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Abstract

We merge detailed household level expenditure data from older households with historical local weather information. We then test for a heat or eat trade off: do households cut back on food spending to finance the additional cost of keeping warm during cold shocks? For households who cannot smooth consumption over time, cold weather shocks are equivalent to income shocks. We find evidence that the poorest of older households are unable to smooth spending over the worst temperature shocks. Statistically significant reductions in food spending are observed in response to winter temperatures two or more standard deviations colder than expected (which occur about one winter month in forty) and reductions in food expenditure are considerably larger in poorer households.

1 Introduction

In recent winters, media outlets reported that unseasonable weather and rising energy costs forced elderly households in the United Kingdom to choose between "heating and eating".[1 2 3] In other words, households were said to be forgoing food to pay for the increased cost of staying warm. In this paper, we study the empirical evidence for a "heat or eat" trade-off in the United Kingdom. We show analytically how, for some households, cold weather shocks can translate into adverse income shocks. We then ask whether, empirically, there are households who are unable to smooth these relatively small shocks, and whether these shocks are large enough that these households must reduce expenditures on other essentials, notably food. We model temperature shocks using historical regional weather data and then merge our estimated temperature shocks with UK household expenditure data in order to study older households' response to unusual temperatures. This research is timely given the recent period of record energy prices, the possibility of future increases in energy prices, and the current pressure on public finances that may lead to reduced support for vulnerable households.

Cold weather can have serious health consequences. On average, the UK experiences thirty thousand "excess deaths" each winter, with older people most at risk (Department of Health, 2009).[4] The epidemiology literature documents a strong correlation between outside temperature and the mortality rate (Curwen (1997), Wilkinson et al (2001), Keatinge (2002)). It also makes clear that the causal link is complicated, with debate about whether it is exposure to colder outdoor temperatures or to lower indoor temperatures that poses the greater risk (Keatinge (1986), Eurowinter (1997), Keatinge and Donaldson (2001), Keatinge et al., (2004)). However, there is evidence that indoor temperatures matter, and Wilkinson et al (2001) concluded that "substantial winter-summer difference in mortality is indeed related to indoor temperature and to dwelling characteristics that are determinants of indoor temperature". Interestingly though, this and other studies (eg., Wilkinson et al (2004), Lawlor et al, (2000), Maheswarana et al (2004)) find no significant effect of socio-economic status on the likelihood of a winter death (relative to any other time of year). However, this finding does not rule out "heat or eat" tradeoffs. It could be that, while richer households can smooth the increased costs over a longer stretch of time, some poorer households have to go without other essentials in order to pay for the increased cost of staying warm. Such cutbacks, if they do occur, will have important welfare consequences (in terms of utility and perhaps long-run health) even if they do not show up in short-run mortality.

[1] http://news.bbc.co.uk/2/hi/uk_news/england/7234223.stm
[2] http://news.bbc.co.uk/1/hi/business/7461635.stm
[3] http://www.channel4.com/news/articles/dispatches/heat+or+eat+the+pensioners+dilemma/1479647
[4] The Office of National Statistics defines excess winter mortality as "Excess winter mortality is calculated as winter deaths (deaths occurring in December to March) minus the average of non-winter deaths (April to July of the current year and August to November of the previous year)."

There is a literature in development economics that studies the ability of rural households to smooth weather shocks (Paxson, 1992); weather shocks affect income through agricultural productivity. In a developed country context, this mechanism is less important. Instead, we show how cold weather shocks can be thought of as increasing the effective *price* of a given internal temperature; these price changes will have income effects for households that are unable to smooth spending over time. We formalise this idea below. Among households for whom home heating represents a significant fraction of the household budget, the negative income effect of an increase in the price of internal temperature is potentially large. Whether some households are unable to smooth such shocks –even in the presence of capital markets and social safety nets– is an empirical question.

There is recent evidence from the United States that low-income households do trade off between food and staying warm during unseasonably cold weather (Bhattacharya et al. (2003) and Cullen et al. (2005)). The authors find that both poorer and richer households in America increase fuel expenditure in response to unusually cold weather, and that low-income households simultaneously decrease food expenditure whereas richer households do not. Bhattacharya et al. (2003) also find a link between spending and nutritional outcomes in US data. We improve on the methodology of the previous literature in a number of ways – notably by allowing for nonlinear effects of temperature shocks– and provide the first evidence on this issue for the UK.

The rest of the paper is organized as follows. The next section develops a model of how consumers respond to cold weather shocks; this analysis informs our subsequent empirical work. Section 3 describes the data and methods we use in our empirical analysis and Section 4 present our results. Section 5 concludes with a discussion of our findings.

2 The Economics of Cold Weather Shocks

We first set out a simple theoretical model of the effects of cold weather shocks on households. We consider two polar cases: households who can smooth consumption over time and those who, without access to credit or savings, solve a static problem. Of course, most actual households will lie somewhere between these polar cases. In general, smoothing of any type of shock will be more difficult if access to credit is limited; if time horizon is short (as in old age); or if the shocks in question are very persistent.

