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Energy poverty in the UK: Is there a difference between rural and urban areas?

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Abstract

Energy poverty is a significant policy issue in the UK. An argument often raised is that rural households are more likely to be energy poor due to the nature of rural housing stock and also the more limited choice of energy sources in rural areas. However empirical evidence to support this argument is limited. This paper uses data from the British Household Panel Survey to explore whether the incidence and dynamics of energy poverty varies between rural and urban areas in the UK. In addition to descriptive analysis, discrete hazard models of energy poverty exit and re-entry are estimated and used to explore the impact of an increase in energy price. The results indicate that the influence of certain housing and personal characteristics differs by place of residence. After accounting for differences in the observed characteristics, the experience of energy poverty in urban areas was found to be on average longer with a higher probability of energy poverty persistence. Vulnerability to energy price increases was found to be high with a 20% increase in price leading to a 74% increase in the probability rural residents being trapped in energy poverty for five or more years. It is argued that a combination of household type and spatial targeting of policy support is required.

1. Introduction

An individual can be defined as energy poor if they are unable to adequately heat their home through both lack of resources and because of the (in)efficiency of the housing insulation and heating (Boardman, 2012; Bouzarovski et al, 2012; Liddell et al, 2012). Energy poverty has implications for physical and mental health of particularly older people and children and has been linked to educational attainment (Barnes et al., 2008; Marmot, 2011; Liddel, 2008). As a result of a growing recognition of the adverse effects of being energy poor, energy poverty has become a major policy issue in the UK over the last decade.

An individual is more likely to fall into energy poverty if they are on low incomes but a range of other factors such as housing, increasing energy prices and climatic conditions are also likely to play an important role. An argument often raised in the policy debate is that rural households are disadvantaged in terms of the nature of rural housing stock and also the more limited choice of fuels available in rural areas. This, it is argued, means that rural residents are more likely to be energy poor and that the time they spend in energy poverty is likely to be longer. However empirical evidence to support either argument is limited.

Understanding the movements into and out of energy poverty, as well as simply the level of energy poverty, in both rural and urban areas is important because the welfare implications and thus policy measures will be different depending on how such poverty is experienced. For example, if many households experience energy poverty for a short period of time, the required policy response will be different to that required if a small number of households experience energy poverty either persistently or repeatedly. Similarly differences in the rate of entry into or out of energy poverty across rural and urban space could influence the choice of policy mechanism and in particular whether or not support should be spatially targeted, targeted on types of housing, and/or types of households.

This paper uses data from the most recent twelve waves of the British Household Panel Survey (BHPS) to compare the level and dynamics of energy poverty in rural and urban parts of the UK. An expenditure-based measure of energy poverty is constructed and used to explore the incidence and degree of energy poverty persistence first at macro-level and then at micro-level. Particular attention is given to the role of an individual's characteristics, housing characteristics and energy prices in determining rural and urban energy poverty transitions (Jarvis and Jenkins, 2003, Phimister et al. 2000; Stevens, 1999).

In the next section we discuss alternative ways of identifying those in energy poverty and explain and justify the particular measure used in the analysis. Having detailed the source of data for the analysis, Section 3 provides findings from some initial descriptive analyses of the level and dynamics of energy poverty, focussing first at the aggregate level and then at individual level. Section 4 then describes and presents results from two state discrete hazard model used to explore the sources of rural urban differences. Section 6 concludes.

2. The measurement of energy poverty and source of data

There is no agreement on exactly how best to measure whether an individual is energy poor or not. At a European level, a ten percent threshold of actual energy expenditure has been widely used (Dubois, 2012; EC2010) but expenditure-based measures, particularly those based on actual expenditure, have a key weaknesses in that they potentially miss those who, in the face of difficulties in heating their home, respond by reducing energy expenditure. Strategies adopted by such individuals include heating a single room, increasing clothing worn, spending more time in bed, reducing lighting (Brunner et al, 2012). Because different types of households may be more or less able to adopt such strategies, the results from studies based on expenditure measures of energy poverty may be misleading.

