Proposal for the NBER Energy Markets and the Macroeconomy

"Brown to Green: Inequality and Fiscal Policy"

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Abstract

This project investigates the distributional consequences of the European Union's new emissions trading system, ETS2, which will extend carbon pricing to household-related emissions from buildings, transport, and other sectors. Using a heterogeneous-agent macroeconomic model with brown and green durables, the study examines how energy price increases under ETS2 affect consumption, welfare, and inequality across income groups. The model incorporates borrowing constraints that limit low-income households' ability to replace high-emission durables with cleaner alternatives, capturing key frictions in the green transition. It also evaluates alternative fiscal interventions, such as lump-sum transfers, progressive rebates, and targeted green subsidies, to determine the optimal policy mix that ensures both equity and efficiency. By linking carbon pricing to household heterogeneity and fiscal redistribution, the project provides quantitative guidance for policymakers seeking to design socially inclusive and economically sound climate policies that promote environmental sustainability without exacerbating inequality.

Keywords: Green transition, Inequality, Fiscal policy

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1 Motivation

As part of the 2023 revisions to the ETS Directive, the European Union introduced a new emissions trading system, ETS2, distinct from the existing EU Emissions Trading Scheme. ETS2 is set to become fully operational in 2027 and will specifically target CO_2 emissions from fuel combustion in buildings, road transport, and additional sectors. This system primarily addresses emissions stemming from household consumption, a significant contributor to the EU's overall carbon footprint. For example, households are responsible for approximately 60% of road transport emissions, while durable goods consumption accounts for nearly 50% of their total carbon footprint.

Under ETS2, fuel suppliers and distributors will be required to buy emission allowances for the fuels they sell. These allowances will be traded in a carbon market, and their prices will determine the carbon cost passed on to consumers through higher fuel and energy prices. Households will thus be indirectly affected by ETS2, participating not as traders but as final consumers facing increased prices for heating, transport, and other energy-intensive goods.

Given these impacts, households are expected to adapt by reallocating spending from high-emission (brown) goods to environmentally friendly (green) durable alternatives. However, the transition to sustainable living is often hindered by the high costs associated with green durables, making them inaccessible to many consumers. For example, while electric vehicles (EVs) represent a key green alternative, their upfront costs remain prohibitive for numerous households. On average, EVs carry a 15%-30% price premium compared to their gasoline-powered counterparts, discouraging widespread adoption.

To overcome these barriers, effective solutions must rely heavily on government intervention. Policies such as subsidies, tax credits, and incentives for adopting green technologies are vital to bridging the affordability gap, ensuring that sustainable living becomes accessible to all households, not just a privilege of the wealthiest. Without targeted government action, the green transition risks exacerbating existing inequalities, placing a disproportionate burden on lower-income households.

2 Research Objectives

This research project seeks to analyze the distributional consequences of the green transition and associated climate policies. Specifically, the objective is to develop a comprehensive macroeconomic model featuring heterogeneous agents to:

(i) deepen our understanding of how climate policies affect different income groups in both the short and long term,

(ii) evaluate the relative burden borne by poorer households compared to wealthier ones and estimate the fiscal capacity required to implement equitable adjustments, and

(iii) explore optimal redistributive policy responses.

The ultimate aim is to provide policymakers with actionable insights to ensure that the transition to a sustainable economy does not exacerbate income inequality but instead promotes an inclusive path towards environmental and social equity.

3 Model

We will build on the heterogeneous-agent macroeconomic framework developed by Bilbiie et al. (2013), extending it to incorporate the consumption of brown and green durables. The modeling of durable goods follows the approach of Barsky et al. (2007). Specifically, the model features savers and borrowers who differ in their income and access to financial markets. Borrowers face a binding borrowing constraint, which limits their ability to smooth consumption and restricts their capacity to finance the replacement of brown durables with green alternatives. Each household derives utility from a composite of nondurable goods and durables. Brown durables require energy inputs that generate carbon emissions, while green durables rely on cleaner energy inputs. Moreover, a climate block links aggregate emissions to atmospheric carbon concentration through a persistence process.

In our model, ETS2 is represented through a carbon price that raises the cost of energy inputs used in brown durables. This price transmits the effects of ETS2 to household consumption decisions and allows us to study the redistributional and welfare implications of climate policy in a general equilibrium framework. Additionally, we will evaluate alternative policy options, such as lump-sum transfers and targeted green subsidies, to assess their distributional impacts and identify the optimal fiscal responses required to achieve effective and equitable redistribution.

