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A Cause for Concern: Household Energy Price Resilience and Wellbeing

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A cause for concern: household energy price resilience and wellbeing

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Abstract

Much has been said about the need for resilient energy systems, an issue recently emphasised by the global energy crisis. However, despite policies attempting to bolster household resilience with different forms of financial support, the resilience of households to high energy prices has yet to be defined in the related literature. In this paper we propose a new concept of resilience, specifically 'energy price resilience', we put forward an empirical approach to capture low energy price resilience (*LENRES*) and we assess its associated socio-economic and demographic factors using a representative UK panel: *Understanding Society – the UK Household Longitudinal Study*. Using models that account for time-invariant unobserved heterogeneity, we also explore the association between *LENRES* and a set of wellbeing outcomes for adults and children through two fundamental routes: (1) the energy and thermal affordability channel; and (2) the energy and financial solvency channel. We find that employment status, housing tenure, household composition, inability to save or having no access savings and energy prepayment methods are systematically associated with *LENRES*. Moreover, using a rich set of wellbeing outcomes, we establish that *LENRES* is associated with lower wellbeing levels for both adults and adolescents. Our findings may aid targeting of government support to the most vulnerable in society.

Keywords: Energy crisis, energy resilience, energy prices, health and wellbeing

JEL codes: L94, E31, D12, I19

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1. Introduction

Much has been said about the UK's need for a resilient energy system, an issue highlighted by supply chain bottlenecks which emerged during the Covid-19 pandemic. This need has been further elevated by the ensuing energy crisis following the war in Ukraine, resulting in high and volatile energy prices, and pushing millions more households into fuel poverty (IEA, 2022a). In the UK, Government policy has attempted to mitigate the impact of the crisis with different forms of financial support, such as the energy price guarantee; most of these policies have been universal rather than targeted, therefore allowing for speed of action in the intervention but reducing the ability to target support to the most vulnerable in society and making an inefficient use of financial resources[1]. In this paper we investigate whether the concept of (household) energy price resilience can be used to understand the challenges faced by the most vulnerable consumers during energy crises and what socio-economic and demographic factors are associated with low levels of resilience. We also provide empirical evidence on the association between low energy price resilience levels and a rich set of wellbeing outcomes for both adults and adolescents living in the household.

An early study of energy resilience can be traced to Roege et al. (2014: p.250) who rely on the following definition: "*the ability to prepare for and adapt to changing conditions and withstand and recover rapidly from disruptions*". While they provide initial metrics for this concept, they do so from the perspective of the physical energy system. Gupta et al. (2019) further stressed the role of planning and preparation in energy systems characterised by high penetration of non-dispatchable decentralised renewable energy. Recently scholars have attempted to define household energy resilience albeit mainly from an energy security perspective (Hasselqvist et al., 2022, p.3): "*to ensure a good life…in the face of…power outages and shortages…*", with households using various means (backup sources, energy efficiency, flexibility, energy self-sufficiency) to cope with, and recover quickly from, increased supply variability on the path towards a low-carbon future. In this paper we focus on the economic effects of higher energy prices on households' resilience.

Previous research shows that when energy prices rise, households' savings diminish and/or households incur debt in order to maintain acceptable levels of thermal comfort (Harrington et al., 2005; Hills, 2011; Anderson et al., 2012; Grey et al., 2017; Munyanyi et al., 2021). Such

[1] For a theoretical evaluation of the distributional implications of the UK Government's interventions during the recent energy crisis see Farrell (2023)

evidence echoes recent decisions observed in lower-income households across the globe making the difficult choice between energy and other necessities, due to the rising energy prices evident in the months following the invasion of Ukraine (Guan et al., 2023).

The concerns of academics and policymakers about the increasing levels of fuel poverty and energy debt are driven in part by the impact that the persistent disruption to, and affordability of, energy services can have on households' quality of life, more specifically on their physical and mental health and wellbeing. The nature of this impact has been documented in an established body of evidence which has unearthed links between fuel poverty and the physical health of households, including higher rates of mortality and higher cardiovascular, inflammatory and mental health risks (see, e.g., Thomson et al., 2001; Marmot Review Team, 2011; Public Health England, 2014). Moreover, Kahouli (2020)'s and Llorca at al. (2020)'s studies reveal that fuel poverty adversely impacts self-assessed health in France and Spain, respectively, while Awaworyi Churchill and Smyth (2021) revealed a deleterious impact on general health in Australia. Financial distress has been identified as a potential mediator between fuel poverty and health outcomes (Burlinson et al., 2021; Hills, 2011; Marmot Review Team, 2011), while the link between energy poverty (measured by a multidimensional index) and financial inclusion (or participation in financial markets more generally) among Chinese households has recently been investigated by Cheng et al. (2023).

This paper contributes to the related literature by proposing an alternative, yet complementary, perspective on household energy resilience, focused on the issues related to prices and affordability. A change in perspective allows us to develop a novel definition of energy resilience, namely energy *price* resilience. We suggest that households with low energy price resilience struggle to heat the home at reasonable cost and/or experience financial difficulties and indebtedness when faced with high energy price events. We further propose a conceptual framework that shows how high energy price events work through two fundamental routes: (1) the energy and thermal affordability (*EA*) channel; and (2) the energy and financial solvency (*ES*) channel. We also identify a set of household- and individual-level characteristics associated with experiencing low levels of energy price resilience via these channels. Finally, we explore the association between low energy price resilience and a set of wellbeing outcomes for both adults and adolescents living in the household, with a particular interest in the relative role of thermal and energy affordability and the energy and financial solvency channels in shaping the observed associations.

More specifically, our paper contributes to the related literature on several fronts. First, we propose a definition of energy price resilience and an empirical method to *measure* this issue. To achieve this aim, we use commonly accepted measures which underpin the channels for *thermal and energy affordability* and similarly for *energy and financial solvency,* respectively. The proposed definition of energy price resilience is informed by the related literature discussed above, but also by the algorithm for financial resilience put forward by the UK's Financial Conduct Authority (FCA, 2017, Table A.2) and used to identify households with low financial resilience in their Financial Lives survey (FCA, 2022).

Our second contribution is the application of our measure of energy price resilience and its channels to a representative sample of UK households in order to explore and characterise the socio-economic and demographic makeup of low energy price resilience. Further empirical analysis is undertaken to explore the association between energy price resilience and wellbeing outcomes for household members, both young and old, as well as for the relative contribution of the underlying channels (energy and thermal affordability; energy and financial solvency) to the observed associations.

We apply our proposed definition of energy price resilience to a representative UK household panel (Understanding Society: the UK Household Longitudinal Study), drawing upon five waves of individuals participating between January 2016 and May 2022. On average, we find that around one quarter of individuals are members of households with low levels of energy price resilience. Using linear probability models and models accounting for time-invariant unobserved heterogeneity we find that employment status, housing tenure, household composition, inability to save or having no access to savings and energy prepayment methods are systematically associated with low energy price resilience at the household level. We also explore the association between low levels of energy price resilience and a set of wellbeing outcomes for adults and children living in the household, as well as investigate the influence of the *EA* and *ES* channels on these findings. Low levels of energy price resilience are associated with lower wellbeing levels for adults, primarily arising via the *ES* channel, whereas young people's wellbeing appears driven by the *EA* channel.

The rest of the paper is organised as follows: section 2 provides the conceptual framework underpinning our proposed definition of energy price resilience, section 3 presents the data and methodology used in our analysis. Section 4 presents our results, and section 5 offers conclusions and policy recommendations.

