# Decarbonising the Economy: Impact and Role of Trade

Eddy Bekkers, Lory Iunius, Jeanne Métivier, Enxhi Tresa, Ayse Nihal Yilmaz

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# Introduction: decarbonization and trade

- To limit climate change and keep global warming within 1.5-2 degrees Celsius, decarbonization is needed working towards a net zero world by 2050 with nearly zero emissions
- Decarbonization is related to international trade in three ways:
  1. Decarbonization impacts the size and structure of trade
  2. Trade affects the development impact of decarbonization
  3. Trade facilitates decarbonization
- In this paper we extend the recursive dynamic computable general equilibrium (CGE) model GTAP-Power-RD with hydrogen and carbon capture and storage (CCS) and simulate three long-run scenarios to analyse the interaction between decarbonization and trade

# Methodology: model description

- We employ a standard recursive dynamic CGE model with a representative agent allocating a fixed share of factor and tax income to savings, private consumption and government consumption
- Capital accumulation is a function of investment and there are multiple sectors, multiple factor of production, and intermediate linkages in production.
- Carbon emissions emerge from the use of fossil fuels (oil, gas, and coal) by both firms and private households
- Carbon taxes can be imposed on the use of fossil fuels and the model allows for emissions trading generating revenues for regions abating more than their target
- There is a detailed structure for the production of energy to capture substitution between different sources of energy, including green hydrogen and the combination of gas and coal production with CCS
- We add learning by doing in the production of renewable energy and a feedback from specialization in sophisticated sectors to aggregate productivity based on Hausman et al. (2007)

# Methodology: structure of energy production

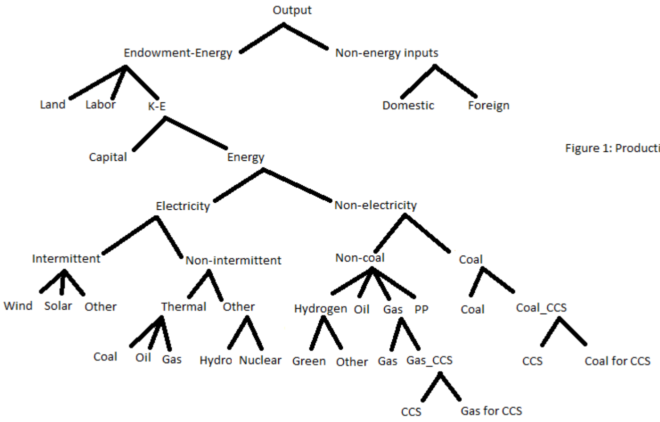


Figure 1: Production structure

- Following WB-IMF-OECD models the elasticity of substitution between energy sources is between 0 and 1 and within electricity is equal to 3-5

# Scenarios

1. **Global Inaction (GI)**: countries do not take further action to decarbonize or to comply with their NDC commitments. ▸ Global Inaction
2. **Divided World (DW)**: countries take unilateral and fragmented action using different instruments. ▸ Divided world
3. **Cooperation towards Net Zero (CNZ)**: countries cooperate to achieve almost net zero emissions by 2050. ▸ NZE pol

- We also model three stylized technology variants of CNZ to analyze the role of trade and impact on trade
  - Decarbonization with renewable energy (CNZ-T-RE)
  - Decarbonization with green hydrogen (CNZ-T-H)
  - Decarbonization with CCS (CNZ-T-C)

# Global Inaction (GI)

We incorporate inputs on :

- Population growth (UN projections).
- Change in skills and labour force participation (IIASA).
- Aggregate productivity growth to target GDP projections from the IMF and OECD.
- Exogenous changes in the savings rate.
- Electricity share at 15% and global share renewable energy at 19%, in 2050.
- Productivity growth of wind and solar energy (IRENA).

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# Divided World (DW)

- Carbon prices in line with the NDCs until 2030, and follow linear growth between 2030-2050.
- Phasing out of coal for the countries which have pledged to do so.
- Cost-neutral increase in the electricity shares, to match the IEA Stated Policies Scenario (2020) by 2050 globally (23% by 2050).
- Subsidies to renewable energy (wind and solar power) financed by the carbon tax revenues (4.5% of carbon pricing revenues) .

