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Climate action and social equity: Mitigation strategies and carbon credits

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Abstract

Carbon taxes are a critical tool in global efforts to reduce greenhouse gas emissions, but they often have regressive effects, disproportionately burdening low-income households. This study examines the economic impact of carbon taxes on different income groups, with a focus on the regressive nature of these policies. Low-income households, which typically spend a higher percentage of their income on energy and carbon-intensive goods, are more adversely affected by carbon taxes. This analysis explores potential mitigation strategies, such as rebates, targeted subsidies, and income-based tax adjustments, to offset these regressive effects. Additionally, the study investigates the role of carbon credits in income distribution, analyzing how the allocation and trading of credits can influence social equity. The research also considers the broader implications of carbon taxes and credits on income distribution, highlighting the need for policies that balance environmental objectives with social equity. By examining the intersection of carbon pricing mechanisms and income inequality, this study provides insights into how policymakers can design carbon taxes and credits that minimize regressive impacts while promoting fair and equitable climate action. The findings underscore the importance of integrating social equity considerations into carbon pricing strategies to ensure that climate policies contribute to sustainable and inclusive economic growth.

Keywords: Carbon taxes; Regressive effects; Mitigation strategies; Carbon credits; Income distribution; Social equity; Climate policy

1. Introduction

Carbon taxes are widely recognized as an effective economic instrument for reducing greenhouse gas emissions by internalizing the environmental costs of carbon pollution (Aldy & Stavins, 2022, Tian, et. al., 2022). By imposing a tax on carbon emissions, governments aim to incentivize businesses and individuals to reduce their carbon footprint and transition to cleaner energy sources. This approach aligns with the broader objective of mitigating climate change and promoting sustainable development (Goulder, 2021, Sun, et. al., 2022). Despite their environmental benefits, carbon taxes are often criticized for their regressive nature, disproportionately impacting low-income households who spend a higher proportion of their income on energy and carbon-intensive goods (Doğan, et. al., 2022, Metcalf, 2022).

The regressive nature of carbon taxes arises from the fact that low-income households, due to their relatively higher expenditure on energy and transportation, bear a greater financial burden relative to their income compared to higher-income households (Hassett & Mathur, 2021, Hsu, 2020). As a result, carbon taxes can exacerbate income inequality and disproportionately affect vulnerable populations. This concern has spurred interest in exploring mitigation strategies to alleviate the financial impact on low-income households and ensure that climate policies do not inadvertently worsen economic disparities (Borenstein & Davis, 2023, Cevik & Jalles, 2023).

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This study focuses on examining potential mitigation strategies to address the regressive effects of carbon taxes, with particular attention to rebates and targeted subsidies. Rebates and subsidies are commonly proposed solutions to offset the financial burden on low-income households, aiming to redistribute the tax revenue in a manner that supports those most affected (Caro, et. al., 2020, Hassett et al., 2023). Additionally, the study explores how carbon credits and taxes influence income distribution and social equity, analyzing their broader impacts on socioeconomic outcomes. By investigating these mitigation strategies and their effectiveness, the study aims to contribute to the development of equitable carbon pricing mechanisms that balance environmental objectives with social fairness (Goulder & Parry, 2023, Wang & He, 2022).

2. Understanding Carbon Taxes and Their Economic Impact

Carbon taxes are a market-based mechanism designed to reduce greenhouse gas emissions by assigning a cost to carbon pollution. The principle behind carbon taxes is to internalize the external costs associated with carbon emissions, which include environmental degradation and health impacts, thereby incentivizing reductions in emissions and fostering a transition to cleaner energy sources (Aldy & Stavins, 2022, Yan, Qamruzzaman & Kor, 2023). By pricing carbon emissions, carbon taxes aim to reflect the true cost of carbon pollution in the price of fossil fuels, which should theoretically lead to reduced consumption and investment in low-carbon technologies (Goulder & Parry, 2023, Lilliestam, Patt & Bersalli, 2021).

The economic impact of carbon taxes manifests in several ways, notably through changes in energy prices and the cost of goods and services. When a carbon tax is implemented, the price of carbon-intensive fuels, such as coal, oil, and natural gas, increases (Metcalf, 2022, Stevens & Carroll, 2020). This rise in energy prices often translates into higher costs for goods and services that rely heavily on these fuels for production and transportation. Consequently, consumers experience increased prices for a range of products, from gasoline to food and household goods (Hassett & Mathur, 2021, Sek, 2017). These changes can affect different income groups differently, with low-income households facing a disproportionate burden due to their higher relative expenditure on energy and essential goods.

Low-income households typically spend a larger share of their income on energy compared to higher-income households, making them more vulnerable to the regressive impacts of carbon taxes (Chaney, 2021, Hassett & Mathur, 2021). For instance, families with low incomes may spend a large percentage of their income on transportation and heating, two areas where carbon pricing has a direct influence. These households experience increasing living expenses without corresponding gains in income as energy prices rise, which can worsen economic inequality (Andersson & Atkinson, 2020, Borenstein & Davis, 2023). Additionally, the increased costs of goods and services due to higher energy prices can further strain household budgets, leading to potential reductions in consumption and quality of life.

