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Distributional impacts of energy transition pathways and climate change

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ABSTRACT/RÉSUMÉ

Distributional impacts of energy transition pathways and climate change

This report reviews the literature on the distributional consequences of climate change and mitigation and transition pathways. The heterogeneous levels of exposure and vulnerability to climate change across countries, regions, households, and workers hint at the significant distributional costs of inaction. Climate policies will likely trigger a reallocation from "high-polluting" sectors to "green" sectors, disproportionately affecting certain regions and low-skilled workers. Price-based policies, such as carbon taxation, show varied effects across countries: they tend to be more regressive in developed countries and more progressive in developing countries where energy affordability and energy poverty are major concerns. Non-market-based policies are often regressive and can result in equity issues. Effective climate action requires balancing distributional outcomes, ensuring political acceptability, and understanding the link between policy perceptions and support.

Key words: distributional impacts, inequality, climate change, environmental policy

JEL codes: D30, H23, J23, Q52, Q58

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Impacts distributifs des trajectoires de transition énergétique et du changement climatique

Ce rapport passe en revue la littérature sur les conséquences distributives du changement climatique, des mesures d'atténuation et des trajectoires de transition. L'hétérogénéité des niveaux d'exposition et de vulnérabilité au changement climatique entre les pays, les régions, les ménages et les travailleurs laisse entrevoir les coûts distributifs importants de l'inaction. Les politiques climatiques déclencheront probablement une réaffectation des secteurs « très polluants » vers les secteurs « verts », affectant de manière disproportionnée certaines régions et les travailleurs peu qualifiés. Les politiques fondées sur les prix, telles que la taxation du carbone, ont des effets variables d'un pays à l'autre : elles tendent à être plus régressives dans les pays développés et plus progressives dans les pays en développement, où l'accessibilité de l'énergie et la pauvreté énergétique sont des préoccupations majeures. Les politiques non fondées sur le marché sont souvent régressives et peuvent poser des problèmes d'équité. Pour être efficace, l'action climatique doit équilibrer les résultats distributifs, garantir l'acceptabilité politique et comprendre le lien entre les perceptions et les politiques de soutien.

Mots clés : impacts distributifs, inégalité, changement climatique, politique environnementale

Codes: D30, H23, J23, Q52, Q58

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Distributional impacts of energy transition pathways and climate change

By Jule Hodok and Tomasz Kozluk[1]

Executive Summary

The direct impacts of climate change are unevenly distributed across countries, regions, and households. However, climate change policies also have distributional effects. Adaptation, mitigation, and transition policies hence face trade-offs among equity, efficiency, and effectiveness objectives.

The extent to which a specific group of people is affected by the impacts of climate change is determined by exposure and vulnerability, which vary significantly across countries, regions, and socioeconomic groups. Developing countries are more exposed on average and more vulnerable due to lower levels of adaptive capacity and resilience. Evidence suggests that urban areas face higher risks of extreme temperatures and intense flooding, while rural communities are more vulnerable to climate change exposure due to a stronger reliance on resource-based industries. Lower-income households are likely disproportionately affected, as they tend to live in riskier areas and lack the resources to adapt, exacerbating existing inequalities.

The green transition will require a reallocation of labour and capital, from "high-emission" sectors, firms, and activities to low carbon emitters. The effects of climate change policies on employment are predicted to be modest on aggregate, however, they will vary significantly across sectors and population groups. Labour market shifts are expected to be geographically concentrated, for example due to high-emission industries being clustered in resource-rich regions. This can lead to significant regional shocks beyond direct job losses in specific sectors. Low-skilled workers and those with lower educational attainment may be most negatively affected as they have higher adjustment costs and face greater barriers to reskilling and job mobility.

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Climate policies that result in changes in relative prices will affect households differently due to differences in the goods they tend to consume. Empirical research reveals that the effect of carbon and energy taxation is heterogeneous across countries, finding mostly regressive effects in advanced economies and mostly progressive effects in developing countries. Progressive effects in developing countries stem from the fact that a large subset of the population have relatively limited fossil fuel energy use. Many developing countries are therefore particularly boldly confronted with the trade-off between energy affordability and addressing climate change. Even small increases in the price of energy may significantly aggravate energy poverty and intensify the global energy challenge. The regressivity of a policy also depends on the actual policy itself. For example, transport fuel taxation is mostly neutral in countries with higher GDP per capita and progressive in countries with lower GDP per capita.

Importantly, factors other than income may be crucial in driving the distributional effects of carbon and energy taxation. This highlights the importance of considering behavioural changes and the availability of substitute technologies and infrastructure when assessing which individuals are most affected by a policy. Most evidence shows that rural households are more vulnerable to carbon taxation or rising energy prices, due to, for example, limited access to public transport. More generally, distributional effects hinge on the ability to adjust consumption of carbon-intensive goods which often requires investment, for example into energy-saving appliances.

Non-market-based and demand-side policies are often found to be regressive in advanced economies. Non-market-based policies - including bans, standards, and direct regulation – tend to disproportionately affect lower-income households and may result in equity concerns through possibly unaffordable replacement costs. Limited research on subsidies and feed-in-tariffs (e.g. for electric vehicles, solar panels, or home insulation) suggests that they tend to primarily benefit higher-income households who have the required capital to invest in the low-carbon solution.

The political acceptability of climate mitigation policies is closely linked to how their perceived costs are distributed. Support for climate change policies increases if they are perceived as effective and progressive. Information provision also plays an important role and explanations of policies can significantly increase support.

Introduction

The macroeconomic costs and distributional consequences of the physical impact of climate change are substantial and the potential costs of inaction are significantly higher than those of a green transition (Intergovernmental Panel on Climate Change (IPCC), 2023). The direct impacts of climate change are often unevenly distributed across countries, regions, and households; and mitigation and transition policies also have distributional effects. With the primary goal of reducing or preventing the emission of greenhouse gases (GHGs) to alleviate the physical, social, and economic impacts of global warming, climate mitigation policies will need to avoid or minimise adverse distributional outcomes. This leads to a challenge of balancing equity, efficiency, and effectiveness. Perceived adverse distributional outcomes can be a barrier to climate action so gaining political acceptability will be crucial for the successful implementation of climate policies and requires understanding the link between acceptability and distributional effects.

When interpreting the findings of this report, some caveats should be considered. First, most of the empirical evidence is based on data from advanced economies due to better data availability and more extensive research. While evidence from developing countries is included where possible, it is less comprehensive and often limited to a few countries. Second, evidence cited in this report often estimates only the partial effect of individual policies (“ceteris paribus”) without accounting for the interplay between multiple policies, tools, and conditions. In reality, complex interactions may influence the overall impact. Third, distributional results and in particular behavioural responses to policies are often estimated to be small ex post but may be more significant in response to much larger future policy changes, due to threshold effects and non-linearities.

