Discussion:

Mitigating Policies for Pollutant Emissions in a DSGE for the Brazilian Economy

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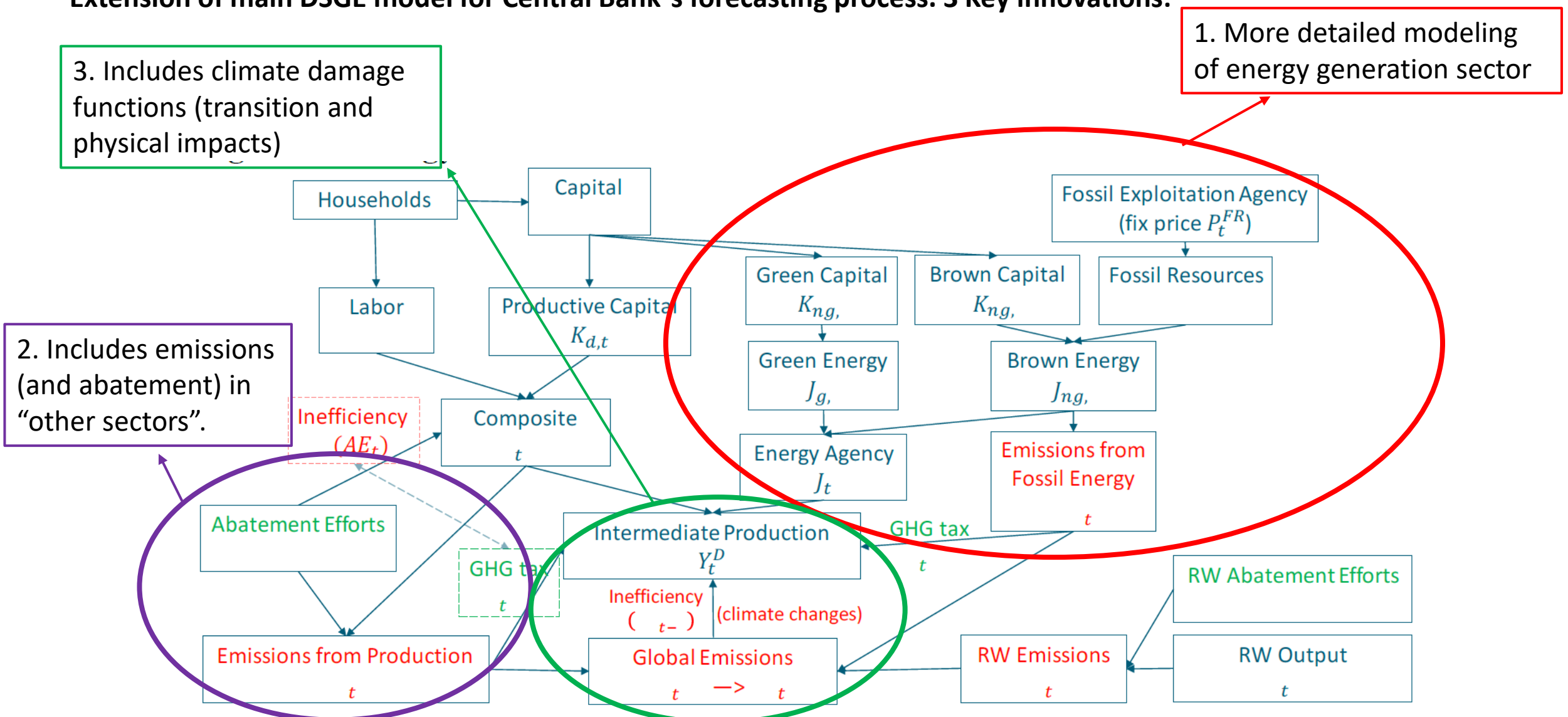
Well executed paper --from a Central Bank that has a pivotal role to play in the world´s climate transition

Agenda

1. Overview of model and key results
2. (Small) Comments about the model
3. (Big) Comments about Brazil: the 80/20 in reverse

