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An Estimate of Climate-Related Transition Risk in Irish Mortgage Lending

Tamanna Adhikari, James Carroll and Derek Lambert

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Tamanna Adhikari[1], James Carroll[2] and Derek Lambert [3] [4]

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Abstract

Climate change will potentially affect households through direct weather/climate-related damages ("physical risks") and the policy changes required to achieve a global decarbonisation of production and consumption ("transition risks"). The potential financial stability and economic implications of various transition risk channels are currently difficult to measure due to the nature of data available to most authorities. This paper proposes a new methodology to populate loan-level data with borrower energy and emissions estimates to facilitate the analysis of transition risks. Using these estimates, we consider the possible impacts of a number of future medium and long run carbon price scenarios to household resilience. In our framework, the current carbon intensity of households is key to explaining vulnerability in the transition to net zero, with rural and, in particular, low-income households most at risk. The speed of adopting energy-saving technologies and behaviours are important determinants for mitigating these vulnerabilities. We note that our estimation framework, while providing a platform to analyse climate risk, does not replace the need to collect data from source.

1 Introduction

Increasing global temperatures in the coming decades will lead to more frequent and intense weather-related damages to communities, ecosystems and economic assets ('physical risks'). While long-term damages can be reduced through a rapid global decarbonisation of production and consumption, the policies which underpin such a significant technological and behavioural net-zero transformation will disproportionally impact the financial resilience ('transition risks') of emission-intensive businesses and households. There are potential implications for the banking sector if climate policies reduce borrower ability to service debts (increasing default risk) or erode collateral values (increasing loss given default). Quantifying the share and magnitude of households most affected by climate change is clearly important for overall economic stability as households account for approximately two thirds of outstanding loans provided by banks.[5]

[1] Economist, Macro-Financial Division, tamanna.adhikari@centralbank.ie

[2] Senior Economist, Climate Change Unit, james.carroll@centralbank.ie

[3] Associate Economist, Macro-Financial Division, derek.lambert@centralbank.ie

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[5] Central Bank of Ireland Credit and Banking Statistics (link)

The goal of this article is to explore the impact of long-run policy-driven energy price increases on household financial resilience, to describe the types of households most at risk, and to consider the potential financial stability implications. The main policy driver underpinning this analysis is increased energy prices as a result of carbon (CO_2) tax changes. For example, the current policy commitment in Ireland is to increase CO2 taxes from €41 per tonne (2022) to €100 per tonne in 2030. While there are no additional commitments beyond 2030, long run macroeconomic forecasts (NGFS, 2021) show that CO_2 shadow prices would need to increase continuously to approximately €750 per tonne by 2050 to achieve global net zero emissions.

There are also market-based drivers of energy price increases. For example, a shift in investor sentiment away from fossil fuel sectors would reduce long-run supply and inflate prices, as well as having direct employment effects in the most-emitting sectors. The likelihood of such policy and market changes could increase as weather-related damages (IPCC, 2022) become more frequent and intense.

The impact of rising energy prices on energy bills is highly heterogeneous. For example, a household's demand for "energy services" (for example, litres of hot water and kilometres of transportation) depends on the type and number of occupants (for example, family composition and time spent in the home). Other drivers of household energy costs include scale (simply – bigger properties and vehicles) and the energy efficiency of technologies (higher efficiency increases the volume of energy services per unit of fuel). The specific pass-through of CO_2 taxes to final fuel prices also depends on the CO_2-intensity of fuels used by the household, with, for example, renewable electricity (zero CO_2 per kilowatt) and coal (very high CO_2 per kilogram) occupying the extremes. This heterogeneous impact may also have different welfare implications for households depending on their energy expenditure as a share of their income, which itself is a function of underlying household characteristics. Climate impact hence, may be shared disproportionately by households depending upon their economic and geographical characteristics.

A central bank's ability to monitor this potential source of financial instability is inhibited by data gaps – internationally, the vast majority of credit registers do not contain energy and emissions information. Until data gaps are filled, this article presents a methodology to estimate these missing variables using observable borrower and property characteristics (variables shown to be significantly correlated with these energy variables). Finally, our analysis applies a number of energy price shocks to households by incorporating a number of future CO_2 tax scenarios to explore the characteristics that affect vulnerabilities. Our main results show that the energy/carbon intensity of households differs considerably, and that household characteristics (location, size, type and income, for example) explain current/future vulnerability to energy price increases. The medium/long run implications for broader financial stability will also depend on income growth and, in particular, the speed of household decarbonisation through, for example, energy efficiency improvements, switching to lower emission fuels (renewable electricity) and behavioural change.

2 Methodology and Data

Our methodology for populating mortgage loans with energy and emissions estimates is outlined in Table 1. Our mortgage loan-level dataset (LLD) is sourced from the Central Bank of Ireland's *Monitoring Templates Data*. This dataset collects information on all new mortgages within each six-month period and is submitted by financial institutions as part of the macroprudential mortgage measures introduced in 2015.[6] For this exercise, our data includes 218,311 loans from eight lenders representing €50.6 billion of new lending between 2015 and 2021 (latest full year)[7].