Suppose utility is defined over ambient temperature (h), food (f), and other goods (x): $U(f, h, x)$. Suppose further that the amount of fuel z required to maintain ambient temperature h given outside temperature τ is give by some function: $Z(h, \tau)$, $Z_h > 0$, $Z_\tau < 0$. We first consider consumers who can borrow and lend freely. Assume such consumers maximize expected lifetime utility:

$$E\sum_{s=0}^{T}U(f_{t+s},x_{t+s},h_{t+s})$$

subject to the intertemporal budget constraint

$$A_{t+s+1}=A_{t+s}+m_{t+s}-p^{f}_{t+s}f_{t+s}-p^{x}_{t+s}x_{t+s}-p^{z}_{t+s}Z(h_{t+s},\tau_{t+s})$$

where A denotes assets and m denotes income. The first order conditions of the consumer's intertemporal problem are:

$$U_f(f_{t+s},x_{t+s},h_{t+s})=\lambda_{t+s}p^{f}_{t+s} \tag{1}$$

$$U_x(f_{t+s},x_{t+s},h_{t+s})=\lambda_{t+s}p^{x}_{t+s} \tag{2}$$

$$U_h(f_{t+s},x_{t+s},h_{t+s})=\lambda_{t+s}p^{z}_{t+s}Z_h(h_{t+s},\tau_{t+s}) \tag{3}$$

$$\lambda_{t+s}=E\lambda_{t+s+1} \tag{4}$$

Equation 4 is the familiar condition describing optimal intertemporal asset allocation which prescribes that the consumer holds her marginal utility of wealth constant across periods, at least in expectation. The consumer's intratemporal decision regarding allocation between food and heat is given by rearranging equations 1 and 3 to eliminate λ_{t+s}, giving the marginal rate of substitution (MRS) condition:

$$U_f(f_{t+s},x_{t+s},h_{t+s})/U_h(f_{t+s},x_{t+s},h_{t+s})=p^{f}_{t+s}/p^{z}_{t+s}Z_h(h_{t+s},\tau_{t+s}) \tag{5}$$

Equations (1), (2) and (3) link the consumer's intertemporal and intratemporal allocation decisions; their solution gives Frisch, or marginal utility (λ) - constant, demands for food and heat:

$$f_{t+s}=f(\lambda_{t+s},p^{f}_{t+s},p^{x}_{t+s},p^{z}_{t+s}Z_h(h_{t+s},\tau_{t+s}))$$

$$x_{t+s}=x(\lambda_{t+s},p^{f}_{t+s},p^{x}_{t+s},p^{z}_{t+s}Z_h(h_{t+s},\tau_{t+s}))$$

$$h_{t+s} = h(\lambda_{t+s}, p^f_{t+s}, p^x_{t+s}, p^z_{t+s} Z_h(h_{t+s}, \tau_{t+s}))$$

and a derived Frisch demand for fuel:

$$z_{t+s} = Z(h(\lambda_{t+s}, p^f_{t+s}, p^x_{t+s}, p^z_{t+s} Z_h(h_{t+s}, \tau_{t+s})), \tau_{t+s})$$

Looking at the MRS condition (equation 5), if we, reasonably, assume that $Z_{h\tau}(h_{t+s}, \tau_{t+s}) < 0$ then a decrease in outside temperature is like an increase in the price of heating. For consumers that can smooth transient shocks (hold λ constant), the only effect of a temperature shock is through the change in relative prices. This effect is captured by the own- and cross-price Frisch elasticities. Note that if food and heat are Frisch-substitutes (e.g. a warm bowl of soup substitutes for indoor heat) the effect will be in the opposite direction to the "heat or eat" trade-off: the increased price of indoor heat associated with low outdoor temperatures will induce consumers to substitute towards food (and away from fuel), *increasing* food expenditures. Of course, if substitution possibilities between indoor heat and food are limited, this effect will be unimportant.

Now consider consumers who cannot smooth and face a within period budget constraint of:

$$p^z z + p^f f \leq m$$

(where we have dropped the time subscripts for simplicity). For ease of exposition, suppose that $Z(h, \tau)$ is homogeneous of degree one in h. Then we can write:

$$p^z z = p^z Z_h(h, \tau) h \equiv p^h h$$

Denoting the demand function for food by $f*$, note that:

$$\frac{d \log f*}{d \log \tau} = \frac{d \log f*}{d \log p^h} \frac{d \log p^h}{d \log \tau} = \frac{d \log f*}{d \log p^h} \frac{d \log Z_h(h, \tau)}{d \log \tau} \tag{6}$$

From the (cross-price) Slutsky equation:

$$\frac{d \log f*}{d \log p^h}|_{dm=0} = \frac{d \log f*}{d \log p^h}|_{dU=0} - w^h \frac{d \log f*}{d \log m} \tag{7}$$

where w^h is the budget share of heat, which equals the budget share of fuel, w^z, since $p^z z = p^h h$. Combining (6) and (7) gives:

$$\frac{d\log f*}{d\log \tau}|_{dm=0} = \left(\frac{d\log f*}{d\log p^h}|_{dU=0} - w^z \frac{d\log f*}{d\log m}\right)\frac{d\log Z_h(h,\tau)}{d\log \tau} \tag{8}$$

If cold weather increases the "price" of ambient heat ($Z_{h\tau}(h,\tau) < 0$), then $\frac{d\log Z_h(h,\tau)}{d\log \tau} < 0$ and a decrease in temperature renders the term outside the brackets in (8) positive. The first term inside the brackets is the substitution effect. The second term is the income effect of the "price" change, and this is the term that is not present for consumers who are fully able to smooth over time. This income effect is larger for poorer households because they have a higher fuel budget share. It also depends on the income elasticity of food.

