The impact of trade on emissions through diffusion of ideas

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Introduction: background

- Rapid expansion of international trade and global output in the last few decades.
- Reduction in trade barriers in the major export destinations.
- In parallel, carbon dioxide (CO2) concentration in the atmosphere increased drastically.
- What is the effect of trade on emissions ?
- Trade affects emissions through production, consumption and transportation.
- Open trade contributes to more innovation and enabling the access of domestic firms to foreign technology, knowledge and know-how.
- What is the role of diffusion of ideas through trade in reducing emissions ?

This paper: scenarios

- We use the energy/power version of the WTO Global Trade Model, a recursive dynamic computable general equilibrium model, expanded with diffusion of ideas.
- A baseline projection until 2050 for the global economy is generated with different ingredients towards reaching Net Zero (increase in energy efficiency, increase of renewable shares, electricity shares, coal phase out, carbon pricing).
- We compare the emissions in a Cooperation towards Net Zero Scenario until 2050 with emissions in three policy scenarios:
    1. Revival of multilateralism : Several reductions in tariffs based on spillover effects from other trade liberalization episodes, NTMs reduce by 25%.
    2. Decoupling of the global economy: there are 3 blocks: US and allies, China and allies, neutral countries. Level of tariffs goes to trade war level and NTMs have an increase based on Larch et al. (2019)
    3. Trade costs are reduced (tariffs and NTMs) in two sectors from which wind and solar source most of their intermediates: sophisticated manufacturing and other services.
    4. As 3 but with increased strength of diffusion of ideas through β parameter from 0.3 to 0.6.

This paper: preview of results

- We decompose the impact of trade on CO2 emissions into three different channels:
  1. Scale effect: the expansion of economic activity, which can result in a positive effect on emissions.
  2. Composition effect: a change in the production mix which can be negative or positive depending on whether a country has a comparative advantage in emission-intensive sectors.
  3. Technique effect: changes in the technique of production can change emissions, for example through changes in the mix of energy inputs or through the diffusion of ideas as a result of trade.
- We find that (preliminary results):
  - In the baseline (from 2021 to 2050) the technique and composition effect more than compensate for the scale effect and reduce emissions in most regions.
  - The role of transportation in emissions is positive but small, confirming earlier work (Shapiro, Cristea et al.).
  - There is only a marginal role of trade liberalization in the diffusion of green technologies for the trade liberalization scenarios evaluated.

Related literature

- Trade helps innovation and diffusion of ideas:
  - Higher profits resulting from the use of cheaper inputs increase firms' incentives to invest in **R&D** (Bøler, Moxnes and Ulltveit-Moe, 2015).
  - An increase in demand in the destination market (i.e., export shock) increases **firms' incentives to innovate**, with more productive firms more likely to benefit from such market expansion (Aghion et al., 2018).
  - Open trade increases the diffusion of more productive ideas, which boost productivity growth (Buera and Oberfield (2020), Bekkers and Goes (2022)).
- Diffusion of green technologies through trade (empirical analysis):
  - Verdolini and Galeotti (2011), Ghisetti and Quatraro (2017), Wurlod and Noailly (2018), Chakraborty and Mazzanti (2020).
- Trade helps with cost sharing for green technologies :
  - Ghosh and Shah (2015), Xu and Xie (2016), Mattingly (2017).
- Effect of trade on emissions:
  - Cristea et al. (2013), Shapiro (2016), Shapiro (2021).

Data and diffusion of ideas module

- WTO Global Trade Model: recursive dynamic General Equilibrium (GE).
- GTAP 10 data base: 12 regions and 20 sectors.
- Baseline model is similar to the NZE scenario.
- We work with a version of the Global Trade Model that includes a diffusion of ideas module.
- The module is parameterized to replicate historical growth rates (between 2004 and 2019). (Bekkers and Goes, 2022).
- Productivity growth is a function of the level of productivity of trading partners weighted by the import shares from trading partners.
- Regions importing more intermediates from regions with a high level of productivity will display higher growth rates.
- The Eaton-Kortum technology parameter obeys the following law of motion:

$$\Delta\lambda^{i}_{d,t} = \alpha_t \sum_{j \in \mathcal{I}} \Gamma(1-\beta)\eta^{i,j}_{d,t-1} \sum_{s \in \mathcal{D}} (\pi^{i,j}_{sd,t-1})^{1-\beta} (\lambda^{j}_{s,t-1})^{\beta} \tag{1}$$