Table 1: **Estimation Steps and Data Sources**

Analysis Step	Data Source	Details
1. Identify common variables in LLD and HBS	HBS (CSO); LLD (CBI)	Exercise considers all property and occupant characteristics which are expected to be correlated with energy consumption
2. Estimate annual energy expenditure variable	HBS (CSO)	Combine weekly figures for different fuel expenditures (electricity, gas, heating oil, diesel, petrol and solid fuels) and convert to annual
3. Estimate carbon emissions variable	HBS (CSO); Conversion Factors (SEAI); Prices (Eurostat; SEAI; EC)	For each fuel expenditure, divide by national price level and multiply by emission conversion factors
4. Explore energy/emission correlates	HBS (CSO)	Regress (OLS) dependent variables from Step 2 and Step 3 on independent variables from Step 1
5. Populate loans with energy and emissions estimates	LLD (CBI)	For each variable from Step 1, multiply associated coefficient values from Step 4; combine to create energy and emissions estimate for each loan
6. Simulate future energy price shocks	CO_2 Tax Scenarios (NGFS); National Policy Commitments	Measure change in resilience/vulnerability share a range of carbon price scenarios,

Source: The Household Budget Survey (HBS) is sourced from the Irish Social Science Data Archive (University College Dublin); Conversion factors sourced from the Sustainable Energy Authority of Ireland (SEAI); Electricity, gas, petrol and diesel prices sourced from Eurostat; Kerosene and solid fuel (coal) prices sourced from SEAI; Future carbon prices based on national policy commitments up to 2030 and from the Network for Greening the Financial System up to 2050 (net zero scenario); Carbon dioxide emissions for petrol and diesel are sourced from www.ecoscore.be
Notes: Electricity price refers to "band DC"; Gas price refers to "band D2"; "Premium coal" price and conversion factors employed for HBS solid fuel expenditure; "Kerosene (typical discounted price)" price and conversion factors employed for HBS home heating oil.

Our estimation method hinges on the assumption that many of the non-energy variables available in mortgage datasets are in fact correlated with energy consumption (for example, property size, property location and borrower income). To provide energy estimates for each borrower in the LLD, we first estimate an energy expenditure model using data from the Irish Central Statistics Office (CSO) *Household Budget Survey* (HBS) from 2015/2016, the results from which quantify the relationships between individual household/property characteristics and total energy expenditure.[8] Using these results, we then create our new energy expenditure estimate for each loan in the mortgage dataset (by multiplying model coefficients with LLD variable values).

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[6] This return is only required of financial institutions that advance at least €50 million of new mortgage lending over a six month period (January – June or July to December), and covers most new mortgage lending in Ireland. When compared with BPFI Mortgage Drawdown data for 2021, new mortgage lending data in the MTD covers approximately 95 per cent of new PDH mortgage lending for 2021 in both volume and value of new lending.

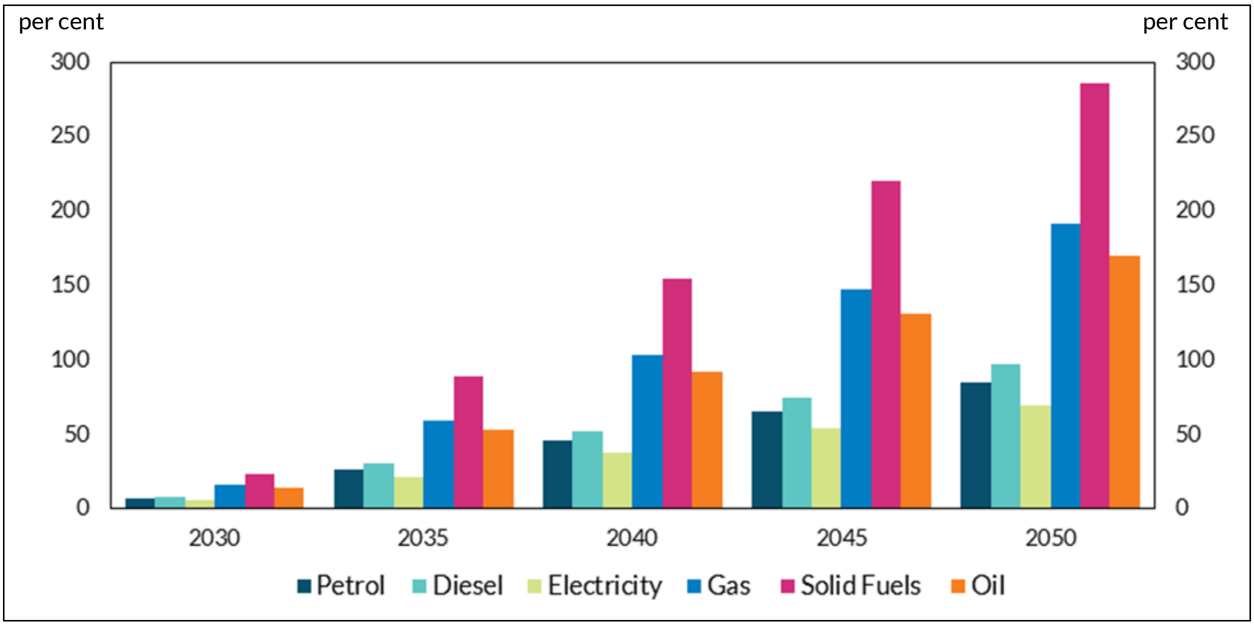
[7] Data derived from a 4 lender sample for 2015, 5 lender sample for 2016, a 6 lender sample for 2017, a 7 lender sample from 2018-2020, and an 8 lender sample for 2021.

[8] The HBS is a nationally representative survey carried out every five years, with the latest available dataset covering February 2015 to February 2016. The survey collects data on all household expenditure, including

This process is repeated for household CO_2 emissions. While the HBS does not contain environmental information, we estimate the emissions associated with each household fuel by first converting expenditures into quantities (dividing by common price levels for survey year) and then converting quantities into CO_2 emissions using energy conversion factors sourced from the Sustainable Energy Authority of Ireland.[9]

To assess the impact of carbon tax increases on the ability of households to service their mortgage related debt, we use the methodology outlined in Adhikari (2022) who describes a household "at risk" if it has with less than 10% disposable income left as buffer after accounting for mortgage payments and essential expenditure. Using this methodology, we explore the share and types of households at risk under various income growth, responsiveness (price elasticity of demand), and energy price scenarios.[10] Our future energy price trajectories are based on current Irish government CO_2 tax commitments to 2030 (from €41/tonne of CO_2 in 2022 to €100 in 2030) and the CO_2 prices which would be required to meet 2050 net zero emissions from the NGFS (approximately €750/tonne by 2050).[11] Figure 1 presents the price forecasts for various household fuels based on these policy changes.