To address the weaknesses of expenditure based energy poverty measures, various authors have used subjective measures based on answers to survey questions as to whether an individual's feels their accommodation has adequate heating or not (Healy and Clinch, 2004). While such measures avoid missing households that are "rationing their energy consumption" (Dubois 2012, p109), many of the questions used in the subjective measures have possible interpretations beyond energy poverty.[1]

Even within the UK, the way in which energy poverty is measured differs. In Scotland the traditional threshold based on ten percent required expenditure is used, while in England and Wales a new measure has been introduced which defines an individual as energy poor if they live in a household whose income falls below 60% of median income and whose energy expenditure is above median household expenditure (Hills, 2012). Although the latter captures the dual aspects of energy poverty arising from poverty and housing energy (in)efficiency, it has been criticized as insensitive to the impact of energy price or climate changes (Moore, 2012).

In the analysis below we adopt and expenditure measure of energy poverty. In particular, total equivalized annual household energy expenditures is calculated using answers from individual questions on the household's annual expenditure on electricity, gas, and heating oil plus information on equivalence scales used in energy poverty calculations by DECC (2013). An individual in the sample is then defined as being in energy poverty if they are living in a household where household energy expenditure is above 10% of household income, where income is measured net after housing costs and equivalized using a post-housing cost equivalence scale.

While recognizing its limitations, this type of measure is arguably best placed for capturing rural-urban differences in the energy poverty. Because rural residents have a more limited range of fuel options, all other things being equal, they are likely to be affected differently by changes in energy prices. Moreover structural differences in the housing stock in rural areas

[1] Subjective energy poverty measures are often based on individual answers to multiple questions such as whether their house has leaks or damp, whether their household can afford to keep the dwelling heated warm in the winter and whether any utility bills were paid late recently Phimister et al (2015) Healy and Clinch, (2002, 2004) .

(e.g. more detached houses, fewer apartment blocks), would also be expected to be reflected in energy poverty via higher energy expenditure levels.

Analysis is based on data from the last 12 waves of the British Household Panel Survey (BHPS) (1997/98 to 2008/09)[2]. There were large changes in energy prices over this period which differed considerably by fuel type (see Figure 1).

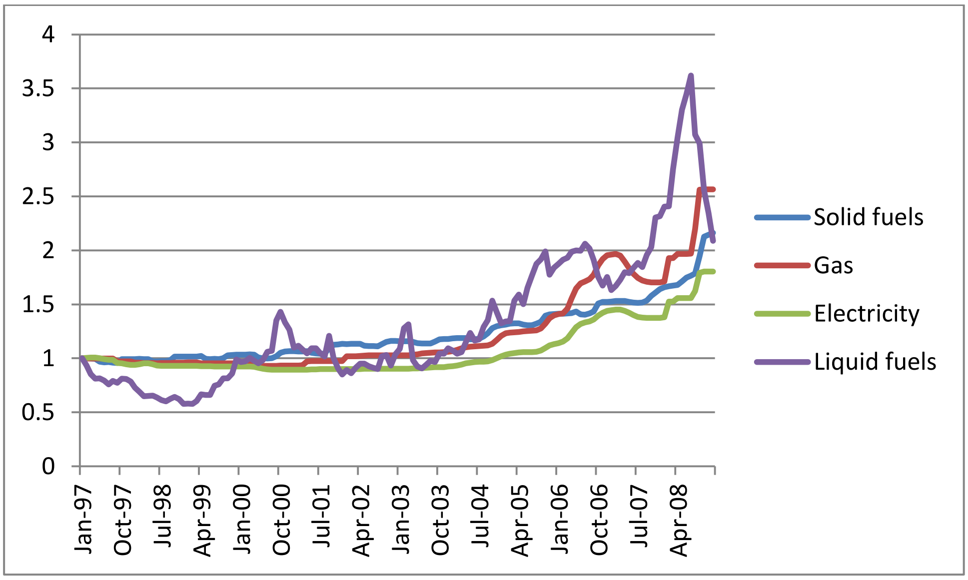


Figure 1 Changes in fuel prices, 1997-2008.

From the data an unbalanced panel of individuals who have remained in the sample for at least 3 years continuously was constructed, excluding those participants recruited in later years, i.e. only those with a longitudinal weight are included.

Reflecting the different definitions in use across the UK, the rural indicators available in the BHPS vary across the Scottish and England and Wales samples. However, they both can be used to identify individuals living in settlements with fewer than ten thousand inhabitants and this is used as the threshold to identify whether an individual is defined as being part of the "rural" sample or not. The overall sample contains 1506 and 4812 individuals classified as rural and urban respectively. Using twelve waves results in 15,144 rural and 46,211 urban observations.

