs. Grants are available for roof/attic insulation, one of three types of wall insulation (cavity insulation, external wall insulation or internal dry-lining), three types of boiler upgrade (oil boiler or gas boiler with heating controls upgrade or heating controls upgrade only) and solar collector (panel or tube) installation. This means that a household may adopt up to a maximum of four EEMs as only one type of wall insulation or boiler upgrade may be awarded grant aid. Upgrades must meet SEAI standards for grant applications to be successful. For the purposes of our analysis, we view both types of solid wall insulation (external insulation and internal dry-lining) and both types of boiler upgrade (oil or gas boiler) as one measure, referred to in future as solid wall insulation and boiler upgrades. The level of grant aid available has changed over time, with information on the dates of these amendments and the changes made detailed in Table 1. As part of the application process, certain information on the household is required, alongside estimation of the energy efficiency of the applicant property and an assessment of the energy efficiency of the property following adoption of the relevant EEMs. This provides a detailed dataset, including information on the EEMs adopted, the household and the contracting arrangement in place for EEM adoption.

Table 1: Grant Structure

Measure	Category	Scheme 1 Mar-09 €	Scheme 2 Jun-10 €	Scheme 3 May-11 €	Scheme 4 Dec-11 €	Scheme 5 Mar-15 €
Roof	Attic Insulation	250	250	200	200	300
Wall	Cavity Wall Insulation	400	400	320	250	300
	Internal Dry-Lining	2500	2500	2000	.	.
	Apartment or Mid-terrace House	.	.	.	900	1200
	Semi-detached or End of Terrace	.	.	.	1350	1800
	Detached House	.	.	.	1800	2400
	External Wall Insulation	4000	4000	4000	.	.
	Apartment or Mid-terrace House	.	.	.	1800	2250
	Semi-detached or End of Terrace	.	.	.	2700	3400
	Detached House	.	.	.	3600	4500
Heating Controls	High efficiency boiler (oil or gas) upgrade with heating controls	700	700	560	560	700
	Heating Controls upgrade only	500	500	400	400	600
	Solar Heating	.	.	800	800	1200
BER	Before & After Building Energy Rating	100	.	.	.	.
	After Works Building Energy Rating	.	100	80	50	50
Bonus	Bonus for 3rd measure	.	.	.	.	300
	Bonus for 4th measure	.	.	.	.	100

Our dataset considers all first-time applications from March 2009 to March 2015, inclusive. Additional data available to October 2015 were excluded as abandonment of applications from April 2015 onward could not be identified. The breakdown of first-time applications in our data is presented in Figure 1. As shown, 69% of applications were successful, with a further 2% partially successful and 3% ongoing upon receipt of the data. While 1% of

Table 2: Descriptive Statistics

	Observations	Proportion		Observations	Proportion
First-Time Applications			*Period of Construction*		
Not Fully Abandoned	192,771	0.8409	pre - 1900	6,887	0.0300
Fully Abandoned	36,475	0.1591	1901 - 1920	4,998	0.0218
	229,246		1921 - 1940	11,559	0.0504
Measures			1941 - 1960	22,638	0.0987
1	69,138	0.3016	1961 - 1980	66,873	0.2917
2	138,812	0.6055	1981 - 2000	83,675	0.3650
3	19,588	0.0854	2001 -	32,616	0.1423
4	1,708	0.0075		229,246	
	229,246		*Location*		
Combination			Greater Dublin Area	58,331	0.2544
Boiler	40,426	0.1763	Counties w/ City	73,491	0.3206
Solid Wall Insulation	13,694	0.0597	Border-Midlands-West (ex. G)	48,494	0.2115
Solar Collector	7,087	0.0309	South-East (ex. GDA,C,L,W)	48,930	0.2134
Attic + Cavity Insulation	115,010	0.5017		229,246	
Attic + Solid Wall Insulation	11,921	0.0520			
Attic + Cavity + Boiler	7,866	0.0343	*Island Status*		
Attic + Solid Wall + Boiler	6,236	0.0272	Mainland	228,956	0.9987
Attic + Cavity + Boiler + Solar	580	0.0025	Island	290	0.0013
Attic + Solid Wall + Boiler + Solar	834	0.0036		229,246	
Other (1 EEM)	7,931	0.0346	*Obligated Party Status*		
Other (2 EEMs)	11,881	0.0518	Private	214,734	0.9367
Other (3 EEMs)	5,486	0.0239	OP 1	1,545	0.0067
Other (4 EEMs)	294	0.0013	OP 2	411	0.0018
	229,246		OP 3	10,271	0.0448
Scheme			OP 4	1,581	0.0069
1	73,299	0.3197	OP 5	356	0.0016
2	62,873	0.2743	OP 6	348	0.0015
3	34,582	0.1509		229,246	
4	57,473	0.2507	*Season*		
5	1,019	0.0044	Winter	64,351	0.2807
	229,246		Spring	55,360	0.2415
			Summer	48,899	0.2133
Dwelling Type			Autumn	60,636	0.2645
House	223,970	0.9770		229,246	
Apartment	5,276	0.0230			
	229,246				

	Observations	Mean	Std. Dev.	Min	Max
GDP (000,000)	229,246	36,300	1,690	34,700	42,700

applications were declined, 10% were abandoned with the household subsequently re-applying and the remaining 15% were completely abandoned, i.e. the household did not make any subsequent applications through the BEH scheme. We thus analyse the likelihood of the complete abandonment of first time applications. Using unique household identifiers, these applications are such that have been cancelled, or allowed to expire by the household, without any further applications from that household occurring in the data.

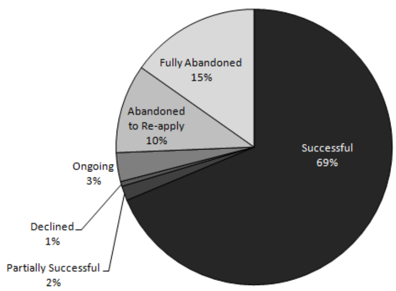

Figure 1: Breakdown of first-time applications

Information is also provided on the location of the household, on a county by county basis. In order to look at regional variations and variations between urban and rural areas, we have divided applications into four categories. The first of these is the Greater Dublin Area (Dublin, Meath, Kildare and Wicklow). Secondly, as a proxy for urban areas, we have identified the four largest urban areas outside of the GDA and categorised applications from the counties in which these cities are located (Cork, Limerick, Galway and Waterford). The remaining applications were then divided by regional assembly, being the South and East NUTS II region (excluding the GDA, Cork, Limerick and Waterford) and the Border Midlands West NUTS II region (excluding Galway). Also provided are the type of dwelling, i.e. house or apartment, and whether the dwelling is located on an island, in which case households are entitled to 150% of the grant aid available. Information on which EEMs a households intends to adopt and the date of application are included.