Figure 1: Energy Price Changes, 2022 to 2050



Source: own calculations using Irish government carbon tax commitments to 2030 and approximate shadow carbon prices from NGFS (*net zero scenario*)
Notes: the relationship between carbon taxes and final fuel prices depends on the carbon intensity of each fuel. In this regard, we employ carbon conversion factors for each fuel (sourced from the SEAI). Base period is May 2022.

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how much it spends on individual energy items – electricity, gas, petrol, diesel, solid fuels and heating oil. For the majority of expenditure items, the household maintains a detailed expenditure diary over the two-week survey period. For irregular items, such as electricity/gas bills or bulk oil/solid fuel expenditures, households provide their most recent bill amount and this is converted into indicative weekly figures by the CSO.

[9] Available here

[10] Due to the difficulties in predicting long-term inflation rates, we assume that the share of expenditure on each category of essential spending remains constant. This assumption might seem restrictive at the household level but less so when one considers the mean values for the entire economy.

[11] We do not assume any major changes to the technological improvements in the production of energy in estimating these changes in energy expenditure over the period under consideration.

3 Results

3.1 Descriptive Analysis of Household Energy Expenditure Data

We begin the analysis by providing a general description of total household energy expenditure (fuel expenditure for property and transport) and estimated CO_2 emissions in the latest HBS from 2015/2016. The goal of this section is to quantify the significant heterogeneity in energy consumption that can be explained by building and occupant characteristics.[12] Although one might think that differences are largely structural/fixed in the short run, it is possible that different household types could respond differently to an energy price shock by adjusting the speed with which they adopt energy efficient technology.[13]

Figure 2 uses box plots to show how energy expenditure (left panel) and CO_2 emissions (right panel) are affected by income (quintiles), location (urban/rural), occupants (defined using the EU's 'equivalent adults' methodology), rooms and type (detached, apartment etc.) for the full sample (nationally representative, including non-mortgaged households). The "box" displays (from left to right) the first quartile (25 per cent of households are below this point), median (50 per cent below/above) and third quartile (75 per cent below), while the outer markers are an estimate of extreme values.[14]

Average energy expenditure and CO_2 emissions in 2016 were €3,803 (mean energy-to-income ratio is 12.2 per cent) and 9.2 tonnes respectively, both of which are positively correlated with income, number of occupants and property size.[15] For example, for each additional occupant, room and €10,000 increase in gross income, energy expenditure increases by approximately 34 per cent, 20 per cent and 5.2 per cent, respectively. Such effects translate directly into emissions – for example, average annual CO_2 emissions in the highest income group (top 20 per cent) is over double (110 per cent higher) than the lowest income group (12.4 tonnes versus 5.9). Differences are also evident across location, with energy expenditure in rural areas 40 per cent higher than urban, which is largely due to higher transport fuels (66 per cent higher) and larger properties (14 per cent more rooms).[16]

[12] We do not vary the fuel expenditure of households in event that they change the number of vehicles that they own, over the horizon of this analysis. We believe this assumption to not be restrictive as it is conceivable that at each point of time in the forecast horizon there will be cohorts of household that would have similar ownership positions.