3. Descriptive analysis

[2] Earlier waves were excluded as the nature of the questions asked on household energy expenditure changed substantially in wave 7 (1997/98) and are consistent thereafter.

Table 1 reports the level of energy and income poverty in the UK, differentiating by place of residence, over the entire period (the number of observations is provided in brackets). The overall level of energy poverty in rural and urban parts of the UK is shown to be almost identical at just over 16%. This, as anticipated, is higher than the level of income poverty where the latter is based on the standard definition of those with 60% or less of equivalized medium household income. The extent of overlap between individuals in income and energy poverty reflects the fact that the latter includes higher income individuals in energy inefficient homes.

Table 1. Levels of energy and income poverty (%), BHPS 1997-2008.

	Also in		
Given in	Energy poverty	Income Poverty	Total
Rural			
Energy poverty	-	27.5%	16.3%
		(681)	(2,474)
Income Poverty	42.2%	-	10.7%
	(681)		(1,615)
Urban			
Energy poverty	-	29.2%	16.4%
		(2,216)	(7,579)
Income Poverty	40.0%	-	12.0%
	(2,216)		(5,542)
Total	16.4%	11.7%	
	(10,053)	(7,157)	

A basic picture of the energy poverty mobility is provided in Table 2 which reports the average year to year rates of mobility into and out of energy poverty across the rural and urban samples for entire period. Mobility levels are high (much higher than those typically observed for movements into and out of income poverty) and again very similar for rural and urban areas. For example, over the period 1997-2008, 50.4% of the rural sample who were in energy poverty at the beginning of the year had left energy poverty by the beginning of the next compared to 51.4% of urban residents. Similarly, of those who were not in energy poverty at the beginning of a period, 9.8% of rural residents (10.6% of urban residents) had entered energy poverty be the beginning of the next.

Table 2. Average Year to Year Mobility into (out of) Energy Poverty

		Year t+1		
		Not Energy poor	*Energy poor*	*N*
Rural				
Year t	*Not Energy*	90.2	9.8	*11,192*
	Energy poor	50.4	49.6	*1,969*

Urban				
Year t	*Not Energy*	89.4	10.6	*34,809*
	Energy poor	51.4	48.6	*6,171*

However, the results in Tables 1 and 2 mask significant changes in energy poverty rates over the period and, importantly, significant differences in these changes between rural and urban parts of the UK. Figure 2 indicates the incidence of energy poverty in each of the waves of data. In addition to changes in climatic conditions from one year to the next it also reflects the large changes in energy prices (shown in Figure 1 above). While the general trends in energy poverty in rural and urban parts of the UK are similar, there is a statistically significant difference between the two trends with rural poverty rates first higher and then post 2003/04 lower than those observed in urban areas.