The report is structured as follows: It begins by summarising the main distributional impacts of the physical risks and consequences of climate change. Next, it discusses the distributional effects of different mitigation and transition pathways, distinguishing income effects ("source-side") and consumption effects ("use-side"). Lastly, the report presents the main factors driving the political acceptability of climate mitigation policies.

The distributional impacts of climate change

The physical risks and consequences of climate change are a major threat to natural systems, economic growth, society, and well-being. Impacts will be unevenly distributed across countries, regions, and households. The extent to which a specific group of people is affected by the physical effects of climate change is determined by two variables: exposure and vulnerability (OECD, 2021):

- **"Exposure"** is the presence of people, livelihoods, species, or ecosystems in places and settings that could be adversely affected by environmental degradation (Intergovernmental Panel on Climate Change (IPCC), 2023).
- **"Vulnerability"** is the propensity or predisposition to suffer from the adverse effects and/or the lack of capacity to cope or adapt after exposure (Intergovernmental Panel on Climate Change (IPCC), 2023).

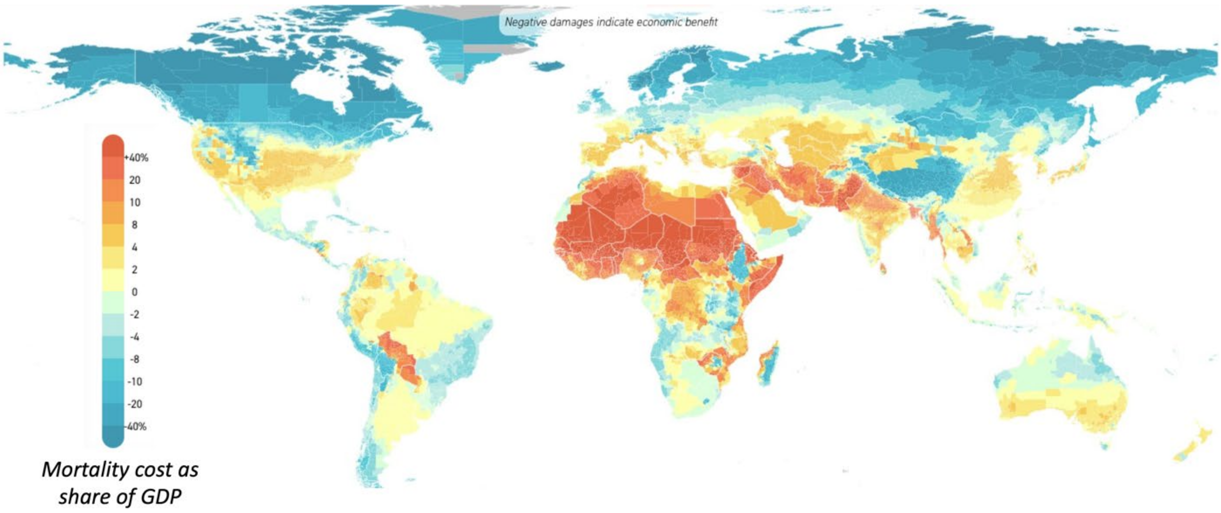
Hence, exposure is a necessary but not sufficient condition to being negatively affected and both variables are important in understanding the implications of physical climate change costs and risks.

Between-country distributional impacts of climate change

Climate change *exposure* is heavily geographically concentrated (see Figure 1). There is evidence that developing countries (particularly small island states) are most exposed to physical climate change impacts. Within developing countries, low-income populations are particularly exposed. A country's *vulnerability* is intricately linked to its level of adaptive capacity and resilience. Due to financial, institutional, or technological barriers, lower-income countries often have lower levels of adaptive capacity than more advanced economies. This is called an adaptation deficit (Fankhauser, 2017). Evidence shows that poorer countries are therefore not only more exposed to climate impacts, such as higher temperatures, but are also more vulnerable, or less able to adapt to exposure, with potentially vast implications for economic growth and development. (Dell, Jones, & Olken, 2012). Recent evidence on the macroeconomic impact of climate change suggests that most regions in the world will experience substantial negative effects in response to global temperature shocks and the strongest effects are estimated in relatively hot regions such as Southeast Asia and Sub-Saharan Africa (Bilal & Känzig, 2024). These between-country distributional impacts are already felt today; as a result of greater exposure and vulnerability, it is estimated that 60% of economic losses and 90% of reported deaths due to weather-, climate-, and water-related disasters are reported in developing economies[2] (World Meteorological Organisation, 2022).

[2] Based on data from 11,776 reported disasters between 1970 and 2019.

Figure 1. Predicted mortality cost as a share of GDP under a high emissions scenario



Notes: Estimates are based on a high emission scenario (RCP 8.5) for the end of the century (2080-2099). The methodology for estimating the mortality costs of climate change (temperature-related) derived from (Carleton, et al., 2022).[3]
Source: (Climate impact Lab, 2024)

Within-country distributional effects of climate change

Within-country evidence, i.e., comparisons between regions, cities, urban and rural areas, and neighbourhoods are mixed, and conclusions vary case-by-case (Mackie & Haščič, 2019). For example, evidence from the United States suggests potentially stark differences in climate change impacts. (Hsiang, et al., 2017) predict that by the end of the century, the (currently) poorest third of counties in the US will experience severe negative impacts while some richer counties will in fact experience positive impacts. The risk of natural disaster exposure also varies significantly across regions (OECD, 2021).

Comparing urban and rural regions reveals that people living and working in urban areas are more likely to be exposed to higher temperatures (OECD, 2021). The urban landscape, with significant use of concrete and asphalt, leads to higher temperatures in cities and the sealed surfaces can cause more intense flooding (Fankhauser & McDermott, 2016). This so-called urban heat island phenomenon will become increasingly important as the urban population is expected to grow by an additional 2.5 billion people by 2050, with 90% of this increase occurring in Africa and Asia (UN DESA 2019, cited in (Intergovernmental Panel on Climate Change (IPCC), 2023)). Rural communities are particularly vulnerable to climate change impacts and risks as their local economies often rely on resource-based industries such as agriculture. Additionally, the propensity to adapt to and prepare for those challenges is lower in rural communities due to remoteness and limited economic diversity. Differences in the vulnerability between urban and rural areas more generally risk exacerbating spatial polarisation and the “rural-urban divide” (OECD, 2021). This could lead to substantial rural-urban migration, further exacerbating the challenge of rapid urbanisation especially in developing countries. Rapidly growing cities, especially in Africa and Asia, often lack the resources to adapt their urban structures to climate change and to provide refuge to the increasing number of urban poor living in areas that are highly exposed to climate hazards (Intergovernmental Panel on Climate Change (IPCC), 2023).