2. Definition and conceptual framework

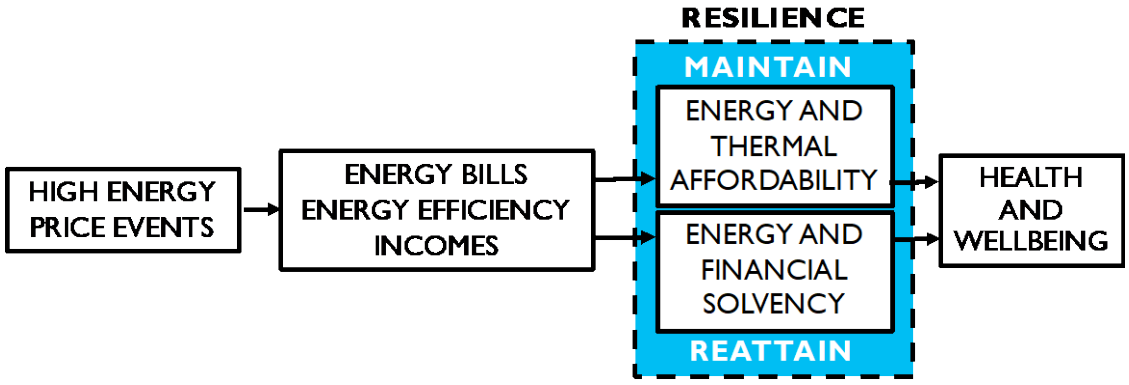
As outlined above, several scholars have sought to define energy resilience from various perspectives, predominantly relating to supply disruptions (focusing on the energy security of systems, communities and more recently households). However, there is a gap in the literature related to energy resilience from the demand-side, specifically focusing on the resilience of households to high energy price rises.

In this section, we put forward an alternative, yet complementary, definition of household 'energy *price* resilience' as follows:

> *The ability of a household to maintain (reattain) sufficient levels of energy and thermal affordability and/or energy and financial solvency in the face of high energy price events.*

Our definition complements those by Abi Ghanem et al. (2016) and Hasselqvist et al. (2022), in their efforts to establish ways in which households can be resilient within energy systems. However, our definition deviates from those established in the literature in several important ways, particularly in its focus on *prices* (and therefore on issues related to affordability), rather than the supply of energy. We discuss these innovations in turn, using Figure 1 to visualise the overarching conceptual framework.

Figure 1. *A conceptual framework of household energy price resilience.*



2.1 A cause for concern: high energy price events

First and foremost, we deviate from the current definitions of supply-side energy resilience by recasting the cause (or source) of one's need to be resilient from the demand-side. A seminal study by Abi Ghanem and colleagues (2016: 178) defines household energy resilience, as: *"…modifying the performance of practices through changing material elements, gaining knowledge for how 'to do' things during a power cut, and accepting new meanings for achieving comfort, convenience and cleanliness".* This definition was proposed soon after UK householders were widely affected by storms in February 2014 and, as a result, developed with power outages in mind. In essence, a households' resilience is contextualised on whether they were able to withstand a storm or similar event, as well as adapt and learn from their (families' and communities') experiences in order to bolster health and wellbeing whilst ensuring that their homes remained safe and secure – often prioritising thermal comfort over other basic needs. In developing their definition of energy resilience, Hasselqvist et al. (2022) moved beyond the narrow focus of low frequency high impact events (i.e. blackouts), to account for more frequent low impact, and potentially voluntary (e.g. demand-side management) events such as power shortages that could shape everyday life in a low-carbon energy system. The authors held a view that households could be supported in learning how to live a good life while adjusting, adapting to, and perhaps benefitting from, a more variable supply of electricity.

However, looking at the UK as an example, recent evidence showed that the average number of minutes lost per customer per year lay between 30 and 50 minutes, depending on the network operator, which is equivalent to services remaining uninterrupted 99.999% of the time (Ofgem, 2021a). Similarly, despite average levels of debt owed by energy consumers in arrears (without a debt repayment plan) increasing by 30% for electricity accounts and 48% for gas accounts, between 2016 and 2022 (Q1), the number of disconnections for non-payment of debt have remained close to zero over the same period due to protections enforced by the energy regulator (Ofgem, 2023a). In contrast, the number of *self-disconnections* remained high; this occurs when customers on a pay-as-you-go prepayment meter (PPM) run out of credit because they cannot afford to top up or are unable to top up for other reasons. According to recent evidence, around 2 million households (out of about 4 million PPM customers) disconnected at least once per month and around one fifth of PPM customers disconnected for more than 24 hours

(Citizens Advice, 2023).[2] It is however difficult to measure the extent of self-rationing, where consumers paying by credit, who remain connected to the system, restrict their demand because of financial pressures.

By the end of 2021, UK wholesale energy prices increased by around 400% (compared to Winter 2020) and a similar fourfold rise emerged across Europe (IEA, 2022b; Ofgem, 2023b). To date, the energy-price crisis has affected markets and households for nearly two years and is expected to continue for another year at least (HM Government, 2022). The consequences have been far-reaching, not least because wholesale energy price increases brought about significantly higher energy bills – double (£2500/year) in September 2023 for a typical consumer compared to 2021 (Ofgem, 2021b and 2023c) – and has contributed to pushing inflation above 10% per annum (Bank of England, 2022). Low income and vulnerable households have been adversely affected, despite the UK government paying more than half of the costs during the 2022 winter. This often manifests itself in households choosing between heating the home and other necessities – clearly to a more frequent and deeper extent than captured by the original and dominant definitions of household energy resilience in the relevant extant literature. We therefore identify the starting point for our definition of energy resilience as 'high energy price events' (see Figure 1).

2.2 The first line of defence: energy bills, energy efficiency, income

Our second deviation from the traditional concept of energy resilience, as a result of refocusing the cause (or source) for resilience on high energy price events, recognises that significant and high price changes work through the three key factors that can be considered consumers' first line of defence: energy bills, energy efficiency, and incomes (see Figure 1)[3]. While we recognise that energy affordability is a multidimensional and complex issue (Nussbaumer et al., 2012), it is uncontroversial to state the relevance of the challenges that arise when households face significant and persistent price rises. When a high price event occurs, depending on the extent to which and how quickly energy bills rise, households may struggle to afford their required levels of energy services, and therefore their ability to maintain or

[2] It is important to note that mechanisms to support vulnerable people in the event of a power outage are available through network operators (via the priority service register); however, unlike standard credit meters which were effectively subject to a disconnection ban, over 130,000 households (including those with a family member that either has a disability and/or long-term illness) on a PPM were disconnecting at least once per week (Citizens Advice, 2023).

[3] These factors are often referred to as the pillars of fuel poverty.

reattain sufficient levels of energy and thermal affordability and/or energy and financial solvency could be at risk, thus limiting the household's ability to afford other essential goods.

2.3 Channels of energy price resilience

Third, we introduce the channels underpinning household resilience to high energy prices. We propose that households are resilient if, despite facing significant increases in energy prices, they are able to maintain, or at least reattain (without detriment), sufficient levels of energy and thermal affordability and/or energy and financial solvency (Figure 1). These channels are akin to the thermal comfort and financial security pathways previously identified by Gilbertson et al. (2006; 2012); they can be seen as the key psycho-social routes through which the benefits (or costs) of energy-related interventions can impact health and wellbeing. While the timeframe of the study restricted Gilbertson and colleagues' ability to observe the benefits of warmer homes and lower energy bills on physical health, such links have nonetheless been documented in detail elsewhere (see, e.g., Davillas et al., 2022). The authors argue that, at least in the short term, the financial security pathway is of critical importance for mental health. Indeed, Burlinson et al. (2021) later showed a strong association between fuel poverty and financial distress (i.e. provided evidence which suggests that an intermediate route from high energy costs to the financial security pathway exists).

Depending on the extent to which energy prices rise, particularly if this happens unexpectedly, households may have to rely on their current financial liquidity (income, savings, credit and so on) in order to maintain levels of affordability and solvency, and potentially help to protect their health and wellbeing (Figure 1). However, when a household is at the limit of what can be done in the event of a price rise[4], given budgetary and other constraints, higher prices may result in a reduction in energy consumption, adverse internal conditions of the home (e.g., low temperatures) and/or increased levels of financial precarity (e.g., falling behind on bills).

