Potential of supporting developing countries by using carbon tax revenue

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Introduction

Achieving the temperature goals of the Paris Agreement requires substantial reductions in global emissions. In many integrated assessment models' global scenarios, a uniform global carbon price is widely assumed as a cost-effective policy instrument, yet equity-oriented climate finance is rarely assessed within these frameworks. This study quantitatively evaluated the potential of carbon tax revenues as a source of international climate finance through transfers from developed to developing countries under mitigation pathways consistent with the 1.5°C target. We found that such revenues would average approximately USD 1.2 trillion annually between 2030 and 2050. Without additional financial support, cumulative macroeconomic losses in developing countries would reach 7.5% by 2050, exceeding those in developed regions. In contrast, transferring 100% of carbon tax revenues from developed countries would reduce these losses to 2.8%, yielding near parity in consumption loss rates between developed and developing regions. Such transfers would also lower the number of people living in extreme poverty in 2050 by 44 million (9.9% of the poverty headcount). These results underscore the significant potential of carbon tax revenues to advance equity and alleviate economic and social burdens in developing countries while sustaining cost-effective global mitigation pathways.

Introduction

The Paris Agreement aims to limit global warming to 1.5°C[1], requiring 73–98% reduction in greenhouse gas emissions by 2050 relative to 2019 levels[2]. This transition necessitates a structural shift toward renewables, driven by carbon pricing[3–6]. By internalizing the cost of emissions, it provides a strong economic incentive to reduce emissions and promote technological innovation by increasing the costs of carbon-intensive activities and commodities[7,8].

Carbon pricing, together with the additional investments required to achieve substantial emissions reductions, imposes an economic burden on developing regions[9,10] and may exacerbate inequality, particularly among low income populations[11–15]. Without redistribution, mitigation pathways consistent with the 1.5°C target could increase global poverty by 50 million by 2050[11]. Most Integrated Assessment Models (IAMs) prioritize cost-optimal pathways[2] but often overlook these distributional impacts, highlighting a tension between climate efficiency and social equity.

One way to address these issues is financial support from developed to developing nations[16]. Although the target was raised from USD 100 billion in COP15 to USD 300 billion annually in COP29[17], this remains insufficient. Estimates suggest that developing countries may require over USD 600 billion annually by 2030[18]. Some equity-based calculation calls for transfers ranging from USD 0.5 to 7.4 trillion[19].

Carbon taxes are a promising mechanism for increasing financial resources and their international distribution has the potential to reduce disparities in global infrastructure [20]. Fujimori et al. (2020)[12] reported that 20% of the carbon tax revenue collected by developed countries would be enough to close the global poverty gap in 2030 under the 2°C pathway with a uniform global carbon price. Soergel et al. (2021)[11] found that combining domestic redistribution of carbon price revenues with international transfers could achieve both significant poverty reduction in Sub-Saharan Africa and the 1.5°C target. However, the potential of such revenues remains underexplored, with few IAM studies quantifying their use as financial assistance.

In this study, we extend the existing literature by not only examining household-level outcomes such as poverty reduction, but also quantifying the broader macroeconomic implications at the regional level. Specifically, we assess the impacts on aggregate indicators, such as consumption losses, thereby providing a more comprehensive evaluation of the economic consequences of using carbon pricing revenues as international transfers. This dual perspective allows us to capture both distributional and economy-wide effects, which have not been jointly analyzed in previous IAM-based studies.

First, we examined the potential impact on macroeconomic indicators for carbon tax revenues from developed regions as financial transfer to developing regions, using computable general equilibrium model (CGE). Then, we estimated income distribution using the output from the upstream model.

Methods

Overview

We employed the computable general equilibrium model AIM-Hub[21]. To capture the distributional impacts on household income and consumption, we linked the AIM-Hub outputs with the model AIM-Poverty, Household, and Income Distribution (AIM-PHI)[12], which estimates household-level poverty and changes in expenditures. As the climate change mitigation scenario, we used an emissions pathway consistent with limiting the global mean temperature increase to 1.5°C[22].