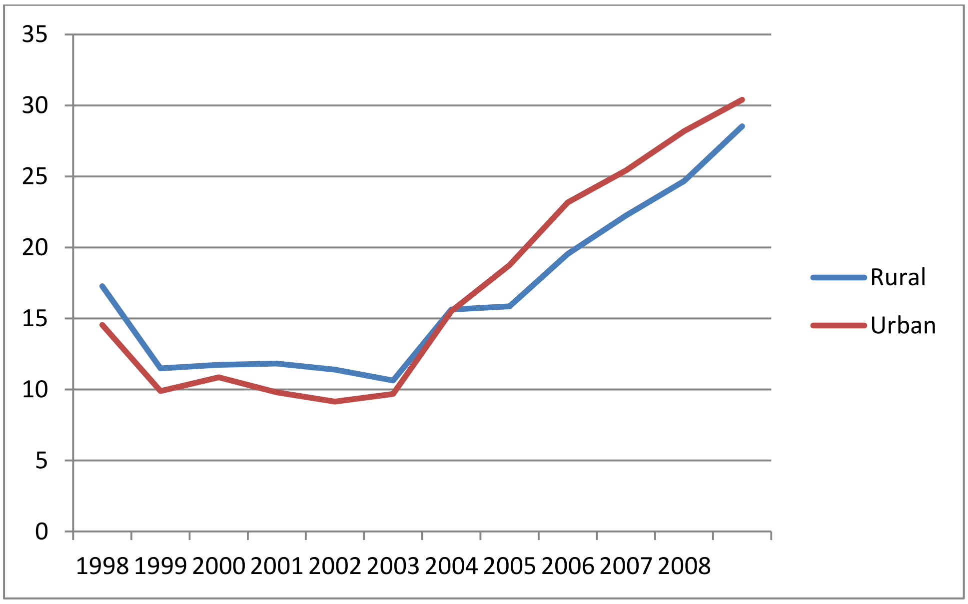
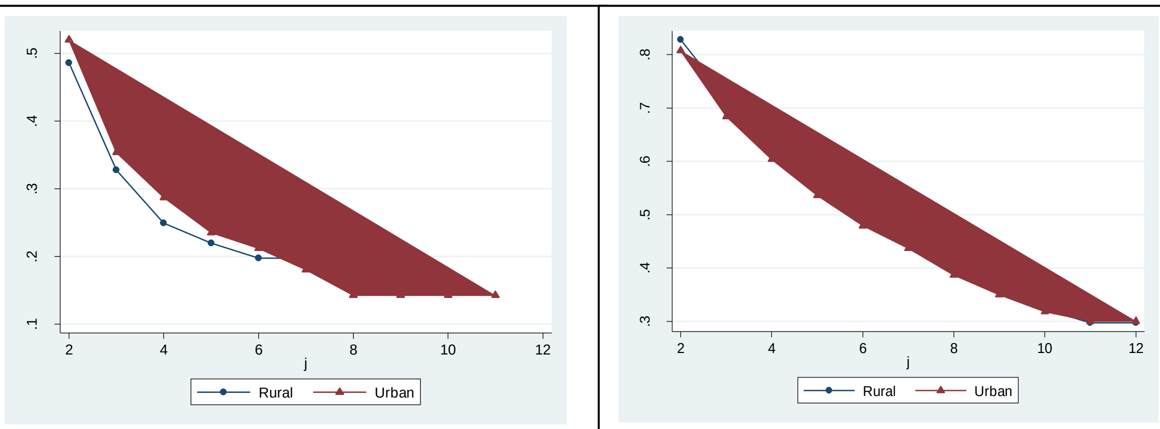


Figure 2 Changes in fuel poverty rates, 1997-2008.

To explore further the divergence in rural and urban patterns of energy poverty, a sample of energy poverty spells at the individual level was constructed. Excluding left censored spells, 1157 rural and 3647 urban spells in energy poverty were found, and 1028 rural and 3124 urban spells out of energy poverty.

Based on this Figure 3 illustrates the rural and urban survivor functions for spells in energy poverty (Fig 3a) and spells out of energy poverty (Fig 3b), where the survivor function is the probability that a spell which has just begun lasts for more than *t* periods. For both the survivor functions the log rank test suggests that there are statistically significant differences between the rural and urban survivor functions at 5%. For energy poverty survivor rates are initially lower for the urban sample although there is a cross over in rates as time spent in energy poverty increases indicating that the probability that an energy poverty spell lasts longer than 7 periods is higher for the rural sample. Hence, a rural resident who has just entered a spell of energy poverty is more likely to exit this state in the first few years but is less likely to exit in later years than an urban resident. In contrast for periods out of energy poverty the rural survivor function is consistently above the urban one.



1a Energy Poverty Spells
(Sample 1157 rural and 3647 urban spells, Log Rank test of Survivor Functions equality p-value 0.002)

1b Spells Out of Energy Poverty
(Sample 1028 rural and 3124 urban spells, Log Rank test of Survivor Functions equality p-value 0.04)

Figure 3: Survival Function Exits out of and Re-entry into Energy poverty

4. Modelling Differences in the dynamics of Energy Poverty

The above analysis suggests differences in the dynamics of energy poverty experienced in rural and urban parts of the UK but does not explain why. Observed rural urban differences in energy poverty mobility may arise due to different behavioural responses or from the differences in the composition of the two subsamples including both the observed and unobserved characteristics of individuals.

To explore further, we specify a discrete proportional hazard model. Consider two types of spells *j* of energy poverty (or time out of energy poverty) where *t* measures the length or duration of the spell type *j*, *i* is the individual. Define the hazard function $h_{ij}(t)$ as the probability that a spell of type *j* ends between the end of year *t-1* and *t* for individual *i*.