Overall, our definition of household energy price resilience refocuses the previously proposed concepts by arguing that high energy prices can permeate the first line of defence (via energy bills, energy efficiency and consumption, and income) and place a significant burden on households. We also acknowledge that, as a result of this burden, energy price increases may

[4] Such as making incremental changes to energy consumption by turning down the thermostat.

impact the health and wellbeing of households if they are unable to maintain or reattain sufficient levels of energy and thermal affordability and/or energy and financial solvency.

3. Data and methodology

Our data comes from the longitudinal survey of the UK, Understanding Society: the UK Household Longitudinal Study (UKHLS) (University of Essex, 2022). Given that our estimation strategy requires outcome variables to be measured in every wave of the panel, we draw upon a panel of individuals participating in the UKHLS between Wave 8 (January 2016 – May 2018) and Wave 12 (January 2020 – May 2022) of the UKHLS. Our panel in the main analysis consists of 100,848 person-wave observations over the period of interest (roughly 20,170 individuals per wave given it is an unbalanced sample), upon adjusting for outliers, item and unit missingness. All data used in the analysis is weighted using UKHLS' longitudinal sample weights.

3.1 Measuring energy price resilience

We discuss the construction of the two channels of energy price resilience and our combined measure of such resilience in the next sub-sections. Summary statistics and descriptions of the variables used to measure energy price resilience can be found in Table 1.

Energy and thermal affordability (EA)

We capture this channel utilising perception- and expenditure-based measures typically associated with energy and thermal affordability (*EA*). Our measures capture homes in low energy-related affordability (*LEA*), specifically if the household:

1) is unable to keep the accommodation warm enough during winter, due to inability to afford it;
2) spends more than 10% of their income on energy[5].

Table 1 shows that around 5% of households in our sample indicated that they are unable to keep the home warm due to affordability reasons. Whereas, around 17% of households spend

[5] Income (after deducting housing costs) and energy expenditure are equivalised factors following the approach adopted in Hills (2012) and are deflated using the retail price index (base year, 2009) (ONS, 2023).

more than 10% of their income on energy. Combining the two dichotomous measures, it is evident that around 20% of individuals live in a household that is unable to afford adequate levels of heating *and/or* that spends more than a tenth of their income on energy.

A wealth of literature has utilised perception- and expenditure-based measures to capture energy affordability in various contexts in order to explore how they relate to health and financial outcomes (see, e.g., Awaworyi Churchill and Smyth, 2021; Burlinson et al., 2021; Davillas et al., 2022). Indeed, such variables have often been used in the literature as indicators of fuel/energy deprivation and are underpinned by several factors affecting households' ability to maintain sufficient levels of thermal comfort, including energy prices, energy efficiency, income, and consumer behaviour.

Energy and financial solvency (ES)

As for the energy and thermal affordability channel, we rely on a perception-based variable to capture financial difficulties, but also on a (quasi-) objective variable to capture issues related to energy and financial solvency (*ES*). We identify low levels of *ES* (*LES*) for those individuals who:

1) are currently and personally finding managing their finances at least quite difficult;
2) belong to a household which has fallen behind on at least some of their bills, including electricity, gas, and other utilities.

Whilst these may be considered as proximal measures of energy insolvency and indebtedness, they have been found to be strongly associated with energy-cost related financial issues (Burlinson et al., 2021). Indeed, our measure of energy insolvency also evokes the Financial Conduct Authority (FCA, 2021)'s concept of financial resilience, not least because the FCA view resilience as one of four key drivers of vulnerability and identify adults with low levels of financial resilience by measuring, among other factors, whether they are overindebted and/or finding managing their finances to be burdensome.

In so doing, we aim to capture the experience of households in the face of high energy price events that runs through the financial insecurity channel. Table 1 shows that just under 7% of individuals in our sample found managing their current personal financial circumstances to be quite or very difficult. Similarly, almost 5% of households had fallen behind on at least some of their household bills (including electricity, gas, water rates, telephone, and other bills). Combining our dichotomous variables representing the energy and financial insolvency

channel, around 10% of adults experienced financial difficulties and/or belong to a household which is behind on paying utility bills.

Table 1. Definitions and mean values: a) low energy and thermal affordability (*LEA*) measures; b) low energy and financial solvency (*LES*) measures.

Variables	Definition	Mean
Low Energy and thermal affordability (LEA)		
(1) Inadequate heating	In winter, are you able to keep this accommodation warm enough? If you cannot afford to, please answer no; 1 = 'no' and 0 = 'yes'.	0.046
(2) 10% of income spent of energy	1 = Equivalised annual household energy expenditure exceeds 10% of annual equivalised household income (after deducting housing costs); 0 = otherwise.	0.170
(1) And/or (2)	1 = Inadequate heating and/or spending 10% of income on energy; 0 = otherwise	0.199
Low energy and financial solvency (LES)		
(3) Financial difficulties	How well would you say you yourself are managing financially these days? 1 = Finding it quite difficult or very difficult; 0 = otherwise.	0.069
(4) Behind on bills	Sometimes people are not able to pay every household bill when it falls due. May we ask, are you up to date with all your household bills such as electricity, gas, water rates, telephone and other bills or are you behind with any of them? 1= Behind on some or all bills; 0 = otherwise.	0.050
(3) And/or (4)	1 = Financial difficulties and/or behind on utility bills; 0 = otherwise	0.099
N		100,848

Notes: Mean values are weighted using sample weights. Energy expenditure and income have specific equivalisation factors following the approach adopted in Hills (2012) and are deflated using the retail price index (base year, 2009) (ONS, 2023).

A composite measure of low energy price resilience

The above combined indicators representing the two channels (*LEA* and *LES*) are used to create a composite overall measure of household low energy price resilience (*LENRES*). Table 2 presents the cross-tabulations between the two channels. We find that that about 75.1% of individuals do not belong to households with low levels of energy price resilience (cell A). In contrast, around one quarter (24.9%) of individuals are described as living in households with low energy price resilience defined using the *LEA*, the *LES* channel, or a combination of both (cells B, C and D, respectively).

It is important to note that the level of low energy price resilience appears to be relatively stable over time[6], however, there is a marked increase to 32% of individuals living in households characterised by *LENRES* in 2022. This captures the onset of the energy crisis affecting households' ability to remain resilient across the UK during our period of study.[7]

Table 2. Cross-tabulations (percentages) of indicators of low energy and thermal affordability (*LEA*) and low energy and financial solvency (*LES*) used to measure low energy price resilience *LENRES* (cells B, C and D)

	LES = No	LES = Yes	Total
LEA = No	(A) 75.13% (n= 75,764)	(B) 4.98% (n=5,027)	80.11% (n=80,790)
LEA = Yes	(C) 14.95% (n= 15,075)	(D) 4.94% (n=4,983)	19.89% (n=20,058)
Total	90.07% (n=90,839)	9.93% (n=10,009)	100% (N=100,848)

Notes: Results are weighted using longitudinal sample weights on the pooled sample (UKHLS wave 8-12). Correlation coefficient= 0.249. N= 100,848.

[6] Figure A1 in the Appendix shows that the proportion of the households with low levels of resilience to be around 25% each year between 2016 and 2021.

[7] Our sample covers the period up to and including April 2022. Hence, at present, we are only able to observe the initial impact of the energy price crisis, given the schedule of release of the official UK longitudinal survey.

3.2 Covariates

Our analysis exploring the socio-economic and demographic correlates of low energy price resilience controls for a standard set of covariates expected to be associated with household energy price resilience. We account for age (*AGE*), gender (*FEMALE*, *MALE*) and ethnicity (*WHITE, MIXED, ASIAN*, and *BLACK*). We also control for household composition, specifically an indicator for a single parent household (*LONEPARENT*), and housing tenure (a 4-category variable; *OWNER, MORTGAGE, SOCIAL_RENTER*, and *PRIVATE_RENTER*). Household size (*HHSIZE*) and its squared term (*HHSIZE2)* are also accounted for to capture non-linear associations with our resilience outcome variables.