The analysis covered 2005–2050, with uniform global carbon prices imposed from 2030 onward. In the default setting, carbon tax revenues are redistributed to domestic households. In some aid scenarios, part or all of the revenues from developed countries are transferred to households in developing countries. Socioeconomic conditions are based on the Shared Socioeconomic Pathway 'middle-of-the-road' scenario (SSP2) [23,24].

Model

The AIM-Hub model is a 1-year-step, recursive, dynamic general equilibrium model with global coverage, including 17 regions and 58 sectors[21]. The model is calibrated to social accounting matrices from the Global Trade Analysis Project (GTAP)[25] and energy balance tables from the International Energy Agency (IEA)[26,27]. The results for energy supply and consumption generally align with IEA World Energy Balances through 2022[28].

AIM-PHI estimates income distribution, poverty incidence, and household consumption, using socioeconomic assumptions and policy impacts on household expenditure and commodity prices derived from an upstream model, AIM-Hub. It features a nonlinear demand system based on a lognormal distribution of disposable income [12,13,29], which captures national average household consumption and aligns with the Gini projections of the corresponding SSPs[30] across 184 regions.

Scenario framework

The overall framework of the model is illustrated in Fig. 1. To evaluate the impacts of carbon tax revenue transfers on macroeconomic and poverty conditions, we utilized an IAM framework starting with a non-climate policy (NCP) baseline for reference. Mitigation scenarios were then implemented beginning in 2030, employing a uniform global carbon price to limit cumulative CO_2 emissions to 400 Gt, consistent with the 1.5°C target[31].

Regarding financial transfers from developed to developing countries, we designed six mitigation scenarios: no transfers (0%), and transfers of 20%, 40%, 60%, 80%, and 100% of the carbon tax revenues collected in developed regions (1.5C–XX%). The amounts of finance were endogenously determined by the model and are shown in Fig. 2. The maximum annual transfer was approximately USD 2 trillion in 2040, equivalent to about 3–4% of the GDP of all developed countries. The annual average was about USD 231.8 billion for the 1.5C–20% scenario and USD 468.9 billion for the 1.5C–40% scenario, values comparable to the USD 300 billion target adopted at COP29.

In the 1.5C–XX% scenarios, XX% of the carbon tax revenues in developed countries was transferred directly to households in developing countries as additional income, thereby increasing household consumption. The remainder of the tax revenue stayed in the developed country and was also redistributed to households, which represented the model's default setting. The total financial support was distributed across developing regions in proportion to each region's share of GDP. All revenue was assumed to be from carbon taxes; emissions trading systems were not considered. Tax revenues were calculated by multiplying GHG emissions from all sectors, including households, industry, and transportation, by carbon price.