Given the variety of physical climate change impacts, such as droughts, sea level rise, and floods, it is difficult to draw clear conclusions about the income gradient in people’s exposure to climate change risks

[3] Mortality costs are just one part of health-related impacts of climate change and account for an even smaller share of the overall costs of climate change.

and impacts. Furthermore, different relationships can be observed at different spatial levels (countries, regions, cities, neighbourhoods), making it difficult to draw general conclusions about the socioeconomic status and climate change exposure (Mackie & Haščič, 2019). There is evidence, however, that climate exposure is capitalised in house prices, resulting in lower-income households living in riskier areas, such as flood-prone zones (McDermott, 2022; Rentschler, Salhab, & Jafino, 2022). Low-income households tend to be more vulnerable to climate change, due to a lower ability to invest in adaptive technologies, lower baseline health, potentially limited access to good quality healthcare and infrastructure, and fewer resources to effectively participate in civic action or fully benefit from public policy responses. For example, poorer households often struggle to cool their homes during heatwaves. Additionally, lower-income households are more vulnerable to financial losses in response to extreme weather events due to them holding less or less diversified assets (both geographically and financially) as well as restricted access to insurance and credit (OECD, 2021). This can lead to a vicious cycle where poorer households suffer disproportionate losses of their income and assets in response to climate change, making them even more vulnerable in the future (Bijnens, et al., 2024; Islam & Winkel, 2017).

Exposure to climate change can be particularly high for groups relying heavily on the environment, for example, Indigenous people or subsistence farmers who depend on natural resources or ecosystem services for their livelihood and survival (OECD, 2021). Research in the context of natural disasters such as Hurricane Katrina finds that more affluent individuals were more likely than low-income individuals to evacuate before the disaster (Elliott & Pais, 2006). They also find that post-hurricane, Black people were more likely to report the loss of employment and more likely to report higher levels of distress compared to white people, all else being equal, suggesting that historically marginalised groups are potentially more vulnerable to climate change impacts (Elliott & Pais, 2006). Overall, households with disadvantaged socioeconomic backgrounds tend to be more vulnerable to climate change impacts, are less protected in the event of a disaster due to a lack of adaptive mechanisms, and face barriers to accessing environmental information, with all factors being mutually reinforcing (OECD, 2024).

Climate change impacts and risks are often not gender-neutral (OECD, 2023). Particularly in developing countries, women and girls are disproportionately affected by climate change and environmental degradation. For example, when displaced because of climate change or extreme weather events, women face an increased risk of gender-based violence (ActionAid et al., 2021; OECD, 2023) and in response to income losses due to climate change, girls' education is often the first thing families choose to sacrifice (Plan International, n.d.). This suggests that climate change may exacerbate existing gender inequalities. Moreover, the gender dimension often intersects with other social, physical, or geographical factors, making those at the intersections particularly vulnerable (UNHCR and PIK, 2020).

Lastly, climate change also has heterogeneous impacts across industries and workers. Extreme weather events (droughts, heatwaves, floods, etc.) as well as climate change-related biodiversity loss mostly affect industries relying on ecosystems, such as tourism and agriculture. Workers employed in construction, agriculture, and casual work in urban areas – often already characterised by high levels of informal employment - are more affected by heat waves. Those industries are also expected to experience the largest productivity and work hour losses due to heat stress (Kjellstrom, Maitre, Saget, Otto, & Karimova, 2019). Even in industries and regions where both high-skilled and low-skilled workers are exposed to climate change impacts, e.g. by longer episodes of heatwaves, low-skilled workers usually face fewer choices about job type and job location making them more vulnerable (OECD, 2021).

Uncertainty in the magnitude of climate change impacts

While there is strong consensus on the general trends of climate change, the precise timing, location, and magnitude of its impacts remain uncertain. Recent estimates suggest that the macroeconomic damages from climate change could in fact be six times larger than previously thought (Bilal & Känzig, 2024). The uncertainty is compounded by the potential of reaching tipping points, critical thresholds that can lead to significant system changes that are likely irreversible and can lead to far-reaching and unpredictable consequences (Intergovernmental Panel on Climate Change (IPCC), 2023). Consequently, there is also significant uncertainty in predicting the distributional impacts of the physical effects of climate change, particularly in the longer term.

The distributional impacts of climate change mitigation

Channels of distributive impacts

The distributional consequences of the physical risks and impacts of climate change are likely to be significant. However, climate change mitigation policies also have distributional effects that are important to consider. Transition policies impact households along several dimensions and can be broadly summarised into two categories.[4]

- 'Distributional effects through income ('*source-side'*) arise when a climate policy unevenly affects the returns between capital and labour, among different assets, between high- and low-skilled labour or between different types of skills. This can materialise in (relative or absolute) real wage reduction, income, or job losses for certain groups.
- Distributional effects through consumption ('use-side') arise when climate policies result in relative price changes, for example by increasing the price of goods with a higher pollution content. This will lead to heterogenous effects if households have different consumption baskets.

Distributional effects via incomes ('source-side'):

Climate change mitigation policies and the green transition will likely change production and employment patterns (OECD, 2023), even if the aggregate effects of climate mitigation policies on employment are generally predicted to be limited (OECD, 2021; OECD, 2023; Weitzel, et al., 2023; Borgonovi, Lanzi, Seitz, & Bibas, 2023). (Chateau, Bibas, & Lanzi, 2018) estimate that a global tax of USD 50/tCO2 would result in an overall reallocation of jobs of around 0.3% for OECD countries and 0.8% for non-OECD countries[5]. Other literature also suggests small employment impacts (see (OECD, 2021) for an overview of the literature). Evidence from France reveals that an increase in the carbon tax on fossil fuel combustion did not change aggregate manufacturing employment, only leading to a reallocation from energy-intensive to energy-efficient firms (Dussaux , 2020). Other evidence even suggests that green transition policies may generate job gains (OECD, 2021; International Labour Organisation, 2018; Yamazaki, 2017). However, even in the case of the (optimistic) modest net aggregate employment effects, climate policies can still imply substantial heterogeneous effects across sectors, skills, or socio-economic dimensions. Moreover, even if aggregate effects are muted, reallocation can be costly or infeasible in inflexible or geographically dispersed job markets and for certain individuals.

