Distributional and Economy-Wide Impacts of a Carbon Tax in Ethiopia

A top-down macro–micro assessment using DEMETRA and ETMOD

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Why carbon pricing matters for Ethiopia

Climate-development exposure

- Ethiopia is highly exposed to rainfall variability, droughts, floods, and heat stress.
- Livelihoods remain strongly linked to rain-fed agriculture and climate-sensitive natural-resource systems.
- Poverty and limited household buffers increase the welfare cost of climate shocks.

Fiscal and energy-policy relevance

- Fossil-fuel use creates import-cost and foreign-exchange pressure.
- In 2025, Ethiopia introduced restrictions on imports of new petrol and diesel-powered vehicles.
- Carbon pricing can complement regulatory reforms by changing relative prices economy-wide.
- The same tax can generate revenue for compensation, tax reform, or public finance.

US$20/tCO$_2$
carbon tax simulated

5 scenarios
revenue-use options

CGE + micro
economy-wide and household effects

Literature review and research gap

What the literature establishes

- Macroeconomic costs vary with fuel intensity, energy mix, factor mobility, and substitution possibilities.
- Carbon taxes can be either progressive or regressive, depending on household consumption patterns.
- Revenue recycling is central: tax cuts can improve efficiency; transfers can improve equity.

What remains insufficiently addressed

- Evidence for low-income economies is still limited and empirically mixed.
- Ethiopia-specific studies (Mengistu et al., 2019; Timilsina and Sebsibie, 2025) largely rely on representative household groups.
- Poverty, inequality, and within-group heterogeneity require household-level microsimulation.

Research design and policy scenarios

Scenarios evaluated

Scenario	Revenue use
No recycling	Carbon-tax revenue retained by government.
PIT reduction	Revenue is used to reduce household direct-tax liabilities.
Sales-tax reduction	Revenue reduces sales taxes on low fuel-intensity commodities.
Equal transfer	Revenue paid as equal lump-sum transfers to households.
Poverty-weighted transfer	Transfers weighted by poverty headcount shares.

Baseline

All scenarios are evaluated relative to Ethiopia's 2024/25 tax–benefit system without carbon taxation.

Tax level

US\$20/tCO_2 is used as a moderate benchmark, comparable with recent developing-country and Ethiopia-specific CGE studies.

DEMETRA: economy-wide model

Model role

- Static, single-country, open-economy CGE model calibrated for Ethiopia.
- Calibrated using the 2015/16 Ethiopia Social Accounting Matrix (SAM).

Carbon-pricing extension

- Uses GTAP-based coefficients to estimate CO_2 emissions.
- Applies the carbon tax to fossil fuels used as intermediate inputs by producers and final consumption by households.
- Captures energy substitution in both production and household consumption through nested CES structures.

Key modelling assumptions

- Small open economy with exogenous world prices.
- Armington specification for domestic and imported goods.
- Fixed wages with endogenous employment adjustment.
- Savings-driven investment closure.
- Flexible exchange rate with fixed foreign savings.

ETMOD: tax-benefit microsimulation model

Model role

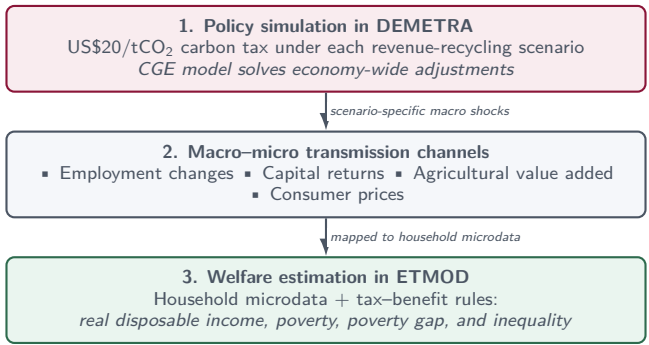
- Based on microdata from the 5th round of the Ethiopian Socioeconomic Survey (4,959 households; 22,687 individuals).
- The underlying data include demographics, labour market outcomes, consumption, and income.
- Simulates direct and indirect taxes, social insurance contributions, and social assistance programs.
- Computes disposable income, poverty, inequality, and fiscal effects at both household and individual levels.

Key modelling assumptions

- Monetary variables are updated to 2024 price levels.
- ETMOD captures first-round effects and does not model behavioural responses.

Macro–micro linkage framework

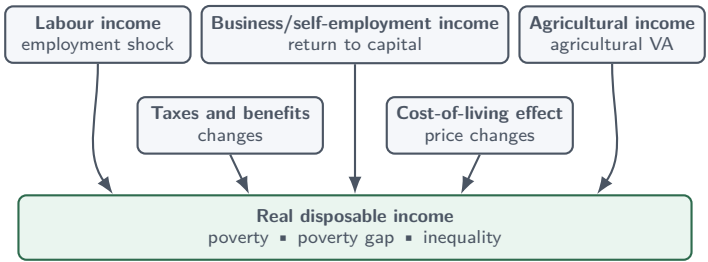
DEMETRA simulates economy-wide impacts; ETMOD estimates household-level welfare effects.



Top-down linkage: CGE outputs are mapped into household microdata to assess distributional and poverty impacts.

Macro–micro welfare mapping

Household welfare is evaluated through changes in real disposable income.



$$\underbrace{\Delta y_h}_{\text{changes in real disposable income}} = \underbrace{\Delta y_h^L}_{\text{labour}} + \underbrace{\Delta y_h^K}_{\text{capital/business}} + \underbrace{\Delta y_h^A}_{\text{agriculture}} + \underbrace{\Delta BT_h}_{\text{taxes and benefits}} - \underbrace{\sum_{i=1}^{32} p_i^0 q_i^h \left(\frac{p_i^s - p_i^0}{p_i^0} \right)}_{\text{cost of living}}$$

$$y_h^{real,s} = y_h^0 + \Delta y_h$$

Price changes are applied to each household's baseline consumption expenditure across 32 expenditure categories.