With a higher β, importer i can benefit more from high levels of technology $\lambda_{s,t-1}$ in region j

Decomposition of emission changes into three effects

$$Scale\_effect = 100 * \frac{\sum_a GO_{(a,r,2021)} * [1 + qo_{(a,r,2050)}]}{\sum_a GO_{(a,r,2021)}} \quad (2)$$

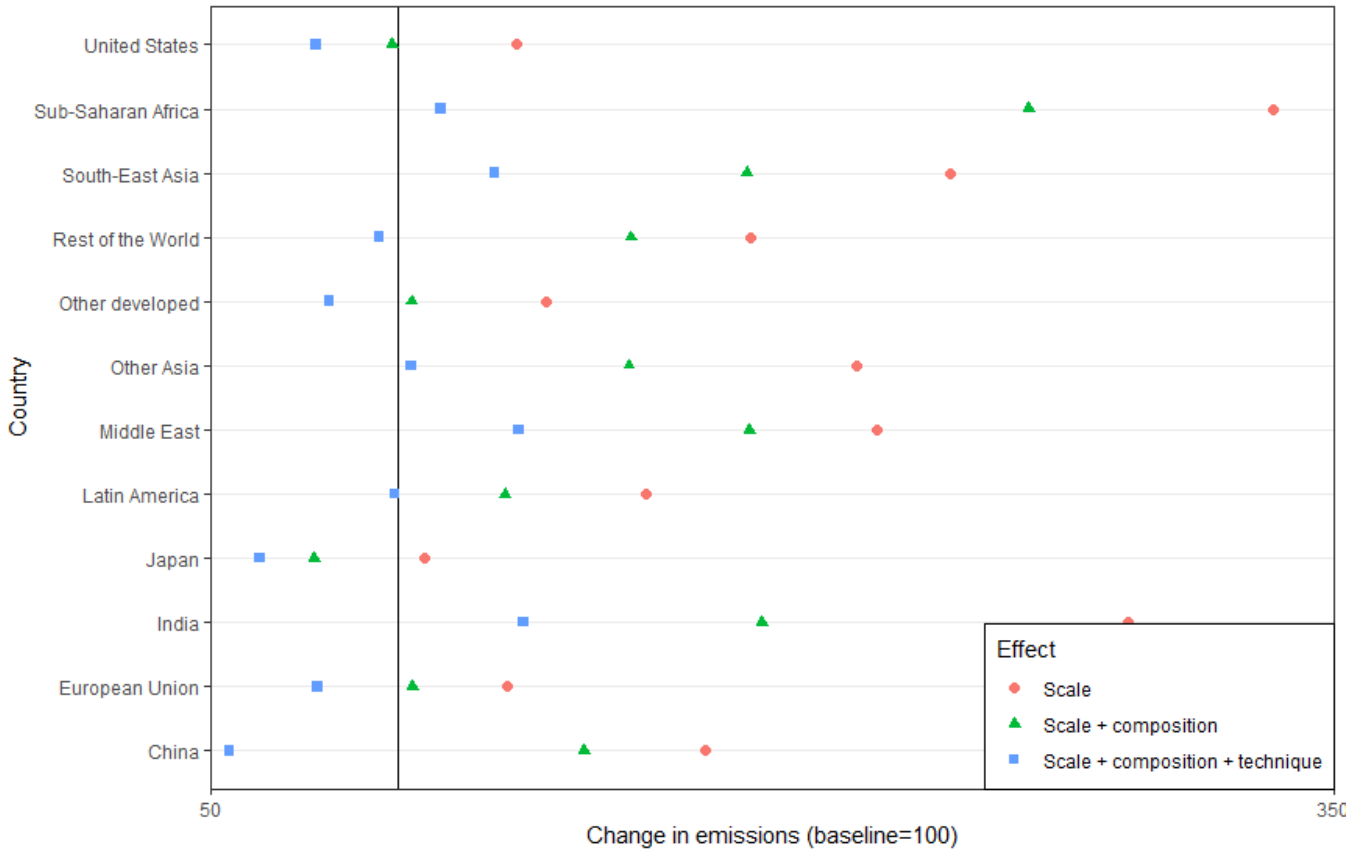
$$Scale\_composition\_effect = 100 * \frac{\sum_a GO_{(a,r,2021)} * [1 + qo_{(a,r,2050)}] * e_{(a,r,2021)}}{\sum_a GO_{(a,r,z,2021)} * e_{(a,r,2021)}} \quad (3)$$