We also control for energy payment by PPM (*PREPAYMENT*). Labour force status is included, using a six-category variable (*EMPLOYED, UNEMPLOYED, RETIRED, STUDENT, DISABILITY,* and *OTHER_JOBSTATUS*). We further account for a dichotomous education variable capturing respondents without A-levels or a degree (*NODEGREE vs ALEVEL_DEGREE*). Regional effects are captured using regional dummies (the nine government office regions of England, Northern Ireland, Scotland, and Wales), and an indicator of rural location (*RURAL vs URBAN*). Finally, we also control for survey wave, year and month of interview time effects. Mean values and definitions of the explanatory variables used in the analysis are presented in the Appendix A (Table A1).

The same set of covariates (unless otherwise stated) are used in our subsequent analysis exploring the association of our energy price reliance measures with a wide set of wellbeing outcomes for both adults and their children living in the household.

3.3 Econometric analysis

To explore the social and economic characteristics associated with low energy price resilience, we regress our set of covariates on the *LENRES* indicator, using the following general linear probability model specification:

$$LENRES_{it} = X_{it}'\beta + \omega_t + \mu_r + \alpha_i + \varepsilon_{it} \quad (1)$$

where $LENRES_{it}$ represents the dichotomous outcome of low energy price resilience for individual i at wave t. The vector X_{it} contains the socioeconomic and demographic covariates discussed above, with β representing the vector of regression coefficients to be estimated; α_i denotes the time-invariant unobserved fixed effect. ω_t is the vector of wave and month indicators, and a year-on-year trend, capturing the seasonality in $LENRES_{it}$. μ_r captures regional and urban/rural location effects. Finally, ε_{it} denotes the idiosyncratic error term. Equation 1 is estimated using pooled OLS and fixed effects models.

In the subsequent analysis, we explore whether our measure of low energy price resilience is associated with a set of wellbeing outcomes for adults and young people living in the household. We proceed by using the following general linear specification:

$$WELLBEING_{it} = LENRES_{it} + X_{it}'\beta + \omega_t + \mu_r + \alpha_i + \varepsilon_{it} \quad (2)$$

Where $WELLBEING_{it}$ stands for the vector of wellbeing outcomes of interest, while all remaining vectors are defined analogously to Eq 1. Pooled OLS and fixed effects estimators, respecting the panel nature of the data, are used to estimate Eq 2. It should be also noted that linear probability models are used for the analysis of dichotomous health outcome variables.

4. Results

4.1 Exploring the socio-economic and demographics of low energy price resilience

Our results on the socio-economic and demographic characteristics associated with low levels of energy price resilience are presented in Table 3; column (1) presents the OLS results, while fixed effects estimates are presented in column (2). Overall, the observed differences in the magnitude of the estimates between the OLS and the fixed effects models highlight the role of time-invariant unobserved heterogeneity.

Focusing on the fixed effects estimates that account for such unobserved heterogeneity (Column 2), we find that relying on PPMs as a fuel payment method has a positive and statistically significant association with low energy price resilience; those using PPMs experience a 4.6 percentage point (ppt) higher probability of *LENRES* compared to other

payment methods. We also observe a positive and statistically significant association between labour market status and *LENRES*. For example, being unemployed or retired is systematically positively associated with *LENRES* – 24.6 point and 13.2 point higher probability respectively – compared to the baseline category of being employed. Respondents who are out of the job market due to long-term illness and/or disability experience a 13.6 ppt higher probability of *LENRES* compared to those employed.

We also find housing tenure to have a positive and systematic association with *LENRES.* Compared to individuals who own their home, all other tenure types are associated with a lower probability of energy resilience. For example, individuals renting in the private sector exhibit a higher probability of low energy price resilience (9.7ppt) than those with mortgages (4.2ppt), compared to the reference group of owners. In addition, our findings reveal single parent households to be positively associated with low levels of resilience, with a 10 ppt higher probability of *LENRES* than other household compositions.

The quadratic term on household size reveals a U-shaped association with low energy price resilience, which remains robust when controlling for fixed effects (Column 2). In other words, relatively small and relatively large households both appear to be associated with a higher probability of low energy price resilience. In addition, the association with low energy price resilience is increasing with the size of the property (captured by the number of bedrooms). It is worth noting that this finding is conditional on holding the household size constant, hence similar sized households living in larger (and potentially more inefficient) housing appear at greater risk of *LENRES.*

The pooled OLS model's results highlight the presence of positive associations between *LENRES* and being female, not obtaining educational qualifications (vs GCSEs or above), and being of black, mixed or other ethnicities (vs white). However, we are unable to test the robustness of these findings in the fixed effects regressions, as they are time invariant.

Table 3. Pooled and fixed effects linear regressions of *LENRES*

	Pooled OLS (1)	Fixed effects (2)	Pooled OLS (3)	Fixed effects (4)
Dependent variable	LENRES	LENRES	LENRES	LENRES
NOSAVINGS			0.203***	0.081***
			(0.008)	(0.009)
CANNOTSAVE			0.098***	0.034***
			(0.004)	(0.007)
PPM	0.175***	0.046***	0.139***	0.045***
	(0.010)	(0.014)	(0.010)	(0.014)
AGE	0.000	-0.008	0.000	-0.008
	(0.000)	(0.008)	(0.000)	(0.009)
MALE	-0.015***		-0.012***	
	(0.005)		(0.004)	
MIXED	0.060***		0.042**	
	(0.021)		(0.019)	
BLACK	0.096***		0.090***	
	(0.012)		(0.011)	
OTHER_ETHNICITY	0.140***		0.128***	
	(0.021)		(0.019)	
NODEGREE	0.060***		0.056***	
	(0.008)		(0.007)	
UNEMPLOYED	0.327***	0.246***	0.278***	0.239***
	(0.014)	(0.015)	(0.013)	(0.015)
STUDENT	-0.046***	-0.028	-0.037***	-0.030
	(0.015)	(0.017)	(0.014)	(0.017)
RETIRED	0.037***	0.132***	0.045***	0.130***
	(0.007)	(0.012)	(0.007)	(0.012)
DISABILITY	0.172***	0.136***	0.136***	0.133***
	(0.010)	(0.011)	(0.009)	(0.011)
OTHER_JOBSTATUS	0.047***	0.016***	0.035***	0.016***
	(0.005)	(0.005)	(0.005)	(0.005)
SINGLEPARENT	0.194***	0.100***	0.156***	0.100***
	(0.016)	(0.022)	(0.015)	(0.022)
HHSIZE	-0.076***	-0.119***	-0.080***	-0.118***
	(0.007)	(0.014)	(0.006)	(0.014)
HHSIZE2	0.011***	0.014***	0.010***	0.014***
	(0.001)	(0.002)	(0.001)	(0.002)
NBEDS	0.007**	0.015**	0.011***	0.015**
	(0.003)	(0.006)	(0.003)	(0.006)
MORTGAGE	0.022***	0.042***	0.017***	0.040***
	(0.006)	(0.009)	(0.005)	(0.009)
PRS	0.159***	0.097***	0.119***	0.093***
	(0.010)	(0.023)	(0.009)	(0.023)
SRS	0.164***	0.068***	0.135***	0.065***
	(0.010)	(0.017)	(0.010)	(0.017)
RURAL	0.035***	0.014	0.036***	0.013
	(0.005)	(0.016)	(0.005)	(0.016)
Regional effects	Y	Y	Y	Y
Time effects	Y	Y	Y	Y
N	100848	100848	100848	100848

Notes: All model specifications also account for a set of regional, wave and month indicators, as well as a time trend (results not presented here). Columns 3 and 4 add controls for savings. All statistics are weighted using survey weights. Robust standard errors clustered at individual level in parentheses.
$^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$.