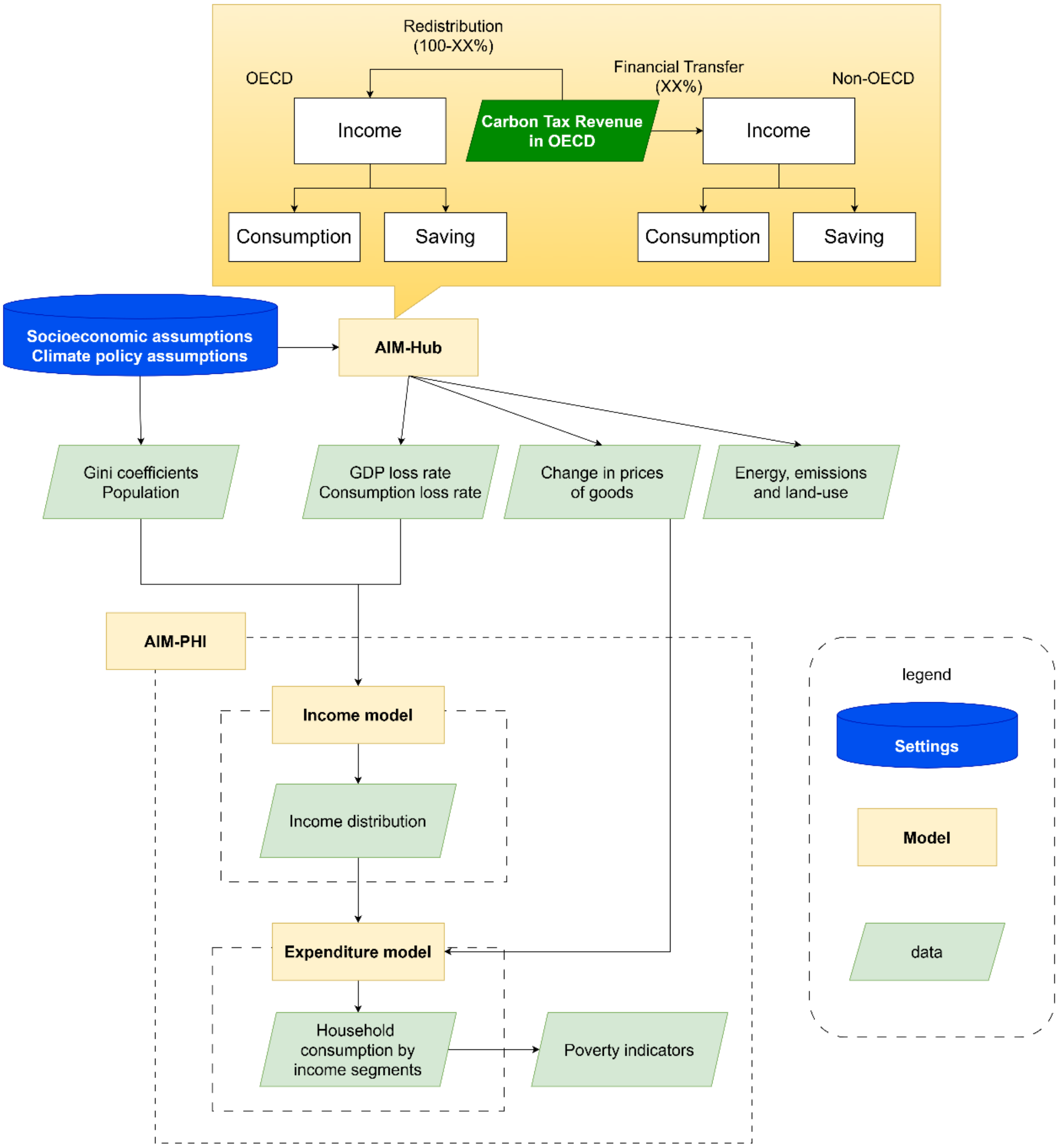

Fig. 1 Modelling framework. In the 1.5C–XX% scenarios, XX% of the carbon tax revenues are transferred directly to households as additional income. The rest of the tax revenue stayed in the developed country, and was also distributed to households.

Results

GHG emissions and carbon prices

Fig. 3a illustrates the greenhouse gas emission trajectories, with mitigation efforts commencing in 2030 across all policy scenarios. Within these pathways, increased financial transfers from developed to developing nations resulted in a slight rise in emissions in the latter, likely driven by boosted household consumption from the provided aid. To remain within the established global carbon budget, emissions in developed regions declined accordingly. Carbon prices were slightly lower in the 100% transfer scenario (1.5C–100%) compared to the no-transfer scenario (Fig. 3b).