where $e_{(a,r,2021)}$ is the emission intensity in the base year:

$$e_{(a,r,t)} = \frac{\sum_c [CODF_{(c,a,r,t)} + COMF_{(c,a,r,t)}] + CODP_{(a,r,t)} + COMP_{(a,r,t)}}{GO_{(a,r,t)}}$$

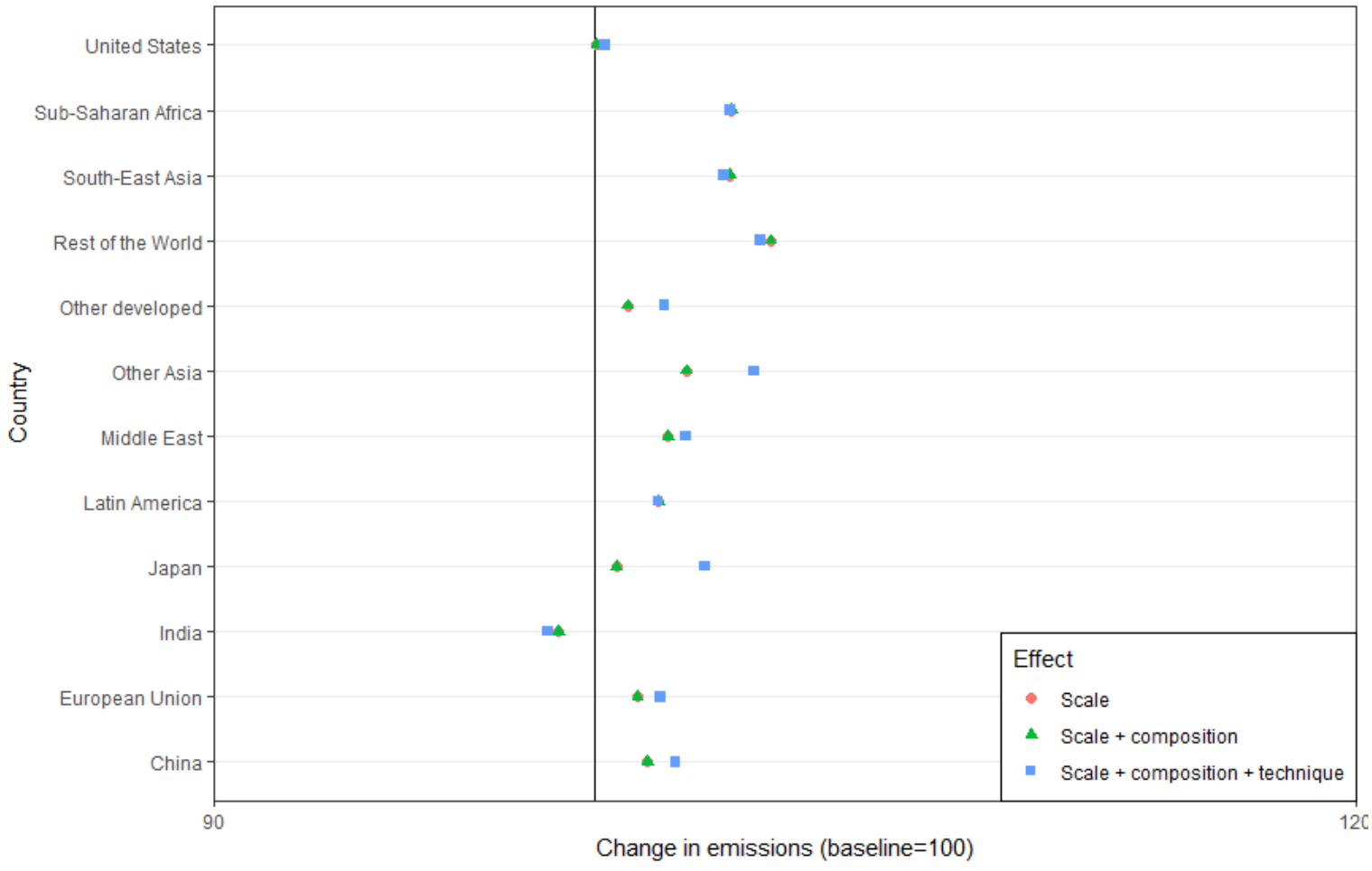
$$All\_effects = 100 * \frac{\sum_a [\sum_c CODF^{2050}_{(c,a,r)} + COMF^{2050}_{(c,a,r)}] + CODP^{2050}_{(a,r)} + COMP^{2050}_{(a,r)}}{\sum_a [\sum_c CODF^{2021}_{(c,a,r)} + COMF^{2021}_{(c,a,r)}] + CODP^{2021}_{(a,r)} + COMP^{2021}_{(a,r)}} \quad (4)$$