3.1 Households

There are two household types in this economy: savers (fraction $1 - \lambda$) and borrowers (fraction λ). Savers can intertemporally smooth consumption through bond holdings, while borrowers face a tight exogenous borrowing limit and therefore behave hand-to-mouth. This structure generates heterogeneity in marginal propensities to consume and in the response of households to energy prices, carbon taxation, and green subsidies.

Households maximize discounted lifetime utility:

$$\mathbb{E}_0 \sum_{t=0}^{\infty} {\beta^i}^t U^i \left(C^i_{N,t}, X^i_t, N^i_t\right), \quad i \in \{b, s\}, \tag{1}$$

where $\beta^i \in (0,1)$ denotes the household-type-specific discount factor, with $\beta^s > \beta^b$ implying that savers are more patient than borrowers. The operator $\mathbb{E}_0$ denotes expectations taken at time 0 over future realizations of shocks. At each date t, household i chooses non-durable non-energy consumption $C^i_{N,t}$, the effective stock of durables X^i_t, and labor supply N^i_t to maximize the expected discounted sum of per-period utility $U^i(\cdot)$. Period utility is additively separable in a CES consumption aggregator and disutility from labor:

$$U\left(C^i_{N,t}, X^i_t, N^i_t\right) = \frac{\left((C^i_{N,t})^{\psi_N}(X^i_t)^{1-\psi_N}\right)^{1-\sigma}}{1-\sigma} - \chi^i \frac{(N^i_t)^{1+\varphi}}{1+\varphi}. \tag{2}$$

The composite consumption bundle is a CES aggregate of non-durable consumption $C^i_{N,t}$ and durables X^i_t, with $\psi_N \in (0,1)$ governing the weight of non-durables in utility. The parameter $\sigma > 0$ is the coefficient of relative risk aversion (and the inverse of the intertemporal elasticity of substitution in the case of time-separable preferences in the composite), while $\chi^i > 0$ scales the disutility from supplying labor. The parameter $\varphi > 0$ controls the curvature of the labor disutility term and thus the Frisch elasticity of labor supply.

Durables combine brown and green stocks via a CES structure:

$$X^i_t = \left(\psi_B^{i\,\frac{1}{\zeta^i}} \left(X^i_{B,t}\right)^{\frac{\zeta^i-1}{\zeta^i}} + \left(1-\psi^i_B\right)^{\frac{1}{\zeta^i}} \left(X^i_{G,t}\right)^{\frac{\zeta^i-1}{\zeta^i}}\right)^{\frac{\zeta^i}{\zeta^i-1}}. \tag{3}$$

In this aggregator, $X^i_{B,t}$ and $X^i_{G,t}$ denote the effective service flows from brown and green durables, respectively. The parameter $\psi^i_B \in (0,1)$ captures the relative importance of brown durables in household i's durable service bundle, and can differ across borrowers and savers to reflect heterogeneous exposure to brown-intensive technologies. The elasticity of substitution between brown and green durables is governed by ζ^i: when ζ^i is large, households can more easily substitute green for brown durables in response to changes in relative prices or policy interventions, while a low ζ^i implies that the composition of the durable stock adjusts only sluggishly to environmental policies or energy price shocks.

Each durable stock is itself a CES composite of the physical durable good and the associated energy use. For brown durables,

$$X^i_{B,t} = \left(\left(1-\psi_{E_B}\right)^{\frac{1}{\eta_B}} \left(D^i_{B,t}\right)^{\frac{\eta_B-1}{\eta_B}} + \psi_{E_B}{}^{\frac{1}{\eta_B}} \left(E^i_{B,t}\right)^{\frac{\eta_B-1}{\eta_B}}\right)^{\frac{\eta_B}{\eta_B-1}}, \tag{4}$$

and for green durables,

$$X^i_{G,t} = \left((1-\psi_{E_G})^{\frac{1}{\eta_G}} \left(D^i_{G,t}\right)^{\frac{\eta_G-1}{\eta_G}} + \psi_{E_G}{}^{\frac{1}{\eta_G}} \left(E^i_{G,t}\right)^{\frac{\eta_G-1}{\eta_G}} \right)^{\frac{\eta_G}{\eta_G-1}}. \tag{5}$$

