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Impact of Energy Mix Transition in China's Power Sector on the Domestic and Global Economy and CO₂ Emissions



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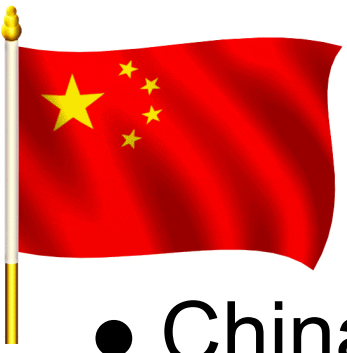


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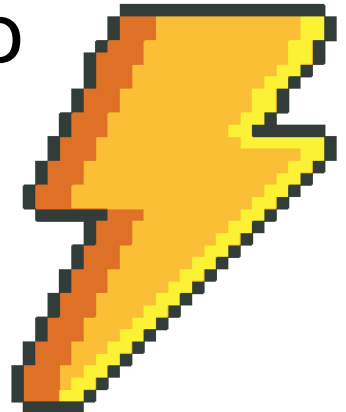
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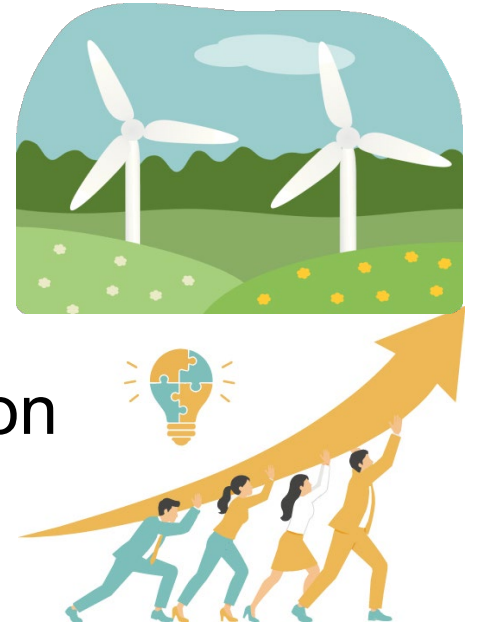
1. Introduction

- China is the world's largest emitter of CO₂.
 - High reliance on coal power generation
 - Industrial structure centered on manufacturing
- China's "Dual Carbon Goals"
 - Peak out of CO₂ emissions by 2030
 - To achieve carbon neutrality by 2060
- Decarbonization of the power sector is essential to achieving the "Dual Carbon Goals".



1. Introduction: Objective

- Conventional measure for decarbonization
 1. Transition from coal power to renewable energy
 2. Efficiency Improvement of coal-fired power generation
- Objective of this study
 - To examine the impact of changes in China's power mix and efficiency Improvement on the domestic / other countries' CO₂ emissions
 - To examine “Carbon Leakage” from the perspective of countries/regions and sectors.



2. Model and Data: Model

- The GTAP-E-Power (GTAP-EP) model
 - The power generation sector consists of multiple activities and allows for the switching of power generation technologies.
 - Peters, J. C. (2016). GTAP-E-Power: An Electricity-detailed Economy-wide Model. *Journal of Global Economic Analysis*, 1(2), 156-187.
- Power sector
 - See the sector classification 
- Production factors
 - Mobile, Sluggish, and Fixed
 - We modified the model where we can fix (change) the capitals of the power sector activities.

2. Model and Data: Aggregation

- The GTAP-Power Data Base, version 11
 - Corresponding to the 2017 global economy
 - 160 countries/regions
 - 76 sectors
- Aggregation in this study
 - 22 countries/regions mainly in Asia
 - 20 sectors same as Peters (2016)

2. Model and Data: Elasticity of substitution

	Among production factors σ_{VAE}			Between capital and energy σ_{KE}		
	Ver.10 Default	Ver.11 Default	Our study	Ver.10 Default	Ver.11 Default	Our study
Nuclear	0.00	1.26	0.00	0.00	0.50	0.00
Renewable	0.00	1.26	0.00	0.00	0.50	0.00
Coal fired	1.17	1.26	0.00	0.50	0.50	0.00



3. Simulation : Scenarios

- Scenario 1: Total capital stock remains constant
 - 10% of China's coal power capital shifts to renewable energy power generation capital.
- Scenario 2: Total power generation is constant
 - 10% decrease in the capital of coal power generation in China
 - Increase in capital of renewable energy power generation.
- Scenario 3: Total power generation is constant
 - 10% efficiency improvements in coal power generation in China.

