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The Economics of Inequality and the Environment†

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Environmental degradation and economic inequality are two of the defining challenges of the twenty-first century. We synthesize conceptual mechanisms that underpin inequality–environment linkages and take stock of the relevant empirical evidence. We propose three channels of interaction. We first describe how environmental benefits vary with household income. Second, we discuss how the cost of environmental policy is distributed across households. Third, we consider how income inequality and redistribution shape environmental outcomes. The three channels determine how both environmental quality and economic inequality matter for policy appraisal. We argue that it is crucial to consider inequality–environment linkages in economic research and policy design, as neither issue can be fully understood in isolation. We close by highlighting future research needs. (*JEL* D31, D63, H23, Q54, Q56, Q58)

1. *Introduction*

Environmental degradation and economic inequality have emerged as two of the defining challenges of the twenty-first century. Policymakers from around the world increasingly prioritize both issues in their national and global agendas, as exemplified by the United Nations

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Sustainable Development Goals. Along with this public interest is a resurgence in academic research, especially in economics, driven by recent advances in understanding the nature, causes, and consequences of both economic inequalities (Anand and Segal 2008; Johnson and Papageorgiou 2020) and environmental deterioration (Dasgupta 2021; Nordhaus 2019; Stern 2007).

When the environment and inequality are studied separately, important interactions are missed. As Douenne and Fabre (2022) show in the case of the yellow vest movement in France, distributional concerns can stand in the way of implementing environmental policies, in this case a fuel tax increase. More recently, governments have shown heightened interest in the interdependencies between economic inequality and the environment. Both the United States and the European Union increasingly emphasize "environmental justice" and a "just transition." For example, the recent Justice40 initiative in the United States and the Just Transition Mechanism in the European Union combine climate-friendly investment with redistributive objectives. Similar issues feature prominently in China's latest Five-Year Plan. Economic research is increasingly following suit.

This review synthesizes the growing literature on the interactions of inequality and the environment in a single conceptual framework. While facets of this interaction have been explored in previous reviews (e.g., Fullerton 2011; Bento 2013; Banzhaf, Ma, and Timmins 2019; Hsiang, Oliva, and Walker 2019; Cain et al. 2024), we bring together research on different channels of interaction that have been consigned to separate strands of literature. This allows us to identify previously unrecognized feedback, synergies, and rebound effects.

We ask how environmental policy design can take into account the ways in which inequality interacts with environmental outcomes. To keep our review manageable, we focus on income inequality among individuals and households within countries, as opposed to intergenerational inequality (see, e.g., Kverndokk, Nævdal, and Nøstbakken 2014 for a joint analysis of intra- and intergenerational inequality), racial disparities (e.g., Banzhaf, Ma, and Timmins 2019), or other forms of inequality. Our conceptual framework, presented in Section 2, yields three major components of the welfare change induced by an environmental policy. First, there are nonmarket benefits and market-mediated effects from improved environmental quality (Section 3). Second, there are costs of the policy due to changes in consumer prices and incomes (Section 4). Third, governmental redistribution, both as a component of environmental policy and as a standalone policy, can alter environmental outcomes (Section 5).

In each of these sections, we review the theoretical underpinnings, synthesize the available evidence, and outline knowledge gaps. A common theme that emerges is the role of income elasticities. These help structure discussions on linkages between environmental change and inequality, and we delineate key income elasticities that have not yet been explored. Although our conceptual framework is general, much of the empirical evidence we discuss is focused on climate change and air pollution because these are better explored in the literature than other domains of environmental policy.

By summarizing the current state of the literature, we aim to provide students, researchers and policymakers with an overview of the existing literature and the various linkages between these two issues that are of interest to so many. In the conclusion, we suggest priorities for future research and ways in which inequality–environment linkages can inform policymaking. We especially hope to provide an impetus for research that reaches across the boundaries between largely distinct strands of literature on economic inequality and environmental change. For example, an economist exploring compensatory measures to counteract undesired distributional effects of environmental policy should also consider unintended feedback effects that undermine the environmental objective motivating the policy. Similarly, an economist who uses monetary estimates of the willingness to pay (WTP) for improved environmental quality in a cost–benefit analysis should also consider how aggregate WTP changes when inequality is taken into account. And an economist concerned with economic inequality may wish to consider additional inequalities from environmental change and how redistributive measures shape them. These examples highlight the value of our proposed integrative approach to tackling both economic inequality and environmental change.

2. *The Conceptual Framework*

To conceptualize the objective of a policymaker who considers both the environment and inequality, we start from a Bergson–Samuelson understanding of social welfare (as reviewed, for instance, in Fleurbaey 2009). Environmental policy is herein evaluated using a social welfare function (SWF):

$$SWF = \Phi(\ldots, U_i, \ldots), \tag{1}$$

where U_i is the utility of individual i. For small variations, and assuming that the SWF is totally differentiable, an environmental policy should be introduced if the change in social welfare,

$$\Delta SWF = \sum_i \Phi'(U_i) \cdot \Delta U_i, \tag{2}$$

is positive and larger than under all alternative policies. The first component of the change in social welfare due to the environmental policy, $\Phi'(U_i)$, describes the weight that society places on utility changes accruing to different individuals. The second component, ΔU_i, is the change in well-being experienced by individuals.[1]

Individual well-being depends on the consumption of goods and services, leisure, and environmental quality. Changes in well-being can be represented through changes in indirect utility, $V_i(\mathbf{p}, w, r; T_i, K_i, \bar{L}, E_i)$, which depends on prices $(\mathbf{p}, w, r)$ and endowments $(T_i, K_i, \bar{L}, E_i)$. Here, $\mathbf{p}$ is the vector of prices of goods and services (each denoted by j), w is the wage rate, and r is the return on capital. In terms of the endowments, T_i are net governmental transfers, K_i is initial capital, and each individual, i, is endowed with total available time, $\bar{L}$. Finally, environmental quality is denoted by E_i, which is the same for all individuals in the case of pure public environmental goods ($E_i = E \;\forall\, i$).

A change in environmental policy may affect all components of indirect utility (except for total time, $\bar{L}$, allocated to work or leisure). Therefore, we represent each policy as a set of changes in prices, wages, and rental rates as well as transfers, capital, and environmental quality $\{\Delta \mathbf{p}, \Delta w, \Delta r, \Delta T_i, \Delta K_i, \Delta E_i\}$. Using the envelope theorem, the first-order change in indirect utility of individual i under small, policy-induced changes can be approximately disentangled

[1] In addition to representing ordinal preferences, it is common to assume that utility, U_i, is absolutely measurable and fully comparable, so that aggregating it across individuals is meaningful (Roemer 1996).

into three parts. These are (1) nonmarket benefits from environmental change, (2) price changes, and (3) income changes:

$$(3)\quad \Delta V_i \approx \frac{\partial V_i}{\partial E_i}\cdot \Delta E_i + \sum_j \left(\frac{\partial V_i}{\partial p_j}\cdot \Delta p_j\right) + \frac{\partial V_i}{\partial w}\cdot \Delta w + \frac{\partial V_i}{\partial r}\cdot \Delta r + \frac{\partial V_i}{\partial T_i}\cdot \Delta T_i + \frac{\partial V_i}{\partial K_i}\cdot \Delta K_i$$

$$= \frac{\partial V_i}{\partial T_i}\Bigg[\underbrace{\frac{\partial V_i/\partial E_i}{\partial V_i/\partial T_i}\cdot \Delta E_i}_{\text{Nonmarket env. benefits}} + \underbrace{\sum_j -C_{ij}\cdot \Delta p_j}_{\text{Price changes}} + \underbrace{\Delta y_i}_{\text{Income changes}}\Bigg],$$

where we have used Roy's identity for individual i's consumption of good j: $C_{ij} = -\frac{\partial V_i}{\partial p_j}/\frac{\partial V_i}{\partial T_i}$. Individual i's income change, Δy_i, can result from a changing wage rate, changing capital rate, and changing government transfer income ($\Delta y_i = \Delta w \cdot L_i + \Delta r \cdot K_i + r \cdot \Delta K_i + \Delta T_i$). These in turn depend on labor supply, $L_i = \frac{\partial V_i}{\partial w}/\frac{\partial V_i}{\partial T_i}$, capital, $K_i = \frac{\partial V_i}{\partial r}/\frac{\partial V_i}{\partial T_i}$, and return on capital, $r = \frac{\partial V_i}{\partial K_i}/\frac{\partial V_i}{\partial T_i}$, using the envelope theorem.[2] Because income is the sum of income from labor, returns on capital, and governmental transfers ($y_i = w \cdot L_i + r \cdot K_i + T_i$), the marginal utility of transfers is equal to the marginal utility of income ($\partial V_i/\partial T_i = \partial V_i/\partial y_i$). Hereafter, we use the more common term of marginal utility of income to represent changes in well-being.

The change in well-being expressed in equation (3) is first order and takes into account general equilibrium effects under marginal changes for prices for goods and services, factor prices, and environmental quality. In Sections 3 and 4, we discuss further general equilibrium effects where prices, demand and supply of goods and services, and input factors adjust non-marginally to an environmental policy (e.g., Känzig 2023). We further consider individual-specific prices, such as heterogeneous wage rates.

Equation (3) depicts three additive effects on indirect utility. First, there are direct benefits (or costs) from the change in environmental quality induced by a policy (the first term). Second, there are price changes (the second term), which can occur for a number of reasons. Most immediately, prices of targeted goods (usually polluting goods) change, either because price instruments directly apply to them or because regulation makes them more expensive to produce. These are commonly denoted as "use-side" policy costs. Further price changes may arise because changes in environmental quality can affect productivity or production costs. In addition, some policy instruments generate revenue, which can be used to lower the prices of goods, usually through tax cuts or subsidies. Therefore, we divide price changes into three channels: policy-induced price changes, market-mediated environmental quality effects, and redistribution of revenue: $\Delta p_j = \Delta p_j^P + \Delta p_j^E + \Delta p_j^R$.[3] For example, congestion or fuel pricing will raise the cost of driving downtown (Δp_j^P) and will affect housing prices in areas with

[2] We follow Fullerton and Ta (2019) and represent i's choices through the following utility maximization problem: $V_i(\mathbf{p}, w, r; T_i, K_i, \bar{L}, E_i) = \max_{\mathbf{C}_i, L_i} U_i(\mathbf{C}_i, \bar{L} - L_i, E_i)$, subject to $\mathbf{p} \cdot \mathbf{C}_i = w \cdot L_i + r \cdot K_i + T_i$. Goulder et al. (2019) provide a multi-period extension of this static model.

[3] For larger changes, interaction effects make the split into three elements less clear-cut.

improved air quality (Δp_j^E), while the collected revenue may be used to grant rebates or tax breaks (Δp_j^R) to commuters.

Finally, there are income changes (the third term), which we split into three similar effects: $\Delta y_i = \Delta y_i^P + \Delta y_i^E + \Delta y_i^R$. First, incomes can change as a direct consequence of the environmental policy (P) affecting returns to production factors. These are commonly denoted as "source-side" policy costs. Second, incomes can be affected by changes in environmental quality (E) that result from the policy. Third, revenue recycling can act as income redistribution. For example, a carbon tax may reduce the incomes of workers in the energy sector (Δy_i^P), while reduced climate damages can increase agricultural productivity and thus the income of farm workers (Δy_i^E). In addition, the tax revenue can be paid out to households (Δy_i^R), for instance as a "carbon dividend."

Introducing these distinctions and rearranging gives the individual contribution to the change in social welfare, $(\Phi'(V_i) \cdot \Delta V_i)$:

$$\text{(4a)} \qquad \Delta SWF_i \approx \Bigg[\underbrace{\underbrace{\frac{\partial V_i/\partial E}{\partial V_i/\partial y} \cdot \Delta E_i}_{\text{Nonmarket}} + \underbrace{\left(-\mathbf{C}_i \cdot \Delta \mathbf{p}^E - \Delta y_i^E\right)}_{\text{Market-mediated}}}_{\text{Environmental benefits}}$$

$$\text{(4b)} \qquad + \underbrace{\underbrace{\left(-\mathbf{C}_i \cdot \Delta \mathbf{p}^P\right)}_{\text{Use-side}} + \underbrace{\Delta y_i^P}_{\text{Source-side}}}_{\text{Environmental policy costs}}$$

$$\text{(4c)} \qquad + \underbrace{\left(-\mathbf{C}_i \cdot \Delta \mathbf{p}^R\right) + \Delta y_i^R}_{\text{Revenue recycling (where available)}} \Bigg] \underbrace{\bar{\Phi}(V_i) \cdot \frac{\partial V_i}{\partial y}}_{\text{Distributional weights}} .$$

We use this rearranged equation (equations 4a–4c) to structure our review. To illustrate, consider the effects of a carbon tax on a household, i, whose head is working as a self-employed building contractor. First, the policy may improve climate conditions and generate environmental benefits. These can include direct benefits to the contractor from reduced climate damages (ΔE_i) as well as market-mediated effects from changes in the price of climate-sensitive goods, such as cheaper food ($\Delta \mathbf{p}^E$). Benefits can also include changes in the ability to generate income, such as increased labor productivity of the contractor (Δy_i^E). Second, the environmental policy brings costs. In particular, the carbon tax will increase the prices of polluting inputs, such as fuel ($\Delta \mathbf{p}^P$). Because in equilibrium the price paid by the contractor's clients may not rise fully with the increased cost of materials or fuel inputs (Δy_i^P), due to imperfect cost pass-through, the contractor's net income could fall. Third, the contractor may benefit if the government uses tax revenues, for instance, to subsidize the training of workers ($\Delta \mathbf{p}^R$) or to reduce income taxes (Δy_i^R). Finally, the change in the contractor's utility will enter the SWF through distributional weights ($\Phi'(V_i) \cdot \frac{\partial V_i}{\partial y}$), which describe the marginal effect of an additional unit of income for the building contractor, i, on social welfare.

The choice of these distributional weights relates to fundamental welfare economic considerations recently reviewed for environmental policy appraisal by Adler (2016) and Fleurbaey and Abi-Rafeh (2016). $\Phi'(V_i)$ is the weight of individual i in the SWF, sometimes referred to as the social weight, and $\partial V_i/\partial y$ is the marginal utility of income of individual i at the status quo. In the simplest form of a utilitarian SWF, for example, all individuals have the same social weight $\Phi'(V_i) = 1$. However, distributional weights attached to different individuals can still differ because of differences in the marginal utility of income. A common generalization is an isoelastic, additively separable SWF with a single parameter for society's inequality aversion regarding the distribution of individuals' utility (see, e.g., Adler 2016): $SWF = \sum_{i=1}^{n} \frac{V_i^{1-\rho}}{1-\rho}$, with $V_i > 0$ as a positive representation of individual utility. Here, $\rho \geq 0$ measures society's aversion to inequality in utilities, so that $\Phi'(V_i) = V_i^{-\rho}$. The larger society's inequality aversion, ρ, the more weight is given to those who have less utility. Utility is typically considered to be increasing in income but at a decreasing rate, commonly captured by an isoelastic utility function: $V_i = y_i^{1-\gamma}/(1-\gamma)$. Distributional weights across individuals for income-equivalent changes induced by an environmental policy then depend on both the social weights, determined by ρ, and the elasticity of marginal utility, determined by γ. Accordingly, distributional weights, as represented in equation (4a), are then given by: $\Phi'(V_i) \cdot \frac{\partial V_i}{\partial y} = y_i^{-(\gamma+\rho-\gamma\rho)}$ (e.g., Nurmi and Ahtiainen 2018).

