Impacts of developed countries' degrowth and capital redistribution on international economic convergence under climate change mitigation policies

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Abstract

Degrowth is proposed to reduce energy and resource throughput while improving quality of life, offering an alternative to technology-heavy climate mitigation. However, developing countries still require economic growth. Redistributing surplus capital from developed to developing countries could accelerate economic convergence, but it raises concerns about hindering the 1.5°C target due to developing regions' higher emission intensities.

This study evaluates how redistributing surplus capital, resulting from a transition to a zero-growth trajectory in developed countries, affects the difficulty of climate mitigation. We simulated a zero-growth scenario incorporating international capital redistribution under a 1.5°C constraint using the Asia-Pacific Integrated Modeling-Hub (AIM-Hub), a global-scale recursive dynamic CGE model.

Our results demonstrate that international capital redistribution does not significantly compromise global mitigation. In the capital redistribution scenario under the 1.5°C target, the global average annual change rates for energy intensity and renewable energy expansion, along with cumulative carbon dioxide removal (CDR) utilization, were -2.1%, 9.1%, and 980 GtCO2, respectively. These are comparable to the standard economic growth scenario (-2.2%, 8.8%, and 1000 GtCO2). Furthermore, GDP per capita in developing regions increased significantly, leading to a substantial reduction in international economic inequality.

Capital redistribution enables international economic convergence while remaining compatible with stringent climate goals. Future research should address limitations regarding technological progress dynamics and domestic wealth redistribution.

1. Introduction

The limits of continuous economic growth have increasingly become a focal point of global concern. Meadows et al. (1972)[1] highlighted the consequences of exponential growth in human population and economic activity, concluding that if such trends persisted, the planet would eventually reach a breaking point, leading to a sudden and uncontrollable decline in both population and industrial capacity. In recent years, the debate over the limits of continuous economic growth has been extensively revisited in the literature[2–5].

Empirical evidence consistently demonstrates that economic growth is a primary driver of climate change. The Intergovernmental Panel on Climate Change (IPCC) Sixth Assessment Report (AR6) Working Group III report[6] utilized the Kaya identity to decompose the factors driving carbon dioxide (CO_2) emissions from fossil fuel combustion into population, GDP per capita, energy intensity, and carbon intensity. The report concluded with robust evidence and high agreement that the increase in population and GDP per capita has been the most powerful driver of the global rise in fossil fuel-related CO2 emissions. While technological advancements have improved energy and carbon intensities, these gains have been outpaced by the sheer scale of economic growth, resulting in a continuous upward trend in global emissions.

In response to growing concerns over the feasibility of conventional climate mitigation, degrowth has emerged as a potential alternative pathway. Degrowth facilitates emission reductions by deprioritizing continued GDP growth in favor of a fundamental transformation. Within the context of climate policy, it is often defined as a process of political and social transformation that reduces a society's energy and resource throughput while improving the quality of life[3]. Compared to technology-driven pathways, degrowth has the potential to reduce reliance on large-scale Carbon Dioxide Removal (CDR) technologies and rapid renewable energy transitions, thereby lowering sustainability and socio-technical feasibility risks[7].

Within the literature on degrowth, there has been limited discussion from the perspective of developing countries. While previous studies suggest that further economic growth in developed countries does not necessarily contribute to human well-being, continued growth remains essential for social development in many developing countries[8]. However, the Shared Socioeconomic Pathways (SSPs) frequently used in climate policy analysis often depict futures where several developing countries fail to converge to the income levels of developed regions[9]. Previous degrowth research emphasizes an equitable downscaling of both production and consumption to reduce energy and material throughput. In model studies, reductions in production capacity have been modelled through decreases in labor productivity, labor input, and capital input[10]. However, no study has explored the reallocation of the surplus production capacity to the Global South to accelerate its economic growth.

From a climate mitigation perspective, this reallocation raises significant concern. As noted in the IPCC AR6 WG3 report[6], developing countries often exhibit higher emission intensities than developed economies due to less efficient technologies and a more carbon-intensive fuel mix. Consequently, transferring production capacity through the redistribution of surplus capital from developed regions could potentially hinder the achievement of stringent climate targets. However, this risk has yet to be quantitatively verified in existing literature.