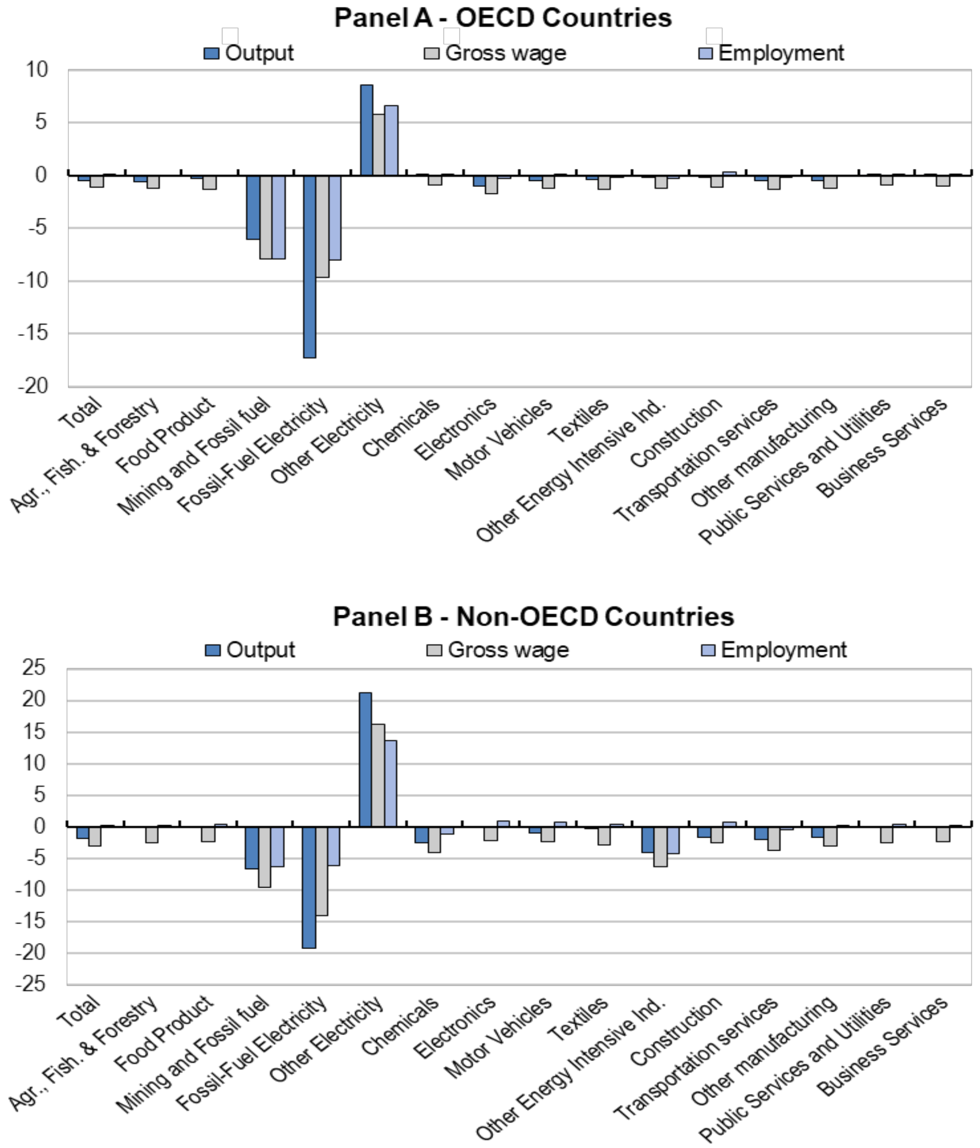
[4] Framework from (Vona, 2021).

[5] The (Chateau, Bibas, & Lanzi, 2018) paper uses the OECD ENV-Linkages computable general equilibrium (CGE) model as a tool for the analysis.

Heterogenous effects across sectors and skills

The green transition induced by climate mitigation policies will likely result in a significant reduction in jobs related to carbon-intensive sectors and firms, so-called “high-polluting” jobs, and a significant increase in jobs associated with low-carbon and emission-saving technologies (OECD, 2023). (Chateau, Bibas, & Lanzi, 2018) predict that in response to energy price increases, energy-intensive industries are expected to experience a modest fall in employment while the largest job gains are expected in low-carbon power generation. More specifically, a global tax of USD 50/tCO2 would result in employment decreases of about 8% in fossil fuel extraction and fossil-based power generation (Chateau, Bibas, & Lanzi, 2018) (see Figure 2 for an overview of sector-specific effects). These results rely on the assumption of a global tax. In a world with multiple carbon markets and varying policy stringency levels across countries (including due to unilateral action), there are concerns about reduced sectoral competitiveness and carbon leakage. Competitiveness can decrease in countries with more stringent policies and activity can shift to countries with less stringent policies resulting in further potential job and income losses, on aggregate or in some sectors and regions (Koźluk & Timiliotis, 2016). Ex-post evidence from British Columbia’s carbon tax supports this by reporting that carbon-intensive and trade-intensive industries experienced the largest employment reductions (Yamazaki, 2017). Evidence on the job effects of the European Union Emissions Trading System (EU ETS) has been limited so far (Dechezleprêtre, Nachtigall, & Venmans, 2023). Research on the effect of the European Union’s Fit for 55 targets projects that employment of blue-collar and farm workers is projected to decrease most, and that training participation is particularly low among impacted workers (Borgonovi, Lanzi, Seitz, & Bibas, 2023; OECD, 2023). Overall, it is expected that, in response to uncompensated climate mitigation policies, workers who are employed in high-polluting occupations face higher displacement risks than workers in non-polluting occupations with some research estimating 20% higher odds of unemployment (Causa, Soldani, Nguyen, & Tanaka, 2024).

Figure 2. Change in output, employment, and gross wage by sector in response to central scenario



Notes: a carbon tax of USD 50/tCO2 is applied in all regions of the world; percentage change w.r.t reference equilibrium, 2011
Source: (Chateau, Bibas, & Lanzi, 2018)

The magnitude of distributional effects relating to job reallocation depends on the level of reallocation costs and welfare costs, i.e. how easy it is for someone to acquire new skills and qualifications needed (Vona, Marin, Consoli, & Popp, 2018). Employment effects tend to be geographically concentrated and may require workers to pursue jobs for which they might need substantial retraining. Evidence from mass layoffs in Germany suggests that, compared to workers in low carbon-intensity sectors, displaced workers in carbon-intense sectors suffer, on average, larger earnings losses and find it more difficult to find a new job, indicating the difficulty of transferring skills to other sectors. They are also on average older and due to regional clustering of carbon-intensive jobs, face strong local labour market concentration (Barreto, Grundke, & Krill, 2023). Generally, such labour market shifts have disproportionately negative effects on low-skilled workers who face higher adjustment costs as lower levels of education and competencies are found to be a barrier to reskilling and job mobility (OECD, 2023). While low-skilled workers are most negatively affected (Chateau, Bibas, & Lanzi, 2018), some claim that the transition will likely increase the demand for science, technology, engineering, and math (STEM) and managerial skills (Vona, Marin, Consoli, & Popp, 2018). Overall, the skill-biased effects of climate mitigation policies can be compared to those of automation and globalisation in terms of harming low-skilled workers most, except that in the green transition technical skills seem to be more important than digital skills (Vona, 2021).

Heterogeneous effects along the socio-economic and gender dimension

On average, high-polluting jobs are associated with medium and lower educational attainment (Causa, Soldani, Nguyen, & Tanaka, 2024). Workers with higher levels of education are already more likely to have so-called "green jobs"[6] (Causa, Nguyen, & Soldani, 2024) and less likely to work in high-polluting jobs (Causa, Soldani, Nguyen, & Tanaka, 2024) compared to workers with middle or lower levels of education. Furthermore, green jobs are overrepresented at the higher end of the wage distribution while high-polluting jobs tend to be concentrated in the middle of the wage distribution which means that on average, both green and high-polluting jobs are underrepresented at the lower end of the wage distribution (Causa, Nguyen, & Soldani, 2024). Overall, with green jobs having 20% higher pay than other jobs on average, high-skilled and more educated workers have benefitted from the green transition so far (OECD, 2024).