Much of the literature, however, tends to ignore distributional weights (both the social weight and the weight for the marginal utility of income), as does environmental policy appraisal in practice, thereby implicitly assuming a utilitarian welfare function with constant marginal utility of income. Indeed, it is common to classify distributional effects as either "regressive" or "progressive" based on the relationship between relative welfare changes and initial welfare levels, typically measured by annual income or expenditure (Parry et al. 2006). To maintain consistency with this literature, we adopt this terminology. A policy increases inequality if the costs as a share of income (or expenditure) fall disproportionately on the less well-off; it is then termed *regressive*. By contrast, a *progressive* policy reduces inequality because its costs fall disproportionately on the better-off. On the benefits side, we define the effects as regressive (progressive) if benefits disproportionately accrue to better-off (worse-off) individuals.[4]

Our classification of the principal effects of an environmental policy on individual welfare motivates the following sections and subsections of our review. First, in Section 3, we discuss how the benefits from environmental improvements induced by a policy are distributed. Subsections discuss separately the literature on direct nonmarket benefits and that on market-mediated ones. Second, in Section 4, we discuss how the costs of an environmental policy instrument are distributed across income levels. In subsections, we assess both the longstanding literature on the incidence of costs from higher prices ("use side") and the more recent literature on the costs from changing factor incomes ("source side"). Third, Section 5 considers redistributive policies. Environmental policy proposals are oftentimes accompanied by complementary redistributive measures in the form of revenue recycling, as we discuss in the first subsection. But even stand-alone redistribution may have considerable repercussions for the environment, as we discuss in the second subsection.

[4]While the technical definition of "progressive" ("regressive") refers to a cost or benefit that rises more quickly (more slowly) than income, we use the common terminology of "progressive" ("regressive") to capture effects that disproportionately benefit the poor (rich). Thus, a progressive distribution of benefits and a progressive distribution of costs are both "pro-poor."

3. *The Incidence of Environmental Benefits*

This section investigates how environmental benefits resulting from environmental policy are distributed. First, we consider nonmarket environmental benefits as a direct source of utility. Second, we examine how environmental benefits are mediated by markets to alter the prices of goods and the returns to production factors and, thus, incomes.

3.1 *Nonmarket Environmental Benefits*

We start by isolating how a marginal change in environmental quality, ΔE_i, due to an environmental policy translates into utility changes, as captured by the term $\frac{\partial V_i}{\partial E_i} / \frac{\partial V_i}{\partial y_i} \cdot \Delta E_i$ in equation (4a) along the income distribution.

First, we consider changes in the provision of an environmental public good that is consumed equally by everyone, so that $\Delta E_i = \Delta E$. An example of this is a nonuse service derived from biodiversity, such as an existence value attached to a threatened species. Let us assume that individuals differ in income, y_i, but not in their preferences. Then, distributional effects are solely determined by differences in the valuation of environmental quality—commonly assessed using the WTP for a marginal change in E—along the income distribution (Ebert 2003; Baumgärtner et al. 2017). Let us consider a standard constant elasticity of substitution (CES) utility function with an environmental good, E, and a numeraire consumption good, $C_i = y_i$:

$$U(C_i, E) = \left(\alpha E^{(1-\eta^W)} + (1-\alpha) C_i^{(1-\eta^W)}\right)^{\frac{1}{1-\eta^W}}, \tag{5}$$

where α is the share parameter for the environmental public good in utility, and $\eta^W = \frac{\partial WTP_i}{\partial y_i} \frac{y_i}{WTP_i}$ is the *income elasticity of WTP*, which is inversely related to the elasticity of substitution, σ, with $\sigma = 1/\eta^W$ (Ebert 2003). Individual marginal WTP for the environmental improvement can then be approximated as (Ebert 2003; Baumgärtner et al. 2017; Smith 2023):[5]

$$WTP_i = \kappa y_i^{\eta^W} \text{ with } \kappa = \frac{1-\alpha}{\alpha} E^{-\eta^W}. \tag{6}$$

The *income elasticity of (marginal) WTP* is a summary statistic for the distributional effect of the benefits of a pure public good. For instance, when $\eta^W < 1$, WTP for a marginal increase in the environmental public good increases by less than 1 percent when income increases by 1 percent. In that case, lower-income households have a higher WTP for a marginal increase in public goods relative to their income. This means that environmental benefits are distributed progressively, that is, pro-poor (Ebert 2003). If, in contrast, WTP

[5] WTP is here derived from a "pseudo-choice problem" (Ebert 2003) describing an individual's WTP for a hypothetical environmental improvement, as the level of environmental quality cannot be individually chosen for rationed public goods. As such, the income elasticity of WTP for the environmental good at the rationed quantity also differs from the income elasticity of demand (Flores and Carson 1997).

increases more than proportionally with income ($\eta^W > 1$), benefits are distributed regressively, that is pro-rich.

Most empirical studies obtain estimates of income elasticities of WTP for environmental benefits that are smaller than unity (e.g., Jacobsen and Hanley 2009; Drupp 2018; Drupp and Hänsel 2021).[6] This implies that environmental benefits are distributed in a pro-poor manner. Jacobsen and Hanley (2009) estimate an income elasticity of WTP for biodiversity conservation of 0.38, based on 145 WTP–income pairs from 45 contingent valuation studies. Drupp et al. (2024b) provide a meta-analysis encompassing all types of nonmarket environmental goods, drawing on 735 WTP–income pairs from 396 contingent valuation studies. Using multivariate, random effects regressions, they find an income elasticity of WTP of 0.59 (95 CI: 0.45 to 0.72). The income elasticity does not differ much between regulating and cultural ecosystem services, but there is notable variation in ecosystem service subcategories. The 95 percent confidence intervals of the estimated income elasticities of WTP overlap with unity only in a single subcategory (see left panel in Figure 1). The evidence to date thus suggests that the distribution of environmental benefits tends to be pro-poor.

Second, we consider changes to environmental goods that are heterogeneously distributed across individuals, often based on where they live. Then, to evaluate the distributional effects of an environmental policy, we have to consider how changes in environmental exposure, ΔE_i, vary along the income distribution. Because environmental policies often target places with lower levels of environmental quality, ΔE_i tends to be itself a function of E_i. Examples of this include the distance to an environmental (dis)amenity to be improved, such as an urban green park or a source of pollution, as well as baseline climate conditions that shape uneven changes in heat exposure from climate change (e.g., Carleton et al. 2022; Cohen and Dechezleprêtre 2022).

Keeping with our focus on income elasticities, the relevant empirical relationship could also be conceptualized with an *income elasticity of environmental exposure*, although this is rarely done explicitly. This relationship will take as given many dynamics outside of a household's control, such as siting decisions by firms that shape exposure (e.g., Banzhaf, Ma, and Timmins 2019; Hsiang, Oliva, and Walker 2019). However, certain mediating factors, over which households have control, also alter the relationship between income and exposure changes (ΔE_i) or the willingness to pay for them (WTP_i). For example, there is a nascent empirical literature investigating how adaptive behavior depends on income. This mainly looks at defensive expenditures, avoidance behavior, sorting, and migration. Concerning defensive expenditures, Sun, Kahn, and Zheng (2017), for instance, show that higher-income households in China are more likely to invest in expensive air filters. While they only compare effects across three income groups, their results tentatively suggest that defensive expenditures increase the inequality in exposure to air pollution. Concerning avoidance behavior, Chen et al. (2020) examine the impact of air pollution on short-term aviation trips in China and show that the number of passengers on the flight increases with the amount of air pollution in the origin city relative to the destination city. The number of first-class passengers increases about three times faster than

[6] While most studies assume constant elasticities, it is plausible that income elasticities of WTP vary along socioeconomic characteristics, such as income. Barbier, Czajkowski, and Hanley (2017), for instance, estimate that the income elasticity of WTP for water quality improvement in the Baltic sea is 0.1–0.2 for low-income respondents, while it is 0.6–0.7 for high-income respondents. A cross-country meta-analysis by Drupp et al. (2024b) suggests that the income elasticity is almost three times as large in the top 25 percent of the considered income distribution. So far, however, there is limited theory to inform the shape of nonconstant elasticities (Barbier, Czajkowski, and Hanley 2017; Drupp 2018).

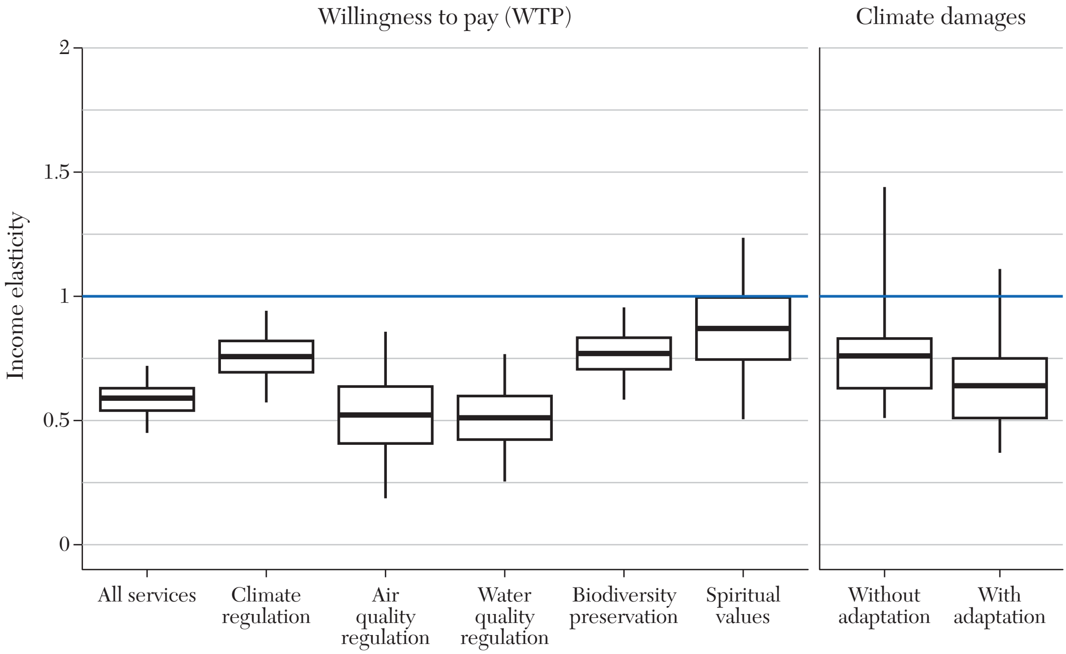

Figure 1. Income Elasticities of Willingness to Pay for Ecosystem Services and of Climate Damages

Notes: Estimates of income elasticities of willingness to pay (WTP) for all ecosystem services combined as well as for selected subcategories, based on a meta-analysis of contingent valuation studies provided to us by Drupp et al. (2024a, b) (left panel). Estimates of the income elasticity of climate damages reported in Gilli et al. (2024) (right panel). Mean estimates (middle lines), interquartile ranges (boxes), and 95 percent confidence intervals (whiskers). Income elasticities below (above) unity imply that environmental benefits, or benefits from avoided climate damages, are pro-poor (pro-rich). Data and code underlying this figure are available in Drupp et al. (2025).

the number of economy-class passengers, suggesting differential avoidance behavior along the income distribution. Along similar lines, Zivin, Neidell, and Schlenker (2011) investigate changes to bottled water purchases following water quality violations. Comparing the lowest and the top income quartiles, they find no significant differences for short-term violations related to microorganisms and nitrates. However, richer households respond by buying relatively more bottled water when faced with violations that lead to longer-term health risks, such as those related to levels of chemicals.

While avoidance typically involves shorter-term behavioral change that temporarily alters effective exposure (ΔE_i) or associated damages (ΔWTP_i), sorting and migration tend to persistently shape the distribution of environmental exposure. The sorting literature, à la Tiebout, considers households that trade off higher housing costs with higher amenities and "vote with their feet" in sorting toward neighborhoods with a desired bundle of taxes and local public goods, including environmental amenities (e.g., Banzhaf and Walsh 2008; Depro, Timmins, and O'Neil 2015; Banzhaf, Ma, and Timmins 2019; Chen, Oliva, and Zhang 2022). Both the desire to sort, expressed in terms of WTP for a cleaner environment, and the ability to sort depend on income—as is also often the case for mediating factors, such as information access (e.g., Hausman and Stolper 2021; Gao, Song, and Timmins 2023).[7] Theory predicts that higher-income households will sort into neighborhoods with better environmental amenities (e.g., Brueckner, Thisse, and Zenou 1999; Lee and Lin 2018). Lee and Lin (2018) show that persistent natural amenities attract high-income households, an effect that may be denoted as "coming to the amenity," while low housing prices in polluted areas may lead poorer households to engage in "coming to the nuisance" (e.g., Depro, Timmins, and O'Neil 2015).[8] If environmental policy disproportionately benefits areas with the lowest environmental quality, any previous sorting along those lines will result in progressive benefits. For example, it has been documented that regional targeting under the US Clean Air Act helped narrow pollution exposure differentials (Currie, Voorheis, and Walker 2023; Sager and Singer 2025). Whether or not there is re-sorting following such improvements depends on market conditions as well as social and institutional contexts.

Because adaptive behavior tends to be a function of income, it can be helpful to conceptualize an *income elasticity of adaptive capacity* when exploring distributional effects. Gilli et al. (2024) estimate the income elasticity of climate damages and contrast a case with and without adaptation, pairing the climate impact functions by Burke, Hsiang, and Miguel (2015) with data on income deciles at the country level. Gilli et al. (2024) estimate income elasticities of climate damages of 0.76 before and 0.64 after adaptation, which we illustrate in the right panel of Figure 1. Because the income elasticity of climate damages tends to be smaller than unity, the results suggest that they may hurt the poor disproportionately and that the benefits from avoided climate damages are likely distributed in a pro-poor manner. The drop in the elasticity when adaptation is considered suggests that adaptation may exacerbate the regressivity of damages from climate change (see Carleton et al. 2022 for qualitatively similar results concerning the distribution of mortality impacts from climate change in the presence of adaptation). This suggests that the income elasticity of adaptive capacity, at least in the climate context, is likely larger than unity.

In sum, the incidence of nonmarket environmental benefits is shaped by the *income elasticity of WTP*, which can in itself depend on how *environmental exposure* and *adaptive capacity* vary with income.

3.2 *Market-Mediated Environmental Benefits*

Besides direct utility benefits, environmental improvements can have effects that are mediated by markets, such as altering prices of goods or incomes, as represented by $\Delta \mathbf{p}^E$ and Δy_i^E in equation (4a).

Let us first consider the effect of a policy that improves local air quality. All else equal, these benefits increase the utility of local residents (see above discussion). This, in turn, renders neighborhoods more attractive, driving up rental prices. While this generates an extra cost to renters, it is a benefit to property owners (e.g., Grainger 2012; Bento, Freedman, and Lang 2015). Typically, this benefits rich owners disproportionately, but it can vary by local context. Bento,

[7] The environmental justice literature also explores related effects due to (racial) discrimination (see, e.g., Banzhaf, Ma, and Timmins 2019; Christensen, Sarmiento-Barbieri, and Timmins 2021; Christensen and Timmins 2022).

[8] The nuisance may also come disproportionally to disadvantaged communities via siting decisions of firms (e.g., Wolverton 2009); they may be relocated from such communities (Wang et al. 2021); or the nuisances may be less-often remedied by legal settlements (Campa and Muehlenbachs 2024).

Freedman, and Lang (2015), for instance, examine the distribution of housing price benefits induced by the 1990 US Clean Air Act Amendments. They find that, because the most polluted areas were targeted for cleanup, housing price appreciation following air quality improvements disproportionately favored households in the lowest quintile of the income distribution. Such nuanced effects also explain why effects of "environmental gentrification" (Banzhaf, Ma, and Timmins 2019), which may follow changes in environmental quality, depend on preexisting ownership and rental constellations. Further knock-on effects from better air quality might include restaurants charging higher prices for serving guests outdoors, as well as outdoor workers becoming more productive and thus collecting higher wages (Aguilar-Gomez et al. 2022).

