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DISCUSSION PAPER SERIES

IZA DP No. 15959

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ISSN: 2365-9793

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ABSTRACT

Energy Price Shocks and the Demand for Energy-Efficient Housing: Evidence from Russia's Invasion of Ukraine

How do private consumers adapt to changes to energy prices, in particular do they invest in energy-saving measures? We study this question in the context of the rapid rise in energy prices caused by the Russian invasion of Ukraine in February 2022 and the demand for energy efficiency in the UK housing market. We find that the housing market barely reacted to a 60% increase in the price of energy. This finding holds in multiple contexts and across various robustness checks. Supplementary survey evidence suggests that people believe the energy price increases are temporary, not permanent.

JEL Classification: Q35, Q41, Q51, R31

Keywords: gas prices, energy efficiency, property markets

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1 Introduction

To what extent do consumers adjust their behaviour in response to changes in energy prices? We study this question in the context of the UK housing market and sudden increases to energy prices caused by Russia's invasion of Ukraine in February 2022. The invasion and the resulting shortage of natural gas triggered substantial price increases for gas and electricity across Europe. Many countries initiated policies aimed to balance the need to insure household incomes against a trebling of prices relative to the late 2010s and the necessity to maintain price signals to spur energy savings and alleviate – or indeed avoid – eventual shortages during the Winter of 2022.

The UK is in many ways an ideal setting to study this question. First, as displayed in Table 1, energy poverty – defined as households having an income after energy costs that leaves them below the poverty line – is a serious problem in the UK, even before the recent price increases: in 2020, more than 3 million households were in fuel poverty, ranging from 8.6% of all households in the South East and 17.8% in the West Midlands. Second, the UK has an unusually transparent housing market when it comes to the energy efficiency of buildings: each seller needs to provide an official energy performance certificate (EPC) which details the energy efficiency of the sold property. This certificate does not only include the current energy efficiency but also contains information on the potential energy efficiency that could be obtained and which measures would be necessary to achieve it. This setting ensures that market actors (buyers and sellers) are knowledgeable of current, and future, energy costs. Third, past research has suggested that attributes of properties as well as the wider environment, such as local school quality (Rosenthal, 2003; Gibbons and Machin, 2003), crime rates (Gibbons, 2004; Braakmann, 2017) or transport access (Gibbons and Machin, 2005), get capitalised into UK property prices fairly quickly. Finally, the energy market in the UK is regulated: since 2018, the UK has had an energy price cap on the per unit costs of energy. The cap is set by the regulator, Ofgem, and derived from wholesale prices. Following the invasion of Ukraine, Ofgem announced that the price cap would more than double. Figure 1 displays the relationship between the gas price, the cheapest available tariff for a "typical" household – which is the usual way Ofgem communicates caps and tariffs to the general public – and the corresponding annual Ofgem cap for this household. As we can see gas prices began to increase in the summer of 2021 following a drop in supply of Russian gas via the Yamal-Europe pipeline, which was, already at the time, suspected to be politically motivated.[1] Domestically, this largely led to the cheapest available tariff approaching the price cap. Following the invasion of Ukraine in February 2022, the price cap and cheapest tariff increased in unison, while wholesale prices also reached new heights. This setting ultimately allows us to use two, plausibly exogenous, sources of price variation – the sudden increase in wholesale prices in the summer of 2021 or the increase in price caps and domestic tariffs following the invasion in February 2022.

In this paper, we use administrative data on the universe of house sales in England and Wales from January 2021 to the end of June 2022, which are linked to a database of energy performance certificates. In our preferred specification, we exploit the timing of the Russian invasion of

[1] https://www.theguardian.com/business/2021/sep/28/uk-wholesale-gas-prices-highs-winter-energy-crisis-suppliers

Table 1: Fuel poverty in 2020

		Fuel poverty	
	Number of households	Number of HHs	% of HHs
North East	1,197,595	172,828	14.4
North West	3,225,129	465,325	14.4
Yorkshire and The Humber	2,395,086	418,084	17.5
East Midlands	2,036,649	289,735	14.2
West Midlands	2,477,936	441,693	17.8
East	2,638,892	348,406	13.2
London	3,520,281	403,807	11.5
South East	3,861,161	331,687	8.6
South West	2,516,148	286,641	11.4

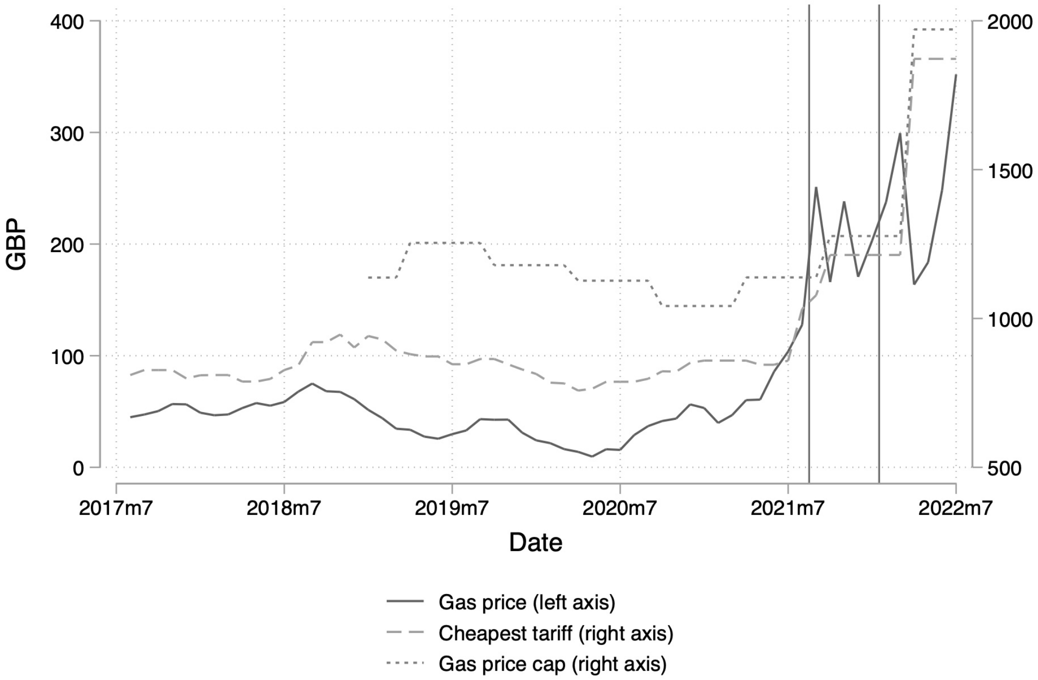
Notes: HHs stands for households. Department for Business, Energy and Industrial Strategy, Sub-regional Fuel Poverty England 2022 (2020 data). *A household is considered to be fuel poor if they are living in a property with a fuel poverty energy efficiency rating of band D or below and when they spend the required amount to heat their home, they are left with a residual income below the official poverty line. There are 3 important elements in determining whether a household is fuel poor: household income, household energy requirements and fuel prices.*

Ukraine to identify energy price shocks. We exploit this setting using a hedonic price model, estimated within a difference-in-differences (DiD) framework to establish causality. Specifically, we compare the price evolution of the most and least energy efficient properties with those of a typical property. The underlying notion is that more energy efficient homes should command a price premium after the invasion and the resulting high energy prices as these properties face relatively lower running costs. As the supply of housing is fixed in the short run, we would expect to see this increase in demand to manifest itself largely in higher property prices. The opposite argument holds for the least energy-efficient properties. An important potential confounder in this setting are possible macroeconomic effects of energy price shocks (see, e.g., Kilian (2008) for a review) that might translate into differential local shocks, for example, based on local industry composition. We control for these using increasingly granular area-by-time effects, our most comprehensive version is at the neighbourhood-by-month-by-year level.

Our paper contributes to multiple literatures. The first deals with the way environmental risk and external shocks get capitalised into house prices. Examples from this literature include Bauer et al. (2017) who find that house prices near nuclear power stations declined following the Fukushima Daiichi accident in Japan in March 2011, Greenstone and Gallagher (2008) who find no evidence that the clean up of hazardous waste sites in the US affected prices of nearby properties, Bosker et al. (2019) who find that flood risk affects prices in the Netherlands and Pinchbeck et al. (2020) who find that the publication of Radon levels affect property prices in England. Just as in this literature, our paper relies on the existence of an underlying exposure to a specific risk, in our case the lack of energy efficiency, that is revealed through an unexpected event, the sudden increase in gas and energy prices caused by actions of the Russian state.

Our paper also contributes to a small, but growing literature dealing directly with the economic consequences of, and reactions to, Russia's invasion of Ukraine. Most of this literature has focused on government policy responses such as the design of energy price caps and related measures to support households and firms, as well as trying to quantify the possible size of the resulting economic shock (Bachmann et al., 2022b,a; Bhattacharjee et al., 2022; Fetzer, 2022).

Figure 1: Gas prices, domestic tariffs and Ofgem cap



The graph compares the evolution of the gas price (Intercontinental Exchange UK NBP Natural Gas Electronic Monthly Energy Future), the cheapest available tariff for a "typical household" and the Ofgem price cap for a "typical" household. The first solid line marks the drop in Russian gas supplied to Europe in September 2021, the second line the beginning of the Russian invasion of Ukraine in February 2022.

An exception is a recent paper by Ruhnau et al. (2022) who estimate energy saving behaviour by households and industry in Germany and find that from March to September 2022 households and small firms reduced consumption by between 10% and 36% while large firms reduced consumption by between 4% and 19%. A YouGov poll for the UK from October 2022 mirrors these findings and suggests that 74% of households have reduced their energy consumption, largely by heating properties less and reducing the number of electrical appliances and lights in use (YouGov, 2022). In contrast to their paper, we focus on the role of energy prices for long-term investment decisions by households rather than short-term energy savings, such as turning down heating. The most closely related paper from this literature is Fetzer et al. (2022) who use detailed building and consumption data to evaluate the energy savings potential of buildings in the UK and the extent to which recent UK government policies weaken incentives for property owners to invest in energy efficiency improvements.

