Fuel poverty and financial distress

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Andrew Burlinson[*], Monica Giulietti[‡], Cherry Law[†] and Hui-Hsuan Liu[§]

Abstract

Governments and advocacy groups have drawn attention to the precarious position of those members of society who are unable to attain an adequate level of energy services, i.e. the fuel poor. Concerns have also arisen about the ability of fuel poor individuals to adapt to the hardship recently brought about by the COVID-19 pandemic. This paper contributes to the literature by exploring empirically the link between fuel poverty and financial distress prior to and during the first wave the COVID-19 pandemic. The analysis is based on the most recent longitudinal, nationally representative survey of the United Kingdom, Understanding Society (UKHLS, Wave 10, January 2018-February 2020). After correcting for the effects of potential endogeneity in the variables of interest, our results identify a statistically robust relationship between fuel poverty indicators and self-reported measures of current financial distress, with stronger effects for subjective indicators. The fuel poverty indicators however exert only a limited influence on an individual's expectation of their future financial situation. Our analysis of the first wave of the COVID-19 pandemic also confirms that fuel poverty contributed to financial distress. Our main findings are robust to a suite of specification and sensitivity checks. Our results lead to recommend assessing measures which target fuel poverty on the basis of their potential indirect effect on financial distress.

Keywords: fuel poverty, energy poverty, financial distress, household finance, COVID-19

JEL codes: Q40, D12, D14

[*] Corresponding author: Norwich Business School, University of East Anglia, NR4 7TJ, UK, email: a.burlinson@uea.ac.uk

[‡] School of Business and Economics, Loughborough University, LE11 3TU, email: m.giulietti@lboro.ac.uk

[†] Department of Public Health, Environments and Society, London School of Hygiene and Tropical Medicine, WC1E 7HT, UK, email: cherry.law@lsthm.ac.uk

[§] Department of Comparative Biomedical Science, Royal Veterinary College, NW1 0TU, UK, email: cliu@rvc.ac.uk

1. Introduction

Fuel poverty is considered a distinct form of poverty, not least because tackling it has the potential to garner a "win-win-win" for policymakers through improvements in economic hardship, mental and physical health, and energy/carbon savings (Boardman, 1991; Green and Gilbertson, 2008; Hills, 2011). Broadly, over the last three decades, fuel poverty has been defined as the household's inability to achieve thermal comfort to levels commensurate with a healthy standard of living at a reasonable cost (Boardman, 1991; Hills, 2012).[1] The incidence of fuel poverty depends on three central drivers – income, energy efficiency and energy prices (Moore, 2012; Thomson et al., 2017). Recent estimates show fuel poverty affects over 20% of households in the United States (US) and China, 10% of households in Australia and France and close to 10% of households in Japan (Legendre and Ricci, 2014; Okushima, 2017; Zhang et al., 2019; Awaworyi Churchill et al., 2020; Wang et al., 2021).[2] The prevalence of fuel poverty in Great Britain (GB) – the focus of the present paper – varies by nation with 10% of households identified as fuel poor in England, 25% in Scotland and 12% in Wales (BEIS, 2021a; Hinson and Bolton, 2020). A near consensus has formed around the body of evidence documenting the deleterious impact that fuel poverty exerts on the health of households, including higher rates of mortality and higher risk of cardiovascular, inflammatory and mental health conditions (see e.g. Crossley and Zilio, 2018; Marmot Review Team, 2011; Public Health England, 2014; Thomson et al., 2001). Whilst financial distress is a potential mediator between fuel poverty and health outcomes (Hills, 2011; Marmot Review Team, 2011), the fuel poverty and financial distress nexus is hitherto underexplored, especially in the economics literature.[3]

[1] The term 'fuel' poverty is utilised, rather than 'energy' poverty, due to the regional context of the data.
[2] It is important to note that cross-country rates of fuel poverty are not directly comparable due to differences in methodology.
[3] At the time of writing, searching the keywords "fuel poverty" or "energy poverty" and "financial distress" in the Scopus Database retrieves no documents. Several papers are retrieved when replacing the latter term with

A better understanding of fuel poverty-induced financial distress is paramount in order to evaluate the full impact of policy interventions affecting energy consumption and expenditure. With rising energy prices and stagnant real income in GB (BEIS, 2020a), low-income households face difficult trade-offs between energy and other necessities, diminishing savings and/or incurring debt in order to maintain optimal levels of thermal comfort (Harrington et al., 2005; Hills, 2011; Anderson et al., 2012; Grey et al., 2017; Munyanyi et al., 2021). In 2018, just over 1.1 million gas and 1.3 million electricity consumers were in arrears or repaying fuel debt in GB (Ofgem, 2019). In 2017, the total amount of debt and arrears accruing by gas and electricity consumers has been shown to reach around £1.1 billion in total for GB (Citizens Advice Bureau, 2018). What is more, financial distress has also manifested itself in countries characterised by lower energy prices and a wider adoption of cooling technologies. For example, according to the most recent US Residential Energy Consumption Survey, at least 7 million households' forgone necessities to pay energy bills, 6 million (7 million) households are unable to cool (heat) their homes due to financial constraints and 2 million households received disconnection notices every month (EIA, 2018). Fuel poverty may not only impose financial constraints, but also further impacts the mental health and well-being of households (Ofgem, 2019; Ofgem, 2021). Indeed, Hills (2011:89)'s review of early evidence on the measurement, causes and impacts of fuel poverty suggests that a "chain of causation could potentially be from income (not exclusively low income), to debt, to poor mental health".

Crucially, this 'financial security' chain represents one of two key pathways that could explain the causal mechanism between fuel poverty indicators and well-being and self-reported health outcomes established in recent economics literature. Most recently, using the Household Income and Labour Dynamics in Australia longitudinal survey, Awaworyi Churchill et al.

"household finance", the most relevant, of which, explores household self-disconnection from energy supply (Rocha et al., 2019)

(2020) unveil the negative relationship between fuel poverty and subjective well-being. Similarly, Kahouli (2020)'s and Awaworyi Churchill and Smyth (2021)'s findings further reveal that fuel poverty adversely impacts self-assessed health in France and general health in Australia, respectively. However, the intermediate mechanisms linking fuel poverty to health outcomes requires further investigation. First, alleviating fuel poverty through the "living conditions" pathway could impact health psychosocially (e.g. anxiety and depression), in all age groups, and/or physiologically, particularly the elderly and infants, via higher levels of thermal comfort (Harrington et al., 2005; Green and Gilbertson, 2008; Hills, 2011; Marmot Review Team, 2011; Gilbertson et al., 2012: 12; Ormandy and Ezratty, 2012). Second, tackling the deleterious impacts of fuel poverty through the "financial security" pathway could improve health via lower levels of financial stress (Hills, 2011; Gilbertson et al., 2012: 12):

"Fuel poverty could also damage mental health as a result of stress arising from financial worry" – (Harrington et al., 2005: 263)

However, the second pathway, despite its potential importance, remains underexplored in the relevant literature.[4] This is somewhat surprising since the quasi-experimental evaluation of the United Kingdom's flagship fuel poverty initiative (The Warm Front Scheme) concluded:

"The alleviation of fuel poverty and the reduction of stress associated with greater financial security emerge as the most likely route to health, both mental and physical." – (Gilbertson et al., 2012: 132)

Gilbertson et al. (2012) analysed cross-sectional surveys of 2685 low-income households living in five urban areas of England, collecting pre-intervention (2001/2) and post-intervention (2002/3) data. Their analysis indicates that the "financial security" pathway is the principal

[4] For detailed reviews of studies evaluating the first 'thermal comfort' pathway, particularly those using randomised or quasi-randomised control household energy efficiency interventions, see e.g. Liddell and Morris, 2010; McAndrew et al., 2021.

route connecting the alleviation of fuel poverty to self-reported health (*i.e.* fuel poverty – stress – health), whilst the "living conditions" pathway serves as the secondary route (*i.e* indoor temperature – thermal comfort – health) (Green and Gilbertson, 2008; Gilbertson et al., 2012).

The present paper draws upon a nationally representative survey of the UK, Understanding Society: the UK Household Longitudinal Study (UKHLS), in order to empirically examine this intermediate link between fuel poverty and financial distress. Considering the growing policy attention on the precarious position of the fuel poor and on the increased deprivation caused by the current pandemic, we employ three UKHLS' COVID-19 web surveys to examine whether fuel poverty contributes to financial distress during the first wave of the Coronavirus (COVID-19) pandemic. The empirical analysis focuses only on Great Britain (GB) which includes England, Scotland, and Wales due to the different energy market and regulatory arrangements in Northern Ireland. In this paper, we suggest that fuel poverty increases the probability of falling behind on bills and finding one's current financial distress difficult to deal with, prior to and during the COVID-19 pandemic. Our findings are not only robust across a series of specification checks, but also rely on methodologies which address potential endogeneity concerns including instrumental variable estimation and Oster (2019)'s bounding approach. However we find less pronounced evidence to suggest that fuel poverty affects the surveyed individuals' expectations about their financial future.

We contribute to the existing literature in three key ways. First, to the best of our knowledge, this is the first paper to quantitatively investigate fuel poverty as a determinant of financial distress using representative surveys. Using more recent data, the present paper complements quasi-experimental (Gilbertson et al., 2012) and qualitative (Harrington et al., 2005: 263; Grey et al., 2017) analyses of energy efficiency interventions in low-income households/communities, by testing the external validity of the key intermediate link (fuel poverty – stress) in the "financial security" pathway. Establishing determinants of financial distress is crucial due to its long-term consequences for income and health inequalities, particularly for low-income households who are more exposed during periods of economic and financial crises (Arber et al., 2014; Olafsson, 2016). Most recently, for example, sharp falls in income are expected as a result of the COVID-19 pandemic, potentially sharpening the trade-offs between expenditure on necessities, savings and debt. Indeed, "what they [households] normally spend their money on will matter for how well they can weather this storm" (IFS, 2020: 2). Necessity goods, such as gas and electricity (Meier et al., 2013), will form a rising proportion of disposable income for households unable to flexibly adjust their spending in response to a fall in income (IFS, 2020).

We therefore add to the growing literature seeking to uncover the determinants of financial distress. Over the last decade, studies have investigated financial distress through the lens of the difficulties associated with student loan debt (Elliott and Lewis, 2015; Bricker and Thompson, 2016), medical insurance (Dobkin et al., 2018; Hu et al., 2018; Mazumder and Miller, 2016), and mortgage repayment (Gathergood, 2012). Notable contributions in the economics and finance literature explore the channels through which cognitive and noncognitive abilities affect measures of financial distress (Xu et al., 2015; Parise and Peijnenburg, 2019). Yet the role of energy, and thus fuel poverty, in determining household financial distress has so far been overlooked.

Perhaps most closely related to the present paper is Dorsey-Palmateer (2020)'s study of financially-constrained households in the US. Using a sub-sample from the 2017 American Housing Survey, the author examines the association between several indicators of financial distress (e.g. utility notices/disconnections, missed rent payments) and monthly *combined* utility costs (including energy and other utilities), monthly housing costs and monthly income. The author finds utility payments to be associated with a greater (dollar-for-dollar) impact on financial distress than monthly income and housing costs. Contrary to this approach, the present paper models the relationship between energy-specific covariates (fuel poverty) and financial distress, using a nationally representative survey. An important methodological difference from Dorsey-Palmateer (2020) is our deployment of methods to alleviate potential endogeneity concerns.

In order to address endogeneity concerns, we propose a set of novel set of instrumental variables which complement those currently implemented in the literature in order to formalise the empirical relationship between fuel poverty and financial distress. It is important to note that due to practical challenges Green, Gilbertson and colleagues (2008, 2012) are unable to precisely target fuel poor households and subsequently rely on proxies for measurement of fuel poverty and financial distress. The authors ask households whether they "had difficulties paying their fuel bills". In addition, the authors use a four-point scale of general stress from no stress (1) to high stress (4) levels. In essence, the positive association between the two sets of variables is interpreted as the stress effects of fuel-induced financial pressure. The present paper, in contrast, uses commonly implemented indicators of fuel poverty (both objective and subjective) and self-reported measures of financial distress (quasi-objective and subjective). We therefore model a more proximal relationship between fuel poverty, unpaid bills and perceptions about financial distress now and finances in the future.