The influence of access and ability to save

In this sub-section, we explore whether the preceding results hold whilst controlling for the household's ability to make regular savings and/or have access to savings. This draws upon the FCA's definition of low financial resilience, which deems adults to have low financial resilience if, for example, they have a limited capacity to withstand financial shocks due to low or erratic incomes or savings. A comprehensive investigation of these issues is however impeded by the fact that UKHLS collect data that could potentially proxy for low or erratic savings only at low time frequency (i.e. at specific waves), as discussed below.

In order to explore the influence of saving behaviour, we are able to utilise two variables contained in UKHLS at specific waves. The first dichotomous variable, collected at Waves 8, 10 and 12, takes the value of one if the household does not have enough money to make regular savings of £10/month or more for rainy days or retirement, and zero otherwise (*CANNOTSAVE*).[8] Our second variable, collected at Waves 8 and 10, it set equal to one if the individual does not have any savings, and zero otherwise (*NOSAVINGS*). Due to the infrequent collection of these variables, we approximate savings behaviour by carrying forward the values for each individual across the panel (i.e., from Wave 8 to 12). Hence the results in this sub-section (Table 3, columns 3 and 4), should be interpreted with caution.

Table 3 (Columns 3-4) reveals a positive association between the (low) savings proxies and low energy price resilience, which is robust after accounting for time-invariant unobserved heterogeneity. We also note that our preceding results on the socio-demographic correlates of low energy price resilience, after accounting for unobserved heterogeneity, remain almost identical to those without controlling for savings behaviour (Table 3, Column 2 vs Column 4). Assuming that measurement errors in our savings variables play a limited role, these results suggests that the association between savings behaviour and our composite energy price resilience measure is independent from the role of all other variables included in our models, upon removing individual time-invariant heterogeneity.

4.2 Exploring the low energy price resilience channels

We also explore the socio-economic and demographic characteristics associated with the two channels of low energy price resilience, i.e. low energy and thermal affordability (*LEA*) and

[8] The household is only asked this question if they have children living at home (aged 0-15) or no children (if there is no member of pensionable age).

low energy and financial solvency *(LES*). Again, we estimate linear probability models (pooled OLS and fixed effects) using *LEA* and *LES* respectively as the dependent variable in the general linear specification outlined in Equation 1. The fixed effects results for *LEA* and *LES* are displayed in Table 4.[9]

Overall, there are differences in the systematic socio-economic and demographic associations between the two low energy price reliance channels – energy and thermal affordability (LEA) and energy and financial solvency (LES). Individuals living in households paying for energy using a PPM appear to be associated with systematically lower probability of experiencing *LEA,* but this is not the case for *LES*. This conforms to the view that PPMs, despite being an effective way to manage budgets, typically result in higher energy costs and lower levels of affordability.

Turning to job market status, notable differences are observed for the elements of our composite low price energy resilience measure. For example, our results reveal that *LEA* appears more prevalent for those in retirement than *LES*. These findings are concerning from a policy perspective given the well-known health risks for the elderly living in colder homes. Moreover, it is perhaps expected that people with a temporary or insecure job (OTHER JOB STATUS) might experience solvency issues (*LES*), and affordability (*LEA*), with the latter having a statistically significant effect.

Consistent with lower levels of energy efficiency in the rented sector, the *LEA* component appears more robustly associated with low energy price resilience for those renting in the private or social sector (versus the homeowner reference group). More specifically, we found the relevant coefficients for those living in rented accommodation to be only statistically significant in the case of the fixed effects *LEA* model. Similarly to our results for the composite *LENRES* measure, household size appears to have a U-shaped association with both *LEA* and *LES*. Conversely, holding household size constant, the number of bedrooms remains systematically associated with *LEA* but not *LES*. Similarly, being single parents, compared to the reference group of all other household compositions, appears to be associated only with lower levels of affordability (*LEA*).

[9] For brevity, the pooled OLS estimates are available upon request.

Table 4. Fixed effects linear regressions for the two *LENRES* channels– energy and thermal affordability (*LEA*) and energy and financial solvency (*LES*).

Dependent variable	LEA	LES
PPM	0.070***	-0.003
	(0.015)	(0.013)
AGE	-0.008	-0.002
	(0.009)	(0.006)
UNEMPLOYED	0.231***	0.107***
	(0.015)	(0.013)
STUDENT	-0.003	-0.024
	(0.018)	(0.015)
RETIRED	0.137***	0.002
	(0.012)	(0.007)
DISABILITY	0.125***	0.053***
	(0.011)	(0.010)
OTHER_JOBSTATUS	0.007	0.014***
	(0.005)	(0.004)
SINGLEPARENT	0.131***	0.020
	(0.023)	(0.021)
HHSIZE	-0.127***	-0.035***
	(0.014)	(0.011)
HHSIZE2	0.013***	0.006***
	(0.002)	(0.002)
NBEDS	0.021***	0.001
	(0.006)	(0.004)
MORTGAGE	0.042***	0.013**
	(0.009)	(0.006)
PRS	0.105***	0.003
	(0.025)	(0.018)
SRS	0.084***	-0.003
	(0.017)	(0.012)
RURAL	0.020	-0.001
	(0.015)	(0.010)
Regional effects	Y	Y
Time effects	Y	Y
N	100848	100848

Notes: All model specifications also account for a set of regional, wave and month indicators, as well as a time trend (results not presented here).
Robust standard errors clustered at individual level in parentheses.
** p < 0.1, ** p < 0.05, *** p < 0.01.*

4.3 Low energy price resilience, wellbeing and long-term illness and disability measures

In this subsection we turn to a rich set of wellbeing outcomes potentially associated with low levels of energy price resilience (i.e., *LENRES*). A full description of the wellbeing outcomes used in these models, along with their mean values, can be found in Appendix A (Table A2).

In Table 5 (Panel A) we assess whether *LENRES* is associated with life satisfaction (Column 1) and mental health (Column 2) measures; the former is captured by a 7-point variable of whether an individual is satisfied with their life overall, while mental health is proxied by the General Health Questionnaire (GHQ) which captures psychological distress (Davillas and Jones, 2021). Apart from using the overall GHQ-12 caseness score as an outcome – an increasing score of mental distress ranging from one to twelve – we also explore separately each of the twelve items underpinning this score; these individual items range from one's ability to concentrate (Column 3) to general happiness (Column 14) and are coded as dichotomous variables, with the value of one given the worst outcomes and zero to the others.

Overall, our fixed effects models (Table 5, Panel A) show a starkly consistent association between *LENRES* and our set of life satisfaction and wellbeing measures. Specifically, after taking into account time invariant unobserved heterogeneity, these results suggest that *LENRES* is systematically associated with lower levels of life satisfaction (Column 1), higher levels of psychological distress (Column 2), and worse outcomes for each of the individual elements of our GHQ-12 psychological distress measure (Columns 3 to 14).

In a subsequent analysis (Table 5, Panel B) we explore the relative contribution of the two components underpinning our composite measure of low energy price resilience (*LENRES*). More specifically, by estimating fixed effects models that include both the energy and thermal affordability (*LEA*) and energy and financial solvency (*LES*) dichotomous variables, we explore the relative strength of the observed association between low energy price resilience and our wellbeing outcomes in each pathway. We found that the associations between our set of wellbeing outcomes and the composite *LENRES* are primarily driven by the energy and financial solvency (*LES*) component. On the other hand, the role of the energy and thermal affordability (*LEA*) component appears less pronounced; not only are the coefficients lower in magnitude, but they are also strongly associated (statistically significant at the 5% level) with only a few of our wellbeing outcomes. For example, life satisfaction and the GHQ-12 psychological distress measure are systematically associated with *LEA*, with the related

coefficients lower in magnitude, compared with the corresponding results for the *LES* component.