3. Simulation: Scenario 2

Scenario	Transition from coal to renewable power generation
Wind	Coal power capital –10%, Wind power capital increases
HydroBL	Coal power capital –10%, Const. power output increases
HydroPL	Coal power capital –10%, Const. power output increases
Solar	Coal power capital –10%, Const. power output increases

3.Simulation: Domestic Impacts

- The electricity prices will rise slightly except for Solar scenario.
- Coal consumption will be reduced.
- China's CO₂ emissions will decrease by about 3 ~ 4%.

Domestic impacts (% deviations from the initial state)

%	GDP %	Electricity %		Coal %		CO ₂ %	
		Output	Price	Output	Price	China	World
Wind	0.04	0.00	0.30	-4.84	-1.70	-4.16	-1.19
HydorBL	0.02	0.00	1.74	-4.82	-1.59	-4.06	-1.17
HydroPL	0.08	0.00	0.14	-4.87	-1.69	-3.86	-1.14
Solar	-1.23	0.00	31.28	-4.38	-0.84	-2.85	-0.95

3.Simulation: Domestic Sectoral Impacts

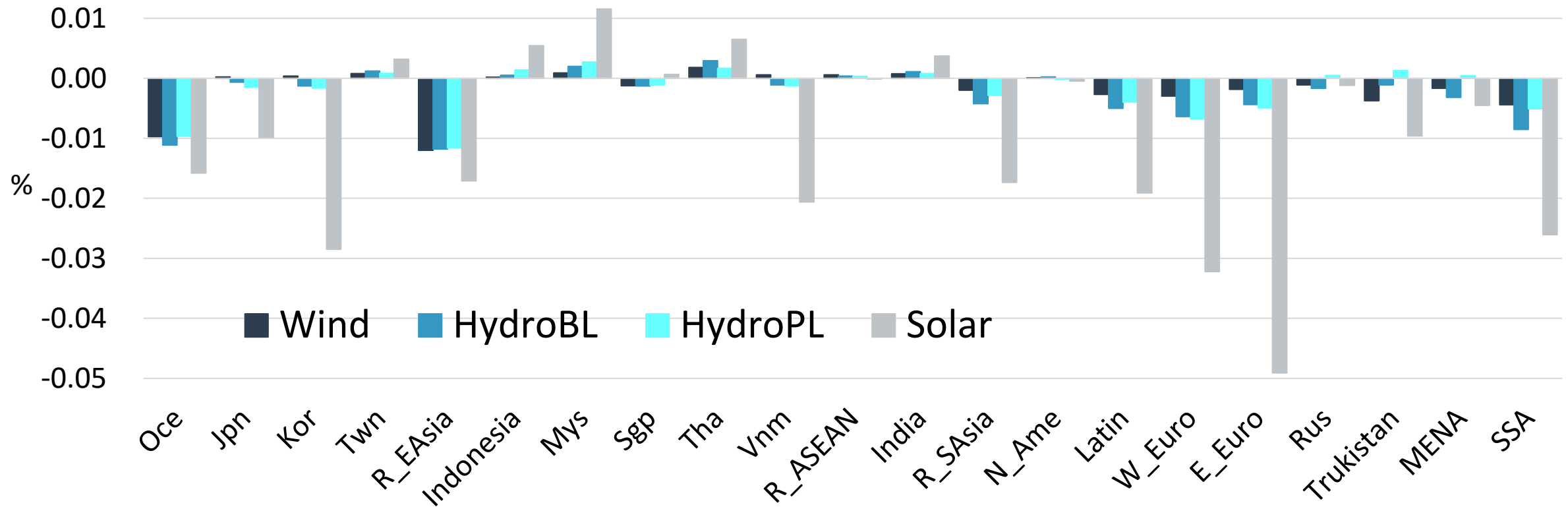
- Capital productivity of renewables is lower than that of thermal power generation → Change in output of renewables is quite large.
- Aside from solar power generation, the economic burden will be offset by increased production in the service sector.