(1) $$h_{ij}(t) = h_{jt0}\exp\left(\mathbf{x}_{ij}\boldsymbol{\beta}_j + \left(d_i\mathbf{x}_{ij}\right)\boldsymbol{\delta}_j + u_j\right)$$

where h_{jt0} is the baseline exit (or re-entry) hazard, $\mathbf{x}_{ij}$ are the observed covariates[3], d_i is a rural dummy, with $\boldsymbol{\beta}_j$ capturing the urban impact of each covariate and $\boldsymbol{\delta}_j$ the extent of any

[3] Although the *t* subscript is omitted for brevity time varying covariates are included in this.

rural-urban difference in impact. The data from Table 2 indicates that energy poverty mobility is relatively high and hence that many individuals are likely to have experience repeated spells of energy poverty (and time out of energy poverty), where any unobserved individual factors might be correlated. The u_j term captures the unobserved heterogeneity for spell type *j* where the u_j are assumed jointly normally distributed across spell types to capture possible correlations between unobserved heterogeneity across states.

The covariates included in the Hazard functions reflect observed characteristics which are expected to play a role in energy poverty exits and reentry and where their impact might be expected to differ across rural and urban samples. Hence we include information on housing characteristics (whether the residence is a flat or a house, the number of rooms) and tenure type (Healy and Clinch, 2002). Also included are demographic characteristics of the household in particular, the number of children under 16, whether the head of household is employed, and their level of education. Finally, two potentially time varying factors are used: regional average heating degree days to reflect the average climatic conditions in the year, plus fuel price (DECC, 2010). The high degree of correlation between the available energy price series (including heating oil and electricity) meant that the separate impact of multiple energy price series could not be identified in the estimations so a single price was used to represent the general movement in energy prices over the period. In this case the credit sales gas price was chosen as it had the highest correlation with the heating oil price and therefore it was best able to capture the impact of changes in heating energy prices in rural areas without gas grid.

After reorganising the data onto a binary format and defining individual dummy variables to capture the baseline hazard within each state, the two-state discrete hazard model defined were estimated within a multi-level modelling framework applying standard estimation techniques (Rabe-Hesketh and Skrondal 2012).

Results from the Hazard models

Table 3 reports the estimation results, presenting the marginal effects for each covariate and for the interaction with the rural dummy. The model fitted has reasonable explanatory power overall with a number of variables individually statistically significant. From the second panel the results indicate that unobserved heterogeneity is significant in both states and that, as expected, these effects are negatively correlated. That is, an individual with an unobserved effect which increases the exit hazard from energy poverty is likely to have unobserved effect which decreases the exit hazard from out of energy poverty. Although not reported within each state, 5 individual dummy variables capture the baseline hazard for the first four possible exit periods and then for period 5 and above. These dummy variables are also well determined and are individually and jointly significant at 1%.

In terms of rural-urban differences, the joint hypotheses tests in the bottom panel suggest that the impact of the covariates for both exits and re-entry to energy poverty differs for the rural sample. In addition, the rural dummy is also statistically significant in both cases suggesting that the base line hazard is higher for both rural exits and re-entry than for the urban sample.

There is also some limited evidence of individual rural-urban differences. Consistent with claim that rural residents have less flexibility due to nature of accommodation and energy choices, the impact of being in a flat, in Private Rented accommodation and energy price all having a statistically more negative effect in the exit model. There are few individually significant rural urban differences for re-entry to energy poverty, although notably the impact of heating degree days is more negative in the rural sample which is not consistent with expectations.

The signs on the majority of the individual coefficients are as expected. For example, being in a household with an older head, or being in private rented accommodation (relative to owner occupancy) decreases the probability of an energy poverty exit. Similarly increases in energy prices (as captured by the representative gas price) and in heating degree days also reduce the probability of an energy poverty exit. Although there are fewer individual coefficients which are significant in the re-entry equation, residing in a flat reduces the probability of a return to energy poverty while residing in a house with more rooms, having an older head of household or being in private renter accommodation increases the probability. In contrast, the impact of the head of household being employed is statistically significant but has the opposite effect to expected for both exits and re-entry, while for re-entry neither the energy price nor the heating degree days are significant.