As a proxy for income over time, we include data on GDP at the month of application, measured in constant 2013 euro. It may be noted that for model estimation, GDP has been standardised about zero. This allows the estimated coefficients of these variables to be interpreted relative to the standard case, where continuous variables are at their mean values. Descriptive statistics are presented in Table 2.

With regard to the contracting relationship, the majority of applications are made privately, with a household first contacting a SEAI registered contractor, before applying for the grant. The contractor then installs the relevant EEMs, which is followed by a BER assessment and processing of the grant application. Other applications are made via 'obligated parties' and 'counterparties'.

Obligated parties are energy distributors and retail energy sales companies. The Energy Efficiency Obligation Scheme, pursuant to the EU Energy Efficiency Directive, imposes a legal obligation on member States to reduce annual energy sales to final consumers by 1.5% by 31 December 2020 (European Parliament and the Council of the European Union, 2012). The State requires obligated parties to reach certain energy targets, 20% of which must be achieved by reducing residential energy consumption (SEAI, 2014). The remaining 80% is divided into 5% energy poor residential and 75% non-residential. The obligated parties are SSE Airtricity, Bord Gáis Energy, Bord na Móna, Calor Gas, Electric Ireland, Energia, Flogas, Gazprom, Lissan Coal

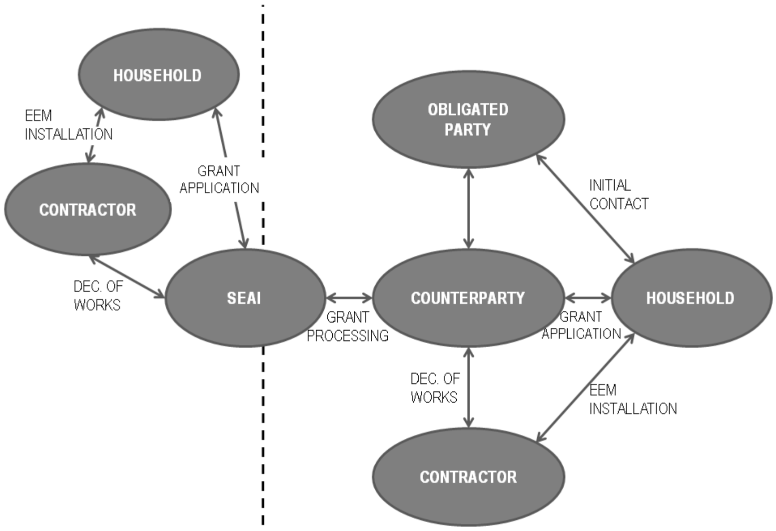

Figure 2: Obligated Parties and their Relationships

Company, Enprova/REIL and Vayu[1]. Of these 11 parties, six have engaged customers via the BEH scheme. Within our dataset, obligated parties have unique, anonymous identifiers.

Counterparties facilitate grant applications, interacting with the relevant obligated party, home owner, contractor and SEAI. These counterparties are related to obligated parties and are set up as a means of incorporating the grant application process into their own service offerings. In our dataset, all applications made via an individual obligated party are also made via the same counterparty. In our dataset, most obligated parties appear to possess a relationship with an individual counterparty, which processes all applications made via that obligated party. Obligated parties may use more than one counterparty but in the period examined, only one obligated party used more than one counterparty.

In the context of the BEH scheme, the relationship between these obligated parties and others involved in the grant process is described in Figure 2. As shown on the right of the figure, obligated parties make initial contact

[1]Retrofit Energy Ireland Limited (REIL) is an obligated party, representing the Irish oil industry, for which Enprova is a designated counterparty. All other obligated parties are individual energy distributors and retail energy sales companies. For further information see `http://www.seai.ie/eeos/`

with households offering EEMs in the home. If a household is interested in EEM adoption, the obligated party will then engage a counterparty to contact the household with regard to EEM installation. The counterparty will then assign a contractor to complete the works and process the grant application on behalf of the SEAI, who will then award the relevant grant aid, provided the required standards are satisfied. Private applications, which are more common, are illustrated on the left of Figure 2. Households engage contractors to install EEMs and apply for a BEH grant, once the installation is complete the grant application is processed.

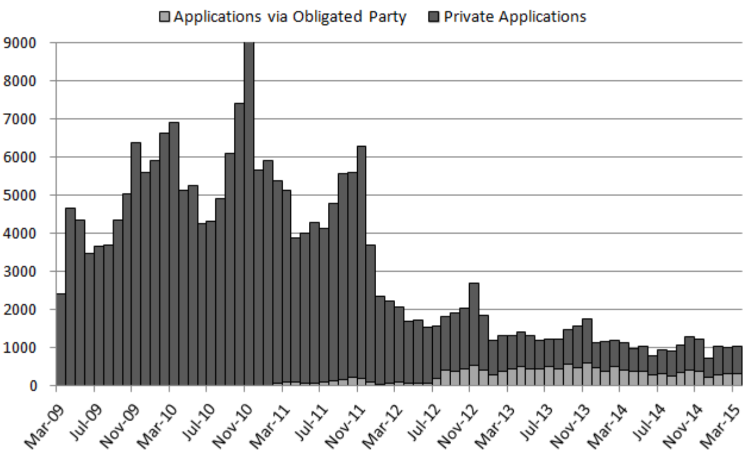

Figure 3: First-time applications to the BEH scheme(by month)

Following implementation of the BEH scheme in March 2009, an average of over 5,000 applications from unique households were received each month to the end of 2011. As shown in Figure 3, this was followed by a significant reduction in applications, falling to an average of 1,294 first-time applications each month, from January 2012 to September 2015. The first set of applications made via obligated parties and counterparties were received in February 2011 and the number of applications received in this manner was quite variable for the following eighteen months before rising to a steady level of approximately 350-400 applications each month from mid-2012 onward. As the total number of applications each month fell, and the number of applications made through obligated parties/counterparties rose, these applications amounted to an average of 33% of first-time applications each month from July 2012 onward.