Next, let us consider an environmental policy that reduces carbon emissions and thus mitigates climate change. The reduced occurrence of excessive heat may improve human capital formation and labor productivity (e.g., Park et al. 2020; Somanathan et al. 2021; De Lima et al. 2021), raising wage incomes as well as lowering capital depreciation, Δy_i^E. For example, Dillender (2021) uses panel fixed-effects models to show that temperature extremes increase occupational injury rates in Texas as well as in the mining industry throughout the United States. High temperatures have more severe adverse effects in warmer climates, suggesting limited potential of avoidance behavior as an adaptation strategy for outside workers. Relatedly, Park, Pankratz, and Behrer (2021) draw on injury claims between 2001 and 2018 from the United States' largest workers' compensation system to explore the relationship between temperature and workplace safety. They find that the effect of heat days (with temperatures exceeding 90 degrees Fahrenheit) on work injuries tends to hit the poor disproportionately. Similarly, climate policy can mitigate crop yield losses (e.g., Ortiz-Bobea et al. 2021; Schlenker and Roberts 2009). Thus, improved environmental quality can lead to higher incomes for farmers or lower prices of agricultural goods.

Overall, the incidence of price changes due to an environmental policy may be summarized by the *income elasticity of demand for environmentally exposed goods*, η^{C_E}, and the incidence of income changes by the *income elasticity of income from environmentally exposed factors*, η^{F_E}, including effects on both labor and capital incomes. Consider the case in which improved environmental quality leads to lower prices for certain agricultural products (e.g., due to fewer crop failures). Agricultural products, as a share of the total budget, typically are consumed disproportionately by lower-income households. Accordingly, the *income elasticity of demand for environmentally exposed goods*, η^{C_E}, may be lower than unity. In that case, market-mediated environmental benefits of the environmental policy would benefit poorer individuals disproportionately. More generally, though, income elasticities will vary across domains, that is, they may be different for housing than food. Income elasticities will also differ across levels of aggregation. While food overall may be an inferior good, specific food products may be luxury goods. Such plausible context dependencies of income elasticities highlight the need for nuanced analyses of the resulting distributional effects.

4. *The Incidence of Environmental Policy Costs*

This section considers how environmental policy costs are distributed and thus affect inequality. We extend prior reviews (e.g., Fullerton 2011; Bento 2013) by synthesizing recent theoretical and empirical contributions.

The incidence of environmental policy costs is represented by $-\mathbf{C}_i \cdot \Delta \mathbf{p}^P + \Delta y_i^P$ in equation (4b). The first component shows that individuals are affected by changes in the prices of goods and services ("use-side incidence"). The second component represents changes in factor incomes ("source-side incidence"), which can be passed on as indirect effects via producers. This flows from the basic insight that the economic costs of a tax are generally shared between producers and consumers, irrespective of who nominally pays. If a policy directly applies to consumers, as in the case of public transport subsidies, consumers adjust their demand and firms adjust their supply, resulting in an overall shift of prices and incomes. If policies target firms and increase their costs of production—for example, a carbon tax—firms pass on part of the extra costs to consumers. Direct compliance costs of an environmental policy are thus partly passed on to consumer prices, while the rest are borne by producers. Weyl and Fabinger (2013) consider the case of a tax increase in a perfectly competitive market, where the pass-through rate, ψ, describes what share of a tax is passed on as higher consumer prices. In their model, consumers have a negative price elasticity of dirty demand, ϵ^D, and producers a positive price elasticity of dirty supply, ϵ_S. Without market distortions, the pass-through rate of a tax to consumers is $\psi = \epsilon^S/\left(\epsilon^S - \epsilon^D\right)$. Hence, the more inelastic party bears a larger share of the policy cost burden.

Empirical estimates have often found pass-through rates to consumers of close to 100 percent: See Li, Linn, and Muehlegger (2014) for taxes on gasoline in the United States, Andersson (2019) for energy and carbon taxes on gasoline in Sweden, and Fabra and Reguant (2014) for emission taxes on electricity production in Spain. A recent body of literature, however, highlights deviations from these close-to-complete pass-through rates. First, pass-through rates depend on socioeconomic variables. Harju et al. (2022) study a large increase in the Finnish carbon tax on fuel, reporting an average pass-through rate of only 80 percent. This varies between 76 percent and 91 percent depending on income and the urban/rural divide of retail locations, with lower-income or more rural areas facing higher pass-through rates. They note that both geographical characteristics and salience of the tax increase may be responsible for rather low pass-through rates. Second, the scope of the regulation matters. Muehlegger and Sweeney (2022) show that idiosyncratic cost shocks to oil refineries in the United States are barely passed on. By contrast, common cost shocks to all firms—for example, a comprehensive carbon tax—are fully passed on to consumers. Third, market structure matters. Preonas (2024) shows that market power in the railroad sector may decrease the pass-through rate of a carbon tax on coal-fired power plants, finding a value as low as 75 percent for some plants. Coal power plants in the United States adjust their coal demand due to changes in gas prices when gas competes with coal for electricity generation. In response, rail carriers operating under imperfect competition re-optimize their mark-ups. Spurlock and Fujita (2022) also find no price increase in response to stricter energy efficiency standards for clothes washers in the United States. They attribute this to strategic pricing of suppliers and, possibly, innovation externalities when producers developed products to comply with the efficiency requirements. Finally, Ganapati, Shapiro, and Walker (2020) study the pass-through of energy cost shocks for six US manufacturing industries with a focus on intermediate goods; they find that marginal cost pass-through rates often deviate strongly from unity. While the pass-through rate of marginal costs to prices is 70 percent on average, it exceeds 100 percent for some industries, likely due to imperfect competition.

We now turn to reviewing how environmental policy costs differ by income groups. We consider use-side and source-side effects in turn. We distinguish studies with respect to which economic adjustments to a policy change are taken into account. First, we review how policy costs affect individuals through use-side effects, represented by the term $\left(-\Delta\mathbf{p}^P \cdot \mathbf{C}_i\right)$ in equation (4b). Second, we examine how policy costs change individual incomes via source-side effects, represented by the term Δy_i^P in equation (4b).

4.1 *Use-Side Effects*

On the use side, environmental policy adversely affects individual welfare by raising the prices of pollution-intensive goods and services, captured by $\Delta \mathbf{p}^P$ in equation (4b). The literature commonly relies on exogenously fixed pass-through rates and assumes that consumers bear 100 percent of the additional costs from the policy (e.g., Dorband et al. 2019; Cronin, Fullerton, and Sexton 2019). Here, it is important to include all goods and services in order to capture both direct and indirect price changes. Direct price changes relate to polluting goods (e.g., heating fuel). Indirect price changes matter for goods and services that contain dirty intermediate inputs (e.g., electricity to produce electronic devices). Using input–output analysis to calculate how carbon taxes affect the prices of all goods and services, Cronin, Fullerton, and Sexton (2019) and Feindt et al. (2021) show that indirect price effects can be important and can sometimes even overturn the incidence of direct effects. The meta-analysis in Ohlendorf et al. (2021) collects evidence from 53 empirical studies in 39 countries and indicates a higher likelihood of a progressive incidence of carbon pricing for studies that include indirect effects.

With that said, much of the use-side incidence tends to be driven by relative price increases of dirty consumption targeted by environmental policy. Denoting total demand for dirty goods, D_i, and the associated price change, $\Delta p^D > 0$, the use-side effect $\left(-\mathbf{C}_i \cdot \Delta \mathbf{p}^P\right)$ in equation (4b) becomes $\left(-D_i \cdot \Delta p^d\right)$ when clean consumption is the numeraire (i.e., the price of clean consumption is constant). When prices increase and demand is inelastic, the distribution of this burden across income groups follows the *income elasticity of dirty demand*: $\eta^D = \mathrm{d}\ln(D_i)/\mathrm{d}\ln(y_i)$. The burden is regressive (i.e., pro-rich) if η^D is smaller than 1: Budget shares of dirty consumption determine the burden of the policy as a share of income $\Delta p^d D_i/y_i \propto y_i^{\eta^D-1}$, which decreases in income if $\eta^D < 1$. Likewise, the burden is progressive (i.e., pro-poor) if η^D is larger than 1.

Table 1 reports income elasticities of demand for specific goods. The goods covered here can be expected to experience an increase in their relative price due to environmental regulations for, for instance, CO_2 emissions, sulfur emissions, pesticides, or water contamination. Due to the lack of systematic evidence, selected studies for each good are reported from diverse countries. In the selected studies, the income elasticities of electricity and water are consistently below unity, contributing to a regressive use-side incidence, particularly for water. The picture is less clear for gasoline and beef.

Analysis of policy incidence has stressed the importance of the welfare measure by which households are compared, usually either annual income or expenditure. Poterba (1989) argues that incidence analysis should be based on expenditure rather than income because, under the permanent income hypothesis, expenditure is a proxy for lifetime income (Friedman 1957).[9] Studies frequently find that a policy that resembles an excise tax is less regressive when incidence is measured based on expenditure instead of income (Fullerton and Heutel

[9] Hassett, Mathur, and Metcalf (2009) consider two proxies for lifetime income. The first is current expenditure, which corrects for smoothing shocks to current income anticipating lifetime income. The second measure corrects for a potential bias due to life-cycle consumption patterns. For instance, a specific age group might have a high share of dirty goods in their current expenditures, yet a smaller share over the entire lifetime.

TABLE 1
Annual Income, Expenditure, and Price Elasticities of Selected Goods

Good	Income elasticity of demand	Expenditure elasticity of demand	Price elasticity of demand
Electricity	0.05 (USA)[a] 0.1 (China)[b]	0.4 (Germany)[c] 0.6 (China)[d]	−0.1 (short term)[e] −0.4 (long term)[e]
Water	0.1 (USA/Canada)[f] 0.1 (Vietnam)[g]	0.1 (Spain)[h] 0.2 (Cambodia)[i]	−0.4[j]
Gasoline	0.2-0.3 (USA)[k] 1.2 (Mexico)[l]	0.3 (USA)[m] 1.2 (China)[n]	−0.3 (short term)[e] −0.8 (long term)[e]
Beef	1.0 (Sweden)[o] 0.4 (China)[p]	0.9 (USA)[q] 1.9 (Malaysia)[r]	−0.9[s]

Sources: [a]Alberini, Gans, and Velez-Lopez (2011). [b]Zhou and Teng (2013). [c]Schulte and Heindl (2017). [d]Sun and Ouyang (2016). [e]Labandeira, Labeaga, and López-Otero (2017). [f]Olmstead, Hanemann, and Stavins (2007). [g]Cheesman, Bennett, and Son (2008). [h]Suárez-Varela (2020). [i]Basani, Isham, and Reilly (2008). [j]Sebri (2014). [k]Blundell, Horowitz, and Parey (2012). [l]Díaz and Medlock (2021). [m]Wadud, Graham, and Noland (2010). [n]Sun and Ouyang (2016). [o]Säll (2018). [p]Zhu et al. (2021). [q]Tonsor and Marsh (2007). [r]Sheng et al. (2010). [s]Gallet (2010).

2011; Cronin, Fullerton, and Sexton 2019; Douenne 2020). This finding was confirmed in a meta-analysis of carbon pricing: Ohlendorf et al. (2021) find that using proxies for lifetime income instead of annual income increases the likelihood of a progressive incidence. Table 1 thus also reports expenditure elasticities. These tend to be larger than income elasticities, confirming that analyses based on expenditure yield less regressive incidence patterns than those based on income.

The use-side incidence of environmental policy often takes into account that consumer demand reacts to price changes of goods and services. Under such demand adjustments, the first-order approximation of welfare changes in equation (4b) is no longer valid and needs to include higher-order terms. Welfare changes should be calculated as the equivalent or compensating variation, or approximations such as the change in consumer surplus. These indicators can include changes at the intensive margin, such as consuming less of a good, and at the extensive margin, such as switching to a different technology. The most comprehensive studies of demand adjustments include leisure as a good, taking into account that more or less time may be spent working (Goulder et al. 2019). Demand adjustments reduce the policy burden when households avoid polluting behavior. West and Williams III (2004), for instance, compute the incidence of a fuel tax based on four measures of welfare change: (i) equivalent variation, (ii) consumer surplus change under income-specific demand adjustments, (iii) consumer surplus change under demand adjustments that are not income-specific, and (iv) assuming inelastic demand. They show that demand adjustments reduce the regressivity of a fuel tax. Ohlendorf et al. (2021) confirm this finding in a meta-analysis on carbon pricing.

The extent to which demand reacts to price changes is often summarized by price elasticities of demand, which are estimated via demand systems. The influence of price elasticities on use-side incidence has two important components. First, elasticities differ by product type. Households will particularly suffer from an environmental policy that targets a good that they inelastically demand and disproportionately consume. Table 1 reports price elasticities of demand from meta-analyses. The estimates thus represent an average across the countries that are considered in the meta-studies. Demand is generally inelastic to price increases for polluting goods, especially in the short term. We note two important caveats to the reported low average absolute price elasticities. First, recent research finds stronger demand responses to price changes induced by (environmental) taxes than from variation in market prices (Li, Linn, and Muehlegger 2014; Andersson 2019; Basaglia, Behr, and Drupp 2025). Second, meta-analyses report a large variation of elasticity estimates depending on the methods of analysis or geographical location. Comparing countries at different development stages, households in lower-income countries are more responsive to higher energy prices in the long term (Labandeira, Labeaga, and López-Otero 2017) and to higher food prices (Green et al. 2013; Femenia 2019).

Second, for distributional analysis, it is important to know whether different income groups react differently to price changes. There is limited systematic evidence on the patterns between income and price elasticities of demand for different goods and different countries. We report existing evidence, which is partly conflicting. The meta-analysis of Green et al. (2013) finds that lower-income groups tend to respond more elastically to food prices. However, results again depend on the specific good and socioeconomic context. Kumar et al. (2011) find that higher-income groups react more elastically to price increases for vegetables, fruit, and milk in India. No systematic evidence exists for energy prices; in some settings, low-income households react more strongly to energy price changes (West and Williams III 2004 for the United States), while others report the opposite (Frondel, Kussel, and Sommer 2019 for Germany).

The literature reviewed in this section so far reveals that the use-side incidence of an environmental policy is pollutant-specific and depends on socioeconomic characteristics, such as a country's development stage, climate, and geography. We now focus on incidence estimates for transport, carbon, and local air pollution policies. The literature for these cases is more developed and better comparable across more than one country.

Taxing transport fuels is progressive in many countries, with high-income countries showing a less progressive or a regressive effect. This is the finding of Sterner (2012, chapter 19), who summarizes the incidence of fuel taxes in 22 developing and developed countries. Steckel et al. (2021) report an inverted U-shaped incidence, with middle-income groups having the largest burden, in some countries of developing Asia. A contributing factor is that car ownership in poorer countries is limited to better-off households. The review in Wang et al. (2016) and the meta-analysis in Ohlendorf et al. (2021) find that pricing instruments in the transport sector tend to be more progressive than general carbon pricing. Again, results are country-specific. Steckel et al. (2021) consider eight countries in developing Asia and find that taxing liquid fuels would be regressive in Bangladesh, where they are used for cooking. The transportation mode also plays an important role when considering effects of transport subsidies. Serebrisky et al. (2009) find that public transport subsidies fail to disproportionately benefit the poor in many developing countries because many low-income households do not have access to public transport and rely on walking. Geographic characteristics are also important for local policies. If low-income households live in the outskirts of a city, they particularly benefit from public transport subsidies (Hörcher and Tirachini 2021). Beyond consumption of different transport modes, Parry (2009) highlights the role of leisure consumption for distributional analyses in the transport sector, classifying congestion charges as likely regressive. The reason is that if higher-income households have higher opportunity costs, they benefit disproportionately from saved travel time per mileage because they tend to drive higher total miles.