Conversely, higher-income households, who typically spend a smaller percentage of their income on energy, are less affected by the increased prices. They also have greater financial flexibility to invest in energy-efficient technologies and alternative energy sources, which can mitigate their exposure to carbon taxes (Chen, et. al., 2022, Goulder, 2021, Peersman & Wauters, 2024). This discrepancy in the impact of carbon taxes across income groups highlights the regressive nature of such policies, which can inadvertently widen income inequality if not accompanied by appropriate mitigation measures. The Evolution of CO_2 emissions for the countries included in the sample in the period 1750–2020 by Firtescu, et. al., 2023, is shown in Figure 1.

There have been several mitigating techniques put forth and put into practice to counteract these regressive implications. Utilizing targeted subsidies and rebates to offset the higher expenses for low-income households is one popular strategy. Rebates can be set up to provide households with a percentage of the money raised by the carbon tax, which lessens their financial burden and preserves equality overall (Cronin, Fullerton & Sexton, 2019, Hänsel, et. al., 2022, Hassett et al., 2023). Similarly, targeted subsidies can be used to reduce the costs of energy-efficient technologies and essential services for low-income families, promoting access to cleaner energy options and reducing their exposure to higher energy prices.

Another effective strategy is to implement progressive tax designs, where the revenue generated from carbon taxes is reinvested in ways that benefit lower-income households. For instance, using carbon tax revenue to fund public transportation improvements, energy efficiency programs, and social safety nets can help offset the higher costs incurred by low-income individuals (Brown, et. al., 2019, Brown, et. al., 2020, Frondel & Schubert, 2021). These measures not only mitigate the adverse effects of carbon taxes but also contribute to broader social and economic benefits, including improved public health and enhanced energy security.

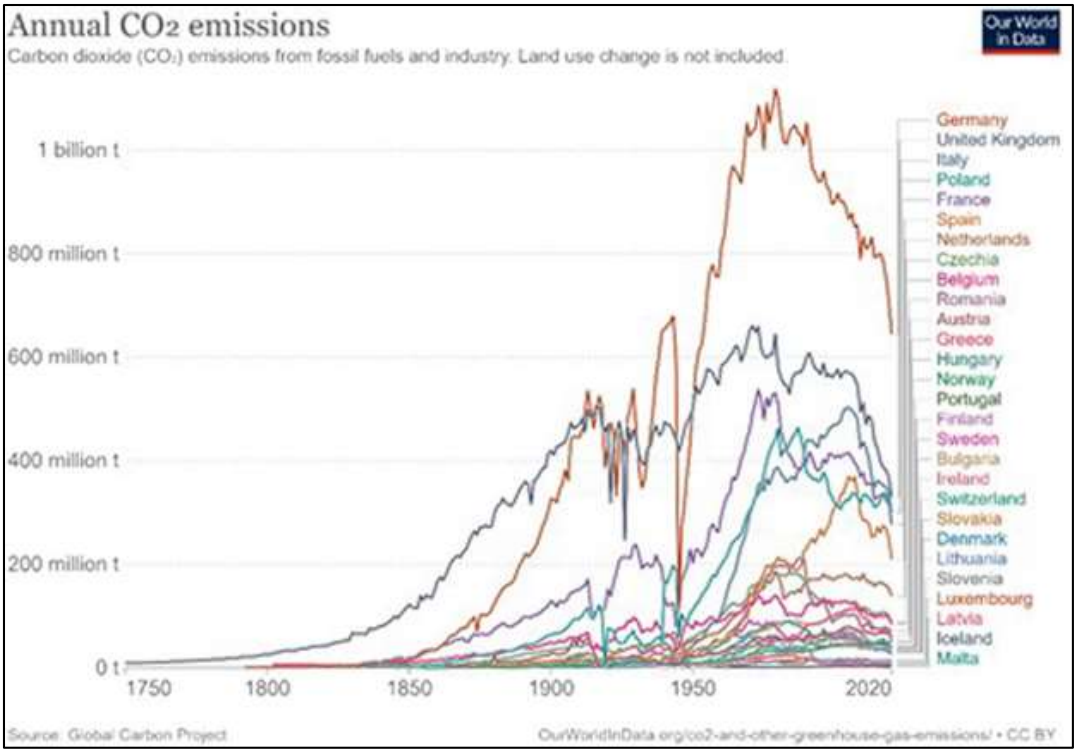

Figure 1 Evolution of CO_2 emissions for the countries included in the sample in the period 1750–2020 (Firtescu, et. al., 2023)

In conclusion, carbon taxes are an essential instrument for lowering greenhouse gas emissions and promoting the shift to a low-carbon economy, but their effects on the economy vary greatly depending on the income level. Because carbon prices are regressive, effective mitigation methods must be put in place to prevent low-income households from being disproportionately impacted. Policymakers may contribute to a more equitable and sustainable transition to a low-carbon future by balancing the environmental benefits of carbon pricing with social fairness through the integration of rebates, subsidies, and progressive tax schemes. (Goulder & Parry, 2023; Borenstein & Davis, 2023).