Results: Baseline with diffusion of ideas

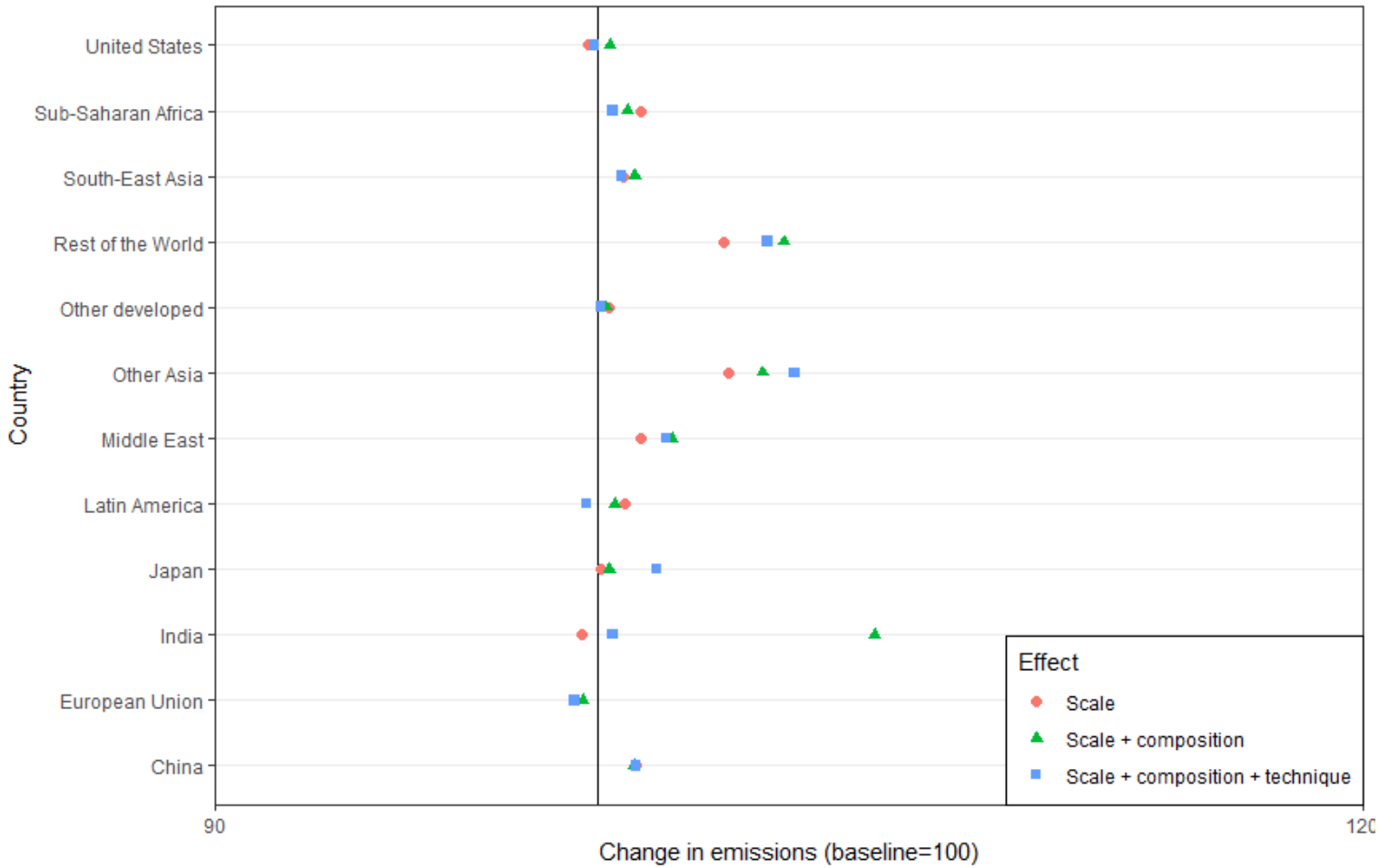


- Emissions tend to increase by the scale effect in all regions.
- Emission tend to fall in most regions by the composition effect, because of structural change from manufacturing towards services and from fossil fuels to electricity in consumption.
- Emissions also tend to fall by the technique effect because of improvements in energy efficiency and shifts in the use of fossil fuels in production.

Results: Liberalising in selling sectors of renewables, decomposition of emissions in transportation