We also explore whether the composite low energy price measure *(LENRES)* is associated with a set of long-standing disability indicators. Given the relatively high levels of disability in the the UK and its significant social and economic ramifications (e.g., Pudney et al., 2011; Jones, 2016; Davillas and Pudney, 2020), these results are of particular importance. Table 6 presents the results of regressing disability measures on our low energy price resilience measure, after accounting for time-invariant unobserved heterogeneity. The outcomes include whether an individual has a long-standing illness or disability (LTSD, Column 1), and measures of specific functional difficulties such as moving objects (Column 2) and memory and concentration (Column 3).

Table 6 shows a positive association between *LENRES* and disability (Panel A, Column 1), driven largely by the energy and financial solvency (*ES*) component (Panel B). Turning to the specific disability indicators, we found systematic associations between *LENRES* and the inability to move objects (Column 2) and with memory and concentration difficulties (Panel A, Column 3). We observe an association with *LES* for all the three disability indicators, while memory and concentration is also associated with *LEA* at the 5% significance level (Panel B, Column 3).[10]

[10] As a robustness check, we utilised SF12 mental and physical health outcomes to further test the *LENRES* associations and those established through its channels. In so doing, we follow the preceding approach to reveal the association between the (log of) SF12-M and SF12-P with *LENRES* and its underlying components. The results are generally confirmed as we found a clear negative association between *LENRES* and mental health. Like Table 5, this association is more associated with energy and financial solvency. Indeed, there is some evidence to support that the *LES* component is also associated with worse physical health outcomes. For brevity these results are available upon request.

Table 5. Fixed effects linear regressions of our wellbeing outcomes on the composite low energy price resilience measure (*LENRES*; Panel A) and its underlying components (energy and thermal affordability (*LEA*) and energy and financial solvency (*LES*); Panel B).

Specifications	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
Dependent	Life Satisfaction	GHQ-12	Concentration	Sleep	Useful	Decision making	Under strain	Overcome difficulties	Enjoy activities	Problem solving	Confidence	Depressed	Self-worth	Happiness
							Panel A.							
LENRES	-0.172***	0.375***	0.024***	0.036***	0.024***	0.022***	0.037***	0.043***	0.024***	0.034***	0.036***	0.033***	0.029***	0.034***
	(0.017)	(0.038)	(0.005)	(0.005)	(0.005)	(0.004)	(0.005)	(0.005)	(0.006)	(0.005)	(0.006)	(0.005)	(0.004)	(0.005)
Controls	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Regional effects	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Time effects	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
							Panel B.							
LEA	-0.038**	0.082**	0.004	0.009	-0.002	0.005	0.004	0.015***	0.004	0.010**	0.007	0.010*	0.010**	0.006
	(0.018)	(0.042)	(0.006)	(0.006)	(0.005)	(0.005)	(0.006)	(0.005)	(0.006)	(0.005)	(0.006)	(0.005)	(0.004)	(0.005)
LES	-0.492***	1.155***	0.085***	0.105***	0.087***	0.062***	0.119***	0.120***	0.086***	0.099***	0.120***	0.092***	0.079***	0.099***
	(0.028)	(0.071)	(0.009)	(0.009)	(0.009)	(0.008)	(0.010)	(0.009)	(0.010)	(0.009)	(0.010)	(0.009)	(0.008)	(0.009)
Controls	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Regional effects	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Time effects	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y

Notes: Controls include socioeconomic, demographic characteristics, and regional/time effects. All statistics are weighted using sample weights.
Robust standard errors clustered at individual level in parentheses.
Sample size for all models is 98457.
$^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$.

Table 6. Fixed effects linear regressions of measures of long-term illness and disability on *LENRES* (Panel A) and its its underlying components – energy and thermal affordability (*LEA*) and energy and financial solvency (*LES*) (Panel B).

Specifications	(1)	(2)	(3)
Dependent variable	LTSD	Moving objects	Memory and concentration
		Panel A.	
LENRES	0.015***	0.009**	0.010***
	(0.005)	(0.004)	(0.003)
Controls	Y	Y	Y
Regional effects	Y	Y	Y
Time effects	Y	Y	Y
		Panel B.	
LEA	0.005	0.002	0.008**
	(0.005)	(0.004)	(0.003)
LES	0.026***	0.018***	0.016***
	(0.007)	(0.006)	(0.005)
Controls	Y	Y	Y
Regional effects	Y	Y	Y
Time effects	Y	Y	Y

Notes: Controls include socioeconomic, demographic characteristics (excluding LTSD), and regional/time effects.
All statistics are weighted using sample weights. Robust standard errors clustered at individual level in parentheses.
Sample size for all estimations is 100848.
** p < 0.1, ** p < 0.05, *** p < 0.01.*

4.4 Children's health and wellbeing outcomes

In this subsection, we explore whether living in a home with low energy price resilience is associated with the wellbeing and/or health of children and adolescents.[11] The young people's data is matched to household-level variables via their mother's personal identifier.

We focus on two outcomes: a 7-point scale representing their life satisfaction (*YLIFESAT*) – with higher values reflecting lower perceptions of life satisfaction; and a 5-point variable capturing the young respondents' evaluation of their own general health ranging between (1) excellent and (5) poor (*YHEALTH*).

Only a limited set of variables are collected in the UKHLS in each wave of the longitudinal survey of young people, limiting the extent of our investigation for this group. We control for children's age, number of close friends, perceptions on the importance of doing well in GCSE's, desire to proceed to higher education, whether they smoke, drink alcohol, belong to a social website, or regularly eat meals with their family. It is worthwhile noting, we find that the adult (mother's) individual socio-economic and demographic characteristics yield neither robust nor statistically significant associations in the young people's fixed effects regressions. Hence, we employ the mother's mental health measure as the only adult-individual variable in these regressions.[12] Time invariant characteristics (e.g., ethnicity, gender) are not included as control variables in our fixed effects estimator of the association between low energy price resilience and children's wellbeing outcomes.

The results from the fixed effects models presented in Table 7 show that our composite measure of low household energy price resilience is systematically associated only with young people's life satisfaction measures rather than with their general health. Looking closely at the components underpinning these results, Panel B reveals that the households facing energy and thermal affordability (*LEA*) issues (as opposed to than energy and financial solvency (*LES*) difficulties) are associated with deleterious life satisfaction outcomes for young people. This is in stark contrast to the situation of adults, for whom we find *LES* to be the key channel associated with our set of wellbeing outcomes in general. These results may indicate that what matters for the children's wellbeing is energy and thermal affordability, reflecting the heating conditions at home, and not the potential financial solvency issues that may be associated with

[11] After accounting for item and unit missingness, we rely on the UKHLS' panel of 8,457 young individuals (aged 10 to 16) participating between Wave 8 (January 2016 – May 2018) and Wave 12 (January 2020 – May 2022) who are living in the same household with the adult participants.

[12] Descriptions and mean values for all variables used in our young people analysis can be found in the Appendix (Table A3). In addition, we control for the same set of time and regional effects specified in Equation 1.

falling behind on energy bills, for example. In other words, adults' wellbeing is associated with struggling to maintain energy and financial solvency, while children and adolescents are shielded from solvency issues.

Table 7. Fixed effects linear regressions of measures of young people's wellbeing on *LENRES* (Panel A) and its components – energy and thermal affordability (*LEA*) and energy and financial solvency (*LES*) (Panel B)

Specifications	(1)	(2)
Dependent variable	*Health*	*Life Satisfaction*
	Panel A.	
LENRES	0.033	0.101**
	(0.032)	(0.048)
Controls	Y	Y
Regional effects	Y	Y
Time effects	Y	Y
	Panel B.	
LEA	0.040	0.111**
	(0.034)	(0.051)
LES	-0.070	0.060
	(0.042)	(0.054)
Controls	Y	Y
Regional effects	Y	Y
Time effects	Y	Y

Notes: Controls include socioeconomic, demographic characteristics, and regional/time effects.
Robust standard errors clustered at individual level in parentheses.
Sample size for all estimations is 8547.
** p < 0.1, ** p < 0.05, *** p < 0.01.*

5. Conclusions

The unexpected and substantial increase in energy prices observed across Europe as a result of the energy crisis which followed developments of the war in Ukraine has heightened Governments' and civil society's concerns about its potential impact on many consumers, and especially on the most vulnerable. As financial and other policy interventions enacted at the start of the energy crisis are slowly being reduced or completely removed, it is important to reflect on the recent experience of high energy price volatility in order to assess the ability of different households to withstand and adapt to sudden and significant increase in prices.

