Global Trade Analysis Project

GTAP-E: Energy Environmental Version of the GTAP Model

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Group Members

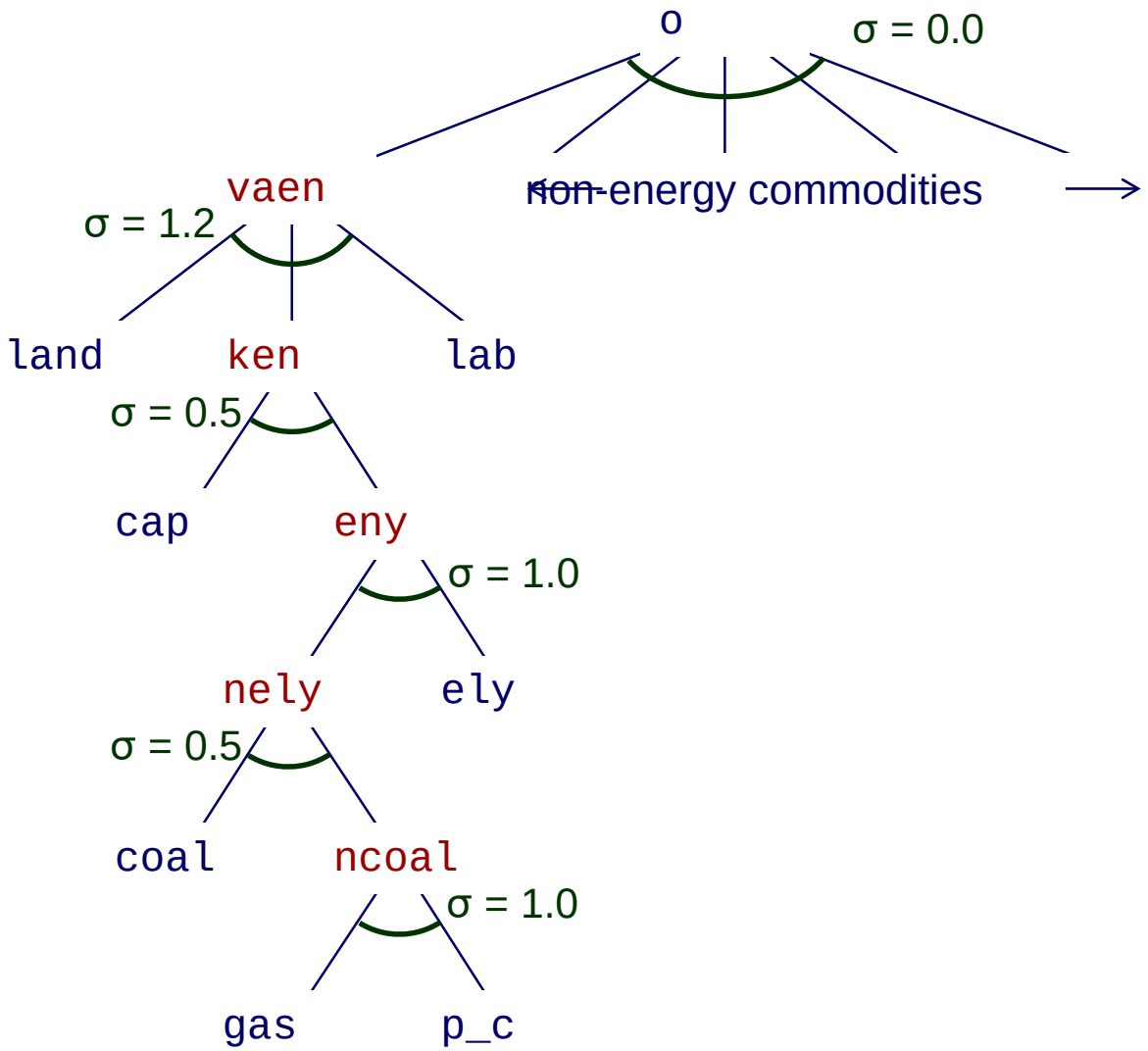
- **Sarah Drought, Alex Kravchenko**
  - Effect of removal of fossil fuel and energy subsidies on emissions, welfare, output and trade
- **Joe Lane, Cicero Zanetti De Lima**
  - Chasing the investment:
    a journey in the wrong direction
- **Enkhbayar Shagdar, Mark Staples**
  - Implications of a carbon tax in GTAP-E model

GTAP-E

- Captures features missing in standard GTAP, including:
  - Energy-capital substitution
  - Energy-energy substitution
  - Emissions accounting – CO2 by combustion

- Mechanism to model emissions trading and carbon taxes and carbon leakage

Production Structure: GTAP-E



Results: Kyoto targets, partial ETS

	Target	NEXI	u|notr	u|tr	u|wtr
EU	−17	−1.6	−0.12	−0.08	−0.01
Jpn	−30	−2.0	−0.41	−0.13	−0.03
EEFSU	+9	+13.5	−0.94	+1.08	−0.09
EEx	0	+16.1	−0.61	−0.43	−0.37
Chn	0	−1.8	+0.01	+0.01	+0.13

Target : (quota – actual) / actual × 100%
NEXI : net energy export intensity: exports / *Y* × 100%
u|notr : percentage change in utility, with no trading
u|tr : percentage change in utility, with trading among Annex 1 countries
u|wtr : percentage change in utility, with worldwide trading

The leakage rate is low (< 7%);

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Effect of removal of fossil fuel and energy subsidies on emissions, welfare, output and trade

Sarah Drought, Alex Kravchenko

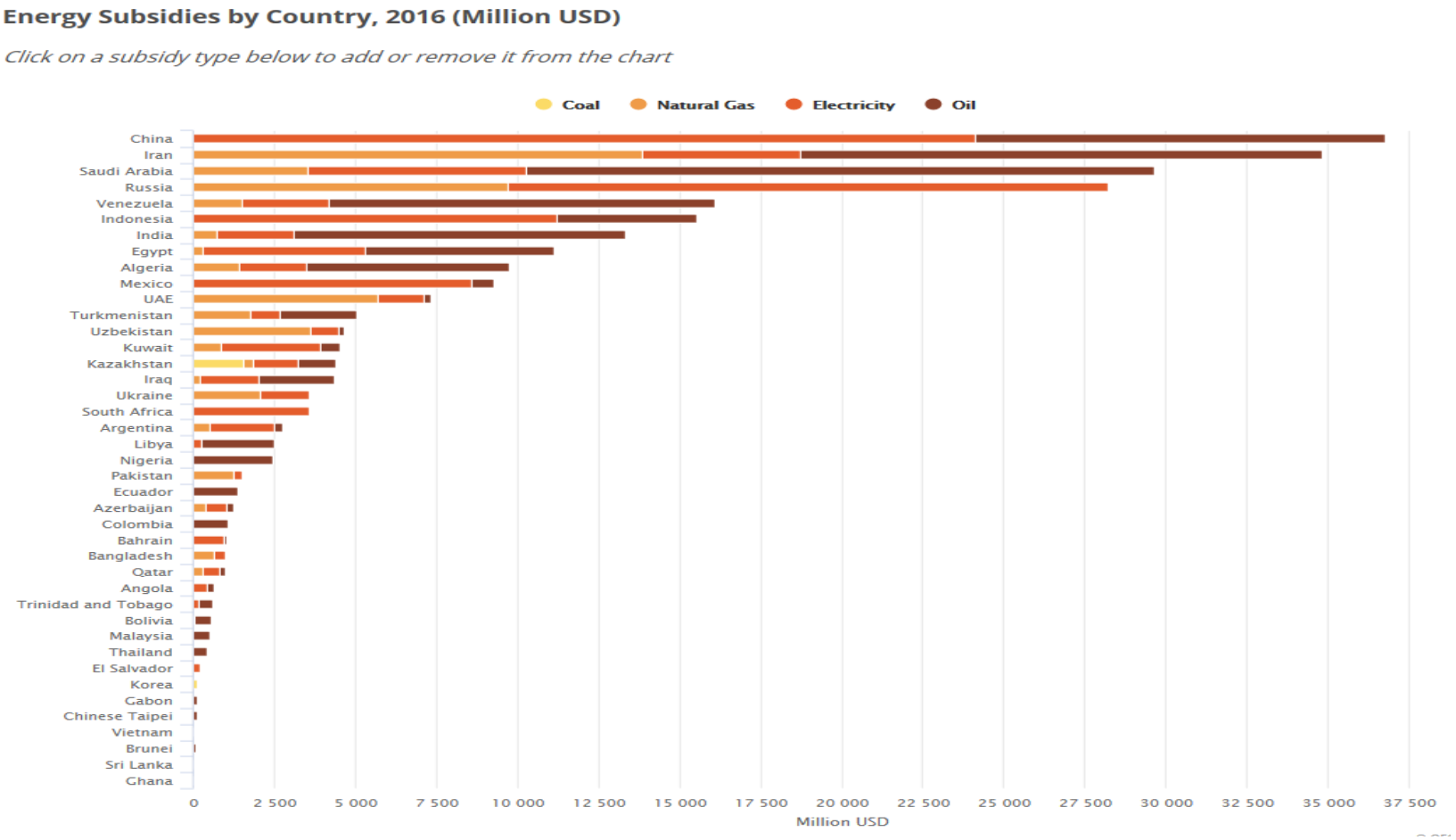
Disclaimer: The views represented in these presentation notes do not represent official positions or policy of Purdue University or the Center for Global Trade Analysis.