To alleviate endogeneity concerns, we rely upon regional variation in energy prices (Awaworyi Churchill et al., 2020; Kahouli, 2020; Awaworyi Churchill and Smyth, 2021; Munyanyi et al., 2021), and further add to the literature by introducing a robust set of instruments. We exploit the between- *and* within-region variation of nonlinear pricing in GB's retail energy market using annual regional-level gas and electricity retail unit prices (£/kWh), fixed charges (£/year), and the fixed charge to unit price ratio – all of which are further disaggregated by payment methods (i.e. credit, direct debit and prepayment). This approach provides additional within-variation compared to regional-level energy consumer price indices (Awaworyi Churchill et al., 2020; Awaworyi Churchill and Smyth, 2021; Munyanyi et al., 2021) and appears more robust than the sole use of unit prices (Kahouli, 2020).

Finally, we investigate the financial vulnerability of the fuel poor during the UK's first wave of the COVID-19 pandemic, April 2020-July 2020. COVID-19 has impacted the welfare of people worldwide, particularly the poorest, and has further exposed existing inequalities within and across countries (Fuchs-Schündeln et al., 2020; The Economist, 2020; Wildman, 2021). Indeed, governments and advocacy groups have drawn attention to the precarious position of the fuel poor and their ability to adjust to income shortfalls prior to and during the pandemic (Citizens Advice Bureau, 2020; National Energy Action, 2020a; Scottish Government, 2020; The End Fuel Poverty Coalition, 2020). The remainder of the paper is structured as follows: section 2 describes the data and presents our empirical methodology; section 3 presents our results, before discussing policy implications and drawing conclusions in section 4.

2. Data and methodology

2.1 Understanding Society

Our data are obtained from a longitudinal, nationally representative survey of the UK, Understanding Society: the UK Household Longitudinal Study (UKHLS) (University of Essex, 2020). We utilise the most recent General Population Sample, a random sample of the general UK population, Wave 10 (January 2018 – May 2020) – referred to hereafter as the 'main survey'. We focus specifically on GB as the instrumental variables are confined to England, Scotland, and Wales.[5] As part of the main survey, a set of financial distress measures and fuel poverty indicators are collected alongside economic and socio-demographic characteristics.

[5] The identification strategy hinges upon gas prices which are currently not provided for NI by the data source (BEIS, 2021b, 2021c).The baseline results without the instrumental variables are robust to the inclusion of Northern Ireland (NI).

The final sample consists of 23,210 individuals with valid/non-missing values for our outcomes, key variables of interest and controls within the main survey. [6,7]

Drawing upon relevant literature, we use three dichotomous self-reported measures of financial distress (Table 1).[8] *BEHINDBILLS* equals 1 when respondents report being behind on some or all bills, and 0 otherwise (Parise and Peijnenburg, 2019). We set *FINNOW* equal to 1 if individuals found their current financial situation difficult or very difficult, and 0 otherwise. Whereas *FINFUT* equals 1 if the individual believes their financial situation will be worse off a year from now, and 0 otherwise. The latter two measures capture the individual's current and future expectations of their financial situation (Keese, 2012). The sample statistics in Table 1 report that, on average, 5.4% of individuals were not up to date with all of their household bills, 7.5% find their current finances at least difficult, and 12.5% think they would be financially worse off a year from now.

Whilst the measurement of fuel poverty remains somewhat contested (Deller et al., 2021; Thomson, 2020), recent literature has drawn upon the strengths of objective and subjective approaches by employing both sets of indicators (see e.g. Awaworyi Churchill et al., 2020; Kahouli, 2020; Llorca et al., 2020; Awaworyi Churchill and Smyth, 2021). The seminal work of Waddams Price et al. (2012) evaluate the positive yet complex overlap between official objective indicators and subjective indicators. The authors conclude the latter complements the former by way of informing energy policy on the extent to which it alleviates the *feeling* of being unable to afford energy. More recently, Llorca et al. (2020) argue for the use of subjective

[6] We removed 71 individuals who participated in the main survey between March 2020 and May 2020 in order to avoid overlap with the COVID-19 pandemic. The sample statistics and estimates are quantitatively identical when including the 71 individuals (Table A5, Column 1, Appendix A). More importantly, their removal provides a clean cut-off prior to the pandemic (January 2018-February 2020).

[7] All sample statistics and estimation results presented in the paper are unweighted and consistent with cross-sectional survey weights adjusted for item and unit non-response.

[8] Declaring being behind on bills is clearly less subjective than stating whether one's current (future) financial situation is difficult (expected to become worse). Nonetheless, we reserve the objective/subjective lexicon for fuel poverty indicators to avoid confusion and refer to the financial distress variables simply as 'self-reported measures' hereafter.

fuel poverty indicators, alongside objective indicators, in order to capture the personality underpinning self-reported outcomes and their covariates.

Table 1. Definitions and summary statistics – financial distress and fuel poverty
Main survey (Jan/2018-Feb/2020)

Variables	Definition	Mean
Financial distress		
	Question: 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?	
BEHINDBILLS	1 if behind with some bills or if behind with all bills; 0 if up to date with all bills	0.054
	Question: How well would you say you yourself are managing financially these days? Would you say you are…	
FINNOW	1 if finding it quite difficult or if finding it very difficult; 0 if living comfortably, if doing alright or if just about getting by	0.075
	Question: Looking ahead, how do you think you will be financially a year from now? Will you be…	
FINFUT	1 if worse off than you are now; 0 if better off or if about the same	0.125
Fuel Poverty		
LIHC	1 if low-income, high-cost; 0 otherwise	0.112
FP10	1 if proportion of income spent on energy exceeds 10% and low-income; 0 otherwise	0.139
	Question: In winter, are you able to keep this accommodation warm enough? If you cannot afford to, please answer 'No'.	
IHEAT	1 if unable to afford to keep the house adequately warm in winter; 0 otherwise	0.044
N		23210

We employ two objective indicators of fuel poverty, namely the 10% expenditure threshold *FP10* and the low-income-high-cost indicator *LIHC* (Boardman, 1991; Hills, 2012), as well as one subjective indicator, that is whether the household can afford to keep the home warm *IHEAT* (Waddams Price et al., 2012). *FP10* equals 1 if the individual's household spends more than 10% of their income on energy bills, and 0 otherwise.[9] *LIHC* takes a value of 1 if the individual's household meets two conditions: 1) they spend more than the national median on energy in the last year and 2) upon deducting energy expenditure and housing costs, their residual household net income falls below the poverty threshold (i.e. 60% of the national median household net income); and 0 otherwise.[10] The *IHEAT* indicator takes the value of 1 for those individuals (or a member of their household) who report inadequate heating during winter due to affordability issues, and 0 otherwise. On average, 11.2% of respondents are part of a fuel poor household according to *LIHC*, whereas *FP10* and *IHEAT* identify 13.9% and 4.4% respondents as fuel poor respectively (Table 1).

2.2 Econometric specifications

Empirically the paper proceeds by estimating the probability of exhibiting financial distress using ordinary least squares regression. The general specification for the linear probability models (LPM) of financial distress on fuel poverty is defined as follows:

$$FINDIS_i^* = \alpha_i + FUELPOV_i'\beta + X_i'\rho + \omega_t + \mu_r + \varepsilon_i \qquad (1)$$

where, $FINDIS_i^*$ represents the latent variable for each of the financial distress measures (*BEHINDBILLS*, *FINNOW* or *FINFUT)* for individual *i*. $FUELPOV_i$ represents three separate models each containing a single fuel poverty indicator (*LIHC*, *FP10* or *IHEAT*). X_i contains

[9] We further adjust *FP10* by restricting the classification of fuel poverty to only those below the poverty threshold (60% of the national median household net income), negating the inclusion of relatively high-income high-energy expenditure households.
[10] Income and energy are equivalised – see Hills (2012).

the economic and socio-demographic covariates identified as determinants of financial distress in the literature (e.g. Xu et al., 2017; Parise and Peijnenburg, 2019). β and ρ are the estimated regression coefficients, with β being the set of parameters of interest. ω_t is the vector of seasonal effects that capture the month and year in which the individual participated in the survey in the main wave. μ_r represents the vector of 11 GB regional effects capturing England's nine government office levels, and one for Scotland and Wales respectively. ε_i is the heteroskedastic robust error term. Table A1 (Appendix A) provides the definitions and summary statistics for the control variables.

2.3 Instrumental variables

One potential concern regarding identification of the pathway between fuel poverty and financial distress through the above model is endogeneity. For example, reverse causality may exist if financial exclusion and debt arising from worsening economic conditions add to the precarious position of households, increasing the likelihood of falling into fuel poverty (Lacroix and Chaton, 2015). As discussed above, whilst Gilbertson et al. (2012) argue that the most logical direction of causality runs from fuel poverty to financial stress (i.e. the "financial security pathway"), we cannot rule out that these variables are simultaneously determined or at least correlated via omitted variables (Liddell and Guiney, 2015). A potential confounder is the lack of internal temperature readings for each home – a variable often missing from national surveys. Internal temperatures may be linked indirectly to financial distress as suboptimal temperatures are linked directly to fuel poverty through expenditure shares. The bias attributed to internal temperatures is likely to be toward from zero since, all else constant, it is reasonable to assume $\beta_{INTERNAL\text{-}TEMP}>0$ and $Corr(INTERNAL\text{-}TEMP, FUELPOV)<0$.

A third source of endogeneity could be attributed to measurement error. For instance, there may be a non-zero correlation between the errors made by households when self-reporting information underpinning fuel poverty indicators and financial distress measures. Unlike the omission of internal temperatures, one would expect the bias arising from self-reporting measurement error to be away from zero.[11] Therefore, in order to alleviate concerns surrounding endogeneity, we employ a suite of instrumental variable (IV) estimators.

We add to the literature by implementing IVs based on the components of GB's nonlinear energy retail pricing system. It has been argued previously that exogenous movements in energy prices are a plausible instrument, similar to the use of other commodity prices (e.g. food) in the fuel poverty-health literature (Kahouli, 2020). Indeed, energy prices have the potential to satisfy the exclusion restrictions condition. Not least because prices are assumed to work directly through fuel poverty, specifically the expenditure share of income, thereby indirectly affecting outcomes of interest, in our case, financial distress (Awaworyi Churchill et al., 2020; Kahouli, 2020; Awaworyi Churchill and Smyth, 2021; Munyanyi et al., 2021). Moreover, energy prices have further potential to satisfy the relevance condition, since one would expect energy prices to be positively and strongly associated with fuel poverty. However, the preceding literature acknowledges concerns about whether prices are exogenous to the error term from a statistical perspective (see e.g. Awaworyi Churchill et al., 2020; Kahouli, 2020) and about the potential weak correlation between the IVs (i.e. energy prices) and the endogenous variable (i.e. fuel poverty) (Munyanyi et al., 2021). Considering such concerns, the present paper employs a novel yet complementary array of IVs, including: the marginal price *M* per unit of gas and electricity (£/kWh); the fixed charge *F* for supplying gas and/or electricity to the meter (£/year). Fixed charges are independent of consumption and typically cover the costs of the meter (e.g. maintaining connection to supply, meter reading and other customer account services); and, the fixed-to-marginal (FM) ratio. Davies et al. in 2014

[11] *If* $FINDIS + e = f(FUELPOV + v, X)$ and $Corr(e, v)>0$, where e and v are measurement errors.

introduce the FM ratio as a sufficient statistic that describes the time/regional evolution and asymmetry of two-part tariffs for representative consumers.[12]

The regional variation in GB's retail energy pricing reflects the cost differences of incumbent companies (i.e. suppliers, distributed network operators and transmission network operators). Since the 1990s wave of privatisation and liberalisation, the "Big 6" suppliers have dominated the GB retail energy market with 70% of consumers still supplied by the five electricity incumbents and the single gas incumbent (Ofgem, 2019). The retail suppliers also pass on transmission and distribution network costs charged by the regulated operators. The transmission and distribution network operators are monopolies regulated by the Office for Gas and Electricity Markets (Ofgem, 2015). Three transmission operators (TOs) own and operate the national transmission (high pressure) gas and (high voltage) electricity networks. The low pressure and low voltage networks are split into fourteen electricity distribution networks (DNOs) and eight gas distribution networks (GDNs). Indeed, the number of DNOs and GDNs correspond to the locations managed by the regional gas and electricity boards that exist pre-privatisation (Ofgem, 2015). The regulated part of prices reflects the regional differences in costs incurred by the network operators. The institutional and infrastructural legacy of GB's energy system allows us to exploit the regional differences in regional gas and electricity pricing (marginal and fixed) – oftentimes called the "postcode lottery" (Deller et al., 2020).