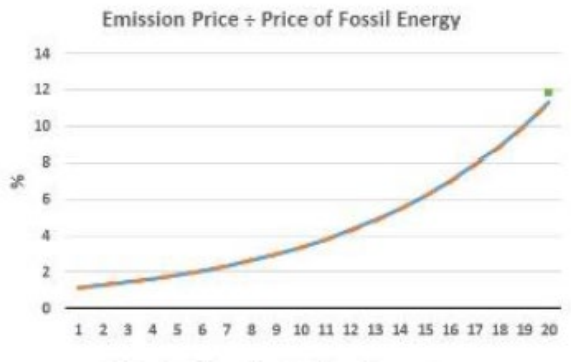
Overview of model…

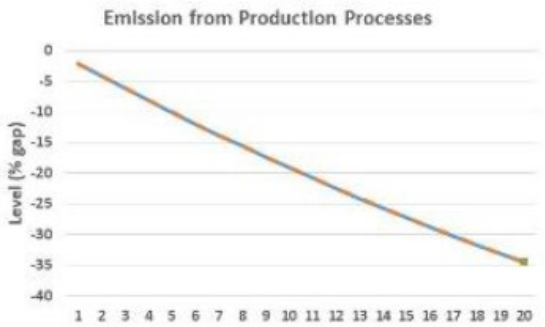
- **Extension of main DSGE model for Central Bank´s forecasting process. 3 Key innovations:**

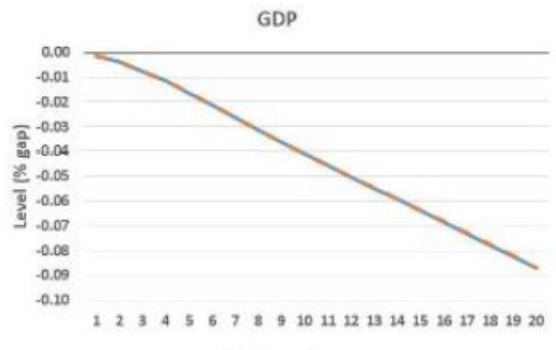


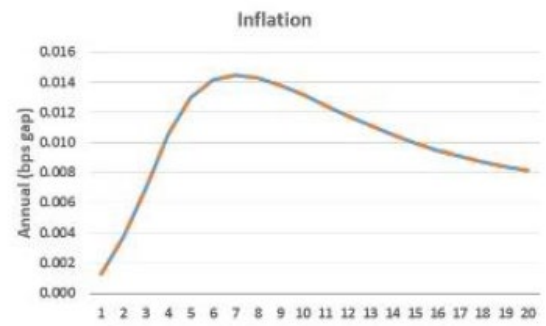
…and (selected) key results

1. Shocks to emission taxes consistent w. NGFS NZ scenarios –35% reduction in emissions in production processes-- have mild macro impacts.