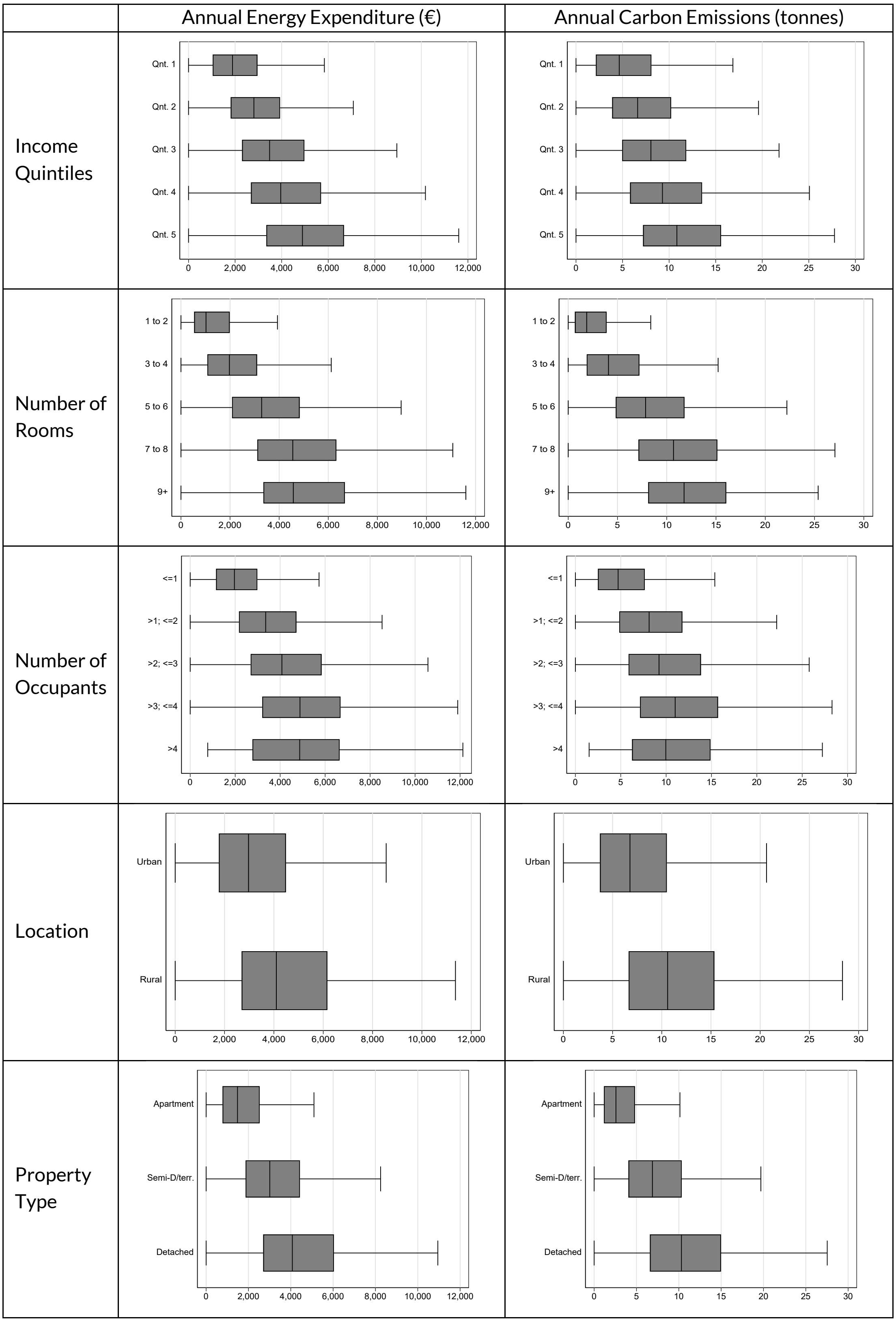
[13] It is also important to note that energy efficiency improvements are slow at a national level. Grant application data (link) show that there were 219,988 household energy grant applications between 2009 and 2018 or approximately 25,000 per year, which is approximately 1 per cent of the households annually.

[14] Box plot extremes are lower/upper adjacent values

[15] Figures weighted using HBS population weights. Income for this calculation is after tax. The median energy-to-income ratio is 8.2%.

[16] Additionally, expenditure on fuel as a proportion of income for the bottom income quintile is 3 times that of households in the top income quintile.

Figure 2: Annual Energy Expenditure and Carbon Emissions



Source: own calculations using Central Statistics Office *Household Budget Survey* Data from 2015/2016 (microdata sourced from the ISSDA)

Notes: The boxplot (from left to right) displays the 25th percentile, median and 75th percentile, while the outer markers are an estimate of extreme values (lower/upper adjacent values). Energy expenditure is estimated using weekly data for oil, gas, electricity, petrol, diesel and solid fuels. Emissions are estimated by dividing by prices and using emission conversion factors for each fuel

3.2 Energy and Emissions Estimates for Mortgage Loans

We populate the LLD with energy and emission estimates using the results from two statistical models (see Appendix – Table 2): Model 1 displays the magnitude of correlations between household variables and estimated energy expenditure; Model 2 shows how these variables affect estimated CO_2 emissions. In each model, we only include household variables that are common to both the LLD and the HBS, with one exception – seasonal variation in energy consumption is captured by controlling for the month of survey (HBS is carried out over a twelve-month period). To increase statistical precision, these relationships are estimated using the full HBS sample (mortgage and non-mortgage).[17]

The coefficients in Table 2 measure the magnitude of relationships between household variables and energy/emissions, while the p-values describe whether this relationship is statistically significant.[18] Table 2 shows that all household variables are statistically significant in both models (except for one regional variable in Model 1). We use these coefficient values to create our new energy and emissions estimates in the LLD, which is simply the product of LLD variable values and coefficient values, summed across all variables. While HBS/LLD income values are recorded at the time of survey (in the case of the HBS) or loan origination (in the case of the LLD), we extrapolate these forward to 2022 using national wage indices at the sectoral level.[19] We stress that these new variables are estimates based on the available household characteristics – notable omissions include exact distance from urban centres, number of occupants, presence of children and energy efficiency.

Figure 3 displays three charts for energy expenditure (column 1) and CO_2 (column 2): distribution for the national HBS sample (row 1), distribution for estimates in the LLD mortgage population (row 2), and the share of outstanding mortgage balances within different energy and CO_2 intensity (per metre squared) categories (row 3). There are three takeaways from Figure 3: first (and unsurprising given earlier findings) energy and emissions vary considerably across households; second, energy/CO_2 in the mortgage population is higher than in the general population (row two versus row one), which can be partly explained by higher income, larger properties and higher energy prices in 2022; third, bank exposure to energy intensive households is likely to be sizeable – according to these intensity bounds, close to 60 per cent of household mortgages are in the "high" or "very high" energy intensity (expenditure per square metre) group.[20] The methodology also allows us to estimate the share of mortgages below long run national efficiency targets. For example, focusing only on building CO_2 intensity (per m^2) suggests that 74.3 per cent of outstanding balances are to properties with indicative *Building Energy Rating* (BER) categories of less than "B3" (more than 35kg CO_2/m^2).[21] This share is very similar to national statistics – 73.1 per cent of BER assessments carried out between 2015 and 2021 (period of MTD data) are less than B3.

[17] As a robustness check we also estimated these models on the mortgage-only HBS (not shown). For all variables except income, there is no statistical difference in coefficient values between the full sample and the mortgage sample.