The regional variation in GB energy pricing can be understood from two prevailing perspectives. On the one hand, according to Ofgem's study in 2015, differences in retail pricing are primarily attributed to national and local network charges i.e. the cost of building and maintaining the transmission and distribution network infrastructure (Ofgem, 2015). Ofgem's

[12] Like Davies et al. (2014) the fixed element of the ratio F is weighted by the variable price p for a median electricity (E) consumer (3600kWh, *i.e.,* $FM_E=F_E/3600p_E$) and median gas (G) consumer (13600kWh, i.e., $FM_G=F_G/13600p_G$). We use the most recent median typical domestic consumption values (BEIS, 2021b, 2021c).

report finds electricity network charges exert greater influence on retail prices than gas network charges. Nonetheless, Ofgem acknowledges that whilst some regions exhibit higher distributional charges they are, in some instances, partly offset by lower transmission charges. On the other hand, Davies et al. (2014) argue that the key source of price dispersion, in a given time period, is *within-region* (e.g. attributed to incumbent suppliers) rather than *between-regions* (e.g. associated with legacy networks). In fact, Davies et al. (2014) find over 63% of the variance in marginal prices and at least 82% of the variance in fixed charges can be explained by the variation within-region. Their study further suggests that asymmetric costs and other factors, including brand loyalty and market frictions, only partially influence price dispersion compared to tariff differentiation. Instead, dispersion arises through suppliers segmenting the market post-liberalisation into high (low) consumption consumers by charging high (low) fixed charges and low (high) marginal prices (Davies et al., 2014). Our IVs therefore rely on the between- and within-region variation in GB *nonlinear* pricing – as the first perspective most closely relates to fixed charges and second perspective relates to both the fixed and marginal components.

Gas and electricity average retail marginal prices and fixed charges are collected annually for each GB region by the Department of Business, Energy and Industrial Strategy (BEIS, 2021b, 2021c). The data contains marginal prices and fixed charges by fuel type, region, and year. Moreover, the data further differentiate gas and electricity marginal prices and fixed charges by credit, direct debit, and prepayment methods of payment. For a given region and year, we calculate the fixed-marginal (FM) ratio by fuel and payment type. The data are matched to individuals in the UKHLS sample by region, year, fuel type and payment method – the procedure is detailed in Appendix B (Table B1).

Table B2 (Appendix B) presents the definitions and summary statistics for the annual average gas and electricity prices between 2018 and 2020 (the years in which the respondents participated in the main survey) as well as between 2016 and 2018. It is important to note that our main IV results use prices from the period 2016 to 2018 for two key reasons: 1) prices two-years prior to the year in which the respondents take part in the main survey have a stronger correlation with our indicators of fuel poverty. This is likely driven by the UKHLS asking participants to provide last year's household expenditure on gas, electricity or other fuels in their current residence. In addition, the individual's household representative is likely to be reporting the estimates of annual bills that appear on monthly/quarterly/annual statements and such billing estimates tend to be based on preceding years' consumption and prices determined at the start of a long-term contract[13]; and 2) lagged prices will clearly be more exogenous than current prices (Charlier and Kahouli, 2018). Hence, we can avert the issue of tariffs and thus energy expenditure that is contemporaneously influenced by either local or national demand and supply forces dictated in the wholesale and retail energy markets. Table B2 shows that average marginal gas prices have decreased slightly over the two time periods, whilst electricity prices have increased, in line with movements in the wholesale markets. Gas and electricity fixed charges have increased, driving up the fixed-marginal ratio between 2016 and 2020. It is important to note that the between-region variation (represented by the R^2 in Table B2) shows that regional variation is not constant over time and varies across the three price measures. Indeed, in-line with previous studies (Davies et al., 2014; Deller et al., 2020)[14], within-region and time variation explains most of the price dispersion and provides further support as to why differentiating prices by payment method in the IV procedure is of importance.

[13] Contracts are set typically set between 12 and 24 months. There is no set price or contract for standard variable tariffs.
[14] For example, Deller et al. (2020) show that regional price differences represented around a third of the average electricity bill in the 1970s and 8-18% of the average bill since 2009.

The first stage regression of the IV estimator, estimated using LPM, involves a reduced form equation specified as follows:

$$FUELPOV_i^* = \alpha_i + PRICES_i'\gamma + X_i'\rho + \omega_t + \mu_r + u_i \tag{2}$$

Where $PRICES_i$ represents the vector of gas (G) and electricity (E) prices. The prices (M, F and FM) enter as separate pairs in order to reduce multicollinearity between the gas and electricity marginal prices and fixed charges. Hence, we employ three specifications which separately include the pairs M_G and M_E, F_G and F_E, or FM_G and FM_E. γ denotes the vector of coefficients for the respective pairs of prices, whilst u_i represents the first stage regression error term. All other variables and coefficients are as defined in the second stage regression (Equation 1).

3. Results

This section first investigates the relationship between financial distress and fuel poverty prior to the pandemic using the main survey. These findings are scrutinised using a suite of specification and robustness checks in order to alleviate concerns about endogeneity. Next, this section explores the role of fuel poverty in determining financial distress during the pandemic.

3.1 Baseline results

Table 2 presents the coefficients associated with fuel poverty using our baseline (LPM) specifications outlined in Equation 1. The models either include objective indicators of fuel poverty, *LIHC* (Columns 1 and 2) and *FP10* (Columns 3 and 4) or a subjective indicator of fuel poverty *IHEAT* (Column 5 and 6). All even Columns (2, 4 and 6) include economic and socio-demographic controls and regional/time fixed effects.

Table 2. Baseline (LPM) regressions of financial distress on indicators of fuel poverty

UKHLS Main survey (Jan/2018-Feb/2020)

Specifications	(1)	(2)	(3)	(4)	(5)	(6)
Fuel poverty indicator						
Panel A. Behind on bills (*BEHINDBILLS*)						
Objective: LIHC	*0.081****	0.041***				
	(0.007)	(0.006)				
Objective: FP10			*0.0881****	0.043***		
			(0.006)	(0.006)		
Subjective: IHEAT					*0.278****	0.216***
					(0.015)	(0.014)
Controls	N	Y	N	Y	N	Y
Observations	23210	23210	23210	23210	23210	23210
R^2	*0.013*	0.116	*0.018*	0.117	*0.063*	0.149
Panel B. Current financial situation (*FINNOW*)						
Objective: LIHC	*0.106****	0.064***				
	(0.008)	(0.007)				
Objective: FP10			*0.116****	0.069***		
			(0.007)	(0.007)		
Subjective: IHEAT					*0.285****	0.226***
					(0.015)	(0.015)
Controls	*N*	Y	*N*	Y	*N*	Y
Observations	23210	23210	23210	23210	23210	23210
R^2	*0.016*	0.085	*0.023*	0.087	*0.049*	0.109
Panel C. Future financial situation† (*FINFUT*)						
Objective: LIHC	*0.017***	0.019**				
	(0.007)	(0.007)				
Objective: FP10			*0.0112**	0.015**		
			(0.006)	(0.007)		
Subjective: IHEAT					*0.122****	0.130***
					(0.014)	(0.014)
Controls	*N*	Y	*N*	Y	*N*	Y
Observations	23210	23210	23210	23210	23210	23210
R^2	0.000	0.012	0.000	0.012	0.001	0.018

Notes: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Robust standard errors in parentheses. Controls include economic and socio- demographic characteristics and regional/time fixed effects (Table A1, Appendix A). †Future financial situation time horizon is "a year from now".

There is a clear positive association between the indicators of fuel poverty and measures of financial distress, either in the form of being behind on bills (Panel A), finding current finances difficult (Panel B) or expecting future finances to be worse in a year's time (Panel C). Focusing on the specifications that include controls, the objective (subjective) indicators suggest that fuel poverty, compared with not being in fuel poverty, is associated with an increased probability of falling behind on bills by 4.1 and 4.3 (21.6) percentage points (Panel A), finding the current financial situation difficult by 6.4 and 6.9 (22.6) percentage points (Panel B) and expecting future finances to become worse by around 1.5 and 1.9 (13.0) percentage points (Panel C), on average, *ceteris paribus.*

Hence, for all measures of financial distress, we find the estimated probabilities are consistent in magnitude and in significance levels for both objective indicators (*LIHC, FP10*) despite their different definition. By contrast, the magnitude of the coefficient associated with these indicators appears smaller than that associated with the subjective indicator (*IHEAT*). This is consistent with relevant literature which finds a more pronounced relationship between self-assessed (health) outcomes and subjective, rather than objective, indicators of fuel poverty (see e.g. Awaworyi Churchill et al., 2020; Kahouli, 2020; Llorca et al., 2020).

3.2 Instrumental variable results

To help address endogeneity concerns, we instrument the fuel poverty indicators (*LIHC, FP10, IHEAT*) sequentially by employing three separate pairs of gas and electricity prices i.e. marginal prices (M_G and M_E), fixed charges (F_G and F_E), and the fixed-marginal ratio (FM_G and FM_E). [15] All specifications include economic and socio-demographic controls and regional/time fixed effects.

For each measure of financial distress, at least one pair of instruments (M_G and M_E, F_G and F_E, or FM_G and FM_E) is valid according to the Sagan-Hansen test (i.e. the null of exogeneity cannot be rejected). Not only is F_G and F_E the most relevant pair according to the first stage *F*-statistic, but also in all but one specification this pair of instruments appear valid. In Table 3, we focus on the specifications with the most relevant pair of instruments (i.e. the largest F-statistic reported in the first stage regressions) that are also valid (i.e. the J-statistic p-value > 0.1 in the

[15] The results are consistent with the use of current prices (2018-2020) (Table A3, Appendix A) and a one-year lag in prices (2017-2019) – for brevity these results are available upon request.

second stage regressions). The complete set of IV results are presented in Table A2 (Appendix A).

The first stage regression results are contained in upper panel in Table 3. The second stage regressions, which estimate the instrumented relationship between the fuel poverty indicators and our three self-reported measures of financial distress, are placed below. Column 1 presents the instrumented results for the *LIHC* indicator, followed by *FP10* in Column 2 and finally *IHEAT* in Columns 3-4. The results for *BEHINDBILLS, FINNOW* and *FINFUT* are displayed in Panels A, B and C, respectively. As expected, in the first stage, increases in energy prices increase the likelihood of fuel poverty. For example, according to the *LIHC* indicator, the probability of being identified as fuel poor (*c.f.* non-fuel poor) increases between 0.87 and 2.92 percentage points given a respective £10/year rise in F_G and F_E (Column, 1). Similarly, turning to *IHEAT* (Column 3), increasing M_G and M_E by 0.01p/kWh increases the probability of being fuel poor by around 7.4 and 0.37 percentage points respectively, on average, *ceteris paribus.* Across all models, the strength of the instruments is markedly improved when fixed charges either enter exclusively or working as part of the FM-ratio (Table 3; Table A2, Appendix A).