Pricing carbon emissions encompasses all fossil-fuel based consumption in energy (beyond transport, e.g., heating and electricity). Many energy services, such as heating and electricity, have income elasticities of demand below one, at least in higher-income countries. Consequently, carbon taxation tends to be regressive in those countries (Wang et al. 2016; Pizer and Sexton 2019). The recent literature has identified a number of adjustments that make a carbon tax look more progressive. First, a carbon tax affects indirect emissions in household consumption and raises the prices of goods and services that use energy as an intermediate input; this often shows a less regressive consumption pattern. Second, a carbon tax is less regressive when using expenditure instead of annual income as the welfare measure. Cronin, Fullerton, and Sexton (2019), for the United States, and Feindt et al. (2021), for 23 member countries of the European Union, find that a comprehensive carbon tax on all emissions embodied in production ranges from neutral to progressive when expenditure is the welfare measure. The literature review in Wang et al. (2016), the meta-analysis in Ohlendorf et al. (2021), and the meta-study in Budolfson et al. (2021a) report a tendency of carbon pricing to be more progressive in developing countries. However, they highlight that the incidence remains country-specific, as also reported for eight countries in developing Asia by Steckel et al. (2021).

Beyond energy and carbon taxes, a few papers examine the use-side incidence of taxing other air pollutants, such as fine or coarser particulate matter ($PM_{2.5}$, PM_{10}). Johne, Schröder, and Ward (2023) study nitrogen emissions in Germany. Parry (2004) examines nitrogen oxides (NO_X) and sulphur dioxide (SO_2) emissions in the United States. García-Muros et al. (2017) scrutinize local air pollutants (NO_X, SO_2, PM_{10}, and a non-methane volatile organic compound, ammonia) in Spain. Mardones and Mena (2020) assess NO_X, SO_2, and PM_{10} emissions in Chile. The results suggest regressive effects, yet more research is needed to gather systematic evidence about how the costs of air pollution policies affect inequality.

Policies other than pricing pollution can be quite different in their incidence. Davis and Knittel (2019), for instance, consider fleet-wide fuel economy standards under the US Corporate Average Fuel Economy (CAFE) regulation. Using a simple model of car producers' choices, combined with a numerical application, they show that producers price fuel-efficient cars lower than they would in the absence of the regulation. Fuel-inefficient cars are priced higher. Because new vehicles compete with used vehicles, price changes in the two markets are linked. Davis and Knittel find that fuel economy standards have a mildly regressive effect because prices of used vehicles increase in response to the regulation. Similarly, Levinson (2019) calibrates a model to describe the incidence of the US CAFE regulations, finding that they look weakly more regressive than an energy tax would be. The intuition is that an energy efficiency standard acts like a tax on inefficient appliances. If both the inefficiency tax and the energy tax raise the same amount of revenue, high-income households pay less under the inefficiency tax compared to the energy tax because they have more energy-efficient appliances. Zhao and Mattauch (2022) extend the model of Levinson by recognizing that appliances that provide the same energy service (such as miles traveled per gallon) may differ in the quality of the service (such as driving a mile in an SUV versus on a moped). They show that standards can be less regressive than taxes if high-income households have preferences for more polluting service qualities.

4.2 *Source-Side Effects*

The part of policy costs that are borne by producers affects households through changes in factor incomes. The total source-side effect is denoted with ΔY_i^P in equation (4b). Consider a pollution tax and inelastic supply of labor and capital by households. Following Rausch and Schwarz (2016), we can write the welfare change from source-side effects relative to income as $\Delta Y_i^P/Y_i = \frac{\Delta w}{w} S_i^L + \frac{\Delta r}{r} S_i^K$. The relative change of the wage rate, $\Delta w/w$, and of the capital rental rate, $\Delta r/r$, affect income from both sources through each household's share of the factor in total income: $S_i^L = w L_i/Y_i$ for labor and $S_i^K = r K_i/Y_i$ for capital.

According to Fullerton and Metcalf (2002) and Fullerton and Heutel (2007), the distributional impact on the source side depends on which factor price declines relative to the other. We call the factor that bears the larger burden from the policy the *policy-exposed factor*. Fullerton and Heutel (2007) show that if the polluting sector is relatively more capital-intensive, or if labor is a better substitute for pollution, the relative capital rental rate tends to decline compared to the relative wage rate. In that case, capital tends to be the policy-exposed factor.

To summarize source-side effects, one can adopt an income elasticity approach similar to that for use-side effects. To do so, we introduce the *income elasticity of income from the policy-exposed factor*. It measures how much income from the policy-exposed factor increases when household income increases: $\eta^F = \mathrm{d}\ln(p_F F_i)/\mathrm{d}\ln(Y_i)$, where p_F is the price of the policy-exposed factor (either wage or capital rental rate) and F_i is the endowment of the policy-exposed factor (either labor or capital). If $\eta_F > 1$, source-side effects tend to be progressive.[10] In this case, households with high income rely more heavily on income from the factor whose price declines due to environmental policy, relative to the other factor, such that source-side effects have a progressive component. Likewise, source-side effects tend to be regressive if $\eta_F < 1$.

Similar to the use-side effects, the empirical evidence on source-side effects varies with the pollutant addressed, the type of policy in place, and the socioeconomic circumstances of the specific region considered. Including source-side effects within general equilibrium models often renders a carbon tax more progressive. Multiple reasons have been identified for this finding. A key driver is a larger reduction in relative capital rental rates compared to wages, at least in studies of Austria, Canada, Indonesia, and the United States (Rausch, Metcalf, and Reilly 2011; Dissou and Siddiqui 2014; Yusuf and Resosudarmo 2015; Mayer et al. 2021). Rich households face a higher share of policy costs because they receive larger income shares from capital. This outcome, however, is not guaranteed. Beck et al. (2015), for instance, find that a larger burden of a carbon tax in British Columbia falls on wages. In the context of British Columbia, where higher-income households have larger labor income shares and smaller transfer income shares,

[10] To illustrate this, we follow Fullerton and Heutel (2007) and Rausch and Schwarz (2016) and split total income into the sum of labor, capital, and transfer income: $Y_i = w L_i + r K_i + T_i$ (factors are supplied inelastically by households). For the sake of argument, assume that capital is the policy-exposed factor so that $\Delta r/r - \Delta w/w < 0$. The income elasticity of income from capital is $\eta^F = \mathrm{d}\ln(r K_i)/\mathrm{d}\ln(Y_i)$, so that $r K_i = A Y_i^{\eta_F}$, with some constant A, which determines the total level of income from capital. The source-side effect relative to income is: $\frac{\Delta Y_i}{Y_i} = \frac{\Delta w}{w}\left(1 - \frac{T_i}{Y_i}\right) + \left(\frac{\Delta r}{r} - \frac{\Delta w}{w}\right) A Y_i^{\eta_F - 1}$. If $\eta_F > 1$, the second part of the relative burden declines in income and the source-side effects are likely progressive. As can be seen, source-side effects could have a more nuanced shape depending on the absolute values of the elasticity, income shares, and price changes.

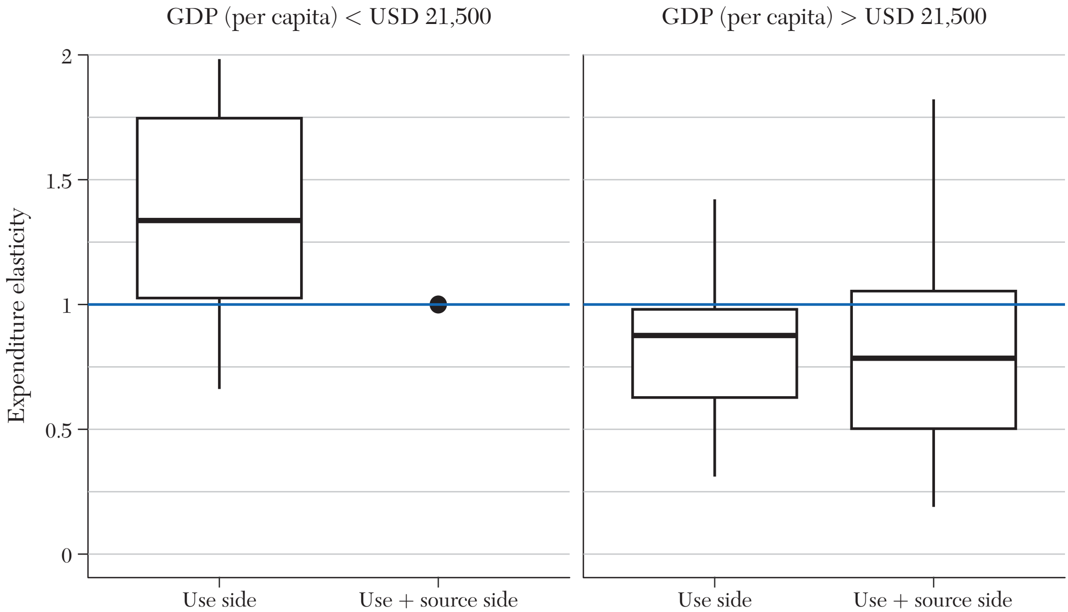

Figure 2. Expenditure Elasticities of Carbon and Fuel Taxation Policy Costs

Notes: Expenditure elasticities of policy costs from carbon and fuel taxation (before revenue recycling), archived at Budolfson et al. (2021b), based on 63 original incidence studies. We distinguish estimates by national income and by modeling choice of the underlying literature (only one estimate in the lower-income category includes source-side effects). Estimates below (above) the unity line imply that policy costs are distributed pro-rich (pro-poor). Median estimates (middle lines), interquartile ranges (boxes), and largest/lowest value of data within 1.5 times the interquartile range (whiskers). Data and code underlying this figure are available in Drupp et al. (2025).

this renders source-side effects progressive. Additionally, price changes may shift governmental transfers that are indexed by inflation, which would have a progressive effect in the United States (Rausch et al. 2010; Goulder et al. 2019; Cronin, Fullerton, and Sexton 2019). This effect is separate from explicit revenue recycling, as discussed in Section 5.1.

Fullerton and Monti (2013) further differentiate between high- and low-skilled workers in a theoretical model (but exclude capital as a production factor). They show that wages of high-skilled workers increase relative to low-skilled workers when dirty production relies more on low-skilled workers or when high-skilled work is a better substitute for pollution. A numerical illustration with US data shows that the gross wage of low-skilled workers decreases relative to high-skilled workers in the majority of considered scenarios, which contributes to the regressivity of a carbon tax. Yusuf and Resosudarmo (2015) further differentiate factor incomes in a computable general equilibrium analysis of a carbon tax. They show that wages of unskilled workers, particularly in the agricultural sector, are reduced relatively less than wages of skilled workers; this contributes to the progressivity of a carbon tax in Indonesia. In addition, returns to capital fall relative to returns to land, which adds to the tax's progressivity. The incidence of source-side effects, depending on the channels through which it exerts its influence, can thus also differ considerably across countries.

Budolfson et al. (2021a) provide a summary of climate policy incidence by reviewing the cost incidence literature of fuel and carbon taxation. The authors extract 97 policy cost distributions among households from 63 studies (before tax revenue recycling) and compute the corresponding expenditure elasticities by matching cost distributions to consumption distributions by study country. Figure 2 shows the range of elasticity estimates. In the figure, estimates are grouped by national per capita GDP. Budolfson et al. find, on average, a progressive (pro-poor) incidence for GDP levels below a value of roughly USD 21,500 and a regressive incidence (pro-rich) for GDP levels above that value. We additionally identified whether the studies of Budolfson et al. calculate only the use-side incidence or combine use-side and source-side effects in one expenditure elasticity of policy costs (see the replication data for details). We show the distribution of elasticity estimates in Figure 2, separately for these two modeling choices. Elasticity estimates range between 0 and 2. Budolfson et al. (2021a) confirm the previous finding that climate policy costs tend to be more progressive in lower-income countries. Elasticity estimates are above 1 for the majority of studies on countries with average per capita GDP below USD 21,500. By contrast, estimates are mostly below 1 in countries with higher income, implying that climate policy costs tend to be more regressive in higher-income countries. There is no clear trend that including source-side effects renders climate policy more or less regressive; however, the evidence is limited.

Apart from carbon taxes, Chen et al. (2022) study the distributional effect of raising taxes on SO_2 and NO_X emissions in China. Including labor and capital income in a general equilibrium model, they show that low-income groups suffer a larger relative income loss than high-income groups due to the policy change.

Source-side effects can also look quite different for other, nontax instruments. Fullerton and Heutel (2010) show that pollution intensity standards act like a pollution tax combined with an implicit output subsidy, benefiting policy-exposed factors relative to a tax-only scenario. Under cap-and-trade systems with grandfathered permits and pollution quotas, scarcity rents accrue to whoever is the owner of the restricted quantity. Parry (2004) shows that grandfathered permits in US cap-and-trade systems for SO_2, NO_X, and CO_2 emissions disproportionately benefit high-income households that own more capital in affected industries.

While much of the literature on source-side effects relies on general equilibrium modeling, some recent papers estimate distributional effects of environmental regulation using ex post data.[11] Huang and Yao (2023), for instance, study an SO_2 regulation implemented in China in 1998. Based on a difference-in-difference approach and a panel dataset, the study finds that stricter regulation decreased income inequality. The effect is driven by an income decline of high-income households, while low-income households experienced no detectable change. Jha, Matthews, and Muller (2019) investigate particulate matter and ozone pollution control under the US Clean Air Act. In a panel from the period 2005–2015, they use a difference-in-difference approach to compare counties facing stricter regulation because they were out of compliance to a matched set of otherwise similar counties in compliance; non-attainment counties experienced a substantial increase in income inequality, as measured by the Gini coefficient.

Another strand of literature uses ex post data to study the distributional effects of environmental policy among workers. Walker (2013) takes advantage of the fact that only some counties

[11] Here, empirical estimates of income will often combine policy costs on income with market-mediated effects of environmental quality changes on income, as discussed in Section 3.2.

fell into non-attainment status for PM_{10} and ozone pollution when the 1990 Clean Air Act amendments were adopted. The difference-in-difference study shows that higher-earning workers experienced larger losses in earnings after 1990. By contrast, Yip (2018) shows that highly educated workers suffered less from unemployment spells after a carbon tax was adopted in British Columbia. Similarly, Krause (2024) estimates that when the share of coal mining jobs decreased by 1 percent in the US Appalachian region, men with only a high school education experienced a decline in wages, while there was no detectable wage effect for other workers. Curtis and Marinescu (2023), studying millions of online job postings in the United States, find that new solar and wind jobs have a wage premium of 21 percent compared to all job postings, that this wage premium is higher than in the fossil fuel industry, and that it is higher for jobs that require a low level of education. Overall, the existing evidence suggests that the effect of environmental policy on employment and worker income varies by context.

5. *The Effects of Redistribution*

We now consider how income redistribution interacts with environmental policy. Two aspects of this relationship have been the focus of the economics literature. First, we consider the distributional effects of compensatory instruments, which may be specifically designed to accompany environmental policy measures. Second, we consider how income redistribution enacted independently of environmental objectives may nevertheless shape environmental outcomes.

5.1 *Complementing Environmental Policy by Redistribution*

Environmental policy can be combined with compensatory measures, often aimed at mitigating the policy costs discussed in Section 4. These measures alter the final distribution of net costs and benefits and may contribute to public acceptance of the combined policy package (Mildenberger et al. 2022).

One important class of compensatory measures recycles revenues collected by environmental taxes and other pricing schemes. This revenue recycling is accounted for in equation (4c) and can take various forms (see, e.g., Klenert et al. 2018a; Nesje, Schmidt, and Drupp forthcoming). Direct cash payments alter incomes (Δy_i^R). Subsidies alter prices ($\Delta \mathbf{p}^R$). Tax cuts alter incomes and/or prices (Δy_i and/or $\mathbf{p}^R$). Additional investments in environmental quality (ΔE) provide environmental benefits. Much of the literature on compensating redistribution takes estimates of policy cost incidence (see Section 4) as a starting point and then calculates net distributional effects after compensation is added.