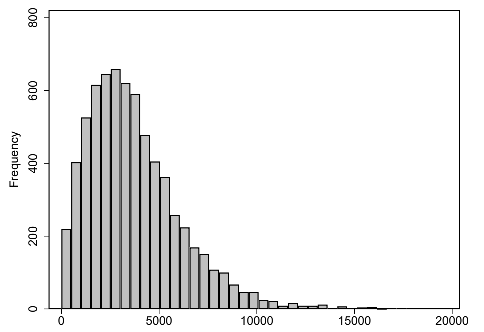
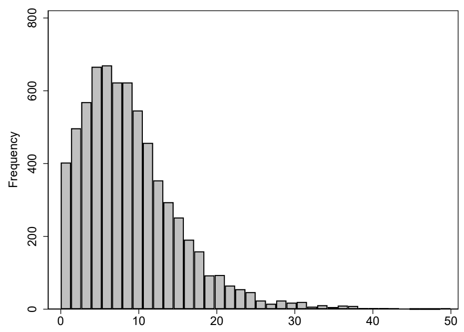
[18] Specifically, the p-value is the probability that the explanatory variable is *not* correlated with the dependent variable.

[19] Wage increases sourced from the CSO's *Average Annual Earnings and Labour Costs.*

[20] Intensity bounds are aligned with quintiles in the full HBS data.

[21] For this estimation, we only consider gas, oil and solid fuels for consistency with the BER's methodology (energy used for water heating, space heating and lighting).

Figure 3: Estimated Energy Expenditure and Carbon Emissions

<table>
<tr><th></th><th>Annual Energy Expenditure (€)</th><th>Annual Carbon Emissions (tonnes)</th></tr>
<tr><td>National (HBS) Distribution (Histogram)</td><td>
</td><td>
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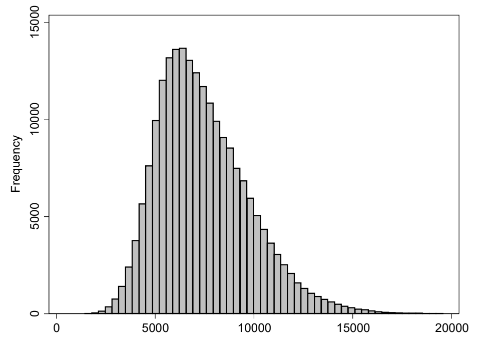
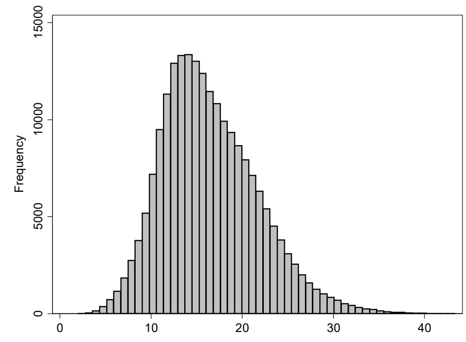
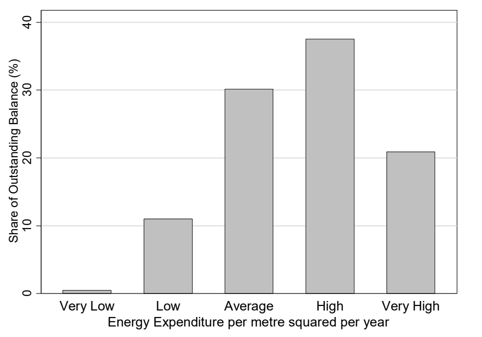
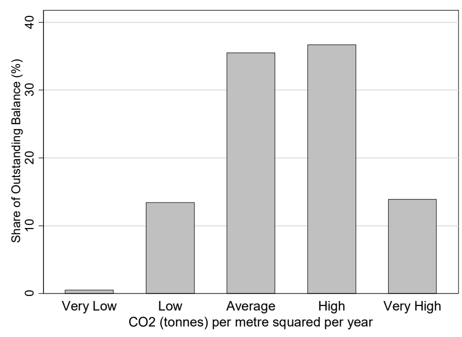
<tr><td>Mortgage (LLD) Distribution (Histogram)</td><td>
</td><td>
</td></tr>
<tr><td>Share of Outstanding Balance by Energy and Emission Intensity Categories (per m^2)</td><td>
</td><td>
</td></tr>
</table>

Source: own calculations using Central Statistics Office *Household Budget Survey* data (2016) and Central Bank of Ireland *Monitoring Template Data* (loans originating between full years 2015 and 2021)
Notes: Energy expenditure includes oil, gas, electricity, solid fuels, diesel and petrol.