The first stage *F*-statistic is consistently greater than 10, in-line with the Staiger and Stock (1997) rule-of-thumb. However, they fall below the level of 104.7, which recent literature suggests the first stage *F*-statistic should exceed (Lee et al., 2020). For each given *F*-statistic therefore, we correct the critical values and calculate “tF 0.05 standard errors” proposed by Lee et al. (2020: 21). Compared to the true standard errors, Lee et al. (2020) consider these values to be somewhat conservative. Despite the conservative nature of this correction, the statistically significant findings remain so at the 5% level.[16]

[16] The findings hold using models that correct for potentially weak instruments including the limited information maximum likelihood (LIML) and jackknife IV estimators (see e.g. Angrist et al., 1999). For brevity these results are available upon request.

Table 3. IV (LPM) regressions of financial distress on indicators of fuel poverty using prices (*M*, *F*, *FM*) between 2016-2018 UKHLS' main survey (Jan/2018-Feb/2020)

Specifications	(1)	(2)	(3)	(4)
FP Indicator	LIHC	FP10	IHEAT	
IVs	F	F	M	F
First stage coefficients				
Gas	0.000869**	0.00144***	7.433***	0.00173***
	(0.000)	(0.000)	(1.008)	(0.000)
Electricity	0.00292***	0.00258***	0.373	0.00103***
	(0.000)	(0.000)	(0.422)	(0.000)
F-statistic	62.46	61.40	52.91	77.85
Second stage coefficients				
Panel A. Behind on bills (*BEHINDBILLS*)				
FP Indicator	0.886***	0.844***	0.924***	
	(0.102)	(0.097)	(0.120)	
tF 0.05 S.E.	[0.112]**	[0.103]**	[0.130]**	
J (p-value)	0.765	0.358	0.836	
Panel B. Current financial situation (*FINNOW*)				
FP Indicator	0.257***	0.248***		0.351***
	(0.073)	(0.069)		(0.094)
tF 0.05 S.E.	[0.080]**	[0.074]**		[0.097]**
J (p-value)	0.539	0.884		0.411
Panel C. Future financial situation† (*FINFUT*)				
FP Indicator	0.0263	0.0294		0.0535
	(0.081)	(0.077)		(0.112)
tF 0.05 S.E.	[0.089]	[0.082]		[0.116]
J (p-value)	0.616	0.645		0.723
N	23210	23210	23210	23210

*Notes: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Robust standard errors in parentheses. All models (first and second stage) include economic and socio- demographic controls and regional/time fixed effects (Table A1, Appendix A). †Future financial situation time horizon is "a year from now". FP denotes fuel poverty. M, F and FM refer to marginal prices, fixed charges and the fixed-marginal ratio respectively. The most relevant pairs (the largest F-Statistic reported in the first stage regressions) out of the valid IVs (J (p-value)>0.1 in the second stage regressions) are presented here (see Table A2, Appendix A, for complete table of IV results).*

Homing in on the preferred specifications in Table 3, fuel poverty exerts a positive and significant impact on falling behind on bills (Panel A) and whether individuals consider their current financial situation to be at least difficult (Panel B). These findings exhibit the same sign as our baseline results and remain statistically significant at the 5% level when employing the more conservative (tF 0.05) standard errors. For example, according to the *FP10* indicator, fuel poverty increases the probability of being behind on bills by 84.4 percentage points, on average, all else constant. In addition, the probability of finding current finances at least difficult increases by 24.8 percentage points if fuel poor (*c.f.* non-fuel poor). In contrast with our baseline results, Panel C suggests that fuel poverty does not exert a significant influence on *future* expectations of financial distress.[17]

3.3 Bounding results and sensitivity analysis

Concerns may remain about endogeneity or about the validity of instruments. Overall, the baseline coefficients presented – with and without controls – in Table 2 are relatively stable, particularly in the case of *FINNOW* (Panel B) and *FINFUT* (Panel C). Whilst coefficient stability has been used as an indication of the limited influence of omitted variable bias (Altonji et al., 2005), Oster in 2019 acknowledges that this argument overlooks the concomitant movements (or lack thereof) in the R^2 i.e. whether (or not) the controls are informative. Utilising movements in coefficients and in the R^2, Oster (2019) formalises an approach that exploits the relative degree of selection on observed and unobserved variables to evaluate the pervasiveness of omitted variables bias in linear models. We therefore implement Oster's

[17] We also implement the IV estimators whilst balancing the covariates using inverse-propensity score weighting to further assess potential selection bias (Aizer and Doyle, 2013). Table A4 shows estimates consistent in significance, albeit smaller in magnitude, with the main IV results (Table 3).

approach to further assess the robustness of the baseline results to selection on unobserved variables.

Oster (2019) defines the relative degree of selection on observed and unobserved variables as δ and equates this to unity if the observed variables are of equal importance to those unobserved. This is an innocuous assumption if the observed variables have been carefully collected based on the relevant literature and given that their inclusion partitions out their effect captured by the unobserved variables. Therefore, we set $\delta=1$.[18]

In addition, Oster (2019) proposes that whilst the R^2 has a limit of one, practically, due to measurement error, its theoretical maximum (R^2_{MAX}) is likely to fall below unity. Appealing to the survival rate of experimental studies in top journals, upon applying her bounding approach, Oster (2019) proposes an R^2_{MAX} equal to $min\left\{1,\ 1.3\widehat{R}^2\right\}$ where $\widehat{R}^2$ is the coefficient of determination taken from the regression in Equation 1.

If $\beta>0$, the bounding set can be defined as $\left[\beta^*(min\left\{1,\ 1.3\widehat{R}^2\right\}, \delta = 1), \hat{\beta}\right]$, where β^* represents the lower bound if there is upward bias or an upper bound if the bias is away from zero, that is $\left[\hat{\beta}, \beta^*(min\left\{1,\ 1.3\widehat{R}^2\right\}, \delta = 1)\right]$.[19] β^* can be estimated as:

$$\beta^* = \hat{\beta} - \delta(\dot{\beta}-\hat{\beta})\frac{R^2_{MAX} - \widehat{R}^2}{\widehat{R}^2 - \dot{R}^2} \tag{3}$$

$\hat{\beta}$ denotes the sample estimate of β using Equation (1) (setting $\delta=0$). Respectively, $\dot{\beta}$ and $\dot{R}^2$ represents the sample estimate of β and the coefficient of determination obtained from

[18] Otherwise, if the unobserved variables are of greater (lesser) importance than the observed in explaining the outcomes then $\delta>1$ ($0<\delta<1$). On average, Oster (2019)'s examination of studies published in top journals found $\delta<1$ hence setting $\delta=1$ provides a more conservative approach.
[19] The converse is true for $\beta<0$.

specification (1) *without* controls. The bounding set contains the true β, therefore if zero falls within this bound the causal effect can be interpreted as non-statistically significant.

Table 4 presents the bounding sets. For comparison purposes, the baseline estimates $\hat{\beta}$ (setting $\delta=0$) are taken from the regressions with controls as presented in Table 2. Oster's approach consistently provides a lower bound to our baseline results for current measures of financial distress (*BEHINDBILLS, FINNOW*). In contrast, an upper bound is established relative to the baseline estimates for expectations of future financial distress (*FINFUT*). All point estimates are statistically significant at least at the 5% level and the bounding sets do not contain zero.

In addition, Table 4 presents the estimated δ that would be required to force the causal effect to be zero. This is positive for current measures of financial distress (*BEHINDBILLS, FINNOW*), consistent with downward bias, and ranges between 2 and 4.1. In contrast, δ is negative for *FINFUT,* in line with the upper bound estimated. In two out of three cases $|\delta|$ exceeds 20 and 80. Therefore, altogether, since it is unlikely that the selection on unobserved variables is between 2 and 80 times greater than the observed variables, and the bounded sets do not contain zero, the baseline results can be interpreted as robust to selection on unobserved variables.

Moreover, it is important to note that our IV estimates are consistent if we relax the underlying assumption that the bias arising from unobserved variables is in the same direction as the observed variables (or the size of the bias is so small the overall direction of bias is unphased). Table 4 presents the estimate value of β^* upon relaxing this assumption. The significant IV estimates (Panels A and B) fall within the upper bound. As with the IV estimates, there is evidence to suggest that fuel poverty has a deleterious impact on current measures of financial distress (*BEHINDBILLS, FINNOW*) yet may not alter expectations of future financial distress since the *FINFUT* bounding sets include zero.

Table 4. Bounded regressions of financial distress on indicators of fuel poverty

UKHLS main survey (Jan/2018-Feb/2020)

Specification	(1) *LIHC*	(2) *FP10*	(3) *IHEAT*
Fuel poverty indicator		Coefficients	
	Panel A. Behind on bills (*BEHINDBILLS*)		
$\hat{\beta}$ (δ=0)	0.041***	0.043***	0.216***
	(0.006)	(0.006)	(0.014)
$\beta^*(min\{1,\ 1.3\hat{R}^2\}, \delta$=1)	0.027***	0.026***	0.183***
	[0.007]	[0.007]	[0.018]
δ	2.700	2.339	3.959
β^* (assuming bias changes direction)	1.373	0.994	1.939
	Panel B. Current financial situation (*FINNOW*)		
$\hat{\beta}$ (δ=0)	0.064***	0.069***	0.226***
	(0.007)	(0.007)	(0.015)
$\beta^*(min\{1,\ 1.3\hat{R}^2\}, \delta$=1)	0.049***	0.049***	0.194***
	[0.009]	[0.009]	[0.020]
δ	3.473	2.768	4.048
β^* (assuming bias changes direction)	1.261	0.883	1.973
	Panel C. Future financial situation† (*FINFUT*)		
$\hat{\beta}$ (δ=0)	0.019**	0.015**	0.130***
	(0.007)	(0.007)	(0.014)
$\beta^*(min\{1,\ 1.3\hat{R}^2\}, \delta$=1)	0.020***	0.016**	0.133***
	[0.007]	[0.007]	[0.012]
δ	-80.877	-0.5	-28.782
β^* (assuming bias changes direction)	-6.939	-2.959	-3.697

Notes: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. *Robust standard errors in parentheses. Standard errors in square brackets are bootstrapped for 1000 replications.* δ *and* β^* *are estimated using Oster (2019)'s psacalc Stata Code. All models include economic and socio- demographic controls and regional/time fixed effects (Table A1, Appendix A).* †*Future financial situation time horizon is "a year from now".*

In addition, the results from the main survey remain robust upon further sensitivity checks (Table 5). We assess whether fuel poverty has a persistent effect on financial distress by including the lag (*t-1*) of fuel poverty indicators – this represents fuel poverty in main survey Wave 9 (January 2017 – May 2019). Table 5 (Column 1) shows, as one may expect, that the coefficients are generally smaller than in the 'static' models, not least because the impact of fuel poverty is somewhat attenuated over time. The findings related to falling behind on bills and current finances remain statistically significant. Lags of fuel poverty provide some additional assurance that the direction of the effect flows from fuel poverty to financial distress rather than vice versa.[20] Like in the IV results, the relationship between fuel poverty and expectations of future financial distress is attenuated. This is a further indication that baseline findings relating fuel poverty to *FINFUT* may be picking up confounding factors.

To further assess potential confounding variables, we draw upon two additional sets of controls: 1) subjective well-being (SWB) and psychological distress (PD) (Table 5, Column 2); and 2) the Big 5 personality traits (Table 5, Column 3). The variable descriptions are detailed in Table A6.

We examine whether the relationship between fuel poverty and financial distress is mediated by levels of psychological distress and life satisfaction. On the one hand, self-reported financial distress has been associated with psychological distress during the COVID-19 pandemic (Davillas and Jones, 2020) and life satisfaction prior to and during the financial crisis (Keese, 2012; Arampatzi et al., 2014). On the other hand, as noted in Section 1, fuel poverty has been reported to affect subjective measures of health and well-being. The findings presented in Table 5 (Column 2) show that the impact of fuel poverty on current measures of financial distress (*BEHINDBILLS*, *FINNOW*) remains statistically significant (Panels A and B). Whilst the link between objective indicators of fuel poverty and expectations of future financial distress (*FINFUT*) are mediated and consistent with the conclusions drawn from the IV estimates, the relationship remains statistically significant for the subjective indicator of fuel poverty.