The objective of this study is to analyze how transition to a zero-growth trajectory in developed countries, a likely outcome of transitioning to a degrowth society, and the subsequent redistribution of surplus capital to developing countries affect the difficulty of climate change mitigation. To achieve this, we simulate a zero-growth scenario incorporating international capital redistribution using the Asia-Pacific Integrated Modeling-Hub (AIM-Hub), a global-scale recursive dynamic CGE model.

2. Methods

2.1. Overview

In this study, we design scenarios that reflect a transition to a zero growth economy in developed countries under the 1.5°C target, accompanied by the transfer of funds equivalent to their surplus capital to developing regions. These scenarios incorporate assumptions regarding greenhouse gas (GHG) emission constraints and future socioeconomic conditions. The formulated scenarios are then inputted into the AIM-Hub[11] model, a global-scale recursive dynamic Computable General Equilibrium (CGE) model. We analyze the macroeconomic impacts, such as GDP and labor inputs, along with the effects on the energy system and CDR installation across 17 global regions. The simulation period spans from the base year 2005 to 2100.

It is important to note that our model analysis has certain limitations in fully representing a comprehensive degrowth transition. Specifically, it cannot fully capture the assurance of human well-being through quantitative indicators, nor does an exogenous cessation of economic growth fully reflect complex structural transformations. Therefore, following the classification by Edwards et al. (2025)[10], we adopt the broader term, post-growth, which encompasses zero growth and steady-state economics. Despite these methodological simplifications, this approach remains a crucial step for exploring the environmental and supply-side impacts of a post-growth future.

2.2. AIM-Hub model

The AIM-Hub model used in this study is a recursive dynamic CGE model developed by Fujimori et al. (2017)[11]. The model is formulated as a mixed complementarity problem (MCP), with 2005 as the base year, computing equilibrium solutions in perfectly competitive markets in one-year time steps. A key feature of the model is its detailed representation of the agriculture, land, and energy supply sectors, encompassing 58 industrial sectors. To account for economic scale and development stages, the global economy is aggregated into 17 regions: USA, EU-25, Rest of Europe, Japan, China, India, Southeast Asia, Rest of Asia, Oceania, Former Soviet Union, Turkey, Canada, Brazil, Rest of Latin America, Middle East, North Africa, and Rest of Africa.

To enable a comprehensive analysis of the energy system, energy supply technologies are highly disaggregated, with technologies such as wind and solar power treated as independent sectors. The GHG emissions tracked include energy-related CO_2, as well as CO_2, CH_4, and N_2O from other sources. Under climate policy scenarios, the model endogenously determines a uniform carbon price to meet the specified emission constraints. This elevated carbon price incentivizes measures such as the downscaling of carbon-intensive industrial activities and structural shifts in the energy mix. The Autonomous Energy Efficiency Improvement (AEEI), dynamically adjusts based on the GDP growth rates projected in the SSPs[12,13]. In this study, the considered Carbon Dioxide Removal (CDR) technologies include afforestation, bioenergy with carbon capture and storage (BECCS), direct air carbon capture and storage (DACCS), enhanced weathering, soil carbon sequestration, and biochar.

Regarding investment and capital formation, the saving-investment balance in the AIM-Hub model is investment-driven; investment demand is determined exogenously, and savings are determined endogenously to clear the market. Total investment is assumed to grow proportionally with SSPs' GDP, and the sectoral share of investment goods is fixed at the base year level. Capital stock is maintained by sector, with the previous year's investment treated as the capital supply for the following year. The sectoral allocation of supplied capital is governed by capital rental prices, and once deployed, capital becomes sector-specific. A 4% annual capital depreciation rate is assumed. As elaborated in Section 2.3, this study conducts analyses by exogenously varying the total investment across different scenarios.

International trade is modeled using the Armington assumption, which posits imperfect substitutability between domestic and imported goods. To satisfy both the current account and saving-investment balances, foreign savings are fixed, allowing the real exchange rate to adjust endogenously.

2.3. Scenario assumptions

The scenarios are defined across two dimensions: emission constraints and post-growth policies. We adopt SSP2 from the SSPs as the baseline for socioeconomic assumptions. Parameters related to production efficiency, such as AEEI and Total Factor Productivity (TFP), are calibrated based on SSP2.