Finally, our paper contributes to a literature that estimates willingness to pay for energy efficiency measures in housing markets. Within this literature several papers have focused on residential properties, usually using hedonic regressions that control for observable characteristics of properties or relying on a repeated sales approaches to control for unobservable property characteristics. These papers generally find markups for the prices of more energy efficient properties in the Netherlands (Brounen and Kok, 2011), Ireland (Hyland et al., 2013) and the UK (Fuerst et al., 2015). Our paper differs from these studies by relying on a sudden shock to the objective benefit of higher energy efficiency for identification and then studies the adjustment of the housing market to this shock.

Using various DiD and event study specifications, we find evidence for fairly muted price changes related to the energy efficiency of buildings after the Russian invasion of Ukraine – price changes for the most energy-efficient properties are generally close to zero and precisely estimated, while we find evidence for a small emerging penalty for the least efficient properties. We find the same pattern of results when looking at finer definitions of energy efficiency, changing the treatment date to the summer of 2021 or when using alternative data - a monthly panel at the neighbourhood level - and an alternative treatment definition - average gas consumption per household in either 2019 or 2020 that also allows us to look at changes in transaction volumes. Here, we find that following the Russian invasion of Ukraine fewer properties are sold in high gas consumption neighbourhoods.

Our findings do tell us, however, that house prices are, at least in the short run, largely unresponsive to large energy shocks. We subsequently explore potential explanations for this null result. Using Google search trend data for terms such as "energy saving" or "energy bill" we show that our findings are unlikely to be explained by a lack of of public interest or awareness of the price increases – searches for all terms increase following the initial price increase in the summer of 2021 and remain high afterwards. We also explore the possibility that buyers are more interested in the potential rather than the current energy efficiency of a property but, again, find only weak evidence that this matters. Finally, we explore the possibility that the public considers the energy price shock to be transitory and hence see no need to invest in long-term energy savings measures. Evidence from the Bank of England/Ipsos Inflation Attitudes Survey for Q1 2021 to Q3 2022 strongly supports this possibility – while current inflation perceptions and 1-year inflation expectations are increasing throughout the whole period, 2-year and 5-year inflation expectations peak around the same time as the Russian invasion.

The remainder of this paper is as follows. In section 2, we outline the institutional context and background. In section 3, we discuss the data and our empirical strategy. Section 4 presents our main results, robustness exercises and additional analysis that helps to the explain the results. Section 5 concludes.

2 The Russian invasion of Ukraine and gas prices in the UK

The prelude to the Russian invasion of Ukraine began in mid-late 2021 when the wholesale gas price reached, at the time, an all time high, as shown in Figure 2. Gas supplies from Russia into Europe more than halved[2] as Russia wielded its regional gas supremacy to create pressure to approve the Nord Stream 2 pipeline, which was due to run from Russia to Germany and therefore increase European dependency on Russian gas supplies. In October 2021, news outlets reported sustained, unusual troop activity on the Russian and Belarusian side of the Ukrainian border. By

[2]https://www.theguardian.com/business/2021/sep/28/uk-wholesale-gas-prices-highs-winter-energy-crisis-suppliers

January 2022, Russia had reportedly completed their buildup of approximately 127,000 troops and military hardware.

On the 24h February 2022, Russia launched a military invasion of Ukraine and so began a protracted, bloody conflict on Ukrainian soil. Days after the invasion began, a coalition of Western countries announced a series of economic sanctions that were designed to raise the Russian economy to the ground and apply pressure to key political figures. The sanctions were wide ranging and targeted individuals, banks, businesses, monetary exchanges, bank transfers and international trade. The severity of Russia's actions were reflected in the gravitas of the sanctions that were tantamount to "economic war".[3] All of which created even more geo-political uncertainty and pushed gas prices further upwards.

The soaring wholesale gas prices quickly led to a number of small UK energy suppliers to go bust and their customers transferred to larger firms who were able to absorb the shock. The scale of the issue meant that it quickly began to dominate UK news cycles and culminated in Bulb Energy, the 7th largest UK provider with 1.7 million customers, being put into administration by the energy regulator Ofgem.[4] The UK is particularly exposed to gas supply shocks with its minuscule storage capabilities - home to just 1% of Europe's total available storage - which would cover the demand for 4 or 5 winter days.[5] Furthermore, over half the electricity in the National Grid is generated by burning natural gas, which indicates spillovers and thus the vulnerability of electricity prices to gas shocks.

Whilst those households on fixed price gas tariffs were contractually protected from end-user price hikes, those on standard variable tariffs and those seeking a new deal saw their gas bills start to rise. The unit price rises quickly hit the energy price cap – a price ceiling set by Ofgem which the per unit cost of energy (gas and electric) cannot rise above. The headline figure that is usually communicated to the public and varies slightly by government office region. It is indicative of what the average household would spend at the capped price per unit of energy.[6] Since it's inception in mid-2018 the energy price gap was on a gradual downward trend. Once the gas price spiked in October 2021, the energy price cap realised its first significant increase - up 13% from £1,156 to £1,309. The wholesale gas price continued to rise into the new year and in February 2022 Ofgem announced that the energy cap would increase by over 54% in April taking the average household energy bill to £2,017.

Following a period of intense media coverage and public fervour, the then-Chancellor of the Exchequer, Rishi Sunak, announced a package of new policy measures to provide to support. The poorest households will receive a means tested payment of £650 to help with the cost of living increases and every household will get £400 off their energy bills from October 2022 over a 6 month period. This was in part funded by a 25% windfall tax on oil and gas companies and described by the Institute for Fiscal Studies as a "genuinely big package... Mr Sunak is engaging in some serious redistribution from rich to poor".[7]

[3]https://www.bbc.co.uk/news/business-60550610

[4]https://www.bbc.co.uk/news/business-59373198

[5]https://www.theguardian.com/business/2021/sep/24/how-uk-energy-policies-have-left-britain-exposed-to-winter-gas-price-hikes

[6]It is important to note the headline figure is by no means a "cap" as households monthly bills can surpass this.

[7]https://www.bbc.co.uk/news/business-61583651

In late August 2022 Ofgem announced that the energy price cap would rise again from the 1st October 2022 so that the average household would pay upwards of £3,300 per year. Consumers were faced with the prospect of an ever increasing share of disposable income being spent on heating and with the winter closing in, the media narrative turned to inevitable government intervention. Following a change in leadership of the incumbent Conservative party, the new and then-Prime Minister, Elizabeth Truss, announced a fiscal package so that the average household's energy bills would be capped at £2,500 for at least two years from October 2022 at a cost of £150 billion to the UK taxpayer.

3 Data and empirical strategy

3.1 Data

Our main database brings together information on house sales[8] and the Energy Performance Certificates (EPCs). The house-level price data are obtained from the Land Registry and contain information on the universe of house sales in England and Wales. The data on the EPC ratings and house-level characteristics are from the Department for Levelling Up, Housing & Communities. The latest version at the time of writing has 23,155,433 domestic EPCs listed. When being sold each dwelling is given an energy efficiency rating that reflects the current state of the property. The rating is on a ordinal scale from A-G, where A indicates the most energy efficient and G the least. Upon assessment, when the EPC rating is awarded, each dwelling is also given a potential rating that can be achieved by the homeowner undertaking energy efficiency enhancing spends. To provide an example, a rating of D would correspond to a Victorian-era terraced house that has been fitted with double-glazed windows and modern roof insulation and heating, but no further wall insulation beyond the original double-brick walls. Adding further wall insulation and solar panels would move this house to a rating of C.

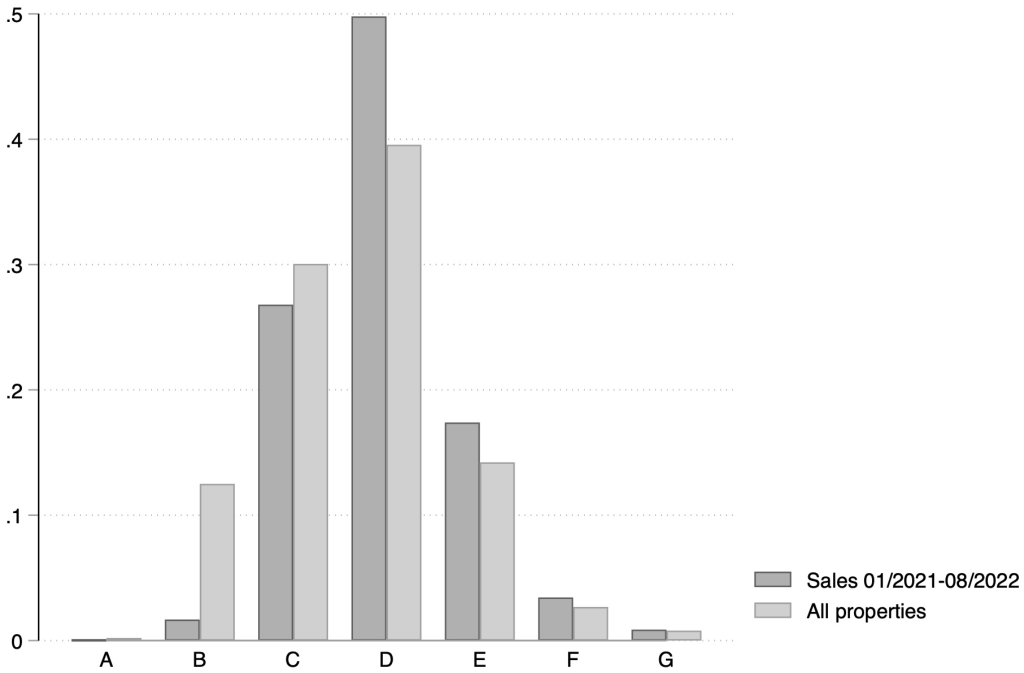
In order to link the house-sale price to its EPC rating the datasets need to be matched, but no common house-level identifier is present. Each dataset does, however, contain the address and postcode. Thus, the data linkage follows a 251 rule process that harmonises and finds *exact* matches between the address and postcode provided in each dataset as set out in Chi et al. (2021). We exclude outlying transactions from the dataset based on six rules (Chi et al., 2021). These are: where the total floor area of number of habitable rooms are missing or 0; where total floor area is smaller than 9m^2 or larger than 974m^2; total price per m^2 is larger than 50,000 £/m^2 or price per m^2 is smaller than 200 £/m^2; floor area per habitable room is larger than 100m^2; where the number of habitable rooms is larger than 20; and where the floor area per habitable room is smaller than 6.51m^2. All in all, our main dataset contains a total of 1,059,518 house sales linked to their EPC ratings from the 1st January 2021 to 31st August 2022. We do not go beyond August 2022 as September 2022 saw several events that also affected the housing market, specifically the announcement of the already mentioned energy support package, directly followed by a period of national mourning due to the passing of Queen Elizabeth II, followed by financial market turmoil and emergency interest rate increases by the Bank of England triggered

