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Abstract

In April 2022, consumers in Great Britain (GB) witnessed a 54% increase in the energy price cap, as a result of Russia's invasion of Ukraine on February 24th, which sent wholesale gas prices spiralling across Europe. We leverage high-frequency data collected by the Smart Energy Research Lab, a representative panel containing daily gas and electricity data for around 13,000 households in Great Britain between January 2021 and December 2023 to investigate the implications. We exploit several datasets linked to the panel data which include time-varying and cross-sectional information. We rely on two price shocks: 1) in October 2021 a wave of energy retail suppliers leaving the industry. At this time over two million consumers on fixed contracts were forced to join a new supplier and pay a variable tariff, and 2) these consumers were exposed to a second price shock caused by the Ukraine-Russia conflict which fed through April 2022's energy price cap. Exploiting this pseudo-natural experiment, we use a difference-in-difference framework to estimate average treatment effects on this group of consumers and find that they would have consumed an additional 10 percentage points more electricity and 16 percentage points more gas had their prices remained fixed. These estimates are robust to a battery of robustness checks and point towards a significant loss in welfare for consumers on variable tariffs in the early stages of the energy price crisis.

Keywords: Difference-in-differences, energy consumption, energy crisis.

JEL codes: L94, E31, D12, I19

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1. Introduction

As other European countries, Britain has experienced significant shocks to energy prices over recent years. Starting with a smaller shock triggered by sudden increases in the world demand for gas in October 2021, then a much larger shock related to the invasion of Ukraine by Russia in February 2022, gas prices rose sharply in the GB wholesale market. Since gas is normally the marginal fuel in electricity generation, electricity prices similarly rose sharply for domestic and business consumers. Over the same period, UK's domestic consumers (referred to as households hereafter) have experienced a decline in their energy consumption; while there was a 6% increase in domestic energy consumption in 2021, this was followed by a considerable fall in energy use in 2022, amounting to 15% decrease in energy consumption (UK Parliament, 2024). This reduction has been attributed notably to higher prices as households cut back on energy use in response to surging bills.

Suppliers to the domestic energy market had been numerous before 2021, but many, in retrospect, were inadequately hedged against fuel price rises and were caught out by the first recent price shock which followed the end of Covid-19 restrictions worldwide. Unable to increase retail prices above the regulatory price-cap, many energy suppliers collapsed, leading to their customers being forcibly switched to alternative suppliers and from fixed contracts to standard variable tariffs (SVT), which were prevalent in the retail market at the time.

The regulatory energy price cap was adjusted twice-yearly, in April and October, and then quarterly following a regulatory change commencing in January 2023. An additional intervention came in October 2022, when the Government introduced the Energy Price Guarantee (EPG), keeping the maximum price per kWh for consumers below the regulated figure through a subsidy (Levell et al., 2024). Nevertheless, most households were now on the

SVT, and therefore experienced large changes in their electricity and gas bills. Only the customers of surviving retailers were able to remain on tariffs that had been fixed by contract prior to these events and were therefore insulated from these changes.

Smart meters measuring households' electricity and gas consumption at half- hourly intervals have gradually been introduced in Britain and now cover around 63% of domestic properties (DESNZ, 2024a). Around 13,000 households with smart meters were recruited by a research team at UCL's Smart Energy Research Lab (SERL) and agreed for their data to be used for research purposes. We were able to use this information on actual consumption and prices, which is not available via the UK's national household surveys[1], for our analysis. We rely on SERL's large dataset to evaluate the households' reactions to significant and unprecedented price changes to their energy bills by comparing the behaviour of a treated group of consumers who experienced the price rises with a control group who faced constant tariffs over the period of the energy price crisis.

This work contributes to the general literature on price elasticity of energy demand, which counts amongst the seminal contributions the GB study by Baker et al. (1989) and the US study by Reiss and White (2005). Recent related studies of energy consumption in GB include those by Druckman and Jackson (2008), Fuerst et al. (2015) and McIntyre (2018). These studies have generally investigated economic aspects of energy consumption at times of relatively stable conditions in energy markets with limited price variations over relatively long periods of time. Recent events in the European energy markets have however caused unprecedented increases in the level and volatility of energy prices, leading to an emerging strand of literature that

[1] For example, the National Energy Efficiency Database (NEED) contains information on energy consumption but not prices. The consumption data obtained from SERL is consistent with the NEED data (Few et al., 2024).

investigates the economic impact of the Ukraine war. This strand of literature includes a small number of contributions with a similar focus to ours, namely the economic impacts of the Ukraine war, and of the policy interventions which followed, on the GB retail market.

Fetzer et al. (2023) and Braackman et al. (2023) assess the implications of the unprecedented increases in energy prices for households' decisions regarding investments in energy efficiency, which could shelter consumers from future high bills. Fetzer et al. reach the conclusion that Government interventions to protect households turned out to be a lost opportunity to promote awareness of the benefits of energy efficiency, both in economic and in environmental terms. Braakman et al. on the other hand conclude that GB households perceived the price increases as being temporary, thus failing to attach a monetary premium to properties characterised by high levels of energy efficiency. However, they identify a small penalty being attached to relatively less efficient properties.

The contributions by Frontier Economics (2023) and Levell et al. (2024) are more akin to ours, in that they investigate the impact of price changes on energy consumption and assess the distributional implications of the energy price crisis. The report on Frontier Economics' Project VENICE provides a novel contribution to the literature as it relies on micro-data from smart meters and on a specially developed survey of domestic energy consumers with a focus on specific actions taken by them to cope with increased prices, rather than limiting their analysis to the changes in prices and income. Among their results, they point out that many consumers have limited awareness of the most effective coping strategies and actions. However, their study, although extensive, relies on a simulated control group strategy using previous weather corrected consumption.

Levell et al. (2024) rely on energy bills from bank accounts to estimate changes in consumption and energy demand elasticity using a flexible demand model and focusing on those consumers who are paying month by month according to consumption, rather than those whose energy supplier aims to even out bills over the year. Theirs is a much more structured analysis than the Frontier study. However, because they leverage a particular source of bank account data, and most households have the same supplier for gas and electricity, they can only observe total energy expenditure and therefore are not able to separately identify impacts on gas and electricity consumption, something that turns out to be important in both our analysis and the Frontier study. Levell et al. identify significant changes in consumption reflecting high levels of demand elasticity; they report that the largest responses were observed for households with the highest levels of pre-crisis consumption, and that the introduction of Government subsidies prevented significant monetary losses for most households.

Our study, like the Frontier Economics study, relies on actual prices and consumption levels, as recorded by the smart meters, rather than on estimated consumption based on regional price indexes, which allows us to estimate changes in consumption based on observed price variations. We extend our understanding of the energy crisis by establishing a causal link between price variations and changes in consumption. This is achieved by comparing the behaviour of households remaining on fixed contracts with that of households who were forced by external events to move to a variable tariff at a time preceding the Ukraine war. Our results, based on a difference-in-difference approach, establish that those consumers who were moved to a variable tariff reduced their consumption by significant amounts. This reduction in consumption was in addition to the general reduction brought about by the unprecedented price increases in winter 2022-23.

The rest of the paper is organised as follows: section 2 presents the empirical strategy while the key features of the data are described in section 3. The main results are discussed in section 4 and section 5 offers conclusions and recommendations. The Appendices contains more details about the data and different aspects of the statistical analysis.

2. Empirical strategy

We exploit an exogeneous energy price shock to energy consumption patterns caused by the gas market volatility which followed the invasion of Ukraine in 2022. In order to make causal inferences about the effect of this considerable price shock we also exploit a previous event which has caused a large number of GB households to move from a fixed price contract to a variable tariff, resulting from the market developments in 2021 described below.

As economies worldwide started opening up, following the removal of COVID-19 restrictions, excess energy demand was generated which led to global gas prices rising by around 50% (Ofgem, 2021) and caused the GB energy price-cap to increase by about 12% in October 2021. This price shock initiated a wave of domestic energy suppliers exiting the retail market. The collapse of around twenty-five suppliers between August and December 2021 forced approximately two million households to join a different energy supplier, typically one of the so-called 'Big 6'[2], and onto a new SVT – otherwise called a 'default' tariff – which tracks movements in the price cap[3] (Ofgem, 2024a). The second and more extreme energy price shock is exploited in order to measure the causal effect of the energy price crisis on gas and electricity consumption. This price shock was caused by the volatility in energy markets around the time

[2] The 'Big 6' includes the legacy suppliers Centrica (aka British Gas), EON, Scottish Power (now owned by OVO), EDF and SSE, and the newer entrant Octopus Energy.

[3] As mentioned in the introduction, the marginal source for electricity generation is typically gas (see e.g. Beltrami et al., 2020).

of the Russian invasion of Ukraine, which sent wholesale gas prices spiralling across Europe. Like the previous fuel price shock, the gas price increase fed into Ofgem's calculations of the subsequent price cap in April 2022. Unlike the previous shock the increase in prices did not lead to further exits of energy suppliers, instead it exposed consumers who were on variable tariffs to a substantial increase in energy prices, while those on a fixed deal were protected.

We take advantage of the quasi-randomisation of households' allocation across suppliers and tariffs, since the shock not only forced many households onto a different energy supplier and SVT, but also massively reduced the options available to those who wanted to change energy supplier from October 2021. Importantly for our empirical strategy, households were unable to apply for a fixed tariff between October 2021 and June 2023[4]. The rapid rise in the price of fixed tariffs, far above the SVTs protected under the cap[5], limited the offer of switching options, especially price-based ones. Indeed, switching rates dropped by around 80% from the hundreds of thousands in 2021 to tens of thousands in 2022 and neither fixed rates nor switching rates have returned to pre-crisis levels (Figure A1, Appendix A; Ofgem, 2024a). This quasi-random process allows us to define our control group (FF) – i.e., any consumer who remained on a fixed tariff throughout 2021/23 – and the treatment (FV) group – i.e., those who were moved to an SVT and were therefore exposed to future energy price shocks for the reasons discussed above. Crucially, the concomitant change in the level of fixed tariffs and lack of switching opportunities prevented consumers from selecting into the (FF) treated group.

[4] Whilst it is plausible some consumers actively switched by directly contacting energy suppliers about non-price factors, such as quality of service (Deller et al., 2021), the new contract will be an SVT regardless.
[5] See Figure A2 in Appendix A.

We employ a difference-in-difference framework with the aim of estimating the causal effect of the energy price crisis on domestic electricity and gas consumption. The general econometric specification can be defined as follows:

$$C_{itj} = \beta_0 + \beta_1 FV_{ij} + \beta_2 PC_{it} + \beta_3 FV_{ij} \cdot PC_{it} + \omega_t + \mu_r + \alpha_i + \varepsilon_{itj} \quad (1)$$

where C_{itj} is energy consumption for household i on day t. We estimate separate equations for gas and electricity, reflected in the j index. We are primarily interested in β_3, the average treatment effect (ATE) on the interaction between the indicators FV_{ij} and PC_{it}. The FV_{ij} indicator is set equal to 1 if the household is on an SVT during the energy price crisis but was previously on a fixed tariff and 0 otherwise. The treatment indicator PC_{it} is set equal to 1 for days following April 1st 2022, and 0 for previous days. The average treatment effect captures the additional impact of the energy price crisis on those exposed to price shocks during this period (i.e., FV) compared to those protected by their fixed rates (i.e., FF). In equation (1) ω_t is the vector of time effects capturing the seasonality in C_{it}, while μ_r represents the vector of regional effects, α_i denotes the time-invariant unobserved household fixed effects. Finally, ε_{itj} denotes the idiosyncratic error term, clustered at the household level.[6]

Equation 1 is estimated using pooled OLS and fixed effects models. Alongside a battery of robustness checks, we include a vector X_{it} which contains a standard set of socio-demographic

[6] The main analysis holds using robust SEs and clustering at the local authority level.

and housing characteristics in the pooled OLS (robustness) specifications, as described in Section 3 (see Table A1, Appendix A).

In order to interpret the findings as a causal effect our groups (FV and FF) should satisfy the parallel trends assumption. This implies that the groups would have followed an identical trend in consumption had the energy price crisis not occurred. While this counterfactual is unobserved, we explore, as is typical in difference-in-difference frameworks, the trends prior to treatment to make inferences about what would have happened in the absence of the treatment. Indeed, as we show, the two groups exhibit patterns of electricity and gas consumption that clearly follow similar trends over an extended period (January 2021-April 2022). Therefore, we assume that, all else constant, there is no reason other than the energy price crisis for the groups to deviate from their common trend. Whilst there are shallow fluctuations around these trends, we will show later that any deviation prior to April 2022 is not significantly different from zero by estimating ATEs for each month relative to the baseline treatment window. Some details of our econometric strategy will be presented later, after the description of the data.

Another potential threat to our identification strategy lies in whether households anticipated the energy price crisis that emerged post April 2022. Some evidence has been provided by Braakman et al. (2024) who suggest that, based on Google Trends data from January 2021 to July 2022, GB households' awareness of, and interest in, energy bills increased over time *in response to* price increases, rather than anticipating energy price increases.[7] Extending Braakman et al.'s period of analysis it is possible to show that consumers' interest was relatively low until a surge in interest later in 2022, around the time of the October price cap

[7] The authors used the search terms "energy saving", "energy price cap" and "energy bill".

adjustment (see Figure A3 in the Appendix A). This evidence could be seen as consistent with the "normal" level of switching observed before the end of 2021 (Figure A1, Appendix A), not least because had savvy households anticipated the first energy price shock there would have been a more pronounced spike in switching when such possibility was still available. Altogether there appears to be little evidence to conclude that consumers' anticipation of price increases prevents a causal interpretation of our findings.