ABSTRACT

- **Effect of removing fossil fuel subsidies ($25 bn)**
  - Global emissions go down by 0.5%, driven by
  - Driven by countries for which data is good (i.e. India)
  - Global welfare rises
  - Global cancer rates drop, happiness index improves, visibility in Beijing increases by 12.43% (oh wait, not captured by GTAP)

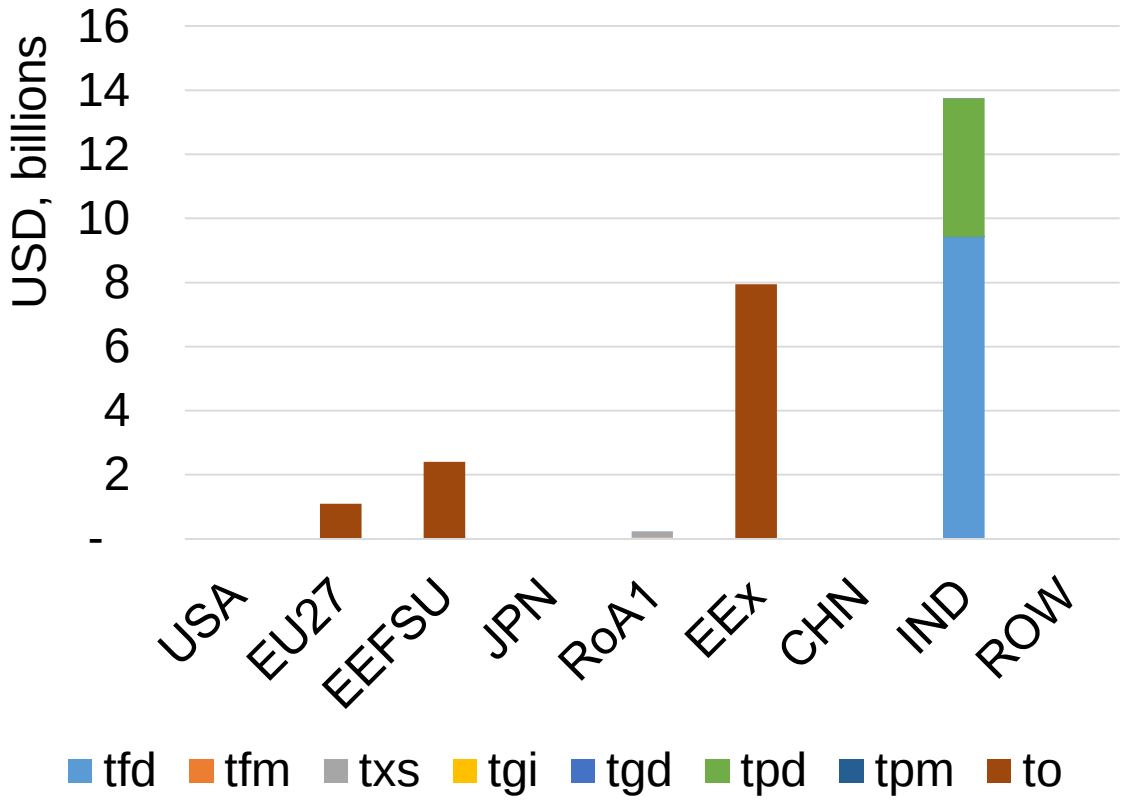
Motivation

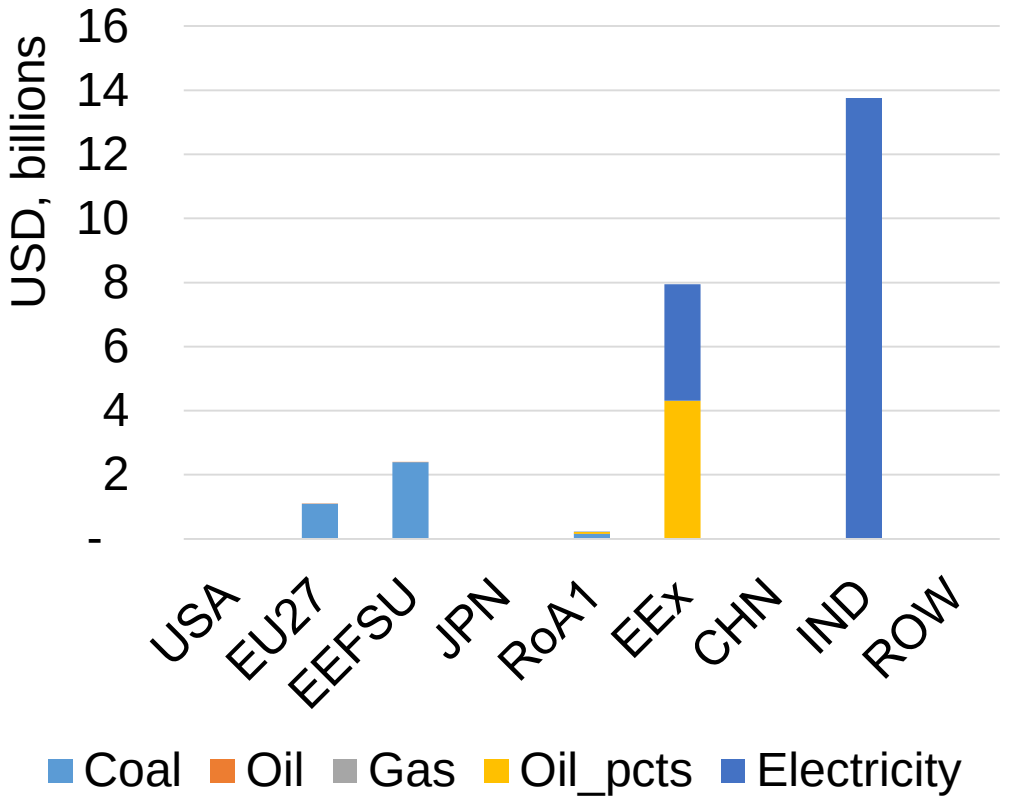
- Subsidies on fossil fuels total over $200 billion