where $D^i_{B,t}$ and $D^i_{G,t}$ denote the physical stocks of brown and green durables (e.g., internal combustion engine vehicles versus electric vehicles or other green capital owned by households), while $E^i_{B,t}$ and $E^i_{G,t}$ are the associated energy flows needed to operate these assets. The parameters ψ_{E_B} and ψ_{E_G} capture the relative importance of energy use in generating services from brown and green durables, respectively. The elasticities of substitution η_B and η_G govern how easily households can adjust the mix between installed durable capacity and energy input within each type of durable: a high η_B implies that a given service level from brown durables can be maintained by substituting away from energy use towards a larger stock of equipment (or vice versa), whereas a low η_B implies a tighter technological link between the stock and its energy use. This nested structure allows carbon pricing and green subsidies to affect both the composition between brown and green durables and the intensity of energy use conditional on the existing stock.

Durables adjust subject to quadratic installation costs, ensuring smooth investment dynamics:

$$D^i_{B,t} = (1-\delta_B)\, D^i_{B,t-1} + C^i_{B,t} - \frac{\phi_B}{2}\left(\frac{C^i_{B,t}}{D^i_{B,t-1}} - \delta_B\right)^2 D^i_{B,t-1}, \tag{6}$$

$$D^i_{G,t} = (1-\delta_G)\, D^i_{G,t-1} + C^i_{G,t} - \frac{\phi_G}{2}\left(\frac{C^i_{G,t}}{D^i_{G,t-1}} - \delta_G\right)^2 D^i_{G,t-1}. \tag{7}$$

In each case, $C^i_{B,t}$ and $C^i_{G,t}$ represent expenditure on new brown and green durable goods, respectively. The parameters δ_B and δ_G are physical depreciation rates. ϕ_B and ϕ_G are the adjustment cost parameters. These costs generate smoother dynamics in durable investment and prevent households from instantaneously rebuilding their entire stock in response to policy shifts such as the introduction of a generous green subsidy or a sharp increase in carbon prices.

Borrowers face the following nominal budget constraint:

$$P_{Y,t}C^b_{N,t} + P_{Y,t}C^b_{B,t} + (1-\tau_{G,t})\, P_{Y,t}C^b_{G,t} + P_{E,t}\left(E^b_{B,t} + E^b_{G,t}\right) + P_{CO_2,t}E^b_{B,t} + R_{t-1}B^b_{t-1} = W_t N^b_t + B^b_t + P_t T^b_t, \tag{8}$$

subject to a tight borrowing limit:

$$B^b_t \leq \bar{B}. \tag{9}$$

$P_{Y,t}$ is the price of the non-energy goods composite. The terms $C^b_{N,t}$, $C^b_{B,t}$, and $C^b_{G,t}$ denote borrower

consumption of non-durables, brown durables, and green durables, respectively. The green subsidy enters as a proportional discount $\tau_{G,t}$ on the price of green durables. The variable $P_{E,t}$ is the consumer price of energy, which is applied symmetrically to brown and green energy uses $E^b_{B,t}$ and $E^b_{G,t}$. Brown energy use additionally triggers a carbon charge $P_{CO_2,t}$ per unit of emissions, so that the effective marginal cost of brown energy is $P_{E,t} + P_{CO_2,t}$ from the borrower's perspective. On the income side, $W_t N^b_t$ denotes labor income, where W_t is the nominal wage. The term $R_{t-1}B^b_{t-1}$ represents gross interest payments on beginning-of-period nominal debt B^b_{t-1} at the gross nominal interest rate R_{t-1}. New borrowing B^b_t relaxes the current budget constraint, but is subject to the exogenous upper bound $\bar{B}$. Finally, $P_t T^b_t$ denotes lump-sum transfers from the government to borrowers. We assume that the borrowing constraint binds in all periods, reflecting limited access to credit and implying a high marginal propensity to consume out of transitory income and transfers for this group.