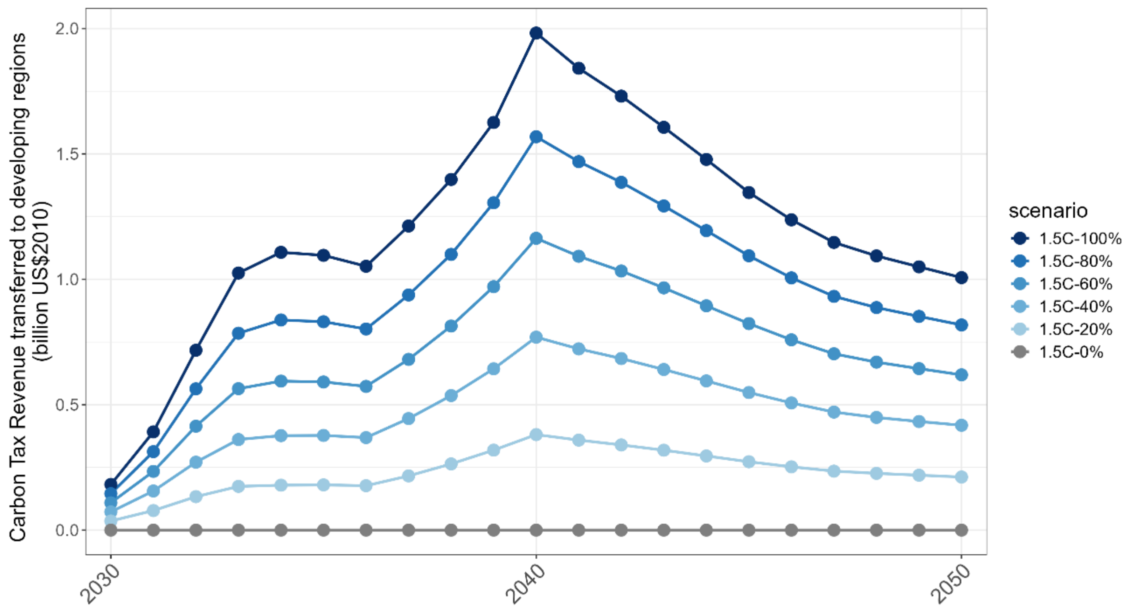

Fig. 2 Annual transfers to developing regions by scenario.

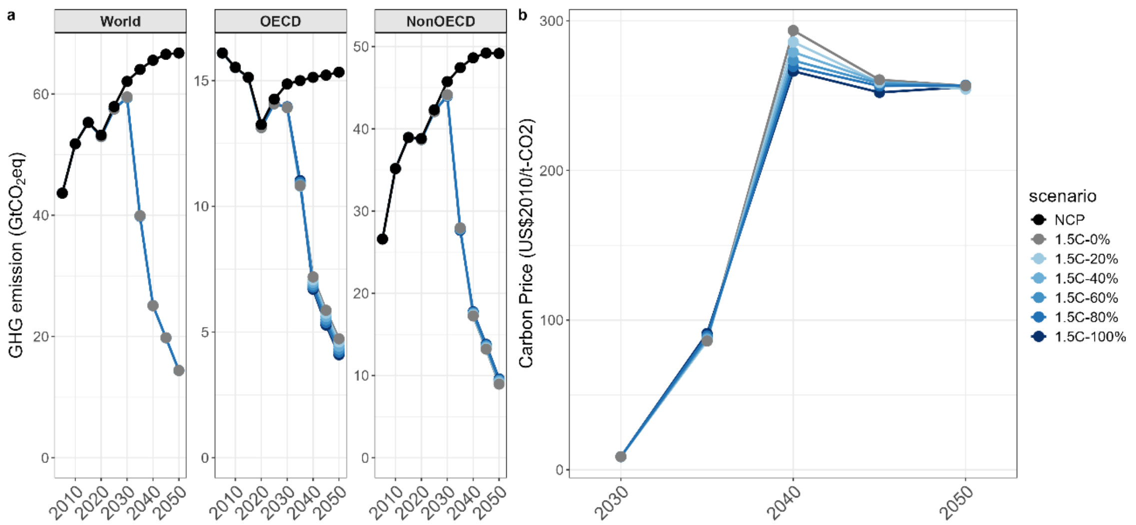

Fig. 3 GHG emissions and carbon price by scenario. (a) GHG emissions from 2005 to 2050. (b) Time series of the global uniform carbon price from 2030 to 2050.