Baseline exposure: input-cost structure (Table 1)

Sector	Fuel	Electricity	Capital
Agriculture and fishing	0.03	0.00	0.84
Mining, manufacturing and utilities	4.28	1.24	26.53
Construction	3.13	0.35	21.38
Wholesale and retail trade	0.05	0.24	60.70
Hotels and restaurants	0.00	0.73	52.06
Transport and communication	**26.84**	0.59	19.89
Financial intermediation	0.46	0.10	**69.79**
Real estate and business	0.00	0.00	32.87
Public administration and defence	4.08	0.34	26.68
Education	1.29	0.62	15.54
Health and social work	1.55	**1.30**	5.85
Other	3.00	1.08	19.82
Country average	**3.20**	**0.37**	**24.03**

Interpretation

- Fuel exposure is highly concentrated across sectors.
- **Transport and communication** is by far the most fuel-intensive sector.
- High capital shares in finance, trade, and hotels/restaurants partly explain heterogeneous sectoral responses.

Source: Authors' calculations from the Ethiopia SAM. Values are shares of total output, percent.

Macroeconomic effects across all scenarios

Source: Authors' simulations. Values are percent changes relative to baseline.

Interpretation

- Fossil-fuel prices increase by **22%**.
- GDP losses are small in all scenarios.
- Sales-tax recycling gives the lowest CPI and smallest GDP contraction.

Sectoral output effects

Interpretation

- Transport and communication contracts most.
- Hotels/restaurants and finance expand.
- Wholesale/retail contracts through transport-input linkages.

Source: Authors' simulations. Values are percent changes in domestic output relative to baseline.

Impact of the carbon tax on purchaser prices

Interpretation

- Transport prices rise most.
- Sales-tax recycling gives the largest price declines.
- Prices transmit CGE shocks to household welfare.

Source: Authors' simulations. Values are percent changes in purchaser prices relative to baseline.

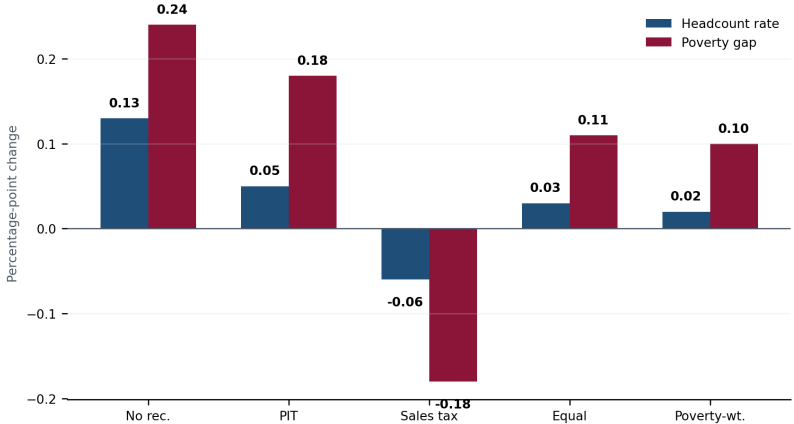
Distributional effects: income by quintile

Interpretation

- Without recycling, Q1 loses most.
- Sales-tax recycling gives the strongest Q1 gain.
- Transfers are progressive but less poverty-reducing.

Source: Authors' simulations. Values are percent changes in equivalized real disposable income.

Distributional effects: poverty headcount and poverty gap

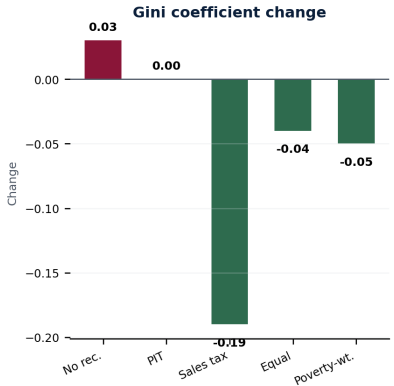


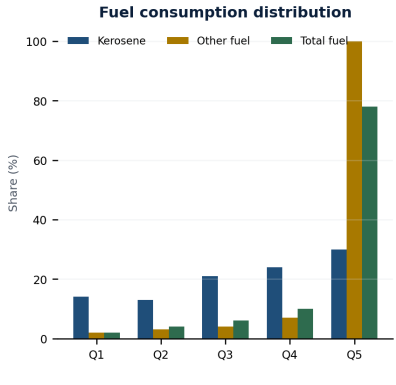
Source: Authors' simulations. Values are percentage-point changes relative to baseline.

Interpretation

- No recycling increases poverty most.
- PIT and transfers soften but do not reverse poverty increases.
- Sales-tax recycling lowers both poverty indicators.

Distributional effects: inequality and fuel-use pattern





Interpretation

- The tax is regressive without compensation.
- Lower- and middle-income households account for 48 percent of kerosene consumption.

Source: Authors' simulations and household fuel-consumption distribution.

Conclusion and policy implications

Empirical conclusions

- A US\$20/tCO_2 carbon tax reduces fossil-fuel combustion emissions by 5.83–6.03 percent.
- Short-run GDP losses are modest, about 0.16–0.18 percent.
- Costs are concentrated in fuel-intensive sectors, especially transport and communication.
- Without recycling, the reform is regressive and increases poverty.

Policy implications

- Revenue recycling is the central design choice, not a secondary add-on.
- Sales-tax recycling performs best for poverty, inequality, CPI, and GDP losses.

Thank you

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