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# Cooperation towards Net Zero (CNZ)

- Carbon pricing under the form of global emission trading with a global redistribution fund based on the global carbon pricing framework.
- Phasing out of coal globally.
- Increasing the electricity shares (Global share of electricity reaches 46% by 2050 and that of renewable energy 71%).
- Increasing in the use of carbon-capture and storage technologies by 2050.
- Renewable energy subsidies to wind and solar power, and green hydrogen, financed by the revenues raised via carbon taxes.
- Removal of subsidies to the consumption and production of fossil fuels.

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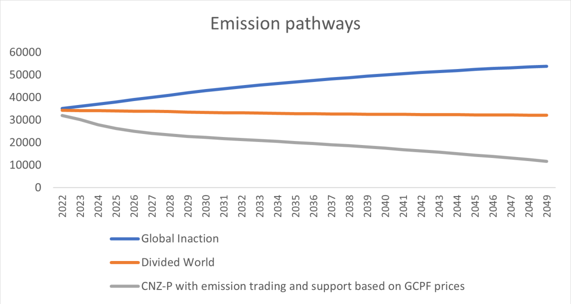
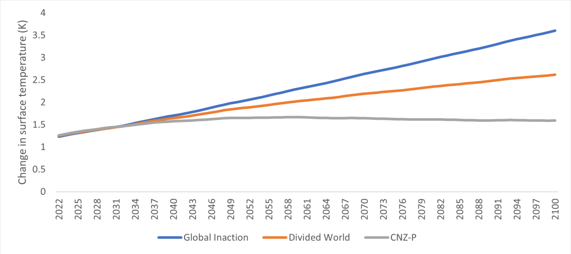
# Data sources

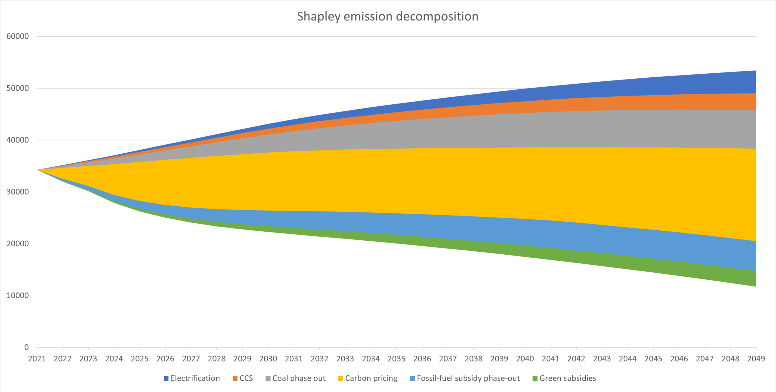
- Growth rates of GDP per capita, employment, population and changes in savings rates: IMF, OECD (SSPs), UN, own estimates
- Carbon taxes in the basedata: World Bank Carbon Pricing Dashboard.
- Nationally Determined Contributions (NDCs): UNFCCC, Climate Action Tracker, GTAP.
- Fossil fuel subsidy phasing out: OECD and IEA database on fossil fuel subsidies.
- Electrification and renewable shares: International Energy Agency (IEA) and Joint Research Center (JRC).
- Coal phase out: IEA and Third Generation Environmentalism (E3G).
- Productivity growth in solar and wind: IRENA.
- Learning by doing in renewables: Weitzel (2010)
- Link between productivity growth and export sophistication: Hausman et al. (2007)