3. Regressive Effects of Carbon Taxes on Low-Income Households

Carbon taxes are designed to reduce greenhouse gas emissions by levying a charge on the carbon content of fuels, thereby incentivizing lower carbon consumption and promoting cleaner energy alternatives (Paltsev et al., 2021, Parry, Black & Zhunussova, 2022, Ramseur & Leggett, 2019). However, the regressive nature of carbon taxes, where the burden disproportionately falls on low-income households, has been a critical concern. This effect arises because low-income households tend to allocate a larger share of their income to energy expenditures, such as heating and transportation, compared to higher-income households (Haites, 2018, Klenert et al., 2021). Figure 2 shows a Typical Institutional Design of Environmental Taxation by Tan, et. al., 2022.

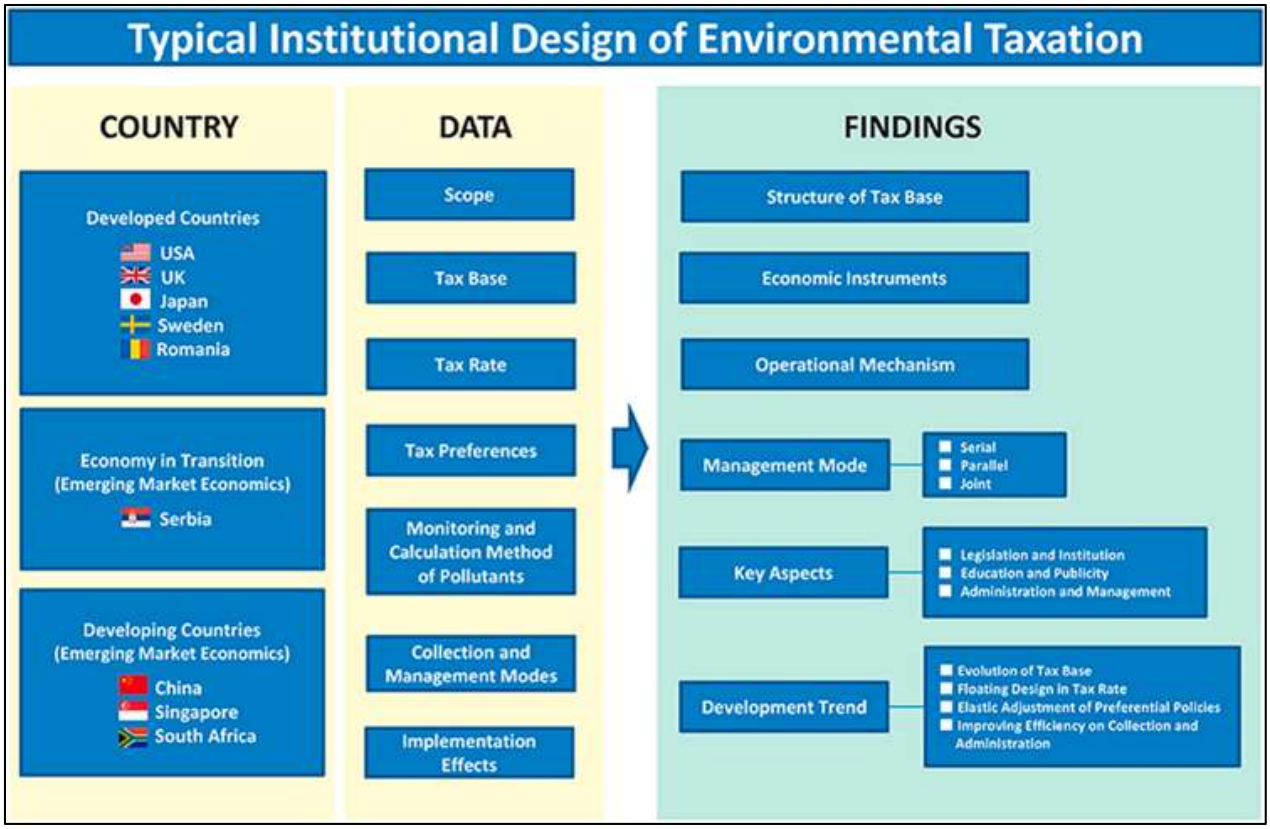

Figure 2 Typical Institutional Design of Environmental Taxation (Tan, et. al., 2022)

Generally speaking, low-income households spend a larger portion of their income on energy demands. For example, these households frequently use energy-intensive forms of transportation and live in older, less energy-efficient dwellings, which makes them more vulnerable to increases in energy prices brought on by carbon taxes (Caron et al., 2022, Kontokosta, Reina & Bonczak, 2020, Memmott, et. al., 2021). According to research, households in the lowest income quintile spend about 11% of their income on energy, while those in the highest quintile spend less than 2% (Klenert et al., 2021, Schleich, 2019, Willand & Horne, 2018). This disproportionate expenditure makes low-income households more sensitive to fluctuations in energy costs, including those induced by carbon taxes.