The green transition induced by climate policies may also have gender implications. The most negatively directly affected industries and jobs are often male dominated (for example, men tend to be more likely employed in fossil fuel extraction) (OECD, 2021). Simultaneously, women often remain underrepresented in STEM fields and entrepreneurship which may constrain women's participation in the industries that are expected to grow in response to climate policies (OECD, 2021). Currently, male workers are significantly overrepresented in green jobs compared to female workers (Causa, Soldani, Nguyen, & Tanaka, 2024).

Heterogenous effects along the spatial dimension

Lastly, regional disparities are substantial as both the risks and the opportunities of the green transition are unevenly distributed (OECD, 2023). Fossil fuel extractive industries are clustered in resource-rich regions resulting in job losses being geographically concentrated (OECD, 2021). For example, in Canada, approximately half of "oil and gas" workers are concentrated in one province, Alberta (OECD, 2021). The impacts on those regions likely go beyond direct job destruction in a specific sector. Knock-on effects such as reduced expenditures on local goods and services, downward pressure on wages in local services, or job losses in other local sectors, will likely exacerbate direct regional effects. Additionally, other negative externalities such as poorer mental health and general dissatisfaction may occur in communities where large high-polluting plants shut down (Vona, 2021). Those high-polluting jobs are systematically overrepresented in rural areas leading to the risk of exacerbating regional inequalities and spatial polarisation between rural and urban areas (Causa, Nguyen, & Soldani, 2024). To balance negative spatially concentrated impacts, jobs would need to be created in areas where job losses occur to avoid significant reallocation costs for workers with negative consequences on families, communities, and general well-being (OECD, 2021).

[6] The terms "green jobs" and "high-polluting jobs" are used for simplicity in this report. The term "green jobs" is used to describe occupations that involve "green" tasks (irrespective of the job's actual impact on the environment) and are expected to increase as a result of the green transition. "High-polluting jobs" relate to occupations that are represented in emission-intensive sectors. See (Causa, Nguyen, & Soldani, 2024) for an overview of definitions for "green" and "polluting" jobs.

Alleviation measures for distributional effects via incomes

Combining climate transition policies with other measures can help mitigate the potential adverse distributional consequences of a climate transition:

I. **Active labour market programs** can help facilitate the reallocation of workers from high-polluting to green jobs (Botta, 2019). This requires effective support for displaced workers through job-search counselling services, requalification programs, and subsidies for employers to retrain workers (Causa, Soldani, Nguyen, & Tanaka, 2024). Requalification and training programs addressing skill mismatches and training gaps should be primarily targeted at low-skilled displaced workers who face higher barriers to reskilling without assistance (D'Arcangelo, Levin, Pagani, Pisu, & Johansson, 2022).

II. Job-counselling and requalification incentives are most successful when combined with **unemployment support and welfare benefits** such that displaced workers are supported during the transition (D'Arcangelo, Levin, Pagani, Pisu, & Johansson, 2022).

III. While public training programs and employer subsidies can be effective in mitigating short-run skill shortages, in the longer run, **structural changes in the education system** are required to meet the growing demand for technical skills related to green jobs (D'Arcangelo, Levin, Pagani, Pisu, & Johansson, 2022). Policy action encouraging women to engage in STEM fields and entrepreneurship can address gender divides in the green labour market transition (Causa, Soldani, Nguyen, & Tanaka, 2024).

IV. Given the uneven geographical distribution of climate transition policies, **place-based policies** targeted at regions relying heavily on the fossil fuel industry or other high-polluting industries can prevent or offset geographically concentrated negative effects and can be particularly effective when combined with removing obstacles to geographic mobility (Botta, 2019). Successful examples of place-based policies can be found in Germany (Ruhr region), Canada, and the United Kingdom (D'Arcangelo, Levin, Pagani, Pisu, & Johansson, 2022; Causa, Soldani, Nguyen, & Tanaka, 2024)[7].

V. Generally, to support job creation and more effective labour market allocation, **product, labour market, and housing regulations** that promote a dynamic business and labour market and facilitate the efficiency of the reallocation process are essential (Causa, Soldani, Nguyen, & Tanaka, 2024).

Distributional effects via consumption ('use-side')

Climate policies often result in a change of relative prices with the price of certain goods and services related to the product's pollution content.[8] For example, a carbon tax or a fuel economy standard raises the relative price of using more energy-intensive transport. If households consume different baskets of goods, climate policies will have heterogeneous effects across households (Vona, 2021). For example, policies that affect the price of energy (e.g. a carbon tax) are regressive if the share of energy consumption decreases with income (Flues & van Dender, 2017).

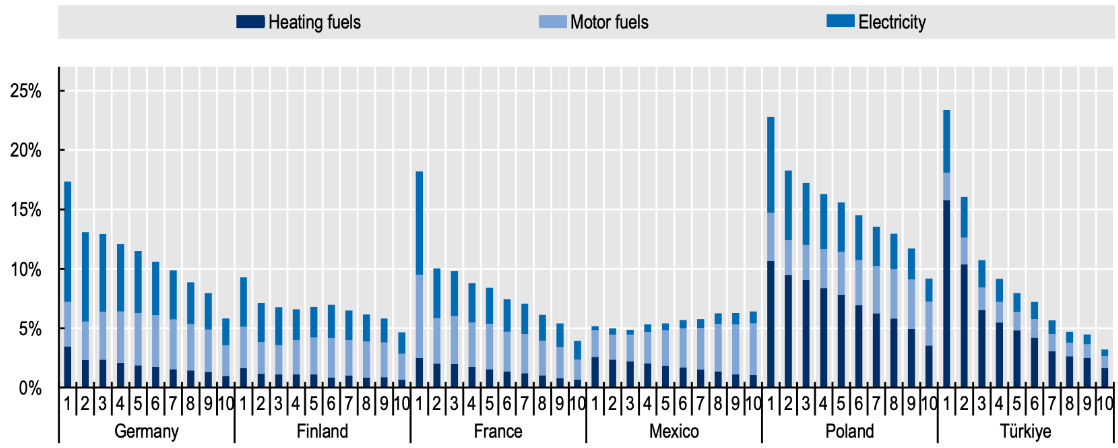
[7] See (Causa, Soldani, Nguyen, & Tanaka, 2024) for an overview of successful place-based policies from Canada, Germany, Scotland (UK), and Australia.

[8] Price changes do not only occur because of a good's pollution content. For example, land use climate policies, such as those affecting public transit development or environmental amenity improvements, can impact house prices and can therefore also have distributional impacts (Farrow, et al., 2022); (OECD, 2021).