Economic and energy implications

Fig. 4a illustrates how financial transfers shift the regional share of cumulative consumption losses from 2030 to 2050. Without transfers, developing regions—particularly in Asia—bear 79% of the global burden. However, as financial assistance increases, the burden rebalances; in the 1.5C–100% scenario, developed regions' share of the loss rises to approximately 53%. Relative to the NCP baseline, consumption loss rates in developed regions increase linearly with higher transfers, while rates in developing regions decline (Fig. 4b). The loss rates for both regions intersect when transfers reach approximately 96% of developed countries' carbon tax revenues. Projections indicate that fully offsetting macroeconomic losses in developing regions would require transfers equivalent to roughly 160% of developed regions' carbon tax revenues, or USD 1.9 trillion annually. Such an arrangement, however, would result in a cumulative consumption loss exceeding 4% for developed nations (Fig. 4b).

Regarding the overall energy supply and demand in 2050 (Fig. 5), no significant differences were observed among scenarios including climate change mitigation measures. In developed countries, energy use shifted from direct fossil fuel combustion to electricity, reflecting efforts to reduce emissions.

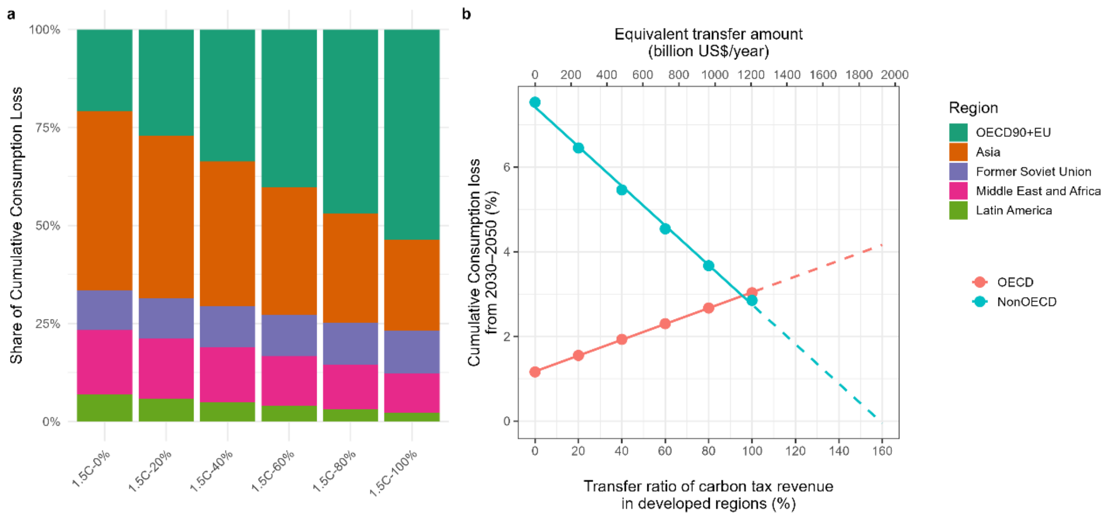

Fig. 4 Share of macroeconomic loss due to the transfer of carbon tax revenues to developing countries between 2030 and 2050. (a) Share of cumulative loss from 2030 to 2050. (b) Relation between transfer ratio and cumulative loss rate. The discount rate was 5%.