Table 5 (Column 3) utilises data contained in the UKHLS Wave 3 (January 2011 – May 2013), the only UKHLS survey containing the Big 5 personality traits – agreeableness, conscientiousness, extraversion, neuroticism and openness. The Big 5 personality traits are considered important factors for economic outcomes, including financial distress (Xu et al.,

[20] Parise and Peijnenburg (2019) also use the lag to emphasise that the direction of causality runs from noncognitive abilities to financial distress.

2015; Parise and Peijnenburg, 2019; Liao, 2020). Unlike SWB and PD, these controls can be considered exogenous as they are generalisable across the life course (Xu et al., 2015).[21] The baseline findings hold upon inclusion of the Big 5 personality traits.

Overall, there is some evidence to suggest that the link between objective indicators of fuel poverty and *FINFUT* is attenuated by measures of subjective well-being and psychological distress. In contrast, there is no evidence to suggest this is the same for subjective indicators of fuel poverty. Hence, in light of the IV results, unobserved factors (e.g. internal temperatures) and/or self-assessed measurement error(s) may be driving the baseline association between subjective fuel poverty and expectations about future financial distress. Indeed, there is an argument for the inclusion of non-financial factors in order to subvert potential biases related to self-reported measures of financial distress (Keese, 2012; Kellstedt et al., 2015). However, since the literature discussed earlier has established a causal link between fuel poverty and health outcomes (see e.g. Awaworyi Churchill et al., 2020; Kahouli, 2020), these controls (SWB and PD) are clearly endogenous and such specification checks should be viewed with caution.

[21] The key pitfall arises from attrition as the number of observations decreases by 6000 individuals, therefore this specification is used as a robustness check rather than a baseline finding. We also used numerical cognitive and verbal ability data taken from Wave 3 (see e.g. Xu et al., 2015; Liao, 2020), however these variables are non-generalisable across one's life course. Nonetheless, the baseline results remain intact upon their inclusion and are available upon request.

Table 5. Baseline specification checks of (LPM) regressions of financial distress on indicators of fuel poverty UKHLS Main survey (Jan/2018-Feb/2020)

Specification	(1)	(2)	(3)
	Fuel poverty (t-1)	Including SWB and PD	Including Big 5 personality traits (from Wave 3)
Fuel poverty indicator		Coefficients	
Panel A. Behind on Bills (*BEHINDBILLS*)			
LIHC	0.0545***	0.0377***	0.0275***
	(0.007)	(0.006)	(0.007)
FP10	0.0419***	0.0395***	0.0321***
	(0.006)	(0.006)	(0.006)
IHEAT	0.163***	0.201***	0.207***
	(0.014)	(0.014)	(0.017)
N	19791	23210	17142
Panel B. Current financial situation (*FINNOW*)			
LIHC	0.0572***	0.0568***	0.0632***
	(0.008)	(0.007)	(0.009)
FP10	0.0617***	0.0606***	0.0707***
	(0.007)	(0.006)	(0.008)
IHEAT	0.156***	0.182***	0.247***
	(0.014)	(0.014)	(0.019)
N	19936	23210	17142
Panel C. Future financial situation† (*FINFUT*)			
LIHC	0.0102	0.0126*	0.0216**
	(0.008)	(0.007)	(0.009)
FP10	0.0100	0.00827	0.0217***
	(0.007)	(0.007)	(0.008)
IHEAT	0.107***	0.0910***	0.151***
	(0.014)	(0.013)	(0.018)
N	21388	23210	17142

*Notes: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Robust standard errors in parentheses. All models include economic and socio- demographic controls and regional/time fixed effects (Table A1, Appendix A). Specifications: (1) lags fuel poverty in the baseline model (Equation 1); (2) adds subjective well-being (SWB) and psychological distress variables (PD) to the baseline model (Equation 1); and (3) adjusts the baseline model by including the Big 5 Personality traits using answers provided in UKHLS Wave 3 – see Table A6 for variable definitions. †Financial future situation time horizon is "a year from now".*

3.4 Fuel poverty, financial distress and the COVID-19 pandemic

To investigate the relevance of fuel poverty during the current COVID-19 pandemic, we employ UKHLS' COVID-19 web surveys (University of Essex, 2021). We rely on the surveys which take place in April, May and July 2020 as those carried out in June and September 2020 do not contain measures of financial distress. It is important to note that these surveys map onto the peak, decline and trough of the first wave of the pandemic. The number of admissions to hospital peaks at 3115 patients (7-day average) on 4th April 2020, followed by the 7-day average falling to 1199 patients on the 4th May 2020, which then starts to approach the trough of admissions by 4th July 2020 with numbers falling further to 216 patients (HM Government, 2021). The 4th July 2020 coincides with the easing of national lockdown restrictions in the UK – for example, salons and beauty services reopen on 13th July 2020 and the use of public transport for non-essential journeys is permitted by 17th July 2020.

The questions underpinning *BEHINDBILLS* and *FINNOW* are identical to the main survey. The time horizon for *FINFUT* changes from one year to one month. Table 6 shows that the proportion of individuals experiencing financial distress declines from April to July 2020 in line with the pandemic's first wave coming to an end.

Individuals are identified as fuel poor based on their responses and information contained in the main survey data (Table 6). Although the COVID-19 surveys do not contain income or expenditure information, this approach allows us to explore whether those individuals identified as fuel poor prior to the pandemic are more likely to experience financial distress during the pandemic. In the COVID-19 regressions, we include time effects that represent the year in which the individual participates in the main survey (Wave 10) in order to control for annual variation in energy bills, income and therefore fuel poverty.

Table 6. Summary statistics – financial distress and fuel poverty
COVID-19 surveys

Variables	COVID-19 (April 2020)	COVID-19 (May 2020)	COVID-19 (July 2020)
		Mean	
Dependent variables			
BEHINDBILLS	0.045	0.042	0.040
FINNOW	0.049	0.041	0.041
FINFUT†	0.167	0.106	0.085
Fuel Poverty variables			
Time period of fuel poverty indicator		Main survey (January 2018-February 2020)	
LIHC	0.085	0.086	0.084
FP10	0.109	0.109	0.107
IHEAT	0.035	0.033	0.034
N	12052	11064	10293

Notes: †Future financial situation time horizon is "a month from now".

The proportion of individuals we identify as fuel poor in the main survey are similar across the April to July 2020 samples (Table 6). This is supported by the notable stability in the economic and socio-demographic statistics collected from the COVID-19 surveys (Table A7, Appendix A). The controls collected for the baseline results in the COVID-19 surveys matches those specified in Equation 1 with the addition of a variable controlling for individuals mandated to stay at home in accordance with the UK's Coronavirus Job Retention Scheme (CJRS) (Table A7, Appendix). This is crucial since CJRS helps facilitate the transition into lockdown during the first wave of the pandemic, supporting the households' adjustment to the changes in living and working arrangements at home.

Figures 1A-1C below present the COVID-19 surveys' lower bound (*BEHINDBILLS, FINNOW*) and upper bound (*FINFUT*) according to Oster's (2019) approach as outlined in Equation 3. Similar to the results for the main survey, we generally find that fuel poverty continues to exert a positive influence over financial distress during the pandemic. We also observe a similar pattern in terms of the objective fuel poverty indicators exhibiting smaller effects than the subjective indicator.[22] Nonetheless, the confidence intervals presented in Figures 1A-1C suggest that the differences across the first wave of the pandemic and prior to the pandemic (main survey) are statistically insignificant. During these months, the cost of changes in electricity consumption attributable to working at home could be partly recovered by claims for tax relief for additional work-related expenses (around £6/week). Moreover, expenditure on energy and other necessities is indirectly supported through the UK's Coronavirus Job Retention Scheme for workers on furlough, which paid 80% of the regular wage of employed individuals (up to £2500/month). Whilst these schemes provide further assurance that the energy bills and income information used herein are relevant to the first wave of the COVID-19 pandemic, they potentially worked effectively to dampen the financial impact on those identified as fuel poor, relative to those not in fuel poverty, prior to the pandemic.

As a final robustness check, we restrict the main survey to individuals participating in the COVID-19 May 2020 survey (Table A5, Column 2, Appendix A).[23] There is a stark similarity in the economic and statistical significance of the coefficients in Table A5 (Column 2) and those from the main survey (Table 2, Even Columns). This helps to avert concerns that the overlap in the findings prior to and during the pandemic could arise from attrition or potential changes in the sample composition in the COVID-19 surveys.

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[22] Moreover, concerns surrounding the impact of a change in time horizon is alleviated by the fact that the relationship between fuel poverty and *FINFUT* is similar to the main survey by the end of the first wave of the pandemic.

[23] Whilst the results are robust when restricting the sample to individuals participating in either April, May or July 2020, only the results for May 2020 are presented in the Appendix for brevity. Results for April and July 2020 are available upon request.

Figure 1. Bounded estimates and 95% confidence of financial distress on fuel poverty indicators UKHLS' main survey (Jan/2018-Feb/2020) and COVID-19 surveys (April 2020, May 2020 and July 2020)