3. Data

Our data has been obtained from SERL, a panel observatory managing smart meter data, which is maintained by the UK data Service (UKDS). The most recent (6th) edition of the data contains a large representative panel of daily gas and electricity consumption and price information for approximately 13,000 GB households (Webborn et al., 2021; Few et al., 2024).[8] SERL's consumption data dates from 2018, while the tariff information (specifically prices), collected from 2020, has only become available to researchers since late 2022. We utilise information from several other datasets that are linked to the smart meter data in the core panel, including temporal data (such as weather conditions) and static data that provides additional contextual information about the household and housing characteristics. The availability of this data set offers a novel opportunity to explore the impact of the energy price crisis on daily household energy consumption between January 2021 and December 2023. While this time period includes the time after the second national Covid19 lockdown (January-July 2021) the advantage of using a difference-in difference approach is that the effects of the lockdown on

[8] SERL is a proprietary data source and access is restricted but made available to approved researchers in a secure environment under strict conditions through the UK Data Service's secure access program, collected through the Data Communications Company (DCC) gateway. The random sample of GB households with smart meters and is stratified by Index of Multiple Deprivation (IMD) and region see, e.g., Webborn et al., 2021.

consumption will be accounted for in our analysis, as any such effect would have affected both treatment and control group in a similar way.

The raw panel is unbalanced; therefore, given our empirical strategy outlined below, our final sample focuses only on those households with consumption values observed for at least 2.5 years, ensuring that the households are observed pre- and post-crisis – we later relax this condition to one year with the results remaining qualitatively the same. Upon adjusting the dataset in line with our empirical strategy and including only valid reads[9], the sample used in the main analysis of electricity consumption contains around 3.2 million observations (covering around 3,000 households) and about 1.5 million observations for gas consumption (covering almost 1,400 households).

Energy consumption and tariffs

Tables 1 and 2 provide the summary statistics for electricity and gas consumption and prices. Between 2021 and 2023 households typically consumed around 8.8 kWh of electricity[10] and 32.8 kWh of gas per day (equivalent to around 12,000 kWh/year of gas and 3,200 kWh/year of electricity). [11] Average daily electricity consumption has decreased year-on-year with consumption falling from 9.6 kWh in 2021 to 8.3 kWh in 2023. Similarly daily gas consumption has declined from 38.3 kWh in 2021 to 29.1 kWh in 2023.

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[9] It is important to mention here that SERL researchers flag consumption data that may be considered invalid. This includes meter reads that have been recorded as the maximum (or very high), electricity consumption recorded in the incorrect unit, values exhibiting invalid read times but valid reads, as well as suspicious zeros; in addition, we rely on valid half hourly reads that have been aggregated in order to impute missing daily reads. Zapata-Webborn et al. (2024a) provide further details on data collection and error flags.
[10] For homes equipped with photovoltaic (PV) panels, the electricity consumption is reported as net demand from the grid, reflecting the difference between electricity imports from and exports back to the grid.
[11] These values fall between the typical domestic gas and electricity consumption values used by DESNZ (13,600kWh and 3,600kWh, respectively) and Ofgem (12,000 kWh and 2,900 kWh, respectively) (Ofgem, 2020; DESNZ b, 2024).

Unless otherwise stated we interpret our findings as elasticities, and to achieve this we use the inverse hyperbolic sine (IHS) of gas and electricity consumption. This transformation has the benefit of approximating a natural logarithm transformation and the added advantage of maintaining zeros. [12]

Table 1. Summary statistics for electricity

Variable	Mean	Std. Dev
Electricity consumption (kWh/day)	8.821	7.515
Inverse hyperbolic sine of electricity consumption	2.607	0.748
Electricity price (£/kWh)	0.233	0.116
Proportion fixed pre-April 2022 and variable post-April 2022 (FV_E)	0.965	

Notes: Number of observations underlying electricity consumption = 3,234,080. Number of individuals underlying electricity consumption (observed for at least 2.5 years) = 2,980.

Table 2. Summary statistics for gas

Variable	Mean	Std. Dev
Gas consumption (kWh)	32.819	35.410
Inverse hyperbolic sine of gas consumption	3.376	1.529
Gas price (£/kWh)	0.065	0.034
Proportion fixed pre-April 2022 and variable post-April 2022 (FV_G)	0.942	

Notes: Number of observations underlying gas consumption = 1,486,428. Number of individuals underlying gas consumption (observed for at least 2.5 years) = 1,379.

Over the same period, Tables 1 and 2 also show that the average price of gas and electricity is 6.5p/kWh and 23.3p/kWh, respectively. [13] We use gas and electricity prices to identify

[12] Around 2.3% and 5.8% of electricity and gas observations are zeros. Let y and x denote the dependent and independent variable, respectively. The inverse hyperbolic sine (IHS) transformation is defined as: $arcsinh(x) = \ln(x + \sqrt{(x^2 + 1)})$. For large values of the dependent variable (i.e., $\bar{y}$ roughly greater than 10), Bellemare and Wichman (2020) show that the sample coefficient in the IHS transformed equation with an indicator as the independent variable can be interpreted as a semi-elasticity, i.e.$\hat{\xi}_{yx} \approx \hat{\beta}$. In this case, the 'exact' correction can be used with little error, and it is straightforward to check that our ATEs change little using the $\exp(\hat{\beta})$-1 correction.

[13] The average price in our sample falls within one standard deviation of the overall average variable unit price of electricity (25.7p/kWh) and of gas (6.6p/kWh) reported by DESNZ (2024c). This is reassuring given the fact that the tariff information is raw (i.e., there are no error flags or pre-cleaning done by SERL) and collected less frequently than the consumption data. The latter is due to consumers fixed contracts typically lasting 1-2 years and the price cap either being updated bi-annually (2021-2022) or quarterly (2023). McKenna (2024) provides further technical details on the tariff information available in SERL.

households who were exposed to the energy price crisis by using the variation in the series (or lack thereof) as a signal for those on SVTs (or fixed tariffs). The cut-off point we use as the start of the energy price crisis is Ofgem's price cap adjustment on 1st April 2022. The first time when costs fed through to consumers in response to the rise in wholesale prices leading up to and following the initial outbreak the Russian invasion of Ukraine on February 24th, 2022.

One concern might be that the consumers who were on SVTs prior to the start of the energy price crisis may have different characteristics from those on fixed tariffs. To address this issue, we build suitably comparable control and treatment groups, as discussed in relation to the balance of characteristics, by identifying households who were on fixed tariffs *prior to* the energy price crisis. That is, we categorise our control group as those on fixed tariffs prior to, and during, the energy price crisis (the 'FF' group), and the treatment group as households who were forced to move from a fixed tariff *pre-crisis* to a variable one *during the crisis* (that is, the 'FV' group).[14]

With respect to our final sample, Tables 1 and 2 show that for our main analysis around 4-6% of households stayed on a fixed tariff for the duration of our sample (FF), while the remaining 94-96% is comprised of those moving from fixed to variable rates (FV). Whilst the available data in SERL does not contain information about the tariff, beyond prices, official reports stress that using the "*attributes of tariff names provided by energy companies"* only serves as a rough guide as to whether a tariff is fixed or varying (DESNZ, 2024b, p. 10). DESNZ report's estimates show at the end of 2021 (Q4) approximately 30% of all standard electricity and 40% of all standard gas consumers were on fixed tariffs; indeed, by September 2023 only 10% of

[14] We therefore exclude households that exhibited variable rates throughout 2021-2023 (i.e., VV), and households moving from a variable rates pre-crisis to a fixed rate during the crisis (i.e., VF).

all consumers were on fixed tariffs (DESNZ, 2024b). Although not directly comparable, this coincides with the small proportion of households remaining on a fixed contract in our final sample.[15]

Survey and additional data

For the households in our control and treatment group to be considered alike, it is useful to check the balance of sample statistics for key socio-demographic and housing characteristics, i.e., that the difference in the sample means is not statistically different from zero.

Table 3 presents the means, as well as difference in means, of a standard set of socio-economic (age, gender, labour market status, household size), housing (number of bedrooms, property age and type, tenure), and regional characteristics (location, deprivation, temperature) identified in the literature as determinants of household energy consumption (Huang, 2015; Piao and Managi, 2023), for the groups FF and FV.

Most variables in Table 3 are extracted from the *SERL Main Recruitment Survey* and merged using the households' pseudo anonymised participant identifier, including the Index of Multiple Deprivation (IMD) quintiles (1 is most deprived, 5 is least deprived). The only exception is 'mean 2m surface temperature' (labelled as mean temperature in the table) which is linked via grid cells using the climate data available in the SERL observatory.[16]

[15] The proportion of the original sample identified as varying throughout (VV) is 64% for electricity and 77% for gas. We find a small proportion of households (3.5% and 4.8%) who switched onto a fixed tariff pre-April 2022 and remained on one throughout the energy price crisis (VF). The total proportion of households on a fixed tariff from January 2021 to April 2022 (33%, electricity; 18%, gas) therefore is similar, yet smaller, than government estimates – as we are accounting for those with fixed contracts that cover the whole sample period only.

[16] The data originates from Copernicus/ECMWF ERA5 hourly reanalysis data. Further details on the climate data can be found in Zapata-Webborn et al. (2024b).

While the SERL observatory provides high frequency consumption and price data, information on household, housing, and regional characteristics is collected at infrequent intervals. The main survey was circulated at the start of each of the three waves of recruitment and completed by an adult resident household member. Though responding to the main survey was not a requirement for participation, the responses cover 83% of the electricity sample and 88% of the gas sample used in our main analysis. Despite the static nature of the survey data it allows for the comparison in the means between groups.[17] Table 3 shows that the differences in means between FF and FV are not statistically significant at conventional levels for our set of covariates, excluding mean surface temperatures at the 10% level (electricity) and 5% level (gas). Therefore, we control for temperature in all specifications unless stated otherwise.

A single follow up questionnaire to the main survey is available but only has a 45% response rate (Hanmer and Huebner, 2024). This allows us to expand the set of controls in our robustness analysis to include additional socio-economic variables (income bands, payment methods for gas and electricity), and the presence of low-carbon and energy-efficient technologies (i.e., electric vehicles, solar panels, insulation, double-glazed windows, draught-proofing). In addition, the energy efficiency level of the property is captured by the rating ascribed to the Energy Performance Certificates (EPC)[18] available for those properties that have one.[19] About 50-60% of housing stock in Great Britain have EPC rating, either because the property owner or occupier requested it or because it was legally required to have one in order to let or sell the

[17] The definitions and sample summary statistics of these variables are presented in Table A1 in Appendix A.
[18] EPC ratings provide information the efficiency of the property and potential measures that could enhance its performance and range from G-rated (least efficient in terms of fuel costs and carbon dioxide emissions) to A-rated (most efficient),
[19] The collection of EPC data is detailed in Zapata-Webborn and Few (2024).

property (Ministry of Housing, Communities and Local Government, 2024).[20] To avoid dropping over half of the sample, these additional variables are included alongside an indicator variable equal to 1 if the individual participated in this follow up survey and to 0 otherwise, as well as another indicator equal to 1 if the household has an EPC certificate and to 0 if not.[21]

Table 3. Mean values and the difference in means for our socio-demographic, housing and regional variables means by FF and FV groups.

	Electricity			**Gas**		
Variable	FV Mean (1)	FF Mean (2)	Difference (3) = (1)-(2)	FV Mean (1)	FF Mean (2)	Difference: (3) = (1)-(2)
Female	0.446	0.436	0.011	0.433	0.426	0.007
Age >65	0.439	0.448	-0.009	0.435	0.417	0.018
Employed FT	0.357	0.329	0.028	0.368	0.334	0.034
Employed PT	0.090	0.116	-0.026	0.108	0.114	-0.006
LTSD	0.040	0.021	0.019	0.028	0.035	-0.007
Unemployed	0.021	0.032	-0.011	0.018	0.035	-0.017
Retired	0.469	0.459	0.010	0.463	0.413	0.050
Other status	0.013	0.011	0.002	0.010	0.023	-0.013
Owner-mortgager	0.791	0.808	-0.017	0.872	0.863	0.008
Rent	0.209	0.192	0.017	0.128	0.137	-0.008
Household size	2.236	2.127	0.109	2.351	2.400	-0.049
Bedrooms	2.892	2.864	0.029	3.091	3.159	-0.068
Detached	0.594	0.543	0.052	0.653	0.655	-0.002
Terraced	0.226	0.234	-0.008	0.270	0.289	-0.019
Flat	0.180	0.224	-0.044	0.077	0.057	0.021
Property > 2003	0.090	0.148	-0.058	0.065	0.081	-0.016
Gas central heat	0.836	0.872	-0.037	0.973	0.931	0.042
Electric central heat	0.072	0.053	0.019	0.005	0.012	-0.007
Other central heat	0.092	0.075	0.017	0.022	0.058	-0.036
London	0.153	0.138	0.015	0.123	0.126	-0.003
IMD quintile 4-5	0.385	0.466	-0.080	0.405	0.358	0.048
Mean temperature	284.163	284.001	0.162*	284.187	283.994	0.193**
N	2,799,042	102,001		1,292,438	93,968	

*Note: * p<0.10 ** p<0.05 ***p<0.01. Number of observations observed for at least 2.5 years. Tests use bivariate regressions clustered standard errors at the individual level.*

[20] There are other well-known issues related to EPCs, including the fact that EPCs for any property that has not required a new certificate will unlikely be representative of the current condition of the property (see, e.g., Fetzer et al., 2022).

[21] The definitions and sample summary of this set of variables are also presented in Table A1 in Appendix A.

4. Results

Tables 4 and 5 report the main econometric results of the estimation based on equation (1). We are primarily interested in the ATE which corresponds to the coefficient, β_3, capturing the interaction between treatment group (*FV*) and price cap *(PC)* indicators. The dependent variables in Tables 4 and 5 are the daily household electricity and gas consumption, respectively which have been subject to the Inverse Hyperbolic Sine transformation. This implies that the (ATE) coefficient can be interpreted as the percentage point change in household electricity or gas consumption as a result of the changes in energy prices. We estimated the models using the pooled OLS and fixed effects regression, controlling for time-invariant unobserved heterogeneity. Across the columns in our tables, we sequentially add control variables, including regional effects, time effects, linear and polynomial trends, as well as temperature. Time effects include monthly indicators and the interaction between day-of-month and day-of week-indicators. Overall, our results show that the energy price crisis negatively impacted electricity and gas consumption for households who moved to a variable tariff post April 2022, compared to those on a fixed tariff throughout the sample period.