Price-based policies

Carbon pricing is often recommended as it is environmentally effective and argued to be economically efficient. Additionally, it generates revenue for the government (Elgouacem, et al., 2024). Concerns about the potential regressivity of policies affecting the price of carbon and energy stem from the fact that food and some fuels may be a necessity for many households making poorer households unable to reduce their consumption in response to higher prices easily. Hence, such policies may disproportionally affect low-income households and potentially worsen existing inequality issues such as energy poverty (Vandyck, Della Valle, Temursho, & Weitzel, 2023) and food insecurity as well as aggravating ongoing concerns about rising living costs more generally (Elgouacem, et al., 2024). Evidence from six OECD countries reveals that most countries[9] show indeed a regressive consumption pattern in terms of heating fuels and electricity (see Figure 3).

Figure 3. Household expenditures on fuel and other energy, by income decile



Note: Groups 1-10 refer to income deciles. Domestic fuel includes expenditure on gas, liquified hydrocarbons, kerosene, and other liquid fuels, coal, and other solid fuels. Motor fuels includes expenditure on diesel and petrol for transportation
Source: (Elgouacem, et al., 2024), (Screenshot, Figure 5.5 in paper)

Empirical research that has examined the effect of carbon and energy taxation reveals that the progressivity of such a policy is heterogeneous across countries. Overall, effects are found to be regressive, ranging from small to more pronounced[10], in advanced economies (Flues & Thomas, 2015; Douenne, 2020; Hassett, Mathur, & Metcalf, 2009; Immervoll, O'Donoghue, Linden, & Sologon, 2023; Elgouacem, et al., 2024; Sterner, 2012; Wier, Birr-Pedersen, Jacobsen, & Klok, 2005), and mostly progressive in developing countries (Dorband, Jakob, Kalkuhl, & Steckel, 2019; Steckel, et al., 2021). These results give rise to a global inverse U-shaped relationship between energy expenditure shares and income. At very low-income levels, to the so-called energy deprivation line, the energy share in total consumption is very low. This is because, in poorer countries, households at the bottom of the income distribution are confronted with the risk of energy affordability and "energy poverty" (Flues & van Dender, 2017). The share then increases for low-to-middle-income levels, where energy becomes affordable, and

[9] Among the six countries studied (Germany, Finland, France, Mexico, Poland, Turkey), only Mexico shows a non-regressive consumption of energy.

[10] For example, (Elgouacem, et al., 2024) show that regressive effects are more pronounced in Poland and Turkey, where low-income households spend more than one-fifth of their incomes on energy.

finally decreases for high-income countries, as energy is a ‘necessity good’ for which consumption increases less than proportional to income (Vona, 2021; Dorband, Jakob, Kalkuhl, & Steckel, 2019). While in advanced economies, households are mostly concentrated in middle and high-income groups, making a tax regressive, households in developing countries mostly belong to low- or middle-income groups, making a tax progressive on average (Vona, 2021).

Many households in developing countries have relatively low fossil fuel energy consumption, and often limited access to stable energy sources. This is partly behind the finding of progressive distributional effects of carbon and energy taxation, i.e. the incidence of rising energy prices rises with income (Dorband, Jakob, Kalkuhl, & Steckel, 2019). Hence, an underlying challenge many developing countries face is a trade-off between energy affordability and limiting damages from climate change (Greenstone, 2024). An increase in the price of energy may significantly aggravate energy poverty (Vandyck, Della Valle, Temursho, & Weitzel, 2023) and ultimately hinder economic growth in developing countries (Greenstone, 2024).

The empirical evidence is more nuanced depending on the specific policy in question and the regressivity of the policy effects depends on the type of fuel targeted (Flues & Thomas, 2015). Cross-country evidence[11] shows that a tax on transport fuels is mostly neutral in countries with higher GDP per capita (Flues & Thomas, 2015; Sterner, 2012). It is progressive in countries with lower GDP per capita and in countries with moderate car ownership and well-developed public transport systems (Flues & Thomas, 2015; Missbach, Steckel, & Vogt-Schilb, 2024). Evidence from six OECD countries shows that spending shares for motor fuel are mostly ‘flat’ or increasing with income (Figure 3) (Elgouacem, et al., 2024).[12] This indicates that transport fuel is a normal good in most high-income countries (consumption rises in proportion to income resulting in a tax being neutral or proportional) and typically a luxury good in low- and middle-income countries (resulting in a tax being progressive) (Flues & Thomas, 2015; Sterner, 2012; OECD, 2021).

The impact of climate policies affecting the price of emissions does not only depend on the effect on direct fuels for heating and transportation (“direct effect”) but also on the effect on other goods that produce carbon emissions (“indirect effect”). Across six countries[13], research shows that between 45% and 71% of all CO_2 emissions that can be linked to household spending are related to goods other than direct use of fuels and transportation (in years preceding the COVID-19 pandemic). This emphasises the fact that distributional conclusions should go beyond households’ consumption of fuel and energy (see Figure 4) (Elgouacem, et al., 2024). Many empirical studies focus solely on the “direct effect” relating to households’ fuel expenditure and not on the consumption capacity of all other goods. Studies that do consider the indirect effect from higher prices of goods other than fuels suggest that the indirect effect is sizeable and mostly “flat” across the income distribution, dampening the potential regressivity of the direct effect (Immervoll, O’Donoghue, Linden, & Sologon, 2023; Ohlendorf, Jakob, Minx, Schröder, & Steckel, 2020).

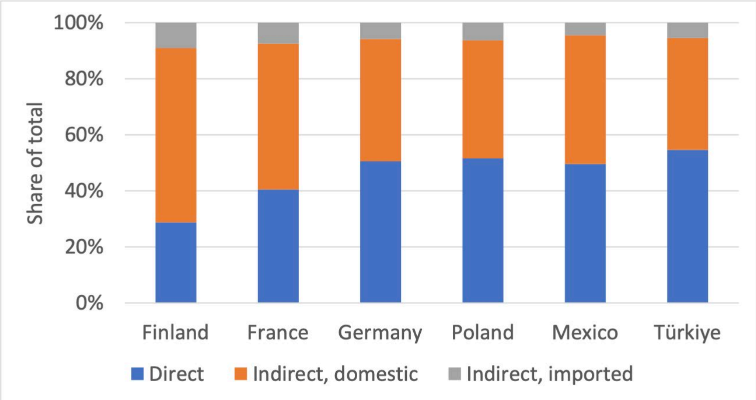
There is also some, albeit limited evidence of differential distributional effects between carbon pricing (i.e. pricing all emissions) and excise taxes on fuel consumption. Studies that do compare the different policies suggest that directly taxing fuel consumption (excise tax) is more regressive than pricing all goods through a carbon tax (Ohlendorf, Jakob, Minx, Schröder, & Steckel, 2020; Immervoll, O’Donoghue, Linden, & Sologon, 2023).