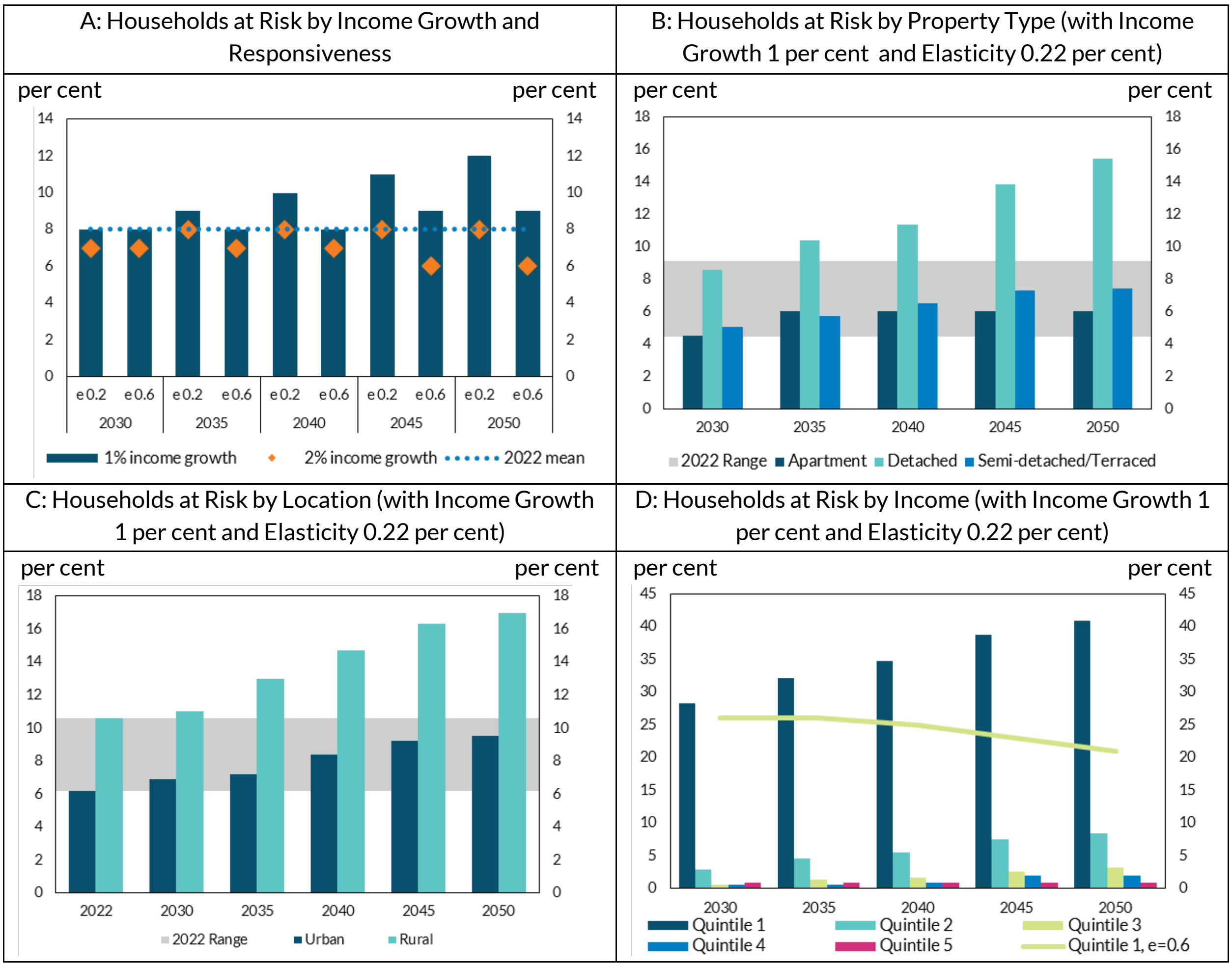
3.3 Scenario Analysis – Vulnerability to Energy Price Increases

In this section, we inflate energy prices according to the NGFS net zero 2050 scenario (see Figure 1 above) and explore how different household types (by income, location and size) are affected. We first estimate a household energy "risk" metric (Adhikari, 2022) using observed expenditures within the HBS. Next, we explore energy-to-income ratios using our new energy expenditure estimates in the LLD. In both cases, we compare different levels of real income growth (1 per cent or 2 per cent) and responsiveness to energy price increases (elasticities of 0.2 or 0.6).[22] The lower elasticity is consistent with a shorter run scenario where households do not change their energy usage due to time or budget constraints. In the longer run, there is more scope for greater technology and behavioural changes consistent with the 60% elasticity estimate. In both the HBS and LLD environments, all income and expenditure data are inflated to our reference period (May 2022).

[22] Labandeira (2017)

Figure 4 presents the results for mortgaged households in the HBS. While the share of households at risk is generally increasing, the trajectory depends entirely on assumptions regarding future income growth and, in particular, household responsiveness, which in the high elasticity case would not lead to increases in households at risk. In the low-income growth/elasticity scenario (Panel A), approximately 12 per cent of households will be at risk by 2050, up from 8 per cent in 2022. In contrast, this declines to 6 per cent in the case of a high-income growth/elasticity scenario in 2050. Even in a low-income growth scenario, the share of households in distress increases marginally to 9 per cent if households significantly change their energy consumption technologies and behaviours.