Consider the revenues from an environmental tax—for example, a tax on carbon emissions. Recall that the *income elasticity of dirty demand* $\left(\eta^D\right)$ shapes the use-side incidence of the resulting price changes. As shown in Table 1, we usually have $\eta^D < 1$ for carbon-intensive goods, so that the initial use-side effects are regressive. Different mechanisms to recycle the tax revenue back to households can substantially mitigate this initial regressivity and sometimes even achieve net progressivity, as shown for a collection of environmental tax reforms simulated in the United States (Metcalf 1999). More recent work incorporates general equilibrium effects in micro-simulations based on household-level expenditure and income data, in order to capture both use-side and source-side costs, as well as the benefits of revenue recycling. An example of this approach comes from Rausch, Metcalf, and Reilly (2011), who pair data from the 2006 US Consumer Expenditure Survey with a multi-region and multi-sector general equilibrium model for the US economy. The authors find that uniform lump-sum rebates of carbon tax revenue, sometimes called "carbon dividends," are strongly progressive. This is compared to using the revenue to finance fixed percentage reductions in income or capital taxes, which are both relatively more regressive. A key insight is that the addition of such lump-sum payments can even result in net progressivity, overturning the initial regressivity of use-side costs. The intuition is simple: While lower-income households spend larger shares of incomes on carbon-intensive goods ($\eta^D < 1$), they tend to spend smaller total amounts on those goods ($0 < \eta^D$). Thus, they contribute less to the carbon tax revenue but they receive the same average lump-sum payment.

This progressivity of carbon dividends has more recently been confirmed at the multinational and global levels (Budolfson et al. 2021a; Sager 2023). For example, Sager (2023) calibrates a non-homothetic demand system using a trade gravity approach, paired with input–output based emissions accounting, to simulate welfare effects of carbon pricing across the global income distribution. The results show that adding carbon dividends to a global carbon price leads to net progressive effects, both within nations and globally. Similarly, Feindt et al. (2021) find progressive effects when complementing a carbon tax with per capita dividends in a micro-simulation based on household expenditure surveys in 23 EU member states. This matches similar general equilibrium model predictions (Fragkos et al. 2021; Weitzel et al. 2023). Going beyond equal lump sums, transfer payments could be targeted to specifically benefit the poor or other disadvantaged groups. With reference to Latin America and the Caribbean, Vogt-Schilb et al. (2019) demonstrate that only 30 percent of carbon tax revenue needs to be returned to the poor, defined as the poorest 40 percent of the population, to offset the adverse distributional effects of carbon taxation.

Revenue recycling also can be used to reduce other (distortionary) taxes or prices. In contrast to lump-sum transfers, pairing a carbon tax with income tax reductions may be insufficient to compensate low-income households, who have lower relative income tax burdens, as shown theoretically by Fullerton and Monti (2013) and using micro-simulations by Rausch, Metcalf, and Reilly (2011). However, ex post empirical evidence suggests that targeted income tax reductions did render British Columbia's carbon tax system moderately progressive (Murray and Rivers 2015). In an example from Germany, reducing taxes on electricity, a necessity good, was shown to be progressive (Neuhoff et al. 2013).

A relatively new insight in this literature is that (progressive) revenue recycling can generate additional benefits in suboptimal tax systems (Klenert et al. 2018b; Budolfson et al. 2021a). Jacobs and de Mooij (2015) extend standard models of optimal taxation à la Mirrlees (1971) to incorporate environmental damages and heterogeneous agents. They show that when the tax system is optimized to satisfy redistributive objectives, the second-best corrective tax on an environmental externality can equal marginal damages. In that case, it no longer needs to be adjusted for the marginal cost of public funds, as was the case in models with a representative agent (Sandmo 1975; Bovenberg and van der Ploeg 1994). Ultimately, optimal revenue use will depend on the preexisting tax system and welfare objectives, possibly giving rise to "hybrid" solutions. For example, Fried, Novan, and Peterman (2024) propose a combination of capital income tax and labor income tax reductions to both alleviate distortions and achieve redistributive goals.

Again, we can conceptualize the incidence of revenue-recycling measures using specific income elasticities. The above discussion suggests an important role for an *income elasticity of* *income from subsidized factors or transfers* (η^T) when revenues are recycled through income transfers or tax reductions (e.g., on household income). If $\eta^T < 1$, a transfer will tend to represent a higher relative share in the income of lower-income households and thus will be progressive. A uniform lump-sum payment, such as a carbon dividend, is characterized by $\eta^T = 0$ and thus is highly progressive. By contrast, using revenues to cut income taxes uniformly tends to be relatively regressive because income taxes tend to be disproportionately paid by higher-income households ($\eta^T > 1$). Similarly, if revenue recycling takes the form of subsidizing certain goods or cutting consumption taxes, we would consider an *income elasticity of subsidized demand* (η^{C_s}). And if revenues are used to finance public goods, such as public infrastructure, the benefit distribution will depend on an *income elasticity of WTP for public goods* (η^P), such as in the case of public infrastructure, or on an *income elasticity of WTP for environmental goods* (η^W), such as when revenues are used to improve environmental quality (see Section 3.1).

5.2 *The Environmental Effects of Income Redistribution*

Even income redistribution that is not linked to environmental policy can have important repercussions for the environment. For example, it is a popular claim that higher levels of economic inequality cause more environmental degradation or less stringent environmental policy (e.g., Stiglitz 2012). However, it is unclear—from both economic theory and the empirical evidence—whether there is indeed a systematic relationship. Conceptually, we think it is useful to distinguish three channels through which income inequality may shape environmental outcomes: (i) consumer demand, (ii) collective action and public good provision, and (iii) political power.

The consumer demand channel is a story of aggregation over nonlinear expenditures. Consumers at different income levels demand bundles of goods with varying environmental intensities, which is also the reason why the use-side cost of an environmental policy is distributed unequally, as discussed in Section 4.1. The relationship between household income and average environmental footprint can be represented by environmental Engel curves (EECs). Levinson and O'Brien (2019) construct EECs for local air pollutants, including particulate matter. They do so by matching household-level consumption data from the US Consumer Expenditure Survey with emissions factors for industries, calculated using input–output accounting methods. They then plot the relationship between after-tax income and average pollution embedded in household consumption, at times controlling for other household characteristics. The resulting EECs for air pollutants are upward sloping and concave, as conceptualized in the left panel of Figure 3.

Concave EECs suggest an *income elasticity of dirty demand* (η^D) below unity. Nonlinear EECs give rise to an aggregation property whereby the distribution of income shapes aggregate environmental outcomes (Scruggs 1998; Heerink, Mulatu, and Bulte 2001). This is demonstrated empirically by Sager (2019), who applies the methodology of Levinson and O'Brien (2019) to greenhouse gas emissions and finds upward sloping and concave EECs for greenhouse gas emissions embedded in the consumption of US households. Consider a progressive income transfer from a richer (Y_2) to a poorer household (Y_1). The propensity to generate emissions by spending additional income on polluting goods, (ϕ), shown by the slope of the EEC, is higher at lower income levels. This gives rise to an "equity–pollution dilemma," as formulated by Sager (2019): Progressive redistribution raises demand for the

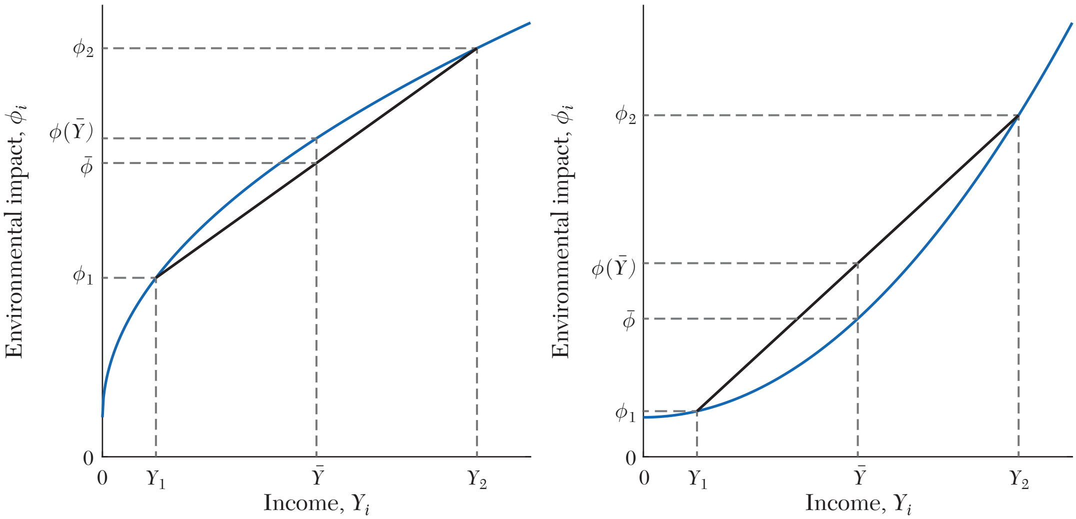

Figure 3. Environmental Engel Curves and the "Equity–Pollution Dilemma"

Notes: Under concave environmental Engel curves (left panel), income dispersion (Y_1, Y_2) leads to lower environmental impact (ϕ) than under the case of equality $(\bar{Y})$. The reverse holds for convex environmental Engel curves (right panel). See Sager (2019) for details.

polluting good.[12] In the extreme, complete income inequality, where both households have income $\bar{Y}$, gives rise to the highest possible per capita environmental footprint, $\phi(\bar{Y})$. As discussed in Table 1, *income elasticities of dirty demand* are often below 1, suggesting that concave EEC's are common.

Inequality can also shape environmental outcomes via collective action dynamics. For example, it can alter society's valuation of environmental public goods through a similar aggregation property: If the *income elasticity of WTP for environmental quality* $\left(\eta^W\right)$ is below unity, as seems common in many settings (see Figure 1), more equal societies will exhibit a higher aggregate WTP for environmental public goods, all else equal (Baumgärtner et al. 2017; Drupp et al. 2018; Meya et al. 2020). Again, for $\left(\eta^W\right) > 1$, the effect would be reversed and aggregate WTP would decrease with income equality.

The distribution of resource endowments may alter strategic incentives to contribute toward environmental public goods and the sustainable management of common-pool resources, such as fisheries or forests, even when holding aggregate WTP constant. The underlying logic is set forth by Olson (1965). The argument is that in large groups that are more equal, the benefits of public good provision are diffuse and members receive similar, relatively small benefits. Meanwhile, the costs of engaging in collective action are relatively high. By contrast,

[12] To show this formally, assume demand for a single polluting good D is a function of price and income, $D_i = f(p_D) \cdot Y_i^{\eta^D}$. A small income transfer of x from a richer household (Y_2) to a poorer one (Y_1), called a Pigou–Dalton transfer, alters aggregate demand for D by approximately $f(p_D) \cdot x\eta^D \left[Y_1^{(\eta^D-1)} - Y_2^{(\eta^D-1)}\right]$, which is positive when $0 < \eta^D < 1$ and $f(p_D) \geq 0$.

incentives to contribute are higher in small groups and in groups with unequal access to the (impure) public good.

The implications of inequality for a group's ability to manage a common-pool resource, such as a fishery, are more ambiguous (Baland and Platteau 1999). Dayton-Johnson and Bardhan (2002) show that, in a noncooperative common-pool resource game, the relationship between inequality and preservation levels is U shaped. Both very low and very high levels of inequality can favor high levels of preservation; this is either because many group members have sufficiently large stakes or because a few dominate. Further, inequality may erode trust and social capital, which have been shown to underpin successful common-pool resource management (Ostrom 2009). Most experimental evidence from public good games tends to find that inequality reduces group cooperation (e.g., Anderson, Mellor, and Milyo 2008; Tavoni et al. 2011; Gächter et al. 2017). This would translate into less ambitious environmental policy, all else equal.

Finally, the political power channel associates the distribution of economic means with the distribution of political influence (Torras and Boyce 1998). To the extent that political influence shapes environmental policy, economic inequality will too. Perhaps most immediately, local politics bears on the spatial distribution of pollution sources and other nuisances, as discussed in Section 3. But even aggregate environmental quality may be shaped by the level of economic inequality under certain circumstances. For example, if richer citizens have more political influence and weaker preferences for environmental public goods, then more inequality would result in less political demand for environmental policy. The result would be a lower level of environmental quality in the aggregate. The political power channel has not received much attention from economists to date, but it is a popular topic in environmental studies and related disciplines (summarized in Cushing et al. 2015). To our knowledge, there is no empirical evidence for the claim that high-income citizens have less concern for the environment. The limited empirical evidence regarding political power comes from cross-sectional and aggregate-level analyses, such as by Boyce et al. (1999), who find an association between measures of political power inequality and weaker environmental policy across US states.

Independent of the underlying mechanism, there is a literature that looks for correlations between income inequality and environmental degradation at aggregate levels, as surveyed by Berthe and Elie (2015). For example, Baek and Gweisah (2013) find a positive association between Gini index values and per capita CO_2 emissions across US states. Similarly, there is some evidence of a positive correlation between measures of within-country inequality and local air pollution levels (Torras and Boyce 1998) as well as biodiversity loss (Mikkelson, Gonzalez, and Peterson 2007). Those findings seem to support the negative environmental effects of inequality hypothesized by proponents of the political power or collective action channels. On the other hand, multiple studies have found negative correlations between country-level income inequality and per capita carbon emissions (Ravallion, Heil, and Jalan 2000; Heerink, Mulatu, and Bulte 2001; Coondoo and Dinda 2008), more in line with the consumption-based equity–pollution dilemma. The conflicting results suggest room for further work and also point to a key problem with empirical investigations of the inequality–environment relationship: the difficulty of interpreting regression results causally. This arises because there are many characteristics of states and countries that covary with both inequality and environmental outcomes.

At the heart of these three channels, we can again identify an important role for income elasticities. We are most concerned with regressive effects of an environmental policy when it targets necessity goods, so that the *income elasticity of dirty demand* $\left(\eta^D\right)$ lies below 1. Yet, it is in these situations that we are likely to face an equity–pollution dilemma when adding progressive income compensation. This is a kind of distributional rebound effect. Similarly, aggregate demand for public goods is shaped in important ways by preference aggregation over the *income elasticity of WTP for environmental public goods* (η^W). However, this is rarely formalized in the literature to date.

6. *Discussion and Conclusion*

Several common themes emerge from our synthesis of the literature. Conceptually, income elasticities facilitate a common framework that connects changes in environmental policy to economic inequality, in ways we summarize in Table 2. The distribution of environmental improvements, for instance, is determined largely by the income elasticity of willingness-to-pay (WTP) for that change, which is mediated by income elasticities relating to exposure and adaptation (Section 3.1). If the income elasticity of WTP is larger than unity, environmental benefits are regressive (pro-rich); if the elasticity is smaller than unity, benefits are progressive (pro-poor). The distribution of policy costs, in turn, is driven by the income elasticity of dirty demand (Section 4.1) and the income elasticity of income from policy-exposed factors (Section 4.2). Policy costs tend to be regressive if these elasticities are smaller than unity, and progressive when elasticities exceed unity. The environmental effects of income redistribution, too, are shaped by the income elasticity of dirty demand. If it lies below unity, we face an equity–pollution dilemma (Section 5). Thus, we recommend that empirical studies more systematically report estimates of income elasticities, where applicable, to facilitate synthesis, allow for meaningful comparisons of effects across settings, and provide input parameters for policy simulations.