Our paper contributes to the literature by shifting the focus in the analysis of energy resilience from supply-side's infrequent and time-limited disruptions to the consumer's required adjustments in response to unexpected and sustained increases in energy prices. However, we recognise that supply reliability is also critical for vulnerable households, as supply failure can significantly harm these households because of lower general resilience.

Our conceptual approach, which is based mainly on demand-side considerations, has allowed us to conceptualise and develop a quantifiable measure of *energy price resilience* for residential households. This measure and its components have been used in our empirical analysis of the socio-economic and demographic factors likely to be associated with low levels of energy price resilience in households. Our analysis was further extended to the investigation of the potential association between energy price resilience and wellbeing; indeed, we explore the relative role of its two underlying channels, a) energy and financial affordability and b) energy and financial solvency, on shaping the observed association between energy price resilience and wellbeing outcomes.

Based on our composite measure of energy price resilience we find that about a quarter of individuals in the UK have experienced the challenging situation of either energy related affordability or energy related insolvency or both, during the period 2016-2022. Turning to the key correlates of our composite low energy price resilience measure, we found a positive association with pre-payment energy payment methods, which are more prevalent amongst vulnerable households (Burlinson et al., 2023). Household's inability to save, or having no access to savings, is positively associated with low energy price resilience, highlighting how access to financial resources can be critical at times of unexpected and significant increases in prices. We also find that employment status is associated with weaker resilience, so that being unemployed, or out of work due to disability or ill health, is positively associated with low levels of resilience. These factors are consistent when we look either at the aggregate measure of energy price resilience or at energy affordability and insolvency as separate measures. In contrast, living in rented accommodation and retirement appears more strongly associated with our composite energy resilience measure via the affordability channel.

When focussing on the role of low energy price resilience in adults' wellbeing outcomes, low energy price resilience not only appears consistently associated with worse life satisfaction and psychological distress outcomes, but also associated with disability (and particularly with moving objects and difficulties with memory and concentration) after accounting for time-invariant unobserved heterogeneity. Looking at the channels of low energy price resilience in adults, we find that the observed association between low resilience and wellbeing outcomes is mostly strongly associated with the energy and financial solvency channel, as opposed to the energy and thermal affordability component. On the other hand, the observed association between low energy price resilience of the household and wellbeing outcomes for children and adolescents living in the household is relatively more evident within the energy and thermal

affordability channel. Bringing these results together, the findings suggest that lower levels of children's wellbeing are observed in households that face energy affordability challenges; this might be a result of adults who are doing their utmost to shield their children from these challenges by balancing the dual pressures of energy and financial solvency, but to the potential detriment of their own wellbeing.

The main limitations of our work are related to the lack of availability of more detailed data on energy consumption but also on the households' financial situation, saving behaviour and access to credit in the representative UK sample used in our analysis; this limits our ability to fully assess the changes in energy consumption patterns during the energy crisis and their impact on the households' financial situation. It is also important to note that our empirical analysis only covers a limited duration of the energy crisis and importantly excludes the winter 2022-23, the period when significant financial pressures were most likely to be felt by vulnerable households, notwithstanding the extraordinary measures introduced by the UK Government at the time.

Despite these limitations, we are able to offer some conclusions and recommendations based on the key results from our empirical analysis. The reaction of most Governments to significant increases in energy prices in the winter of 2022 has been characterised by a desire to act swiftly to protect the majority of energy consumers. Policy interventions which protect most consumers from price shocks reduce their sensitivity to such price signals, with implications for the potentially conflicting objectives of energy affordability and environmental sustainability. This is particularly a problem if those consumers who can afford to pay for energy do not adjust their consumptions patterns as a reaction to price signals because of the availability of far-reaching financial support. On the other hand, our results help to characterise the profile of those individuals and households who are more likely to be exposed to significant challenges when high energy prices events occur and who would most benefit from financial (and other) interventions aimed at preventing them from experiencing hardship in the short term, and possibly also negative health outcomes in the long term. Based on our analysis of the levels of energy price resilience in the UK population in the initial phases of the energy crisis we are led to recommend that enhanced tailored interventions, targeted at the most vulnerable in society, should be implemented in the event of persistently high prices or further price increases as a result of other supply imbalances during the transition to a low-carbon energy system, for example. The associations established in our work between energy price resilience

and wellbeing outcomes reveal the possibility that appropriate interventions in the energy sector might also generate wider societal wellbeing benefits.

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Appendix

Table A1. Control variable definitions and mean values

Variable	Definition	Mean
FIXEDOTHER (reference)	1 if energy payment method is fixed amount or other; 0 otherwise	0.873
PPM	1 if energy payment method is prepayment; 0 otherwise	0.127
AGE	Age in years	51.990
FEMALE (reference)	1 if female; 0 otherwise	0.536
MALE	1 if male; 0 otherwise	0.464
WHITE (reference)	1 if white; 0 otherwise	0.923
MIXED	1 if mixed; 0 otherwise	0.018
BLACK	1 if black; 0 otherwise	0.041
OTHER_ETHNICITY	1 if other; 0 otherwise	0.018
ALEVEL_DEGREE (reference)	1 if A-level/Degree qualification or equivalent; 0 otherwise	0.817
NODEGREE	1 if no qualifications/or basic qualifications; 0 otherwise	0.183
EMPLOYED (reference)	1 if employed or self-employed; 0 otherwise	0.527
UNEMPLOYED	1 if unemployed; 0 otherwise	0.040
RETIRED	1 if retired; 0 otherwise	0.297
STUDENT	1 if full-time student; 0 otherwise	0.045
DISABILITY	1 if long-term illness or disability; 0 otherwise	0.302
OTHER_JOBSTATUS	1 if other economic activity; 0 otherwise	0.137
NO-SINGLEPARENT (reference)	1 if not a single parent household; 0 otherwise	0.971
SINGLEPARENT	1 if single parent household; 0 otherwise	0.029
HHSIZE	Household size	2.668
NBEDS	Number of bedrooms	3.013
OWNER (reference)	1 if owns accommodation; 0 otherwise.	0.389
MORTGAGE	1 if owns accommodation with mortgage; 0 otherwise	0.328
PRS	1 if privately rents accommodation; 0 otherwise.	0.180
SRS	1 if rents social accommodation; 0 otherwise	0.103
URBAN (reference)	1 if living in urban area; 0 otherwise	0.748
RURAL	1 if living in a rural area; 0 otherwise	0.252
Regions		
NEAST (reference)	1 if respondent lives in the North East of England; 0 otherwise	0.047
NWEST	1 if respondent lives in the North West of England; 0 otherwise	0.108
YORKSHIRE	1 if respondent lives in Yorkshire and Humberside; 0 otherwise	0.089
EMIDLANDS	1 if respondent lives in the East Midlands; 0 otherwise	0.081
WMIDLANDS	1 if respondent lives in the West Midlands, 0 otherwise	0.087
EAST	1 if respondent lives in the East of England, 0 otherwise	0.098
LONDON	1 if respondent lives in London, 0 otherwise	0.101
SEAST	1 if respondent lives in the South East of England, 0 otherwise	0.136
SWEST	1 if respondent lives in the South West of England, 0 otherwise	0.089
WALES	1 if respondent lives in the Wales, 0 otherwise	0.048
SCOTLAND	1 if respondent lives in the Scotland, 0 otherwise	0.087
Savings behaviour		

Ability to save		
CANSAVE (reference)	1 if the household does have enough money to make regular savings of £10/month or more for rainy days or retirement; and 0 otherwise.	0.851
CANNOTSAVE	1 if the household does not have enough money to make regular savings of £10/month or more for rainy days or retirement; and 0 otherwise.	0.149
Existing savings		
SAVINGS (reference)	1 if the individual does have any savings; and 0 otherwise	0.468
NOSAVINGS	1 if the individual does not have any savings; and 0 otherwise	0.532
N		100,848

Notes: UKHLS Wave 8 – 12 (Jan/2016-May/2022) data.
All statistics are weighted using sample weights.