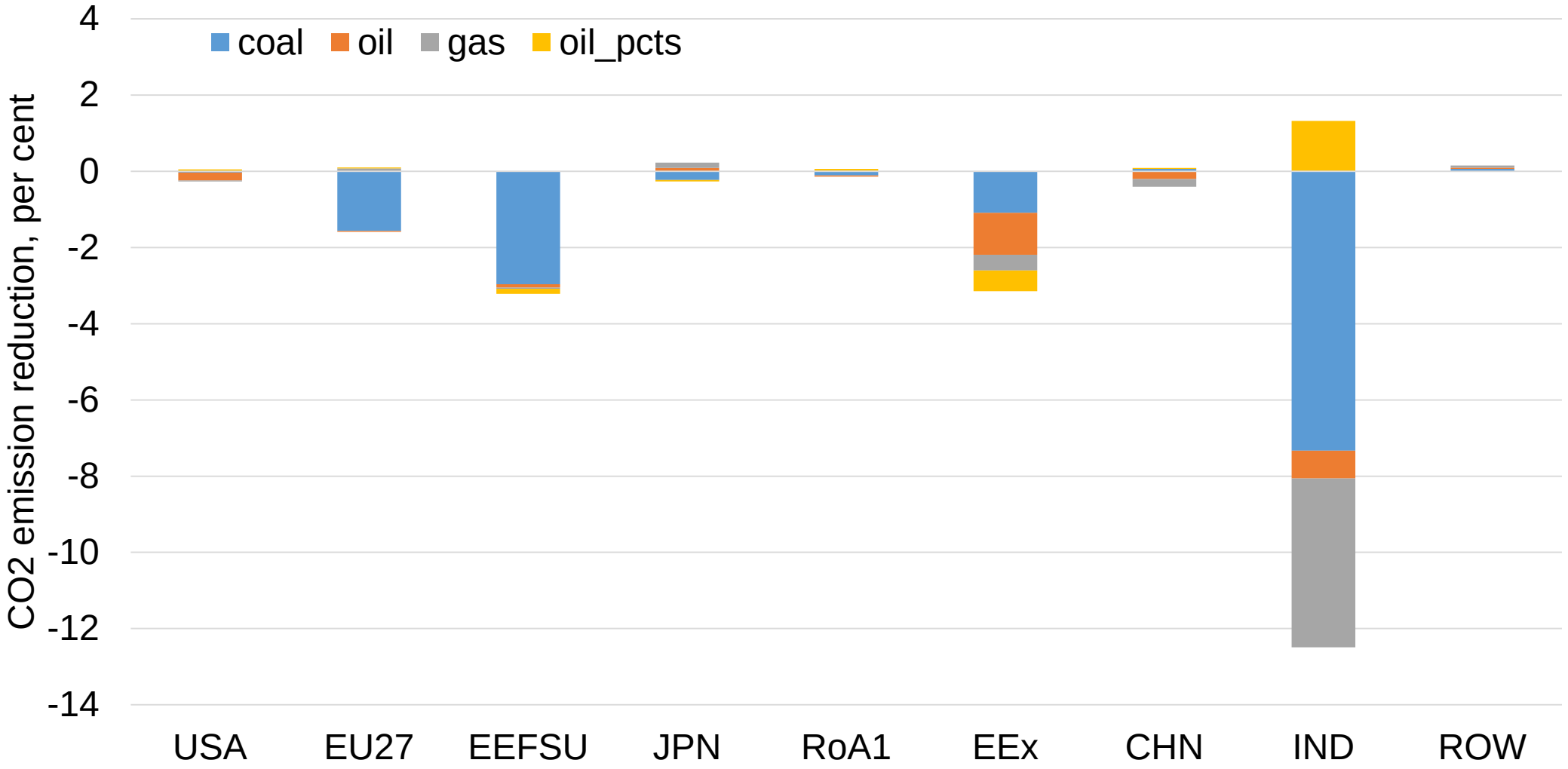
Simulation

- Shocks: Approx. $25bn reduction in subsidies
- Country aggregation and data (e.g. for China) are limitations