Finally, if heat is truly essential (at an ambient temperature of $\bar{h}$) so that it responds neither to income nor price, the "price" (temperature) shock becomes just a disposable income shock. The within period constraint is just then:

$$p^f f + p^x x \leq m - p^h h = m - p^z Z(\bar{h},\tau) \tag{9}$$

and:

$$\frac{d\log f*}{d\log \tau} = -w^z \frac{d\log f*}{d\log m}\frac{d\log Z(\bar{h},\tau)}{d\log \tau} \tag{10}$$

In sum, temperature shocks change the price of indoor temperature. Households will face a heat or eat trade-off if they are unable to hold the marginal utility of money constant, so that these price shocks have income effects. This is more likely to be true among poorer (as they will be less able to use saving and credit to smooth) and older households (as they have a shorter time horizon). The income effect will be larger the higher the budget share of fuel; as fuel is a necessity, this again points to poorer households. Multiplying the income effect by the income elasticity of food gives the effect on food demand.

Note that we follow the literature in focussing on food expenditures. However, Browning and Crossley (2009) emphasize that food does not afford the most sensitive test of households' ability to smooth, both because of its low income elasticity and because households can mitigate the welfare costs of a shock by delaying the replacement of durable goods, so that purchases food should preferentially smoothed. The corrolary of this point though, is that failures to smooth that show up in food expenditure are likely to be associated with important welfare losses. More generally, food is of particular interest, because it is a necessity and because of the connection through nutrition to health. It is worth noting that the theory sketched here does not imply that positive and negative temperature shocks have symmetric effects on food expenditures. Neither the function $Z_h(h,\tau)$ (that maps temperatures in the price of indoor heat), nor the food Engel curve (that maps income effects into food expenditures) need be linear, and in general they will not be.

Finally, the theoretical perspective above, this paper also addresses the more general question of how unexpected changes in the price of a necessity can translate into an income shock. On this question, Givecha, Hastings and Villas-Boas (2010) find some evidence that changes in petrol prices induce statistically significant changes in food spending in the United States.

3 Data and Methods

We measure spending on food and on fuel using the Expenditure and Food Survey (EFS) and the earlier Family Expenditure Survey (FES)[5]. The FES/EFS contains detailed information on household expenditure patterns from an annual nationally representative sample of around 7,000 households, who are asked to keep a two-week expenditure diary, as well as information on more infrequent purchases over longer time horizons, household structure, geographic location, and income. Data from the FES/EFS is available from 1968; for reasons of consistency in the information available, we study data from 1974 through to 2007. We focus on households with at least one member aged 60 or over; 80,966 such households are observed in the data. Households from all standard regions are present in the sample each month.[6]

The effects of unanticipated cold weather are likely to differ over the course of a year – a winter shock is presumably more important than a summer shock – and between households, as the theory sketched in the previous section suggests that poorer households are less able to respond to temperature shocks than better off-households. To this end, we study four subsets of our population of interest: 1. All households 2. All households observed during the winter months (November, December, January and February) 3. The poorest quarter of households in the bottom quartile of the expenditure distribution 4. The poorest quarter of households in the bottom quartile of the expenditure distribution, observed during the winter months. We define affluence in terms of total spending as recent research suggests that living standards are better measured by spending than income, particularly for poor households (Meyer and Sullivan, 2003 and Brewer et al., 2006).

Currently, the UK government makes a Cold Weather Payment (of 25 pounds) to eligible households for for each seven day period of very cold weather between 1 November and 31 March. A period of very cold weather is defined as one in which the local average temperature is forecast or recorded to be below 0 degrees celsius for 7 consecutive days. Eligible households are those receiving pension credit, and some households that receive income support or income-based job-seekers' allowance, notably those with a young

[5] From 2008, this survey has been known as the Living Costs and Food Survey.

[6] The sampling design for the FES/EFS is a multi-stage stratified random sample with clustering. It is drawn from the Small Users file of the Postcode Address File - the Post Office's list of addresses. Postal sectors (ward size) are the primary sample unit. 672 postal sectors are randomly selected during the year after being arranged in strata defined by standard regions.

or disabled child. Thus some households in our sample received this payment. Most of the households in our sample received the separate Winter Fuel Payment, which is actually an unconditional cash transfer paid each November or December to households in which one member is 60 years or older.[7]

Before turning to the relationship between unseasonably cold weather and fuel and food expenditures, we first document patterns of spending on fuel among older UK households. We consider both how much households spend on heating fuel, and how they pay for fuel. If households have an ongoing arrangement with a provider by which they make equal payments each month (an installment plan), then a spell of unseasonably cold weather does not generate a contemporaneous expense. On the other hand, households with "pay as you go" arrangements (such as payment cards or slot meters), unseasonably cold weather generates an expense that must be met immediately. For each of the groups defined above we look at the mean share and the 90th percentile of total expenditure spent on food and fuel over several recent survey years, as well as the the fraction of households paying for heating in different means ("pay as you go", retrospective payment on account and equal installment plans).