Specifically, we observe that the ATE in Table 4 is negative and statistically significant at 1% in all specifications. The results suggest that, on average, the energy price crisis led to a reduction in electricity consumption for households on variable tariffs by around 10 percentage points relative to those on fixed unit rates. The effects are very similar in both the pooled OLS and fixed effects specifications, after controlling for time-invariant and several time-varying individual effects. Overall, the results reflect the negative impact of the energy price crisis on electricity consumption, over and above reduction driven by other factors, such as economic or temperature shocks.

Looking at the pooled OLS specifications in Table 5 (columns 1-5), the additional effect of the energy price crisis for households on variable tariffs is a reduction in their gas consumption by around 13-14 percentage points, compared to those on fixed rates. The results are consistent with the fixed effects estimates in columns 6 and 7. The ATE is statistically significant at the 5% level in all specifications.

Despite being protected from price increases during this period, the average reduction in electricity consumption during the energy price crisis for the control group (FF) is estimated to be around 0-5 percentage points, using fixed effects regression (Table 4, columns 6 and 7). The average reduction in gas consumption during the energy price crisis for the same group is estimated to be around 20-34 percentage points using fixed effects regression (Table 5, columns 6 and 7).

Comparing the impact of the price increases on gas and electricity consumption, households on variable tariffs post-April 2022 responded by reducing their gas consumption considerably more than they did for electricity consumption during the energy prices shocks. This larger average treatment effect implies that consumers were more price responsive to gas price changes than electricity. This result aligns with a recent study that shows that households reacted to the energy price shock by reducing gas consumption more than electricity consumption (Zapata-Webborn et al., 2024).

It is important to note here that the coefficient estimated on the FV indicator is not statistically significant in Tables 4 and 5. This provides evidence that the energy consumption for the two groups was statistically similar prior to April 2022 leading us to expect that it would have remained similar had the energy price crisis not occurred.

To explore the assumption of parallel trends further, Figure 1 plots the seasonal patterns in the monthly mean of (IHS) daily electricity consumption for the FF and FV groups. Leading up to the Russian invasion of Ukraine and the increase in the subsequent energy price cap, the FV group enjoyed slightly higher levels of electricity consumption on average during 2021.This is in line with Figure 2, showing that electricity prices for the FV group are slightly lower pre-crisis.

Electricity consumption for the FV group however has since fallen below the FF group except during the winter when the EPG was in operation (1st October 2022-30th June 2023). Hence, despite facing higher prices during the winter of 2022/23 (see Figure 2), the FV group were able to consume electricity in line with the FF group. Similar levels of consumption between the two groups, during the 2022/23 winter, could be due to the significant price protection consumers received from the UK government's EPG[22] and potentially also through the accumulation of energy-related debt and arrears which had escalated to record levels (£3.1 billion) by the end of 2023 (Ofgem, 2024b).

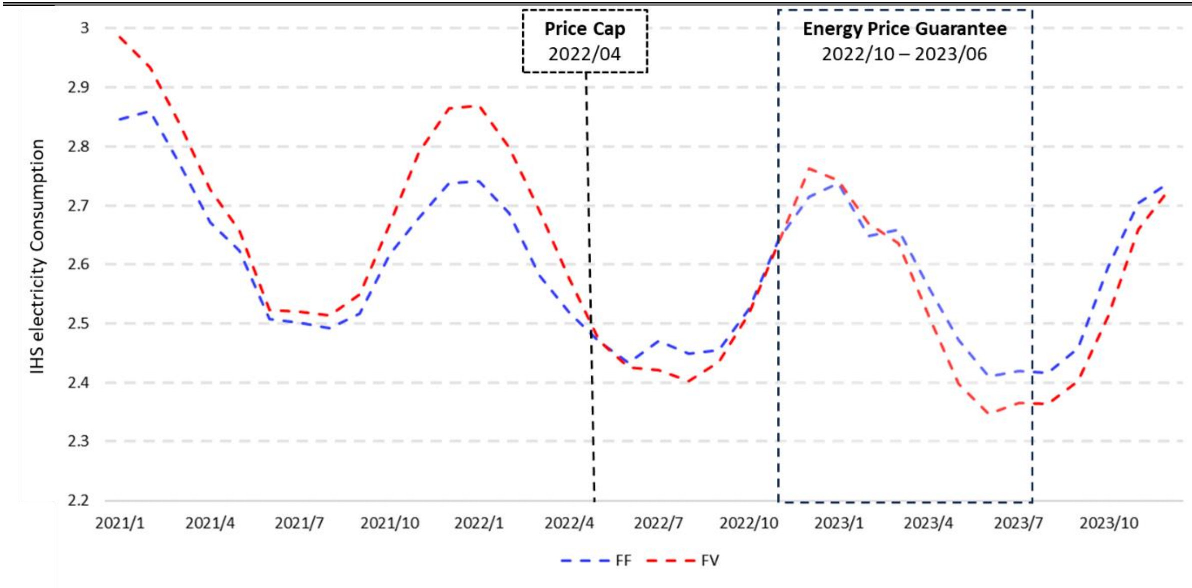
Comparing Figure 1 with Figure 3 we can see that consumers on variable rates post April 2022 (FV) show similar levels of gas consumption to the FF group before April 2022. While gas consumption for the FV group fell below the consumption of those on fixed rates (FF) after April 2022, the reduction in gas consumption for FV (compared to FF) becomes most apparent once the EPG ends at the end of June 2023. These levels of consumption are consistent with the higher prices faced by households who were not protected by a fixed tariff; however, also in this case the drop in consumption may be lower than expected because of the price

[22] Around £27 billion according to Bolton and Stewart (2024).

protections and the ability to accrue debt and arrears to heat the home during the winter of 2022/23.

The differences in the monthly means for daily electricity and gas consumption (IHS transformed) and for daily prices are presented in Appendix A (Figures A4-A7). Figures 1 and 3 show that FF and FV groups not only display parallel trends in consumption, as required for our empirical strategy, but also in prices, as one would expect given that their tariffs were fixed prior to the treatment and that they share similar socio-demographic and other characteristics.

Figure 1. Monthly mean of (inverse hyperbolic sine) daily electricity consumption by FF and FV groups

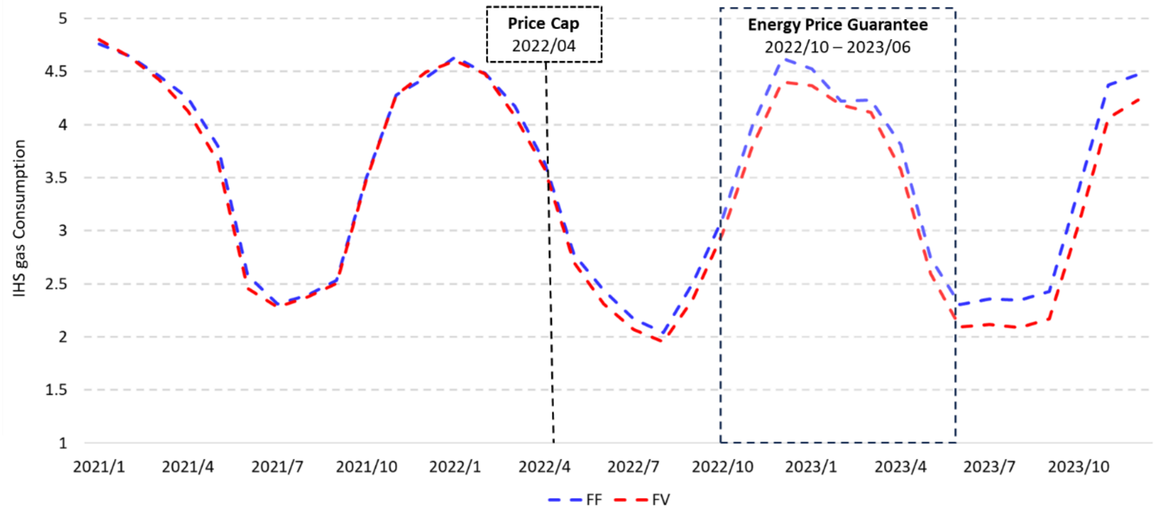


Notes: Monthly mean of (inverse hyperbolic sine) daily electricity consumption (kWh) between 01/01/2021 and 31/12/2023 by control group (households with fixed electricity prices, ***FF****) and treated group (households with variable electricity prices post-April 2022,* ***FV****). N = 3,234,080 (N_{FF}=111,279; N_{FV} =3,122,801).*

Figure 2. Monthly mean of daily electricity unit prices (£/kWh) by FF and FV groups

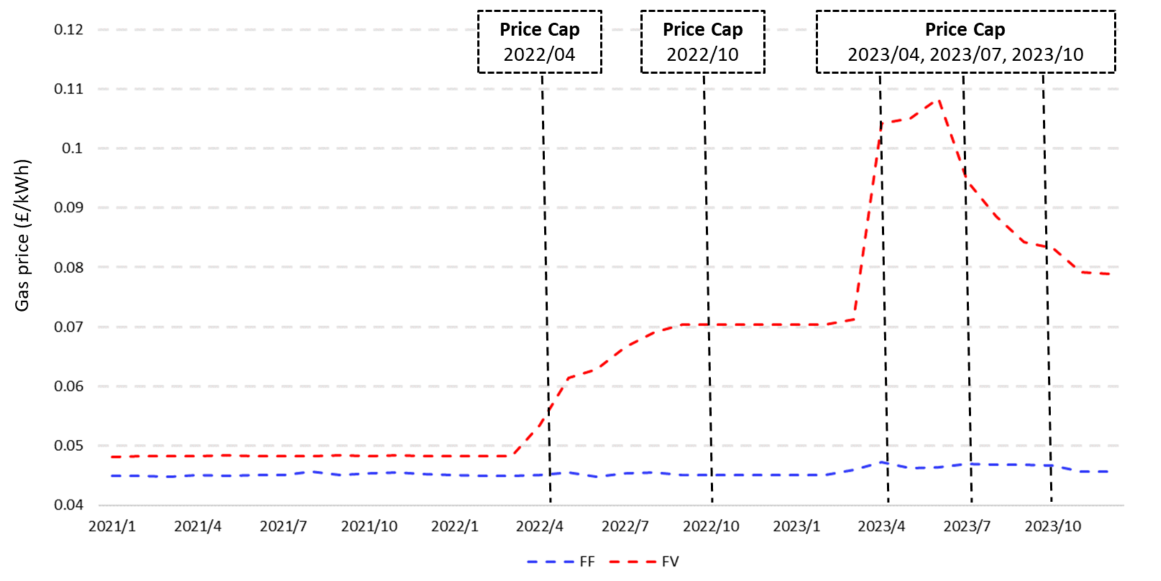
Notes: Monthly mean of daily electricity unit prices (£/kWh) between 01/01/2021 and 31/12/2023 by control group (households with fixed electricity prices, ***FF****) and treated group (households with variable electricity prices post-April 2022,* ***FV****). N = 3,234,080 (N_{FF}=111,279; N_{FV}=3,122,801).*

Figure 3. Monthly mean of (inverse hyperbolic sine) daily gas consumption by FF and FV groups



*Notes: Monthly mean of (inverse hyperbolic sine) daily gas consumption (kWh) between 01/01/2021 and 31/12/2023 by control group (households with fixed gas prices, **FF**) and treated group (households with variable gas prices post-April 2022, **FV**). N = 1,486,428 (N_{FF}=85,668; N_{FV}=1,400,760).*

Figure 4. Monthly mean of daily gas unit prices (£/kWh) by FF and FV groups



*Notes: Monthly mean of daily gas unit prices (£/kWh) between 01/01/2021 and 31/12/2023 by control group (households with fixed gas prices, **FF**) and treated group (households with variable gas prices post-April 2022, **FV**). N = 1,473,941 (N_{FF}=82,113; N_{FV}=1,391,828).*

Alternative specifications and robustness checks

We conduct multiple specification checks to test the robustness of our results. Tables 6 and 7 report the respective electricity and gas ATEs (the coefficients of interaction term) for the pooled (OLS and Poisson) and fixed effects regressions. The ATEs remain largely unchanged and are statistically robust across a broad range of estimation specifications.

To address the concern that the reduction in energy consumption might have been influenced by multiple cost-of-living pressures and weather conditions, and not only by the rise in energy bills, we controlled for confounding factors that may drive the results. We include socio-demographic and housing variables across all *pooled* specifications given the cross-sectional nature of the data. Whether controlling for socio-demographic and housing characteristics alongside geographical office regional indicators (column 1) or more granular lower super output area (LSOA) indicators (column 2), the ATEs for electricity and for gas remain close to our main estimates discussed above (9 and 16 percentage points respectively) and exhibit the same level of statistical significance.

Turning to the fixed effects specifications in Tables 6 and 7, we augment our baseline regression with region-specific polynomial trends (column 3) and temperature polynomials (column 4).[23] Also in this case our results remain consistent with the main results in Table 4 and 5, respectively.

The main analysis relies on consumption data for households observed for at least 2.5 years. This requirement is relaxed in column 5, which presents the estimates for all households observed for at least one year. This specification check shows that the results are consistent

[23]The results also hold when controlling for different types of weather variables, including rainfall. For brevity these results are available upon request.

despite the restriction placed on the main sample. Indeed, whilst the point estimates are slightly attenuated, it is important to note that the 95% confidence intervals overlap with the relevant estimates presented in Table 4 (column 6) and Table 5 (column 6).

We also used the log adjusted transformation $ln\ (C_{itj}+1)$ in column (6), instead of the Inverse Hyperbolic Sine. These results are contrasted with specifications that a) use the IHS transformation while dropping observations equal to zero for electricity consumption only (column 7),[24] and b) use Poisson regression while retaining zeros for electricity and gas (Table 6 column 7; Table 7 column 8). The point estimates of these specifications are similar to those obtained with the original specification and statistically significant at the same levels.

[24] This coincides with electricity consumption data with zero values identified and flagged by SERL as suspicious in their technical reports.