Figure 1A. *Behind on bills (BEHINDBILLS)*

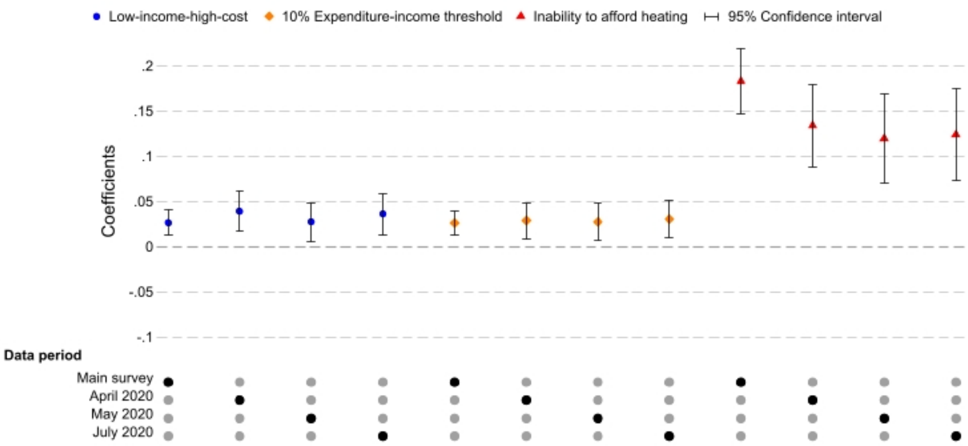


Figure 1B. *Current financial situation (FINNOW)*

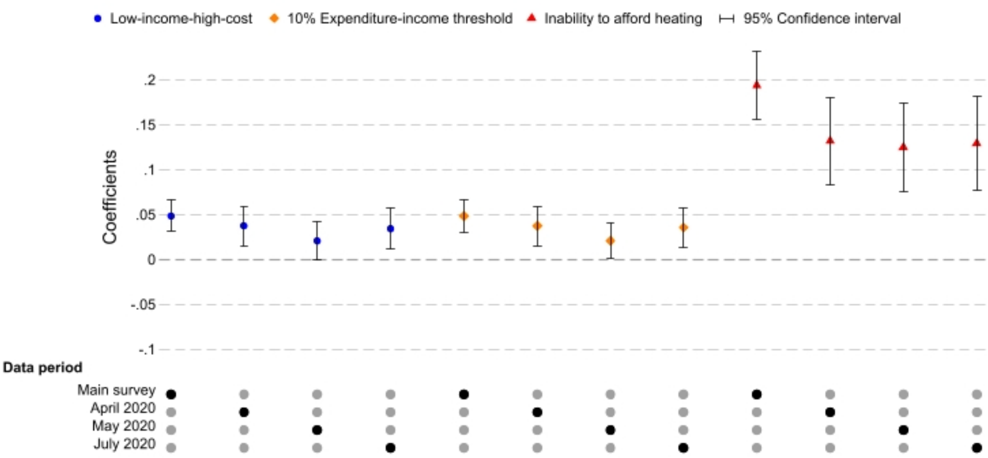
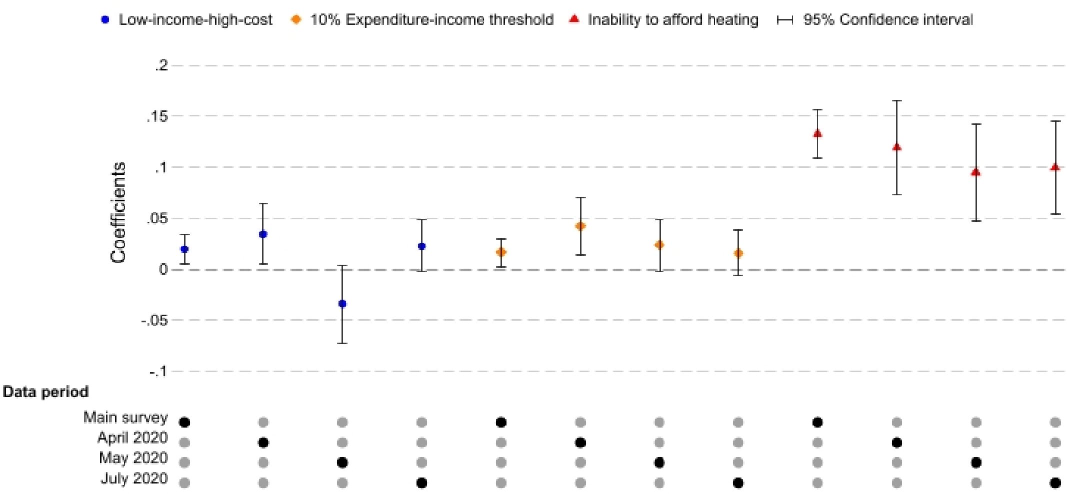


Figure 1C. *Future financial situation (FINFUT)*



Notes: LIHC, FP10 and IHEAT represents low-income-high-costs, 10% expenditure-income threshold and inability to afford heating.

4. Discussion and conclusion

Fuel poverty is an increasingly relevant dimension of social deprivation which is observed and monitored in many high-income countries where economic inequality is persistent or even growing. In most of these countries policy measures are in place to reduce the extent and the effects of this social inequity. These policies have achieved mixed results in the past due to the complex and multidimensional nature of the issues being addressed by policy makers. The adoption of well targeted and effective policy measures aims at tackling fuel poverty and its effects on the mental and physical wellbeing of the individuals who are affected by it will be even more important during the economic recovery from the current pandemic, as many households will have suffered losses or reductions in income and potentially also increases in expenditure due to the effect of lockdowns on mobility and travel.

This paper investigates the relationship between fuel poverty indictors (both objective and subjective) and self-reported measures of financial distress. While fuel poverty in itself is a source of concern in society, its broader effects are also concerning due to their potential long-term effect on health and wellbeing. The literature on fuel poverty, which has been briefly discussed in the paper, has identified a link between fuel poverty and health outcomes and has suggested two potential pathways through which the link can be established. On the one hand the "living conditions" pathway could impact health, via anxiety and depression or as a result of insufficient thermal comfort. On the other hand, the "financial security" pathway can affect individuals' wellbeing as a result of financial stress. This latter relationship is investigated empirically in our paper based on the responses to nationally representative surveys of GB held between January 2018 and February 2020. The responses to surveys run between March and May 2020 are instead used to extend the analysis to the early phases of the Covid-19 pandemic.

The paper therefore offers an original contribution to knowledge by investigating intermediate links within the recognised relationship between fuel poverty and health and wellbeing outcomes, via the role of financial distress. Our results are obtained using econometric methodologies aimed at dealing with the effects of potential sources of endogeneity.

Our results have identified a statistically significant and positive relationship between objective and subjective measures of fuel poverty and current situations of financial distress among fuel poor households. The link between fuel poverty and expectations about future financial circumstances however is less statistically robust. Our results are confirmed, but not necessarily, strengthened for the Covid-19 period.

Hence, according to our instrumental variable estimates, those identified as fuel poor find their current finances more difficult yet are no more likely to think their finances will be worse off, in the future, than those not considered fuel poor. This finding accords with scarcity theory, which predicts that poverty leads to reinforcing behaviour (e.g. overborrowing), since "attention is allocated to the most pressing financial problems and needs. Future needs loom far away." (de Bruijn and Antonides, 2021: 10). Whilst scarcity increases focus on limited resources, attentional focus on pressing present outgoings (e.g. utility expenses, groceries, rent) may come at the expense of neglecting future outgoings (Shah et al., 2012; Shah et al., 2018). This line of thought is consistent with (but does not necessarily imply) low-income consumers behaving as if they employ larger intemporal discount rates than high-income consumers (Train, 1985; Lawrance, 1991; Shah et al., 2012; de Bruijn and Antonides, 2021).

The key policy implications of our empirical analysis are that the evaluation of the effectiveness and potential benefits of policy measures aimed at addressing situations of fuel poverty should be assessed by taking into consideration the avoidance of, or reduction in, financial distress among fuel poor households, with indirect individual and societal benefits in terms improved health and wellbeing outcomes. While fortunately the impact of the COVID-19 pandemic does not seem to have significantly worsened the situation of financial distress among fuel poor households, this may be due to the extraordinary support measures put in place by the Government and the energy regulator in order to mitigate the worst financial effects of the pandemic, including a furlough scheme and a ban on evictions and disconnections. It is therefore important that any future policy of recovery from the pandemic continues to shelter these vulnerable individuals in order to make sure that any adverse impact of financial distress and eventually health has not simply been delayed through the existing measures. Indeed, National Energy Action (2020b) has argued for utility debt reform in order to protect households, energy suppliers and the economy from the "gathering storm" of utility debt that has been either been exacerbated or newly accrued during the pandemic.

Looking more broadly to the energy and environmental policy landscape, it is important to point out that the recently adopted net zero objectives and the associated strategies aimed at meeting them need to take into account the potential implications for individuals who find themselves in fuel poverty or are at risk of it. Indeed, the ambitious environmental objectives currently being adopted by many countries might actually increase the risk of excluding parts of society from access to affordable fuels and appliances, or even of eliciting the exploitation of the most vulnerable in society if they are unable to take advantage of the sustainable and energy efficient technologies that will make the achievement of those objectives possible.

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Appendix A. *Summary and other statistics*

Table A1. Control variable definitions and summary statistics
UKHLS' main survey (Jan/2018-Feb/2020)

Variable	Definition	Mean	SD
Socio-economic and demographics			
AGE	Age in years	51.818	17.557
FEMALE	1 if female; 0 otherwise	0.553	0.497
SINGLE	1 if single; 0 otherwise	0.257	0.437
HHSIZE	Number of adults in household	2.792	1.441
RENTING	1 if renting accommodation; 0 otherwise	0.227	0.419
NOCHILD	1 if no child; 0 otherwise	0.748	0.434
ONECHILD	1 if one child; 0 otherwise	0.104	0.305
TWOCHILD	1 if two child; 0 otherwise	0.148	0.356
DEGREE	1 if qualifications/ or basic qualification; 0 otherwise	0.432	0.495
GCSE-ALEVEL	1 if GCSE level; 0 otherwise	0.400	0.490
NOQUALS	1 if no qualifications/ or basic qualification; 0 otherwise	0.167	0.373
WHITE	1 if white; 0 otherwise	0.850	0.357
MIXED	1 if mixed; 0 otherwise	0.018	0.132
BLACK	1 if black; 0 otherwise	0.087	0.282
OTHER	1 if other; 0 otherwise	0.045	0.208
EMPLOYED	1 if employed; 0 otherwise	0.491	0.500
SELFEMPLOYED	1 if self-employed; 0 otherwise	0.084	0.277
UNEMPLOYED	1 if unemployed; 0 otherwise	0.032	0.177
RETIRED	1 if retired; 0 otherwise	0.280	0.449
OTHERSTATUS	1 if other job status; 0 otherwise	0.114	0.317
Regions			
NEAST	1 if respondent lives in the North East of England; 0 otherwise	0.039	0.195
NWEST	1 if respondent lives in the North West of England; 0 otherwise	0.110	0.313
YORKSHIRE	1 if respondent lives in Yorkshire and Humberside; 0 otherwise	0.092	0.288
EMIDLANDS	1 if respondent lives in the East Midlands; 0 otherwise	0.079	0.270
WMIDLANDS	1 if respondent lives in the West Midlands, 0 otherwise	0.091	0.287
EAST	1 if respondent lives in the East of England, 0 otherwise	0.095	0.293
LONDON	1 if respondent lives in London, 0 otherwise	0.108	0.310
SEAST	1 if respondent lives in the South East of England, 0 otherwise	0.129	0.335
SWEST	1 if respondent lives in the South West of England, 0 otherwise	0.092	0.289
WALES	1 if respondent lives in the Wales, 0 otherwise	0.070	0.255
SCOTLAND	1 if respondent lives in the Scotland, 0 otherwise	0.097	0.295
N		23210	

Table A2. IV (LPM) regressions of financial distress on indicators of fuel poverty using prices (*M*, *F*, *FM*) between 2016-2018

UKHLS main survey (Jan/2018-Feb/2020)

Specifications	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
FP Indicator		LIHC			FP10			IHEAT	
IVs	M	F	FM	M	F	FM	M	F	FM
First stage coefficients									
Gas	2.953**	0.000869**	1.816***	4.420***	0.00144***	2.183***	7.433***	0.00173***	1.515***
	(1.326)	(0.000)	(0.377)	(1.408)	(0.000)	(0.400)	(1.008)	(0.000)	(0.295)
Electricity	2.153***	0.00292***	1.282***	2.380***	0.00258***	1.040***	0.373	0.00103***	0.549***
	(0.544)	(0.000)	(0.254)	(0.576)	(0.000)	(0.270)	(0.422)	(0.000)	(0.208)
F-statistic	22.88	62.46	58.16	30.33	61.40	53.63	52.91	77.85	49.94
Second stage coefficients									
Panel A. Behind on bills (*BEHINDBILLS*)									
FP Indicator	0.823***	**0.886*****	0.852***	0.692***	**0.844*****	0.830***	**0.924*****	1.155***	1.295***
	(0.161)	**(0.102)**	(0.106)	(0.123)	**(0.097)**	(0.106)	**(0.120)**	(0.114)	(0.155)
tF 0.05 S.E.	[0.206]**	**[0.112]****	[0.114]**	[0.148]**	**[0.103]****	[0.115]**	**[0.130]****	[0.118]**	[0.170]**
J (p-value)	0.001	**0.765**	0.031	0.002	**0.358**	0.004	**0.836**	0.000	0.001
Panel B. Current financial situation (*FINNOW*)									
FP Indicator	0.246**	**0.257*****	0.263***	0.205**	**0.248*****	0.262***	0.260**	**0.351*****	0.416***
	(0.120)	**(0.073)**	(0.077)	(0.096)	**(0.069)**	(0.076)	(0.109)	**(0.094)**	(0.118)
tF 0.05 S.E.	[0.154]	**[0.080]****	[0.083]**	[0.115]	**[0.074]****	[0.083]**	[0.119]**	**[0.097]****	[0.130]**
J (p-value)	0.343	**0.539**	0.825	0.423	**0.884**	0.921	0.830	**0.411**	0.753
Panel C. Future financial situation† (*FINFUT*)									
FP Indicator	0.296**	**0.0263**	-0.0466	0.231**	**0.0294**	-0.0423	0.180	**0.0535**	-0.0629
	(0.146)	**(0.081)**	(0.075)	(0.117)	**(0.077)**	(0.075)	(0.135)	**(0.112)**	(0.120)
tF 0.05 S.E.	[0.187]	**[0.089]**	[0.080]	[0.140]	**[0.082]**	[0.082]	[0.147]	**[0.116]**	[0.132]
J (p-value)	0.231	**0.616**	0.533	0.178	**0.645**	0.501	0.0372	**0.723**	0.484
N	23210	23210	23210	23210	23210	23210	23210	23210	23210