# Long run emissions pathways and implied global warming



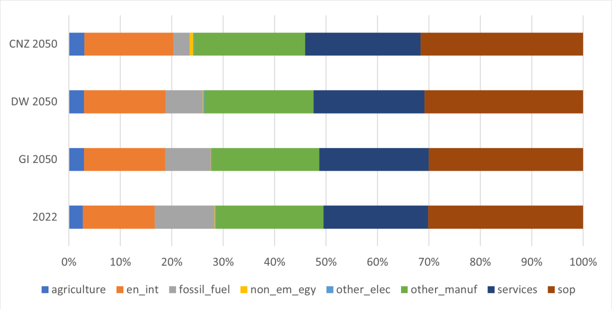



# Contribution of instruments to emission reductions (CNZ)



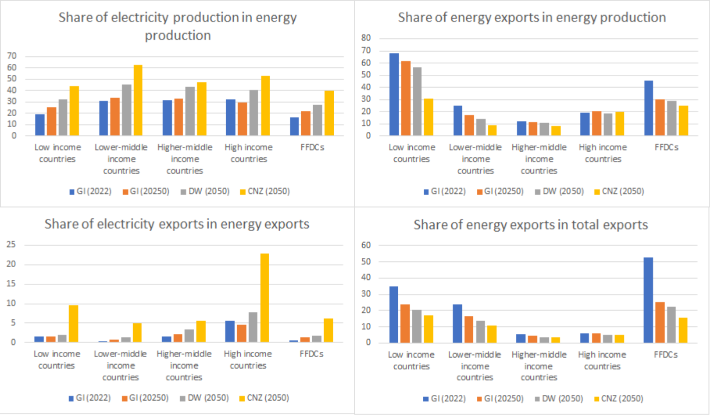

- We calculate the contribution of each policy instrument if only that instrument were introduced
- According to this approach, carbon pricing delivers the largest contribution, followed by coal phase out and fossil fuel subsidy phase out

# Global export shares by sector



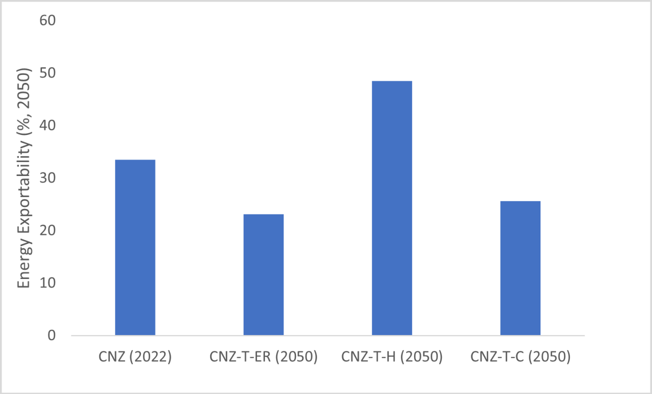

- The share of fossil fuel exports falls drastically. Under CNZ non-emitting electricity achieves 1% of global trade
- The falling share is allocated proportionally to all other sectors
- The share of energy intensive manufacturing rises as well.
  - Substitution elasticities are low and this sector thus decarbonizes as well and maintains its share

# Decarbonization and energy exportability



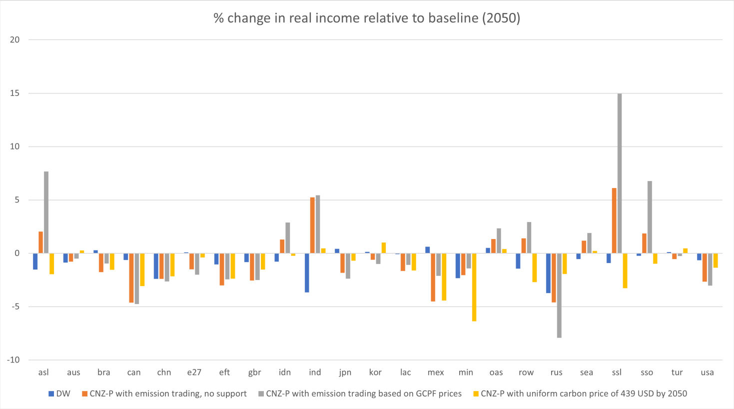

- Electricity share in energy production rises (left upper), generating a rising share of electricity exports in energy exports (left lower)..
- Reducing energy exportability (upper left) and importance of energy exports in total exports because electricity is non-tradable (lower left)

# Decarbonization technology and energy exportability




- The degree of exportability of energy has important implications
  - Smaller geopolitical role of energy trade (critical raw materials not considered here)
  - Less scope to employ international trade to absorb shocks