Table 3 Discrete Hazard Model: Covariate Marginal Effects Energy Poverty Exit and Re-entry

	Exits		***Re-entry***	
	Urban	**Rural-Urban Difference**	**Urban**	**Rural-Urban Difference**
Rural		0.193+		0.202+
		(0.112)		(0.117)
Flat	0.011	-0.096*	-0.043*	0.054
	(0.015)	(0.042)	(0.017)	(0.046)
No. Rooms	-0.006	-0.002	0.008+	-0.005
	(0.004)	(0.007)	(0.004)	(0.008)
No Children	0.011*	-0.011	-0.006	0.009
	(0.005)	(0.011)	(0.006)	(0.012)
Head65plus	-0.044*	-0.032	0.023+	0.049*
	(0.011)	(0.023)	(0.012)	(0.024)
HeadEmployed	-0.038*	0.032	0.045*	0.0004
	(0.015)	(0.027)	(0.016)	(0.029)
A Level plus	0.006	0.009	0.013	-0.030
	(0.015)	(0.032)	(0.017)	(0.035)
Public Rented	0.013	0.023	0.003	0.010
	(0.014)	(0.033)	(0.014)	(0.031)
Private Rented	-0.032*	-0.066*	0.074*	-0.012
	(0.015)	(0.032)	(0.018)	(0.035)
Gas Price	-0.161*	-0.029+	-0.001	-0.009
	(0.009)	(0.017)	(0.008)	(0.016)
Heat. Degree Days	-0.088*	-0.028	-0.006	-0.076*
	(0.016)	(0.033)	(0.017)	(0.035)
Var(InEP)	0.186	*Var(OutofEP)*	0.485	
	(0.076)		(0.115)	
Cov(In,OutofEP)	-0.30			
	(0.074)			
Log Likelihood	-9935.5	Total No Spells	3843	
N Spells by type				
Hypothesis Tests	Overall	Rural-Urban Diffs.: All	Rural-Urban Diffs: Exits	Rural-Urban Diffs.: Re-entry
Chi-squared (d.f.)	4388.01(52)	42.95 (22)	23.75 (11)	20.76 (11)
p-value	<0.001	0.0048	0.0138	0.0359

Estimation includes 5 dummy variables to capture the exit baseline hazards which are common across the urban and rural sample and 5 dummy variables to capture re-entry baseline hazards, which are similarly common across the two samples. Standard Errors in brackets

The final set of analyses take the results from the Hazard models and uses them in two ways. First they are used to determine whether differences in the experience of energy poverty between rural and urban residents is due to differences in the average characteristics of the two samples or differences in the impact of the covariates on the exit and re-entry into energy poverty. Second they are used to explore the response of particular household types to an increase in energy price. In both cases the focus is on repeated spells over a six year period given that the individual has just fallen into energy poverty (Jenkins and Rigg, 2001; Stevens, 1999) and zero random effects are assumed.

Table 4 shows that, having allowed for repeated spells, a rural resident with average characteristics who has just fallen into energy poverty would be expected to spend an average of 2.9 years in energy poverty over the next six years. It also shows that the probability of spending one period in energy poverty is 0.3 while the probability that he or she spends five or more periods in energy poverty is 0.23 (0.09+0.14). The second row provides the comparable results for the urban sample using the urban estimated coefficients. In this case both the expected time spent in energy poverty (3.11) and the probability of spending five or more in energy poverty is higher (0.27) suggesting that, on average, the experience of energy poverty in urban places is longer with a higher probability of energy poverty persistence.

To provide an indication of the effects of covariates relative to sample average characteristics, the final row of Table 4 reports the predictions based on the rural average characteristics but with the urban coefficients. This therefore provides an estimate of what a rural individual (with average characteristics) falling into energy poverty might experience if the impact of the covariates was identical to the urban estimates. In this case the average time spent in energy poverty and energy poverty persistence increases beyond the urban values suggesting that the rural-urban differences in the coefficients are not only statistically significant (as suggested in Table 3) but they also have economic significance in explaining energy poverty outcomes.

Table 4 Predicted Number Years in Energy poverty next Six Years

	Number of years						
	1	*2*	*3*	*4*	*5*	*6*	*Expected Time*
Rural	0.30	0.20	0.15	0.12	0.09	0.14	2.90
Urban	0.26	0.19	0.15	0.13	0.10	0.17	3.11
Rural (Urban Coefficients)	0.25	0.19	0.15	0.13	0.11	0.17	3.16

To assess the vulnerability of different types of households to energy price shocks we undertake the following exercise. For first average urban and rural characteristics and then for two distinct types of household, we calculate the predicted pattern of energy poverty for a base case with the energy price at its mean value. Following this, identical simulations are carried out but in this case the energy price is increased by 20%. Household Type 1 is defined as an employed individual of working age with three children, living in a flat in the public rental sector. Household Type 2 is defined as a retired pensioner with no children living in a house in the private rental sector. The results are reported in Table 5.