Spending on fuel includes gas and electricity payments, coal, coke, and bottled gas and coke for central heating. Clearly some electricity and gas use may have been for cooking, lighting etc and not heating, but it is not possible to separate this out. Spending on food is all expenditure on food and non-alcoholic drink for consumption at home, although results are very similar when we include spending on food consumed away from home.

We measure temperatures using publicly available Met Office[8] data and calculate monthly averages from different U.K. regions. Our focus is the effects of an unexpected increase in heating costs associated with unseasonable weather, rather than routine seasonal variation. For example, if households routinely spend more on food in winter simply because some items (e.g. fresh fruit) are seasonally more expensive, then that is not an effect that we would wish to include in our evaluation.

In order to isolate unexpected weather events, we must first model expected temperatures. We use linear regression to decompose observed temperatures into a regional component (capturing geographic differences), a monthly component (capturing normal seasonal variation) and a quadratic time trend (to capture long-run changes in weather over the period 1974-2007). A temperature shock is then defined as the residual from this regression (that is, the difference between the predicted temperature and the realized temperature). We construct two measures of unseasonal weather based on either a single month averages or on a 3-month running averages. This is due to the fact that the food and fuel questions in the EFS/FES record expenditure over different time horizons. As a result, we compute a one-month average for use in

[7] The effect of this transfer on fuel spending is studied in Beatty, Blow, Crossley and O'Dea (2011).

[8] http://www.metoffice.gov.uk/climate/uk/datasets/index.html

analyzing food expenditure and a three-month average for use in analyzing fuel expenditure.

Finally, we regress the logarithm of fuel expenditures on temperature shocks and other conditioning variables, and similarly for log food expenditures. The additional contols we condition on are: month, region, a quadratic time trend, household size, dummies for tenure status (rented, owned and council housing) and the log of the number of rooms in the home. To model shocks, we construct four different dummy-variable indicators of abnormal temperatures in a given month or 3-month period:

1. More than two standard deviations colder than expected
2. Between one and two standard deviations colder than expected
3. Between one and two standard deviations warmer than expected
4. More than two standard deviations warmer than expected.

Given that we work with logarithms of expenditure, 100 times the resulting coefficient estimates analyses can be interpreted as percentage changes in expenditure on food or fuel associated with a shock of a given size. We cluster standard errors on our regression coefficients at the region level to account for the possibility of correlation within given climatic regions.

4 Results

4.1 Fuel Spending by Older Households

Food and fuel are necessities: as total expenditure increases, the share of expenditure spent on these goods declines. Table 1 shows (using our four most recent years of data) that the average fuel budget share declines from 11% of total household expenditure for households in the lowest quartile to 3.3% for households in the highest quartile. Similarly, the average food budget share declines from 25% of expenditure to 9% of expenditure. Within each expenditure quartile, the table also shows the budget share at the 90th percentile (that is, where 10% of households have a budget share equal to or larger than this value). It is important to note that, in the lowest expenditure quartile, 10% of households spend more than 20% of their budget on fuel[9] and 41% on food. For those households interviewed during the winter, average budget shares were marginally (1-2%) larger.

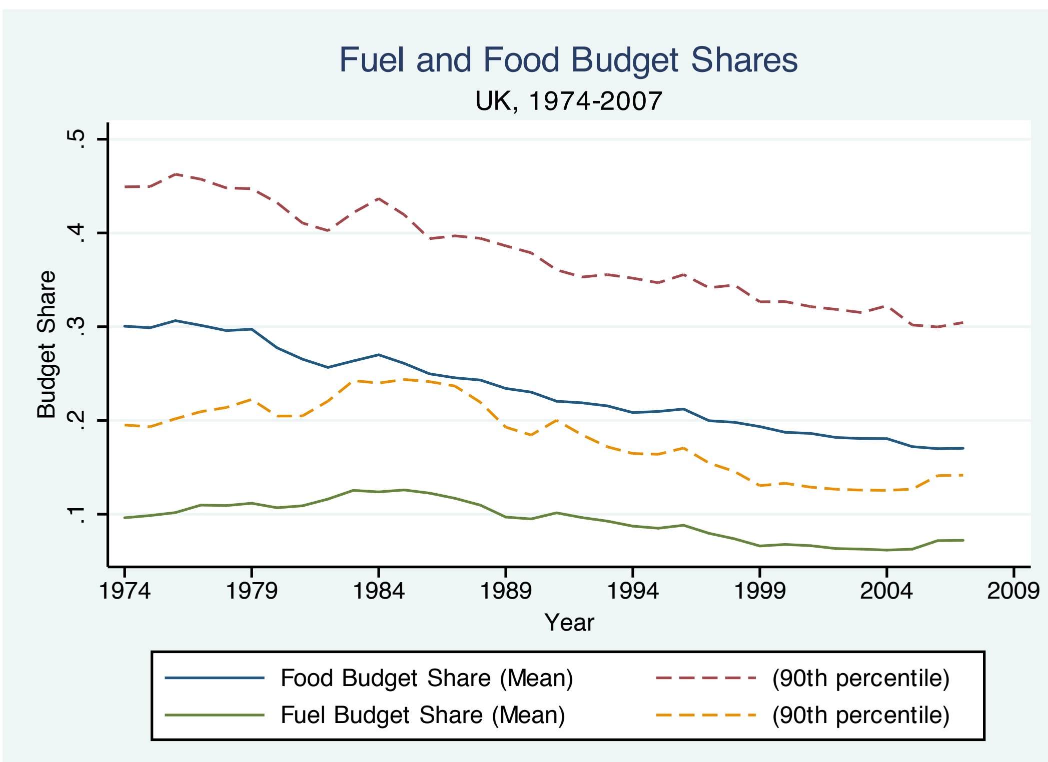
Figure 1 shows that these shares have declined over time. Fuel shares have broadly declined since 1986, reaching a low in 2004, but have increased most recently. Food shares have broadly declined over the same period.