[8]We use the term "house sales" to refer to the sale of all dwellings: bungalows, flats, houses, maisonettes and park homes.

by a budget announcement on September 23rd and leading to the resignation of the Chancellor Kwasi Kwarteng, followed by that of Prime Minister Elizabeth Truss, in October 2022.

A natural question is: how does the distribution of EPC ratings for the houses sold in our sample period compare to the distribution of all certificates? This comparison is displayed in Figure 2. There are a number of things to note: First, properties with ratings from B to E make up in excess of 90% of all properties with very few properties rated as A, F or G. In fact, properties rated as C and D comprise about 70% of all properties. Second, in terms of how typical sales during our observation period are, we can observe that the ranking of energy ratings does not change and in fact proportions are comparatively similar with the exception of B which are slightly less common in our sample and and rating D dwellings that are more common. All in all, our sample appears quite representative of longer term trends in sales.

Figure 2: Distribution of energy efficiency ratings among current sales and all properties



The graph compares the distribution of energy efficiency certificates amongst sales between 01/2021 and 06/2022 and all properties with an energy efficiency certificate.

We also assemble a complimentary neighbourhood-level dataset that allows us to estimate our relationship of interest in a slightly different setting. A neighbourhood is defined as the lower-layer super output area (LSOA). In England and Wales there are almost 35,000 LSOAs, these are relatively small spatial units with a minimum population of 1,000 (with a mean of 1,500), equal to approximately 650 households. They are designed for the publication of census data and have remained stable since their introduction in the 2001 census. By design, they cover a homogeneous population and can be interpreted as a neighbourhood.[9]

[9]LSOAs are an aggregation of adjacent Census Output Areas (OA) with similar social characteristics that align with local authority district boundaries. These OAs were built following the 2001 Census outputs from clusters of adjacent postcode units, and designed to be socially homogeneous (in terms of dwelling types and housing tenure)

LSOAs are nested within local authorities (LA), the basic level of local government in the UK with responsibility for public service provision within their boundaries (roughly equivalent to US counties). Local authorities usually consist of a city or amalgamations of smaller towns and rural areas. London as a special case is split into 32 boroughs each designated as a local authority. There are a total of 348 LAs in England and Wales, each contain on average 100 LSOAs but with a large amount of variation, from 1 (Isles of Scilly) to 639 (Birmingham).

Our neighbourhood level dataset is a monthly panel covering the period 01/2021 to 08/2022, which we build by aggregating house price data from the Land Registry at the LSOA-date level. We merge this data to gas consumption data for 2019 and 2020 from the Department for Business, Energy & Industrial Strategy. We focus specifically on the mean gas consumption (kilowatt hour (kWh) per gas meter) in a LSOA and use data for 2019 and 2020 to generate measures of historic energy consumption at a time of low prices. As the worldwide COVID-19 pandemic will have influenced consumption in 2020 due to widespread working from home and stay at home orders – some of which have lasted beyond 2020/21 and so might influence consumption patterns in 2022 – we use data on both a pre-COVID-year and the first pandemic-year as alternative measures.

Table 2: Descriptive statistics

	Mean	Std. dev.
Panel A: Property sales data		
EPC rating A, B or C	0.29	0.45
EPC rating D	0.50	0.50
EPC rating E, F or G	0.22	0.41
Sale after 02/2022	0.35	0.48
Price (£1,000)	343	340
Price per square meter (£)	3,537	2,087
Observations	1,059,518	
Panel B: LSOA panel data		
Avg. gas consumption per meter (kWh)...		
...in 2019	13.7	3.3
...in 2020	13.9	3.3
Avg. property price (£1,000)	370	951
Number of transactions	2.3	2.3
Observations	553,212	

Note: The LSOA panel is unbalanced as not every LSOA will have a property sale, and hence an observed property price, in every month.

3.2 Empirical strategy

To fix thoughts, consider a standard hedonic pricing model where house prices depend on features of the property, such as floor space, energy efficiency or views, and the general location, such as local crime rates or access to amenities. Interest in this paper lies in identifying the marginal

and of similar population sizes. The OAs tend to follow natural boundaries, such as roads. The OAs target size is 125 households, and cannot be lower than 40, with an average population of 297. The total numbers of OAs in England and Wales in 2011 were 171,372 and 10,036 respectively. Following the 2001 census, LSOA were created by aggregating four to six OAs so that they have a population between 1,000 and 3,000, and are as homogeneous as possible. In 2011, after some minor changes, there were 32,844 LSOAs in England and 1,909 in Wales.

increase or decrease in willingness to pay for houses of a specific energy efficiency following the sudden increase in energy prices.

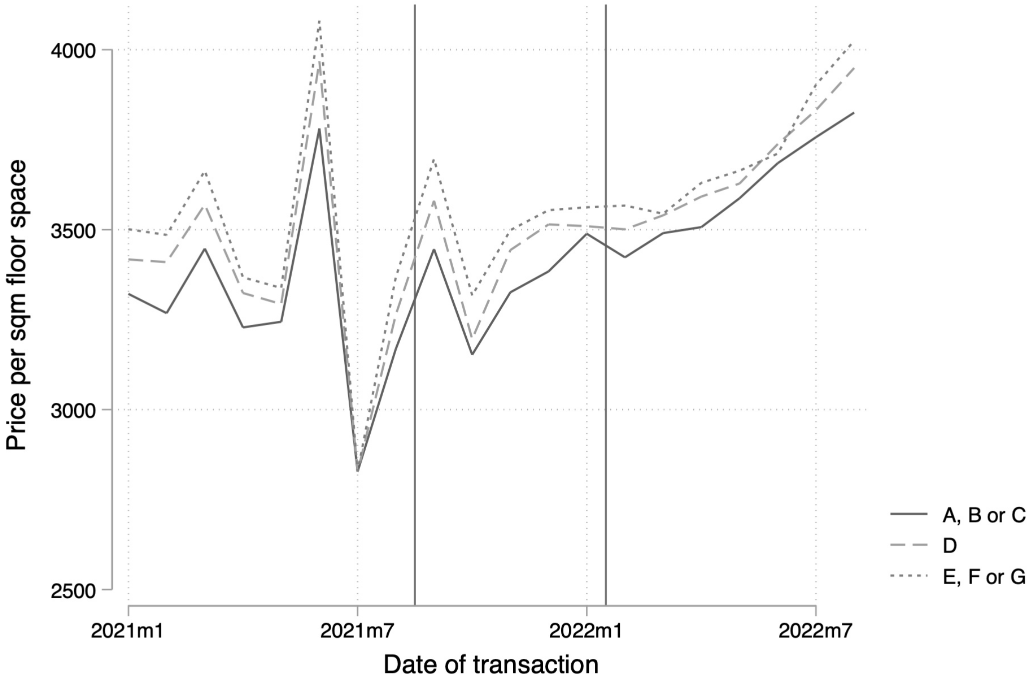
We estimate this general hedonic model within a difference-in-differences (DiD) framework as follows:

$$\text{Ln}(P_{int}) = \alpha + \text{EPC}_i^e + \tau(\text{Post-invasion}_t \times \text{EPC}_i^e) + \lambda_{nt} + \epsilon_{it}$$