Figure 4. illustrates the rate at which first-time applications were aban-

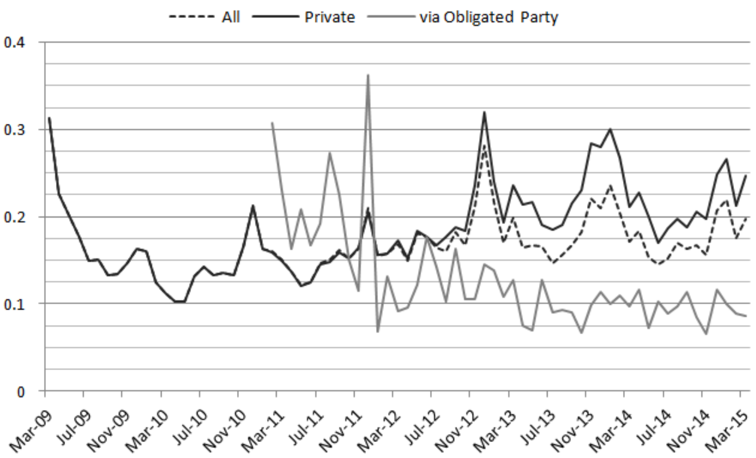

Figure 4: Abandonment rates of first-time applications (by month)

doned across the lifespan of the BEH scheme. As can be seen, abandonment rates fell from an initial rate of around 30% to a reasonably steady rate between 10% and 20% until mid-2012. From mid-2012 onward, overall abandonment rates have varied between 20% and 30%. Abandonment of applications made via obligated parties were quite variable during 2011 and 2012 but from mid-2012 have fallen to steadier levels of between 7.5% and 15%, remaining lower than private applications. A seasonal trend also appears to be present for private applications, rising during winter months, although this is not clear in obligated party applications.

3 Methodology

3.1 Modelling the Likelihood of Abandonment

Like Aravena et al. (2016) and Wilson and Dowlatabadi (2007), we see EEM investments as a multi-stage process. This investment process begins with the decision to retrofit and the evaluation of the type of retrofit required, i.e. which EEMs to adopt. In the Irish context, this may be followed by the grant application stage whereby, prior to EEM installation, households apply for grant aid through the BEH scheme. If approved, the next stage is comprised of the decision to complete the retrofit. This is the stage at which this paper is concerned. As discussed in section 1, various barriers to completion exist and, with 15.8% of all first-time applicants abandoning their applications, we investigate abandonment behaviour as a function of applicant characteristics.

Once a grant application has received initial approval, we investigate the probability that a household will choose to abandon their application. This probability is expressed as follows:

$$Pr(abandonment_{ijm} = 1) = f(Z_i, M_i, R_i, C_j, O_m) \tag{1}$$

Where Z_i is a vector of household characteristics. This includes technical characteristics such as the age of a dwelling, and the preferences of the household, which vary by household depending on opportunity costs, behavioural biases such as non-standard beliefs and preferences (DellaVigna, 2007) and the disruptive impact of retrofit installation. M_i represents the characteristics of the retrofit, including the types of EEM and retrofit intensity for which grant aid was applied. R_i represents the regulatory conditions, such as the amount and structure of grant aid available and minimum retrofit standards required for grant application success. C_j is a vector of characteristics of the contractor and O_m a vector of characteristics of the obligated party involved, where applicable. To specify our model we define a matrix X_{ijm}, comprising factors affecting the application abandonment decision, such as Z_i, M_i, R_i, C_j and O_m:

$$Pr(abandonment_{ijm} = 1) = Y_{ijm} = f(X_{ijm}) \tag{2}$$

This paper aims to gain a greater understanding of the relationship between these characteristics and the decision to abandon an application for energy efficient retrofit funding. We do this by specifying a logistic regression model, which is described next.

3.2 Logistic Regression

As the choice between whether to fully abandon an application or not is a binary choice, a logistic regression model is used to model the probability that a household will abandon.[2] This probability is measured as follows:

$$Y_{ijm} = \frac{e^{(\Sigma \beta_{ijm} X_{ijm})}}{1 + e^{(\Sigma \beta_{ijm} X_{ijm})}} \tag{3}$$

where X_{ijm}, as discussed in section 3.1. For the purposes of interpretation, odds ratios are estimated for the above equation. Odds ratios show the

[2] A probit regression was also considered but this did not cause any significant changes to the estimates of the model.

odds of an abandoned application for a one unit increase in the associated explanatory variable. [3]

4 Results and Discussion

As we are using data on actual behaviour, we also avoid a common limitation of energy efficiency research, which is the reliance on the use of stated preference data about energy efficiency upgrades (Wilson et al., 2015). We are able to use revealed preference data to identify variations in household behaviour across the population of applicants to the BEH scheme, providing new information on abandoned application within the scheme context. Table 3 presents the odds ratios of the estimated coefficients of the model, controlling for retrofit intensity. Model 1 is the baseline specification of the model, looking at all obligated parties across the lifespan of the BEH scheme, while model 2 controls for the first six months of an obligated party's activity. This allows us to examine whether obligated parties possess a learning phase with regard to improving their application completion rates. The dummy variable 'New' controls separately for each party's first six months of activity in the BEH scheme. Model 3 looks at all obligated parties as one, using indicator variables for applications made via an obligated party during its first six months of activity and thereafter.

Looking at the number of retrofit measures undertaken, relative to one-measure retrofits, two-measure retrofits are less likely to be abandoned, while 3- and 4-measure retrofits are more likely to be abandoned. It may be reasonable to assume that among the reasons why 3- and 4-measure retrofits are more than 3 times more likely to be abandoned compared to 1 measure retrofits is due to the greater levels of disruption and expense.