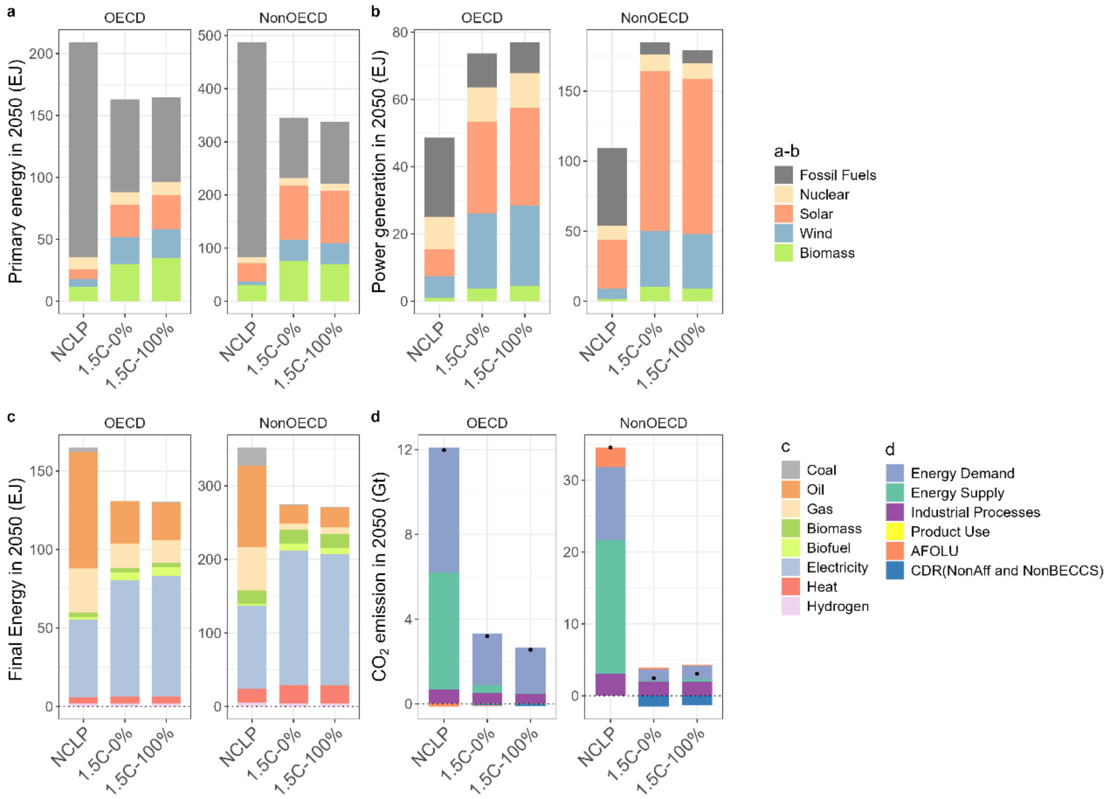

Fig. 5 (a) Primary energy supply in 2050. (b) Share of electricity generation in 2050. (c) Structure of final energy demand in 2050. (d) Emissions source by sector in 2050.

Poverty implications

Projections indicate that the global population living in poverty will decline through 2050, though climate change mitigation measures tend to slow this progress (Fig. 6a). In the no-transfer scenario, the economic pressures of carbon pricing—including rising prices and falling income levels—result in an additional 180 million people falling into poverty compared to the NCP baseline. However, implementing financial transfers effectively counteracts these impacts. Under the 1.5C–40% and 1.5C–60% scenarios, the number of people in poverty decreases by approximately 20–30 million, while the 1.5C–100% scenario achieves a reduction of over 40 million (Fig. 6b). This improvement is primarily driven by the boost in household income provided by the transfers, with price fluctuations playing only a minor role. While larger transfers consistently yield better outcomes for poverty alleviation, their overall impact remains modest when measured against the levels achieved in the NCP scenario.