Another insight from our synthesis concerns measurement. There is far more research on the distribution of economic resources—in terms of consumption, income, and wealth—than on the distribution of environmental goods, such as clean water, access to urban green spaces, or opportunities for recreation in biodiverse landscapes (Section 3.1). Economic resources are often easier to observe and measure. Yet, recent advances in measuring environmental quality with improved precision and granularity, combined with more systematic surveys on preferences for the environment, should help close this gap. Many research opportunities remain, as the dynamics discussed in this review may vary across spatial scales and environmental domains.

In some areas, there appears to be sufficiently strong evidence to draw conclusions about how environmental policy interacts with economic inequality. Consider the incidence of climate policy. Climate policy drives up the prices of carbon-intensive goods and services and thus entails costs for consumers of those goods and services (termed a use-side effect). Evidence suggests that the income elasticity of dirty demand is typically smaller than unity in developed countries (Section 4.1). This drives a regressive use-side incidence of carbon pricing. Because the income elasticity is almost certainly positive, recycling revenues via lump-sum carbon dividends is likely progressive (Section 5.1).

In other areas, considerable knowledge gaps remain. While a number of empirical studies investigate source-side effects of climate policy via labor markets, little is known about source-side effects via capital (Section 4.2). Furthermore, fundamental parameters are often context-dependent; for example, the income elasticity of dirty demand appears larger in

TABLE 2
Income Elasticities and Distributional Effects

	Income elasticity of		
	Demand for	Income from	WTP for
Direct env. benefits (Sec. 3.1)			Env. quality $\eta^{W} < 1$: progressive $\eta^{W} > 1$: regressive
Market-mediated env. benefits (Sec. 3.2)	Env. exposed goods $\eta^{C_E} < 1$: progressive $\eta^{C_E} > 1$: regressive	Env. exposed factors $\eta^{F_E} < 1$: progressive $\eta^{F_E} > 1$: regressive	
Policy costs (Sec. 4)	Dirty goods $\eta^{D} < 1$: regressive $\eta^{D} > 1$: progressive	Policy-exposed factors $\eta^{F} < 1$: regressive[a] $\eta^{F} > 1$: progressive[a]	
Benefits of redistribution (Sec. 5.1)	Subsidized goods $\eta^{C_S} < 1$: progressive $\eta^{C_S} > 1$: regressive	Subs. factors & transfers $\eta^{T} < 1$: progressive $\eta^{T} > 1$: regressive	Public goods $\eta^{P} < 1$: progressive $\eta^{P} > 1$: regressive
Env. effects of redistribution (Sec. 5.2)	Dirty goods $\eta^{D} < 1$: pollution $\uparrow$ $\eta^{D} > 1$: pollution $\downarrow$		Env. quality $\eta^{W} < 1$: $\overline{WTP}$ $\uparrow$ $\eta^{W} > 1$: $\overline{WTP}$ $\downarrow$

Notes: Summary of the role of various income elasticities—of demand, of income factors, and of willingness to pay (WTP)—for distributional analysis of environmental policy. Progressive [regressive] refers to pro-poor [pro-rich] costs and benefits, i.e., benefits that fall disproportionately on those with lower [higher] incomes and costs that fall disproportionately on those with higher [lower] incomes. Details in the text.

[a]This assumes that transfer income is proportional to income (or that the factor not exposed to the policy is the numeraire); see Section 4.2.

developing countries. This relates to an important gap identified in our review: Most empirical studies focus on the United States and, to a lesser degree, Europe. The extent to which these can be extrapolated to other countries, in particular developing ones, remains to be investigated. Similarly, not all environmental domains are equally well studied. Our review has largely focused on climate, energy, and air pollution. This choice was dictated by availability. More research is needed on benefit and cost incidence relating to other environmental domains, such as water quality, biodiversity, and other ecosystem services.

Another limitation in the literature is the frequent reliance on constant income elasticities, which may obscure more nuanced relationships in some contexts. For example, a constant income elasticity cannot capture an inverted U-shaped distribution of environmental policy costs where the middle income segments bear the largest burden. Future research should explore nonconstant elasticities across the income distribution and how elasticities change with policy stringency, across population groups, and across time, as well as with the evolution of production technologies.

Environmental policy appraisal also depends on how preexisting inequalities are weighted in the social welfare function (equation (4c)). The common, unweighted approach to benefit–cost analysis rests on strong assumptions regarding both individual utility (i.e., quasi-linear utility with constant marginal utility of income) and the social welfare function (i.e., a utilitarian welfare function without inequality aversion). One explanation for the infrequent use of equity weights is the lack of ready-to-use parameters (Fleurbaey and Abi-Rafeh 2016). This suggests a need for more empirical studies that elicit both individual and social preferences. Such work is emerging in some areas—for example, in climate economics when estimating the social cost of carbon. However, the use of distributional weights is usually restricted to income inequality between regions. Recent efforts to explicitly model the role of inequality within regions are a welcome development (Dennig et al. 2015; Emmerling, Andreoni, and Tavoni 2024). Del Campo, Anthoff, and Kornek (2024) review 24 studies that estimate social inequality aversion and mostly find a positive degree of inequality aversion, typically larger than unity, suggesting that respondents dislike inequality and often assign much more weight to those with lower initial utility.

Beyond equity weights that take into account preexisting economic inequalities, it would be useful to investigate environmental distributional weights that take into account how marginal utility of income varies with the preexisting endowment of environmental goods (Adler 2016; Meya 2020). In addition to the elasticity of marginal utility with respect to consumption—often referred to as "intratemporal consumption inequality aversion" (e.g., Groom and Maddison 2019)—we would then consider the elasticity of the marginal utility with respect to environmental goods. Venmans and Groom (2021) present a first experimental study to elicit environmental inequality aversion. Going further, alternative normative frameworks—besides the anthropocentric, utilitarian approach—may place more emphasis on animal welfare and the "intrinsic value" of nature (Carlier and Treich 2020; Fleurbaey and Van der Linden 2021).

Our review also highlights the importance of interdependencies and feedback effects. While there is a lot of research on each inequality–environment linkage that we consider, few studies engage with multiple linkages, and none consider all. Such omissions can generate flawed policy analysis. Consider again the case of carbon pricing. An analysis of the distributional effects of a carbon tax (Section 4) raises the issue of regressive use-side costs driven by the income elasticity of dirty demand, although source-side effects may add a progressive element. The literature generally focuses on transfer payments and other revenue-recycling schemes as additional elements through which greater progressivity can be achieved (Section 5.1). However, the distribution of direct and market-mediated environmental benefits is often not explicitly taken into account. Furthermore, shifting income toward low-income households with a higher propensity to consume carbon-intensive goods may counteract emissions reductions from pricing carbon (Section 5.2). Accounting for such linkages will likely alter the optimal design of both instruments.

Another case in point is the issue of poor air quality in low-income neighborhoods (Section 3). We may interpret this as a mere manifestation of income inequality, where air quality is a residential amenity reflected in house prices and lower-income households are willing or able to spend less on this amenity. Policymakers could then focus on income redistribution alone and expect pollution exposure inequality to self-correct. This reasoning overlooks that worse air quality may lead to higher health-care expenditures or lower levels of human capital accumulation (e.g., in terms of the ability to learn and thus education) amongst low-income households. Such externalities would exacerbate the effects of the unequal distribution of air quality. Moreover, low-income households may find it more difficult to influence the political process, which might reinforce a vicious cycle (Section 5.2). Explicit consideration of the covariation of income and pollution may alter benefit–cost analyses of measures to improve and/or to spatially reallocate air quality.

In sum, many gaps remain in our understanding of key links between environmental change and economic inequality. First, research should focus on further investigating individual inequality–environment links. This includes empirically capturing the novel income elasticities that we identify (Table 2), as well as assessing inequality–environment links across different temporal and spatial scales. Second, the normative assumptions underlying economic welfare analysis should be made explicit and scrutinized. Third, more research is required to investigate distributional effects of environmental policies beyond climate and air pollution and in developing countries. Finally, economic research will have to better integrate analyses of multiple inequality–environment interlinkages to come closer to an understanding of the full distributional effects of environmental policies or the environmental effects of redistribution. Filling these gaps is a prerequisite for economists to competently advise policymakers, who increasingly require such integrated analyses when trying to implement key public policy aims, such as the UN Sustainable Development Goals.

References

Adler, Matthew D. 2016. "Benefit-Cost Analysis and Distributional Weights: An Overview." *Review of Environmental Economics and Policy* 10 (2): 264–85.

Aguilar-Gomez, Sandra, Holt Dwyer, Joshua Graff Zivin, and Matthew Neidell. 2022. "This Is Air: The "Nonhealth" Effects of Air Pollution." *Annual Review of Resource Economics* 14: 403–25.

Alberini, Anna, Will Gans, and Daniel Velez-Lopez. 2011. "Residential Consumption of Gas and Electricity in the US: The Role of Prices and Income." *Energy Economics* 33 (5): 870–81.

Anand, Sudhir, and Paul Segal. 2008. "What Do We Know about Global Income Inequality?" *Journal of Economic Literature* 46 (1): 57–94.

Anderson, Lisa R., Jennifer M. Mellor, and Jeffrey Milyo. 2008. "Inequality and Public Good Provision: An Experimental Analysis." *Journal of Socio-Economics* 37 (3): 1010–28.

Andersson, Julius J. 2019. "Carbon Taxes and CO2 Emissions: Sweden as a Case Study." *American Economic Journal: Economic Policy* 11 (4): 1–30.

Baek, Jungho, and Guankerwon Gweisah. 2013. "Does Income Inequality Harm the Environment?: Empirical Evidence from the United States." *Energy Policy* 62: 1434–37.

Baland, Jean-Marie, and Jean-Philippe Platteau. 1999. "The Ambiguous Impact of Inequality on Local Resource Management." *World Development* 27 (5): 773–88.

Banzhaf, Spencer, Lala Ma, and Christopher Timmins. 2019. "Environmental Justice: The Economics of Race, Place, and Pollution." *Journal of Economic Perspectives* 33 (1): 185–208.

Banzhaf, H. Spencer, and Randall P. Walsh. 2008. "Do People Vote with Their Feet? An Empirical Test of Tiebout's Mechanism." *American Economic Review* 98 (3): 843–63.

Barbier, Edward B., Mikołaj Czajkowski, and Nick Hanley. 2017. "Is the Income Elasticity of the Willingness to Pay for Pollution Control Constant?" *Environmental and Resource Economics* 68 (3): 663–82.

Basaglia, Piero, Sophie M. Behr, and Moritz A. Drupp. 2025. ""Fuel Taxation and Environmental Externalities: Evidence from the World's Largest Environmental Tax Reform." CESifo Working Paper 11949.

Basani, Marcello, Jonathan Isham, and Barry Reilly. 2008. "The Determinants of Water Connection and Water Consumption: Empirical Evidence from a Cambodian Household Survey." *World Development* 36 (5): 953–68.

Baumgärtner, Stefan, Moritz A. Drupp, Jasper N. Meya, Jan M. Munz, and Martin F. Quaas. 2017. "Income Inequality and Willingness to Pay for Environmental Public Goods." *Journal of Environmental Economics and Management* 85: 35–61.

Beck, Marisa, Nicholas Rivers, Randall Wigle, and Hidemichi Yonezawa. 2015. "Carbon Tax and Revenue Recycling: Impacts on Households in British Columbia." *Resource and Energy Economics* 41: 40–69.

Bento, Antonio M. 2013. "Equity Impacts of Environmental Policy." *Annual Review of Resource Economics* 5: 181–96.

Bento, Antonio, Matthew Freedman, and Corey Lang. 2015. "Who Benefits from Environmental Regulation? Evidence from the Clean Air Act Amendments." *Review of Economics and Statistics* 97 (3): 610–22.

Berthe, Alexandre, and Luc Elie. 2015. “Mechanisms Explaining the Impact of Economic Inequality on Environmental Deterioration.” *Ecological Economics* 116: 191–200.

Blundell, Richard, Joel L. Horowitz, and Matthias Parey. 2012. “Measuring the Price Responsiveness of Gasoline Demand: Economic Shape Restrictions and Nonparametric Demand Estimation.” *Quantitative Economics* 3 (1): 29–51.

Bovenberg, Ary Lans, and Frederick van der Ploeg. 1994. “Environmental Policy, Public Finance and the Labour Market in a Second-Best World.” *Journal of Public Economics* 55 (3): 349–90.

Boyce, James K., Andrew R. Klemer, Paul H. Templet, and Cleve E. Willis. 1999. “Power Distribution, the Environment, and Public Health: A State-Level Analysis.” *Ecological Economics* 29 (1): 127–40.

Brueckner, Jan K., Jacques-François Thisse, and Yves Zenou. 1999. “Why Is Central Paris Rich and Downtown Detroit Poor? An Amenity-Based Theory.” *European Economic Review* 43 (1): 91–107.

Budolfson, Mark, Francis Dennig, Frank Errickson, Simon Feindt, Maddalena Ferranna, Marc Fleurbaey, David Klenert, et al. 2021a. “Climate Action with Revenue Recycling Has Benefits for Poverty, Inequality and Well-Being.” *Nature Climate Change* 11 (12): 1111–16.

Budolfson, Mark, Francis Dennig, Frank Errickson, Simon Feindt, Maddalena Ferranna, Marc Fleurbaey, David Klenert, et al. 2021b. *Data for: “Climate Action with Revenue Recycling Has Benefits for Poverty, Inequality, and Wellbeing.”* Zenodo. https://doi.org/10.5281/zenodo.5552749.

Burke, Marshall, Solomon M. Hsiang, and Edward Miguel. 2015. “Global Non-linear Effect of Temperature on Economic Production.” *Nature* 527 (7577): 235–39.

Cain, Lucas, Danae Hernandez-Cortes, Christopher Timmins, and Paige Weber. 2024. “Recent Findings and Methodologies in Economics Research in Environmental Justice.” *Review of Environmental Economics and Policy* 18 (1): 116–42.

Campa, Pamela, and Lucija Muehlenbachs. 2024. “Addressing Environmental Justice through In-Kind Court Settlements.” *American Economic Journal: Economic Policy* 16 (1): 415–46.

Carleton, Tamma, Amir Jina, Michael Delgado, Michael Greenstone, Trevor Houser, Solomon Hsiang, Andrew Hultgren, et al. 2022. “Valuing the Global Mortality Consequences of Climate Change Accounting for Adaptation Costs and Benefits.” *Quarterly Journal of Economics* 137 (4): 2037–105.

Carlier, Alexis, and Nicolas Treich. 2020. “Directly Valuing Animal Welfare in (Environmental) Economics.” *International Review of Environmental and Resource Economics* 14 (1): 113–52.

Cheesman, Jeremy, Jeff Bennett, and Tran Vo Hung Son. 2008. “Estimating Household Water Demand Using Revealed and Contingent Behaviors: Evidence from Vietnam.” *Water Resources Research* 44 (11).

Chen, Shuai, Yuyu Chen, Ziteng Lei, and Jie-Sheng Tan-Soo. 2020. “Impact of Air Pollution on Short-Term Movements: Evidence from Air Travels in China.” *Journal of Economic Geography* 20 (4): 939–68.

Chen, Shuai, Paulina Oliva, and Peng Zhang. 2022. “The Effect of Air Pollution on Migration: Evidence from China.” *Journal of Development Economics* 156: 102833.

Chen, Zhengjie, Renpei Zhang, Feng Wang, Fan Xia, Beibei Liu, and Bing Zhang. 2022. “The Distributional Effects of China’s Environmental Taxation: A Multi-regional Analysis.” *Journal of Environmental Management* 324: 116276.

Christensen, Peter, Igancio Sarmiento-Barbieri, and Christopher Timmins. 2021. “Racial Discrimination and Housing Outcomes in the United States Rental Market.” NBER Working Paper 29516.