The impact of carbon taxes on living costs is particularly pronounced in energy-dependent sectors. For example, as carbon taxes increase the cost of fossil fuels, prices for heating, transportation, and goods transported using fossil fuels also rise. These increased costs are not easily offset for low-income households, who already face budget constraints and are less able to absorb additional expenses (Burtraw & Woerman, 2023, Eisner, 2023, Zhang, et. al., 2024). Consequently, the burden of carbon taxes can lead to a higher cost of living and reduced disposable income, compounding financial pressures on these households.

Empirical studies highlight the regressive impacts of carbon taxes through various case studies. For instance, research on the implementation of carbon taxes in regions like British Columbia and California reveals that low-income households experience a more significant financial burden compared to higher-income groups (Harris & Reiner, 2022, Köppl & Schratzenstaller, 2023). In British Columbia, while the carbon tax contributed to a reduction in emissions, it also led to higher energy prices that disproportionately affected lower-income households, who spent a larger portion of their income on energy compared to wealthier residents (Ghazouani, et. al., 2020, Murray et al., 2021). Similarly, in California, studies indicate that low-income households face a substantial economic burden from the state's cap-and-trade program, which, although designed to be revenue-neutral, results in higher costs of living for those with fewer resources (Ohlendorf, et. al., 2021, Rausch & Metcalf, 2022).

Numerous mitigating techniques have been put forth and put into practice to mitigate these regressive consequences. Introducing tailored rebates and subsidies is a popular strategy used to lessen the financial burden on low-income households. For instance, the money collected from carbon taxes can be used to directly reimburse low-income families, offsetting a portion of the higher expenses (Aldy, 2023, Hanna & Olken, 2018, Moran, et. al., 2019). Targeted subsidies can also support investments in energy-efficient technologies, such as improved home insulation and low-emission

vehicles, which can help reduce overall energy expenses for low-income households (Burtraw & Woerman, 2023, Sassi, et. al., 2018).

Moreover, the design of carbon tax policies can include measures to address their regressive nature, such as progressive revenue recycling mechanisms where funds are redistributed to support low-income communities (Bourgeois, Giraudet & Quirion, 2021, Klenert et al., 2021, Muth, 2024). Low-income households can also be less affected by policies that invest in public transit and other necessary services since they offer alternatives that are less dependent on energy sources that emit large amounts of carbon dioxide. In conclusion, carbon taxes present serious obstacles due to their regressive effect on low-income households, even if they are an effective instrument for lowering greenhouse gas emissions and advancing environmental sustainability. The larger percentage of income allocated to energy costs and rising living expenses, especially in energy-intensive industries, are the causes of the unequal burden (Malerba, Gaentzsch & Ward, 2021, Semet, 2024). Addressing these challenges through targeted rebates, subsidies, and progressive policy designs is crucial to ensuring that carbon pricing mechanisms contribute to both environmental goals and social equity.

4. Potential Mitigation Strategies

Carbon taxes are an effective tool for reducing greenhouse gas emissions by imposing a financial cost on carbon emissions. However, these taxes can disproportionately affect low-income households, given their higher percentage of income spent on energy. Mitigation strategies are essential to address the regressive nature of carbon taxes and ensure that low-income households are not unduly burdened (Rivers & Wigle, 2018, Xu & Wei, 2022). Three key mitigation strategies include rebates and cash transfers, targeted subsidies, and social welfare adjustments.

Rebates and cash transfers are direct financial mechanisms used to counterbalance the impact of carbon taxes on low-income households. These measures aim to return some of the revenue generated from carbon taxes to households, particularly those with lower incomes, to offset the increased cost of energy (Hassett & Metcalf, 2022, Nong, Simshauser & Nguyen, 2021). Rebates can be structured in various ways, including lump-sum payments or income-based rebates. Lump-sum payments provide a fixed amount of money to all eligible households, which can help simplify administration and ensure immediate relief (Klenert et al., 2021, Parry, Black & Zhunussova, 2022). Income-based rebates, on the other hand, are tailored to the income level of the household, providing higher amounts of support to those with lower incomes (Aldy, 2023, Koval, et. al., 2022). This model can be more equitable by targeting assistance to those who need it most but requires careful calibration to avoid administrative complexities and ensure adequate support for all eligible households (Metcalf & Stock, 2023, Villoria-Sáez, et al., 2016).

Targeted subsidies for energy efficiency improvements represent another critical strategy for mitigating the regressive impacts of carbon taxes. These subsidies are designed to support investments in energy-saving measures such as home insulation, efficient appliances, and renewable energy installations (Baker et al., 2022, Wei, Ayub & Dagar, 2022). By reducing the overall energy burden, targeted subsidies can alleviate the financial pressure on low-income households. For instance, subsidies that cover a significant portion of the cost of upgrading home insulation or installing energy-efficient appliances can lower energy bills and improve living conditions (Burtraw & Woerman, 2023, Jia, Lin & Liu, 2023, Li, Wang & Wang, 2022). This approach not only reduces immediate energy costs but also contributes to long-term savings and enhanced energy security.