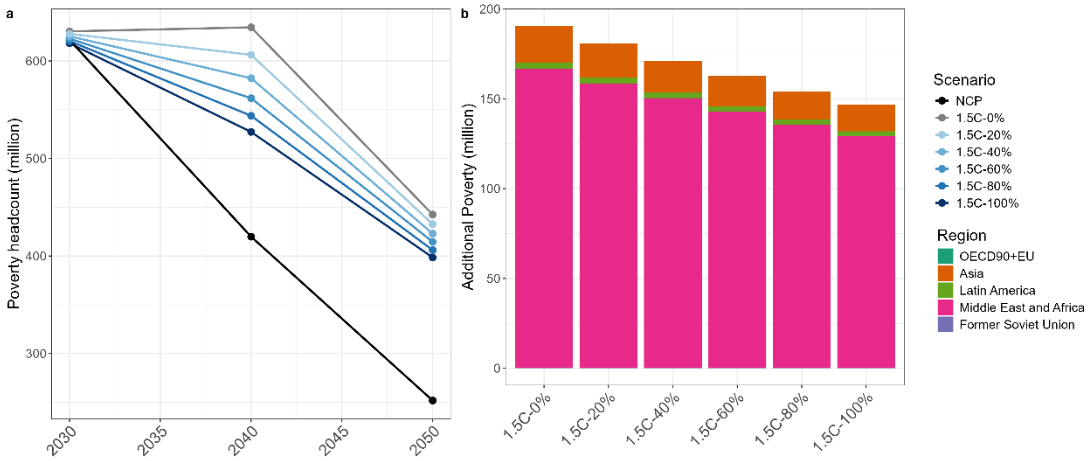

Fig. 6 Impact of financial transfers on global poverty. (a) Projected poverty population by scenario, using a poverty line of USD 2.15 per person per day. (b) Additional poverty due to climate change mitigation compared to the non-climate policy scenario.

Discussion

We found that carbon tax revenues in developed countries are projected to average approximately USD 1.2 trillion annually between 2030 and 2050. Redirecting a portion of these revenues to developing countries could substantially mitigate adverse economic impacts, reducing cumulative consumption losses from 7.5% to 2.8% and thereby helping to balance the global economic burden. However, fully offsetting these losses would require transfers of about USD 1.9 trillion per year.

In terms of poverty, such transfers could lower the number of people living in poverty by up to 44 million, although poverty levels would remain above those in the NCP scenario. The results indicate a near-linear relationship between financial transfers and both economic and poverty outcomes, while the energy system remains largely unchanged, as transfers were assumed to increase household consumption rather than energy investments. Future research should therefore incorporate frameworks that explicitly evaluate the role of carbon revenues in financing energy transitions.

In practice, carbon pricing revenues already serve diverse roles within countries, such as reducing income or corporate taxes or financing renewable energy investments [32,33]. This raises questions about the feasibility of scenarios in which revenues are redirected as aid. Accordingly, our study should be interpreted as a thought experiment illustrating the potential of carbon tax revenues. However, the assumption that carbon tax revenues could be used to support developing countries aligns with the broader principle of redistributive tax policy: reallocating resources from wealthier to poorer populations in a cost effective manner, with the aim of fostering a more equitable world.

This study has several limitations. First, the allocation of financial transfers across developing countries is based on their GDP shares, which does not adequately capture equity-related factors such as vulnerability or mitigation needs. This represents an area for potential improvement. However, as the analysis adopts a macro-level perspective that distinguishes only between developed and developing regions, differences within developing country allocation methods do not substantially affect the overall results. Second, carbon tax revenues were modeled as distributionally neutral in AIM-PHI; incorporating progressive redistribution could yield greater benefits for low-income populations, especially in regions with high poverty levels[11,14,15].

Despite these limitations, the results contribute to discussions on international equity. Future research could develop integrated frameworks that combine international financial transfers with domestic redistribution schemes, such as equal per capita transfers. This would enable joint assessment of macroeconomic impacts, measured by consumption or income losses, and micro level distributional outcomes, including domestic inequality. Applying such frameworks across multiple integrated assessment models would also be essential to ensure the robustness of results.

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