[9] Note that according to Department for Environment, Food and Rural Affairs (2004), "A household is in fuel poverty if, in order to maintain a satisfactory heating regime it would be required to spend more than 10% of its income (including Housing

Tab. 1: Fuel & Food Shares, 2004-2007 (Households With At Least One Member Over 60 Years of Age)

Fuel				
Expenditure Quartile	1	2	3	4
Mean Budget Share	0.11	0.068	0.049	0.033
90th Percentile	0.20	0.11	0.082	0.059
Food				
Expenditure Quartile	1	2	3	4
Mean Budget Share	0.25	0.18	0.14	0.09
90th Percentile	0.41	0.27	0.22	0.16
Sample Size	2536	2219	2019	1966

Fig. 1: Fuel and Food Budget Shares: 1974-2007 (Households with At Least One Member over 60 Years of Age)



Tab. 2: Fuel Payment Methods, 2004-2007

Expenditure Quartile	**1**	**2**	**3**	**4**
Pay as you go (Slot Meter)	0.28	0.15	0.08	0.03
Retrospective Payment	0.36	0.35	0.33	0.37
Equal Installment Plan	0.34	0.49	0.58	0.59
Other	0.02	0.01	0.01	0.01

Table 2 reports how households pay for heating. For each quartile of the expenditure distribution, we report the share of households paying for heating by different methods of payment. Paying in advance for heating ("pay as you go": using a slot or a card meter) is most prevalent among households in the lowest expenditure quartile, 28%, and lowest in the highest quartiles, 3%. The proportion paying retrospectively on account is broadly constant across income quartiles at between 33% and 37%. Finally paying on installment, which involves making roughly constant installment payments over the course of a year, increases from 34% of households in the lowest expenditure quartile to 59% in the highest expenditure quartile.

Figure 2 shows the change in payment methods over the period 1977-2007. Methods of payment have changed a great deal over this time period. The share of households smoothing fuel payments on an equal installment plan has increased from 15% in 1977 to roughly half of all households in more recent survey years. The share of households paying retrospectively on account has declined steadily from 81% in 1977 to 36% in 2007. Figure 2 also shows recent growth in the share of households paying for heating using "pay as you go" methods, from 2% in 1977 to 14% in 2007.

4.2 Temperature Shocks

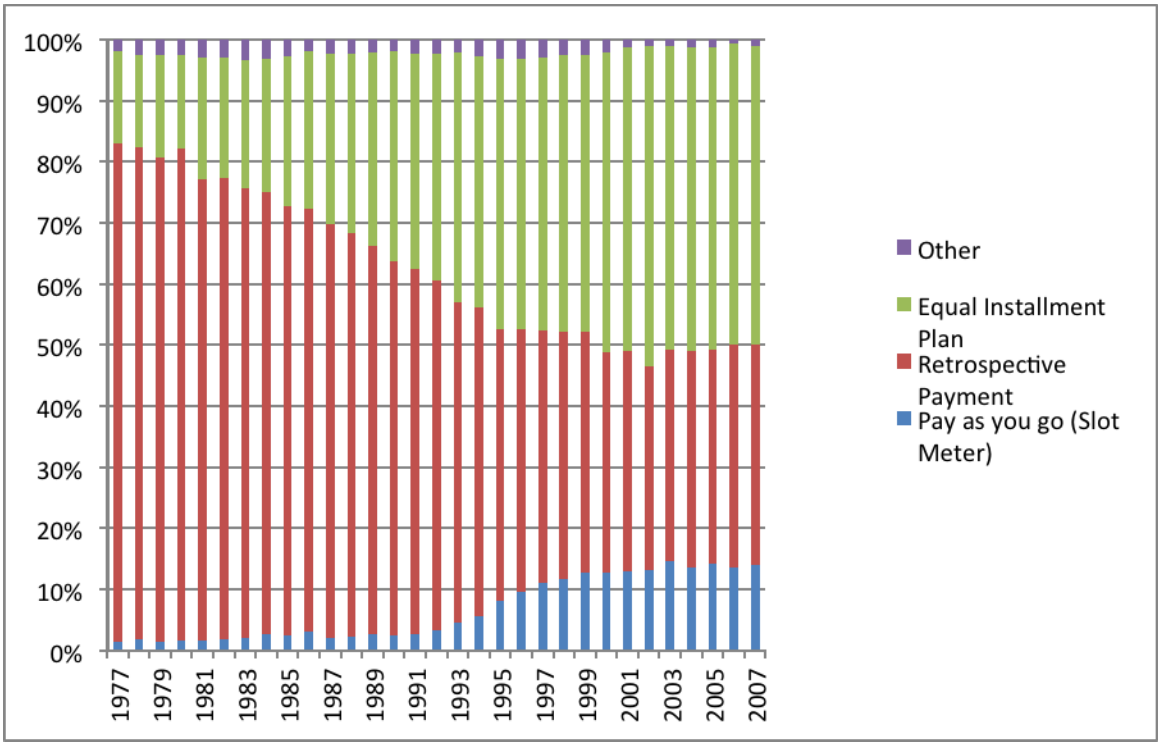
Figure 3 and Table 3 summarize our measures of unseasonal weather. We present histograms of one-month temperature shocks and three-month temperature shocks over a full year and over winter months only, with a reference normal distribution superimposed.