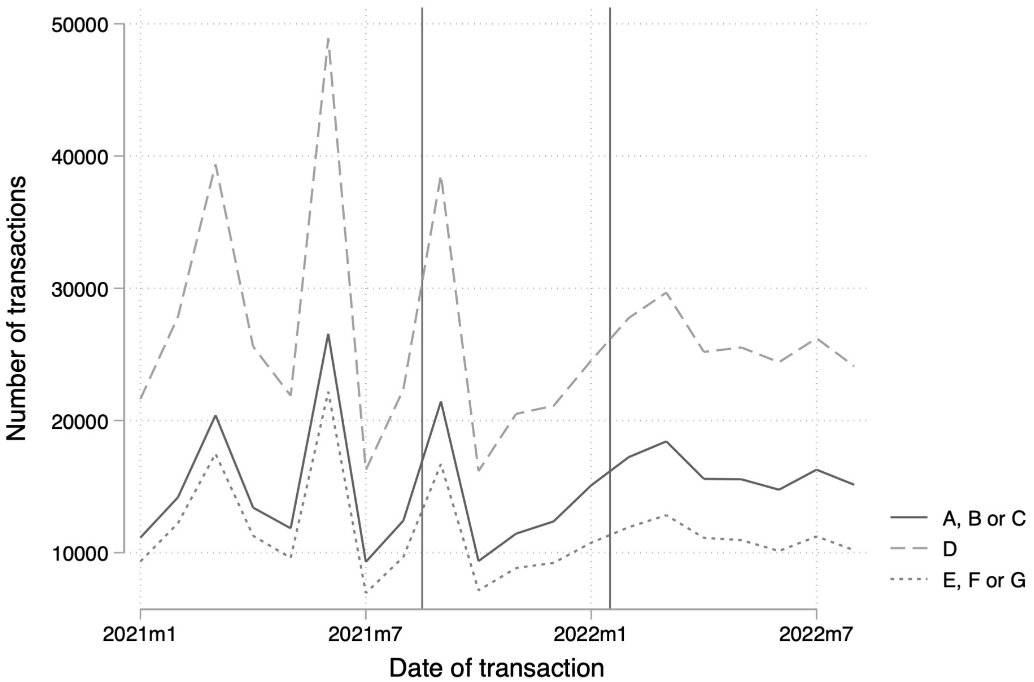
where $\text{Ln}(P_{it})$ is the natural logarithm of the transaction price per square meter for house i located in neighbourhood n in month t. EPC_i^e denotes an EPC rating fixed effect where e can be high (category A, B, or C), medium (D) or low (E, F, G) – our omitted group throughout the paper is the medium EPC rating unless stated otherwise. Post-invasion_t takes the value 1 if the house was sold after February 2022, and 0 otherwise; in some specifications we set this date to September 2021 to capture the earlier increase in gas prices. ϵ is an idiosyncratic error term. We also include a range of fixed effects to capture unobserved factors at the neighbourhood and time level. In our preferred specification we include neighbourhood-by-time fixed effects, λ_{nt} – the interaction between the neighbourhood n fixed effect and the month (t) fixed effect – that captures time-varying and time-constant neighbourhood-level confounders, such as local house price trends, access to amenities, gentrification or the quality of the local housing stock as well as any possibly regionally-differentiated macroeconomic shocks. In alternative specifications, we replace these with separate fixed effects for neighbourhoods and time or a combination of neighbourhood and local-authority-by-time fixed effects. We also estimate more comprehensive versions using repeated sales in the same street and including street fixed effects as well as property characteristics. While these can be expected to capture more potential confounders, they also drastically reduce the effective sample size as the street fixed effects absorb any case where only one property in a street was sold. We cluster standard errors at the neighbourhood level. Our source of identifying variation comes from moving to the post-invasion period across houses in the same local area, after accounting for time specific local area confounding factors and allowing houses with different EPC ratings to have different price levels.

In order for τ to be interpreted as a causal effect, two key identifying assumptions should be met. First, the parallel trends assumption, i.e., both treated and control units would have followed an identical trend in the absence of the Ukrainian invasion and the resulting increase in energy prices. While the common trend assumption is fundamentally untestable as it involves counterfactual situations, a commonly used supporting piece of evidence are identical trends in the pre-treatment period. Figure 3 Panel (a) presents the average price per m^2 for each month in the sampled period by energy rating. Panel (b) shows the number of transactions split in the same way. The solid grey lines mark February 2022 in which the Russian invasion of Ukraine took place. Up to this point – and indeed beyond – both the price and number of transactions appear to fluctuate in tandem irrespective of the energy rating. The plots suggest that common trends hold prior to February 2022 and that house prices were not differentially affected after the invasion of Ukraine and the ensuing energy price cap rises. We test this assumption more formally later using a full event study framework where we estimate monthly treatment effects relative to January 2022. We also use a recent method proposed by Rambachan and Roth (2022) that uses violations of common trends in the pre-treatment period to place restrictions on possible

Figure 3: Property transactions and prices by energy rating



(a) Price per m^2 floor space



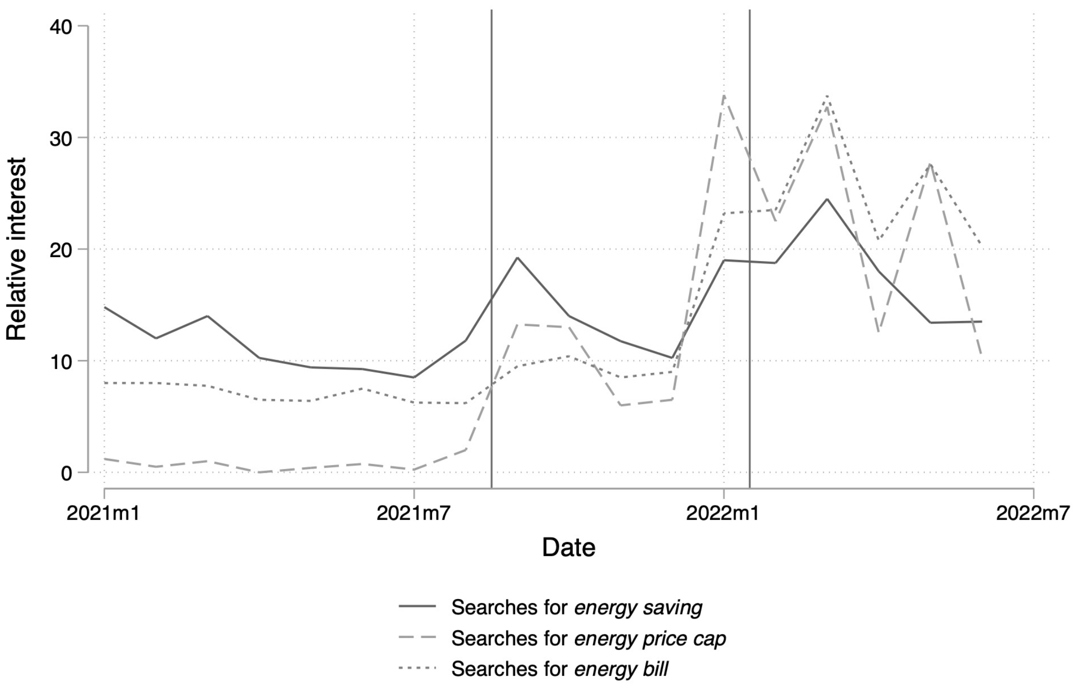
(b) Number of transactions

Notes: The first solid line marks the drop in Russian gas supplied to Europe in September 2021, the second line the beginning of the Russian invasion of Ukraine in February 2022.

violations in the post-treatment period.

Second, we need to assume a no anticipation condition, i.e., potential buyers were unaware that energy price would increase – depending on what is used as the treatment timing, either of the drop in Russian supply from the summer of 2021 or the Russian invasion of Ukraine. While this appears to be a reasonable assumption given the context, we investigate this possibility using Google trend data for three search terms, "energy savings", "energy price cap" and "energy bill" from January 2021 to June 2022. Additionally, this also allows us to test whether prospective buyers could reasonably be assumed to be aware of the energy price increases once they actually occurred. Figure 4 suggests that interest in these terms first increases during the summer of 2021, increased further at the beginning of 2022 and remained high until the summer of 2022. Overall this pattern suggests that there does not appear to be a great deal of anticipation and that the UK population became increasingly aware of and interested in high energy prices once these prices increased.

Figure 4: Public interest in energy prices, Google searches



The graph compares interest measures from Google trends for the respective terms. Numbers represent search interest relative to the highest point on the chart for the given region and time. A value of 100 is the peak popularity for the term. A value of 50 means that the term is half as popular. A score of 0 means there was not enough data for this term. The first solid line marks the drop in Russian gas supplied to Europe in September 2021, the second line the beginning of the Russian invasion of Ukraine in February 2022.

We then conduct a battery of robustness checks. We first implement a randomisation inference procedure, where we randomise each property's EPC rating and recalculate our estimates 500 times to investigate to what extent our results could be explained by chance. In a next step, we explore alternative definitions of the outcome, using levels instead of logarithms and using the raw price of the whole property instead of the price per square meter of floor space. We also explore the effects of setting the treatment timing to September 2021 when the first sudden increase in gas prices was observed. Finally, we use the neighbourhood level data for a supplementary analysis. Specifically, we estimate the following difference-in-differences regression at the neighbourhood level:

$$Y_{nlt} = \alpha_n + \lambda_{lt} + \tau(\text{Post-invasion}_t \times \text{Avg. gas consumption in } 2019/20_n) + \epsilon_{nlt}.$$

Our outcome is either the (logarithm of the) average price per neighbourhood n (nested within a local authority l) and month t or the number of transactions in that neighbourhood, α_n and λ_{lt} are neighbourhood and local authority-by-time fixed effects respectively and ϵ_{nlt} is again an error term. Our cross-sectional treatment intensity is based on a neighbourhood average gas consumption per household in either 2019 or 2020. We use three different measures - a continuous treatment intensity, the consumption in kilowatt hours per household, and two dummy variables indicating whether a neighbourhood was in the top 25% or top 10% of gas consumption nationwide. Our post-period is again defined to begin after the Russian invasion.

4 Results

4.1 Main results and robustness

Table 3 presents our main results, distinguishing between properties with a rating of A, B and C or E, F and G respectively. In column (1) we begin with a parsimonious specification and add increasingly granular fixed effects for time and space. This exercise culminates in column (7) where we include neighbourhood-by-month-by-year fixed effects which partials out all local area time specific trends in house prices. This is our preferred specification as it makes a comparison of property sales within a tightly-defined geographic location at the same point in time. Columns (8) and (9) add further controls for property characteristics that attenuate possible concerns regarding composition bias, while columns (10) and (11) additionally add street segment fixed effects.[10] Inspecting the two DiD interaction terms across the table, the results are not suggestive of a premium for the most energy efficient houses as soon as any area fixed effects are included, but are suggestive of a penalty slightly below 1% for the least energy-efficient properties – although this disappears when looking at repeated purchases in the same street.