# Decarbonization and development

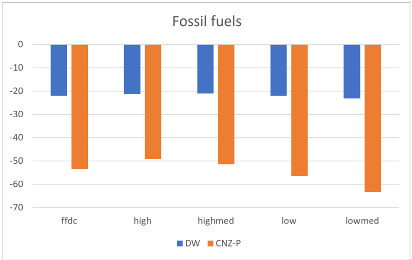


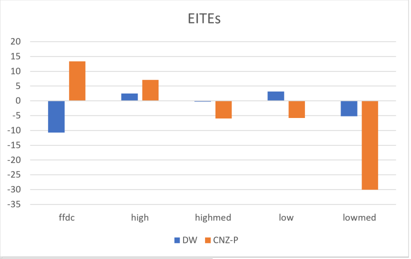

- The way in which global decarbonization is organized matters a lot for the distribution of economic costs
  - Uniform price and divided world better for high income (US, EU) and worse for lowest income (Asia least developed, ASL; Sub-Saharan Africa least developed, SSL)

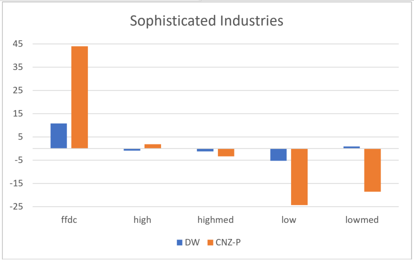
# Decarbonization and development: role of trade specialization

- Hypothesis from the literature: there is a risk that FFDCs increasingly specialize in energy intensive sectors because falling fossil fuel prices benefit these sectors most in fossil fuel producers.
- This precludes these regions from shifting towards sophisticated sectors such as electronic equipment with most growth potential
- Simulations do not support this hypothesis: decarbonization is projected to generate large increase in FFDCs exports of energy intensive and sophisticated sectors
  - Difficult to identify strength of channel, since it is driven by falling fossil fuel prices which cannot be sterilized
- Further promoting specialization in sophisticated sectors through policies such as the promotion of education can still be good as described in Peszko et al. (2020)

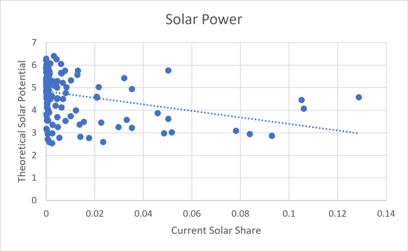
# Decarbonization and development: role of trade specialization

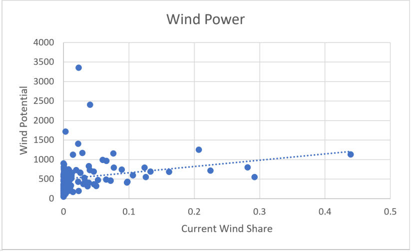


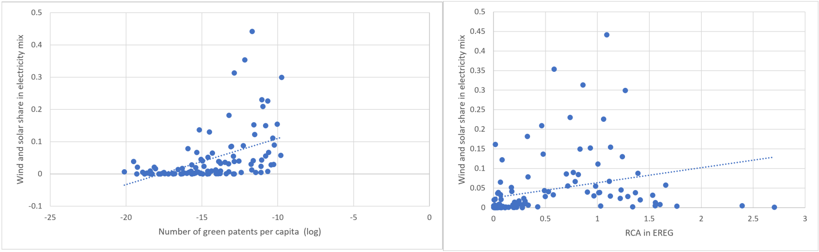
# Role of trade in decarbonization: empirical mismatch



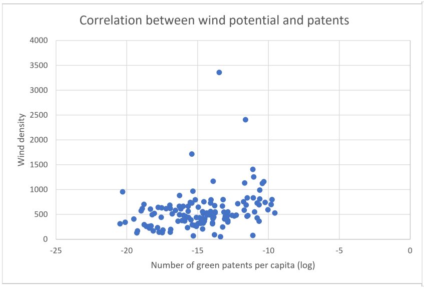

- There is a mismatch between the potential for solar energy generation and the actual shares of electricity generated with solar energy generated by regions

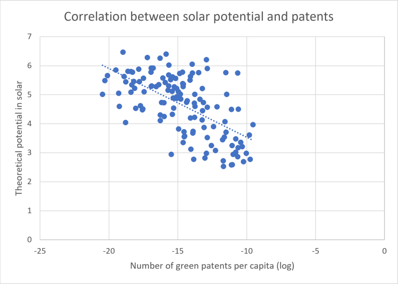
# Role of trade in decarbonization: empirical mismatch