Table 3 shows that one in forty months is more than 1.99 C colder than average and one in forty three month intervals is more than 2.09 C colder than usual. Cold weather shocks in winter are slightly larger with one in forty winter months more than 2.17 C colder than usual and one in forty three-month intervals more than 2.03 degrees colder than usual.

From these estimated temperature shocks we construct our indicator variables for months (or three month periods) that are between one and two standard deviations colder and warmer than expected two or more standard deviations colder or warmer than expected. Estimated temperature shocks are roughly normally distributed (as can be seen in Figure 3). This implies that temperatures are two or more standard deviations

Benefit or Income Support for Mortgage Interest) on all household fuel use."

Fig. 2: Methods of Payment 1977-2007



Tab. 3: Temperature Shocks in the UK

Percentile	**Full Year**		**Winter Only**	
	1 Month Shock	**3 Month Shock**	**1 Month Shock**	**3 Month Shock**
2.5	-1.99	-2.09	-2.17	-2.03
5	-1.59	-1.72	-1.82	-1.71
10	-1.26	-1.22	-1.28	-1.34
25	-0.62	-0.62	-0.56	-0.70
50	0.01	0.03	0.08	0.04
75	0.69	0.65	0.66	0.68
90	1.27	1.2	1.16	1.30
95	1.60	1.62	1.56	1.61
97.5	1.89	1.94	1.84	1.80