Regarding emission constraints, we established two cases: the 400C case, which aligns with the 1.5°C target carbon budget, and the NCP (No Climate Policy) case, serving as a baseline. In the 400C case, a uniform global carbon price is introduced from 2031 onwards. Regarding post-growth policies, three pathways were prepared: EG (Economic Growth), following standard SSP-based economic expansion; PG (Post-Growth), assuming zero economic growth in developed regions; and PGcapR (Post-Growth + Capital Redistribution), assuming zero growth combined with global capital redistribution.

In the PG setting, all regions continue to grow until they reach the projected 2031 GDP per capita of OECD countries (excluding Turkey). Until this threshold is reached, regional GDP is computed endogenously; once reached, GDP is determined exogenously to maintain a constant GDP per capita. For investment, an assumption is introduced wherein investment demand exogenously decreases after post-growth economy transition until it balances with capital depreciation. Labor input, initially provided exogenously to grow at the same rate as the population, becomes endogenously adjusted post-transition to the exact amount required to achieve the stabilized GDP target. For developed countries projected to surpass the threshold before 2031, their GDP per capita from 2031 onwards is fixed at their respective 2031 levels.

In the PGcapR setting, a capital redistribution mechanism is integrated into the PG assumptions. Regions that initiate growth suppression transfer funds equivalent to their surplus production capacity to non-OECD countries (plus Turkey). The transfer amount from a donor region is calculated as the difference between its investment demand in the EG scenario and the PG scenario. These funds are allocated among recipient countries in proportion to the reciprocal of their per capita GDP. Non-OECD regions (plus Turkey) that reach the income threshold and initiate zero growth transition into donor regions the following year. To prevent abrupt macroeconomic fluctuations and ensure computational stability, the allocation ratio is gradually phased out for recipient regions once their per capita GDP exceeds 38,000 US$. Furthermore, the total contribution amount from donor regions is programmed to decrease as the number of eligible recipient regions shrinks.

3. Results

3.1. Economic impact

Transfer funds generated by degrowth in developed countries increased annually. In the absence of emission constraints (NCP), an average of 9.0 trillion US$2010 (2031–2100) was transferred to regions below the threshold; under emission constraints (400C), this amount was 8.2 trillion US$2010 (Fig. 1a). In both cases, the changes in the financial support trajectory are explained by two factors: the addition of new donor regions as they reach the income threshold, and the built-in mechanism that reduces contributions as the number of recipient regions decreases.

This scale of financial aid significantly accelerated economic growth in developing countries. Most developing regions reached the developed country standard of 48,000 US$2010 (Fig. 1b). However, due to the lower baseline per capita GDP assumptions in SSP2, the Rest of Africa region did not reach the threshold. Even in developing regions projected to reach the threshold without aid, financial support accelerated the timing of reaching the threshold. Without financial support, zero growth in developed countries yielded no positive economic spillover to developing countries.

Furthermore, in regions transitioning to zero-growth, stabilizing GDP per capita under constrained investment levels exogenously results in a decrease in labor input per labor capita. This holds true even when accounting for massive capital outflows, such as in the 400C_PGcapR scenario (Fig. 1c). Because TFP improvements are assumed to be consistent across all scenarios regardless of GDP change from the endogenous simulation, achieving the targeted, stabilized per capita GDP requires less labor input over time.

3.2. Emissions

In the absence of emission constraints, there was no significant difference in global cumulative emissions between the continuous economic growth scenario (NCP_EG) and zero-growth scenarios (NCP_PG and NCP_PGcapR) (Fig. 2a). The cumulative emissions (2020–2100) for NCP_EG, NCP_PG and NCP_PGcapR were 4200 Gt, 4300 Gt, and 4300 Gt respectively. In the scenarios with zero-growth assumption, the trend in emissions begins to change from the year in which developing countries start to transition zero growth economy, and by around 2080, annual CO_2 emissions fall below those of the standard economic growth scenario. Regionally, zero growth reduced CO_2 emissions in developed countries. However, reduced energy demand in developed countries lowered global energy prices (Fig. 2b), stimulating energy consumption in developing countries which leads to the increase of CO_2 emissions.

3.3. Effect on mitigation feasibility

This study evaluates the technological difficulty of climate mitigation pathways by analyzing mid-term (2030-2050) indicators, the average annual change rate of final energy demand per MER based GDP (energy intensity) and of the expansion of renewable energy, and a long-term (2030-2100) indicator of cumulative CDR utilization (Table. 1).