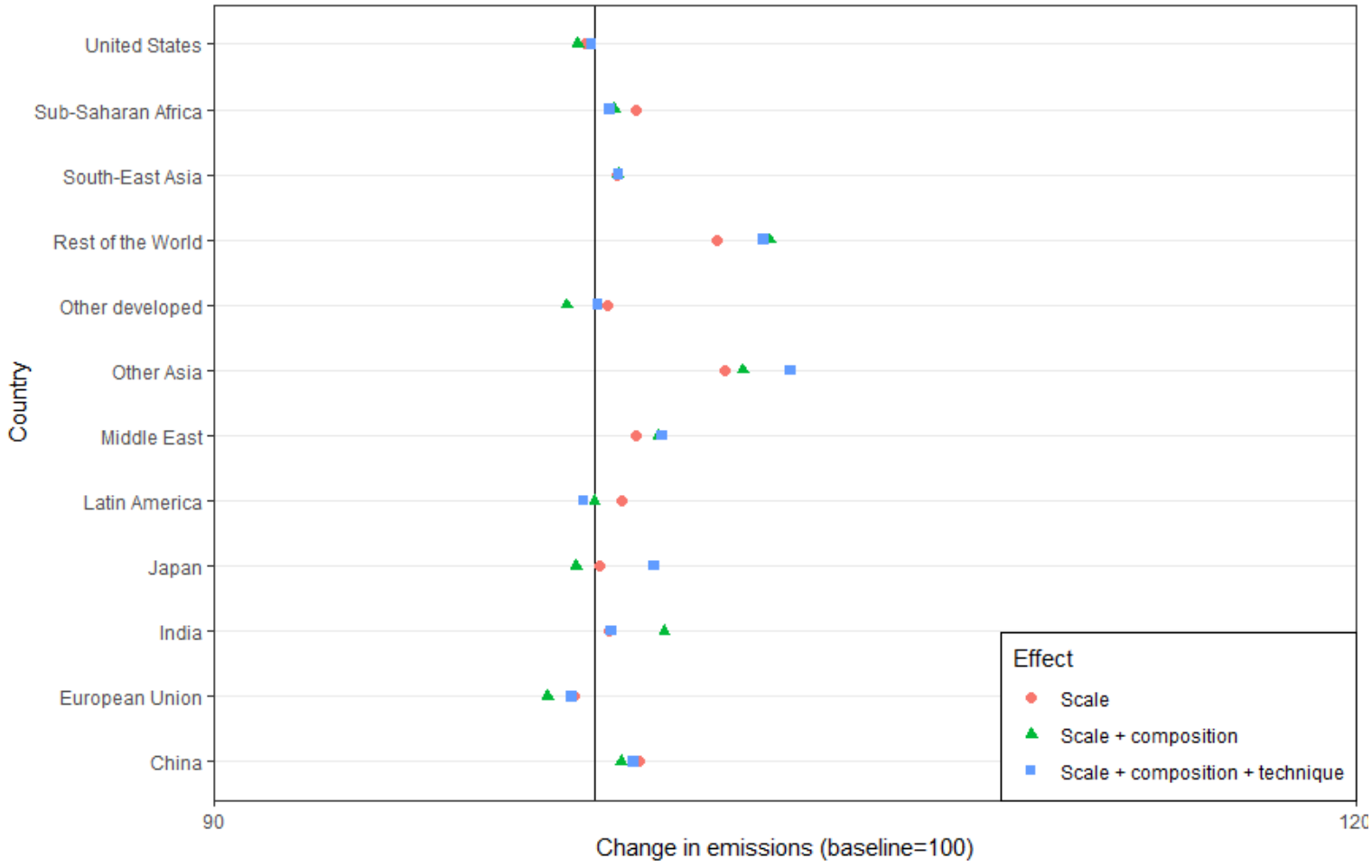


Results: Liberalising in selling sectors of renewables, other sectors



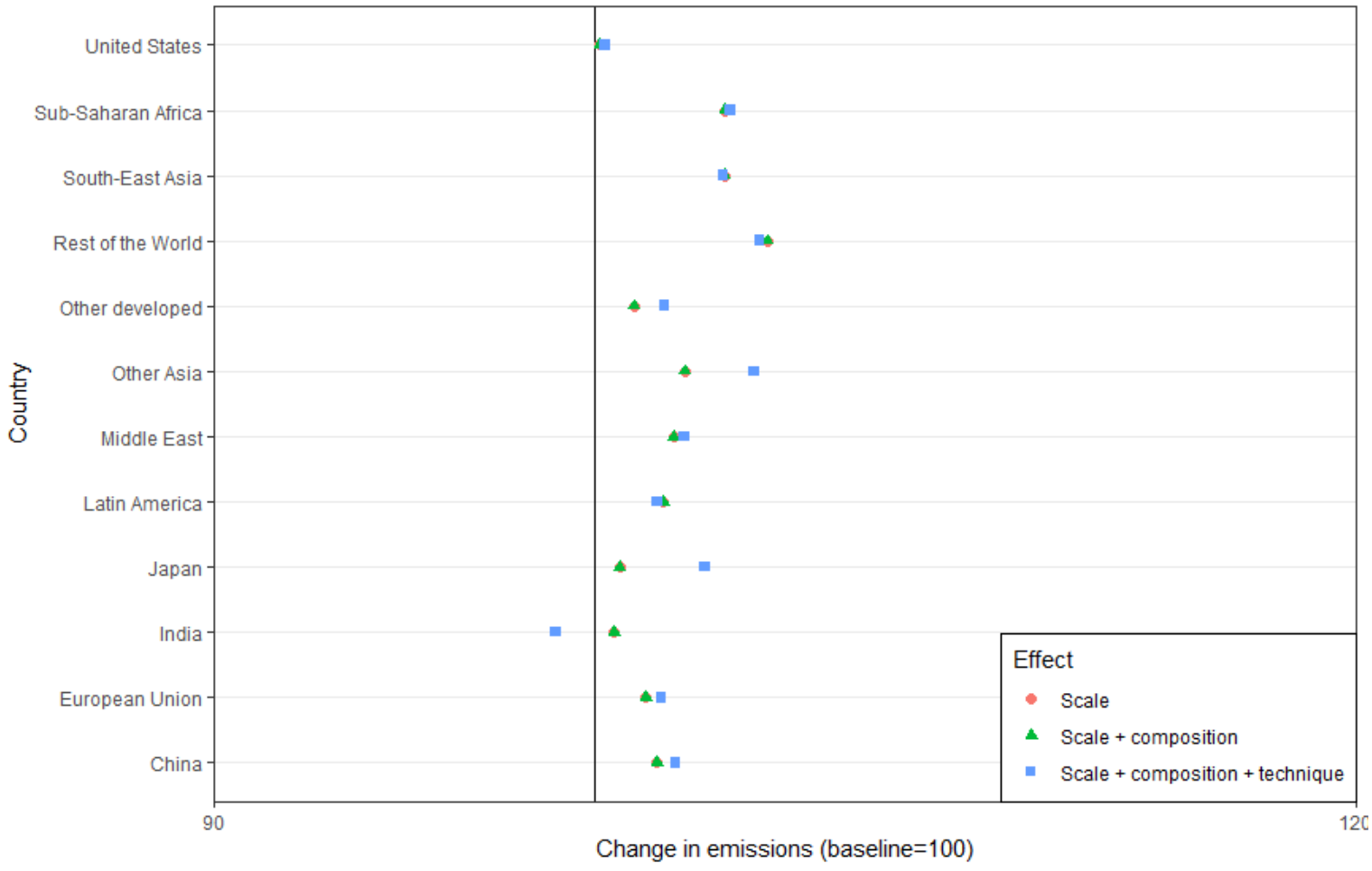
- Scale and composition effects are positive in some regions (expanding production and shift towards dirtier industries) and negative in other regions (shrinking production and shift towards cleaner industries).