Fig. 3: Distribution of Temperature Shocks

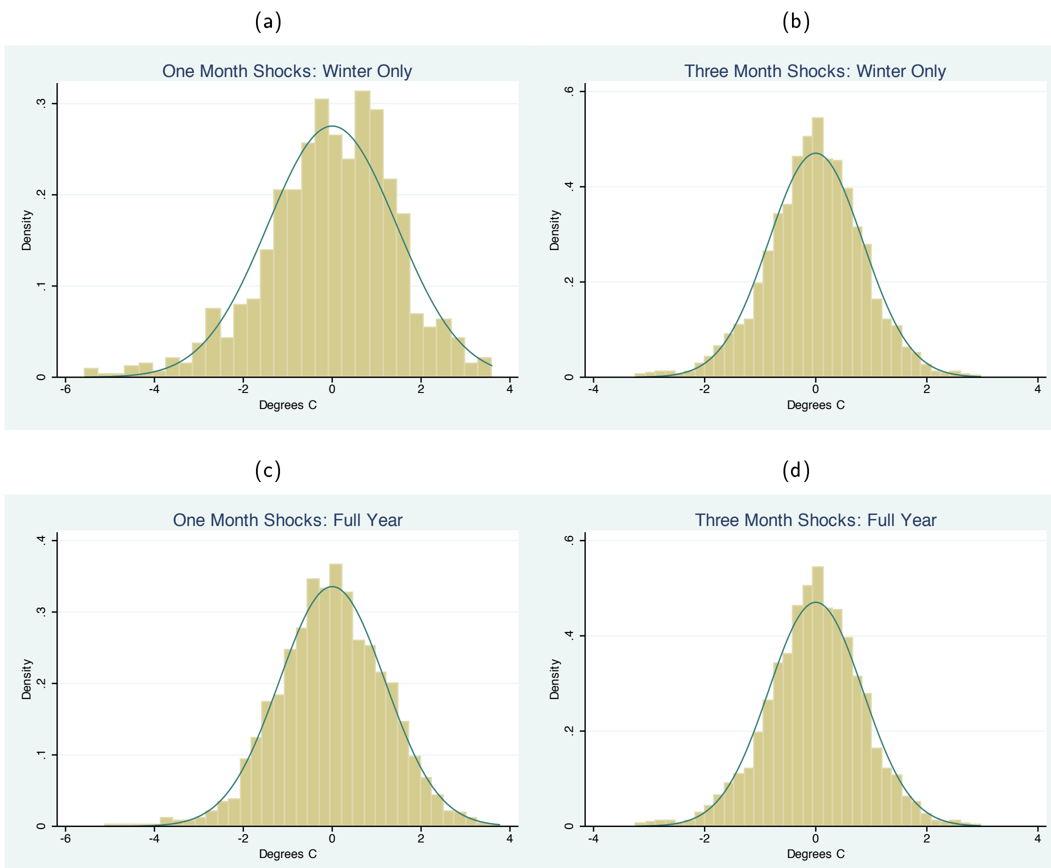
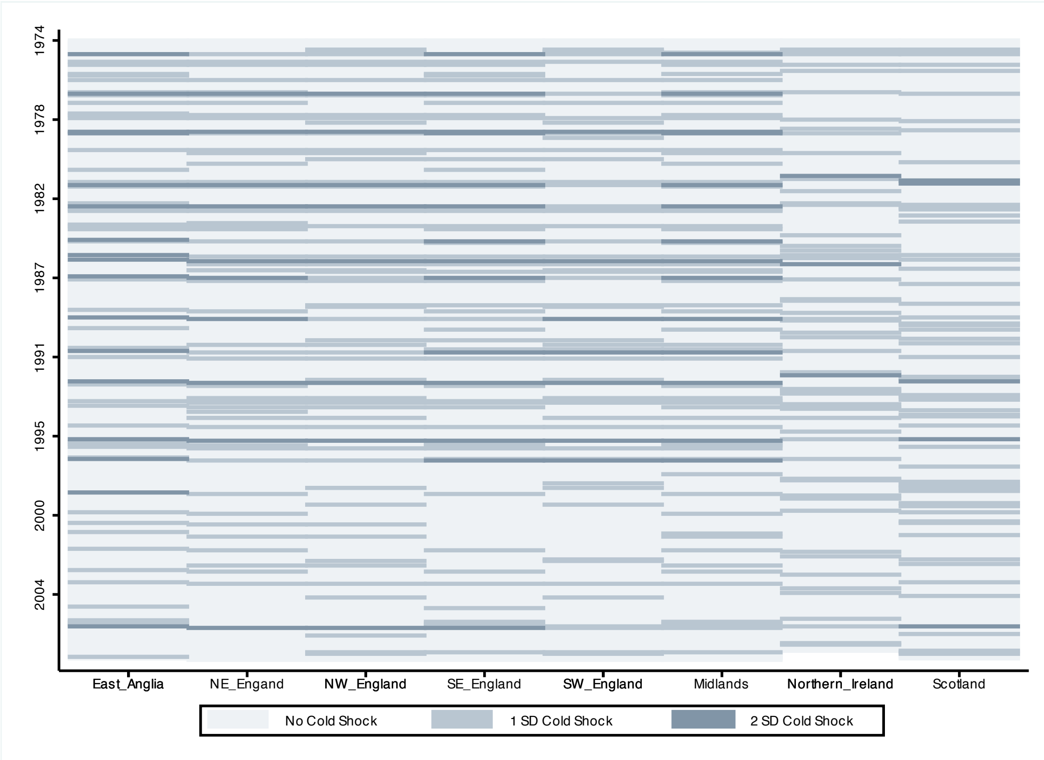


Fig. 4: Distribution of Cold Weather Shocks



colder than expected approximately one month in forty. Of course temperatures are also two or more standard deviations warmer than expected approximately one month in forty. Similarly, temperatures are between one and two standard deviations colder than expected almost one month in seven, as a temperatures between one and two standard deviations warmer than expected.

Figure 4 provides information on when and where unseasonably cold months occurred. Each column represents a region and light grey bars show a 1 to 2 SD cold weather shock and darker bars show a 2 or greater SD shock. Two things bear noting, first cold weather shocks occur in all regions of the country and occur across periods, though less frequently in more recent years. Second, shocks appear broadly correlated in time; more often than not unusually cold periods occur in several regions simultaneously.

4.3 Spending Responses to Weather Shocks

Tables 4a and 4b summarize the main findings. These tables display the estimated effects of positive and negative temperature shocks that are between one and two standard deviations from the mean and two or more standard deviations on household fuel and food expenditure. As noted above, we consider the effects on four groups: all households, all households during the winter months, households in the bottom quartile of the expenditure distribution and households in the bottom quartile of the expenditure distribution during the winter months.

Households respond to a one to two standard deviation cold shock by increasing spending on fuel. The increase is between 3.1% and 3.7% over all months and between 6.6% and 6.8% in response to a winter cold shock between one and two standard deviations. These effects are statistically significant at all conventional levels. Magnitudes are also similar between all households and households in the lowest income quartile. Overall, households reduce spending in response to warm weather shocks. Over all months, reductions of between 1.6% and 1.9% occur in response to a one to two standard deviation shock. These effects are significant at the 5% level. When only winter months are considered, reductions of between 9% and 13% occur in response to a two or more standard deviation warm shock; these effects are significant at the 1% and 10% levels respectively.