Figure 4: Scenario Analysis Using National HBS Data

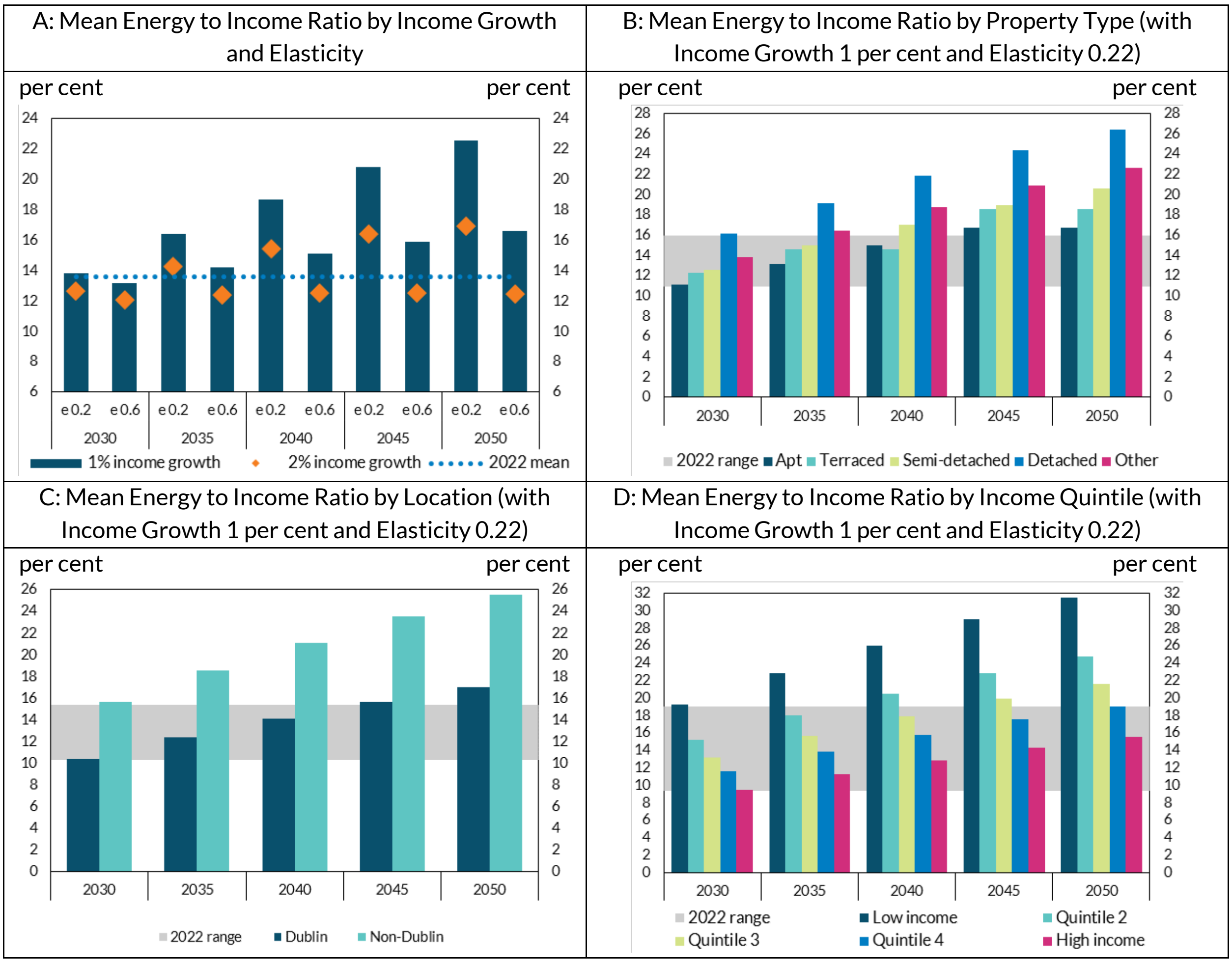


Source: own calculations using Central Statistics Office *Household Budget Survey* data (2016)
Notes: the "household at risk" are households with less than 10% of disposable income left after accounting for essential expenses. Energy expenditure includes all property and transport fuel expenditures. Income is after tax. Future energy price is based on approximate NGFS net zero modelling output. Base month is May 2022. Estimates are based on responsiveness to energy price increases (elasticities of 0.22 or 0.6) and income growth (1 or 2 per cent per year).

It is also evident that household risk depends on characteristics of the property, such as type (Panel B), location (Panel C) and income (Panel D). For example, the risk of mortgage delinquency is higher for rural households and detached properties. Although not show in Figure 4, properties built between 1980-2000 are also more at risk. The exceptionality high risk of the lowest income quintile (Panel D) is noteworthy – households in this quintile are clearly the main drivers of headline forecasts in Panel A. In a high adaptability scenario, these households can reduce their risk rate by half as shown by the line in Panel D.

We turn next to the LLD environment and calculate energy-to-income ratios under the same assumptions (Figure 5). In 2022, total energy costs equate to approximately 12 per cent of net household income (average).[23] Our estimates increase slightly by 2030 (Panel A), our first milestone year in terms of carbon reduction targets, assuming 1 per cent income growth and low elasticities. By 2050, our estimates fluctuate between 12.5 or 16.9 per cent depending on income growth (assuming a high elasticity).

Figure 5: Scenario Analysis using LLD Data Energy and Emissions Estimates



Source: Authors' own calculations using Central Bank of Ireland new mortgage Loan level data (2015-2021)
Notes: Energy expenditure includes all property and transport fuel expenditures. Income is pre-tax. Future energy price is based on approximate NGFS net zero modelling output. Base month is May 2022. Estimates are based on responsiveness to energy price increases (elasticities of 0.22 or 0.6) and income growth (1 or 2 per cent per year).

Household income growth and responsiveness (elasticity) will be key to future impacts. Under our model's best-case scenario (2 per cent income growth and high elasticity), the average household energy-to-income ratio in 2050 would be one percentage point lower than our 2022 estimate. However, assuming 1 per cent income growth and low elasticity, the average household energy-to-income ratio could exceed 20 per cent. This implies that the ability of households to adapt to increasing energy prices via investment in greater household energy efficiency will be key to ensuring household financial resilience.

[23] Note: HBS estimates include all mortgaged households in the HBS whereas the mortgage data includes only new mortgage loan originations.

We also explore the financial impact of rising energy costs on households by property size/type, income quintile, and region. Our results are broadly in line with expectation. Larger properties (Panel B) and those outside of Dublin (Panel C) are more impacted by energy price increases.[24] For the latter, this is clearly related to differences in rural/urban energy use (highlighted in Figure 4 above).

Similar to Figure 4, it is clear that lower income households are significantly more exposed to future energy price increases. Even in 2022, the average energy to income ratio for lower income households is estimated at just below 20 per cent. Even assuming our model's best-case scenario, energy costs would still be significantly high for this group by 2050, at 17.4 per cent. However, lower income households will likely face greater obstacles to energy efficiency transitions, both in terms of the 'out-of-pocket' monetary costs and access to loans required to finance green energy household solutions. Income growth is also unlikely to be uniform across household income quintile groups, and lower income households may not necessarily realise equivalent income growth rates to other groups. Under our worst-case assumptions (1 per cent income growth and low elasticity), lower income households could reach energy costs in excess of 30 per cent of household gross income. Reducing impact for lower income households (the main driver of overall banking sector transition risk in this analysis) would require targeted technology supports to facilitate the high-elasticity scenario where the financial and economic implications of transition may be broadly mitigated.