In the 400C_DegFS scenario, the world faces an acceleration in mid-term renewable energy expansion and a reduction in long-term cumulative CDR compared to the 400C_DEF. This shift is driven by the economic expansion of developing countries, which increases their mitigation difficulty and necessitates compensatory emissions reductions by developed countries to achieve global climate targets. Within developed regions, the potential for enhanced weathering is largely exhausted in the long term, while DACCS remains economically unviable during the mid-term period. Consequently, developed countries rely on renewable energies to bridge the mitigation gap. This increased reliance on renewables serves as the primary driver for both the accelerated mid-term renewable growth and the long-term reduction in other CDR dependencies.

In contrast, the 400C_Deg scenario exhibits a decrease in the mid-term renewable energy expansion rate. This results from a global decline in economic activity and energy demand, as zero growth in developed countries provides no economic stimulus to developing regions. Furthermore, the improvement rate of energy intensity slows in this scenario. This indicates that the emissions reductions achieved through reduced economic activity diminish the necessity for aggressive supply-side shifts, thereby lowering the incentives for mid-term electrification.

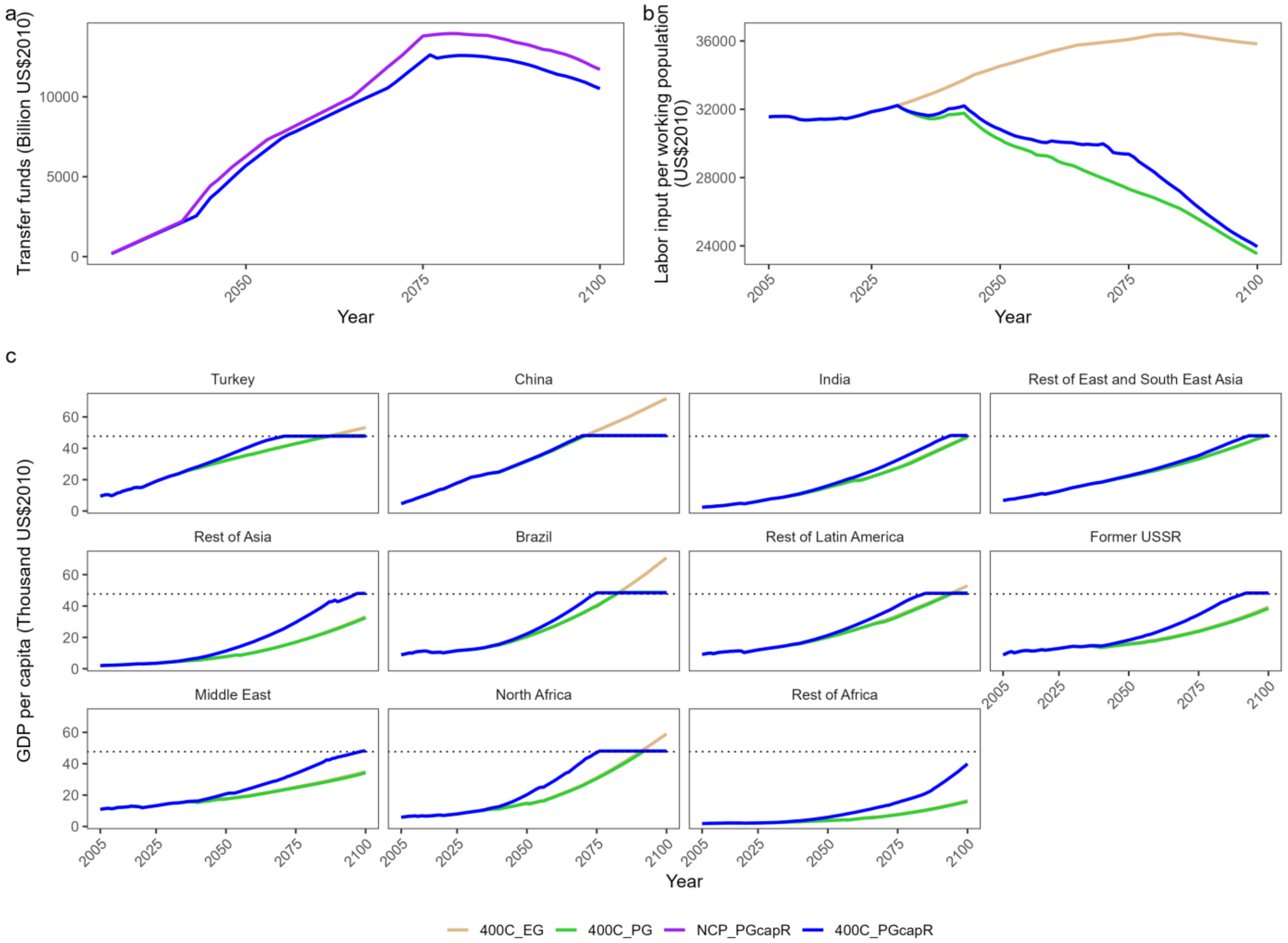

Fig. 1 Economic impact of degrowth scenarios. **a** Total financial support transferred to regions that have not reached the income threshold. **b** Labor input per working population in developed regions. **c** GDP per capita (PPP) in developing regions.