Integrating carbon tax revenues into social welfare programs is another approach to offset the regressive effects of carbon taxes. This strategy involves using funds generated from carbon taxes to bolster social welfare programs that support low-income households, such as income support, food assistance, and housing subsidies (Aldy, 2023, Bertoldi, 2022, Kiss & Popovics, 2021). By funneling revenue into these programs, policymakers can help mitigate the impact of increased energy costs on vulnerable populations. The effectiveness of this approach depends on how well the additional funding is used to enhance the adequacy and accessibility of social welfare services (Hassett & Metcalf, 2022). Evaluations of such programs suggest that well-designed revenue recycling mechanisms can help maintain social equity while advancing environmental objectives (Klenert et al., 2021).

There are benefits and drawbacks to each of these mitigating strategies. Even if they provide temporary support, financial transfers and rebates might not be sufficient to achieve long-term energy efficiency goals. Targeted subsidies require an initial financial commitment and strong program management to reduce long-term expenditures and boost energy efficiency. Social welfare reforms can provide comprehensive assistance, but this depends on how funds are distributed and how well the welfare systems that are now in place function. Combining these strategies can offer a reasonable means of reducing the regressive consequences of carbon pricing. For instance, combining income-based refunds with targeted subsidies for energy efficiency renovations can provide both immediate financial comfort and

long-term benefits (Baker et al., 2022, Daidone, et. al., 2019). Similarly, incorporating carbon tax revenues into social welfare programs can ensure broader support while addressing the specific needs of low-income households (Burtraw & Woerman, 2023, Houde & Aldy, 2017). In conclusion, addressing the regressive effects of carbon taxes on low-income households requires a multifaceted approach. Rebates and cash transfers, targeted subsidies for energy efficiency, and social welfare adjustments each play a vital role in mitigating the financial impact on vulnerable populations. Effective implementation of these strategies can help ensure that carbon pricing mechanisms contribute to both environmental and social equity goals.

5. Analysis of Carbon Credits and Taxes on Income Distribution and Social Equity

By placing a price on carbon emissions, carbon pricing mechanisms such as carbon taxes and credits are essential tools for lowering greenhouse gas emissions. These systems may have a big impact on social justice and wealth distribution. Carbon credits enable organizations to offset emissions by funding initiatives aimed at reducing carbon emissions, whereas carbon taxes impose penalties directly on carbon emissions. Evaluating the effects of these instruments on various socioeconomic classes, especially concerning social justice, is crucial for creating efficient climate policies.

Carbon credits are a component of cap-and-trade systems, where businesses or governments set a cap on total emissions and distribute or auction carbon credits representing the right to emit a certain amount of carbon dioxide. Entities that reduce their emissions below their allocated credits can sell their excess credits to others who need them (Berkouwer & Dean, 2022, Tietenberg & Lewis, 2022). This market-based approach incentivizes emissions reductions and enables more flexible and cost-effective compliance with emissions targets. However, the market dynamics of carbon credits can create disparities in how different income groups are affected by carbon pricing.

Higher-income individuals and corporations often have better access to carbon credit markets, allowing them to participate in or benefit from trading and offsetting programs. This access can enable higher-income groups to mitigate their carbon footprint more effectively, often at a lower cost compared to lower-income households (Hofmann, 2021, Klenert et al., 2021, Okonkwo, 2021). For example, large corporations and affluent individuals can invest in high-quality carbon offset projects, which might not be feasible for lower-income groups due to financial constraints. This disparity can exacerbate income inequality, as those with more resources can more easily navigate and benefit from carbon credit markets, while low-income individuals may face greater financial burdens without similar opportunities for mitigation (Aldy, 2023, Üblackner, 2023). The poverty, emission, and inequality effect of international tax revenue recycling by Feng, et. al. 2023, is shown in Table 1.

Table 1 The poverty, emission, and inequality effect of international tax revenue recycling (Feng, et. al. 2023)

	(T5) Luxury consumption tax + (S4) Social assistance expansion as during COVID-19				**(T5) Luxury consumption tax + (S5) Proxy Means Test (PMT)**		
	Extreme poverty (million)	**CO_2 (MT)**	**Local Gini**	**International Gini**	**Extreme poverty (million)**	**CO_2 (MT)**	**Local Gini**
G1) Historical emissions & poverty headcount	-238	22	-5.81%	-0.79%	-336	11	-8.50%
(G2) Historical emissions & population	-176	29	-6.04%	-0.53%	-214	19	-7.62%
(G3) Historical emissions & poverty gap	-210	42	-5.54%	-0.77%	-336	31	-8.07%
(G4) Current emissions & poverty headcount	-238	22	-5.81%	-0.79%	-336	10	-8.50%

(G5) Current emissions & population	-176	29	-6.04%	-0.53%	-214	18	-7.62%
(G6) Current emissions & poverty gap	-210	41	-5.54%	-0.78%	-336	30	-8.07%
G1) Historical emissions & poverty headcount	-238	22	-5.81%	-0.79%	-336	11	-8.50%

On the other hand, carbon taxes impose a direct financial burden on carbon emissions, which can disproportionately affect low-income households due to their higher relative expenditure on energy (Fragkos, et. al., 2021, Hassett & Metcalf, 2022). As the cost of carbon is passed through to consumers in the form of higher energy prices, low-income households, who spend a larger portion of their income on energy, are more heavily impacted. This regressive effect can contribute to greater income inequality unless targeted interventions are implemented.