Savers, on the other hand, can accumulate financial assets and thus smooth consumption over time. Their nominal budget constraint is:

$$\begin{aligned} P_{Y,t}C^s_{N,t} + P_{Y,t}C^s_{B,t} + (1-\tau_{G,t})\,P_{Y,t}C^s_{G,t} + P_{E,t}\left(E^s_{B,t} + E^s_{G,t}\right) + P_{CO_2,t}E^s_{B,t} + B^s_t \\ = W_t N^s_t + R_{t-1}B^s_{t-1} + \frac{1}{1-\lambda}\left(DIV_{Y,t} + DIV_{E,t}\right) - P_t T^s_t. \end{aligned} \tag{10}$$

Savers choose their consumption bundle, energy use, labor supply, and bond holdings B^s_t subject to this constraint. On the expenditure side, they face the same prices as borrowers for non-durables, durables, and energy, including the green subsidy $\tau_{G,t}$ and the carbon charge $P_{CO_2,t}$ on brown energy. On the income side, they receive labor income $W_t N^s_t$ and interest income $R_{t-1}B^s_{t-1}$ from their bond holdings. In addition, savers receive profit dividends from firms: aggregate dividends from non-energy goods producers $DIV_{Y,t}$ and from energy firms $DIV_{E,t}$ are distributed exclusively to savers, scaled by $1/(1-\lambda)$ to reflect the fact that only the $1-\lambda$ fraction of savers hold shares. Finally, $P_t T^s_t$ denotes lump-sum taxes paid by savers, which are used to finance transfers to borrowers and potentially other fiscal instruments such as green subsidies and carbon-tax rebates.

3.2 Non-Energy Goods Firms

Non-energy intermediate goods are produced by a continuum of monopolistically competitive firms indexed by $j \in [0,1]$. Each firm hires labor from the representative labor market and uses a linear technology.

Production is given by:

$$Y_t(j) = N_{Y,t}(j)\,. \tag{11}$$

Output of variety j equals the amount of labor employed in that firm. The production function is linear and exhibits constant returns to scale.

Demand for each variety arises from a Dixit-Stiglitz aggregator:

$$Y_t(j) = \left(\frac{P_{Y,t}(j)}{P_{Y,t}} \right)^{-\varepsilon} Y_t, \tag{12}$$

where ε is the elasticity of substitution between differentiated varieties. Aggregate demand Y_t is taken as given by each firm.

The CES aggregator over varieties is:

$$Y_t = \left(\int_0^1 Y_t(j)^{\frac{\varepsilon-1}{\varepsilon}} dj \right)^{\frac{\varepsilon}{\varepsilon-1}}, \tag{13}$$

with associated price index,

$$P_{Y,t} = \left(\int_0^1 P_{Y,t}(j)^{1-\varepsilon} dj \right)^{\frac{1}{1-\varepsilon}}. \tag{14}$$

Price setting follows the Calvo (1983) friction. In any period, a fraction $1-\theta$ of firms can optimally reset their price, while a fraction θ keeps the previous price. A firm that receives a price-reset opportunity chooses:

$$P^*_{Y,t} = \frac{\varepsilon}{\varepsilon - 1} \frac{\mathbb{E}_t \sum_{k=0}^{\infty} (\beta^s \theta)^k \Lambda^s_{t+k} MC_{t+k} Y_{t+k} \left(P_{Y,t+k}\right)^{\varepsilon}}{\mathbb{E}_t \sum_{k=0}^{\infty} (\beta^s \theta)^k \Lambda^s_{t+k} Y_{t+k} \left(P_{Y,t+k}\right)^{\varepsilon}}. \tag{15}$$

This optimal reset price equates the expected discounted marginal revenue to marginal cost over the random duration for which the price will remain fixed. The stochastic discount factor Λ^s_{t+k} corresponds to savers, who own the firms.

Therefore, the aggregate price index evolves as:

$$(P_{Y,t})^{1-\varepsilon} = (1-\theta)\left(P^*_{Y,t}\right)^{1-\varepsilon} + \theta (P_{Y,t-1})^{1-\varepsilon}. \tag{16}$$

Firm profits in the non-energy sector are:

$$DIV_{Y,t} = \int_0^1 \left(P_{Y,t}(j) Y_t(j) - W_t N_{Y,t}(j) \right) dj. \tag{17}$$

3.3 Energy Goods Firms

The energy sector is modeled as a competitive industry that produces a homogeneous energy good using labor as the only input as in Känzig (2023).

Production follows a simple linear technology:

$$E_t = N_{E,t}. \tag{18}$$

Energy output E_t is proportional to labor employed in the sector.