To explore our results more thoroughly we estimate an event study DiD. We normalise treatment effects to zero in the month before the invasion, January 2022, and present estimates from our main specification with neighbourhood-by-time fixed effects graphically in Figure 5. While pre-trends are generally close to zero there is some evidence for a divergence in the summer of 2021. Focusing on the time period after the invasion of Ukraine, we see little evidence for a divergence in prices for either EPC ratings A, B and C or E, F and G relative to D.

As the event study estimates suggest possible deviations from the common trend assumption in the pre-treatment period, we conduct a formal sensitivity test proposed by Rambachan and Roth (2022). The underpinning idea is to place restrictions on the possible deviations from the common trend assumption in the post-treatment period based on the observed deviations in the

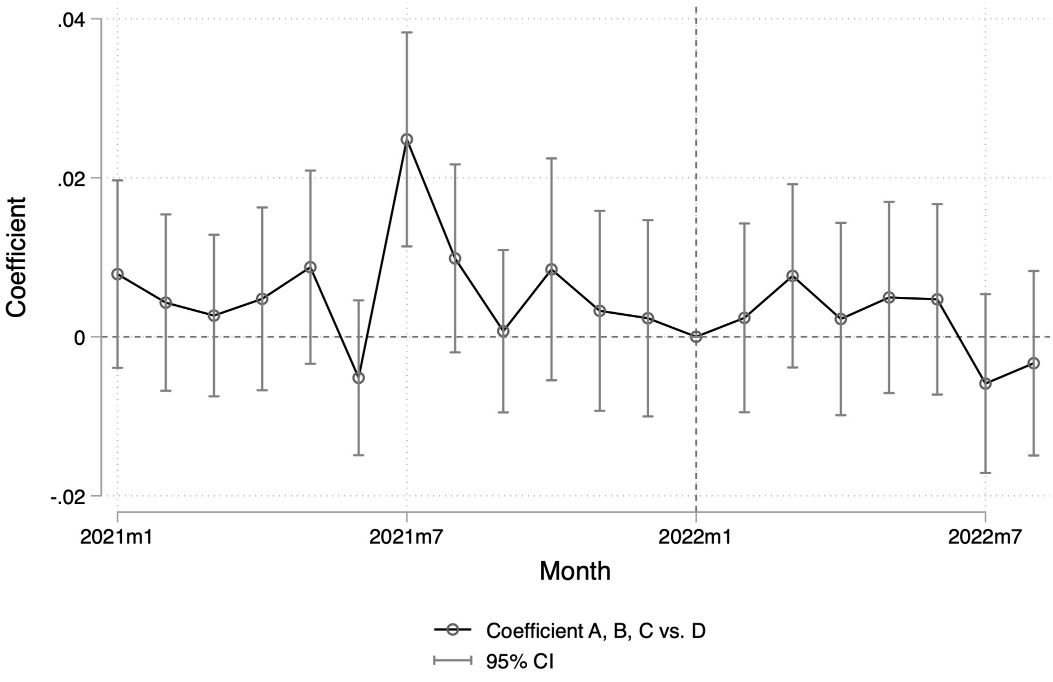
[10]Our measure of a street segment is a UK unit postcode. These cover on average 15 addresses.

Table 3: Impact of energy efficiency on property prices, main estimates

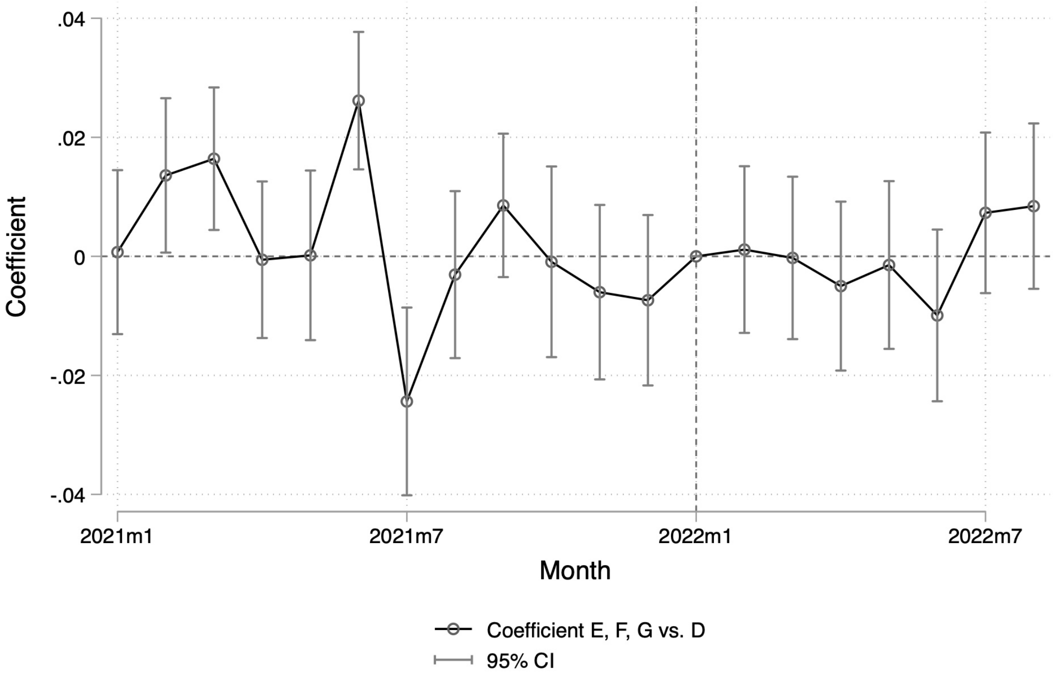
	Ln(Price per m^2 floor space)										
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Energy rating (A, B or C) × Post-invasion	0.015***	0.014***	-0.001	-0.006***	-0.002	-0.005***	-0.000	-0.003***	0.001	-0.007***	-0.007***
	(0.003)	(0.003)	(0.002)	(0.001)	(0.002)	(0.001)	(0.002)	(0.001)	(0.002)	(0.001)	(0.001)
Energy rating (E, F or G) × Post-invasion	-0.015***	-0.014***	-0.007***	-0.004**	-0.009***	-0.005***	-0.007***	-0.008***	-0.009***	-0.002	-0.002
	(0.003)	(0.003)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.001)	(0.002)	(0.002)	(0.002)
Observations[(1)]	1,059,518	1,059,518	1,059,518	1,059,465	1,059,510	1,059,457	857,073	1059457	857,073	767,090	767,090
EPC FEs	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Month-by-year FE		✓	✓	✓							
Local authority FE			✓								
Neighbourhood FE				✓		✓		✓			
Local authority × Month-by-year FE					✓	✓		✓		✓	
Neighbourhood × Month-by-year FE							✓		✓		✓
Street FE										✓	✓
Property characteristics[(2)]								✓	✓	✓	✓

*Notes: Coefficients, standard errors adjusted for clustering at the LSOA level in parentheses. */**/*** denote statistical significance on the 10%, 5% and 1% level respectively.* [(1)] *Observations are effective sample sizes excluding singleton observations for the respective set of fixed effects.* [(2)] *Property characteristics are: The number of habitable rooms, total floor space in m^2 as well as fixed effects for property type, built form, age of construction (15 categories) and the tenure at the time the EPC was obtained (9 categories).*

Figure 5: Event study estimates



(a) Rating A, B, C vs. D

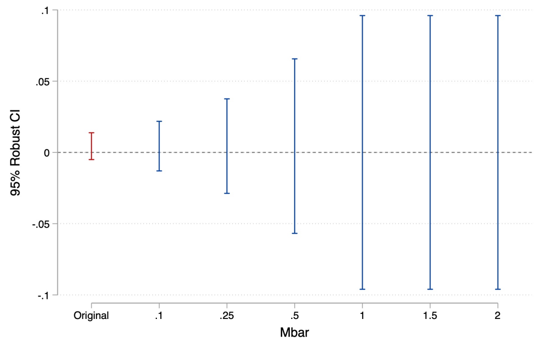


(b) Rating E, F, G vs. D

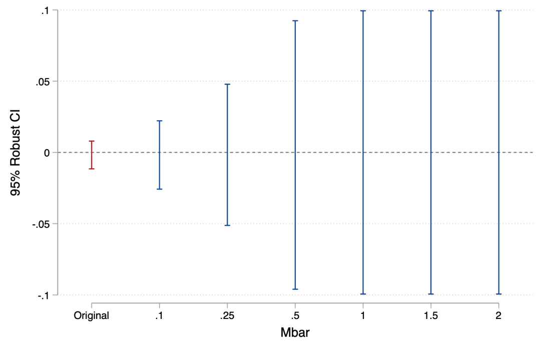
Notes: The figure displays the estimates, along with their 95% confidence interval, relative to January 2022. Estimates include LSOA-by-time fixed effects.

pre-treatment period. Figure 6 presents 95% confidence intervals based violations of the post-treatment common trend equal to 0.1, 0.2, 0.5, 1, 1.5 and 2 times the maximum observed deviation in the pre-treatment period. Panels (a) and (b) do this for the overall effect in the post-treatment period. In line with the event study evidence, estimates are not suggestive of any statistically significant change in property valuations.