Table 4. Impact of April 2022 price cap on the inverse hyperbolic sine of electricity consumption by control (FF) vs treatment group (FV)

	Pooled OLS					Fixed Effects	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
FV	0.074	0.071	0.071	0.071	0.071	-	-
	(0.055)	(0.055)	(0.055)	(0.055)	(0.055)	-	-
PRICECAP	-0.106***	-0.101***	-0.155***	-0.008	-0.051**	-0.010	-0.051**
	(0.020)	(0.021)	(0.022)	(0.022)	(0.020)	(0.021)	(0.020)
FV x PRICECAP	-0.099***	-0.099***	-0.099***	-0.098***	-0.099***	-0.098***	-0.099***
	(0.021)	(0.021)	(0.021)	(0.021)	(0.021)	(0.020)	(0.020)
Regional effects	NO	YES	YES	YES	YES	-	-
Time effects	NO	NO	NO	NO	YES	NO	YES
Linear trend	NO	YES	NO	NO	NO	NO	NO
Polynomial trend	NO	NO	YES	YES	NO	YES	NO
Temperature	NO	NO	NO	YES	YES	YES	YES
N (observations)	3,234,080	3,234,080	3,234,080	3,234,080	3,234,080	3,234,080	3,234,080
N (control)	111,279	111,279	111,279	111,279	111,279	111,279	111,279
N (treated)	3,122,801	3,122,801	3,122,801	3,122,801	3,122,801	3,122,801	3,122,801
N (individuals)	2,980	2,980	2,980	2,980	2,980	2,980	2,980

*Notes: * p<0.10 ** p<0.05 ***p<0.01, individual-level cluster robust standard errors in the parentheses. Time effects include monthly indicators and the interaction between day of month and day of week indicators. Includes individuals observed for at least 2.5 years.*

Table 5. Impact of April 2022 price cap on the inverse hyperbolic sine of gas consumption by control (FF) vs treatment group (FV)

	Pooled OLS					Fixed Effects	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
FV	-0.048	-0.041	-0.037	-0.038	-0.035		
	(0.080)	(0.080)	(0.080)	(0.080)	(0.080)		
PRICECAP	-0.559***	-0.847***	-1.355***	-0.346***	-0.201***	-0.337***	-0.197***
	(0.064)	(0.064)	(0.066)	(0.065)	(0.063)	(0.064)	(0.063)
FV x PRICECAP	-0.132**	-0.131**	-0.134**	-0.136**	-0.136**	-0.141**	-0.140**
	(0.065)	(0.065)	(0.065)	(0.064)	(0.064)	(0.065)	(0.065)
Regional effects	NO	YES	YES	YES	YES	-	-
Time effects	NO	NO	NO	NO	YES	NO	YES
Linear trend	NO	YES	NO	NO	NO	NO	NO
Polynomial trend	NO	NO	YES	YES	NO	YES	NO
Temperature	NO	NO	NO	YES	YES	YES	YES
N (observations)	1,486,428	1,486,428	1,486,428	1,486,428	1,486,428	1,486,428	1,486,428
N (control)	85,668	85,668	85,668	85,668	85,668	85,668	85,668
N (treated)	1,400,760	1,400,760	1,400,760	1,400,760	1,400,760	1,400,760	1,400,760
N (individuals)	1,383	1,383	1,383	1,383	1,383	1,383	1,383

*Notes: * p<0.10 ** p<0.05 ***p<0.01, individual-level cluster robust standard errors in the parentheses. Time effects include monthly indicators and the interaction between day of month and day of week indicators. Includes individuals observed for at least 2.5 years.*

Table 6. Robustness of April 2022 price cap on the inverse hyperbolic sine of electricity consumption by control (FF) vs treatment group (FV)

	Pooled OLS		**Fixed Effects**					**Pooled Poisson**
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
FV x PRICECAP	-0.091***	-0.092***	-0.097***	-0.099***	-0.053***	-0.084***	-0.081***	-0.091***
	(0.022)	(0.022)	(0.021)	(0.020)	(0.016)	(0.018)	(0.026)	(0.022)
Regional effects	YES	NO	-	-	-	-		YES
LSOA effects	NO	YES	-	-	-	-		NO
Household and housing controls	YES	YES	-	-	-	-		NO
Time effects	YES	YES	NO	YES	YES	YES	YES	YES
Regional specific polynomial trends	NO	NO	YES	NO	NO	NO	NO	NO
Temperature polynomial	NO	NO	NO	YES	NO	NO	NO	NO
Individuals observed > 1 year	NO	NO	NO	NO	YES	NO	NO	NO
Ln(electricity consumption+1)	NO	NO	NO	NO	NO	YES	NO	NO
Exclude suspicious zeros	NO	NO	NO	NO	NO	NO	YES	NO
N (observations)	2,882,452	2,882,452	3,234,080	3,234,080	4,018,986	3,234,080	3,234,080	3,234,080
N (control)	102,001	102,001	111,279	111,279	235,812	111,279	111,279	111,279
N (treated)	2,780,451	2,780,451	3,122,801	3,122,801	3,783,174	3,122,801	3,122,801	3,122,801
N (individuals)	2,656	2,656	2,980	2,980	4,031	2,980	2,980	2,980

*Notes: * p<0.10 ** p<0.05 ***p<0.01, individual-level cluster robust standard errors in the parentheses. Time effects include monthly indicators and the interaction between day of month and day of week indicators. Includes individuals observed for at least 2.5 years.*

Table 7. Robustness of April 2022 price cap on the inverse hyperbolic sine of gas consumption by control (FF) vs treatment group (FV)

	Pooled OLS		**Fixed Effects**				**Pooled Poisson**
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
FV x PRICECAP	-0.141**	-0.150**	-0.145**	-0.140**	-0.107**	-0.117**	-0.062**
	(0.072)	(0.073)	(0.065)	(0.065)	(0.050)	(0.055)	(0.030)
Regional effects	YES	NO	-	-	-	-	YES
LSOA effects	NO	YES	-	-	-	-	NO
Household and housing controls	YES	YES	-	-	-	-	NO
Time effects	YES	YES	NO	YES	YES	YES	YES
Regional specific polynomial trends	NO	NO	YES	NO	NO	NO	NO
Temperature polynomial	NO	NO	NO	YES	NO	NO	NO
Individuals observed > 1 year	NO	NO	NO	NO	YES	NO	NO
Ln(electricity gas+1)	NO	NO	NO	NO	NO	YES	NO
N (observations)	1,352,477	1,352,477	1,486,428	1,486,428	1,634,978	1,486,428	1,486,428
N (control)	74,104	74,104	85,668	85,668	136,431	85,668	85,668
N (treated)	1,278,373	1,278,373	1,400,760	1,400,760	1,498,547	1,400,760	1,400,760
N (individuals)	1,258	1,258	1,383	1,383	1,608	1,383	1,383

*Notes: * p<0.10 ** p<0.05 ***p<0.01, individual-level cluster robust standard errors in the parentheses. Time effects include monthly indicators and the interaction between day of month and day of week indicators. Includes individuals observed for at least 2.5 years.*

Heterogeneous effects

In this sub-section we explore the existence of heterogeneous effects in our main results. Given the similarity of the ATEs across econometric specifications and constraints in terms of the number of households that make up the control group, we make this analysis more tractable and efficient by using pooled OLS – controlling for region, time, and temperature effects – and ensuring that the sample is made up of households with at least one year of consumption data.

The heterogeneous analysis is split into two dimensions. The first dimension investigates whether the ATEs apply to households who *state* that they engage in energy saving practices. Equation 1 is estimated separately using three indicators: 1) a dichotomous variable that equals 1 if the household representative states that they put on extra clothing rather than turning the heating on or up 'quite often', 'very often' or 'always' (and 0 otherwise, i.e., 'not often' or 'never'); 2) a dichotomous variable that equals 1 if the household representative states that they 'quite often', 'very often' or 'always' turn off the lights in rooms that are not being used (and 0 otherwise, i.e., 'not often' or 'never'); and 3) a dichotomous variable equal to 1 if the household representative states that *their household* puts 'some' or a 'great deal' of effort into limiting or reducing energy consumption (and 0 otherwise, i.e., 'little', 'none' or 'don't know'). It is interesting to note that the households who reported that they often turn the lights off, possibly an indication of a keener than average attention to their energy use, have achieved reductions in both electricity and gas consumption.

Second, we explore the distributional effects of energy price crisis by breaking down our sample by the Index of Multiple Deprivation (IMD). Equation 1 is therefore estimated separately for the first two quintiles (highest levels of deprivation), the third quintile (medium levels) and finally the fourth and fifth quintiles (lowest levels).

At the 5% level of statistical significance, our heterogeneous analysis *reveals* that the ATEs are indeed associated with the households who *state* that they engage in energy saving behaviour. This is true for both electricity (Table 8, columns 2 and 4) and gas consumption (Table 9, columns 2 and 4). Interestingly, the ATEs reflect the behaviour of gas consumers who dedicate at least "some" or a "great deal" of effort into limiting or reducing energy consumption. This result is not only interesting from the perspective of the potential consistency between revealed and stated preferences, but also from a welfare perspective as the energy price crisis (as identified by the ATEs) has promoted reductions in energy consumption as well as greater levels of costly effort (e.g., cognition, time, stress and so on).

The results presented in Tables 10 and 11 show an inverted U-shape in the ATEs across the IMD quintiles. More specifically, the results imply that electricity consumption fell in response to the energy price crisis in the lowest (column 1) and highest (column 3) quintiles, suggesting that households in the middle of the distribution were relatively less responsive to price changes. Indeed, the lowest quintiles may have responded by purely cutting back on consumption using low-cost measures, while the highest quintiles may have installed electricity saving technologies (e.g., solar panels) to counteract the intense and extended period of high energy prices.

Table 11 shows that the gas ATEs reflect changes in consumption by the lowest quintiles of multiple deprivation. While the inverted U-shape still exists, the ATE is only statistically significant at the 10% level for the upper IMD quintiles (column 3). Given that the ATE in column 1 is statistically significant at the 1% level, the heterogeneous results imply that the ATEs in the main findings may be driven in large part by households living in areas with the highest levels of multiple deprivation. Indeed, the ATE point estimate for the lowest two IMD quintiles is numerically larger than in our main findings (22 percentage points versus 13-14 percentage points) which is concerning from the welfare perspective of deprived households.

Expenditure ATEs

Having established that prices increased for the treatment group using a visual analysis and that their consumption decreased as a result, we further attempt to evaluate the extent to which the lower levels of consumption and higher prices translated into changes in expenditure. It is important to consider the changes in household expenditure as this illustrates how much the energy crisis impacted consumers' budgets and welfare.

The divergence in expenditure between the FV and FF group is marked at the start of the energy price crisis. Indeed, the FV group appears to have spent more than FF according to the figures in Appendix A (Figures A8 and A9). To statistically corroborate this finding, Table 12 reports the pooled OLS and Fixed Effects regression to assess the causal impact of the energy price crisis on electricity and gas expenditure.

The ATEs in the pooled and fixed effects regressions coincide with the visual analysis and indicate that consumers spent £0.36 extra per day on electricity (columns 1 and 3), equivalent to around £131 per year. The ATEs in the pooled and fixed effects regressions in Table 12 (columns 2 and 4) imply that consumers spent £0.55 extra per day on gas, equivalent to around £201 per year. Overall, on average, the ATEs suggest that consumers spent an extra £332 per year on energy. The impact of energy price crisis on gas expenditure was more substantial than for electricity expenditure, even though gas is much cheaper than electricity, because households consume significantly more gas than electricity over the year.

Table 8: Heterogeneous (behavioural) impact of April 2022 price cap on the inverse hyperbolic sine of electricity consumption by control (FF) vs treatment group (FV)

	Pooled OLS					
	No extra clothing (not often, never)	Extra clothing (quite or very often, always)	Lights off (not often, never)	Lights off (quite or very often, always)	Effort (little, no, DK*)	Effort (some, great deal)
	(1)	(2)	(3)	(4)	(5)	(6)
FV x PRICECAP	-0.052	-0.072**	-0.039	-0.074**	-0.090*	-0.051
	(0.054)	(0.034)	(0.054)	(0.032)	(0.050)	(0.034)
Regional effects	YES	YES	YES	YES	YES	YES
Time effects	YES	YES	YES	YES	YES	YES
Temperature	YES	YES	YES	YES	YES	YES
N (observations)	1,007,370	3,003,415	570,843	3,445,296	1,001,578	3,017,408
N (control)	63,077	172,263	25,476	210,336	62,235	173,577
N (treated)	944,293	2,831,152	545,367	3,234,960	939,343	2,843,831
N (individuals)	1,015	3,007	563	3,465	999	3,032

*Notes: * $p<0.10$ ** $p<0.05$ ***$p<0.01$, individual-level cluster robust standard errors in the parentheses. Time effects include monthly indicators and the interaction between day of month and day of week indicators. Includes individuals observed for at least 1 year.*

Table 9: Heterogeneous (behavioural) impact of April 2022 price cap on the inverse hyperbolic sine of gas consumption by control (FF) vs treatment group (FV)

	Pooled OLS					
	No extra clothing (not often, never)	Extra clothing (quite or very often, always)	Lights off (quite or not often, never)	Lights off (very often, always)	Effort (little, no, DK)	Effort (some, great deal)
	(1)	(2)	(3)	(4)	(5)	(6)
FV x PRICECAP	-0.149	-0.147**	-0.152	-0.141**	0.022	-0.179**
	(0.135)	(0.066)	(0.103)	(0.067)	(0.083)	(0.072)
Regional effects	YES	YES	YES	YES	YES	YES
Time effects	YES	YES	YES	YES	YES	YES
Temperature	YES	YES	YES	YES	YES	YES
N (observations)	366,418	1,266,262	227,082	1,406,801	384,900	1,250,078
N (control)	31,074	104,823	18,443	117,988	28,884	107,547
N (treated)	335,344	1,161,439	208,639	1,288,813	356,016	1,142,531
N (individuals)	367	1,238	220	1,387	379	1,229

*Notes: * p<0.10 ** p<0.05 ***p<0.01, individual-level cluster robust standard errors in the parentheses. Time effects include monthly indicators and the interaction between day of month and day of week indicators. Includes individuals observed for at least 1 year. DK denotes 'Don't know'.*