Government policies play a crucial role in addressing these equity concerns. To mitigate the regressive impacts of carbon taxes, several strategies can be employed. For instance, revenue generated from carbon taxes can be redistributed to support low-income households through direct rebates or cash transfers (Metcalf & Stock, 2023, Timilsina, 2022). These measures can offset the increased energy costs for vulnerable populations and help maintain social equity. Additionally, targeted subsidies for energy efficiency improvements can reduce long-term energy costs for low-income households, further mitigating the impact of carbon pricing (Burtraw & Woerman, 2023, Fragkos, et. al., 2021).

Moreover, integrating carbon pricing revenues into broader social welfare programs can enhance the overall effectiveness of climate policies in promoting social equity. By using funds from carbon pricing to bolster social safety nets, governments can address the broader economic impacts on low-income groups while advancing environmental goals (Aldy, 2023, Timilsina, 2022). This approach can ensure that carbon pricing mechanisms contribute to both reducing emissions and promoting social fairness.

However, achieving these goals requires careful design and implementation of policies. Effective carbon pricing policies must be complemented by comprehensive support measures to ensure that they do not disproportionately disadvantage low-income households. Policymakers need to ensure that carbon pricing mechanisms are part of a broader strategy that includes measures for income redistribution and support for those most affected by energy price increases (Klenert et al., 2021, Vona, 2023, Zhang & Wang, 2017).

In conclusion, even if carbon taxes and credits are crucial instruments for combating climate change, care must be taken to minimize their effects on social justice and wealth inequality. While carbon taxes might place a heavier burden on low-income households, carbon credits can help higher-income groups with access to markets. Governments must apply focused mitigating measures, such as refunds, subsidies, and social welfare modifications, to guarantee social justice. By taking these steps, we can lessen the regressive effects of carbon pricing and encourage a more equitable distribution of the financial consequences of climate policy.

6. Comparative Analysis of Mitigation Strategies

Rising awareness of carbon taxes as a vital weapon in the fight against climate change has led to their imposition, which puts a price on carbon and reduces greenhouse gas emissions. However, there are worries about these taxes being regressive because low-income people may be disproportionately affected by them. To allay these worries, several mitigating measures have been put forth, such as refunds, subsidies, and modifications to social assistance initiatives. It is necessary to use a comparative approach when analyzing the efficacy of these measures, taking into account how they are implemented in various places and assessing the best techniques for reducing regressive implications.

Direct financial interventions like cash transfers and rebates are meant to counteract the regressive effects of carbon pricing. A percentage of the money raised by the carbon tax is usually returned to households, especially those with lower incomes, as part of these procedures. Several rebate models, such as income-based and lump-sum payouts, have

been suggested. Income-based rebates modify the amount based on household income, whereas lump-sum rebates give a fixed amount to all homes, regardless of income (Huang, et. al, 2024, Metcalf & Stock, 2023).

Research indicates that lump-sum rebates can effectively mitigate the regressive effects of carbon taxes but may not fully address the disparities between high- and low-income households (Bourgeois, Giraudet & Quirion, 2021, Hassett & Metcalf, 2022). Income-based rebates, on the other hand, target assistance more precisely to those most affected, potentially offering a more equitable solution. Studies from Canada, where a carbon tax rebate system is in place, suggest that income-based rebates have successfully reduced the overall financial burden on low-income households while maintaining the environmental efficacy of the carbon tax (Murray & Rivers, 2022, Ravigné & Nadaud, 2023). The net effects of carbon taxation, differentiated by car ownership and car usage by Eisenmann, et. al., 2020 are shown in Figure 3.