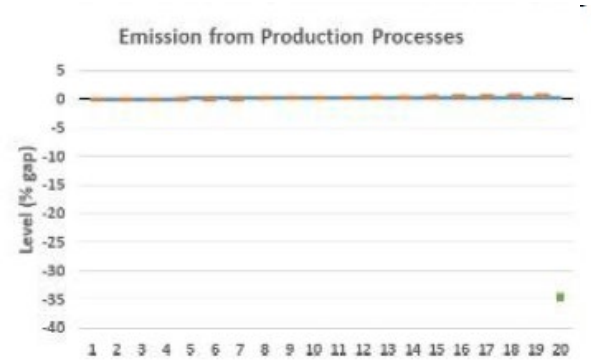


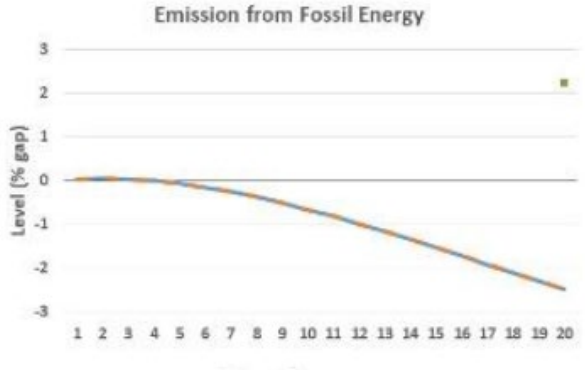


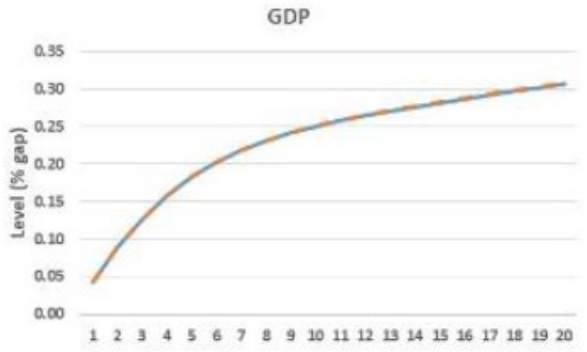


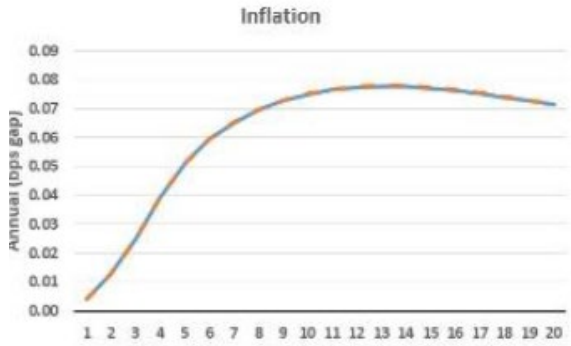


2. Shocks to green energy investments to achieve NGFS NZ scenarios (6% increase in green energy investment) generate mild macro impacts –but essentially do not reduce overall emissions –because emissions from production processes (80% of total) remain unchanged.









(Small) Comments about the model

1. The modeling of investment is a bit “special”
    - Green and brown capital enter separately the production functions of renewable and non-renewable energy –perfect
    - However, both capital stocks, plus intermediate capital, enter (as perfect substitutes) the composite good production – realistic?

$$Y_t^{KN} := (1 - \mathcal{C}(AE_t)) \left[\alpha (K_t)^{1-\frac{1}{\eta}} + (1-\alpha) \left(Z_t \left(N_t - \overline{N} \right) \right)^{1-\frac{1}{\eta}} \right]^{\frac{\eta}{\eta-1}} \qquad \text{where} \qquad K_t = K_{g.t} + K_{ng.t} + K_{d.t}$$

2. Brazil is special in terms of renewable energy production: largest share comes from hydro power
    - This contrasts with many countries whose energy mix is more balanced (or even shifted towards) solar and wind.
    - Is this important? Yes! Hydro is very dependent on water availability. Unfortunately, the Ecosystem Service of (fresh) water availability is heavily dependent on both exogenous factors (global GHG emissions and climate change) and endogenous stressors (e.g., deforestation, which impacts rainfall patterns in the amazon –see next comments).

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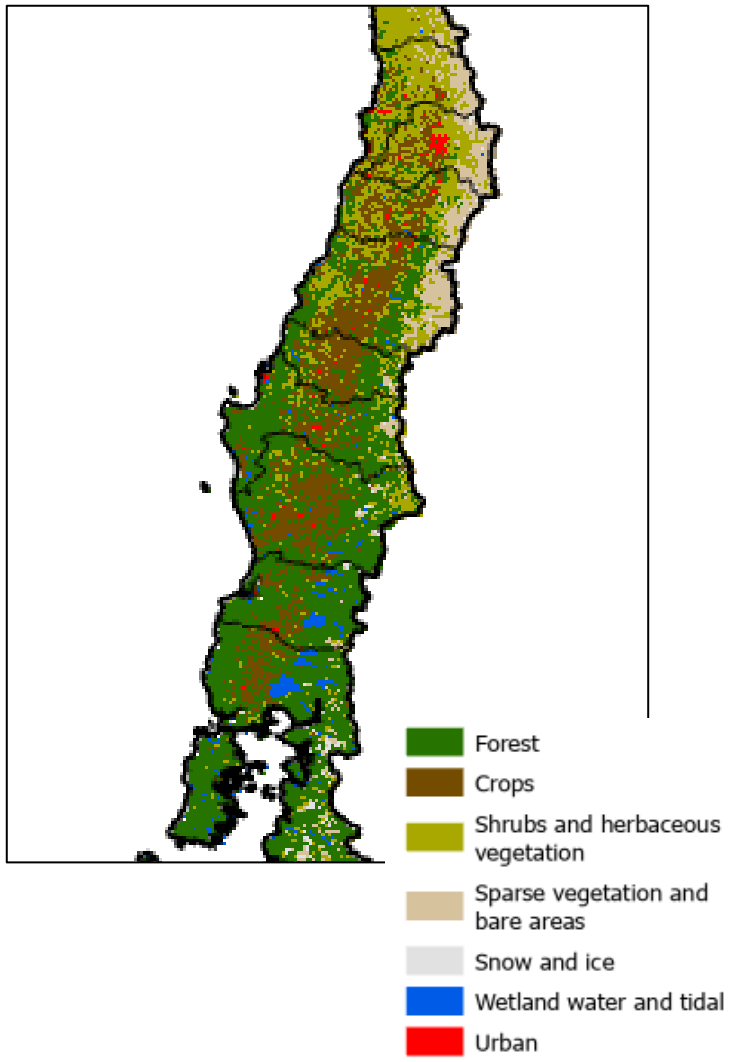
(Big) Comments about Brazil: the 80/20 in reverse