Table 10: Heterogeneous (IMD) impact of April 2022 price cap on the inverse hyperbolic sine of electricity consumption by control (FF) vs treatment group (FV)

	Pooled OLS		
	IMD quintile 1-2	IMD quintile 3	IMD quintile 4-5
	(1)	(2)	(3)
FV x PRICECAP	-0.083**	0.005	-0.089**
	(0.040)	(0.087)	(0.045)
Regional effects	YES	YES	YES
Time effects	YES	YES	YES
Temperature	YES	YES	YES
N (observations)	1,810,075	739,772	1,469,139
N (control)	105,508	35,268	95,036
N (treated)	1,704,567	704,504	1,374,103
N (individuals)	1,819	752	1,460

*Notes: * p<0.10 ** p<0.05 ***p<0.01, individual-level cluster robust standard errors in the parentheses. Time effects include monthly indicators and the interaction between day of month and day of week indicators. Includes individuals observed for at least 1 year. IMD refers to the 'index of multiple deprivation'.*

Table 11: Heterogeneous (IMD) impact of April 2022 price cap on the inverse hyperbolic sine of gas consumption by control (FF) vs treatment group (FV)

	Pooled OLS		
	IMD quintile 1-2	IMD quintile 3	IMD quintile 4-5
	(1)	(2)	(3)
FV x PRICECAP	-0.226***	0.106	-0.175*
	(0.084)	(0.132)	(0.103)
Regional effects	YES	YES	YES
Time effects	YES	YES	YES
Temperature	YES	YES	YES
N (observations)	683,889	305,043	646,046
N (control)	61,074	22,927	52,430
N (treated)	622,815	282,116	593,616
N (individuals)	677	296	635

*Notes: * p<0.10 ** p<0.05 ***p<0.01, individual-level cluster robust standard errors in the parentheses. Time effects include monthly indicators and the interaction between day of month and day of week indicators. Includes individuals observed for at least 1 year.*

Table 12. Impact of April 2022 price cap on the inverse hyperbolic sine of gas and electricity expenditure by control (FF) vs treatment group (FV)

	Pooled OLS		Fixed Effects	
	Electricity	**Gas**	**Electricity**	**Gas**
	(1)	(2)	(3)	(4)
FV x PRICECAP	0.356***	0.548***	0.356***	0.551***
	(0.052)	(0.078)	(0.051)	(0.077)
Regional effects	YES	NO	-	-
LSOA effects	NO	YES	-	-
Household and housing controls	YES	YES	-	-
Time effects	YES	YES	NO	YES
Regional specific polynomial trends	NO	NO	YES	NO
Temperature polynomial	NO	NO	NO	YES
Individuals observed > 1 year	NO	NO	NO	NO
Ln(electricity consumption+1)	NO	NO	NO	NO
N (observations)	3,234,080	1,486,428	3,234,080	1,486,428
N (control)	111,279	85,668	111,279	85,668
N (treated)	3,122,801	1,400,760	3,122,801	1,400,760
N (individuals)	2,980	1,383	2,980	1,383

*Notes: * p<0.10 ** p<0.05 ***p<0.01, individual-level cluster robust standard errors in the parentheses. Time effects include monthly indicators and the interaction between day of month and day of week indicators. Includes individuals observed for at least 2.5 years.*

5. Conclusions

Understanding how unexpected and sustained increases in energy prices are experienced across socio-demographic groups provides the means for policymakers and energy companies to deal with the consequences of future geopolitical shocks to energy markets, but also to guide consumers more generally through the transformations required by energy security and environmental objectives.

The analysis presented in this paper was developed to provide rigorous evidence about the effects of the recent energy price increases on consumers' behaviour using a difference-in-difference approach which exploits the exogenous shocks of the Ukraine war on energy markets and the forced transition of about 2 million households from fixed to variable tariffs. The results are robust to different specifications and placebo tests on the pre-treatment period (discussed in Appendix B) which reinforce the validity of the causal links discussed in the paper, the latter by showing an insignificant difference in consumption between our two groups of households during that earlier period.

Our analysis reveals significant reduction in gas and electricity consumption as a result of the steep and unexpected price increases from 2022, particularly for those consumers who were moved to a variable tariff. However, despite being protected by a fixed tariff, even households on fixed contracts reduced their consumption during the energy crisis period. This result is consistent with general trends in energy demand, technology adoption and social norms in developed countries but also with the extensive media focus on the geopolitical situation as a source of energy price volatility (e.g. see Levell et al, 2024, Peñasco and Diaz Anadon, 2023, Piao and Managi, 2024).

Arguably, the relatively larger impact of the energy crisis on gas consumption which emerges in our study could be ascribed to the differential sensitivity of households to gas prices and bills during the energy crisis. This is consistent with the results of the project VENICE which revealed that the most common actions used to cope with the recent financial pressures included setting lower temperatures on the thermostats and heating fewer rooms in the house in order to reduce heating usage. Our results also reflect the fact that the reduction in consumption during the energy crisis has been achieved through the implementation of energy saving actions which might become established habits in future. However, we find some preliminary evidence that different actions were adopted by households in different categories of social deprivation in response to the price increases. To investigate the overall impact of the price increases on energy expenditure, we also considered electricity and gas expenditure as our outcome variables finding that the overall impact of the price increases was a bigger increase in gas expenditure than for electricity.

It is also worthwhile noting that the ATEs estimated in our analysis reflect the change in variable energy expenditure and do not directly capture the changes in the fixed cost of supplying gas and electricity to domestic meters – known as the ‘standing charge’ – since this element of expenditure is independent of behavioural considerations. Controlling for regional and other fixed effects will largely capture any indirect effects that might arise from incomes falling as a result of increased fixed charges over the same time period.

Data limitations have prevented us from undertaking a more detailed analysis of specific tariffs or long-term contracts held by the consumers in our sample, although the presence of binding price-caps during the period of analysis has mitigated the effects of these limitations. A more detailed assessment of price elasticities across the whole sample of GB consumers, with a focus on different sociodemographic categories, will be the focus of future work which can inform the economic, distributional and environmental policy interventions required for the transition to a net zero economy.

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Appendix A

Table A1. Control variable definitions and sample summary statistics.

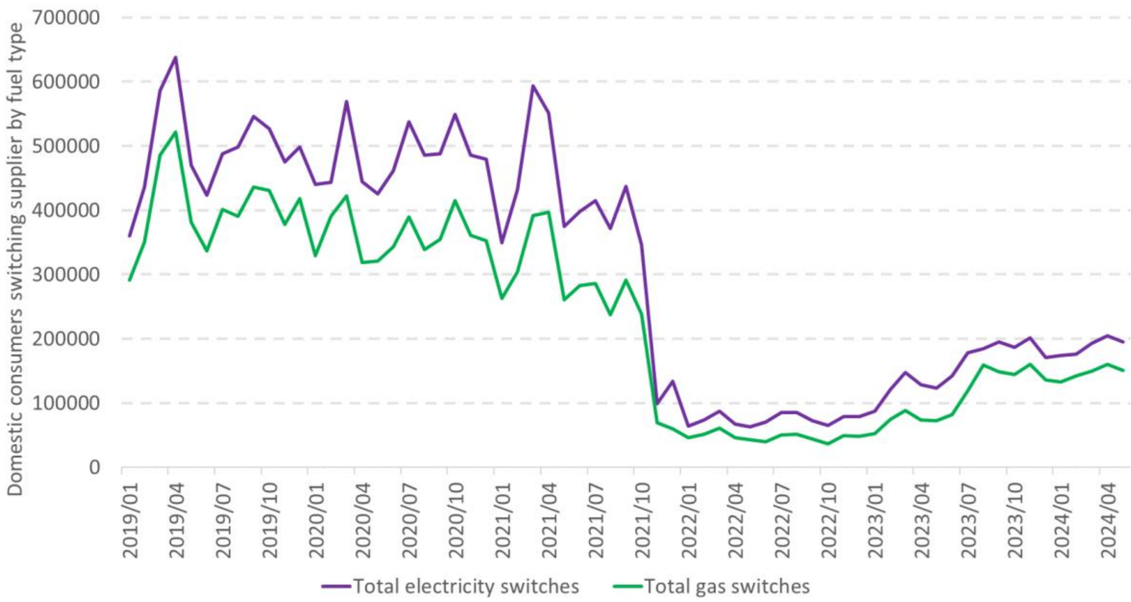
Variable	Definition	Electricity	Gas
*Socio-economic characteristics**		Mean	
Age	Age >64 years; 0 otherwise	0.445	0.431
Female	1 if female; 0 otherwise	0.437	0.433
Employed FT	1 if employed full-time; 0 otherwise	0.358	0.368
Employed PT	1 if employed part-time; 0 otherwise	0.091	0.109
LTSD	1 if long-term illness or disability; 0 otherwise	0.040	0.028
Unemployed	1 if unemployed; 0 otherwise	0.021	0.019
Retired	1 if retired; 0 otherwise	0.466	0.458
Other status	1 if other economic activity; 0 otherwise	0.013	0.011
Owner-mortgager	1 if owns accommodation; 0 otherwise.	0.793	0.872
Rent	1 if renting accommodation; 0 otherwise	0.207	0.128
Household size	Household size	2.235	2.356
*Housing characteristics**			
Bedrooms	Number of bedrooms	2.894	3.097
Detached	1 if living in a detached house; 0 otherwise	0.593	0.655
Terraced	1 if living in a terraced house; 0 otherwise	0.226	0.269
Flat	1 if living in a flat; 0 otherwise	0.181	0.076
Property > 2003	1 if property built post-2003; 0 otherwise	0.093	0.066
Gas central heat	1 if property has gas central heating; 0 otherwise	0.838	0.972
Electric central heat	1 if property has electric central heating; 0 otherwise	0.071	0.006
Other central heat	1 if property has other central heating; 0 otherwise	0.092	0.022
*Index of multiple deprivation (IMD), temperature**and regional characteristics**			
IMD quintile 4-5	1 if classified as IMD quintile 4-5; 0 if IMD quintile 1-3.	0.390	0.405
Mean temperature	Mean temperature of the air at 2m above the surface since last record (K units).	284.158	284.191
East midlands	1 if living in the East Midlands; 0 otherwise	0.071	0.097
East	1 if living in the East of England; 0 otherwise	0.102	0.100
London	1 if living in London; 0 otherwise	0.152	0.127
NE	1 if living in the North East of England; 0 otherwise	0.025	0.020
NW	1 if living in the North West of England; 0 otherwise	0.097	0.114
Scotland	1 if living in the Scotland; 0 otherwise	0.082	0.048
SE	1 if living in South East of England; 0 otherwise	0.157	0.149
SW	1 if living in the South West of England; 0 otherwise	0.093	0.092
Wales	1 if living in the Wales; 0 otherwise	0.071	0.081
West midlands	1 if living in the West Midlands; 0 otherwise	0.091	0.108
Yorkshire	1 if living in Yorkshire; 0 otherwise	0.059	0.065

*Energy Performance Certificate (EPC)****			
No EPC	1 if the property does not have an EPC; 0 otherwise	0.416	0.422
A	1 if the property has an EPC rated A; 0 otherwise	0.001	0.000
B	1 if the property has an EPC rated B; 0 otherwise	0.041	0.030
C	1 if the property has an EPC rated C; 0 otherwise	0.210	0.179
D	1 if the property has an EPC rated D; 0 otherwise	0.235	0.286
E	1 if the property has an EPC rated E; 0 otherwise	0.078	0.073
F	1 if the property has an EPC rated F; 0 otherwise	0.014	0.008
G	1 if the property has an EPC rated G; 0 otherwise	0.005	0.002
*Additional household and housing controls*****			
No follow up	1 if did not respond to the follow up survey; 0 otherwise	0.516	0.470
Income below £10k	1 if household income < £10,000; 0 otherwise	0.035	0.030
Income £10-20k	1 if household income £10,000-20,000; 0 otherwise	0.091	0.086
Income £20-30k	1 if household income £20,000-30,000; 0 otherwise	0.088	0.093
Income £30-40k	1 if household income £30,000-40,000; 0 otherwise	0.056	0.060
Income £40-50k	1 if household income £40,000-50,000; 0 otherwise	0.055	0.061
Income £50-60k	1 if household income £50,000-60,000; 0 otherwise	0.028	0.036
Income £60-70k	1 if household income £60,000-70,000; 0 otherwise	0.019	0.021
Income £70-80k	1 if household income £70,000-80,000; 0 otherwise	0.029	0.037
Income £80-90k	1 if household income £80,000-90,000; 0 otherwise	0.011	0.014
Income £90-100k	1 if household income £90,000-100,000; 0 otherwise	0.001	0.001
Income over £100k	1 if household income £10,000-20,000; 0 otherwise	0.030	0.044
Income (prefer not to say)	1 if household preferred not to declare income; 0 otherwise	0.041	0.047
Gas payment by direct debit	1 if household pays for gas by direct debit; 0 otherwise	0.378	0.510
Gas payment by receipt on bill	1 if household pays for gas on receipt of bill; 0 otherwise	0.022	0.011
Gas payment by prepayment	1 if household pays for gas by prepayment; 0 otherwise	0.005	0.001
Gas payment by other method	1 if household pays for gas using other methods; 0 otherwise	0.079	0.008
Electricity payment by direct debit	1 if household pays for electricity by direct debit; 0 otherwise	0.440	0.510
Electricity payment by receipt on bill	1 if household pays for electricity on receipt of bill; 0 otherwise	0.027	0.011
Electricity payment by prepayment	1 if household pays for electricity by prepayment; 0 otherwise	0.008	0.001
Electricity payment by other method	1 if household pays for electricity using other methods; 0 otherwise	0.009	0.008