Looking at obligated parties, as shown in models 1 and 2, applications made via obligated party 1 (OP1) are found to be between 28% and 40% more likely to be abandoned, while OPs 3, 4, 5 and 6 possess lower probabilities of abandonment, relative to private applications. Controlling for the first six months of an obligated party's activity, applications made via these newly active obligated parties are much more likely to be abandoned. Considering all obligated parties together, there is clear evidence that obligated parties learn over time, as they improve their ability to complete works in the context

[3] See Hosmer Jr and Lemeshow (2004) for further discussion of odds ratios and their calculation

Table 3: Odds ratios of determinants of application abandonment

	(1)		(2)		(3)	
Measures (ref=1-EEM)						
2	0.930***	(0.0135)	0.929***	(0.0135)	0.917***	(0.0133)
3	3.577***	(0.0676)	3.574***	(0.0676)	3.536***	(0.0667)
4	3.025***	(0.156)	3.021***	(0.156)	3.013***	(0.156)
Scheme						
2	0.980	(0.0166)	0.977	(0.0165)	0.988	(0.0167)
3	1.048*	(0.0212)	1.049*	(0.0213)	1.076***	(0.0217)
4	1.348***	(0.0275)	1.344***	(0.0276)	1.337***	(0.0273)
5	1.433***	(0.127)	1.439***	(0.128)	1.426***	(0.125)
Year of Construction (ref=pre-1900)						
1901 - 1920	0.874**	(0.0388)	0.874**	(0.0388)	0.875**	(0.0388)
1921 - 1940	0.721***	(0.0267)	0.721***	(0.0267)	0.720***	(0.0267)
1941 - 1960	0.651***	(0.0218)	0.651***	(0.0218)	0.652***	(0.0219)
1961 - 1980	0.565***	(0.0173)	0.565***	(0.0173)	0.567***	(0.0173)
1981 - 2000	0.531***	(0.0161)	0.530***	(0.0161)	0.532***	(0.0162)
2001 -	0.647***	(0.0210)	0.646***	(0.0210)	0.647***	(0.0210)
Region (ref=GDA)						
County with City	0.781***	(0.0128)	0.782***	(0.0128)	0.773***	(0.0127)
South East (ex. GDA,L,C,W)	0.834***	(0.0153)	0.836***	(0.0153)	0.827***	(0.0151)
Border Midlands West (ex. G)	1.161***	(0.0199)	1.164***	(0.0199)	1.150***	(0.0196)
Apartment	1.389***	(0.0491)	1.388***	(0.0491)	1.383***	(0.0488)
Island	1.149	(0.176)	1.148	(0.176)	1.149	(0.176)
GDP (z)	1.050***	(0.00918)	1.053***	(0.00932)	1.044***	(0.00909)
Obligated Party (ref=private application)						
New Obligated Party			2.811*	(1.142)	0.800***	(0.0462)
Exp. Obligated Party					0.529***	(0.0175)
OP1	1.413***	(0.0940)	1.287**	(0.101)		
OP2	1.122	(0.136)	1.242	(0.153)		
OP3	0.509***	(0.0178)	0.478***	(0.0187)		
OP4	0.180***	(0.0245)	0.177***	(0.0245)		
OP5	0.615**	(0.106)	0.527**	(0.112)		
OP6	0.635**	(0.0969)	0.286***	(0.106)		
New*OP1			0.504	(0.217)		
New*OP2			.	.		
New*OP3			0.494	(0.205)		
New*OP4			0.487	(0.410)		
New*OP5			0.578	(0.313)		
New*OP6			.	.		
Season (ref=Spring)						
Summer	0.923***	(0.0171)	0.920***	(0.0171)	0.916***	(0.0170)
Autumn	0.958*	(0.0175)	0.951**	(0.0175)	0.949**	(0.0174)
Winter	1.187***	(0.0197)	1.184***	(0.0197)	1.184***	(0.0197)

Standard errors in parentheses (*** p<0.01, ** p<0.05, * p<0.1) of the BEH scheme, with odds ratios falling from 0.8 to 0.529. Only OP1 appears to perform poorly relative to private applications.

Over the whole period of retrofit grant availability, the likelihood of abandonment did not vary significantly when moving from scheme 1 to scheme 2, but rose slightly during scheme 3. Schemes 4 and 5 have seen a progressive increase in the probability of abandonment. It may be possible that, as scheme 4 possessed the lowest levels of grant aid, more households were completing works outside of the BEH scheme. This would not explain, however, the further increase in the probability of abandonment during scheme 5, which possesses the highest level of grant aid. It may be more likely that an early adopter effect exists, in that early adopters applied for a BEH grant and subsequently completed works at a higher rate. With these early adopters having already completed works, it is possible that the households making subsequent applications do not consider an energy efficient retrofit to be as much of a priority and are thus less likely to complete their intended retrofit.

Looking at the year of construction of dwellings, relative to dwellings built up to and including 1900, there is a downward trend in abandonment probabilities across all twenty-year periods, except for dwellings built from 2001 onward. The downward trend may perhaps be due to the greater difficulty and disruption required to retrofit older homes, which are likely to be much less energy efficient prior to retrofit works. It is possible that the older cohorts of homes find it more difficult to meet the required energy efficiency standards, and thus abandon works or possibly have works done outside of the scheme to a lower standard and/or cost. With regard to 21st century homes, it is perhaps likely that, as the gains from retrofitting can be expected to be lower, households are less likely to implement retrofit measures, which is a presumption consistent with with the findings of Aravena et al. (2016), who found that greater savings potential increases the probability of completion. Inversely, lower savings potential should increase the likelihood of abandonment, as the returns to investment, both in terms of comfort improvements and energy savings, are lower for homes that are more energy efficient prior to works. Apartments are also more likely to abandon, while island dwellings were found to be no more or less likely to abandon than mainland dwellings.

Regionally, relative to the Greater Dublin Area, counties with a major city were less likely to abandon, with odds ratios of around 0.78. The South and East region has a lower likelihood of abandonment, while the opposite is true of the Border Midlands West region. This regional variation is perhaps due to lower incomes in the Border Midlands West region, as Aravena et al. (2016) found income to be a strong determinant of retrofit completion.

A seasonal time trend also appears to exist. Relative to applications made in spring, applications made during summer and autumn are less likely to be abandoned, while applications made in winter are almost 20% more likely to be abandoned. It may be possible that the disruption and discomfort caused by retrofit works are more of an issue during colder weather, acting as a deterrent to retrofit completion.

We also estimate our models controlling for specific combination of retrofit measures instead of for the number of measures undertaken. Table 4 shows the estimation results of these models, using the 9 most popular EEM combinations. As shown in Table 2, we treat internal dry-lining and external wall insulation as the same measure, named solid wall insulation, and we treat both gas boiler and oil boiler upgrades as the same measure, named boiler. We control for 1-EEM retrofits of boiler only, solid wall only and solar only, with all other measures categorised as other 1-EEM retrofits. We control for two 2-EEM combinations, attic and cavity insulation and attic and solid wall insulation. All other 2-EEM combinations are included as one variable, which we use as our reference category. The 3- and 4-EEM retrofits for which we control are more comprehensive combinations following from our 2-EEM retrofits, first adding boiler upgrades, and then adding boiler upgrades and solar installation. Again, other 3- and 4-EEM retrofits are categorised as other.