Results: Increasing beta, other sectors



- There is stronger diffusion of ideas in wind and solar as absorbing sectors here.
- The impact of the stronger diffusion on the effects of trade liberalization on emissions seem very marginal.

Results: Increasing beta, transport



Share of renewables in different scenarios

Region	2022 Base	2050 Base beta=0.3	2050 Base beta= 0.6	2050-Scen.3	2050-Scen.4
China	8.44	47.40	55.60	47.41	56.14
E27	31.10	66.83	66.00	66.77	65.91
India	8.09	49.05	85.60	49.27	86.13
Japan	8.77	59.50	58.50	59.10	57.83
Latin America	8.18	58.86	58.16	59.01	58.31
Middle East	3.60	50.25	46.65	50.28	46.57
Other Asia	9.80	56.61	51.64	56.51	51.37
Other developed	24.04	70.14	72.40	70.27	72.41
Rest of the World	10.35	54.86	51.06	54.96	51.24
South-East Asia	9.74	57.68	51.60	57.75	51.62
Sub-Saharan Africa	6.09	57.96	68.74	58.27	69.77
United States	12.31	59.34	57.66	59.30	57.61

- With a larger beta the share of renewables in electricity generation rises more in the low income regions benefiting from ideas diffusion (comparing columns 2 and 3).
- The impact of trade liberalization on the share of renewables is small and does not vary much with the strength of diffusion of ideas (beta=0.3 versus beta=0.6).
- Therefore, liberalization of intermediates used by solar and wind does not seem to help in reducing emissions in our model.

Concluding remarks: discussion of results

- There is only a marginal role of trade liberalization in the diffusion of green technologies for the trade liberalization scenarios evaluated.
- Shift in use of inputs to produce electricity towards renewables is not interacting with trade liberalization of intermediates used by renewables.
- The role of transportation in emissions is positive but small, confirming earlier work (Shapiro, Cristea et al.).
- In the baseline scenario the technique and composition effects more than compensate for the scale effect and reduce global emissions.

Concluding remarks: next steps

- Analyse other trade policy experiments to identify when trade plays a beneficial role in diffusion of green technologies (liberalization of intermediates purchased by renewables with end use control requiring MRIO version of the model).
- Split transportation sector per country into transportation sector delivering domestic and exported transportation services and sector selling only to international transportation sector.
  - Identify changes in contribution international transportation to changes in emissions.
  - Take into account emission intensity per bilateral route as in Shapiro (2016) and Cristea et al. (2013) and allowing at the same time changes in emission intensity of transport.

Thank you!