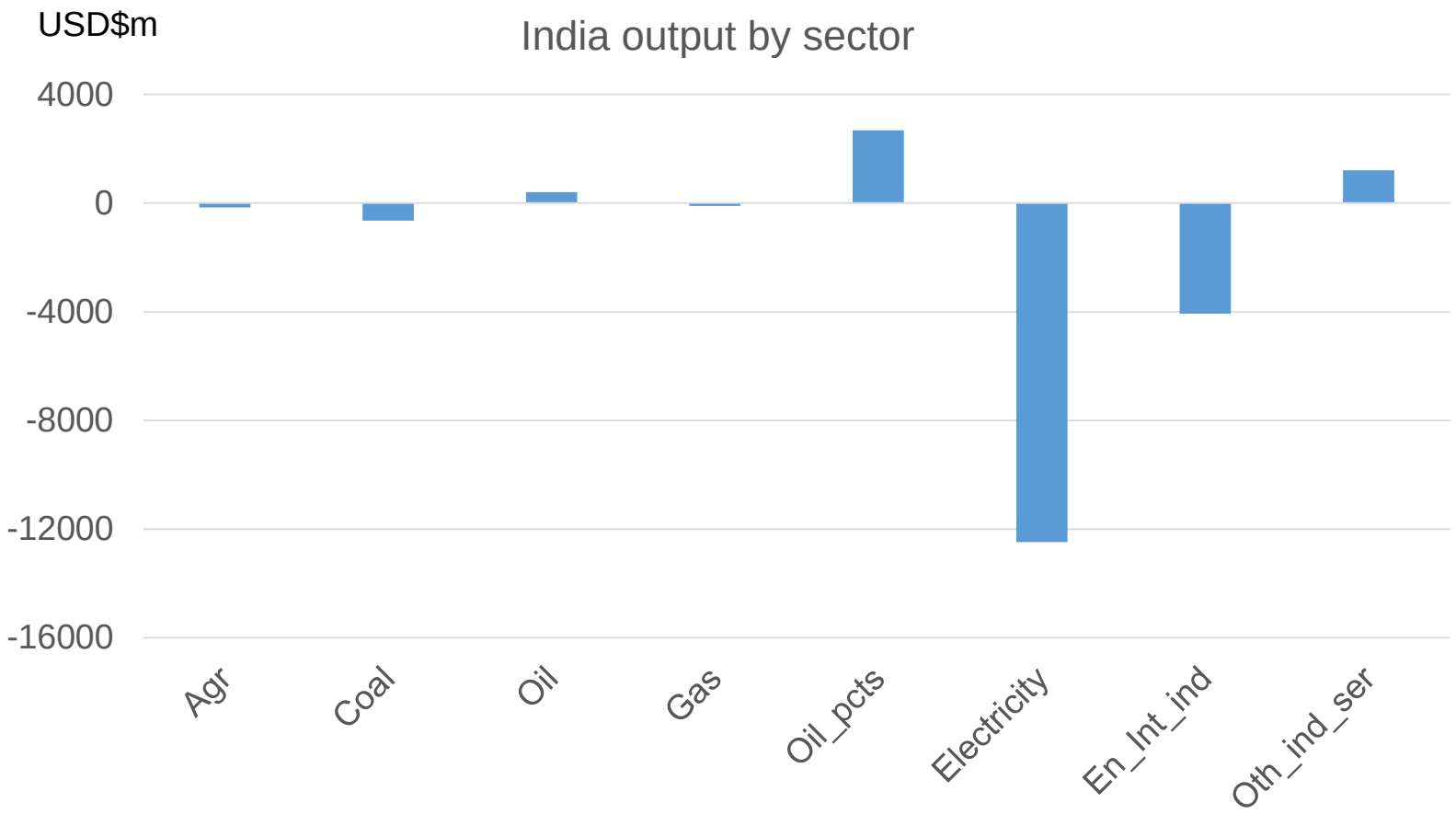


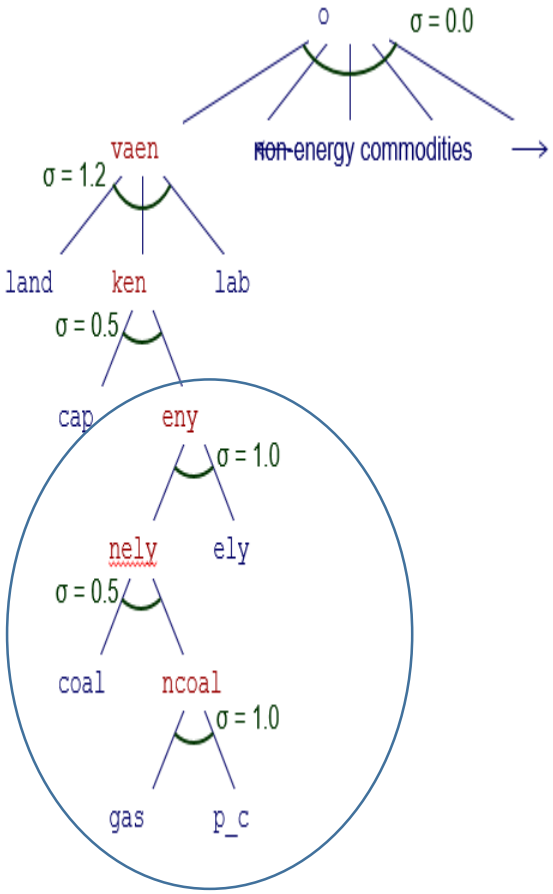


Finding 1: Global emissions fall by 0.5%

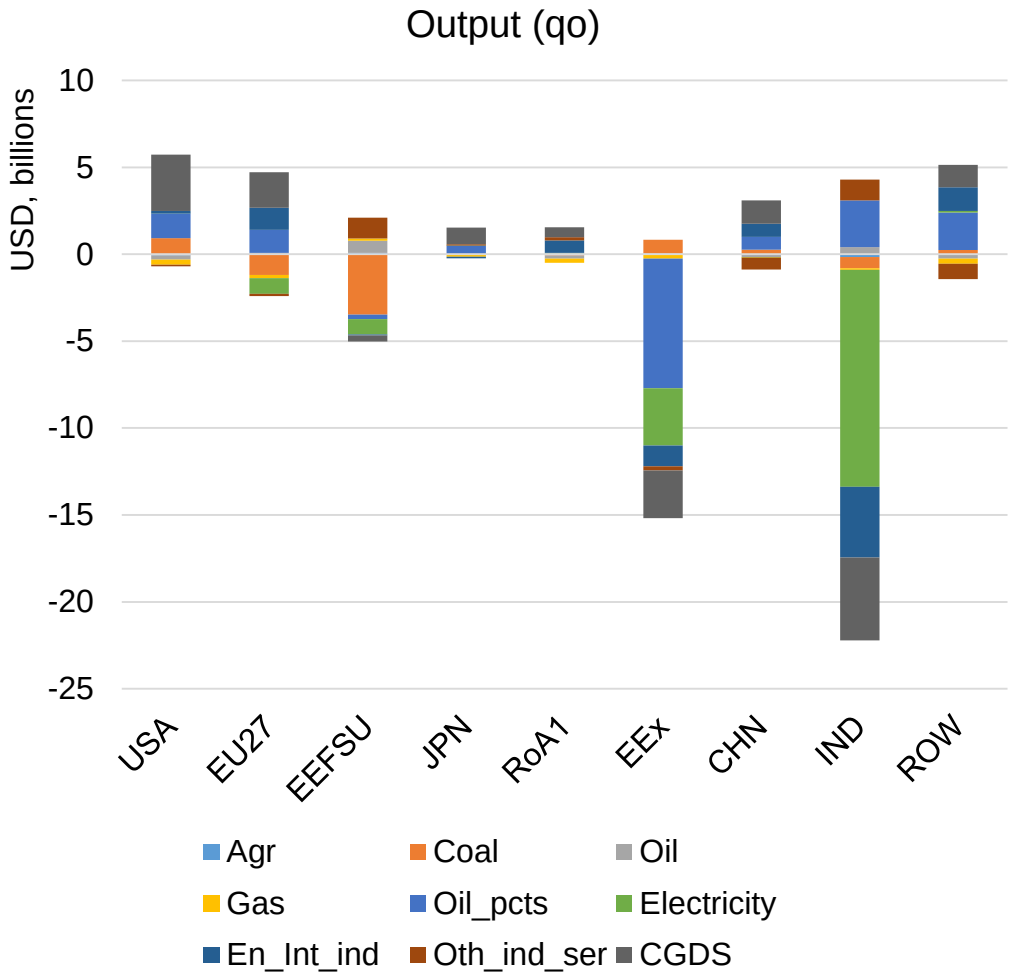


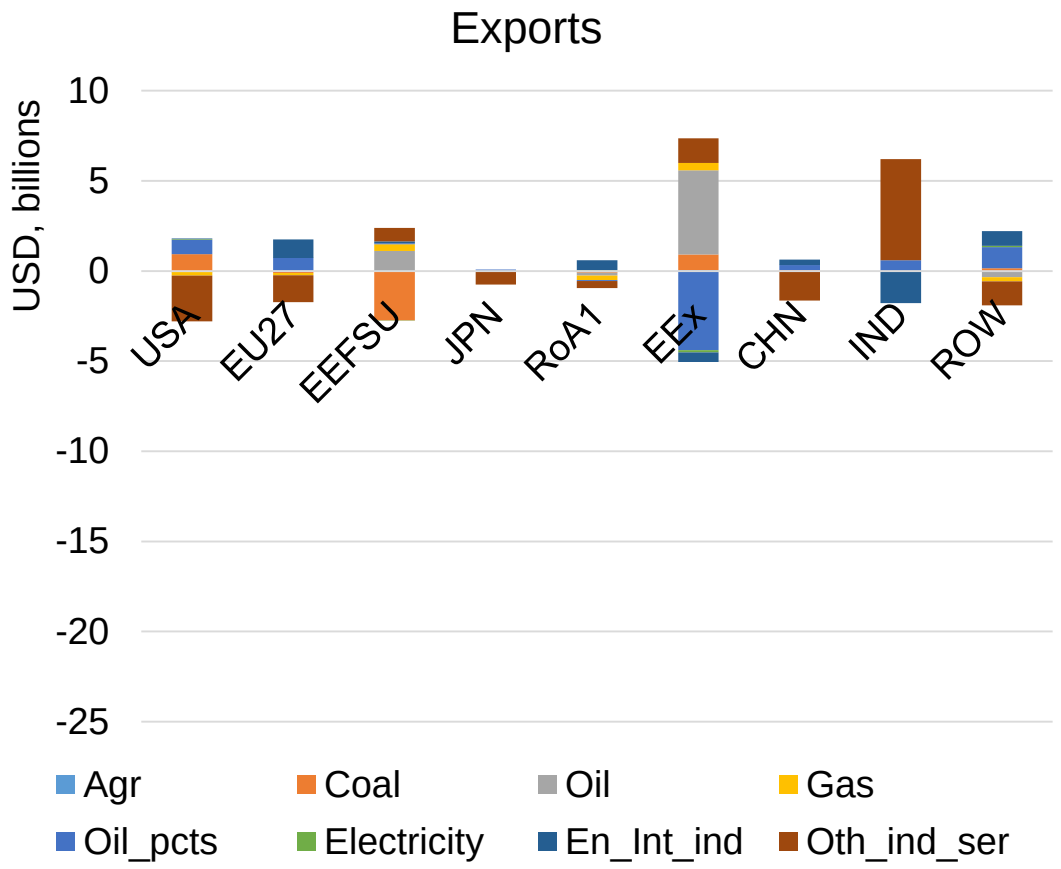
Finding 2: Output in India falls…



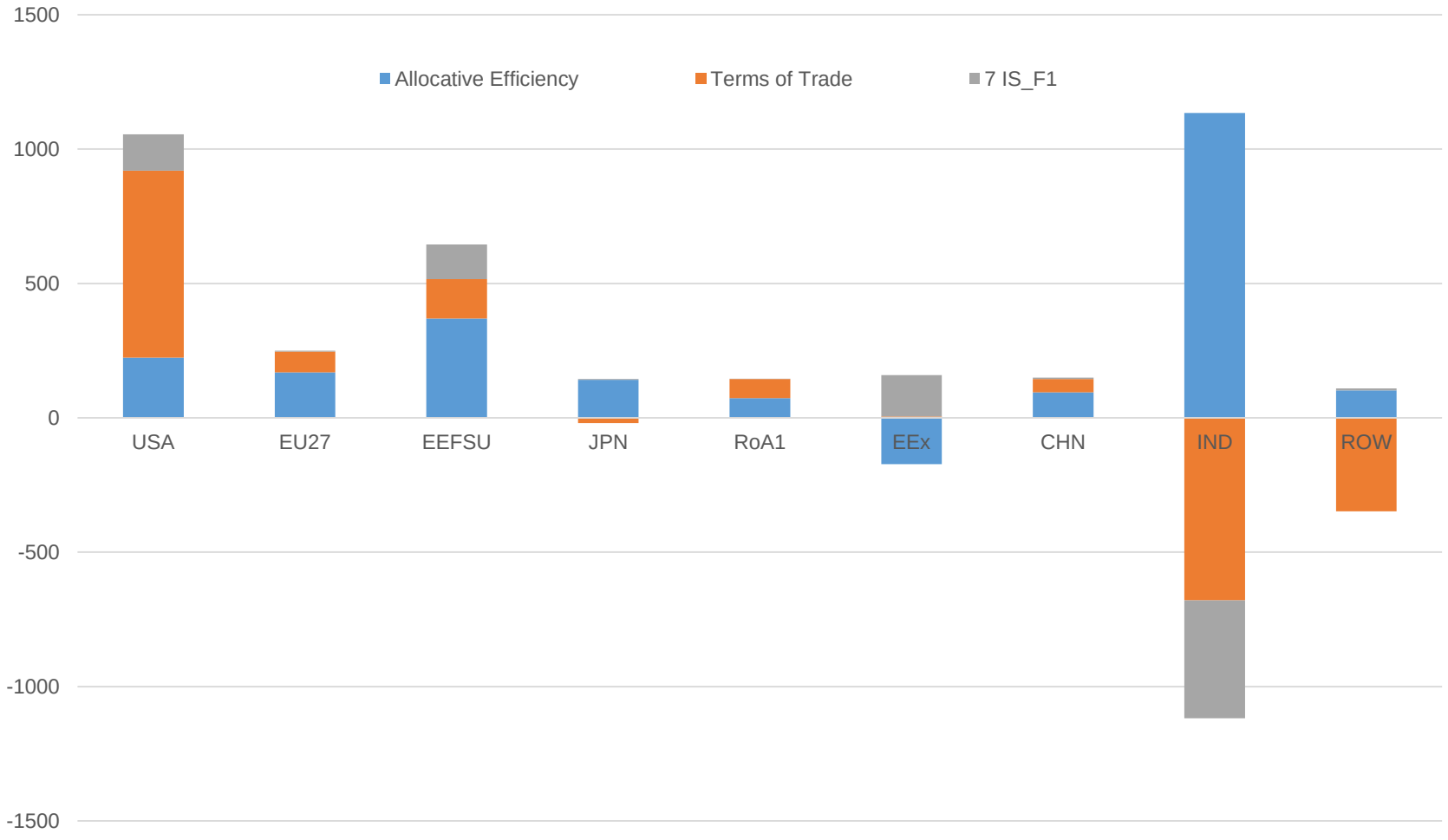


…but GDP in India increases slightly due to X and M





Finding 3: Welfare rises by $2136m



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Chasing the investment

a journey in the wrong direction

Cicero Lima and Joe Lane

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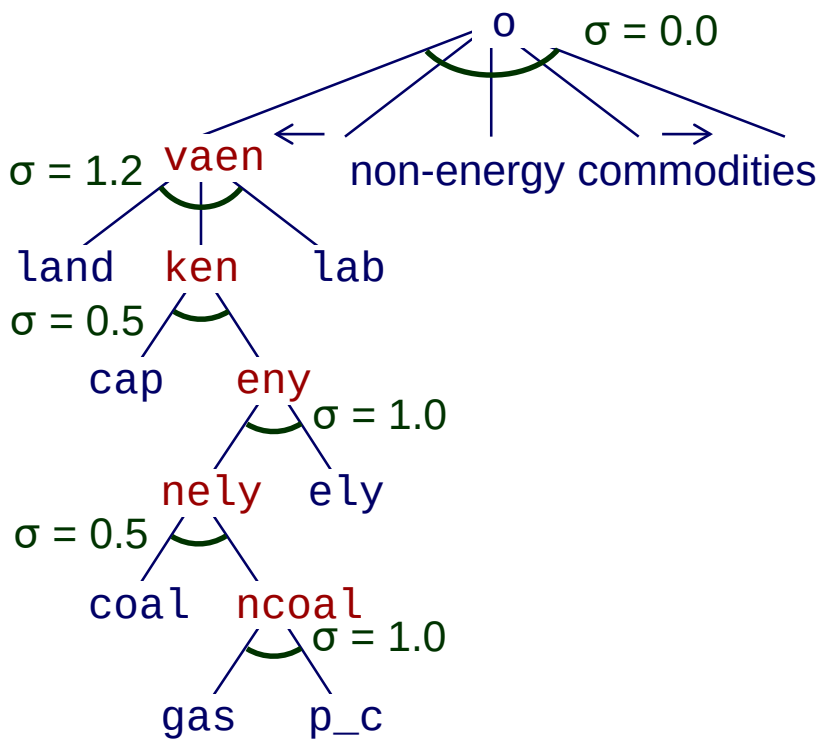
ABSTRACT

- The static-comparative GTAP-E doesn’t characterize renewables, & doesn’t characterize investment