Models 4, 5 and 6 treat obligated parties in the same manner as Models 1, 2 and 3, respectively. The findings of these models generally confirm the findings of models 1-3 with regard to changes in grant levels, dwelling characteristics, obligated party behaviour and seasonal trends. A slight difference, however, exists when looking at regional variations and new insights are added when looking at combinations of EEMs.

The reduced likelihood of abandonment when moving from 1- to 2-EEM retrofits is likely due to the very low probability of abandonment of retrofits comprised of attic and cavity wall insulation, which made up 50% of all applications, as seen in Table 2. Only retrofits of attic insulation only, cavity insulation only and heating controls only were found to be less likely to be abandoned than attic and cavity insulation retrofits. Relative to attic and cavity retrofits, solid wall only or boiler only retrofits were the next least likely to abandon, respectively, followed by solar and then attic and solid

Table 4: Odds ratios of determinants of application abandonment

	(4)		(5)		(6)	
Measures (ref=Attic + Cavity)						
Boiler only	1.480***	(0.0270)	1.483***	(0.0271)	1.514***	(0.0276)
Solid Wall only	1.151***	(0.0331)	1.151***	(0.0331)	1.148***	(0.0329)
Solar only	1.658***	(0.0575)	1.680***	(0.0586)	1.680***	(0.0579)
Attic + Solid Wall	1.882***	(0.0495)	1.883***	(0.0496)	1.884***	(0.0496)
Attic + Cavity + Boiler	4.742***	(0.122)	4.744***	(0.122)	4.758***	(0.122)
Attic + Solid Wall + Boiler	4.198***	(0.126)	4.197***	(0.126)	4.216***	(0.126)
Attic + Cavity + Boiler+Solar	5.703***	(0.486)	5.706***	(0.486)	5.762***	(0.490)
Attic + Solid Wall + Boiler+Solar	3.343***	(0.249)	3.347***	(0.250)	3.380***	(0.252)
Other (1 EEM)	0.870***	(0.0336)	0.873***	(0.0337)	0.875***	(0.0338)
Other (2 EEMs)	2.393***	(0.0584)	2.399***	(0.0586)	2.411***	(0.0588)
Other (3 EEMs)	5.232***	(0.154)	5.234***	(0.154)	5.253***	(0.155)
Other (4 EEMs)	3.668***	(0.450)	3.673***	(0.450)	3.710***	(0.455)
Scheme						
2	1.010	(0.0172)	1.006	(0.0172)	1.017	(0.0173)
3	1.066**	(0.0221)	1.066**	(0.0221)	1.097***	(0.0225)
4	1.353***	(0.0280)	1.343***	(0.0280)	1.340***	(0.0278)
5	1.486***	(0.131)	1.485***	(0.132)	1.482***	(0.131)
Year of Construction (ref=pre-1900)						
1901 - 1920	0.883**	(0.0390)	0.883**	(0.0390)	0.884**	(0.0390)
1921 - 1940	0.745***	(0.0275)	0.745***	(0.0275)	0.746***	(0.0275)
1941 - 1960	0.708***	(0.0237)	0.708***	(0.0237)	0.710***	(0.0238)
1961 - 1980	0.636***	(0.0196)	0.636***	(0.0196)	0.638***	(0.0197)
1981 - 2000	0.610***	(0.0189)	0.609***	(0.0189)	0.611***	(0.0189)
2001 -	0.753***	(0.0250)	0.753***	(0.0250)	0.753***	(0.0250)
Region (ref=GDA)						
County with City	0.854***	(0.0143)	0.855***	(0.0143)	0.848***	(0.0142)
South East (ex. GDA,L,C,W)	0.924***	(0.0174)	0.926***	(0.0174)	0.920***	(0.0172)
Border Midlands West (ex. G)	1.251***	(0.0218)	1.254***	(0.0219)	1.243***	(0.0216)
Apartment	1.319***	(0.0472)	1.318***	(0.0472)	1.318***	(0.0472)
Island	1.117	(0.171)	1.116	(0.171)	1.115	(0.171)
GDP (z)	1.027**	(0.00904)	1.032***	(0.00919)	1.022*	(0.00896)
Obligated Party (ref=private application)						
New Obligated Party			2.783*	(1.133)	0.868*	(0.0502)
Exp. Obligated Party					0.532***	(0.0179)
OP1	1.426***	(0.0953)	1.350***	(0.107)		
OP2	1.060	(0.129)	1.148	(0.142)		
OP3	0.509***	(0.0182)	0.466***	(0.0186)		
OP4	0.210***	(0.0287)	0.207***	(0.0288)		
OP5	0.710*	(0.122)	0.607*	(0.130)		
OP6	0.677*	(0.103)	0.306**	(0.113)		
New*OP1			0.439	(0.190)		
New*OP2			.	.		
New*OP3			0.575	(0.239)		
New*OP4			0.461	(0.389)		
New*OP5			0.588	(0.319)		
New*OP6			.	.		
Season (ref=Spring)						
Summer	0.906***	(0.0169)	0.902***	(0.0168)	0.898***	(0.0167)
Autumn	0.962*	(0.0176)	0.951**	(0.0176)	0.951**	(0.0174)
Winter	1.217***	(0.0203)	1.211***	(0.0203)	1.212***	(0.0202)

Standard errors in parentheses (*** $p<0.01$, ** $p<0.05$, * $p<0.1$)

wall retrofits. Attic, cavity, boiler and solar combined were found to be the most likely to be abandoned, while attic, solid wall, boiler and solar combined were found to be less likely to be abandoned than both attic, wall and boiler combinations.

Obligated parties are again shown to possess a learning phase of six months of activity. The extent to which applications made via obligated parties during their first six months are more likely to be abandoned than private applications falls slightly. The odds ratio of abandonment of these early obligated party applications falls from 2.811 to 2.783, a very slight reduction. To test that six months is the most accurate estimation of the learning phase, we estimate our model using learning phases of between 2 and 12 months. The results of these estimations are shown in table 5. The increased likelihood of abandonment during the learning phase is statistically significant across phases of 2, 4 and 6 months, with the odds ratio varying between 2.695 and 3.105. There is no statistically significant evidence of variation in the likelihood of abandonment found for learning phases of 8 months or greater. We can therefore assume a learning phase of six months is the correct specification.