Domestic Sectoral impacts (% deviations from the initial state)

	Output change of renewables %	Output change of other sectors %		
		Energy intensive	Other manufacture	Services
Wind	321.37	-0.10	-0.13	0.10
HydroBL	414.28	-0.27	-0.27	0.13
HydroPL	97.14	-0.13	-0.17	0.14
Solar	8,463.52	-1.86	-2.37	-0.26

3. Simulation: Overseas impacts on GDP

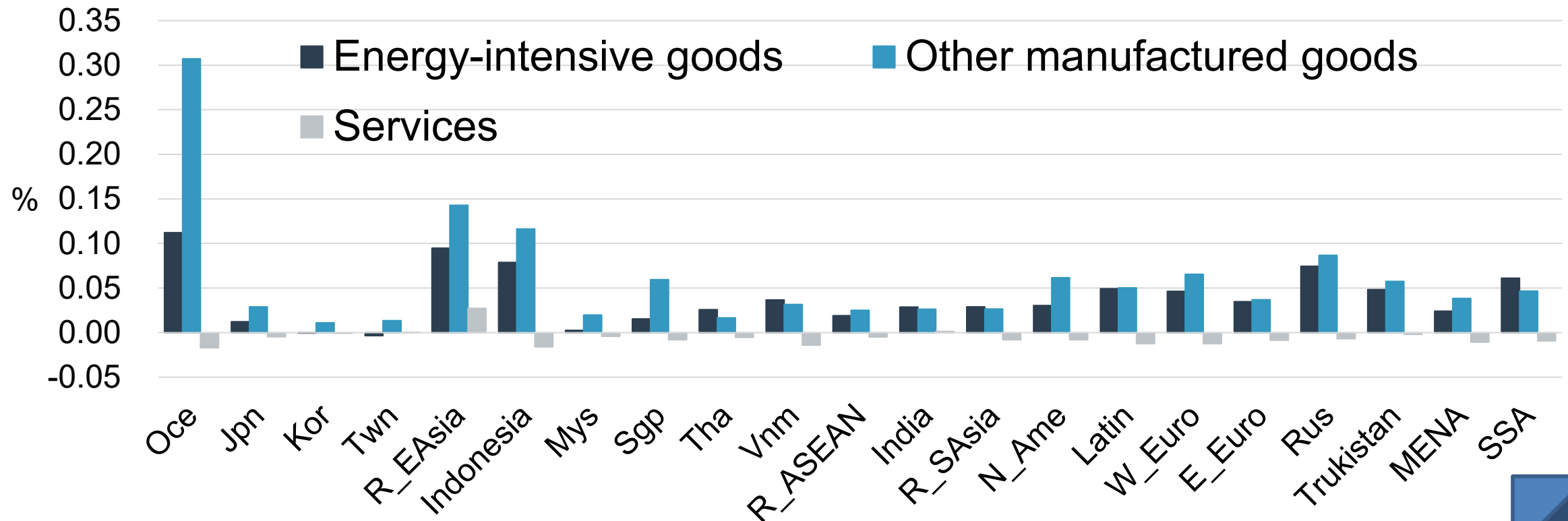
- GDP decreases slightly (in more than half of the C/Rs).