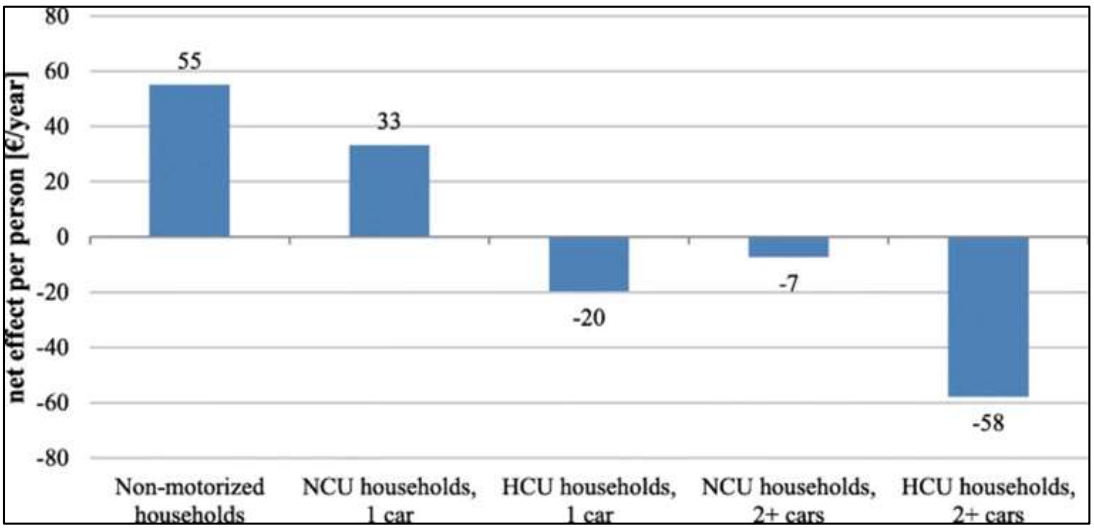

Figure 3 Net effects of carbon taxation, differentiated by car ownership and car usage (Eisenmann, et. al., 2020)

Another tactic to lessen the financial strain on low-income households is targeted subsidies for energy efficiency upgrades. Energy-saving appliances, insulation for homes, and other energy-saving measures can all be paid for using these incentives. Targeted subsidies can assist in offsetting the increased immediate costs associated with carbon taxes by reducing long-term energy prices (Agupugo, 2023, Burtraw & Woerman, 2023). Case studies from the United Kingdom and Germany illustrate the effectiveness of targeted subsidies in reducing energy poverty and promoting equitable outcomes. In the UK, the Energy Company Obligation (ECO) program provides subsidies for energy efficiency improvements in low-income households, demonstrating a significant reduction in energy costs and improved living conditions (Department for Business, Energy & Industrial Strategy, 2021). Similarly, Germany's "Energieeffizienzprogramm" has supported energy efficiency upgrades across various income groups, contributing to a more equitable distribution of the financial impacts of carbon pricing (Agupugo, et. al., 2022, Wagner et al., 2021).

Integrating carbon tax revenues into social welfare programs is a broader approach that involves using funds from carbon taxes to enhance social safety nets. This strategy can support low-income households through increased benefits or expanded social services, thus mitigating the regressive impacts of carbon taxes (Aldy, 2023, Geroe, 2019). Analysis of this approach in Sweden and Australia highlights its potential to address income inequality effectively. In Sweden, carbon tax revenues are used to support social welfare programs, including housing and energy assistance for low-income households. This integration has been associated with a reduction in the regressive effects of carbon taxes and improved social equity (Agupugo, Kehinde & Manuel, 2024, Bollen et al., 2022). Similarly, Australia's approach to using carbon tax revenues for social welfare adjustments has shown promise in balancing the environmental and social impacts of carbon pricing (Fujimori, Hasegawa & Oshiro, 2020, Gillingham & Stock, 2023).

Comparative analysis of these mitigation strategies reveals several best practices for minimizing the regressive impacts of carbon taxes. Effective strategies often involve a combination of approaches tailored to regional and national contexts. For instance, integrating rebates or cash transfers with targeted subsidies can provide immediate relief while promoting long-term energy efficiency (Burtraw & Woerman, 2023, Heine & Black, 2019). Additionally, linking carbon tax revenues to social welfare programs can enhance the overall effectiveness of climate policies in promoting social equity (Aldy, 2023, Green, 2021). It is also essential to consider regional and national variations in the design and implementation of

these strategies. For example, while income-based rebates may be highly effective in some countries, others might benefit more from targeted subsidies or social welfare adjustments. Policymakers must evaluate local economic conditions, energy consumption patterns, and existing social safety nets to develop the most effective mitigation strategies (Green, J2021, Klenert et al., 2021).

In conclusion, a multimodal strategy that incorporates refunds, targeted subsidies, and social welfare modifications is needed to mitigate the regressive effects of carbon taxes. A comparative examination of these tactics, bolstered by case examples from different areas, emphasizes the significance of customized solutions and the fusion of several methods to guarantee fair results. Policymakers can more effectively address the issues raised by carbon pricing and advance social and environmental sustainability by implementing best practices and learning from successful implementations.

7. Policy Recommendations

It is a difficult undertaking needing careful policy advice to design carbon tax systems that address the regressive effects on low-income households while enabling effective climate action. To lessen the negative impact of carbon prices on marginalized groups, authorities need to put in place measures that safeguard these households while simultaneously ensuring that the larger economic and environmental objectives are fulfilled.

The creation of fair carbon price regimes should be the top priority for legislators. First, direct financial support mechanisms for low-income households should be incorporated into the design of carbon tax schemes. The application of targeted rebates or cash transfers is one efficient strategy. Income-based refunds can be designed to ensure that lower-income groups receive appropriate help concerning their financial burden by mitigating the disproportionate impact on them (Johnson, et. al., 2023, Metcalf & Stock, 2023). Studies have shown that income-based rebates can significantly mitigate the regressive nature of carbon taxes, making them a crucial element of equitable policy design (Ascher, 2023, Hassett & Metcalf, 2022).