- A substitution of capital for fossil fuel inputs does include the effect of shifting towards fossil-free (& low opex) renewables generation
- In order to consider whether gives us insight into the renewables investment challenge, we considered:
  1. What can be learned about capital (& investment…?) required to decarbonize electricity supply?
  2. How might the capital (& investment…?) challenges vary under different policy schemes?

Scenarios

Shocks

Country /	Emission reduction		
Region	(%)	(Mt-CO_2)	(t-CO_2 / pp)
USA	-22%	1,124	3.6
EU27	-17%	617	1.2
Japan	-33%	339	2.7
RoA1	-17%	178	2.4
EEFSU	+19%	+456	+



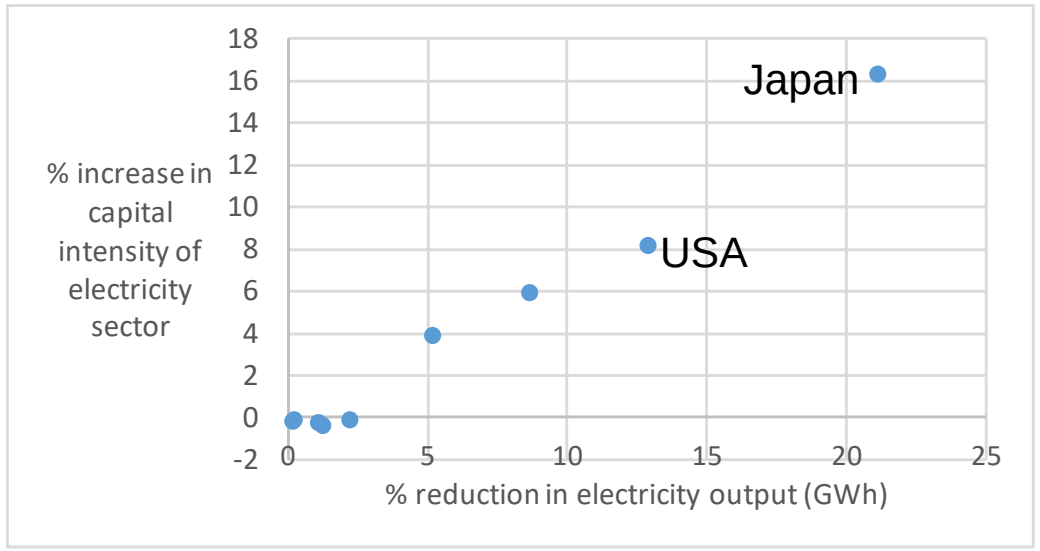
Scenarios

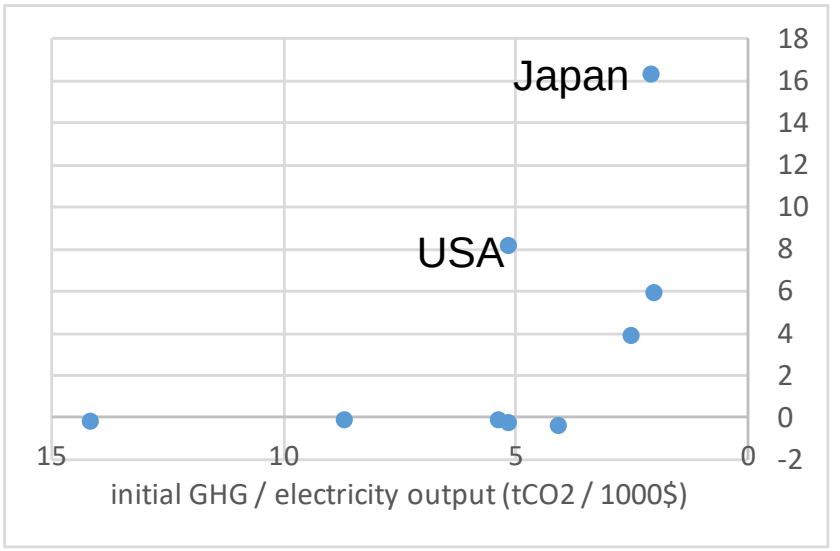
1) Carbon price applied internally in each of the 4x reducing regions *(no trade; EEFSU excluded)*