It is worth noting that, while variations exist in the probability of abandonment across obligated parties, the number of applications made made via certain obligated parties are quite low. Figure 5. shows the proportion of all first-time applications made via each party. For example, while applications made via obligated party 1 are more likely to be abandoned, this party contributes a very low number of applications and in some years has not been active in engaging homes in energy efficient retrofits. It may also be noted that obligated parties have not been particularly active during their first calendar year and thus, while abandonment rates are higher during a party's learning phase, this does not lead to a large number of abandoned applications. As obligated parties have improved in their ability to process applications through to completion over time, the proportion of applications made via obligated parties has also risen.

In terms of regional variation, controlling for retrofit combinations, the South and East region is again found to possess a statistically significant lower likelihood of abandonment, while the Border Midlands West region is found to possess an even higher relative likelihood of abandonment, relative to the GDA. Counties with a city are also confirmed to possess lower likelihoods of abandonment than the GDA, although this difference is reduced, with odds ratios rising to slightly over 0.92. We believe this provides evidence of lower

Table 5: Length of obligated party learning phase

	Model 5											
	2 Months		4 Months		6 Months		8 Months		10 Months		12 Months	
Measures (ref=Attic + Cavity)												
Boiler only	1.479***	(0.0270)	1.483***	(0.0271)	1.483***	(0.0271)	1.481***	(0.0271)	1.486***	(0.0272)	1.483***	(0.0271)
Solid Wall only	1.150***	(0.0330)	1.151***	(0.0331)	1.151***	(0.0331)	1.151***	(0.0331)	1.153***	(0.0331)	1.152***	(0.0331)
Solar only	1.663***	(0.0577)	1.681***	(0.0586)	1.680***	(0.0586)	1.685***	(0.0589)	1.686***	(0.0589)	1.673***	(0.0584)
Attic + Solid Wall	1.880***	(0.0495)	1.883***	(0.0496)	1.883***	(0.0496)	1.882***	(0.0496)	1.885***	(0.0496)	1.884***	(0.0496)
Attic + Cavity + Boiler	4.743***	(0.122)	4.747***	(0.122)	4.744***	(0.122)	4.739***	(0.122)	4.740***	(0.122)	4.736***	(0.122)
Attic + Solid Wall + Boiler	4.198***	(0.126)	4.196***	(0.126)	4.197***	(0.126)	4.193***	(0.126)	4.200***	(0.126)	4.196***	(0.126)
Attic + Cavity + Boiler+Solar	5.697***	(0.485)	5.708***	(0.486)	5.706***	(0.486)	5.703***	(0.486)	5.710***	(0.486)	5.703***	(0.486)
Attic + Solid Wall + Boiler+Solar	3.340***	(0.249)	3.347***	(0.250)	3.347***	(0.250)	3.343***	(0.249)	3.349***	(0.250)	3.343***	(0.249)
Other (1 EEM)	0.870***	(0.0336)	0.872***	(0.0337)	0.873***	(0.0337)	0.872***	(0.0337)	0.874***	(0.0338)	0.873***	(0.0337)
Other (2 EEMs)	2.393***	(0.0584)	2.400***	(0.0586)	2.399***	(0.0586)	2.397***	(0.0586)	2.400***	(0.0586)	2.396***	(0.0585)
Other (3 EEMs)	5.232***	(0.154)	5.233***	(0.154)	5.234***	(0.154)	5.232***	(0.154)	5.236***	(0.155)	5.232***	(0.154)
Other (4 EEMs)	3.665***	(0.449)	3.672***	(0.450)	3.673***	(0.450)	3.670***	(0.450)	3.677***	(0.451)	3.671***	(0.450)
Scheme												
2	1.007	(0.0172)	1.006	(0.0172)	1.006	(0.0172)	1.005	(0.0171)	1.004	(0.0171)	1.004	(0.0172)
3	1.067**	(0.0221)	1.067**	(0.0221)	1.066**	(0.0221)	1.062**	(0.0220)	1.059**	(0.0220)	1.059**	(0.0220)
4	1.351***	(0.0280)	1.344***	(0.0279)	1.343***	(0.0280)	1.341***	(0.0280)	1.336***	(0.0281)	1.340***	(0.0282)
5	1.486***	(0.132)	1.484***	(0.132)	1.485***	(0.132)	1.502***	(0.134)	1.456***	(0.129)	1.458***	(0.129)
Year of Construction (ref=pre-1900)												
1901 - 1920	0.883**	(0.0390)	0.883**	(0.0390)	0.883**	(0.0390)	0.883**	(0.0390)	0.883**	(0.0390)	0.883**	(0.0390)
1921 - 1940	0.745***	(0.0275)	0.745***	(0.0275)	0.745***	(0.0275)	0.745***	(0.0275)	0.745***	(0.0275)	0.746***	(0.0276)
1941 - 1960	0.708***	(0.0237)	0.708***	(0.0237)	0.708***	(0.0237)	0.708***	(0.0237)	0.708***	(0.0237)	0.708***	(0.0237)
1961 - 1980	0.636***	(0.0196)	0.636***	(0.0196)	0.636***	(0.0196)	0.636***	(0.0196)	0.636***	(0.0196)	0.636***	(0.0196)
1981 - 2000	0.609***	(0.0189)	0.609***	(0.0189)	0.609***	(0.0189)	0.609***	(0.0189)	0.609***	(0.0189)	0.609***	(0.0189)
2001 -	0.753***	(0.0250)	0.753***	(0.0250)	0.753***	(0.0250)	0.753***	(0.0250)	0.753***	(0.0250)	0.753***	(0.0250)
Region (ref=GDA)												
County with City	0.854***	(0.0143)	0.855***	(0.0143)	0.855***	(0.0143)	0.855***	(0.0143)	0.855***	(0.0143)	0.855***	(0.0143)
South East (ex. GDA,L,C,W)	0.925***	(0.0174)	0.926***	(0.0174)	0.926***	(0.0174)	0.927***	(0.0174)	0.928***	(0.0174)	0.927***	(0.0174)
Border Midlands West (ex. G)	1.252***	(0.0218)	1.253***	(0.0219)	1.254***	(0.0219)	1.255***	(0.0219)	1.255***	(0.0219)	1.255***	(0.0219)
Apartment	1.319***	(0.0472)	1.317***	(0.0472)	1.318***	(0.0472)	1.319***	(0.0472)	1.318***	(0.0472)	1.318***	(0.0472)
Island	1.117	(0.171)	1.116	(0.171)	1.116	(0.171)	1.117	(0.171)	1.116	(0.171)	1.116	(0.171)
GDP (z)	1.028**	(0.00906)	1.031***	(0.00913)	1.032***	(0.00919)	1.034***	(0.00927)	1.037***	(0.00933)	1.035***	(0.00937)
Obligated Party (ref=private application)												
New Obligated Party	3.105*	(1.499)	2.695**	(0.832)	2.783*	(1.133)	0.937	(0.326)	0.798	(0.274)	1.090	(0.444)
OP1	1.362***	(0.0968)	1.359***	(0.102)	1.350***	(0.107)	1.118	(0.107)	1.227	(0.156)	0.927	(0.163)
OP2	1.062	(0.130)	1.089	(0.134)	1.148	(0.142)	1.198	(0.151)	1.253	(0.159)	1.316*	(0.169)
OP3	0.501***	(0.0181)	0.477***	(0.0180)	0.466***	(0.0186)	0.445***	(0.0187)	0.426***	(0.0190)	0.430***	(0.0202)
OP4	0.211***	(0.0287)	0.210***	(0.0287)	0.207***	(0.0288)	0.197***	(0.0290)	0.206***	(0.0304)	0.223***	(0.0333)
OP5	0.700*	(0.124)	0.599**	(0.118)	0.607*	(0.130)	0.725	(0.164)	0.793	(0.193)	0.660	(0.236)
OP6	0.612**	(0.0996)	0.413***	(0.0968)	0.306**	(0.113)	0.787	(0.299)	0.831	(0.312)	0.610	(0.266)
New*OP1	0.503	(0.264)	0.474*	(0.165)	0.439	(0.190)	1.784	(0.663)	1.556	(0.582)	1.544	(0.694)
New*OP2	.	.	.	.	.	.	0.0779*	(0.0837)	0.0689*	(0.0738)	0.0401**	(0.0438)
New*OP3	0.749	(0.395)	0.723	(0.235)	0.575	(0.239)	1.757	(0.623)	2.098*	(0.734)	1.378	(0.568)
New*OP4	.	.	.	.	0.461	(0.389)	1.671	(0.875)	1.310	(0.680)	0.624	(0.343)
New*OP5	0.435	(0.402)	0.919	(0.468)	0.588	(0.319)	.	.	.	.	.	.
New*OP6	.	.	.	.	.	.	.	.	.	.	.	.
Season (ref=Spring)												
Summer	0.904***	(0.0169)	0.901***	(0.0168)	0.902***	(0.0168)	0.903***	(0.0168)	0.908***	(0.0169)	0.907***	(0.0169)
Autumn	0.962*	(0.0176)	0.952**	(0.0175)	0.951**	(0.0176)	0.951**	(0.0175)	0.955*	(0.0175)	0.957*	(0.0176)
Winter	1.219***	(0.0204)	1.217***	(0.0203)	1.211***	(0.0203)	1.208***	(0.0203)	1.211***	(0.0203)	1.212***	(0.0203)