Figure 6: Sensitivity to common trend violations



(a) Rating A, B, C vs. D, overall post effect



(b) Rating E, F, G vs. D, overall post effect

Notes: The figures show sensitivity estimates based on relative magnitude restrictions as proposed by Rambachan and Roth (2022) and a specification with LSOA-by-time fixed effects. Presented are the original estimate as well as estimates sensitive to violations of the post-treatment common trend equal to 01. 0.25, 0.5, 1, 1.5 and 2 times the maximum observed deviation in the pre-treatment period.

4.2 Robustness checks

In this section we present results from a series of further robustness tests and placebo exercises. First, to evaluate whether our reported estimates are simply observed by chance, we perform a randomisation inference procedure: We randomise the observed EPC rating for each transaction 500 times and estimate a treatment effect for each random draw. Results are summarised in Table 4, where we report the observed effect, the number of replications that resulted in an effect that is larger in absolute value then the observed effect (c), the resulting empirical p-value (equal to $c/500$) and it's standard error. These results essentially confirm our main results – there is little evidence for an increase in the price of more energy-efficient properties after the invasion, but possibly an emerging penalty for the least energy efficient properties. For the former, effect sizes are generally well in the middle of the distribution, while the latter effects is found in the right tail of the placebo distribution.

Next, we consider an alternate post-period. As stated earlier, gas prices experienced a sharp increase in the summer of 2021 after a drop in supply of Russian gas via the Yamal-Europe pipeline. It seems possible that forward-looking consumers reacted to this increase instead of waiting for domestic changes in energy tariff and price cap changes. To test this idea, we set the post-period to begin in September 2021 once the wholesale gas prices had spiked. We re-estimate our main analysis with this timing in Table 5. In the preferred specification in column (2), we again find evidence for a small penalty for the least-energy efficient properties, but no corresponding premium for the most efficient properties.

Table 4: Robustness: Randomisation inference, 500 replications

	Observed effect	c	p = c/500	se(p)
LSOA-by-time FEs				
Energy rating (A, B or C) × Post-invasion	-0.001	216	0.4320	0.0222
Energy rating (E, F or G) × Post-invasion	-0.007	0	0.0000	0.0000

Notes: The dependent variable is Ln(Price per m^2 floor space). Observed effects equals the coefficient from columns (6) and (7) in Table 3. c denotes the number of permutations where $|\tau| > |\tau^{obs}|$. Estimates include LSOA-by-time fixed effects.

Table 5: Robustness: Treatment time set to September 2021

	Ln(Price per m^2 floor space)	
	(1)	(2)
Current energy rating: A, B or C	-0.030***	-0.035***
	(0.001)	(0.001)
Energy rating (A, B or C) × Post-Sep. 2021	-0.008***	-0.002
	(0.001)	(0.002)
Current energy rating: E, F or G	-0.008***	-0.005***
	(0.001)	(0.001)
Energy rating (E, F or G) × Post-Sep. 2021	-0.006***	-0.010***
	(0.001)	(0.002)
Observations[(1)]	1,059,457	857,073
Neighbourhood FE	✓	
Local authority × Month-by-year FE	✓	
Neighbourhood × Month-by-year FE		✓

*Notes: Coefficients, standard errors adjusted for clustering at the LSOA level in parentheses. */**/*** denote statistical significance on the 10%, 5% and 1% level respectively. [(1)] Observations are effective sample sizes excluding singleton observations for the respective set of fixed effects.*

4.3 Additional analysis and possible explanations

Neighbourhood-level evidence: We corroborate our results at an alternative level of analysis that also allows us to investigate changes to the number of market transactions and using an alternative treatment indicator. Specifically, we consider average prices and the number of property transactions per neighbourhood and month and relate these to measures of historical energy consumption as described earlier. Specifically, we estimate two dose-response DiD regressions using average gas consumption in either 2019 or 2020 and four DiD regressions where we class neighbourhoods as having a high energy consumption if they are above the 75^{th} or 90^{th} percentile in, respectively, 2019 or 2020. We then consider changes to prices following the invasion of Ukraine. Table 6 presents results: We find little evidence that prices in neighbourhoods with higher gas consumption drop. However, as the bottom panel of Table 6 suggests that there were fewer transactions in neighbourhoods with high gas consumption following the Russian invasion of Ukraine, which is again suggestive of a decline in the attractiveness of relatively more energy consuming housing.

Disaggregated EPC ratings: If the results suggesting a possible penalty for less energy-efficient properties are indeed due to changes to energy prices, we would expect that the penalty becomes larger, the lower the rating a property has. In Table 7 we present estimates using each EPC rating separately. Focusing on the DiD interactions again does not suggest a premium for properties rated as A, B or C, but there is again evidence for a penalty for the least efficient properties. In our preferred specification, this penalty is also increasing with a lack of energy efficiency: Prices for E-rated properties drop by 0.6%, those for F-rated properties by 1% and those for G-rated properties by 2.8% after the invasion of Ukraine.

Heterogeneity by neighbourhood characteristics: In Table 8 we explore some heterogeneity across properties in different neighbourhoods. Columns (2) to (5) investigate differences across urban and rural areas, while columns (5) to (8) look at more and less affluent areas (proxied by the proportion of the population in higher social classes). There is, however, again little indication that prices changes after the invasion of Ukraine react differentially across these neighbourhood types. While statistical significance changes across columns, point estimates usually have the same sign as the main estimates and are usually of a similar size.

Population expectations: Our estimates so far suggest that prices for more or less energy efficient properties only changed in a fairly muted way in the aftermath of the Russian invasion of Ukraine, despite a sharp increase in the cost of energy. We can rule out one possible explanation, namely, that the population is either unaware of or unconcerned about the sudden increase in energy prices. Both do not align with the Google search trend data presented earlier in Figure 4, while the high prevalence of fuel poverty in the UK (see Table 1) as well as the fact that the UK government felt the need to intervene several times with support packages for households weigh heavily against an unconcerned population as a possible explanation.

However, an open question is whether the UK population thinks about this shock as a permanent or transitory increase in energy prices. Properties are long-term investments, so energy price increases that are perceived as purely temporary might not trigger changes to the valuation of a property's energy efficiency in the same way changes perceived as permanent would. While

Table 6: Neighbourhood-level evidence on prices and transactions

	Ln(Price per m^2 floor space)					
	Based on 2019 consumption			Based on 2020 consumption		
	(1)	(2)	(3)	(4)	(5)	(6)
Avg. consumption per HH	-0.000			0.000		
× Post-invasion	(0.000)			(0.000)		
Avg. consumption ≥ 75^{th} percentile		-0.001			0.000	
× Post-invasion		(0.003)			(0.003)	
Avg. consumption ≥ 90^{th} percentile			0.007*			0.007*
× Post-invasion			(0.004)			(0.004)
Observations[(1)]	553,212	568,814	568,814	553,140	568,814	568,814
	Number of transactions					
Avg. consumption per HH	-0.022***			-0.019***		
× Post-invasion	(0.002)			(0.002)		
Avg. consumption ≥ 75^{th} percentile		-0.105***			-0.097***	
× Post-invasion		(0.011)			(0.011)	
Avg. consumption ≥ 90^{th} percentile			-0.073***			-0.069***
× Post-invasion			(0.015)			(0.015)
Observations[(1)]	676,220	695,040	695,040	676,120	695,040	695,040
Neighbourhood FE	✓	✓	✓	✓	✓	✓
Local authority × Month-by-year FE	✓	✓	✓	✓	✓	✓

*Notes: Coefficients, standard errors adjusted for clustering at the LSOA level in parentheses. */**/*** denote statistical significance on the 10%, 5% and 1% level respectively.*
[(1)] *Observations are effective sample sizes excluding singleton observations for the respective set of fixed effects.*

Table 7: Detailed energy efficiency categories

	Ln(Price per m^2 floor space)	
	(1)	(2)
Current rating:		
A	0.084***	0.094***
	(0.018)	(0.025)
B	-0.101***	-0.109***
	(0.004)	(0.004)
C	-0.029***	-0.032***
	(0.001)	(0.001)
E	-0.010***	-0.009***
	(0.001)	(0.001)
F	-0.001	-0.001
	(0.002)	(0.003)
G	-0.039***	-0.031***
	(0.005)	(0.006)
A × Post-invasion	-0.020	0.001
	(0.028)	(0.041)
B × Post-invasion	-0.027***	-0.012*
	(0.005)	(0.006)
C × Post-invasion	-0.004***	0.000
	(0.001)	(0.002)
E × Post-invasion	-0.005***	-0.006***
	(0.002)	(0.002)
F × Post-invasion	-0.009**	-0.010**
	(0.004)	(0.005)
G × Post-invasion	-0.006	-0.028**
	(0.009)	(0.012)
Observations[(1)]	1,059,457	857,073
Neighbourhood FE	✓	
Local authority × Month-by-year FE	✓	
Neighbourhood × Month-by-year FE		✓

*Notes: Coefficients, standard errors adjusted for clustering at the LSOA level in parentheses. */**/*** denote statistical significance on the 10%, 5% and 1% level respectively. [(1)] Observations are effective sample sizes excluding singleton observations for the respective set of fixed effects.*