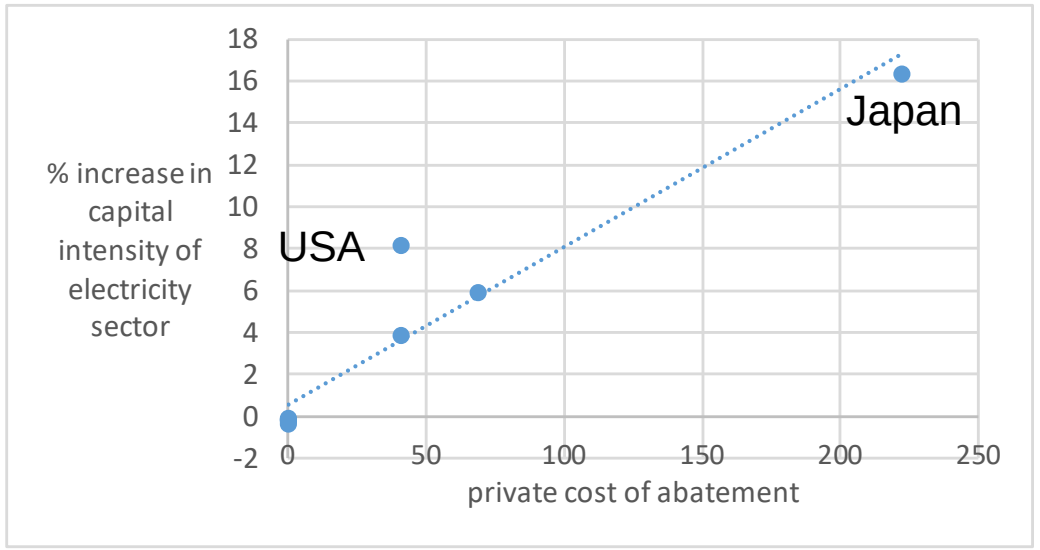
2) Permit trading between each of those 4x regions *(EEFSU excluded)*

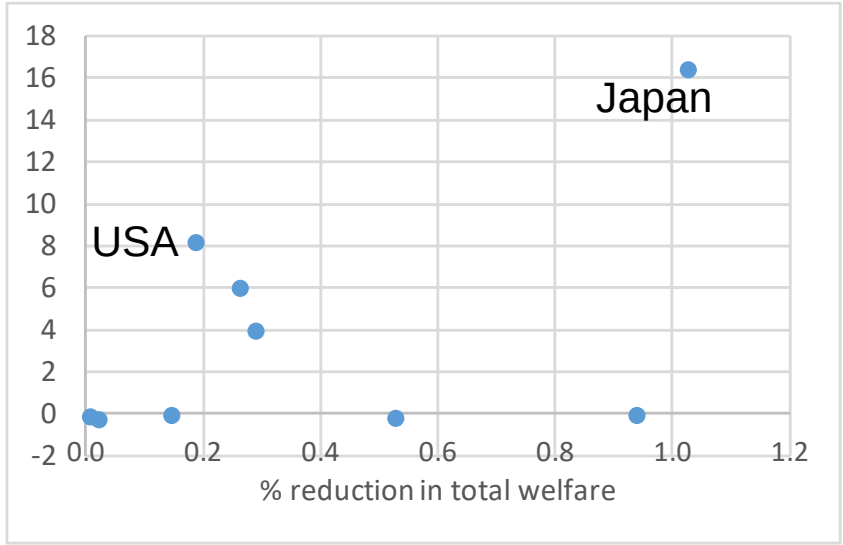
3) EEFSU included in the permit trading scheme

Results – no trade

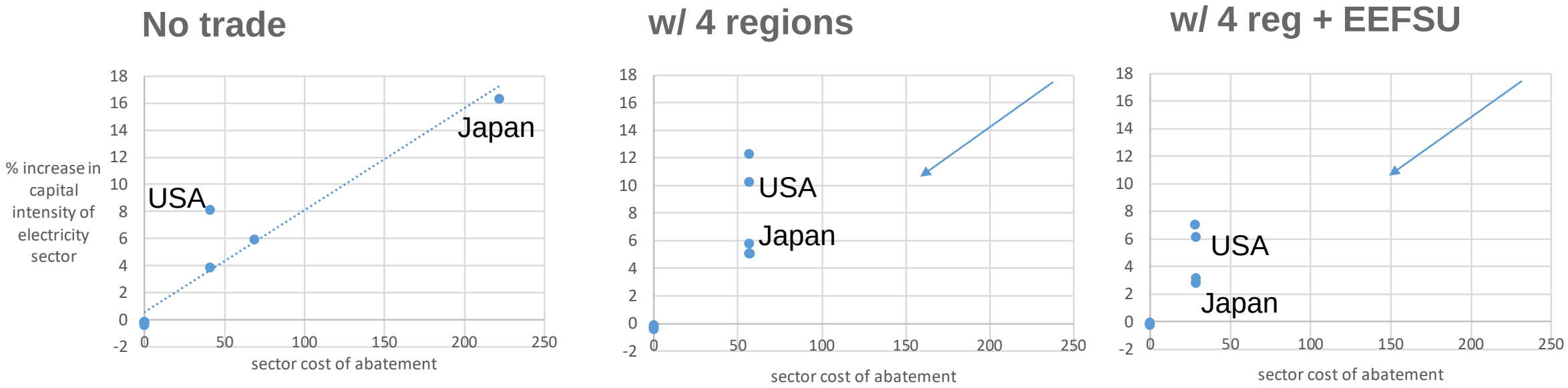








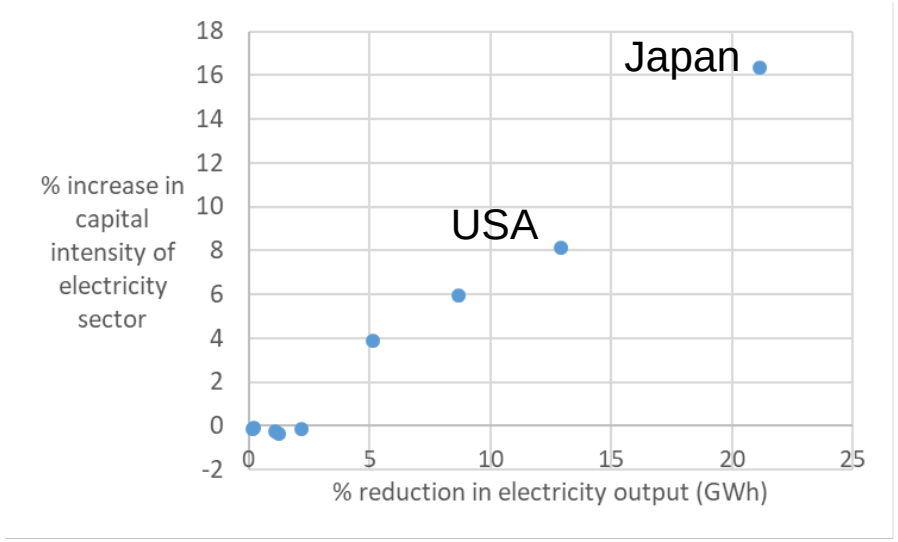
Results – cost of abatement



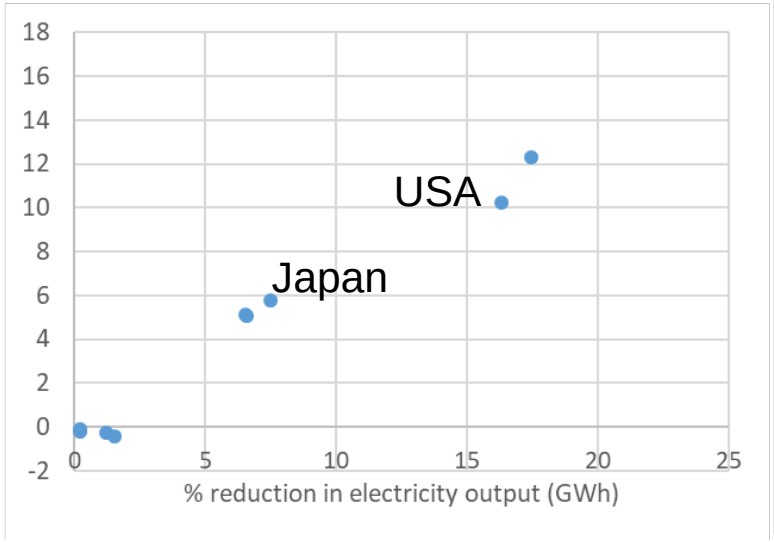
- Trade reduces the abatement cost for countries that required high capital investment for electricity *(under the non-trade scenario)*
- Equalisation of the capital intensities *(of the electricity sector)*