Additionally, integrating carbon tax revenues into targeted subsidies for energy efficiency improvements can further alleviate the financial burden on low-income households. Subsidies for home insulation, energy-efficient appliances, and other measures can reduce long-term energy costs and improve living conditions (Burtraw & Woerman, 2023, Egger, et. al.,2022). Such targeted interventions not only address immediate cost increases but also contribute to overall energy savings and efficiency. Policymakers should also consider the potential benefits of incorporating carbon tax revenues into broader social welfare programs. This approach can help ensure that the revenues generated from carbon taxes are used to enhance social safety nets, such as increasing benefits for low-income households or funding programs that address energy poverty (Aldy, 2023, Zhao, Datta & Soman, 2023). Integrating carbon pricing with social welfare policies can provide a more comprehensive safety net and address the regressive impacts more effectively.

Developing equitable carbon pricing systems requires a strong emphasis on transparency, public awareness, and stakeholder participation. Policymakers must provide transparency in both the development and execution of carbon taxes, facilitating unambiguous communication regarding the allocation of funds and the potential impact on various groups. Campaigns to raise public awareness can help increase support for policies involving carbon pricing and make sure that families are aware of the advantages and resources available to them (Jakob, et al., 2016, Klenert et al., 2021). Engaging stakeholders, including community organizations, industry representatives, and low-income advocacy groups, is essential for creating policies that are both fair and effective. Stakeholder input can provide valuable insights into the real-world impacts of carbon taxes and help identify areas where additional support or adjustments may be needed (Murray & Rivers, 2022, Karapinar, et. al., 2019, Zhao, Wang & Cai, 2022). Inclusive policy development processes can enhance the legitimacy and effectiveness of carbon pricing measures, ensuring that they address the needs of all affected groups.

Going forward, maintaining long-term justice and efficacy will require combining carbon prices with more comprehensive economic and social policies. To better match carbon pricing with more general environmental and equity aims, policy design should take a holistic approach. For instance, tying carbon pricing to investments in green technology and infrastructure for renewable energy sources can open up new business opportunities and support a fair transition for all income levels (Bollen et al., 2022, Khan & Johansson, 2022). Moreover, integrating carbon taxes with regional and national economic development plans can ensure that carbon pricing policies contribute to broader economic growth and social equity objectives. Policymakers should consider how carbon pricing interacts with other economic policies, such as labor market regulations, education and training programs, and regional development initiatives. A coordinated approach can enhance the overall impact of carbon pricing and ensure that it supports sustainable development goals while protecting vulnerable populations (Gillingham & Stock, 2023, Liu, et. al., 2021).

Finally, ongoing evaluation and adaptation of carbon pricing policies are essential to address emerging challenges and ensure continued effectiveness. Policymakers should regularly review the impacts of carbon taxes on different income groups and adjust policies as needed to address any unintended consequences. Long-term monitoring and evaluation can provide valuable insights into the effectiveness of mitigation strategies and inform future policy decisions (Aldy, 2023, Karapinar, et. al., 2019).

8. Conclusion

The examination of carbon taxes reveals their significant regressive impact, particularly on low-income households. Carbon taxes, intended to reduce greenhouse gas emissions by increasing the cost of carbon-intensive activities, disproportionately burden low-income families. This is primarily because these households allocate a larger proportion of their income to energy expenses and necessities compared to higher-income groups. Consequently, the increased costs associated with carbon taxes can strain their financial resources, exacerbating existing economic disparities.

Mitigation strategies are crucial to counteract these regressive effects. Rebates and cash transfers can effectively offset the financial burden on low-income households by providing direct financial relief. Income-based rebates, for example, can be tailored to ensure that those most affected receive adequate compensation. Similarly, targeted subsidies for energy-efficient improvements, such as home insulation and efficient appliances, can reduce the overall energy burden and contribute to long-term savings for these households. Social welfare adjustments, incorporating carbon tax revenues into welfare programs, also offer a pathway to maintain social equity and support vulnerable populations.

Policy plays a vital role in balancing the environmental benefits of carbon taxes with the need for social equity. Effective policy frameworks must integrate transparency, public awareness, and stakeholder engagement to ensure that the transition to a low-carbon economy does not disproportionately disadvantage low-income groups. Policymakers should design carbon tax systems that are equitable and include mechanisms to protect those most affected by the increased costs. By implementing inclusive and equitable policies, the negative economic impacts on different income groups can be mitigated, ensuring that environmental goals are achieved without undermining social fairness. In conclusion, addressing the regressive nature of carbon taxes requires a concerted effort to develop and implement strategies that protect low-income households while advancing environmental objectives. Policymakers must prioritize the creation of fair and inclusive frameworks that consider the economic realities of all income groups, ensuring that the benefits of carbon pricing contribute to sustainable and equitable economic growth.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

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