Solar panel (no)	1 if household does not have solar panels; 0 otherwise	0.425	0.464
Solar panel (yes)	1 if household does have solar panels; 0 otherwise	0.059	0.066
Solar water (no)	1 if household does not have solar water heating; 0 otherwise	0.467	0.510
Solar water (yes)	1 if household does have solar water heating; 0 otherwise	0.017	0.019
Loft insulation (no)	1 if household does not have loft insulation; 0 otherwise	0.082	0.051
Loft insulation (yes)	1 if household does have loft insulation; 0 otherwise	0.402	0.479
Cavity insulation (no)	1 if household does not have cavity wall insulation; 0 otherwise	0.233	0.242
Cavity insulation (yes)	1 if household does have cavity wall insulation; 0 otherwise	0.251	0.287
Solid wall (no)	1 if household does not have solid wall insulation; 0 otherwise	0.443	0.491
Solid wall (yes)	1 if household does have solid wall insulation; 0 otherwise	0.041	0.038
Floor insulation (no)	1 if household does not have floor insulation; 0 otherwise	0.437	0.483
Floor insulation (yes)	1 if household does have floor insulation; 0 otherwise	0.047	0.047
Double glazed windows (no)	1 if household does not have double glazed windows; 0 otherwise	0.054	0.045
Double glazed windows (yes)	1 if household does have double glazed windows; 0 otherwise	0.430	0.484
Draught excluders (no)	1 if household does not have draught excluders; 0 otherwise	0.331	0.354
Draught excluders (yes)	1 if household does have draught excluders; 0 otherwise	0.153	0.176
N		2882452	1352477

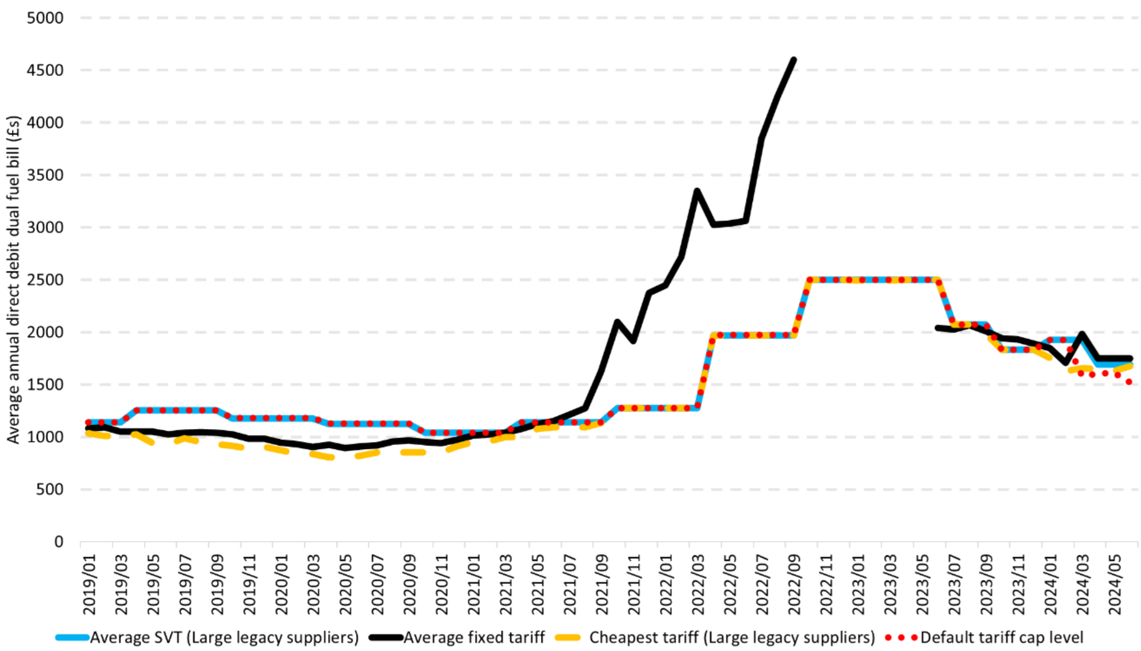
*Notes: *Socio-economic, housing, and regional data extracted from SERL 6th Edition main survey. ** Temperature data originates from Copernicus/ECMWF ERA5 hourly reanalysis data. *** EPC data is extracted from the EPC API. **** Additional socio-economic and housing data extracted from SERL 6th Edition follow-up survey*

Figure A1. Number of domestic consumers switching supplier by fuel type (GB)



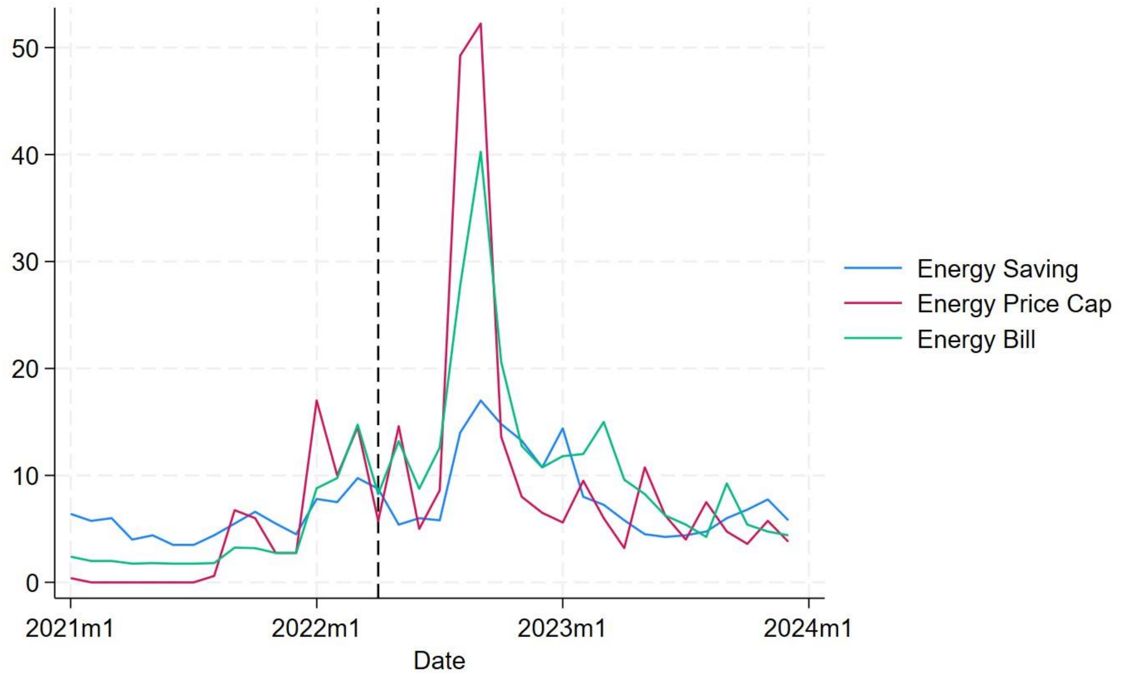
Notes: Ofgem (2024b).

Figure A2. Average direct debit dual fuel bill (£) for typical consumers by supplier, tariff, and price cap level (GB)



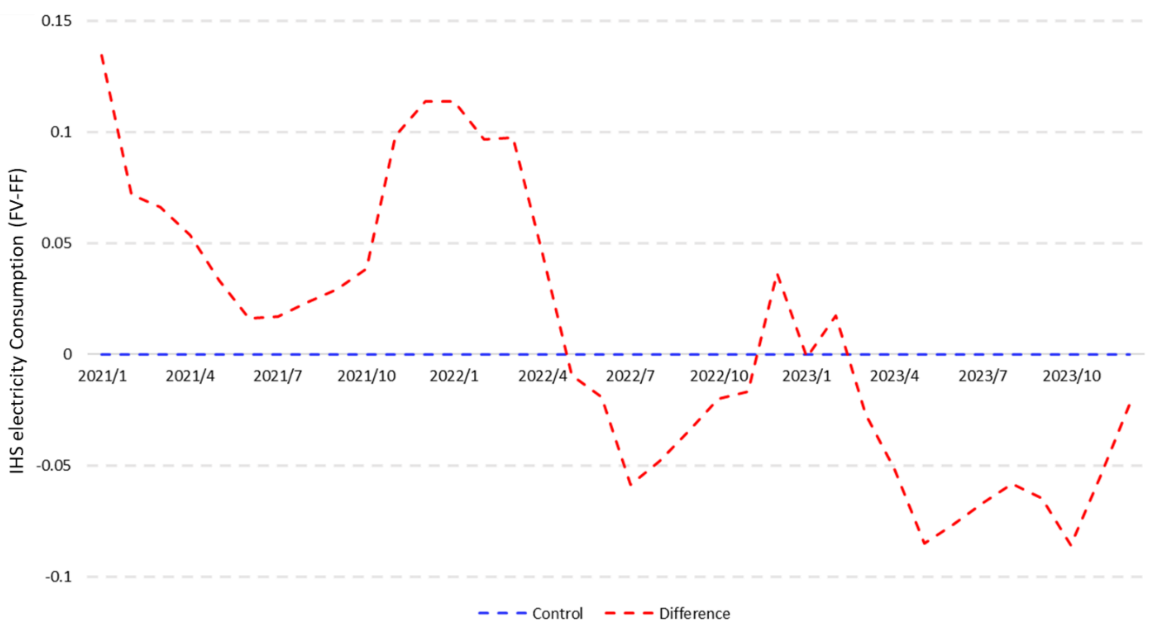
Notes: Ofgem (2024b).

Figure A3. Average "Google Trends" in public interest in energy savings, price caps and bills (GB)



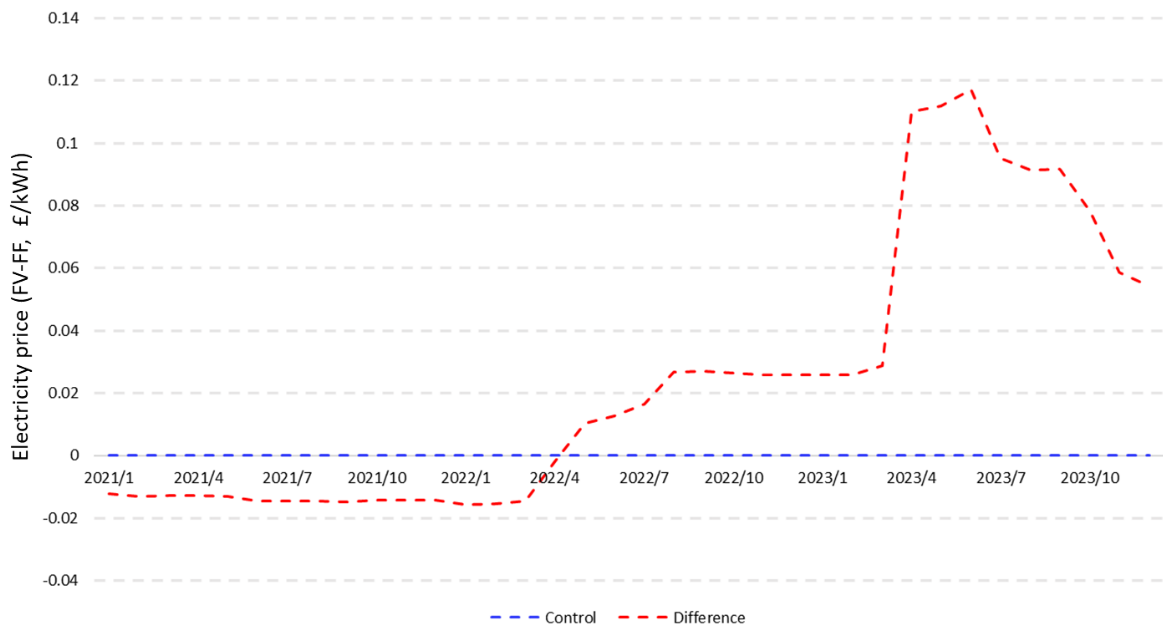
Notes: Google Trend search results for terms "energy saving", "energy price cap" and "energy bill" between January 2021 and December 2023, monthly means. The vertical line represents the start of the energy price crisis, April 2022.

Figure A4. Difference in monthly mean of (inverse hyperbolic sine) daily electricity consumption: FV-FF and FF-FF (control).



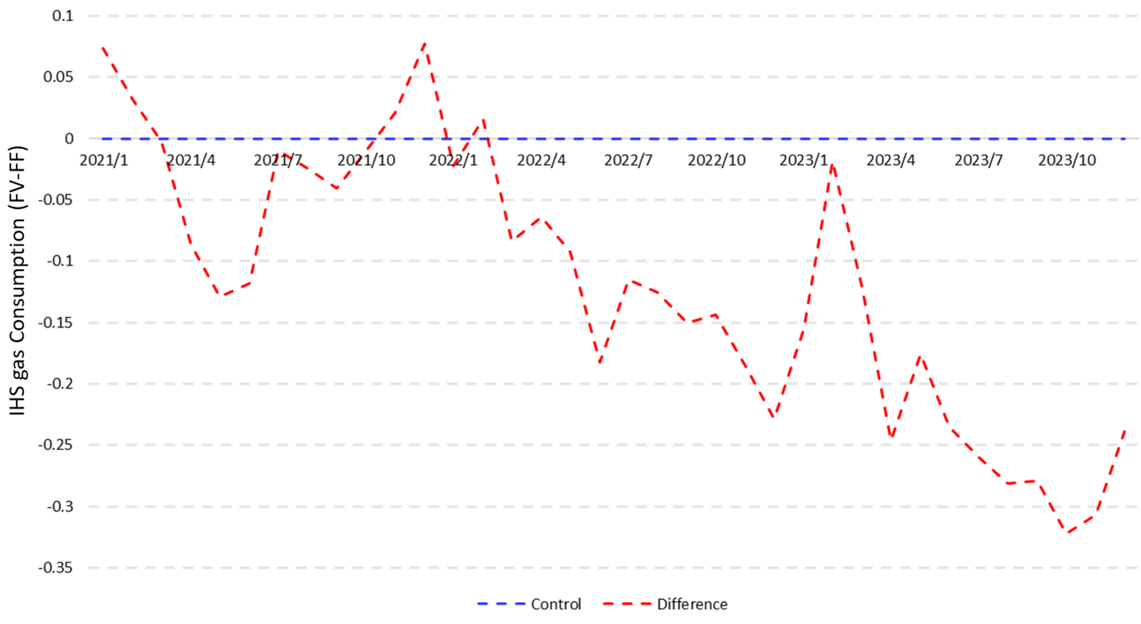
*Notes: Difference in monthly mean (inverse hyperbolic sine) electricity consumption (kWh) between 01/01/2021 and 31/12/2023, subtracting the control group (FF) as a baseline, for households with fixed electricity prices throughout (**FF-FF**) and for households with variable electricity prices post-April 2022 (**FV-FF**). N = 3,235,175 (N_{FF}=112,374; N_{FV}=3,122,801).*

Figure A5. Difference in monthly mean of daily electricity unit prices (£/kWh): FV-FF and FF-FF (control).