Notes: * *$p < 0.1$,* ** *$p < 0.05$,* *** *$p < 0.01$. Robust standard errors in parentheses. All models (first and second stage) include economic and socio- demographic controls and regional/time fixed effects. †Future financial situation time horizon is "a year from now". FP denotes fuel poverty. M, F and FM refer to marginal prices, fixed charges and the fixed-marginal ratio respectively. The most relevant pairs (the largest F-Statistic reported in the first stage regressions) out of the valid IVs (J (p-value)>0.1 in the second stage regressions) are highlighted in bold.*

Table A3 IV (LPM) regressions of financial distress on indicators of fuel poverty using prices (*M*, *F*, *FM*) between 2018-2020

UKHLS main survey (Jan/2018-Feb/2020)

Specifications	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
FP Indicator		LIHC			FP10			IHEAT	
IVs	M	F	FM	M	F	FM	M	F	FM
				First stage coefficients					
Gas	11.98***	0.000499**	0.0556	13.49***	0.000776***	0.112**	12.33***	0.000959***	0.126***
	(1.664)	(0.000)	(0.045)	(1.787)	(0.000)	(0.048)	(1.283)	(0.000)	(0.035)
Electricity	-0.633	0.00222***	1.647***	-0.168	0.00232***	1.658***	-1.590***	0.000758***	0.757***
	(0.554)	(0.000)	(0.198)	(0.599)	(0.000)	(0.210)	(0.432)	(0.000)	(0.153)
F	29.01	47.32	53.28	35.02	53.42	55.96	49.41	46.46	44.38
				Second stage coefficients					
				Panel A. Behind on bills (*BEHINDBILLS*)					
FP Indicator	0.463***	**0.612*****	0.782***	0.325***	0.524***	0.692***	0.614***	0.757***	1.064***
	(0.113)	**(0.096)**	(0.109)	(0.087)	(0.080)	(0.095)	(0.111)	(0.117)	(0.145)
J (p-value)	0.000	**0.105**	0.022	0.000	0.030	0.002	0.001	0.000	0.000
				Panel B. Current financial situation (*FINNOW*)					
FP Indicator	0.173	0.145*	**0.201****	0.115	0.127*	**0.179****	0.247**	**0.202***	0.281**
	(0.108)	(0.082)	**(0.083)**	(0.089)	(0.071)	**(0.075)**	(0.111)	**(0.116)**	(0.120)
J (p-value)	0.0278	0.946	**0.629**	0.0184	0.951	**0.473**	0.0729	**0.557**	0.260
				Panel C. Future financial situation† (*FINFUT*)					
FP Indicator	-0.0157	0.124	**0.0728**	0.0210	0.100	**0.0609**	-0.108	**0.103**	0.0828
	(0.135)	(0.105)	**(0.094)**	(0.113)	(0.091)	**(0.085)**	(0.138)	**(0.151)**	(0.142)
J (p-value)	0.0162	0.221	**0.500**	0.0160	0.192	**0.456**	0.0253	**0.115**	0.390
N	23210	23210	23210	23210	23210	23210	23210	23210	23210

*Notes: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Robust standard errors in parentheses. All models (first and second stage) include economic and socio- demographic controls and regional/time fixed effects. †Future financial situation time horizon is "a year from now". FP denotes fuel poverty. M, F and FM refer to marginal prices, fixed charges and the fixed-marginal ratio. The most relevant pairs (the largest F-Statistic reported in the first stage regressions) out of the valid IVs (J (p-value)>0.1 in the second stage regressions) are highlighted in bold.*

Table A4. IV (LPM) regressions of financial distress on indicators of fuel poverty using prices (*M*, *F*, *FM*) between 2016-2018 using inverse-propensity score weighting UKHLS main survey (Jan/2018-Feb/2020)

Specifications	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
FP Indicator		LIHC			FP10			IHEAT	
IVs	M	F	FM	M	F	FM	M	F	FM
				First stage coefficients					
Gas	5.430	0.00216**	3.705***	6.637*	0.00265***	3.819***	41.47***	0.0108***	9.404***
	(3.861)	(0.001)	(0.922)	(3.523)	(0.001)	(0.854)	(6.025)	(0.002)	(1.440)
Electricity	5.671***	0.00562***	2.145***	5.474***	0.00471***	1.690***	3.349	0.00507***	2.490***
	(1.381)	(0.001)	(0.598)	(1.255)	(0.001)	(0.556)	(2.130)	(0.001)	(0.920)
F	25.50	57.46	57.43	31.57	56.06	53.05	60.75	89.88	83.73
				Second stage coefficients					
				Panel A. Behind on bills (*BEHINDBILLS*)					
FP Indicator	0.427***	**0.493*** **	0.475***	0.436***	**0.511*** **	0.484***	**0.427*** **	0.435***	0.411***
	(0.103)	**(0.073)**	(0.077)	(0.092)	**(0.073)**	(0.078)	**(0.082)**	(0.069)	(0.072)
J (p-value)	0.002	**0.715**	0.083	0.005	**0.629**	0.011	**0.529**	0.035	0.011
				Panel B. Current financial situation (*FINNOW*)					
FP Indicator	0.298***	0.203***	**0.187*** **	0.223**	**0.214*** **	0.207***	0.275***	**0.245*** **	0.210***
	(0.106)	(0.066)	**(0.067)**	(0.090)	**(0.064)**	(0.067)	(0.083)	**(0.072)**	(0.079)
J (p-value)	0.194	0.049	**0.151**	0.253	**0.395**	0.797	0.023	**0.576**	0.936
				Panel C. Future financial situation† (*FINFUT*)					
FP Indicator	0.112	**0.0133**	-0.00409	0.0977	**-0.00533**	-0.0417	0.0961	0.0724	**0.0285**
	(0.110)	**(0.072)**	(0.069)	(0.097)	**(0.073)**	(0.072)	(0.098)	(0.083)	**(0.081)**
J (p-value)	0.886	**0.258**	0.209	0.548	**0.634**	0.597	0.002	0.063	**0.235**
N	23210	23210	23210	23210	23210	23210	23210	23210	23210

*Notes: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Robust standard errors in parentheses. All models (first and second stage) include economic and socio- demographic controls and regional/time fixed effects. †Future financial situation time horizon is "a year from now". FP denotes fuel poverty. M, F and FM refers to marginal prices, fixed charges and the fixed-marginal ratio. The most relevant pairs (the largest F-Statistic reported in the first stage regressions) out of the valid IVs (J (p-value)>0.1 in the second stage regressions) are highlighted in bold.*

Table A5. Baseline specification checks of (LPM) regressions of financial distress on indicators of fuel poverty UKHLS Main survey (Jan/2018-Feb/2020)

Specification	(1)	(2)
	Reintroduce 71 pandemic observations	Restrict to COVID-19 sample (May 2020)
Fuel poverty indicator	Coefficients	
Panel A. Behind on Bills (*BEHINDBILLS*)		
LIHC	0.0403***	0.0279***
	(0.006)	(0.009)
FP10	0.0425***	0.0242***
	(0.006)	(0.008)
IHEAT	0.214***	0.180***
	(0.014)	(0.023)
N	23298	10846
Panel B. Current financial situation (*FINNOW*)		
LIHC	0.0639***	0.0758***
	(0.007)	(0.012)
FP10	0.0683***	0.0727***
	(0.007)	(0.011)
IHEAT	0.224***	0.229***
	(0.015)	(0.025)
N	23298	10846
Panel C. Future financial situation† (*FINFUT*)		
LIHC	0.0181**	0.0233*
	(0.007)	(0.013)
FP10	0.0147**	0.0212*
	(0.007)	(0.012)
IHEAT	0.128***	0.151***
	(0.014)	(0.025)
N	23298	10846

Notes: * *p < 0.1,* ** *p < 0.05,* *** *p < 0.01. Robust standard errors in parentheses. All models include economic and socio- demographic controls and regional/time fixed effects. Specifications: (1) reintroduces 71 individuals participating in the main (Wave 10) survey during the COVID-19 pandemic; and (2) restricts the sample to only include participants of the COVID-19 May survey. †Financial future situation time horizon is "a year from now".*

Table A6. Definitions – General Health Questionnaire (psychological distress) and life satisfaction (subjective well-being)

Variables	Definition
GHQ variables	
Question: Have you recently been able to concentrate on whatever you're doing?	
CONCENTRATE	1 if less than or much less than usual; 0 if same as or better than usual.
Question: Have you recently lost much sleep over worry?	
WORRY	1 if rather more than or much more than usual; 0 if no more than usual or not at all.
Question: Have you recently felt that you were playing a useful part in things?	
USEFUL	1 if less than or much less than usual; 0 if same as or better than usual.
Question: Have you recently felt capable of making decisions about things?	
CAPABLE	1 if less so or much less capable; 0 if same as or more so than usual.
Question: Have you recently felt constantly under strain?	
STRAIN	1 if rather more than or much more than usual; 0 if no more than usual or not at all.
Question: Have you recently felt you couldn't overcome your difficulties?	
OVERCOME	1 if rather more than or much more than usual; 0 if no more than usual or not at all.
Question: Have you recently been able to enjoy your normal day-to-day activities?	
ENJOY	1 if less than or much less than usual; 0 if same as or better than usual.
Question: Have you recently been able to face up to problems?	
FACEUP	1 if less able or much less able; 0 if same as usual or more than usual.
Question: Have you recently been feeling unhappy or depressed?	
HAPPY	1 if rather more than or much more than usual; 0 if no more than usual or not at all.
Question: Have you recently been losing confidence in yourself?	
CONFIDENCE	1 if rather more than or much more than usual; 0 if no more than usual or not at all.
Question: Have you recently been thinking of yourself as a worthless person?	
WORTHLESS	1 if rather more than or much more than usual; 0 if no more than usual or not at all.
Question: Have you recently been feeling reasonably happy, all things considered?	
GHAPPY	1 if rather more than or much more than usual; 0 if no more than usual or not at all.
Life satisfaction	
LIFESAT	1 if completely dissatisfied; 2 if mostly dissatisfied; 3 if somewhat dissatisfied; 4 if neither satisfied nor dissatisfied; 5 if Somewhat satisfied; 6 if mostly satisfied; if 7 = Completely satisfied

Big 5 Personality Traits	
AGREEABLENESS	Likert scale from 1 (=does not apply to me at all) to 7 (=applies to me perfectly)
CONSCIENTIOUSNESS	Likert scale from 1 (=does not apply to me at all) to 7 (=applies to me perfectly)
EXTRAVERSION	Likert scale from 1 (=does not apply to me at all) to 7 (=applies to me perfectly)
NEUROTICISM	Likert scale from 1 (=does not apply to me at all) to 7 (=applies to me perfectly)
OPENNESS	Likert scale from 1 (=does not apply to me at all) to 7 (=applies to me perfectly)