Profits in the energy sector are given by:

$$DIV_{E,t} = P_{E,t}E_t - W_t N_{E,t}. \tag{19}$$

3.4 Climate Block

The evolution of atmospheric carbon concentration follows a simple linear law of motion driven by emissions generated by household consumption of brown energy, in line with Golosov et al. (2014). Only energy used in operating brown durables generates emissions; green energy inputs are assumed to be clean.

The carbon stock evolves according to:

$$S_t = (1 - \vartheta)\, S_{t-1} + \vartheta_0 \left(\lambda E^b_{B,t} + (1 - \lambda)\, E^s_{B,t}\right), \tag{20}$$

where ϑ_0 represents the fraction of emissions that remain in the atmosphere after one period, reflecting imperfect absorption by natural sinks. The parameter $1 - \vartheta$ determines the autoregressive persistence of atmospheric carbon, capturing the slow natural decay of CO_2. Because emissions are proportional to households' brown-energy use, energy consumption choices, shaped by carbon pricing and green subsidies, map directly into the dynamics of climate externalities.

This formulation provides a simple but empirically grounded representation of carbon accumulation consistent with the climate economics literature. It links household energy demand to environmental outcomes, which in turn influence government policy decisions through carbon taxation, subsidies, and fiscal recycling mechanisms introduced elsewhere in the model.

3.5 Fiscal Authority

The fiscal authority collects carbon-tax revenues, finances green subsidies, and redistributes resources across household types through lump-sum transfers. The government operates under a balanced-budget requirement each period, implying that all expenditures must be matched by contemporaneous revenues.

The government budget constraint is:

$$\lambda P_{CO_2,t} E^b_{B,t} + (1-\lambda) P_{CO_2,t} E^s_{B,t} = \lambda \left(\tau_{G,t} P_{Y,t} C^b_{G,t} + P_t T^b_t\right) + (1-\lambda) \left(\tau_{G,t} P_{Y,t} C^s_{G,t} - P_t T^s_t\right). \tag{21}$$

The left-hand side represents total carbon-tax revenues collected from households' brown-energy use. Because only brown energy produces emissions, carbon charges apply exclusively to $E^i_{B,t}$ and are weighted by the population shares of borrowers and savers. The right-hand side consists of expenditures: green-durable subsidies $\tau_{G,t} P_{Y,t} C^i_{G,t}$, which reduce the purchase price of green durables, and net transfers T^i_t paid to each household group. A positive T^b_t reflects a transfer to borrowers, financed jointly by carbon-tax revenues and contributions from savers.

Carbon prices follow a stochastic process:

$$P_{CO_2,t} = (1-\rho_{CO_2}) P_{CO_2} + \rho_{CO_2} P_{CO_2,t-1} + \epsilon_{CO_2,t} \tag{22}$$

The carbon price process captures institutional features of the EU ETS2 system in which the supply of emission permits is adjusted gradually rather than responding instantaneously to shocks.

Green subsidies evolve according to:

$$\tau_{G,t} = (1-\rho_G) \tau_G + \rho_G \tau_{G,t-1} + \epsilon_{G,t}. \tag{23}$$

The subsidy rate $\tau_{G,t}$ is persistent and gradually adjusts toward a long-run target τ_G. This can represent policy reforms, fiscal initiatives to stimulate green adoption, or unexpected political events affecting subsidy generosity.

Redistribution rules determine how government transfers are allocated to borrowers:

$$\lambda P_t T^b_t = \tau_d \left(DIV_{Y,t} + DIV_{E,t}\right) + \mu \left(\lambda P_{CO_2,t} E^b_{B,t} + (1-\lambda) P_{CO_2,t} E^s_{B,t} - \lambda \tau_{G,t} P_{Y,t} C^b_{G,t} - (1-\lambda)) \tau_{G,t} P_{Y,t} C^s_{G,t}\right), \tag{24}$$

where τ_d governs how firm profits are taxed and redistributed to borrowers. The parameter μ determines the extent to which carbon-tax revenues net of green-subsidy expenditures are rebated back to borrowers. This structure allows the model to capture a wide range of fiscal recycling schemes, from profit-funded transfers to carbon-dividend systems.