Table A2. Wellbeing outcome variables definitions and mean values.

Variable	Definition	Mean
Life satisfaction	Satisfied with life overall: 1 (completely satisfied) to 7 (completely dissatisfied)	5.179
GHQ-12	Subjective wellbeing (caseness): 0 (the least distressed) to 12 (the most distressed)	1.893
GHQ ( )	How you have been feeling over the last few weeks…	
Concentration	Have you recently been able to concentrate on whatever you're doing? 1 if much less or less than usual; 0 of better than or same as usual	0.176
Sleep	Have you recently lost much sleep over worry? 1 if much more or rather more than usual; 0 if not at all or no more than usual	0.166
Useful	Have you recently felt that you were playing a useful part in things? 1 if much less or less than usual; 0 if more so or same as usual	0.153
Decision-making	Have you recently felt capable of making decisions about things? 1 if much less capable or less so; 0 if more so or same as usual	0.098
Under strain	Have you recently felt constantly under strain? 1 if much more or rather more than usual; 0 if not at all or no more than usual	0.223
Overcome difficulties	Have you recently felt you couldn't overcome your difficulties? 1 if much more or rather more than usual; 0 if not at all or no more than usual	0.142
Enjoy Activities	Have you recently been able to enjoy your normal day-to-day activities? 1 if much less or less than usual; 0 if more so or same as usual	0.200
Problem solving	Have you recently been able to face up to problems? 1 if much less able or less so; 0 if more so or same as usual	0.110
Confidence	Have you recently been losing confidence in yourself? 1 if much more or rather more than usual; 0 if not at all or no more than usual	0.208
Depressed	Have you recently been feeling unhappy or depressed? 1 if much more or rather more than usual; 0 if not at all or no more than usual	0.166
Self-worth	Have you recently been thinking of yourself as a worthless person? 1 if much more or rather more than usual; 0 if not at all or no more than usual	0.094
Happiness	Have you recently been feeling reasonably happy, all things considered? 1 if much less or less so than usual; 0 if more so or about the same as usual	0.158
N		98,457

Notes: UKHLS Wave 8 – 12 (Jan/2016-May/2022) data.
All statistics are weighted using sample weights

Table A2 (continued). Wellbeing outcome variables definitions and mean values

Variable	Definition	Mean
Long term health problems		
LTSD	1 if individual has a long-standing physical or mental impairment, illness or disability; 0 otherwise	0.302
LTSD ( )	If you have a long-standing health problem, do you have substantial difficulties with…	
Moving objects	1 lifting, carrying or moving objects; 0 otherwise	0.139
Memory and concentration	1 memory or ability to concentrate, learn or understand; 0 otherwise	0.049
N		100,848

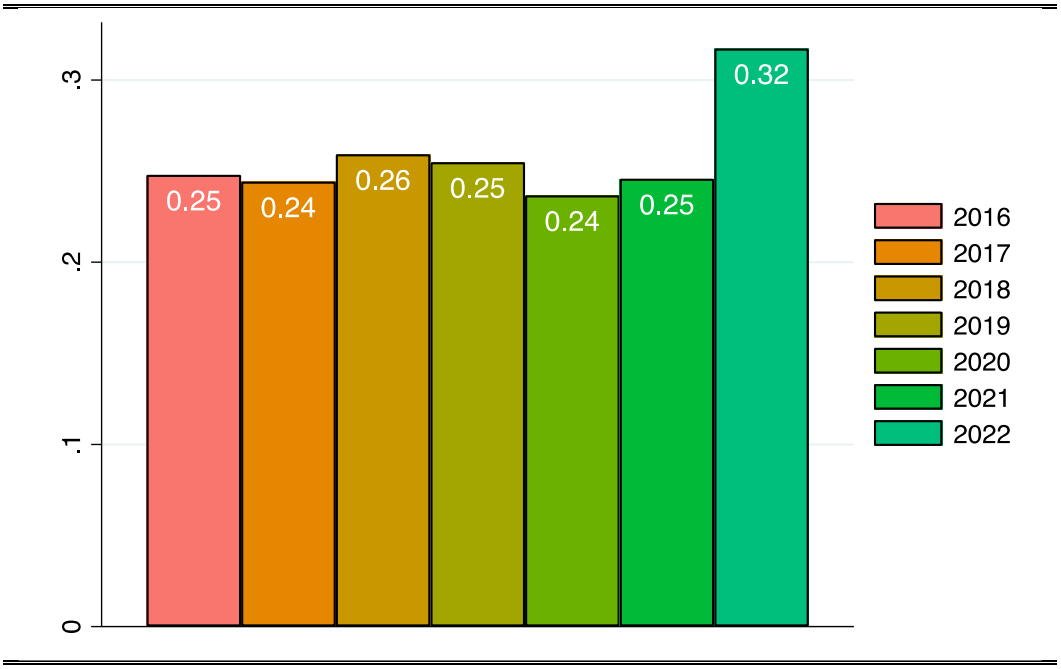
Notes: UKHLS Wave 8 – 12 (Jan/2016-May/2022) data.
All statistics are weighted using sample weights.

Table A3. Youth regression models wellbeing outcomes and control variables: definitions and mean values

Variable	Definition	Mean
Wellbeing outcomes		
Life satisfaction	Satisfied with life as a whole: 1 (completely satisfied) to 7 (completely dissatisfied)	2.274
Health	Overall health is 1 (excellent) to 7 (poor)	2.139
Controls		
Age	Age in years	12.554
Friends	Number of close friends	9.103
GCSEs, very important (reference)	1 if individual thinks GCSE's or equivalents are very important; 0 otherwise	0.729
GCSEs, important	1 if individual thinks GCSE's or equivalents are important; 0 otherwise	0.244
GCSEs, not very important	1 if individual thinks GCSE's or equivalents are not very important; 0 otherwise	0.019
GCSEs, not at all important	1 if individual thinks GCSE's or equivalents are not at all important; 0 otherwise	0.009
Yes, to higher education (reference)	1 if individual would not like to go on to do further full-time education at a college or university; 0 otherwise	0.626
No, to higher education	1 if individual would not like to go on to do further full-time education at a college nor university; 0 otherwise	0.065
Missing, higher education	1 if missing; 0 otherwise	0.309
Smoked (reference)	1 if individual has smoked cigarettes at all; 0 otherwise	0.049
Never smoked	1 if individual has never smoked cigarettes; 0 otherwise	0.951
Yes, to alcohol (reference)	1 if individual has had an alcoholic drink; 0 otherwise YES/NO	0.240
No, to alcohol	1 if individual has never had an alcoholic drink; 0 otherwise YES/NO	0.760
Yes, to social media (reference)	1 if individual does belong to a social website (e.g., facebook); 0 otherwise	0.818
No, to social media	1 if individual does not belong to a social website (e.g., facebook); 0 otherwise	0.182
No family meals (reference)	1 if individual had no evening meals with family in the past week; 0 otherwise	0.060
1-2 family meals	1 if individual had 1-2 evening meals with family in the past week; 0 otherwise	0.171
3-5 family meals	1 if individual had 3-5 evening meals with family in the past week; 0 otherwise	0.266
6-7 family meals	1 if individual had 6-7 evening meals with family in the past week; 0 otherwise	0.503

Notes: UKHLS Wave 8 – 12 (Jan/2016-May/2022) data.

Figure A1. Proportion of households with low energy price resilience (*LENRES*) over time



Notes: All statistics are weighted using sample weights.