Table A7. Control variable definitions and summary statistics
COVID-19 Samples

Variable	Definition	Mean	SD.	Mean	SD.	Mean	SD.
		COVID-19 (April 2020)		COVID-19 (May 2020)		COVID-19 (July 2020)	
Socio-economic and demographics							
AGE	Age in years	53.944	15.640	54.533	15.435	55.326	15.338
FEMALE	1 if female; 0 otherwise	0.574	0.495	0.575	0.494	0.575	0.494
SINGLE	1 if single; 0 otherwise	0.219	0.414	0.212	0.409	0.206	0.404
HHSIZE	Number of adults in household	2.675	1.302	2.629	1.277	2.588	1.242
RENTING	1 if renting accommodation; 0 otherwise	0.166	0.372	0.146	0.354	0.075	0.264
NOCHILD	1 if no child; 0 otherwise	0.733	0.443	0.749	0.433	0.762	0.426
ONECHILD	1 if one child; 0 otherwise	0.116	0.320	0.111	0.314	0.106	0.308
TWOCHILD	1 if two child; 0 otherwise	0.152	0.359	0.139	0.346	0.131	0.338
DEGREE	1 if qualifications/ or basic qualification; 0 otherwise	0.513	0.500	0.517	0.500	0.513	0.500
GCSE-ALEVEL	1 if GCSE level; 0 otherwise	0.379	0.485	0.376	0.484	0.375	0.484
NOQUALS	1 if no qualifications/ or basic qualification; 0 otherwise	0.108	0.310	0.107	0.309	0.113	0.316
WHITE	1 if white; 0 otherwise	0.899	0.301	0.901	0.298	0.904	0.294
MIXED	1 if mixed; 0 otherwise	0.015	0.123	0.015	0.123	0.015	0.122
BLACK	1 if black; 0 otherwise	0.058	0.234	0.058	0.233	0.054	0.226
OTHER	1 if other; 0 otherwise	0.027	0.162	0.025	0.157	0.026	0.160
EMPLOYED	1 if employed; 0 otherwise	0.516	0.500	0.489	0.500	0.498	0.500
SELFEMPLOYED	1 if self-employed; 0 otherwise	0.101	0.301	0.097	0.295	0.096	0.295
UNEMPLOYED	1 if unemployed; 0 otherwise	0.056	0.231	0.037	0.190	0.014	0.119
RETIRED	1 if retired; 0 otherwise	0.258	0.438	0.295	0.456	0.308	0.462
OTHERSTATUS	1 if other job status; 0 otherwise	0.069	0.254	0.082	0.275	0.083	0.276
NOFURLOUGH	1 if not furloughed; 0 otherwise	0.423	0.494	0.402	0.490	0.389	0.488
FURLOUGH	1 if furloughed; 0 otherwise	0.101	0.301	0.024	0.152	0.005	0.068
FURLOUGH-NA	1 if inapplicable or missing data; 0 otherwise	0.476	0.499	0.575	0.494	0.607	0.489

Regions							
NEAST	1 if respondent lives in the North East of England; 0 otherwise	0.037	0.189	0.038	0.190	0.035	0.184
NWEST	1 if respondent lives in the North West of England; 0 otherwise	0.102	0.302	0.101	0.301	0.102	0.303
YORKSHIRE	1 if respondent lives in Yorkshire and Humberside; 0 otherwise	0.087	0.282	0.088	0.284	0.086	0.280
EMIDLANDS	1 if respondent lives in the East Midlands; 0 otherwise	0.083	0.276	0.082	0.274	0.085	0.279
WMIDLANDS	1 if respondent lives in the West Midlands, 0 otherwise	0.089	0.284	0.090	0.287	0.091	0.288
EAST	1 if in the East of England, 0 otherwise	0.101	0.302	0.103	0.305	0.102	0.302
LONDON	1 if in London, 0 otherwise	0.093	0.290	0.091	0.287	0.089	0.285
SEAST	1 if in the South East of England, 0 otherwise	0.147	0.354	0.147	0.354	0.148	0.356
SWEST	1 if in the South West of England, 0 otherwise	0.103	0.305	0.104	0.305	0.106	0.307
WALES	1 if in the Wales, 0 otherwise	0.061	0.239	0.061	0.239	0.060	0.238
SCOTLAND	1 if in the Scotland, 0 otherwise	0.097	0.296	0.095	0.293	0.095	0.293
N		12052		11064		10293	

Table A8. Baseline and bounded (LPM) regressions of financial distress financial distress on indicators of fuel poverty

UKHLS COVID-19 surveys (April 2020, May 2020 and July 2020)

Specifications	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
FP Indicator		LIHC			FP10			IHEAT	
Month	April	May	July	April	May	July	April	May	July
					Coefficients				
					Panel A. Behind on bills (*BEHINDBILLS*)				
$\hat{\beta}$ (δ=0)	0.0523***	0.0406***	0.0482***	0.0449***	0.0333***	0.0426***	0.157***	0.142***	0.146***
	(0.010)	(0.010)	(0.011)	(0.009)	(0.010)	(0.009)	(0.020)	(0.022)	(0.022)
$\beta^*(min\{1,\ 1.3\hat{R}^2\}, \delta$=1)	0.039***	0.027**	0.036***	0.029***	0.027***	0.03***	0.134***	0.120***	0.124***
	(0.011)	(0.011)	(0.012)	(0.01)	(0.011)	(0.011)	(0.023)	(0.025)	(0.026)
					Panel B. Current financial situation (*FINNOW*)				
$\hat{\beta}$ (δ=0)	0.0490***	0.0426***	0.0456***	0.0514***	0.0354***	0.0476***	0.153***	0.147***	0.149***
	(0.010)	(0.009)	(0.010)	(0.009)	(0.009)	(0.009)	(0.021)	(0.021)	(0.022)
$\beta^*(min\{1,\ 1.3\hat{R}^2\}, \delta$=1)	0.037***	0.021*	0.034***	0.037***	0.021**	0.036***	0.132***	0.125***	0.129***
	(0.011)	(0.011)	(0.012)	(0.011)	(0.01)	(0.011)	(0.025)	(0.025)	(0.027)
					Panel C. Future financial situation† (*FINFUT*)				
$\hat{\beta}$ (δ=0)	0.0533***	0.0473***	0.0323***	0.0659***	0.0387***	0.0260**	0.126***	0.0995***	0.105***
	(0.014)	(0.013)	(0.012)	(0.012)	(0.011)	(0.011)	(0.023)	(0.022)	(0.022)
$\beta^*(min\{1,\ 1.3\hat{R}^2\}, \delta$=1)	0.034**	-0.034*	0.022**	0.042***	0.024*	0.016**	0.119***	0.094***	0.099***
	(0.015)	(0.02)	(0.013)	(0.014)	(0.013)	(0.011)	(0.023)	(0.024)	(0.023)
N	12052	11064	10293	12052	11064	10293	12052	11064	10293

*Notes: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Robust standard errors in parentheses. Standard errors in square brackets are bootstrapped for 1000 replications. δ and β^* are estimated using Oster (2019)'s psacalc Stata Code. All models include economic and socio- demographic controls and regional/time fixed effects. †Future financial situation time horizon is "a month from now".*

Appendix B. *Gas and electricity price matching*

We match gas and electricity average retail marginal prices and fixed charges, collected annually for each GB region by the Department of Business and Industrial Strategy (BEIS, 2021b, 2021c), to individuals in our UKHLS sample. Table B1 presents the time, regional and payment method matching process.

Time period matching

As discussed in Section 2, the year individuals participated in the main survey (2018-2020) is either matched to prices from the current year(s) (2018-2020) or matched using prices from two years prior (2016-2018).

Regional matching

Prices are matched by geographical region. For the most part, this is a straightforward match between the 14 regional distribution networks and 12 government office regions (Table B2). In the case of Scotland and Wales, the arithmetic mean of North/South sub-regions is used. Whilst the Northern Wales distribution network also extends across Merseyside, we do not believe this negatively affects the overall results based on the matching process.

Payment method matching

Individuals can pay by credit (i.e. the default standard variable supplier and/or tariff), direct debit (i.e. a fixed or variable tariff allocated after switching supplier and/or tariff) or prepayment (i.e. pay-as-you-go typically using a key card or token). UKHLS does not declare as to whether electricity consumers use time-of-use (Economy 7) tariffs. Nonetheless, the payment methods remain the same for Economy 7 consumers of whom represent only 6% of meters in Wales and 14% of meters in England and Scotland (BEIS, 2020b). Credit prices are matched to those paying each quarter/year (the default method) and other non-standard methods of payment (including frequent cash payments, government schemes). Direct debit prices are allocated to those paying a fixed amount each month by standing order or monthly by direct debit. Prepayment prices are allocated to consumers who pay-as-they-go using a prepaid key, card or token (Table B1). Other configurations of credit and debit prices reveal consistent findings but perform weaker as instruments (i.e. less correlated with the fuel poverty indicators).

Price definitions, summary statistics and within-region variation

Table B2 presents the gas and electricity average retail marginal prices, fixed charges, and fixed-marginal ratio. There are 99 prices in total as we have 11 regions, 3 years and 3 payment methods. The proportion of total variation in prices explained by within-region variation (i.e. the R^2) is estimated using a simple linear regression of prices on a vector of regional indicators.

Table B1. Matching process

BEIS	UKHLS		
Year	Current prices → Interview year	Lagged prices → Interview year	
2016	2018 → 2018	2016 → 2018	
2017	2019 → 2019	2017 → 2019	
2018	2020 → 2020	2018 → 2020	
2019			
2020			
Regions	BEIS Region → UKHLS Region		
North East	North East → North East		
North West	North West → North West		
Yorkshire	Yorkshire → Yorkshire and the Humber		
East Midlands	East Midlands → East Midlands		
West Midlands	West Midlands → West Midlands		
Eastern	Eastern → East of England		
London	London → London		
South East	South East → South East		
South West	South West → South West		
Southern*			
Merseyside and North Wales	Average(Merseyside and North Wales, South Wales) → Wales		
South Wales			
South Scotland	Average(North Scotland, South Scotland) → Scotland		
North Scotland			
Northern Ireland**			
BEIS Payment method	BEIS → UKHLS Payment method		
Credit	Credit →	•	A quarterly bill (by direct debit or other method)
Direct debit		•	An annual bill (by direct debit or other method)
Prepayment		•	Other (included in rent, government schemes, frequent cash payments)
	Direct debit →	•	Fixed amount each month by standing order
		•	A monthly bill by direct debit or other method
	Prepayment →	•	Prepayment meter (i.e. pay-as-you-go using key/card)

*Notes: * UKHLS separates the South into South East and South West, Southern data not matched. ** BEIS does not collect gas price data for NI, therefore GB only. We use the most recent median typical domestic consumption values* (BEIS, 2021b, 2021c).

Table B2. Definitions and summary statistics – Instrumental variables

Variable	Definition	Mean	SD	R^2
Gas and electricity prices (2018-2020)				
P_G	Annual regional average marginal gas price (£/kWh)	0.034	0.003	0.083
F_G	Annual regional average fixed gas charge (£/year)	88.423	10.670	0.048
FM_G	Gas fixed-marginal ratio per representative consumer with median consumption of 13600kWh i.e. $FM_G=F_G/13600P_G$	0.175	0.018	0.065
P_E	Annual regional average marginal electricity price (£/kWh)	0.149	0.009	0.199
F_E	Annual regional average fixed electricity charge (£/year)	81.810	9.350	0.051
FP_E	Electricity fixed-marginal ratio per representative consumer with median consumption of 3600kWh i.e. $FM_E=F_E/3600P_E$	0.140	0.016	0.011
Gas and electricity prices (2016-2018)				
P_G	Annual regional average marginal gas price (£/kWh)	0.037	0.003	0.054
F_G	Annual regional average fixed gas charge (£/year)	87.931	10.637	0.001
FM_G	Gas fixed-marginal ratio per representative consumer with median consumption of 13600kWh i.e. $FM_G=F_G/13600P_G$	0.171	0.015	0.022
P_E	Annual regional average marginal electricity price (£/kWh)	0.143	0.009	0.265
F_E	Annual regional average fixed electricity charge (£/year)	79.294	10.419	0.053
FP_E	Electricity fixed-marginal ratio per representative consumer with median consumption of 3600kWh i.e. $FM_E=F_E/3600P_E$	0.0753	0.051	0.003
N		99		

Notes: N= 11 (regions) x 3 (years) x 3 (methods of payment). Gas (G) and electricity (E) prices – marginal (P), fixed (F) and fixed-marginal ratio (FM). All statistics are adjusted to 2016 prices using the retail price all items index (ONS, 2021).