We find statistically significant food spending responses only to a two or more standard deviation cold weather shock. Over all months and all households a two or more standard deviation cold weather shock reduces food expenditure by 1.2%, though this effect is not statistically significantly different from zero. Households in the lowest quartile of the expenditure distribution reduce spending on food by 4.1%, significant at the 10% level. Looking only at the winter months, reductions in food expenditures are larger: 2.2% for all households and 6.8% for the poorest households and these effects are statistically significant at the 5% and 1% levels respectively. Note that one explanation for these findings is that households simply run down stores during periods of cold weather. However, we find that reductions in food expenditures occur in all major food categories (bakery and cereals, meats, dairy, fruits and vegetables), which include both storable and perishable commodities.[10]

5 Conclusion

A cold weather shock acts as an unexpected negative shock to (disposable) income; households must spend more than anticipated to keep themselves warm. To observe a "heat or eat" trade-off the negative income shock must be sufficiently large that households cannot avoid reducing food consumption. We find robust evidence of the first part: elderly households respond to unusually cold weather by increasing their fuel expenditures. Estimates of the increase in fuel spending due to a one standard deviation temperature shock ranges between 3% and 6.8%. These households also reduce spending on heating in response to unusually warm weather. Concomitant reductions in food spending are less precisely estimated and appear to occur only during the most severe cold weather shocks; these occur approximately one month in forty. The estimated effect is largest for the poorest households during winter months. These households reduce food

[10] Disaggregated results are available from authors upon request.

Tab. 4: Spending Regressions

(a) Fuel Spending Regressions

Group	Interview Months	Sample Size	< -2 SD	-1 to -2 SD	+1 to +2 SD	> +2 SD
All Households	All	80196	-0.0040	0.0371***	-0.0191**	0.0002
			(0.0162)	(0.0032)	(0.0066)	(0.00952)
	Winter	26662	-0.0217	0.0664***	-0.0023	-0.0939***
			(0.0215)	(0.0063)	(0.0079)	(0.0271)
Bottom Expenditure Quartile	All	24226	-0.0153	0.0305**	-0.0162**	0.0160
			(0.0281)	(0.0091)	(0.0053)	(0.0176)
	Winter	7951	-0.0619	0.0683***	-0.0034	-0.1300*
			(0.0554)	(0.0119)	(0.0207)	(0.0597)

Notes: * p<0.10;** p < 0.05; *** p<0.01. Regressions include a quadratic time trend, area and month dummy variables, expenditure ventile dummy variables, dummies indicating housing tenure status, the log of the the number of rooms and the log of household size.

(b) Food Spending Regressions

Group	Interview Months	Sample Size	< -2 SD	-1 to -2 SD	+1 to +2 SD	> +2 SD
All Households	All	80966	-0.0113	0.0011	0.0018	0.0120
			(0.0075)	(0.0050)	(0.0064)	(0.0083)
	Winter	26890	-0.0223**	0.0048	0.0086	0.0141
			(0.0090)	(0.0077)	(0.0070)	(0.0184)
Bottom Expenditure Quartile	All	24629	-0.0411*	-0.0043	-0.0026	-0.0064
			(0.0198)	(0.0073)	(0.0086)	(0.0164)
	Winter	8061	-0.0681***	-0.020	-0.019	0.0069
			(0.0136)	(0.0089)	(0.0128)	(0.053)

Notes: * p<0.10;** p < 0.05; *** p<0.01. Regressions include a quadratic time trend, area and month dummy variables, expenditure ventile dummy variables, dummies indicating housing tenure status, the log of the number of rooms and the log of household size.

spending by about 6.8%. Taken together, these results suggest that, at least for the poorest households, existing social programs may not provide a sufficient buffer.

The extent of the "heat or eat" trade-off in the UK is limited by a number of factors. First, the UK has a moderate climate. Temperature shocks in the UK are relatively small; an exceptionally (1/20) cold winter month is on average 1.8 C below normal. Second, food and fuel budget shares have been shrinking over time. One of the great empirical regularities of economics is that food budget shares are a decreasing function of total expenditure (or income). This is clear in Figure 1. As the UK has become wealthier, on average households are spending smaller fractions of their budget on food and on fuel. With a greater fraction of the budget spent on other goods and services (and in particular, luxuries) there is more scope to absorb an increase in heating costs, without reducing food expenditure. Of course, even today, there remain households of very limited means in the UK.

Finally, the increased use of installment plans for home energy reduces the scope for "heat or eat" trade-offs. As illustrated in Table 2 and Figure 2, equal installment plans are the most common method of payment for all households save the poorest. Moreover, the incidence of these plans has been rising over time. Equal installment plans automatically smooth the increased cost of heating due to unseasonable weather over several payment periods; an unusually cold stretch will not be immediately reflected in households' fuel payments. The increasing prevalence of such plans over time has likely reduced the scope for substitution between heating and eating. Interestingly, we might conjecture that the increase of electronic "pay as you go" schemes amongst the poorest households may increase their vulnerability to unseasonable weather. To investigate this, one would need to deal adequately with the issue that households are not randomly selected into payment groups, and that this selection has changed over time. We leave this for future research.

In summary, this research finds evidence that the poorest of older households are unable to smooth spending over the worst temperature shocks. Statistically significant reductions in food spending are observed in response to temperatures two or more standard deviations colder than expected (which occur about one winter month in forty) and reductions in food expenditure are considerably larger in poorer households. Our evidence also shows that most households in the United Kingdom are able to smooth smaller cold weather shocks. They increase spending on fuel, without reducing spending on food. Fuel spending increases in response to negative temperature shocks and declines in response to positive temperature shocks. We conclude that there is evidence of a trade-off in food vs. fuel spending, amongst the poorest of older households during the coldest winters in the United Kingdom.

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