Christensen, Peter, and Christopher Timmins. 2022. “Sorting or Steering: The Effects of Housing Discrimination on Neighborhood Choice.” *Journal of Political Economy* 130 (8): 2110–63.

Cohen, François, and Antoine Dechezleprêtre. 2022. “Mortality, Temperature, and Public Health Provision: Evidence from Mexico.” *American Economic Journal: Economic Policy* 14 (2): 161–92.

Coondoo, Dipankor, and Soumyananda Dinda. 2008. “Carbon Dioxide Emission and Income: A Temporal Analysis of Cross-Country Distributional Patterns.” *Ecological Economics* 65 (2): 375–85.

Cronin, Julie Anne, Don Fullerton, and Steven Sexton. 2019. “Vertical and Horizontal Redistributions from a Carbon Tax and Rebate.” *Journal of the Association of Environmental and Resource Economists* 6 (S1): S169–S208.

Currie, Janet, John Voorheis, and Reed Walker. 2023. “What Caused Racial Disparities in Particulate Exposure to Fall? New Evidence from the Clean Air Act and Satellite-Based Measures of Air Quality.” *American Economic Review* 113 (1): 71–97.

Curtis, E. Mark, and Ioana Marinescu. 2023. “Green Energy Jobs in the United States: What Are They, and Where Are They?” *Environmental and Energy Policy and the Economy* 4: 202–37.

Cushing, Lara, Rachel Morello-Frosch, Madeline Wander, and Manuel Pastor. 2015. “The Haves, the Have-Nots, and the Health of Everyone: The Relationship between Social Inequality and Environmental Quality.” *Annual*

Review of Public Health 36: 193–209.
Dasgupta, Partha. 2021. *The Economics of Biodiversity: The Dasgupta Review*. HM Treasury.
Davis, Lucas W., and Christopher R. Knittel. 2019. “Are Fuel Economy Standards Regressive?” *Journal of the Association of Environmental and Resource Economists* 6 (S1): S37–63.
Dayton-Johnson, Jeff, and Pranab Bardhan. 2002. “Inequality and Conservation on the Local Commons: A Theoretical Exercise.” *Economic Journal* 112 (481): 577–602.
De Lima, Cicero Z., Jonathan R. Buzan, Frances C. Moore, Uris Lantz C. Baldos, Matthew Huber, and Thomas W. Hertel. 2021. “Heat Stress on Agricultural Workers Exacerbates Crop Impacts of Climate Change.” *Environmental Research Letters* 16 (4): 044020.
Del Campo, Stellio, David Anthoff, and Ulrike Kornek. 2024. “Inequality Aversion for Climate Policy.” *Review of Environmental Economics and Policy* 18 (1): 96–115.
Dennig, Francis, Mark B. Budolfson, Marc Fleurbaey, Asher Siebert, and Robert H. Socolow. 2015. “Inequality, Climate Impacts on the Future Poor, and Carbon Prices.” *Proceedings of the National Academy of Sciences* 112 (52): 15827–32.
Depro, Brooks, Christopher Timmins, and Maggie O’Neil. 2015. “White Flight and Coming to the Nuisance: Can Residential Mobility Explain Environmental Injustice?” *Journal of the Association of Environmental and Resource Economists* 2 (3): 439–68.
Díaz, Araceli Ortega, and Kenneth B. Medlock. 2021. “Price Elasticity of Demand for Fuels by Income Level in Mexican Households.” *Energy Policy* 151: 112132.
Dillender, Marcus. 2021. “Climate Change and Occupational Health: Are There Limits to Our Ability to Adapt?” *Journal of Human Resources* 56 (1): 184–224.
Dissou, Yazid, and Muhammad Shahid Siddiqui. 2014. “Can Carbon Taxes Be Progressive?” *Energy Economics* 42: 88–100.
Dorband, Ira Irina, Michael Jakob, Matthias Kalkuhl, and Jan Christoph Steckel. 2019. “Poverty and Distributional Effects of Carbon Pricing in Low- and Middle-Income Countries—A Global Comparative Analysis.” *World Development* 115: 246–57.
Douenne, Thomas. 2020. “The Vertical and Horizontal Distributive Effects of Energy Taxes: A Case Study of a French Policy.” *Energy Journal* 41 (3): 231–54.
Douenne, Thomas, and Adrien Fabre. 2022. “Yellow Vests, Pessimistic Beliefs, and Carbon Tax Aversion.” *American Economic Journal: Economic Policy* 14 (1): 81–110.
Drupp, Moritz A. 2018. “Limits to Substitution between Ecosystem Services and Manufactured Goods and Implications for Social Discounting.” *Environmental and Resource Economics* 69 (1): 135–58.
Drupp, Moritz A. and Martin C. Hänsel. 2021. “Relative Prices and Climate Policy: How the Scarcity of Nonmarket Goods Drives Policy Evaluation.” *American Economic Journal: Economic Policy* 13 (1): 168–201.
Drupp, Moritz A., Jasper N. Meya, Stefan Baumgärtner, and Martin F. Quaas. 2018. “Economic Inequality and the Value of Nature.” *Ecological Economics* 150: 340–45.
Drupp, Moritz, Ulrike Kornek, Jasper N. Meya, and Lutz Sager. 2025. *Data and Code for: “The Economics of Inequality and the Environment.”* Nashville, TN: American Economic Association; distributed by Inter-university Consortium for Political and Social Research, Ann Arbor, MI. https://doi.org/10.3886/E212661V1.
Drupp, Moritz A., Zachary M. Turk, Ben Groom, and Jonas Heckenhahn. 2024a. *Data for “Global Evidence on the Income Elasticity of Willingness to Pay, Relative Price Changes and Public Natural Capital Values.”* provided via personal communication with Drupp, 11.11.2024, and available in the replication package.
Drupp, Moritz A., Zachary M. Turk, Ben Groom, and Jonas Heckenhahn. 2024b. “Global Evidence on the Income Elasticity of Willingness to Pay, Relative Price Changes and Public Natural Capital Values.” CESifo Working Paper 11500.
Ebert, Udo. 2003. “Environmental Goods and the Distribution of Income.” *Environmental and Resource Economics* 25 (4): 435–59.
Emmerling, Johannes, Pietro Andreoni, and Massimo Tavoni. 2024. “Global Inequality Consequences of Climate Policies When Accounting for Avoided Climate Impacts.” *Cell Reports Sustainability* 1 (1): 100008.
Fabra, Natalia, and Mar Reguant. 2014. “Pass-Through of Emissions Costs in Electricity Markets.” *American Economic Review* 104 (9): 2872–99.
Feindt, Simon, Ulrike Kornek, José M. Labeaga, Thomas Sterner, and Hauke Ward. 2021. “Understanding Regressivity: Challenges and Opportunities of European Carbon Pricing.” *Energy Economics* 103: 105550.
Femenia, Fabienne. 2019. “A Meta-analysis of the Price and Income Elasticities of Food Demand.” *German Journal of Agricultural Economics* 68 (2): 77–98.

Fleurbaey, Marc. 2009. "Beyond GDP: The Quest for a Measure of Social Welfare." *Journal of Economic Literature* 47 (4): 1029–75.
Fleurbaey, Marc, and Rossi Abi-Rafeh. 2016. "The Use of Distributional Weights in Benefit–Cost Analysis: Insights from Welfare Economics." *Review of Environmental Economics and Policy* 10 (2): 286–307.
Fleurbaey, Marc, and Martin Van der Linden. 2021. "Fair Social Ordering, Egalitarianism, and Animal Welfare." *American Economic Journal: Microeconomics* 13 (4): 466–91.
Flores, Nicholas E., and Richard T. Carson. 1997. "The Relationship between the Income Elasticities of Demand and Willingness to Pay." *Journal of Environmental Economics and Management* 33 (3): 287–95.
Fragkos, Panagiotis, Kostas Fragkiadakis, Benjamin Sovacool, Leonidas Paroussos, Zoi Vrontisi, and Ioannis Charalampidis. 2021. "Equity Implications of Climate Policy: Assessing the Social and Distributional Impacts of Emission Reduction Targets in the European Union." *Energy* 237: 121591.
Fried, Stephie, Kevin Novan, and William B. Peterman. 2024. "Understanding the Inequality and Welfare Impacts of Carbon Tax Policies." *Journal of the Association of Environmental and Resource Economists* 11 (S1): S231–60.
Friedman, Milton. 1957. *Theory of the Consumption Function*. Princeton University Press.
Frondel, Manuel, Gerhard Kussel, and Stephan Sommer. 2019. "Heterogeneity in the Price Response of Residential Electricity Demand: A Dynamic Approach for Germany." *Resource and Energy Economics* 57: 119–34.
Fullerton, Don. 2011. "Six Distributional Effects of Environmental Policy." *Risk Analysis* 31 (6): 923–29.
Fullerton, Don, and Garth Heutel. 2007. "The General Equilibrium Incidence of Environmental Taxes." *Journal of Public Economics* 91 (3–4): 571–91.
Fullerton, Don, and Garth Heutel. 2010. "The General Equilibrium Incidence of Environmental Mandates." *American Economic Journal: Economic Policy* 2 (3): 64–89.
Fullerton, Don, and Garth Heutel. 2011. "Analytical General Equilibrium Effects of Energy Policy on Output and Factor Prices." *BE Journal of Economic Analysis and Policy* 10 (2).
Fullerton, Don, and Gilbert E. Metcalf. 2002. "Tax Incidence." In *Handbook of Public Economics*, Vol. 4, edited by Alan J. Auerbach and Martin Feldstein, 1787–872. North-Holand.
Fullerton, Don, and Holly Monti. 2013. "Can Pollution Tax Rebates Protect Low-Wage Earners?" *Journal of Environmental Economics and Management* 66 (3): 539–53.
Fullerton, Don, and Chi L. Ta. 2019. "Environmental Policy on the Back of an Envelope: A Cobb-Douglas Model Is Not Just a Teaching Tool." *Energy Economics* 84 (S1): 104447.
Gächter, Simon, Friederike Mengel, Elias Tsakas, and Alexander Vostroknutov. 2017. "Growth and Inequality in Public Good Provision." *Journal of Public Economics* 150: 1–13.
Gallet, Craig A. 2010. "Meat Meets Meta: A Quantitative Review of the Price Elasticity of Meat." *American Journal of Agricultural Economics* 92 (1): 258–72.
Ganapati, Sharat, Joseph S. Shapiro, and Reed Walker. 2020. "Energy Cost Pass-Through in US Manufacturing: Estimates and Implications for Carbon Taxes." *American Economic Journal: Applied Economics* 12 (2): 303–42.
Gao, Xuwen, Ran Song, and Christopher Timmins. 2023. "Information, Migration, and the Value of Clean Air." Journal of Development Economics 163: 103079.
García-Muros, Xaquin, Mercedes Burguillo, Mikel González-Eguino, and Desiderio Romero-Jordán. 2017. "Local Air Pollution and Global Climate Change Taxes: A Distributional Analysis for the Case of Spain." *Journal of Environmental Planning and Management* 60 (3): 419–36.
Gilli, Martino, Matteo Calcaterra, Johannes Emmerling, and Francesco Granella. 2024. "Climate Change Impacts on the Within-Country Income Distributions." *Journal of Environmental Economics and Management* 127: 103012.
Goulder, Lawrence H., Marc A. C. Hafstead, GyuRim Kim, and Xianling Long. 2019. "Impacts of a Carbon Tax across US Household Income Groups: What Are the Equity-Efficiency Trade-Offs?" *Journal of Public Economics* 175: 44–64.
Grainger, Corbett A. 2012. "The Distributional Effects of Pollution Regulations: Do Renters Fully Pay for Cleaner Air?" *Journal of Public Economics* 96 (9–10): 840–52.
Green, Rosemary, Laura Cornelsen, Alan D. Dangour, Rachel Turner, Bhavani Shankar, Mario Mazzocchi, and Richard D. Smith. 2013. "The Effect of Rising Food Prices on Food Consumption: Systematic Review with Meta-regression." *British Medical Journal* 346: f3703.
Groom, Ben, and David Maddison. 2019. "New Estimates of the Elasticity of Marginal Utility for the UK." *Environmental and Resource Economics* 72 (4): 1155–82.
Harju, Jarkko, Tuomas Kosonen, Marita Laukkanen, and Kimmo Palanne. 2022. "The Heterogeneous Incidence of Fuel Carbon Taxes: Evidence from Station-Level Data." *Journal of Environmental Economics and Management* 112: 102607.

Hassett, Kevin A., Aparna Mathur, and Gilbert E. Metcalf. 2009. “The Incidence of a US Carbon Tax: A Lifetime and Regional Analysis.” *Energy Journal* 30 (2): 155–78.

Hausman, Catherine, and Samuel Stolper. 2021. “Inequality, Information Failures, and Air Pollution.” *Journal of Environmental Economics and Management* 110: 102552.

Heerink, Nico, Abay Mulatu, and Erwin Bulte. 2001. “Income Inequality and the Environment: Aggregation Bias in Environmental Kuznets Curves.” *Ecological Economics* 38 (3): 359–67.

Hörcher, Daniel, and Alejandro Tirachini. 2021. “A Review of Public Transport Economics.” *Economics of Transportation* 25: 100196.

Hsiang, Solomon, Paulina Oliva, and Reed Walker. 2019. “The Distribution of Environmental Damages.” *Review of Environmental Economics and Policy* 13 (1): 83–103.

Huang, Bihong, and Ying Yao. 2023. “Does Environmental Regulation Matter for Income Inequality? New Evidence from Chinese Communities.” *Journal of the Association of Environmental and Resource Economists* 10 (5): 1309–34.

Jacobs, Bas, and Ruud A. de Mooij. 2015. “Pigou Meets Mirrlees: On the Irrelevance of Tax Distortions for the Second-Best Pigouvian Tax.” *Journal of Environmental Economics and Management* 71: 90–108.

Jacobsen, Jette Bredahl, and Nick Hanley. 2009. “Are There Income Effects on Global Willingness to Pay for Biodiversity Conservation?” *Environmental and Resource Economics* 43 (2): 137–60.

Jha, Akshaya, Peter H. Matthews, and Nicholas Z. Muller. 2019. “Does Environmental Policy Affect Income Inequality? Evidence from the Clean Air Act.” *AEA Papers and Proceedings* 109: 271–76.

Johne, Clara, Enno Schröder, and Hauke Ward. 2023. “The Distributional Effects of a Nitrogen Tax: Evidence from Germany.” *Ecological Economics* 208: 107815.

Johnson, Paul, and Chris Papageorgiou. 2020. “What Remains of Cross-Country Convergence? *Journal of Economic Literature* 58 (1): 129–75.

Känzig, Diego R. 2023. “The Unequal Economic Consequences of Carbon Pricing.” NBER Working Paper 31221.

Klenert, David, Linus Mattauch, Emmanuel Combet, Ottmar Edenhofer, Cameron Hepburn, Ryan Rafaty, and Nicholas Stern. 2018a. “Making Carbon Pricing Work for Citizens.” *Nature Climate Change* 8 (8): 669–77.

Klenert, David, Gregor Schwerhoff, Ottmar Edenhofer, and Linus Mattauch. 2018b. “Environmental Taxation, Inequality and Engel’s Law: The Double Dividend of Redistribution.” *Environmental and Resource Economics* 71 (3): 605–24.

Krause, Eleanor. 2024. “Job Loss, Selective Migration, and the Accumulation of Disadvantage: Evidence from Appalachia’s Coal Country.” Preprint, SSRN. http://dx.doi.org/10.2139/ssrn.4794041.

Kumar, Praduman, Anjani Kumar, Parappurathu Shinoj, and S. S. Raju. 2011. “Estimation of Demand Elasticity for Food Commodities in India.” *Agricultural Economics Research Review* 24 (1): 1–14.