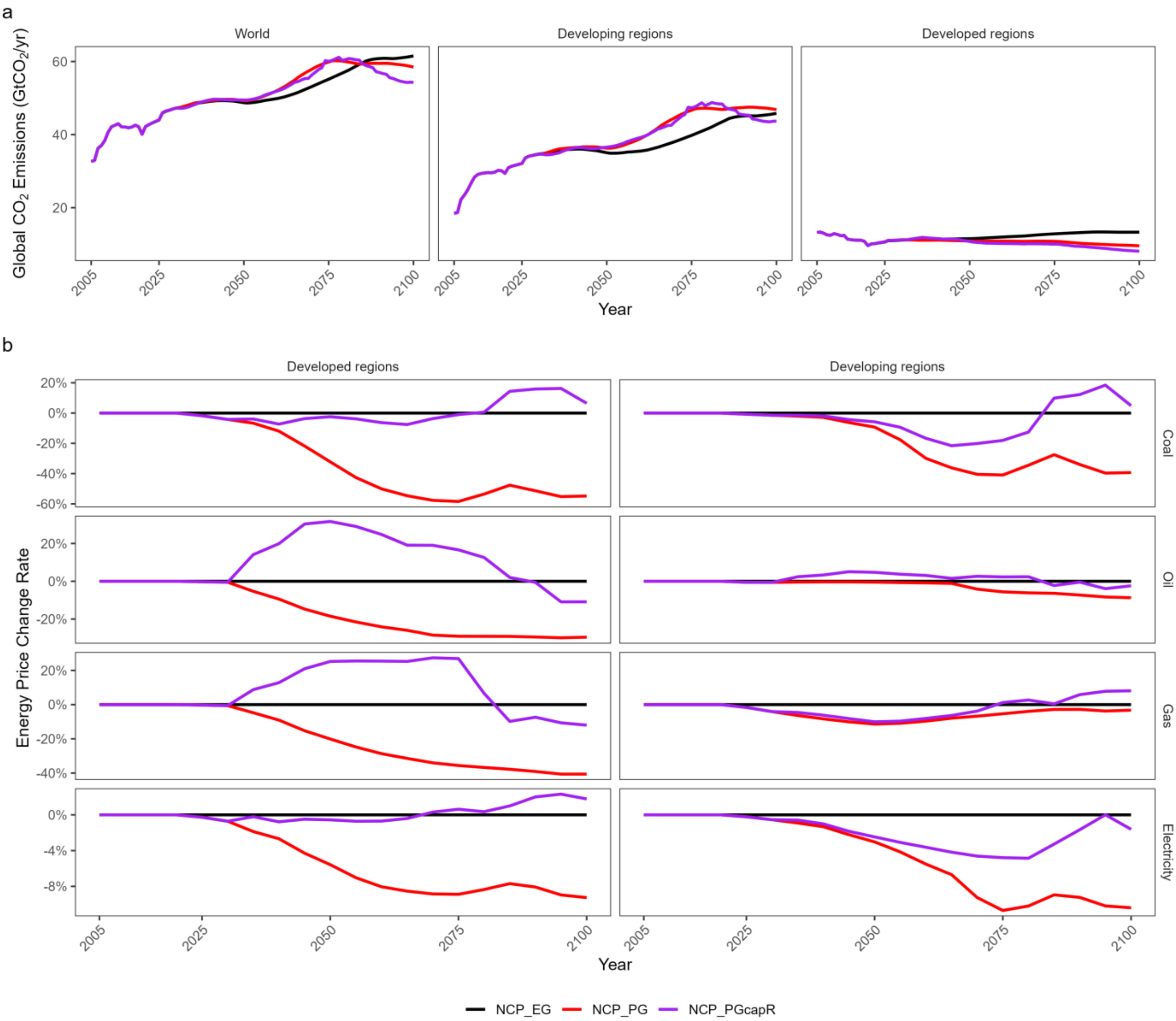

Fig. 2 **a** CO2 emissions in developed countries, developing countries, and the world. **b** Change rate of average consumer price of energy on a basis of economic growth scenario (NCP_EG)

Table. 1 Impact on mitigation measures

Scenario	Energy Intensity Average Annual Change Rates	Renewable Energy Average Annual Change Rates	CDR Installation
400C_NoDeg	-2.2%	8.8%	1000 $GtCO_2$
400C_Deg	-1.9%	8.6%	1000 $GtCO_2$
400C_DegFS	-2.1%	9.1%	980 $GtCO_2$

4. Discussions and conclusion

The objective of this study was to clarify the impacts of redistributing surplus capital, resulting from the transition to a zero-growth trajectory in developed countries, on the difficulty of climate mitigation. Our simulation results provide three key insights into the integration of degrowth transitions and capital redistribution policies. First, at the global scale, these shifts do not impose significant negative impacts on key mitigation indicators, including the expansion rate of renewable energy, the improvement of energy intensity, and the cumulative utilization of CDR technologies. Second, developed regions exhibit a decrease in labor inputs, suggesting potential for enhanced well-being through reduced working hours. Third, GDP per capita in developing regions increases significantly, leading to a substantial reduction in international economic inequality.

Crucially, zero growth in developed countries alone does not provide sufficient emission reductions to solve the climate crisis. This finding is consistent with previous literature; Moyer (2023)[14] notes that while zero or negative growth in the Global North is insufficient to address the global climate crisis, universal zero growth, while reducing emissions, would have severe negative impacts on human development. Therefore, typical mitigation measures, such as carbon pricing, the transition to renewable energy, and the deployment of CDR, remain indispensable for achieving the 1.5°C target while ensuring the welfare of developing nations.