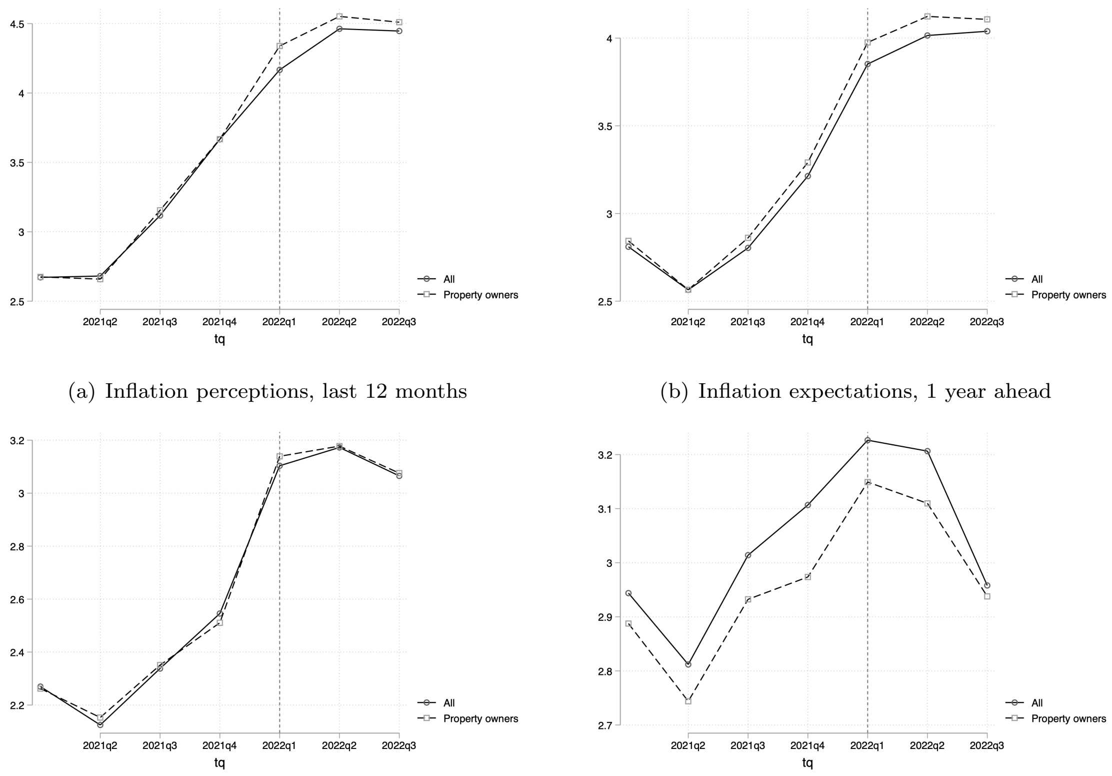
Table 8: Impact of energy efficiency on property prices, heterogeneity by neighbourhood characteristics

	Ln(Price per m^2 floor space)							
		Urban-rural			Higher management & professional		All management & professional	
	Baseline (1)	Urban (2)	Conurbation (3)	Rural (4)	Top 25% (5)	Bottom 25% (6)	Top 25% (7)	Bottom 25% (8)
Specification 1: LSOA FEs and LA-by-time FEs								
Current energy rating: A, B or C	-0.032***	-0.033***	-0.034***	-0.029***	-0.071***	0.019***	-0.070***	0.019***
	(0.001)	(0.001)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Energy rating (A, B or C) × Post-invasion	-0.006***	-0.007***	-0.012***	-0.001	-0.011***	-0.000	-0.011***	-0.001
	(0.001)	(0.001)	(0.002)	(0.003)	(0.002)	(0.003)	(0.002)	(0.003)
Current energy rating: E, F or G	-0.010***	-0.013***	-0.007***	-0.000	0.026***	-0.051***	0.025***	-0.050***
	(0.001)	(0.001)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Energy rating (E, F or G) × Post-invasion	-0.005***	-0.005***	-0.006**	-0.004	-0.002	-0.004	-0.001	-0.005
	(0.002)	(0.002)	(0.003)	(0.004)	(0.003)	(0.004)	(0.003)	(0.004)
Observations[(1)]	1,059,457	861,654	323,864	197,689	294,013	193,400	298,046	185,373
Specification 2: LSOA-by-time FEs								
Current energy rating: A, B or C	-0.036***	-0.037***	-0.038***	-0.029***	-0.071***	0.017***	-0.070***	0.019***
	(0.001)	(0.001)	(0.002)	(0.003)	(0.002)	(0.003)	(0.002)	(0.003)
Energy rating (A, B or C) × Post-invasion	-0.001	-0.002	-0.007**	0.003	-0.009***	0.008*	-0.010***	0.007
	(0.002)	(0.002)	(0.003)	(0.005)	(0.003)	(0.005)	(0.003)	(0.005)
Current energy rating: E, F or G	-0.009***	-0.012***	-0.004**	0.002	0.024***	-0.052***	0.025***	-0.051***
	(0.001)	(0.001)	(0.002)	(0.003)	(0.002)	(0.003)	(0.002)	(0.003)
Energy rating (E, F or G) × Post-invasion	-0.007***	-0.007***	-0.011***	-0.007	-0.004	-0.003	-0.005	-0.006
	(0.002)	(0.002)	(0.004)	(0.005)	(0.004)	(0.005)	(0.004)	(0.006)
Observations[(1)]	857,073	695,923	246,744	161,150	244,684	140,974	248,899	132,885

*Notes: Coefficients, standard errors adjusted for clustering at the LSOA level in parentheses. */**/*** denote statistical significance on the 10%, 5% and 1% level respectively.*
(1) *Observations are effective sample sizes excluding singleton observations for the respective set of fixed effects.*

we do not have information on specific expectations regarding energy levels, we can consider general inflation expectations, both for the population at large and property-owners. As high energy prices are the main driver of general inflation over the period in question, a situation where inflation expectations remained high over the medium term would suggest that people do not expect energy prices to drop in the foreseeable future. To do so we use the quarterly Band of England/Ipsos Inflation Attitudes Survey for the period Q1 2021 to Q3 2022. Figure 7 presents results – separately for all respondents and those who own property – for inflation perceptions in the last 12 months (Panel (a)) as well as inflation expectations for the next year (Panel (b)), the next two years (Panel (c)) and the next five years (Panel (d)). While both inflation perceptions and 1-year inflation expectations keep increasing until the 3rd quarter of 2022, crucially 2-year and in particular 5-year inflation expectations peak at around the time of the Russian invasion in Q1 2022 and subsequently begin to drop – fairly strongly in the case of 5-year expectations. Overall this provides suggestive evidence that the UK population might well expect overall prices to normalise over the short to medium terms. If this applied equally to energy prices, it seems plausible that people's willingness to pay for energy efficiency had not changed after the invasion.

Figure 7: Perceptions and expectations about inflation



(a) Inflation perceptions, last 12 months

(b) Inflation expectations, 1 year ahead

(c) Inflation expectations, 2 years ahead

(d) Inflation expectations, 5 years ahead

Notes: Band of England/Ipsos Inflation Attitudes Survey, data for Q1 2021 to Q3 2022, 20,234 observations, https://www.bankofengland.co.uk/inflation-attitudes-survey/2022/august-2022.

Potential vs. current energy efficiency: It is possible that property buyers are forward looking and care more about future (potential) rather than current energy efficiency. To test this idea we rely on the potential energy rating of each property that is achievable with investments such as additional insulation, the replacement of windows or the installation of solar panels or heat pumps. This data allows us to explore whether buyers are forward looking in the sense that houses with future high (low) EPC ratings command a premium (penalty) price. Table 9 and Figure 8 replicate the results from Table 3 and Figure 5 using potential instead of current EPC ratings. There is some indication in Table 9 that prices of the potentially more energy efficient properties increased after the Russian invasion of Ukraine. However, both the results for the least energy efficient houses and the event studies are less in line with this explanation.

Table 9: Estimates using potential energy efficiency

	Ln(Price per m^2 floor space)	
	(1)	(2)
Potential energy rating: A, B or C	-0.025***	-0.026***
	(0.001)	(0.002)
Potential energy rating (A, B or C) × Post-invasion	0.012***	0.015***
	(0.002)	(0.003)
Potential energy rating: E, F or G	0.022***	0.026***
	(0.003)	(0.004)
Potential energy rating (E, F or G) × Post-invasion	0.004	0.006
	(0.006)	(0.008)
Observations[(1)]	1,059,457	857,073
Neighbourhood FE	✓	
Local authority × Month-by-year FE	✓	
Neighbourhood × Month-by-year FE		✓

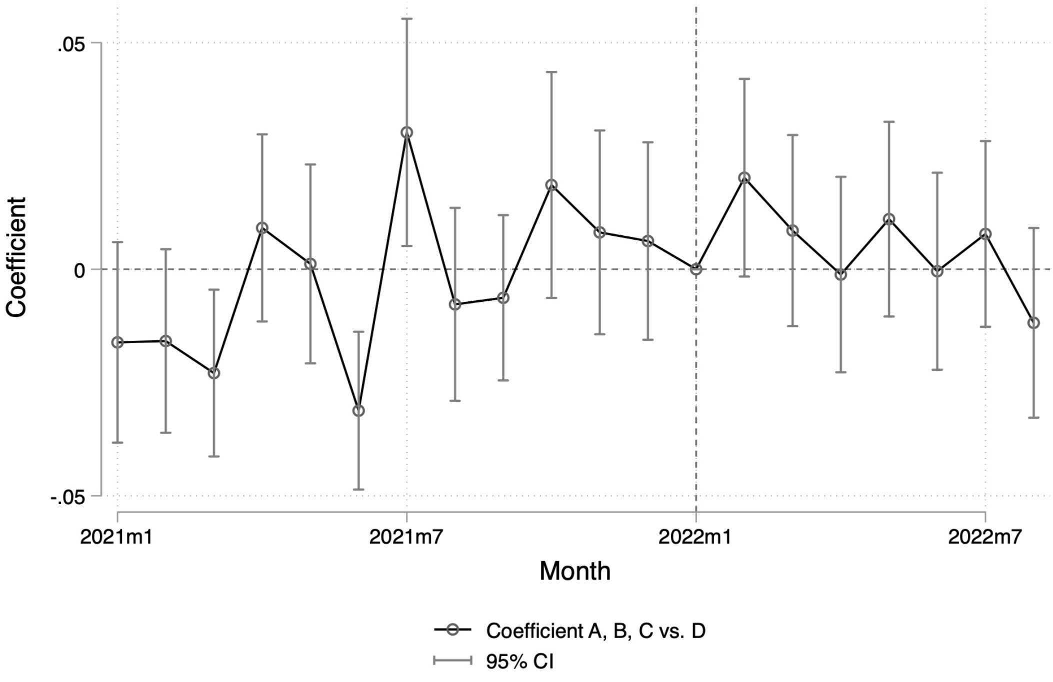
*Notes: Coefficients, standard errors adjusted for clustering at the LSOA level in parentheses. */**/*** denote statistical significance on the 10%, 5% and 1% level respectively. [(1)] Observations are effective sample sizes excluding singleton observations for the respective set of fixed effects.*