[11] (Flues & Thomas, 2015) study 21 OECD countries; (Sterner, 2012) studies seven European countries (France, Germany, United Kingdom, Italy, Serbia, Spain, and Sweden)

[12] (Elgouacem, et al., 2024) show that motor fuel shares increase with income in Mexico and Poland indicating that motor fuel can be a luxury good in some countries

[13] Finland, France, Germany, Mexico, Poland, Turkye

Figure 4. Emission from fuel ("direct") and non-fuel ("indirect") consumption by country



Note: "Direct" includes households' own consumption of fossil fuels (both domestically sourced and imported). "Indirect" accounts for emissions linked to all other domestically, and non-domestically sourced inputs and consumption goods. In percent of total consumption.
Source: (Elgouacem, et al., 2024) (Screenshot, Figure 5.6 in paper)

Importantly, distributional effects, for example across age groups or geography within a single income group are often greater than distributional effects across income groups themselves (Cronin, Fullerton, & Sexton, 2019; Douenne, 2020; Missbach, Steckel, & Vogt-Schilb, 2024; Steckel, et al., 2021). For example, most studies find that the incidence of a carbon tax is much more pronounced in rural areas. Some evidence even suggests that rural households are more vulnerable than low-income households in some countries, for example in the context of rising energy prices (Causa, Soldani, Luu, & Soriolo, 2022). This suggests that potential compensation efforts solely based on income alone may not be effective in alleviating adverse distributional effects.

Behavioural responses should be considered when analysing the distributional effects of climate change policies. The distributional effects hinge on the ability to adjust the consumption of carbon-intensive goods in response to a policy (Elgouacem, et al., 2024). For example, it may be the case that lower-income households have less flexibility to invest in energy-saving appliances due to budget and credit constraints. Similarly, households who live in rural areas may not be able to reduce their car usage due to a lack of access to public transport. At current carbon prices, there is no clear evidence of an income gradient of behavioural responses, however, this may change for larger increases in the future (Elgouacem, et al., 2024; Renner, Lay, & Greve, 2018).

Non-market-based policies and subsidies

Besides price-based mechanisms, demand-side and non-market-based policies play a crucial role in the climate-mitigation policy mix. In many countries, regulations such as fuel economy standards or subsidies for clean energy investments may be more popular than any form of environmental taxation as they can be easier to implement politically (Davis & Knittel, 2019; Levinson, 2019; OECD, 2023). However, the distributional effects of non-market-based policies and subsidies have been less researched than of price-based measures (OECD, 2021).

Non-market-based policies include bans, standards, or direct regulations. Literature focused on the US Corporate Average Fuel Economy (CAFE) standards for passenger cars and light trucks finds regressive effects (Davis & Knittel, 2019; Levinson, 2019). Similarly, evidence from building energy codes in California reports regressive effects (Bruegge, Deryugina, & Myers, 2019). Standards tend to disproportionately affect lower-income households as shifts to low-carbon options are less affordable for them. Higher-income households would also benefit more from any efficiency savings as they consume more in absolute terms (Torné & Trutnevyte, 2024). Bans on the demand side, e.g. on the use of cars or types of heating, have become common in European countries and promise relatively quick decarbonisation in sectors such as residential heating (Braungardt, Tezak, Rosenow, & Bürger, 2023). From a distributional perspective, they can result in equity issues through possibly unaffordable replacement costs for low-income households unless compensation or exception measures are combined with the ban (Elgouacem, et al., 2024) (Torné & Trutnevyte, 2024). Using data from Switzerland, (Torné & Trutnevyte, 2024) show that a compromise between mitigation potential and justice can be reached by combining bans on fossil fuel cars or boilers with exemptions for the lowest-income households.

Another group of demand-side policies are subsidies and feed-in tariffs which can be politically appealing (Elgouacem, et al., 2024). Popular subsidies are those applied to electric vehicles, home insulation, heat pumps, solar panels, or energy-efficient appliances. Limited evidence from implemented subsidies suggests that they are generally regressive. Subsidies that encourage investment in low-carbon technology tend to be taken up by high-income households and hence primarily benefit those at the top of the income distribution with the required capital to invest in the low-carbon solution (Borenstein & Davis, 2016; Levinson, 2019). Feed-in-tariffs for solar energy, as introduced for example in Germany, are regressive because the adoption of solar panels requires home ownership (Grösche & Schröder, 2013; Winter & Schlesewsky, 2019). However, conclusions vary across technologies. Regressive effects are found to be larger for subsidies for electric vehicles than for home insulation and solar panels (Borenstein & Davis, 2016; Elgouacem, et al., 2024) and there is little correlation between the adoption of heat pumps and household income (Davis L. W., 2023).

Alleviation measures for distributional effects via consumption

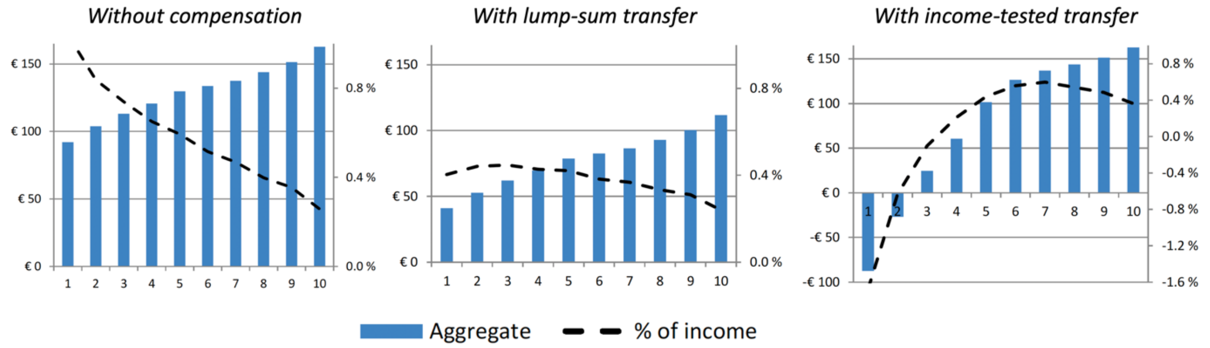
Policies can be designed in a way to mitigate the regressive consumption-side effects of climate policies. Price-based policies offer the advantage of generating revenue that can be used to alleviate negative effects. This can be essential to retain public acceptability for climate mitigation policies (see section 0). Support measures broadly fall into the following categories:

i. Revenue from price-based policies can be used as **income support** for affected households.[14] This can be in the form of uniform lump-sum transfers which are efficient as they do not distort behaviours and are relatively simple to administer. However, targeting every household irrespective of income or other variables reduces their ability to alleviate negative distributional consequences (D'Arcangelo, Levin, Pagani, Pisu, & Johansson, 2022). On the other hand, transfers can be targeted to more negatively affected households or to the most vulnerable households. Targeted transfers (along the income dimension) are often perceived as fairer; however, they are more difficult to administer (D'Arcangelo, Levin, Pagani, Pisu, & Johansson, 2022). (Flues & van Dender, 2017) simulate an energy tax reform in 20 countries comparing an uncompensated tax, a tax combined with lump-sum transfers, and a tax combined with income-tested transfers. Combining an energy tax with income-tested cash transfers can generate a progressive incidence which shows that poorer households can benefit from a tax reform if combined with appropriate transfer measures (Figure 5) (Flues & van Dender, 2017; Hoeller, Ziemann, Cournède, & Bétin, 2023; Mackie & Haščič, 2019). Nevertheless, both uniform lump-sum and means-tested transfers (if based only on income) can be ineffective in addressing distributional impacts within income groups as income is not the only indicator of vulnerability. This suggests that targeting should consider household effective needs and burdens; for example, low-income rural households may need to be compensated more (OECD, 2024).[15]

[14] See (Marten & van Dender, 2019) for an overview of revenue uses from different carbon pricing measures across 40 OECD and G20 economies.