Results – reductions in electricity output

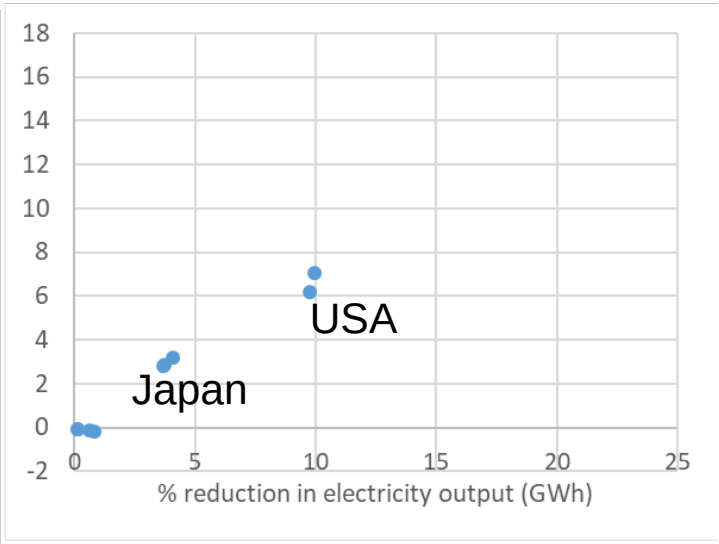
No trade



w/ 4 regions



w/ 4 reg + EEFSU



- Trade reduces the output & capital changes required for the countries that initially had an electricity system with low-GHG intensity

- Regional distribution of capital intensity change
  - ***Can we think of that as a proxy for the distribution of investment challenges…?***

Final remarks

What can you learn about capital investment to decarbonize electricity supply?

- *the low carbon scenarios require substantially higher capital intensity in the electricity sector*
- *proxy for the distribution of challenges with renewables investment…?*

How the investment (?) vary under different policy schemes?

- *Without trade, countries with low-GHG intensity electricity system face substantially larger challenges*
- *Expanding the trade network greatly reduces the abatement cost for the more CO2 efficient economies*

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Implications of a carbon tax in GTAP-E

Mark Staples

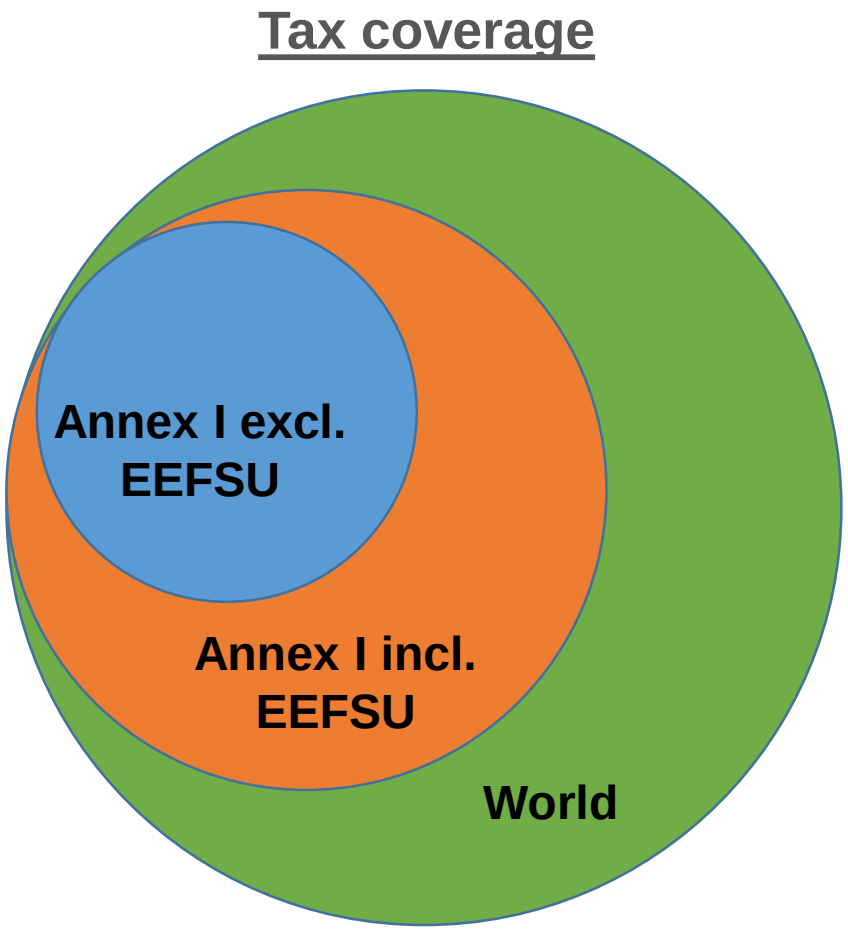
Enkhbayar Shagdar

Research questions & key findings

- **What level of emissions reductions are achieved under different CO_2 taxes?**
  - 50% reduction in emissions requires a global carbon tax > 200 USD/t_{CO2}
  - Marginal emissions reductions decrease with higher CO_2 taxes
- **How do the results change with global or regional coverage?**
  - CO_2 tax is less effective and equitable without global coverage
  - Leakage increases with higher CO_2 taxes
- **What are the macro-economic implications of CO_2 taxes?**
  - CO_2 taxes have a negative impact on global economic welfare
  - Impacts are regionally heterogeneous, and closely tied to emissions intensity of economies

Policy scenarios

- GTAP-E baseline indicates Kyoto commitments are possible with abatement costs of 2.1 USD/t CO_2
- We explore CO_2 tax rates from 2 up to 200 USD/t CO_2
- 3 different coverages of the tax are considered



Implementing a carbon tax in GTAP-E

- In the base version of GTAP-E, CO2 quotas (gCO2q) are exogenous, and permit price is endogenous
- We want to reverse this to implement a carbon tax

Modified closure

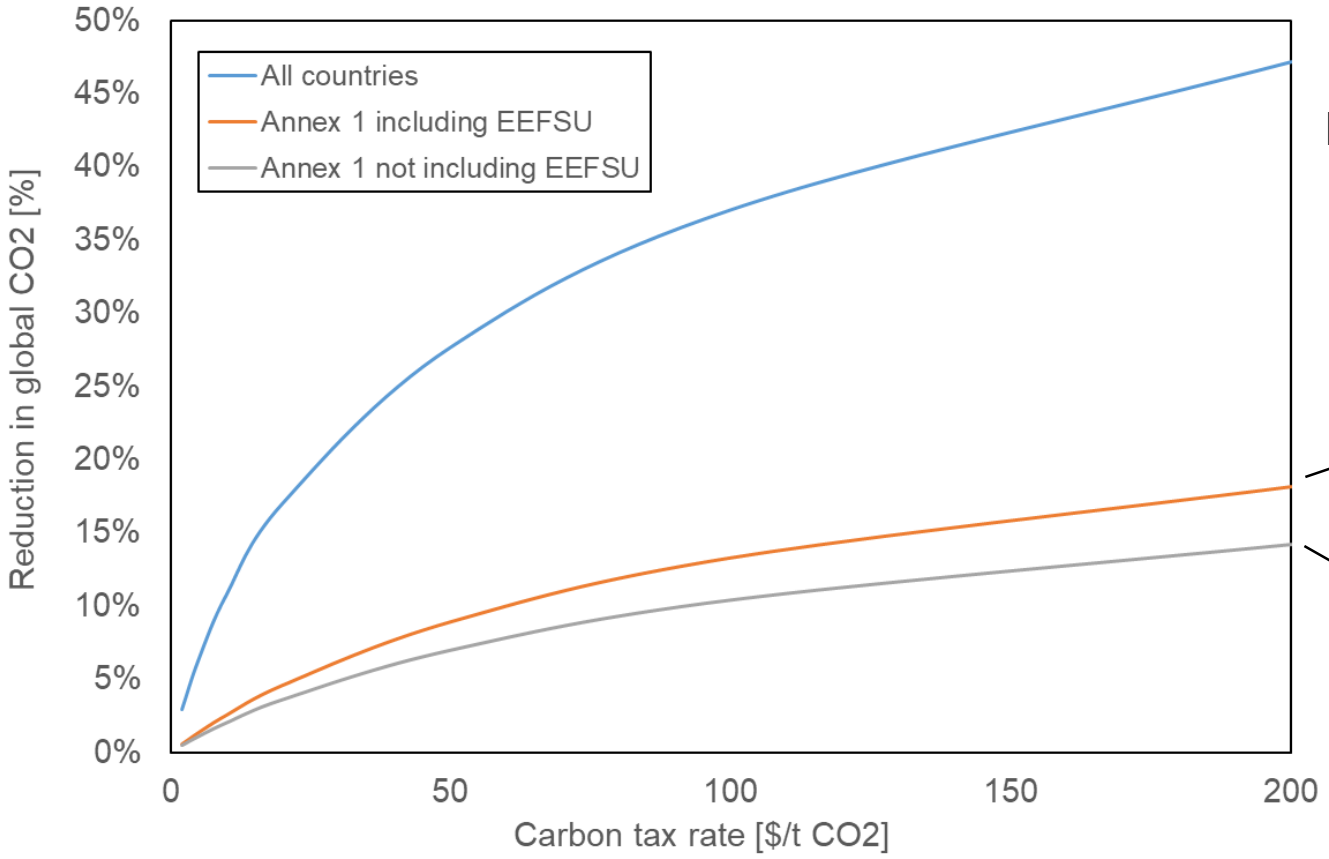
```
! basic closure
exogenous
   afall
   :
   txs
   ;
Rest Endogenous ;
!   DBALCAR (incl. permit trading)  exogenous for all regions except one,
!   and cgdslack exogenous for that one region (which can be any one).
swap cgdslack = DBALCAR;
swap DBALCAR("ROW") = cgdslack("ROW");

swap RCTAXB = NCTAXB;
!swap pempb("world")= NCTAXB("world");
!swap qco2q= pemp;
```