The scale of capital transfer to developing countries estimated in our PGcapR case is massive, averaging approximately 8.2–9.0 trillion US$2010 per year between 2031 and 2100. Such a vast transfer of wealth might be perceived as politically and economically unfeasible or as an excessive form of foreign aid. However, this redistribution finds strong justification through the lens of unequal exchange in international trade. According to Hickel et al. (2022)[15], developed countries unilaterally extract enormous amounts of resources and labor from the Global South without just compensation, utilizing price disparities in global markets. Their study estimates that in 2015 alone, wealth equivalent to 10.8 trillion US$ (in Northern price equivalents) flowed from the South to the North, a figure that remarkably aligns with the annual transfer amounts assumed in our study. Consequently, the capital redistribution mechanism modeled in our PGcapR scenario should not be viewed merely as philanthropic aid. Instead, it represents a corrective process aimed at returning wealth historically and structurally appropriated from the Global South, thereby addressing the fundamental imbalances of the current global economy.

This study has several limitations that highlight avenues for future research. First, the current model structure cannot reflect central degrowth proposals. For example, a single representative household precludes the explicit analysis of domestic wealth redistribution, and treating labor inputs as a single unit of value implies that reducing labor hours is only feasible under the assumption that wages remain constant. Second, technological progress (e.g., TFP) are assumed to be consistent across scenarios; however, in reality, massive capital redistribution and shifts in economic growth could significantly alter innovation rates. Third, while we set the post-growth income threshold at the 2031 OECD (excluding Turkey) average for political feasibility, exploring lower thresholds remains a future task to assess the trade-off between easing mitigation difficulty and risking decent living standards (Kikstra et al., 2024)[16]. Despite these limitations, by quantifying the growth-promoting effects of capital redistribution, this study stimulates research on the often-overlooked impacts of degrowth on the Global South, offering valuable insights for reducing international economic inequality.

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