- There is a role for technology in the uptake of renewable energy: regions with more green patents per capita and a stronger RCA in environmental goods generate a larger share of electricity with solar and wind

# Role of trade in decarbonization: empirical mismatch




- There is a role of technology in the mismatch and thus a potential need for technology diffusion: the number of green patents per capita and the RCA in environmental goods correlate negatively with solar potential

# Correcting for the mismatch: a stylized scenario

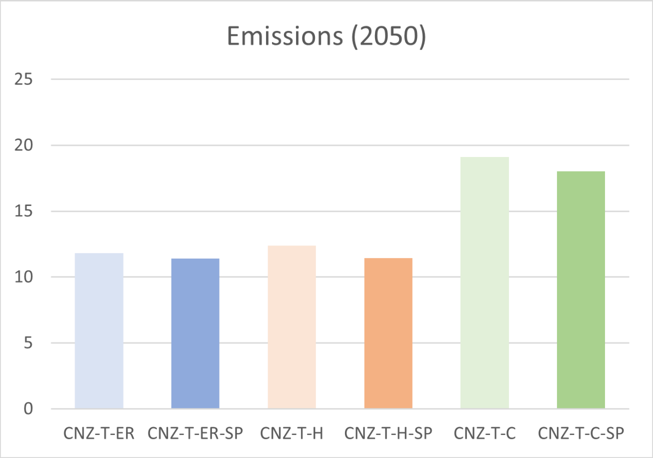
We implement higher than average productivity growth in regions with natural comparative advantage in solar energy such that by 2050, the productivity differences in solar energy reflect differences in natural potential.

- The productivity shock to solar varies regionally, to exploit the differences in natural comparative advantage in solar.

$$\frac{a^{pot}(sol, r)}{a^{act}(sol, r)} = \left(\frac{sh(sol, tl)}{sh(sol, r)}\right)^{\frac{1}{\rho-1}} \left(\frac{pot(sol, r)}{pot(sol, tl)}\right)^{\alpha}$$

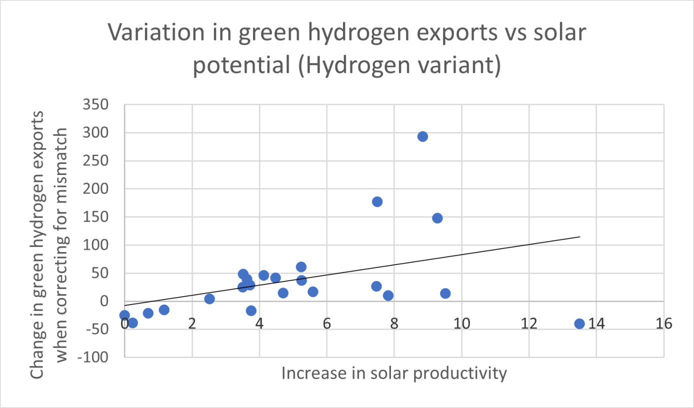
- A caveat is that the use of renewable energy is not only determined by technology, but also by other factors such as infrastructure and regulations, among others

# Emissions with and without technology catch-up




- Technology catch-up helps reducing emissions more in the hydrogen scenario.

# Role of technology catch-up and trade in emissions

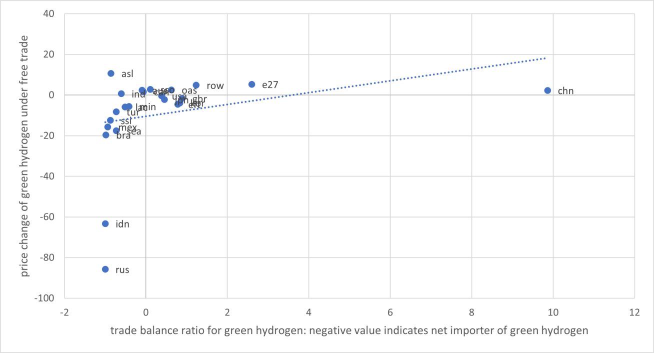



- Countries with higher productivity catch up increase their green hydrogen exports when the shock to solar potential is introduced