3.6 Monetary Authority

The monetary authority sets the nominal interest rate following a standard Taylor rule with interest-rate smoothing:

$$\frac{R_t}{R} = \left(\frac{R_{t-1}}{R}\right)^{\rho_R} \left(\left(\frac{\pi_t}{\pi}\right)^{\phi_\pi} \left(\frac{Y_t}{Y}\right)^{\phi_Y}\right)^{1-\rho_R}. \tag{25}$$

The central bank adjusts the policy rate in response to deviations of inflation $\pi_t \equiv \frac{P_t}{P_{t-1}}$ and output Y_t from their steady-state values, with responsiveness governed by ϕ_π and ϕ_Y. The parameter ρ_R introduces inertia, anchoring the policy rate to its lagged value and stabilizing monetary policy in the presence of shocks.

The aggregate consumption price index (CPI) is:

$$P_t = (P_t^b)^\lambda (P_t^s)^{1-\lambda}. \tag{26}$$

Because borrowers and savers consume different composite bundles of non-durables and durables, the aggregate price index is a population-weighted geometric average of the group-specific CPIs.

3.7 Market Clearing

Non-energy goods must satisfy:

$$Y_t = C_{N,t} + C_{B,t} + C_{G,t}. \tag{27}$$

Total output is absorbed entirely by household consumption of non-durable goods and purchases of brown and green durables.

Non-durable consumption aggregates to:

$$C_{N,t} = \lambda C_{N,t}^b + (1-\lambda)\, C_{N,t}^s. \tag{28}$$

Brown-durable purchases aggregate as:

$$C_{B,t} = \lambda C_{B,t}^b + (1-\lambda)\, C_{B,t}^s, \tag{29}$$

while green-durable purchases satisfy:

$$C_{G,t} = \lambda C_{G,t}^b + (1-\lambda)\, C_{G,t}^s. \tag{30}$$

Energy market clearing is:

$$E_t = \lambda(E^b_{B,t} + E^b_{G,t}) + (1-\lambda)\left(E^s_{B,t} + E^s_{G,t}\right). \tag{31}$$

Total energy supply from the energy sector must meet aggregate household demand for both brown and green energy inputs.

Labor-market clearing requires:

$$N_{Y,t} + N_{E,t} = \lambda N^b_t + (1-\lambda)N^s_t. \tag{32}$$

Total labor used in the non-energy and energy sectors must equal aggregate household labor supply.

The bond market clears when:

$$\lambda B^b_t = (1-\lambda)B^s_t. \tag{33}$$

Borrowers' bond issuance must equal savers' bond holdings.

4 Quantitative Analysis and Policy Implications

Using the heterogeneous-agent model described above, we assess both the distributional consequences of ETS2 and the fiscal policies required to ensure an equitable transition. The analysis proceeds in three steps and directly informs the resulting policy recommendations.

The first step calibrates the model to match key dimensions of household heterogeneity in the European Union, including income dispersion, borrowing constraints, energy consumption profiles, and the ownership of gasoline vehicles versus EVs. The calibration will incorporate observed differences in prices, energy intensities, and depreciation rates across brown and green durables. Parameters governing the stochastic processes for carbon prices and green subsidies will be disciplined by historical EU ETS data and announced features of ETS2.

The second step consists of solving the model and conducting counterfactual simulations to quantify how households respond to rising carbon prices and to targeted green subsidies. The model separates short-run responses, driven by liquidity constraints and heterogeneous marginal propensities to consume, from long-run adjustments in the composition of durable stocks. These simulations also trace the general-equilibrium effects of ETS2 through aggregate demand, inflation, and energy use, thereby providing a macroeconomic perspective on the green transition.

The third step evaluates alternative fiscal recycling schemes, such as lump-sum transfers, progressive rebates, and differentiated subsidies for green durables. The model compares these instruments across welfare and distributional criteria, while also assessing their macroeconomic consequences. This exercise identifies

the fiscal mix that best offsets the regressive effects of carbon pricing without undermining incentives for decarbonization.

Taken together, the quantitative findings will offer policy-relevant insights for implementing ETS2 in a socially inclusive way. By capturing the interaction between carbon pricing, household heterogeneity, and fiscal redistribution, the analysis will clarify which households bear the greatest burden from higher energy prices and which fiscal tools are most effective at mitigating these effects. The results will guide policymakers in designing climate policy packages that are both environmentally effective and equitable, supporting a green transition that promotes sustainability without exacerbating inequality.

Conflict of Interest Statement

The authors declare no financial or other relevant interests, including any ties to the energy industry.

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