- The 80/20 in reverse
  - In most countries, the 80/20 pareto rule for GHG emissions is: 80% fossil fuels (energy; industry), 20% land use change
  - In Brazil, things are closer to the reverse. 80% from land use change
    - Essentially, the “other sectors” are mostly meat and timber products from clearing the amazon rainforest
- This significantly raises the bar and the level of difficulty
  - CBs are beginning to incorporate transition impacts from decarbonization focused on energy (and less often, manufacturing)
  - Very few consider a more detailed modeling of emissions in AFOLU sectors. But in the case of Brazil, this cannot be ignored!
  - Specifically: meat and timber production are roughly linear on land-use change (deforestation), and so are emissions. Thus, reducing emissions by 35% (NGFS scenario) will have a large effect on these sectors (close to 35% perhaps?). But this requires an explicit modeling of the link between land use, production, and emissions.
- **2 directions of research:**
  1. Integration of land use change and ecosystem services into macro models
  2. Exploration of tipping points

1. Integration of land use change and *Ecosystem Services* into standard macro models

- How to do it: recent application in Chile (Banerjee et al –collaboration with CBC researchers) [1]
  - **Research question**: Assess environmental and macroeconomic impacts of the Chile's NDCs FOLU policies, including the role of key Ecosystem Services (ES)
  - **Methodology**: mix of different economic – environmental models/modules
    - Dynamic multisectoral model: Integrated Economic-Environmental Modeling (IEEM)– sectors depend explicitly on land use, and ES.
    - Land Use Land Cover (LULC) allocation model: Dyna-CLUE –realistic description of potential land uses of different pixels (e.g., deserts cannot become forests, but croplands can).
    - Ecosystem Services flow models: InVEST –describe how land use change affect ES provision: reforestation increases pollination, lowers erosion –increase productivity of agricultural sector.
- This approach is useful for assessing both transition and physical impacts
  - Land-use change dynamics implied by the transition have differential impacts on economic activity, employment, and prices across sectors (energy vs. manufacturing vs. agriculture, etc.)
  - Allows to include damage functions from both exogenous and endogenous (deforestation) mechanisms (previous comment), applying knowledge from Ecology (e.g., InVest tool).

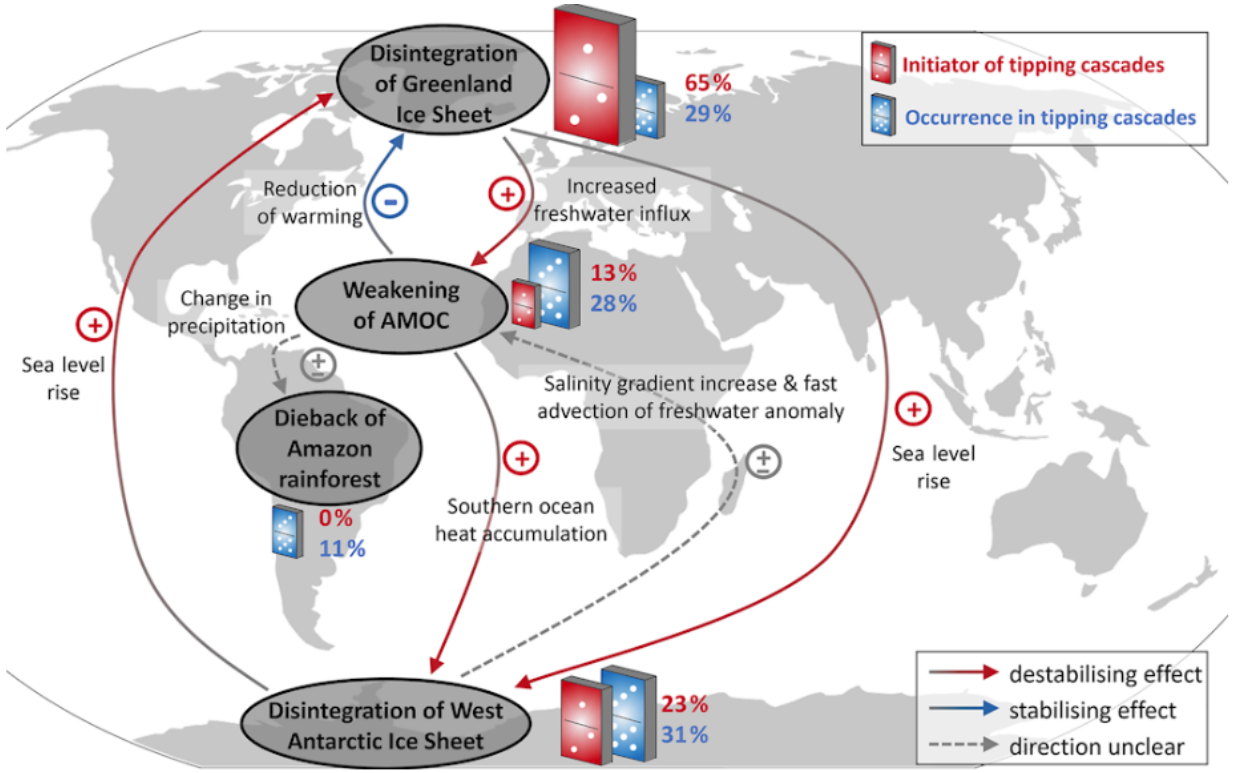
Land use change (NDC commitments)