# The beneficial role of trade in correcting for the mismatch

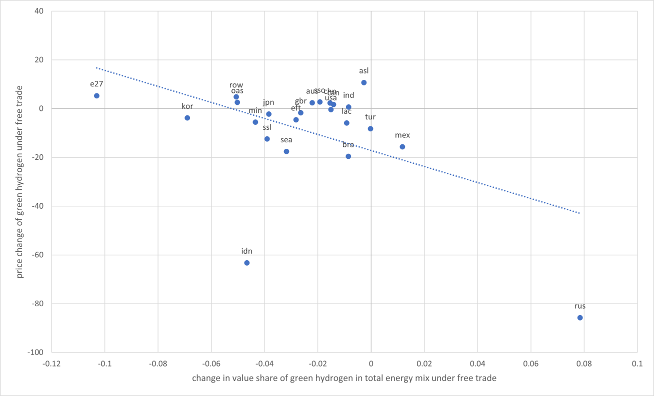
- Technology catch-up generates the largest reduction in emissions in the hydrogen scenario and tradability is largest for hydrogen
- This suggests a beneficial role of trade in reducing emissions
- However, comparing the impact of technology catch-up with and without trade shows that the reduction in emissions is almost identical. There are multiple reasons for this finding:
  - Trade in hydrogen raises emissions from more transportation and production
    - Although hydrogen is produced from renewable energy complementary intermediate inputs and capital goods have to be purchased to produce hydrogen which generate emissions
  - There is a general equilibrium effect of more hydrogen production to more demand for renewables, raising its price and thus reducing the use of electricity generated with renewables
- We confirm these channels in the analysis showing that trade merely reallocates emissions between regions: emissions fall in green hydrogen importers and rise in green hydrogen exporters

# The role of trade in correcting for the mismatch: channels



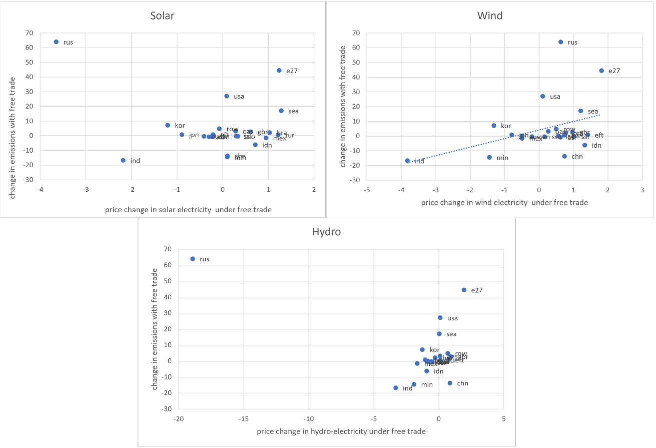

- The price of green hydrogen rises for net exporters of green hydrogen under trade compared to no trade

# The role of trade in correcting for the mismatch: channels




- The value share of green hydrogen in the energy mix falls in regions where the price of green hydrogen rises under trade compared to no trade

# The role of trade in correcting for the mismatch: channels




- Emissions fall in regions with falling energy prices under trade compared to no trade

# Concluding remarks: key findings

- We simulated three long-run stylized scenarios with differing degrees of global decarbonization to analyze the interlinkages between trade and decarbonization. We find:
  - Energy tradability falls under CNZ with geoeconomic and risk-sharing implications although in a hydrogen scenario tradability of energy would rise.
  - The way global decarbonization policies are implemented (uniform price, emissions trading, heterogeneous price with support)matters for the distribution of costs
  - We do not find support for the hypothesis that decarbonization would imply specialization of FFDCs in low value added energy intensive industries
  - There is a mismatch between the actual shares of solar energy in electricity generation and the potential for renewable energy through solar energy which seems driven by different levels of technology
  - Eliminating the role of technology in the use of solar energy reduces emissions, but the possibility to better specialize according to comparative advantage does not play a role in this

# Concluding remarks: possible extensions

- There is scope to extent the current work along the following lines:
  - Model coal phase out with regulations instead of with cost-neutral shifts
  - Model an increase in global electricity trade investing in infrastructure
  - Model the role of critical raw materials in decarbonization and analyse the role of trade and trade policies (data collection in process)