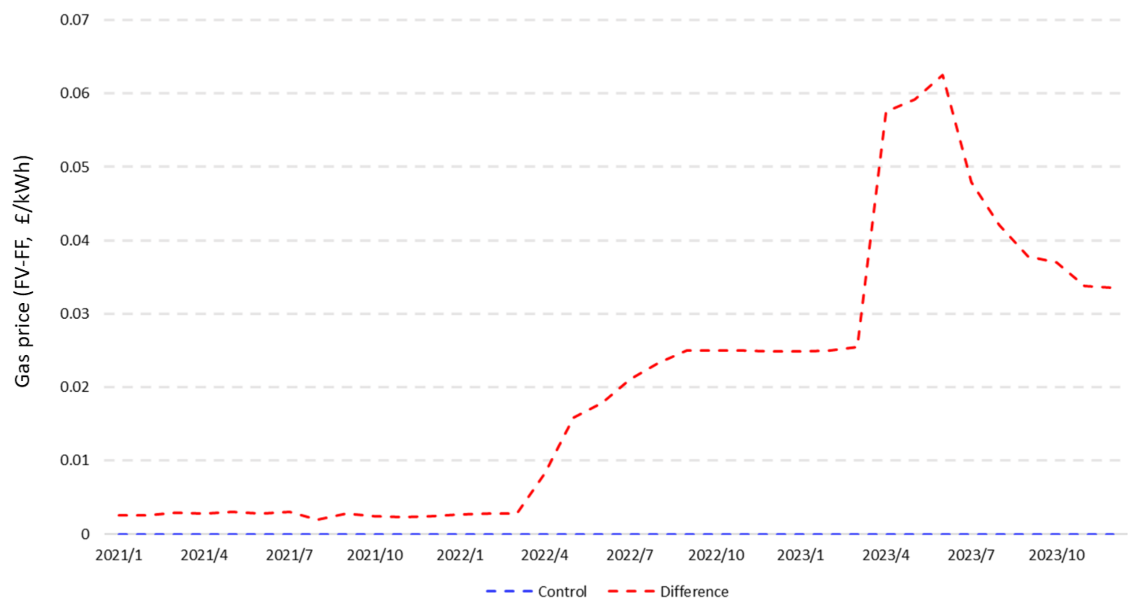
*Notes: Difference in monthly mean of daily electricity unit prices (£/kWh) between 01/01/2021 and 31/12/2023, subtracting the control group (FF) as a baseline, for households with fixed electricity prices throughout (**FF-FF**) and for households with variable electricity prices post-April 2022 (**FV-FF**). N=3,235,175 (N_{FF}=112,374; N_{FV}=3,122,801).*

Figure A6. Difference in monthly mean of (inverse hyperbolic sine) daily gas consumption: FV-FF and FF-FF (control).



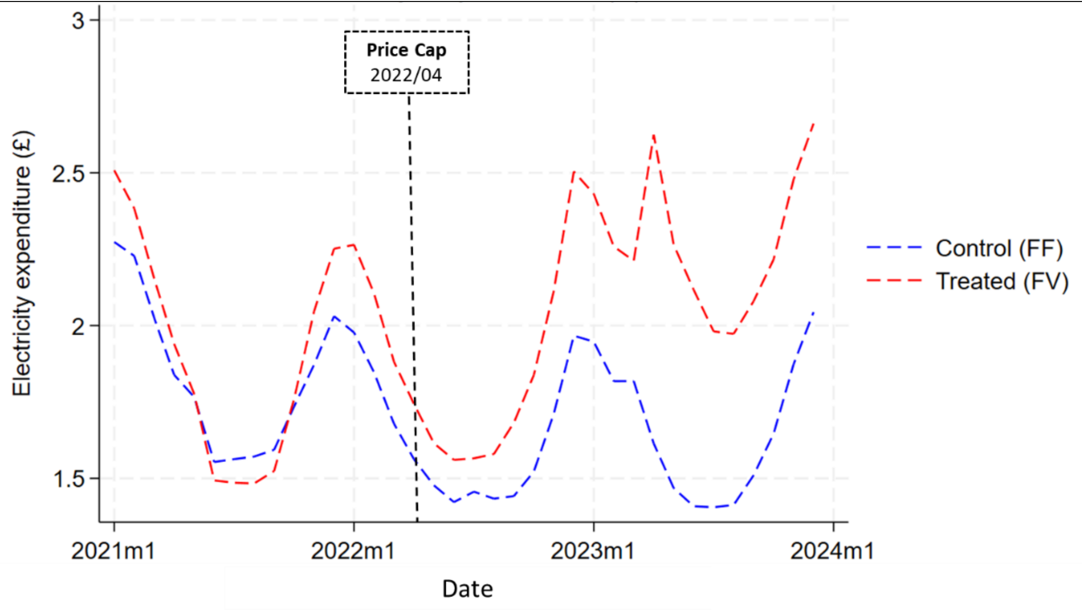
*Notes: Difference in monthly mean (inverse hyperbolic sine) gas consumption (kWh) between 01/01/2021 and 31/12/2023, subtracting the control group (FF) as a baseline, for households with fixed gas prices throughout (**FF-FF**) and for households with variable gas prices post-April 2022 (**FV-FF**). N = 1,473,941 (N_{FF}=82,113; N_{FV}=1,391,828).*

Figure A7. Difference in monthly mean of daily gas unit prices (£/kWh): FV-FF and FF-FF (control).



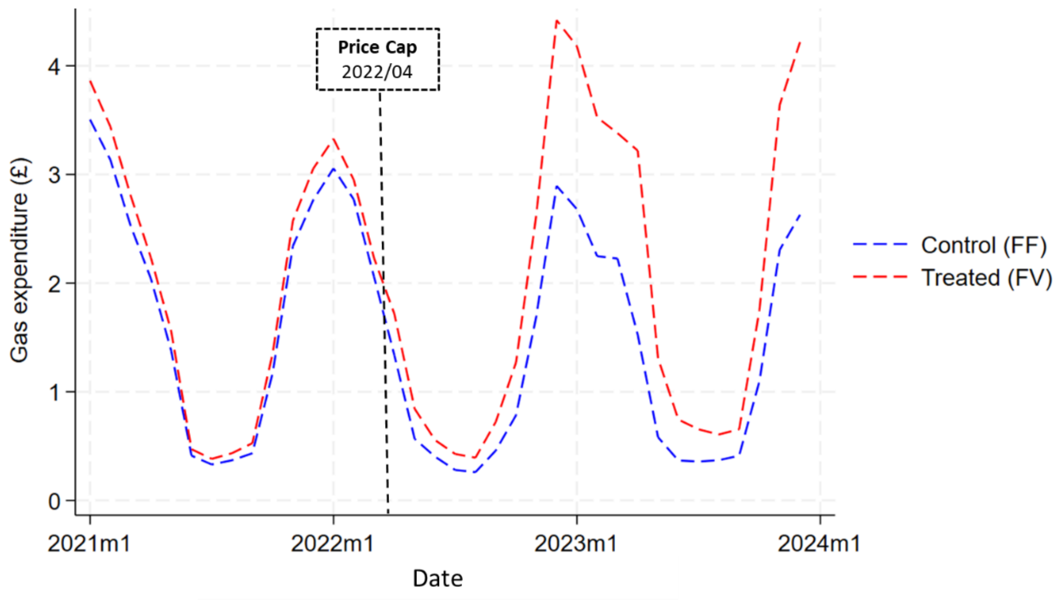
*Notes: Difference in monthly mean of daily gas unit prices (£/kWh) between 01/01/2021 and 31/12/2023, subtracting the control group (FF) as a baseline, for households with fixed gas prices throughout (**FF-FF**) and for households with variable gas prices post-April 2022 (**FV-FF**). N = 1,473,941 (N_{FF}=82,113; N_{FV}=1,391,828).*

Figure A8. Monthly mean of daily electricity expenditure (£/day) by FF and FV



Notes: Monthly mean electricity expenditure (£) between 01/01/2021 and 31/12/2023 by control group (households with fixed electricity prices, ***FF****) and treated group (households with variable electricity prices post-April 2022,* ***FV****). N = 3,234,080 (N_{FF}=111,279; N_{FV}=3,122,801).*

Figure A9. Monthly mean of daily gas expenditure (£/day) by FF and FV



Notes: Monthly mean gas expenditure (£) between 01/01/2021 and 31/12/2023 by control group (households with fixed gas prices, ***FF****) and treated group (households with variable gas prices post-April 2022,* ***FV****). N = 1,486,428 (N_{FF}=85,668; N_{FV}=1,400,760).*

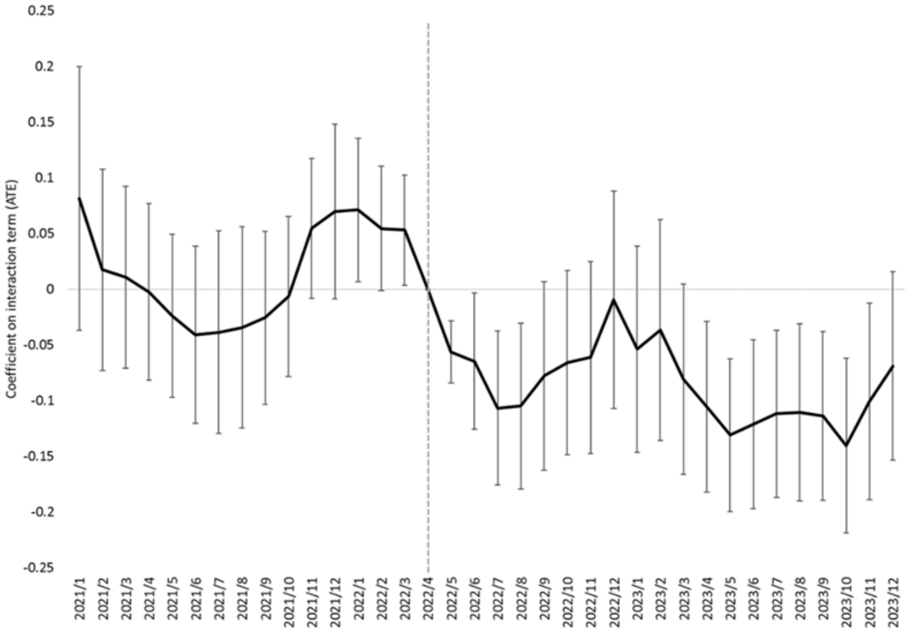
Appendix B

Event study approach.

As a further robustness check, we return to the differences in electricity and gas consumption of the FV group relative to the FF group discussed in the main text (see Figures A4 and A6). Using an event study approach, we test empirically whether these differences were statistically significant prior to April 2022. This is achieved by including indicators for each year-month of the sample (replacing *PC* in equation 1) and interacting the indicators with the treatment indicator (*FV* in equation 1). The baseline is set to April 2022. Figures B1 and B2 present the point estimates and their 95% confidence intervals for each year-month interaction. Overall, the point estimates prior to April 2022 are clearly not significantly different from zero, providing further support for parallel trends hypothesis up to (and therefore throughout) the treatment window.[25] In addition, this event study approach identifies the months of the energy price crisis which may have had the most impact (ATEs) on electricity and gas consumption. Figure B1 suggests that electricity consumption was mainly impacted by prices during summer 2022 and throughout the majority of 2023 (April to November). In contrast, Figure B2 suggests that the main impact of the energy price crisis is observed for gas in the winter of 2023, consistent with the end of the EPG scheme in June 2023.

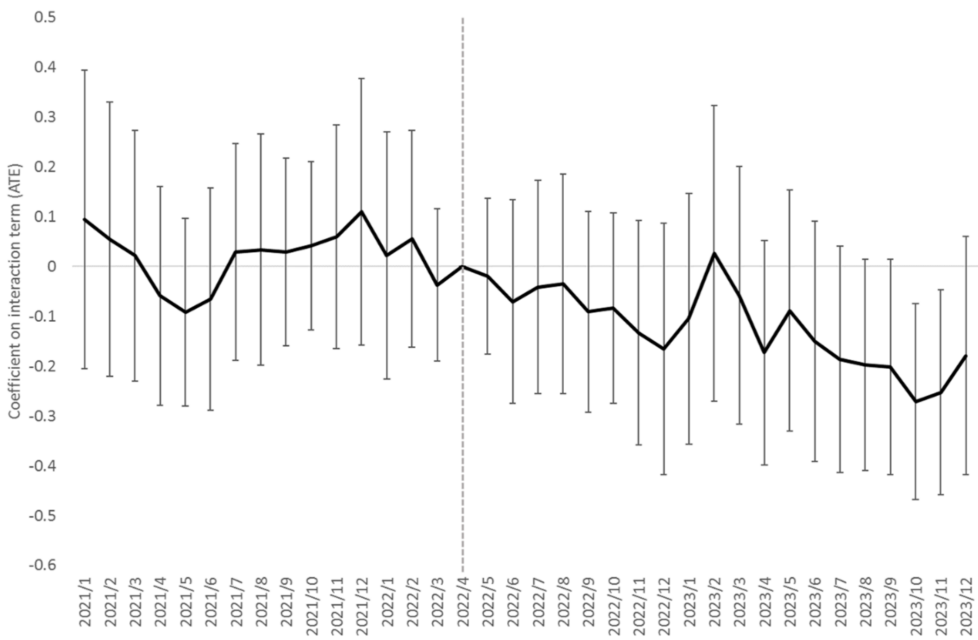
[25] There are a couple of point estimates in Figure B1, i.e., January and March 2022, which are statistically significant at the 5% level, overall, however it is clear that the trends are parallel prior to April 2022.