Standard errors in parentheses (*** p<0.01, ** p<0.05, * p<0.1)

probabilities of abandonment in urban areas, relative to rural areas.

5 Conclusion and Policy Implications

In order to help meet Ireland's obligated reduction in energy consumption, residential energy efficiency retrofits are required across much of the housing stock. To stimulate retrofitting activities, greater support could be provided to applicant households during the application process as a means of preventing abandonment. We examine the likelihood of application abandonment in an attempt to identify whether certain households are more likely to abandon an application than others or whether certain application types are more likely to be abandoned than others. We use Irish data to model the likelihood of abandonment of applications over the lifetime of the BEH scheme.

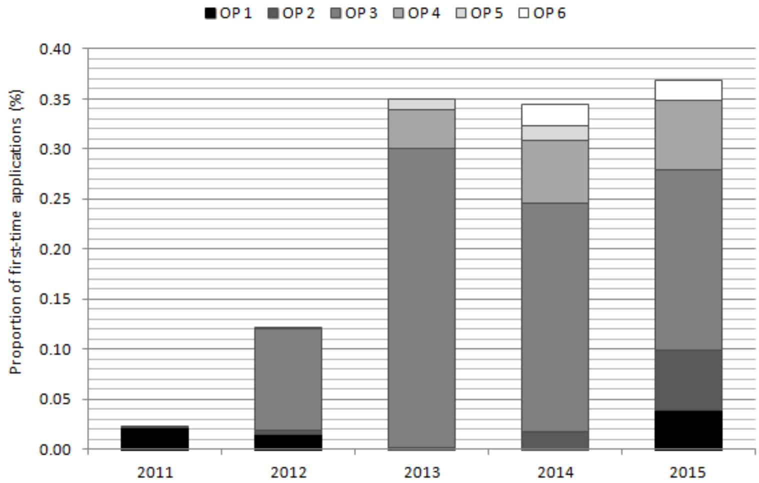

Figure 5: Proportion of first-time applications

Abandonment rates vary across obligated parties, with some showing much lower likelihoods of abandonment than private applications. Obligated parties possess a learning phase of six months, after which applications made via obligated parties are less likely to be abandoned than private applications. Attic and cavity insulation retrofits, which are the most popular combination, are relatively unlikely to be abandoned, while more comprehensive retrofit combinations are most likely to be abandoned. Rural households are more likely to abandon an application than urban households, while apartments are more likely to abandon than houses. Older dwellings are also more likely to abandon an application than newer dwellings.

We compliment the literature on the abandonment of energy efficient retrofit grant applications by introducing a revealed preference approach to measuring the likelihood of abandonment, based on characteristics of the application and applicant property. Various policy implications may be taken from the findings of this research. Reducing abandonment rates is an important policy aim given the need to increase the energy efficiency of the housing stock. As such, it is useful to look at which applications are least likely to be abandoned. As applications made via obligated parties are less likely to be abandoned, lessons may be learned from this type of contracting relationship. Perhaps an independent third party could be formed to facilitate applications made privately. This third party could act as a go-between for home owners, contractors and SEAI. This may be particularly useful for comprehensive retrofits, which are most likely to be abandoned. 3- and 4-

EEM retrofits often require more than one contractor to install the different measures, which may be difficult to manage for a home owner. The results of this analysis may be used to identify applications with a high level of abandonment risk. Administrators of the BEH scheme could therefore liaise with the owners of these homes to reduce the likelihood that they will abandon. Alternatively, a designated third party to aid these applications may improve completion rates for these more comprehensive retrofits. A party such as this may also be able to develop a network of contractors to perform works, which would lessen the likelihood of retrofits being completed outside of the BEH scheme to standards lower than the required levels for grant aid. A market solution could be found for these third parties to charge a commission to contractors, so as not to increase expenditures from SEAI, although incentives would likely be required to prevent these works occurring outside of the BEH scheme. Given the evidence of a learning phase for obligated parties, policy-makers could organise workshops for new obligated parties to advise on best practice or BEH administrators could liaise with new obligated parties during these six months to reduce abandonment rates during this period.