Example shocks

```
Shock NCTAXB("USA") = 100;
Shock NCTAXB("EU27") = 100;
Shock NCTAXB("JPN") = 100;
Shock NCTAXB("RoA1") = 100;
```

CO_2 reductions vs. carbon tax rate



$$\text{Leakage rate} = \frac{\text{Inc. } CO_2 \text{ outside of coverage}}{\text{Dcr. } CO_2 \text{ inside of coverage}}$$

6.8%

5.3%

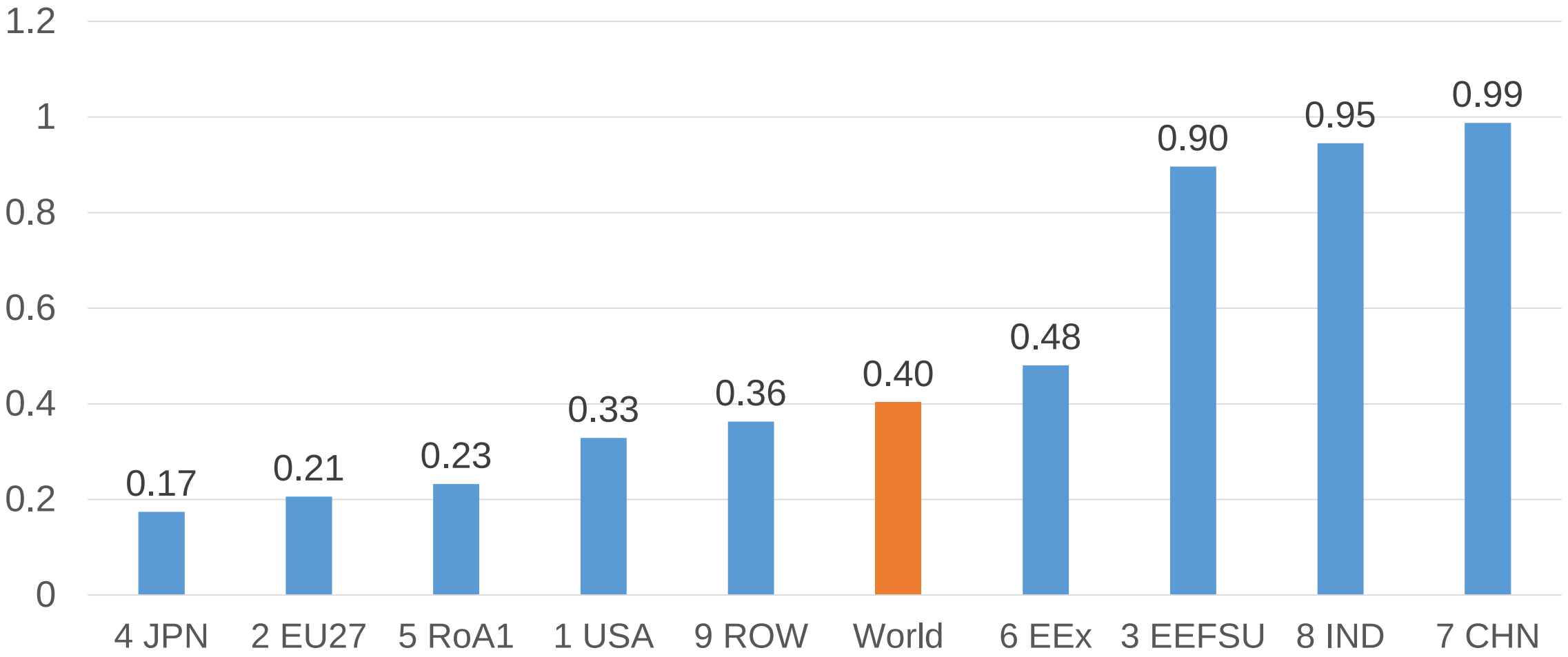
Source: Simulation results

CO_2 reductions & welfare impacts of a global carbon tax

	$2/t CO2		$10/t CO2		$50/t CO2		$100/t CO2		$200/t CO2	
	CO2	u	CO2	u	CO2	u	CO2	u	CO2	u
USA	-1.7%	0.0%	-7.2%	0.0%	-24.3%	-0.2%	-35.5%	-0.5%	-47.3%	-1.1%
EU27	-0.7%	0.0%	-3.2%	0.0%	-12.1%	0.0%	-19.1%	-0.1%	-28.4%	-0.4%
EEFSU	-1.7%	0.0%	-7.1%	-0.2%	-24.1%	-1.1%	-35.8%	-2.7%	-48.4%	-6.2%
JPN	-0.6%	0.0%	-2.8%	0.0%	-10.8%	0.1%	-17.6%	0.1%	-26.6%	-0.1%
RoA1	-1.2%	0.0%	-5.3%	0.0%	-18.4%	-0.3%	-27.5%	-0.7%	-38.4%	-1.4%
EEx	-1.9%	0.0%	-8.4%	-0.2%	-24.2%	-1.2%	-32.3%	-2.3%	-41.6%	-4.3%
CHN	-4.8%	0.0%	-18.0%	-0.2%	-42.8%	-1.2%	-53.9%	-2.3%	-64.0%	-4.3%
IND	-11.4%	0.0%	-31.9%	-0.1%	-51.1%	-0.4%	-57.6%	-0.7%	-64.4%	-1.5%
ROW	-1.8%	0.0%	-6.7%	0.0%	-18.7%	-0.2%	-26.4%	-0.4%	-35.9%	-1.1%
World	**-2.9%**		**-10.7%**		**-27.7%**		**-37.1%**		**-47.2%**	

Source: Simulation results

Carbon Intensity (t_{CO2}/USD)



Source: Simulation results

Welfare decomposition summary

	1 co2trd	2 alloc_A1	6 tot_E1	7 IS_F1	Total
USA	0.20	(94,165.0)	24,412.0	4,075.0	(65,677.0)
EU27	0.00	(67,022.0)	50,747.0	(920.0)	(17,195.0)
EEFSU	0.20	(35,338.0)	(29,096.0)	2,401.0	(62,032.0)
JPN	0.00	(15,836.0)	19,574.0	(492.0)	3,245.0
RoA1	0.00	(18,602.0)	(7,802.0)	(1,141.0)	(27,545.0)
Eex	0.00	(40,464.0)	(94,062.0)	1,215.0	(133,311.0)
CHN	(5.40)	(154,579.0)	13,605.0	(3,927.0)	(144,907.0)
IND	0.00	(21,272.0)	8,342.0	280.0	(12,651.0)
ROW	(0.10)	(49,117.0)	13,822.0	(1,496.0)	(36,792.0)
Total	(5.20)	(496,396.0)	(459.0)	(6.0)	(496,866.0)

Source: Simulation results for 100 USD/t CO_2

Conclusions

- At higher CO2 taxes:
  - Marginal emissions reductions decrease
  - Leakage increases (in the absence of global coverage)

- CO_2 tax is less effective and less equitable without global coverage

- CO_2 taxes have a negative impact on global economic welfare

- Impacts are regionally heterogeneous, and closely tied to emissions intensity of economies

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Panel Q&A

(All presenters from group)

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