[1] Banerjee et al. (2024). Integrated Economic-Environmental Modeling of Chile's Nationally Determined Contributions.

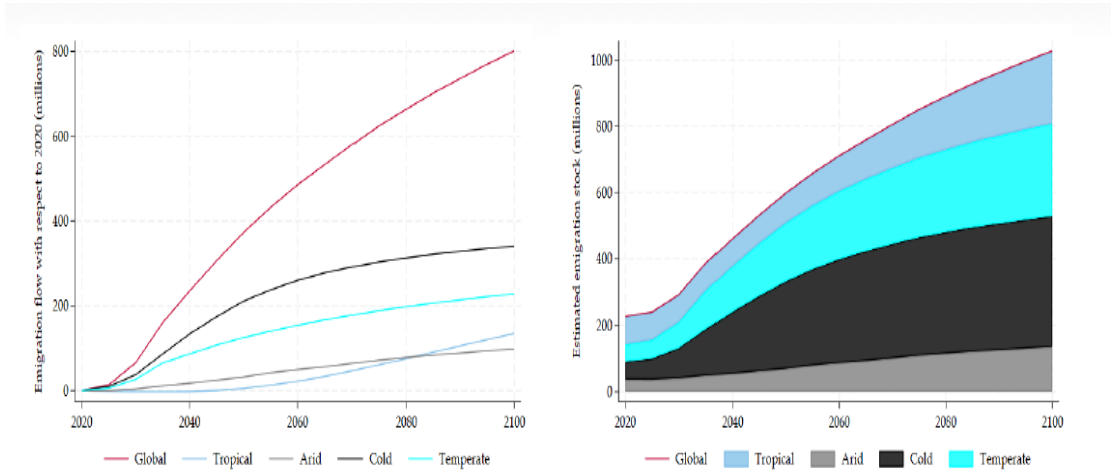
2. Exploration of tipping points: a collapse of the Atlantic Meridional Overturning Circulation (AMOC) – caused by Amazon dieback and Ice Sheet melting --would significantly increase temperature differentials between equator and North Atlantic, with catastrophic impacts to agriculture, livelihoods and migration.

Interactions between climate tipping elements and their roles in tipping cascades



Note: Interactions between the Greenland Ice Sheet, the West Antarctic Ice Sheet, the Atlantic Meridional Overturning Circulation (AMOC) and the Amazon rainforest and their roles in tipping cascades. Destabilising links between the tipping elements are depicted as red arrows whereas stabilising interactions are depicted as blue arrows. Where the direction is unclear, the link is marked in grey. Where tipping cascades arise, the relative size of the dominoes illustrates how many ensemble members the respective climate component initiates tipping cascades in (red domino) or how many tipping cascades the respective climate component occurs in (blue domino).

Emigration projections based on AMOC collapse scenario



(a) Projected emigration growth by type of climate

(b) Projected emigration stock by type of climate

- Tropical countries become warmer and northern countries colder → substantial outward migration for both groups: migration stock increases from 200 million to more than 1 billion under AMOC scenario.
- How to model this? MUCH larger damage functions from emissions in "production processes". It is a tall order to ask from a Central Bank. But who else can we ask it from?
- Scientists have comp. advantages on assessing physical damages. But not on macro impacts of the transition needed to avoid an amazon collapse.

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Source: Albagli et al 2024; Wunderling et al., 2021[4]), OECD, 2021, Kriegler et al, 2009. Cai, Lenton and Lontzek, 2016; Wunderling et al 2021