Housing market frictions: A final explanation are frictions in the housing market. Specifically, the UK housing market is characterised by chains of transactions where buyers need to sell their old home in order to buy a new property. This ultimately creates a situation where buyers or sellers might be reluctant to pull out of or renegotiate already agreed deals and risk collapsing this chain of transactions, even if their valuation of a property changes due to an external shock. To give some perspective on timelines, consumers' advice company Which? (2020) suggests that it takes on average 22 weeks between the start of house hunting and the exchange of contracts (the point at which the purchase become legally binding) and then usually another two weeks between the exchange of contracts and completion. Taking into account that it can easily take 4 to 8 weeks to locate an appropriate property suggests that we should see effects towards the end of our observation period – which is, however, not generally the case.

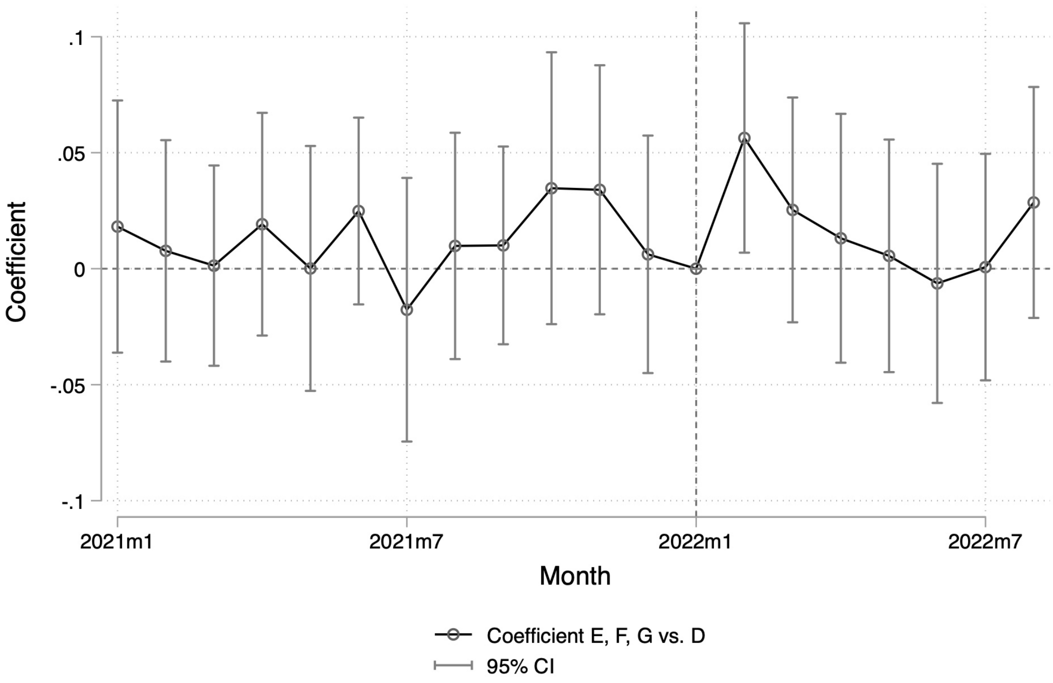
5 Conclusion

Using a difference-in-difference design and leveraging the sharp increase in energy prices due to the Russian invasion of Ukraine in February 2022, we investigated the reaction of UK housing markets to this shock, specifically the question to what extent house buyers' valuation of property energy efficiency changed. Across both a property and a neighbourhood dataset and various

Figure 8: Event study estimates, potential energy rating



(a) Rating A, B, C vs. D, specification 2



(b) Rating E, F, G vs. D, specification 2

Notes: The figure displays the estimates, along with their 95% confidence interval, relative to January 2022. Specification 1 includes LSOA and LA-by-time fixed effects. Specification 2 includes LSOA-by-time fixed effects.

specifications and robustness checks, we find a comparatively muted reaction of housing markets to a roughly 60% increase in domestic energy prices – there does not appear to be a premium to the most energy-efficient properties and only a comparatively small penalty for the least energy-efficient properties. Looking at possible explanations we find weak evidence that property buyers value properties with higher potential rather than current energy efficiency more after the energy price shock. Most importantly, however, we find evidence consistent with the population believing that the energy price increases are transitory rather than permanent, which might explain buyers low willingness to pay for more energy-efficient housing.

From a policy perspective, the UK government has spent much beyond £100 billion to subsidise household expenditure on energy. Recent evidence by Fetzer et al. (2022) suggest that these subsidies have weakened incentives for households to improve the energy efficiency of their properties. However, energy prices remain significantly higher than before the Russian invasion and there is early evidence that indicates individuals have engaged in short-term energy saving behaviour because of this (Ruhnau et al., 2022; YouGov, 2022). This paper ultimately documents that individuals are not engaging in long-term planning to reduce energy consumption and suggests that this might be due to believes that prices will normalise over the short to medium term. Updating the communication and messaging with a longer-term focus could increase efficiency overall even though the current shock is likely only a temporary one. This is critical when considering the 2050 net-zero target, which will require energy savings and efficiency gains in every sector in the economy.

References

Bachmann, R., Baqaee, D., Bayer, C., Kuhn, M., Löschel, A., Moll, B., McWilliams, B., Peichl, A., Pittel, K., Schularick, M., and Zachmann, G. (2022a). How it can be done. *ECONtribute Policy Brief No. 034.*

Bachmann, R., Baqaee, D., Bayer, C., Kuhn, M., Löschel, A., Moll, B., Peichl, A., Pittel, K., and Schularick, M. (2022b). What if? the economic effects for germany of a stop of energy imports from russia. *ECONtribute Policy Brief No. 028.*

Bauer, T., Braun, S. T., and Kvasnicka, M. (2017). Nuclear power plant closures and local housing values: Evidence from fukushima and the german housing market. *Journal of Urban Ecoonomics*, 99:94–106.

Bhattacharjee, A., Mosley, M., and Pabst, A. (2022). A 'variable energy price cap' to help solve the cost-of-living crisis. *NIESR Policy Paper 34.*

Bosker, M., Garretsen, H., Marlet, G., and van Woerkens, C. (2019). Nether lands: Evidence on the price and perception of rare natural disasters. *Journal of the European Economic Association*, 17(2):413–453.

Braakmann, N. (2017). The link between crime risk and property prices in england and wales: Evidence from street-level data. *Urban Studies*, 54(8):1990–2007.

Brounen, D. and Kok, N. (2011). On the economics of energy labels in the housing market. *Journal of Environmental Economics and Management*, 62(2):166–179.

Chi, B., Dennett, A., Oléron-Evans, T., and Morphet, R. (2021). A new attribute-linked residential property price dataset for england and wales, 2011 to 2019. *UCL Open: Environment Preprint.*

Fetzer, T. (2022). Beyond the energy price guarantee. with or without? *NIESR Policy Paper 36.*

Fetzer, T., Gazze, L., and Bishop, M. (2022). How large is the energy savings potential in the uk? *CAGE working paper no. 644.*

Fuerst, F., McAllister, P., Nanda, A., and Wyatt, P. (2015). Does energy efficiency matter to home-buyers? an investigation of epc ratings and transaction prices in england. *Energy Economics*, 48:145–156.

Gibbons, S. (2004). The costs of urban property crime*. *The Economic Journal*, 114(499):F441–F463.

Gibbons, S. and Machin, S. (2003). Valuing English primary schools. *Journal of Urban Economics*, 53(2):197–219.

Gibbons, S. and Machin, S. (2005). Valuing rail access using transport innovations. *Journal of Urban Economics*, 57(1):148–169.

Greenstone, M. and Gallagher, J. (2008). Does hazardous waste matter? evidence from the housing market and the superfund program. *The Quarterly Journal of Economics*, 123(3):951–1003.

Hyland, M., Lyons, R. C., and Lyons, S. (2013). The value of domestic building energy efficiency — evidence from ireland. *Energy Economics*, 40:943–952.

Kilian, L. (2008). The economic effects of energy price shocks. *Journal of Economic Literature*, 46(4):871–909.

Pinchbeck, E., Roth, S., Szumilo, N., and Vanino, E. (2020). The price of indoor air pollution: Evidence from radon maps and the housing market. *IZA Discussion Paper*, 13655.

Rambachan, A. and Roth, J. (2022). A more credible approach to parallel trends. *Review of Economic Studies*, forthcoming.

Rosenthal, L. (2003). The value of secondary school quality*. *Oxford Bulletin of Economics and Statistics*, 65(3):329–355.

Ruhnau, O., Stiewe, C., Muessel, J., and Hirth, L. (2022). Gas demand in times of crisis: energy savings by consumer group in germany. *Working Paper*.

Which? (2020). Exchange and completion. *https://www.which.co.uk/money/mortgages-and-property/first-time-buyers/buying-a-home/exchange-and-completion-a6n6m8p8czvh*.

YouGov (2022). Energy use survey, october 2022.