Table 5 Predicted Number Years in Energy poverty next Six Years

	Probability of five or more years	*% Change*	*Overall Expected Time*	*% Change*
Average Characteristics				
Rural Average base	0.23	-	2.9	-
Rural average +20% energy price	0.40		3.63	25.2
Urban average base	0.27	-	3.11	-
Urban average +20% energy price	0.42		3.74	20.3
Individual in Household type 1				
Rural type 1 coefficients	0.24	-	3.04	-
Rural type 1 +20% energy price	0.41		3.72	22.4
Urban type 1 coefficients	0.18	-	2.70	-
Urban type 1 +20% energy price	0.32		3.26	20.7
Individual in Household type2				
Rural type 2 coefficients	0.50	-	4.15	-
Rural type 2 +20% energy price	0.67		4.74	14.2
Urban type 2 coefficients	0.40	-	3.77	-
Urban type 2 +20% energy price	0.55		4.31	14.3

The top set of results in Table 5 show that an individual with average rural sample characteristics is much more vulnerable to energy price shocks than an average urban resident with both the overall expected time spent in energy poverty and the probability of persistent energy poverty increasing more as a result of the 20% increase in energy price. The increase in probability of spending 5 or more years in energy poverty, from 0.23 to 0.40, is particularly striking. However although the two become much more similar following the price rise, both persistence and expected time in poverty remain higher in the urban case.

Household type 2, urban residents appear more vulnerable to the price increase with a similar increase in overall expected time in poverty but a higher percentage increase in the probability of being in persistent poverty (37.5%). For type 1 households, the results are mixed with rural households being more affected in terms of the overall expected time spent in poverty (the average time rising from 3.04 years to 3.72 years) but persistent poverty increasing most for urban residents. Perhaps as interesting is the large difference in impacts of the price rise between the two household types. This suggests that even though there are discernible differences in the way energy poverty is experienced in rural and urban areas, spatial targeting of policy support may be less effective than targeting based on the characteristics of individuals and their housing.

Summary and Conclusions

The UK Government has recently set new targets for tackling energy poverty (DECC, 2014). The complex nature of energy poverty, depending on ability to afford energy, energy prices, individual and housing needs, means that it is difficult to target limited policy support effectively. Rural residents are often argued to be of particular disadvantage as a result of structural characteristics (lack of access to certain fuel types and particular also inefficient housing stock. This paper has explored the evidence for this drawing on data from twelve waves of the British Household Panel Survey (BHPS). In particular it has explored whether there are rural urban differences in energy poverty levels and dynamics through both descriptive analysis of the panel data and though the estimation of discrete hazard models of energy poverty exit and re-entry.

At an aggregate level and across the whole period, rates of energy poverty appear very similar in both areas. However there were clear differences in changes in the level of energy poverty over the period and statistically significant differences in the survival functions for rural and urban residents both for exits from and re-entry to energy poverty. In particular, a rural resident who has just entered a spell of energy poverty was found to be more likely to exit this state in the first few years but less likely to exit in later years than an urban resident.

The reasons for differences in energy poverty dynamics were further explored through the estimation of a two state discrete hazard models, allowing for both observed and unobserved heterogeneity of respondents. The observed characteristics controlled for in the analysis included both the nature of housing (owner-occupier versus rented accommodation; house type), personal characteristics (gender, age, education level), differences in energy prices and temperature across time and space.

The results indicate that the impact of certain housing, personal characteristics differs across rural and urban space. For example living in private rental accommodation, living in a flat and being over 65 is a more important determinant of energy poverty in rural areas than urban areas. After accounting for differences in the observed characteristics across the two subsamples, the experience of energy poverty in urban areas was found to be on average longer with a higher probability of energy poverty persistence.

Vulnerability to energy price increases was found to be dependent on both place of residence and the characteristics of an individual, with a 20% increase in price leading to large increases in the probability rural residents being trapped in energy poverty for five or more years. However the spatial impact of the price increase varied considerably across households of different types and thus, overall, the results suggest that a combination of household type and spatial targeting of support is required in the objectives of reducing energy poverty is to be achieved.

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