Finally, there are some caveats to the above results. First, our source of energy expenditure data is, at the time of writing, seven years old and may not reflect efficiency improvements since (approximately 1% of households apply for energy grants per year). Second, while Irish policy targets are clear to 2030, estimates beyond this date are very uncertain, although the CO_2 price employed is aligned with achieving global net zero targets. Third, our household adaptability assumptions are highly uncertain and dependent on policy, supports and technical change in the coming years. One notable omission in this regard is a switching of household fuel types from, for example, direct fossil fuel combustion (where CO_2 taxes apply) to electricity (where carbon intensity is rapidly declining due to renewables). The latter could also be incorporated into future analysis.

4 Conclusion

This analysis considers how future energy price increases could affect the economic situation of households and credit risk in the banking sector. While this direct energy price channel is the focus on this article, we fully acknowledge that households are also potentially vulnerable to other climate-related impacts, for example, through general inflationary effects, employment shocks and through wealth channels.

Our analysis proposes a new methodology to populate loan-level data with borrower energy and emissions estimates to fill existing data gaps. We consider the possible impacts of a number of future medium-to-long run carbon price scenarios to household resilience. The results show that broader economic and financial stability implications will depend on income growth and the speed at which households reduce their energy/emissions intensity through technology and behavioural change. On average, the percentage of households at risk would increase by 40% in 2050 if

[24] Note: The other category of property type is composed mainly of bungalow housing.

households are slow to reduce their energy use. However, even a modest increase in income and fast decarbonisation policies reduces the proportion of households at risk considerably.

There is considerable heterogeneity in risk and impact. Household characteristics (location, size, type and income, for example) explain current vulnerability to energy price increases. Our results show that the economic benefits of decarbonisation have a striking distributional character, with households in lower income quintiles benefiting most from implementing mitigation policies. This would make a case for targeted transition supports based on inherent household characteristics. Fiscally, this would likely mean greater economic and stability returns to every euro spent in transition support.

Lastly, we also note that our loan-level energy and emissions estimates will be missing a considerable amount of variation within household groups. In particular, our estimation technique is missing details on occupant (numbers), behaviours (type of occupants), and, in particular, energy efficiency variables and distance from urban centres. Therefore, while this exercise highlights a potential channel through which climate transition can affect the financial position of households, it does not replace the need to collect energy and emissions data from source.

Appendix

Table 2: **Household Energy Model Results**

	Model 1: Annual Energy Expenditure		**Model 2**: Annual CO2 Emissions	
	Coefficient	**P-Value**	**Coefficient**	**P-Value**
Explanatory Variables:				
Age	103.642	0.000	0.226	0.000
Age Squared	-1.053	0.000	-0.002	0.000
Income (euro, 10,000s)	244.305	0.000	0.543	0.000
Income Squared	-3.355	0.000	-0.008	0.000
Property Size	16.491	0.000	0.033	0.000
Property Type: Apartment/Flat [DV]	--- reference category ---			
Property Type: Detached [DV]	1236.532	0.000	4.081	0.000
Property Type: Semi-Detached/Terraced [DV]	514.285	0.000	1.964	0.000
Area: Border, Midland, West [DV]	--- reference category ---			
Area: Dublin [DV]	-733.328	0.000	-2.940	0.000
Area: South West, South East, Mid West, Mid East [DV]	-67.147	0.307	-0.689	0.001
Self-employed [DV]	722.075	0.000	1.573	0.000
Constant	-1839.197	0.000	-3.706	0.000
Model Statistics:				
Observations	6,839		6,839	
R-Squared	0.297		0.222	

Source: own calculations using Central Statistics Office Household Budget Survey Data from 2015/2016
Notes: Results estimates using standard Ordinary Least Squares. "DV" indicates that the variable is a discrete dummy variable. Squared terms are included to capture non-linear relationships. Both models include monthly controls (dummy variables) which to account for seasonal variation in energy consumption. Coefficients measure how a one unit change in the explanatory variable affects energy expenditure/CO_2. P-values describes whether this relationship is statistically significant. This models control for month of survey, which January used as the reference category.

Bibliography

Adhikari, T. (2022). *Inflation and mortgage repayments: the household expenditure channel.* Retrieved from https://www.centralbank.ie/docs/default-source/publications/financial-stability-notes/no-6-inflation-and-mortgage-repayments-the-household-expenditure-channel.pdf?sfvrsn=a2d7941d_12

IPCC. (2022). *Climate Change 2022: Impacts, Adaptation and Vulnerability - Summary for Policymakers.* Cambridge University Press. Retrieved March 1, 2022, from https://report.ipcc.ch/ar6wg2/pdf/IPCC_AR6_WGII_SummaryForPolicymakers.pdf

Labandeira, X. L.-O. (2017). A meta-analysis on the price elasticity of energy demand. *Energy Policy*, Volume 102, pg. 549-568.

NGFS. (2021). *NGFS Climate Scenarios for Central Banks and Supervisors.* Retrieved 05 11, 2022, from https://www.ngfs.net/sites/default/files/media/2021/08/27/ngfs_climate_scenarios_phase2_june2021.pdf

T: +353 (0)1 224 6000
www.centralbank.ie
publications@centralbank.ie

Bosca PO 559, Baile Átha Cliath 1, Éire
PO Box 559, Dublin 1, Ireland

Banc Ceannais na hÉireann
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