Figure B1. Event study ATEs for electricity



Notes: *Difference in monthly mean (inverse hyperbolic sine) and 95% confidence intervals of electricity consumption (kWh) between 01/01/2021 and 31/12/2023 by control group (households with fixed electricity prices,* ***FF****) and treated group (households with variable electricity prices post-April 2022,* ***FV****). N = 3,234,080 (N_{FF}=111,279; N_{FV}=3,122,801). Coefficients and standard errors are estimated using linear regression (difference-in-difference) analysis interacting the treatment with year-month indicators. Standard errors are clustered at the individual level.*

Figure B2. Event study ATEs for gas



Notes: *Difference in monthly mean (inverse hyperbolic sine) and 95% confidence intervals of gas consumption (kWh) between 01/01/2021 and 31/12/2023 by control group (households with fixed gas prices,* ***FF****) and treated group (households with variable gas prices post-April 2022,* ***FV****). N = 1,486,428 (N_{FF}=85,668; N_{FV}=1,400,760). Coefficients and standard errors are computed using linear regression (difference-in-difference) analysis interacting the treatment with year-month indicators. Standard errors are clustered at the individual level.*

Placebo analysis

A placebo (falsification) analysis is conducted to alleviate identification concerns, particularly selection and omitted variable bias, in the context of the difference-in-difference framework. The concept behind the placebo analysis is that the arbitrarily assigned treatment groups should yield a placebo effect with a mean not statistically different from zero when re-estimating the main results using an arbitrary sample period. To carry out this test we restricted the sample period to the years 2020 and 2021. We then reset the control group (FF) as those households with fixed tariffs throughout this period and the treatment group (FV) to those whose tariffs were fixed prior to April 2021 and varied thereafter.

Using the placebo framework we re-estimate versions of Tables 4 and 5. We anticipate a non-statistically significant effect on energy consumption for the placebo treatment coefficient (i.e., the interaction term) due to the randomisation process discussed above. A non-significant effect for the placebo treatment provides further evidence in support of our identification strategy.

Tables B1 and B2 show the placebo tests for the main results in which electricity consumption and gas consumption are dependent variables, respectively. Across the columns we provide the ATEs from the different specifications analogous to our main results. Crucially, we find no statistically significant effects during the placebo period across all specifications, which reinforces the existence of a causal effect in our main set of results.

The placebo framework is also utilised to assess the possibility of parallel trends using visual analysis and of selection bias via balancing tests. Figures B3 and B4 show that while the trends of the two groups average daily and monthly consumption move in parallel, they do not deviate from these trends after April 2021. In addition, Table B3 reports on the balance of socio-demographic and housing characteristics. Compared with our main results in Table 3, the difference-in-means tests show that the socio-demographic and housing characteristics do not balance overall, neither for electricity nor gas consumption. Overall, these results suggest that despite a clear parallel trend there is no apparent (placebo) treatment effect. Moreover, there is selection into the (placebo) treatment in this period (2020-21). This clearly contrasts with the quasi-natural experiment utilised in the main analysis which appears to be effective during the period of the energy price crisis (2022-23).

Table B1. Placebo impact of April 2021 price cap on the inverse hyperbolic sine of electricity consumption by control (FF) vs treatment group (FV) (2020-2021)

	Pooled OLS					**Fixed Effects**	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
FV	0.038***	0.047***	0.047***	0.046***	0.047***		
	(0.014)	(0.014)	(0.014)	(0.014)	(0.014)		
PRICECAP	-0.102***	-0.328***	-0.387***	-0.183***	-0.048***	-0.196***	-0.047***
	(0.004)	(0.007)	(0.010)	(0.010)	(0.004)	(0.005)	(0.004)
FV x PRICECAP	-0.000	-0.001	-0.000	0.000	0.001	-0.003	-0.002
	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)
Regional effects	NO	YES	YES	YES	YES	-	-
Time effects	NO	NO	NO	NO	YES	NO	YES
Linear trend	NO	YES	NO	NO	NO	NO	NO
Polynomial trend	NO	NO	YES	YES	NO	YES	NO
Temperature	NO	NO	NO	YES	YES	YES	YES
N (observations)	4,531,657	4,531,657	4,531,657	4,531,657	4,531,657	4,531,657	4,531,657
N (control)	2,252,438	2,252,438	2,252,438	2,252,438	2,252,438	2,252,438	2,252,438
N (treated)	2,279,219	2,279,219	2,279,219	2,279,219	2,279,219	2,279,219	2,279,219
N (individuals)	6,597	6,597	6,597	6,597	6,597	6,597	6,597

*Notes: * p<0.10 ** p<0.05 ***p<0.01, individual-level cluster robust standard errors in the parentheses. Time effects include monthly indicators and the interaction between day of month and day of week indicators. Includes individuals observed for at least 1.5 years.*

Table B2. Placebo impact of April 2021 price cap on the inverse hyperbolic sine of gas consumption by control (FF) vs treatment group (FV)

	Pooled OLS					Fixed Effects	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
FV	0.033	0.036	0.041*	0.036	0.038		
	(0.024)	(0.024)	(0.024)	(0.024)	(0.024)		
PRICECAP	-0.462***	-1.402***	-2.147***	-0.626***	-0.047***	-0.650***	-0.051***
	(0.012)	(0.017)	(0.024)	(0.020)	(0.012)	(0.015)	(0.011)
FV x PRICECAP	0.002	0.010	0.013	0.003	-0.009	0.005	-0.006
	(0.014)	(0.014)	(0.014)	(0.014)	(0.014)	(0.013)	(0.013)
Regional effects	NO	YES	YES	YES	YES	-	-
Time effects	NO	NO	NO	NO	YES	NO	YES
Linear trend	NO	YES	NO	NO	NO	NO	NO
Polynomial trend	NO	NO	YES	YES	NO	YES	NO
Temperature	NO	NO	NO	YES	YES	YES	YES
N (observations)	3,296,106	3,296,106	3,296,106	3,296,106	3,296,106	3,296,106	3,296,106
N (control)	1,111,372	1,111,372	1,111,372	1,111,372	1,111,372	1,111,372	1,111,372
N (treated)	2,184,734	2,184,734	2,184,734	2,184,734	2,184,734	2,184,734	2,184,734
N (individuals)	4,833	4,833	4,833	4,833	4,833	4,833	4,833

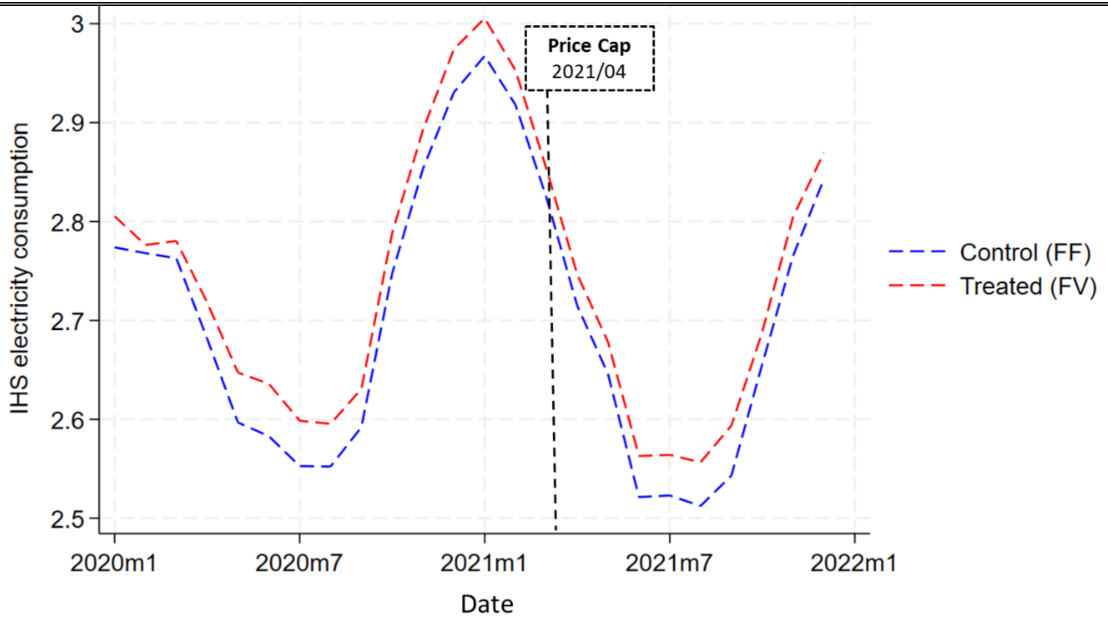
*Notes: * p<0.10 ** p<0.05 ***p<0.01, individual-level cluster robust standard errors in the parentheses. Time effects include monthly indicators and the interaction between day of month and day of week indicators. Includes individuals observed for at least 1.5 years.*

Table B3. Placebo balancing statistics of the difference in socio-demographic means between FV and FV groups (2020-2021)

	Electricity			**Gas**		
Variable	FV Mean (1)	FF Mean (2)	Difference (3) = (1)-(2)	FV Mean (1)	FF Mean (2)	Difference: (3) = (1)-(2)
Female	0.422	0.443	-0.021	0.450	0.427	0.023
Age >65	0.388	0.459	-0.071***	0.392	0.432	-0.041***
Employed FT	0.402	0.348	0.054***	0.399	0.367	0.032**
Employed PT	0.111	0.091	0.020**	0.106	0.107	-0.001
LTSD	0.026	0.031	-0.005	0.031	0.026	0.005
Unemployed	0.014	0.018	-0.004	0.016	0.017	-0.002
Retired	0.423	0.490	-0.067***	0.427	0.461	-0.035**
Other status	0.016	0.016	-0.001	0.016	0.014	0.002
Own-mortgage	0.851	0.818	0.032***	0.849	0.870	-0.021*
Rent	0.149	0.182	-0.032***	0.151	0.130	0.021*
Household size	2.360	2.238	0.122***	2.378	2.319	0.059
Bedrooms	3.036	2.921	0.115***	3.077	3.049	0.028
Detached	0.631	0.609	0.022*	0.643	0.645	-0.001
Terraced	0.243	0.239	0.004	0.263	0.271	-0.008
Flat	0.125	0.151	-0.026***	0.094	0.084	0.010
Property > 2003	0.083	0.092	-0.010	0.079	0.064	0.014*
Gas central heat	0.879	0.862	0.017*	0.979	0.968	0.011**
Electric central heat	0.040	0.057	-0.017***	0.006	0.005	0.000
Other central heat	0.081	0.081	0.000	0.015	0.026	-0.011**
London	0.113	0.136	-0.023***	0.122	0.127	-0.005
IMD45	0.400	0.381	0.019	0.416	0.403	0.013
Mean temperature	283.964	284.075	-0.112***	284.048	284.088	-0.040*
N	2072727	2030931		1990166	1012038	

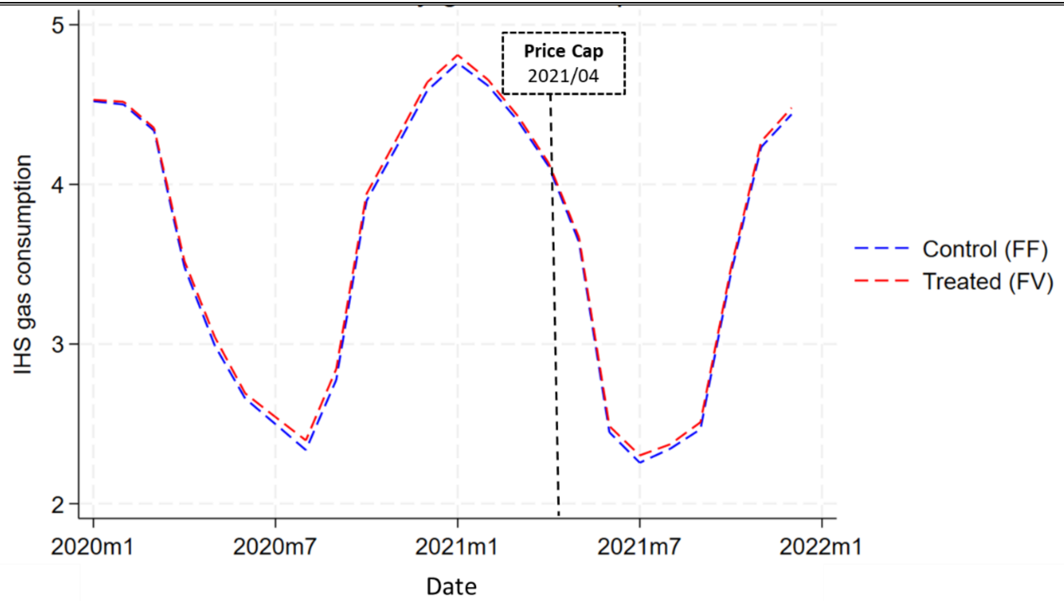
*Note: * p<0.10 ** p<0.05 ***p<0.01. Number of observations observed for at least 1.5 years. Tests use bivariate regressions clustered standard errors at the individual level.*

Figure B3. Placebo monthly mean of (inverse hyperbolic sine) daily electricity consumption by FF and FV



*Notes: Monthly mean (inverse hyperbolic sine) electricity consumption (kWh) between 01/01/2020 and 31/12/2021 by control group (households with fixed electricity prices, **FF**) and treated group (households with variable electricity prices post-April 2021, **FV**). N = 4,531,657 (N_{FV}=2,279,219; N_{FF}=2,252,438).*

Figure B4. Placebo monthly mean of (inverse hyperbolic sine) daily gas consumption by FF and FV



*Notes: Monthly mean (inverse hyperbolic sine) gas consumption (kWh) between 01/01/2020 and 31/12/2021 by control group (households with fixed gas prices, **FF**) and treated group (households with variable gas prices post-April 2021, **FV**). N = 3,296,106 (N_{FV}=2,184,734; N_{FF}=1,111,372).*