References

Amstalden, R. W., Kost, M., Nathani, C., and Imboden, D. M. (2007). Economic potential of energy-efficient retrofitting in the swiss residential building sector: the effects of policy instruments and energy price expectations. *Energy Policy*, 35(3):1819–1829.

Aravena, C., Riquelme, A., and Denny, E. (2016). Money, comfort or environment? priorities and determinants of energy efficiency investments in Irish households. *Journal of Consumer Policy*, pages 1–28.

Caird, S., Roy, R., and Herring, H. (2008). Improving the energy performance of uk households: Results from surveys of consumer adoption and use of low-and zero-carbon technologies. *Energy Efficiency*, 1(2):149–166.

Cameron, T. A. (1985). A nested logit model of energy conservation activity by owners of existing single family dwellings. *The Review of Economics and Statistics*, pages 205–211.

Clinch, J. P. and Healy, J. D. (2000). Domestic energy efficiency in Ireland: correcting market failure. *Energy Policy*, 28(1):1–8.

DCENR (2014). *National energy efficiency action plan 2014*. Department of Communications, Energy and Natural Resources. Available online http://www.dcenr.gov.ie/energy/SiteCollectionDocuments/Energy-Efficiency/NEEAP%203.pdf.

DellaVigna, S. (2007). *Psychology and economics: Evidence from the field*. National Bureau of Economic Research.

European Commission (2011). *Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions: Energy efficiency plan 2011*. COM(2011) 109 final. European Union.

European Parliament and the Council of the European Union (2012). *Directive 2012/27/EU of the European Parliament and of the Council of 25 October 2012 on energy efficiency, amending directives 2009/125/EC and 2010/30/EU and repealing directives 2004/8/EC and 2006/32/EC*. European Union.

Gillingham, K., Newell, R. G., and Palmer, K. (2009). *Energy efficiency economics and policy*. National Bureau of Economic Research.

Henryson, J., Håkansson, T., and Pyrko, J. (2000). Energy efficiency in buildings through information–Swedish perspective. *Energy Policy*, 28(3):169–180.

Hosmer Jr, D. W. and Lemeshow, S. (2004). *Applied Logistic Regression*. John Wiley & Sons.

Howden-Chapman, P., Viggers, H., Chapman, R., OâĂŹSullivan, K., Barnard, L. T., and Lloyd, B. (2012). Tackling cold housing and fuel poverty in New Zealand: a review of policies, research, and health impacts. *Energy Policy*, 49:134–142.

Hyland, M., Lyons, R. C., and Lyons, S. (2013). The value of domestic building energy efficiencyâĂŤevidence from Ireland. *Energy Economics*, 40:943–952.

Jaffe, A. B. and Stavins, R. N. (1994). Energy-efficiency investments and public policy. *The Energy Journal*, pages 43–65.

Lemley, M. A. and Sampat, B. N. (2008). Is the patent office a rubber stamp? *Emory Law Journal*, 58:181.

Mills, B. and Schleich, J. (2012). Residential energy-efficient technology adoption, energy conservation, knowledge, and attitudes: An analysis of European countries. *Energy Policy*, 49:616–628.

Neuhoff, K., Stelmakh, K., Amecke, H., Novikova, A., Deason, J., and Hobbs, A. (2012). *Financial incentives for energy efficiency retrofits in buildings.* ACEEE Summer Study on Energy Efficiency in Buildings. Available online: `http://aceee.org/files/proceedings/2012/data/papers/0193-000422.pdf`.

Phillips, B. and Zhao, H. (1993). Predictors of assistive technology abandonment. *Assistive Technology*, 5(1):36–45.

Sadler, M. (2003). *Home energy preferences & policy: Applying stated choice modeling to a hybrid energy economy model.* PhD thesis, Simon Fraser University.

SEAI (2014). *Energy Efficiency Obligation Scheme - Ireland.* Sustainable Energy Authority of Ireland (SEAI). Available online: `http://www.seai.ie/EEOS/EEOS-Guidance-Document.pdf`.

Sorrell, S., Schleich, J., Scott, S., O'Malley, E., Trace, F., Ostertag, K., and Radge, P. (2000). *Barriers to energy efficiency in public and private organisations: Final report to the European Commission.* Available Online `http://www.sussex.ac.uk/Units/spru/publications/reports/barriers/final.html`.

Volden, C. (2007). Failures: diffusion, learning, and policy abandonment. American Political Science Association Annual Meetings. available: http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.175.7807&rep=rep1&type=pdf.

Wilson, C., Crane, L., and Chryssochoidis, G. (2015). Why do homeowners renovate energy efficiently? contrasting perspectives and implications for policy. *Energy Research & Social Science*, 7:12–22.

Wilson, C. and Dowlatabadi, H. (2007). Models of decision making and residential energy use. *Annual Review of Environment and Resources*, 32:169–203.

Year	Number	Title/Author(s) **ESRI Authors/Co-authors *Italicised***
2016	532	An Examination of energy efficiency retrofit depth in Ireland *Matthew Collins and John Curtis*
	531	Use it or Lose it : Irish Evidence Irene Mosca and Robert E Wright
	530	Exporting under Financial Constraints : Firm-level evidence from EU countries Gavin Murphy and *Iulia Siedschlag*
	529	Fisheries Management for different angler types *John Curtis and Benjamin Breen*
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	526	Modelling the Vietnamese Economy Pho Chi , *John FitzGerald*, Do Lam , Hoang Ha , Luong Huong, Tran Dung
	525	Attitudes to Irish as a school subject among 13-year-olds *Emer Smyth* and *Merike Darmody*
	524	Attitudes of the non-Catholic Population in Northern Ireland towards the Irish Language in Ireland *Merike Darmody*
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