[15] Much depends on the amount of government revenue that is recycled. An analysis based on four OECD countries (France, Germany, Mexico, Poland) shows that recycling all the government revenue from carbon pricing, even with uniform lump-sum transfers, implies that the share of households that would be better off (than without carbon pricing

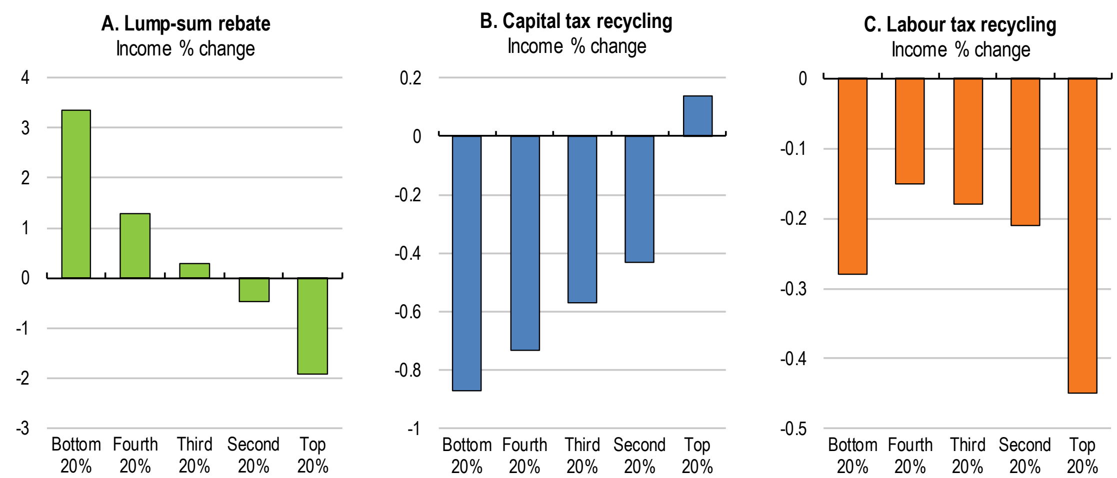
Figure 5. Country average tax difference per household from the simulated energy tax reform



Notes: Simulated tax reform (without demand response) in 20 OECD countries, average tax difference per household
Source: (Flues & van Dender, 2017)

ii. Revenue recycling schemes can also be administered through **tax cuts**. An example is cutting personal income taxes or corporate taxes which could be cost-effective and foster job creation, at least over a limited period of time. However, reducing corporate taxation is likely regressive and reducing personal income taxation likely has a U-shaped effect (hurting households at the top and bottom of the income distribution) (D'Arcangelo, Levin, Pagani, Pisu, & Johansson, 2022) (see Figure 6).

Figure 6. Distributional effects of a carbon tax under different uses of revenues



Note: The y-axis represents percentage change in income, omitting the environmental benefit of the carbon tax from reduced GHG and air pollution. Estimations are based on a general equilibrium model of the United States.
Source: (Williams, Gordon, Burtraw, Carbone, & Morgenstern, 2015) as cited in (D'Arcangelo, Levin, Pagani, Pisu, & Johansson, 2022)

iii. **Investment and social funds** that are targeted at those most negatively affected by transition policies can potentially dampen the regressivity of the policy, for example through infrastructure investments in public transportation or investment in "green" social housing (D'Arcangelo, Levin, Pagani, Pisu, & Johansson, 2022). Such measures can potentially even address horizontal distributional impacts.

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and recycling) would be larger than 50% in all studied countries, mostly concentrated in low-income households (Elgouacem, et al., 2024).

Challenges in implementing alleviation measures

While alleviation measures can mitigate undesirable effects of climate policies on inequality, they may prove challenging to implement in practice. Policies that target displaced workers or vulnerable households can be complex in countries with limited administrative capacity, high informality, underdeveloped social benefit systems, and hence fewer tools to identify and reach vulnerable households. Information barriers may further complicate the process if eligible individuals do not claim their social benefits. Similarly, unemployment support and active labour market programs are difficult to implement in countries where education and retraining systems are not well-developed.

Consequently, labour market programs, targeted income support policies and other alleviation measures would need to be accompanied by general improvements to administrative capacity and social welfare systems. This significantly raises the implementation barrier for many alleviation measures in emerging-market economies (Causa, Soldani, Luu, & Soriolo, 2022). Furthermore, in developing countries in particular, lower-income households face a significant risk of not being able to afford energy at all or are already suffering from “energy poverty” (Flues & van Dender, 2017). This suggests that investments in energy infrastructure could be prioritised. Generally, policies that fall in the category of investment and social funds may prove particularly attractive in emerging-market economies.

Political acceptability of climate transition pathways

A lack of acceptance continues to hinder effective policy measures that would be in line with the Paris Agreement. Hence, understanding and considering people’s perceptions and attitudes towards specific policies is essential. Evidence from a large-scale international survey across 20 countries, including 18 G20 economies, sheds some light on people’s attitudes towards different policies (Dechezleprêtre, et al., 2022). Besides the perceived effectiveness of a policy in terms of reducing emissions, the perceived distributional consequences of a policy are a major predictor of whether people support a given climate policy. Hence, the concern that a policy has regressive impacts can explain why it fails to gather public support. Additionally, the perceived impact on one’s household is important.

Generally, more educated individuals tend to show stronger climate policy support and higher household income is correlated with stronger support only in some countries[16]. The correlation between age and policy support is mixed across countries and no general pattern can be observed. The opposition to climate policies is correlated with “carbon dependency” resulting from, for example, a lack of access to public transport, significant car usage, or high gasoline expenditure (Dechezleprêtre, et al., 2022).

Some policy designs are perceived more positively. For example, targeted investment programs financed by progressive taxes and public debt, carbon taxes with progressive use of revenues, and regulations, such as bans on polluting vehicles from city centres, are perceived as both effective and progressive (OECD, 2023; Dechezleprêtre, et al., 2022).

As perceived impacts of policies may differ from actual ones, information provision also plays an important role. In an experiment, respondents are presented with a video showing either the negative impacts of climate change or an explanation of how policies work and what their distributional implications are. While the former did not significantly affect respondents' perception of policies, explaining the policies and their distributional effects significantly increased the support for the specific climate policy.

[16] A positive correlation between household income and support for climate mitigation policies is found in Brazil, India, Indonesia, Italy, Poland, and Ukraine.

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