Kverndokk, Snorre, Eric Nævdal, and Linda Nøstbakken. 2014. “The Trade-Off between Intra- and Intergenerational Equity in Climate Policy.” *European Economic Review* 69: 40–58.

Labandeira, Xavier, José M. Labeaga, and Xiral López-Otero. 2017. “A Meta-analysis on the Price Elasticity of Energy Demand.” *Energy Policy* 102: 549–68.

Lee, Sanghoon, and Jeffrey Lin. 2018. “Natural Amenities, Neighbourhood Dynamics, and Persistence in the Spatial Distribution of Income.” *Review of Economic Studies* 85 (1): 663–94.

Levinson, Arik. 2019. “Energy Efficiency Standards Are More Regressive than Energy Taxes: Theory and Evidence.” *Journal of the Association of Environmental and Resource Economists* 6 (S1): S7–36.

Levinson, Arik, and James O’Brien. 2019. “Environmental Engel Curves: Indirect Emissions of Common Air Pollutants.” *Review of Economics and Statistics* 101 (1): 121–33.

Li, Shanjun, Joshua Linn, and Erich Muehlegger. 2014. “Gasoline Taxes and Consumer Behavior.” *American Economic Journal: Economic Policy* 6 (4): 302–42.

Mardones, Cristian, and Camilo Mena. 2020. “Economic, Environmental and Distributive Analysis of the Taxes to Global and Local Air Pollutants in Chile.” *Journal of Cleaner Production* 259: 120893.

Mayer, Jakob, Anna Dugan, Gabriel Bachner, and Karl W. Steininger. 2021. “Is Carbon Pricing Regressive? Insights from a Recursive-Dynamic CGE Analysis with Heterogeneous Households for Austria.” *Energy Economics* 104: 105661.

Metcalf, Gilbert E. 1999. “A Distributional Analysis of Green Tax Reforms.” *National Tax Journal* 52 (4): 655–81.

Meya, Jasper N. 2020. “Environmental Inequality and Economic Valuation.” *Environmental and Resource Economics* 76 (2): 235–70.

Meya, Jasper N., Stefan Baumgärtner, Moritz A. Drupp, and Martin F. Quaas. 2020. “Inequality and the Value of Public Natural Capital.” CESifo Working Paper 8752.

Mikkelson, Gregory M., Andrew Gonzalez, and Garry D. Peterson. 2007. "Economic Inequality Predicts Biodiversity Loss." *PloS One* 2 (5): e444.
Mildenberger, Matto, Erick Lachapelle, Kathryn Harrison, and Isabelle Stadelmann-Steffen. 2022. "Limited Impacts of Carbon Tax Rebate Programmes on Public Support for Carbon Pricing." *Nature Climate Change* 12 (2): 141–47.
Mirrlees, J. A. 1971. "An Exploration in the Theory of Optimum Income Taxation." *Review of Economic Studies* 38 (2): 175–208.
Muehlegger, Erich, and Richard L. Sweeney. 2022. "Pass-Through of Own and Rival Cost Shocks: Evidence from the US Fracking Boom." *Review of Economics and Statistics* 104 (6): 1361–69.
Murray, Brian, and Nicholas Rivers. 2015. "British Columbia's Revenue-Neutral Carbon Tax: A Review of the Latest 'Grand Experiment' in Environmental Policy." *Energy Policy* 86: 674–83.
Nesje, Frikk, Robert C. Schmidt, and Moritz A. Drupp. Forthcoming. "Designing Carbon Pricing Policies across the Globe." *Environmental and Resource Economics*.
Neuhoff, Karsten, Stefan Bach, Jochen Diekmann, Martin Beznoska, and Tarik El-Laboudy. 2013. "Distributional Effects of Energy Transition: Impacts of Renewable Electricity Support in Germany." *Economics of Energy and Environmental Policy* 2 (1): 41–54.
Nordhaus, William. 2019. "Climate Change: The Ultimate Challenge for Economics." *American Economic Review* 109 (6): 1991–2014.
Nurmi, Väinö, and Heini Ahtiainen. 2018. "Distributional Weights in Environmental Valuation and Cost-Benefit Analysis: Theory and Practice." *Ecological Economics* 150: 217–28.
Ohlendorf, Nils, Michael Jakob, Jan Christoph Minx, Carsten Schröder, and Jan Christoph Steckel. 2021. "Distributional Impacts of Carbon Pricing: A Meta-analysis." *Environmental and Resource Economics* 78 (1): 1–42.
Olmstead, Sheila M., W. Michael Hanemann, and Robert N. Stavins. 2007. "Water Demand under Alternative Price Structures." *Journal of Environmental Economics and Management* 54 (2): 181–98.
Olson, Mancur. 1965. *The Logic of Collective Action: Public Goods and the Theory of Groups*. With a new preface and appendix. Harvard University Press.
Ortiz-Bobea, Ariel, Toby R. Ault, Carlos M. Carrillo, Robert G. Chambers, and David B. Lobell. 2021. "Anthropogenic Climate Change Has Slowed Global Agricultural Productivity Growth." *Nature Climate Change* 11 (4): 306–12.
Ostrom, Elinor. 2009. "A General Framework for Analyzing Sustainability of Social-Ecological Systems." *Science* 325 (5939): 419–22.
Park, R. Jisung, Joshua Goodman, Michael Hurwitz, and Jonathan Smith. 2020. "Heat and Learning." *American Economic Journal: Economic Policy* 12 (2): 306–39.
Park, R. Jisung, Nora Pankratz, A. Patrick Behrer. 2021. "Temperature, Workplace Safety, and Labor Market Inequality." IZA Discussion Paper 14560..
Parry, Ian W. H. 2004. "Are Emissions Permits Regressive?" *Journal of Environmental Economics and Management* 47 (2): 364–87.
Parry, Ian W. H. 2009. "Pricing Urban Congestion." *Annual Review of Resource Economics* 1: 461–84.
Parry, Ian W. H., Hilary Sigman, Margaret Walls, and Roberton C. Williams III. 2006. "The Incidence of Pollution Control Policies." In *The International Yearbook of Environmental and Resource Economics 2006/2007: A Survey of Current Issues*, edited by Tom Tietenberg and Henk Folmer, 1–42. Edward Elgar.
Pizer, William A., and Steven Sexton. 2019. "The Distributional Impacts of Energy Taxes." *Review of Environmental Economics and Policy* 13 (1): 104–23.
Poterba, James M. 1989. "Lifetime Incidence and the Distributional Burden of Excise Taxes." *American Economic Review* 79 (2): 325–30.
Preonas, Louis. 2024. "Market Power in Coal Shipping and Implications for US Climate Policy." *Review of Economic Studies* 91 (4): 2508–37.
Rausch, Sebastian, Gilbert E. Metcalf, and John M. Reilly. 2011. "Distributional Impacts of Carbon Pricing: A General Equilibrium Approach with Micro-data for Households." *Energy Economics* 33 (S1): S20–33.
Rausch, Sebastian, Gilbert E. Metcalf, John M. Reilly, and Sergey Paltsev. 2010. "Distributional Implications of Alternative US Greenhouse Gas Control Measures." *BE Journal of Economic Analysis and Policy* 10 (2).
Rausch, Sebastian, and Giacomo A. Schwarz. 2016. "Household Heterogeneity, Aggregation, and the Distributional Impacts of Environmental Taxes." *Journal of Public Economics* 138: 43–57.
Ravallion, Martin, Mark Heil, and Jyotsna Jalan. 2000. "Carbon Emissions and Income Inequality." *Oxford Economic Papers* 52 (4): 651–69.

Roemer, John E. 1996. *Theories of Distributive Justice*. Harvard University Press.

Sager, Lutz. 2019. "Income Inequality and Carbon Consumption: Evidence from Environmental Engel Curves." *Energy Economics* 84 (S1): 104507.

Sager, Lutz. 2023. "The Global Consumer Incidence of Carbon Pricing: Evidence from Trade." *Energy Economics* 127 (B): 107101.

Sager, Lutz, and Gregor Singer. 2025. "Clean Identification? The Effects of the Clean Air Act on Air Pollution, Exposure Disparities and House Prices." *American Economic Journal: Economic Policy* 17 (1): 1–36.

Säll, Sarah. 2018. "Environmental Food Taxes and Inequalities: Simulation of a Meat Tax in Sweden." *Food Policy* 74: 147–53.

Sandmo, Agnar. 1975. "Optimal Taxation in the Presence of Externalities." *Swedish Journal of Economics* 77 (1): 86–98.

Schlenker, Wolfram, and Michael J. Roberts. 2009. "Nonlinear Temperature Effects Indicate Severe Damages to US Crop Yields under Climate Change." *Proceedings of the National Academy of Sciences* 106 (37): 15594–98.

Schulte, Isabella, and Peter Heindl. 2017. "Price and Income Elasticities of Residential Energy Demand in Germany." *Energy Policy* 102: 512–28.

Scruggs, Lyle A. 1998. "Political and Economic Inequality and the Environment." *Ecological Economics* 26 (3): 259–75.

Sebri, Maamar. 2014. "A Meta-analysis of Residential Water Demand Studies." *Environment, Development and Sustainability* 16 (3): 499–520.

Serebrisky, Tomás, Andrés Gómez-Lobo, Nicolás Estupiñán, and Ramón Muñoz-Raskin. 2009. "Affordability and Subsidies in Public Urban Transport: What Do We Mean, What Can Be Done?" *Transport Reviews* 29 (6): 715–739.

Sheng, Tey Yeong, Mad Nasir Shamsudin, Zainalabidin Mohamed, Amin Mahir Abdullah, and Alias Radam. 2010. "Demand Analysis of Meat in Malaysia." *Journal of Food Products Marketing* 16 (2): 199–211.

Smith, V. Kerry. 2023. "Accounting for Income Inequality in Benefit Transfers: The Importance of the Income Elasticity of WTP." *Journal of Environmental Economics and Management* 118: 102781.

Somanathan, E., Rohini Somanathan, Anant Sudarshan, and Meenu Tewari. 2021. "The Impact of Temperature on Productivity and Labor Supply: Evidence from Indian Manufacturing." *Journal of Political Economy* 129 (6): 1797–827.

Spurlock, C. Anna, and K. Sydny Fujita. 2022. "Equity Implications of Market Structure and Appliance Energy Efficiency Regulation." *Energy Policy* 165: 112943.

Steckel, Jan C., Ira I. Dorband, Lorenzo Montrone, Hauke Ward, Leonard Missbach, Fabian Hafner, Michael Jakob, and Sebastian Renner. 2021. "Distributional Impacts of Carbon Pricing in Developing Asia." *Nature Sustainability* 4 (11): 1005–14.

Stern, Nicholas. 2007. *The Economics of Climate Change: The Stern Review*. Cambridge University Press.

Sterner, Thomas, ed. 2012. *Fuel Taxes and the Poor: The Distributional Effects of Gasoline Taxation and Their Implications for Climate Policy*. RFF Press.

Stiglitz, Joseph E. 2012. *The Price of Inequality: How Today's Divided Society Endangers Our Future*. WW Norton and Company.

Suárez-Varela, Marta. 2020. "Modeling Residential Water Demand: An Approach Based on Household Demand Systems." *Journal of Environmental Management* 261: 109921.

Sun, Cong, Matthew E. Kahn, and Siqi Zheng. 2017. "Self-Protection Investment Exacerbates Air Pollution Exposure Inequality in Urban China." *Ecological Economics* 131: 468–74.

Sun, Chuanwang, and Xiaoling Ouyang. 2016. "Price and Expenditure Elasticities of Residential Energy Demand during Urbanization: An Empirical Analysis Based on the Household-Level Survey Data in China." *Energy Policy* 88: 56–63.

Tavoni, Alessandro, Astrid Dannenberg, Giorgos Kallis, and Andreas Löschel. 2011. "Inequality, Communication, and the Avoidance of Disastrous Climate Change in a Public Goods Game." *Proceedings of the National Academy of Sciences* 108 (29): 11825–29.

Tonsor, Glynn T., and Thomas L. Marsh. 2007. "Comparing Heterogeneous Consumption in US and Japanese Meat and Fish Demand." *Agricultural Economics* 37 (1): 81–91.

Torras, Mariano, and James K. Boyce. 1998. "Income, Inequality, and Pollution: A Reassessment of the Environmental Kuznets Curve." *Ecological Economics* 25 (2): 147–60.

Venmans, Frank, and Ben Groom. 2021. "Social Discounting, Inequality Aversion, and the Environment." *Journal of Environmental Economics and Management* 109: 102479.

Vogt-Schilb, Adrien, Brian Walsh, Kuishuang Feng, Laura Di Capua, Yu Liu, Daniela Zuluaga, Marco Robles, and Klaus Hubaceck. 2019. "Cash Transfers for Pro-poor Carbon Taxes in Latin America and the Caribbean." *Nature Sustainability* 2 (10): 941–48.
Wadud, Zia, Daniel J. Graham, and Robert B. Noland. 2010. "Gasoline Demand with Heterogeneity in Household Responses." *Energy Journal* 31 (1): 47–74.
Walker, W. Reed. 2013. "The Transitional Costs of Sectoral Reallocation: Evidence from the Clean Air Act and the Workforce." *Quarterly Journal of Economics* 128 (4): 1787–835.
Wang, Qian, Klaus Hubacek, Kuishuang Feng, Yi-Ming Wei, and Qiao-Mei Liang. 2016. "Distributional Effects of Carbon Taxation." *Applied Energy* 184: 1123–31.
Wang, Xiao, George Deltas, Madhu Khanna, and Xiang Bi. 2021. "Community Pressure and the Spatial Redistribution of Pollution: The Relocation of Toxic-Releasing Facilities." *Journal of the Association of Environmental and Resource Economists* 8 (3): 577–616.
Weitzel, Matthias, Toon Vandyck, Luis Rey Los Santos, Marie Tamba, Umed Temursho, and Krzysztof Wojtowicz. 2023. "A Comprehensive Socio-economic Assessment of EU Climate Policy Pathways." *Ecological Economics* 204 (A): 107660.
West, Sarah E., and Roberton C. Williams III. 2004. "Estimates from a Consumer Demand System: Implications for the Incidence of Environmental Taxes." *Journal of Environmental Economics and Management* 47 (3), 535–58.
Weyl, E. Glen, and Michal Fabinger. 2013. "Pass-Through as an Economic Tool: Principles of Incidence under Imperfect Competition." *Journal of Political Economy* 121 (3): 528–83.
Wolverton, Ann. 2009. "Effects of Socio-economic and Input-Related Factors on Polluting Plants' Location Decisions." *BE Journal of Economic Analysis and Policy* 9 (1).
Yip, Chi Man. 2018. "On the Labor Market Consequences of Environmental Taxes." *Journal of Environmental Economics and Management* 89: 136–52.
Yusuf, Ariel A. and Budy P. Resosudarmo. 2015. "On the Distributional Impact of a Carbon Tax in Developing Countries: The Case of Indonesia." *Environmental Economics and Policy Studies* 17 (1): 131–56.
Zhao, Jiaxin, and Linus Mattauch. 2022. "When Standards Have Better Distributional Consequences than Carbon Taxes." *Journal of Environmental Economics and Management* 116: 102747.
Zhou, Shaojie, and Fei Teng. 2013. "Estimation of Urban Residential Electricity Demand in China Using Household Survey Data." *Energy Policy* 61: 394–402.
Zhu, Wen-bo, Yong-fu Chen, Jing Zhao, and Bei-bei Wu. 2021. "Impacts of Household Income on Beef at-Home Consumption: Evidence from Urban China." *Journal of Integrative Agriculture* 20 (6): 1701–15.
Zivin, Joshua Graff, Matthew Neidell, and Wolfram Schlenker. 2011. "Water Quality Violations and Avoidance Behavior: Evidence from Bottled Water Consumption." *American Economic Review* 101 (3): 448–53.