Impacts on GDP overseas (% deviations from the initial state)

3. Simulation: Overseas sectoral impacts for Wind scenario

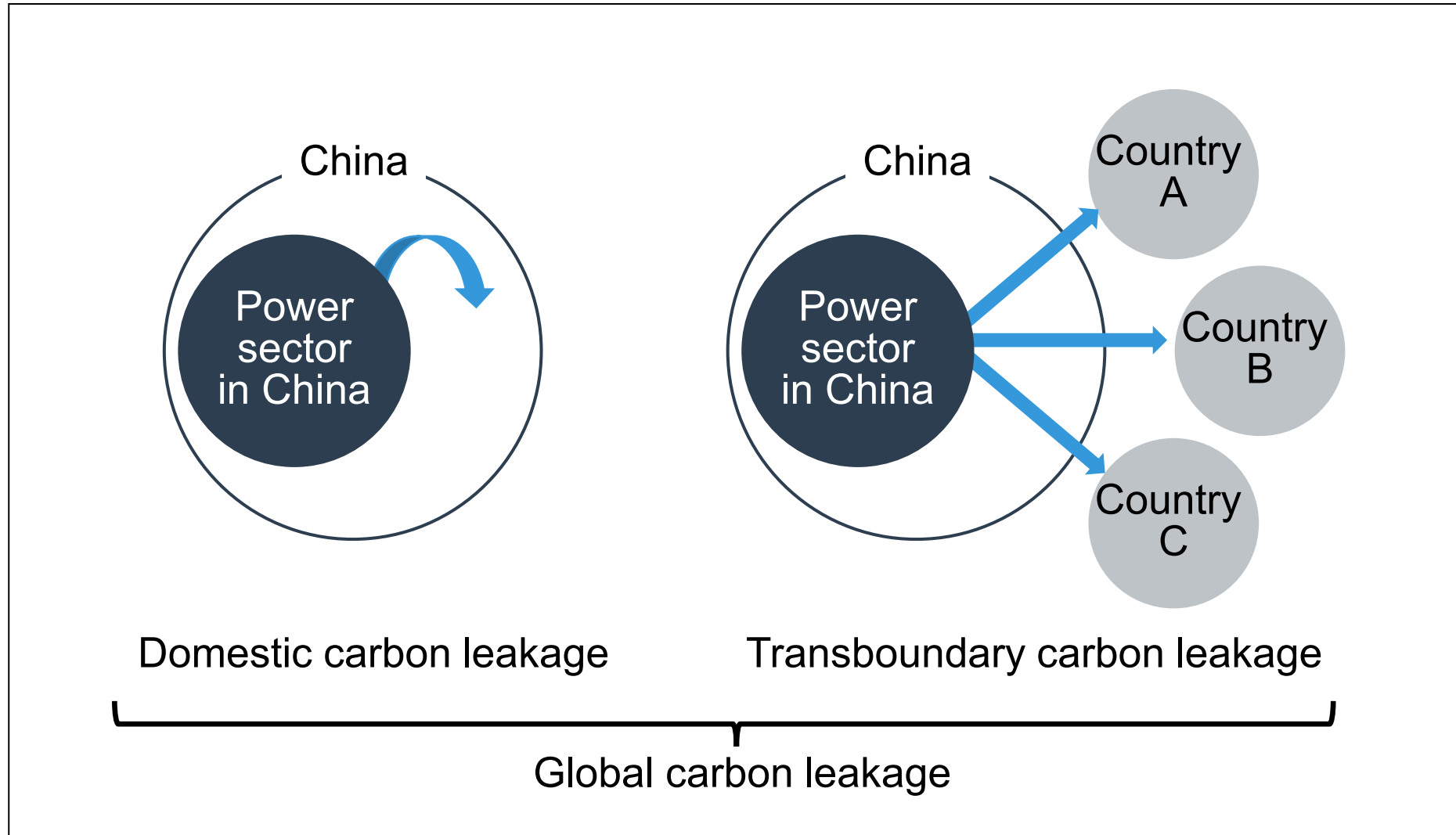
- Outside of China, production of energy-intensive goods and other manufactured goods increase
- On the other hand, production of services decreases.



Overseas sectoral impacts for Wind scenario



4. Country-specific carbon leakage

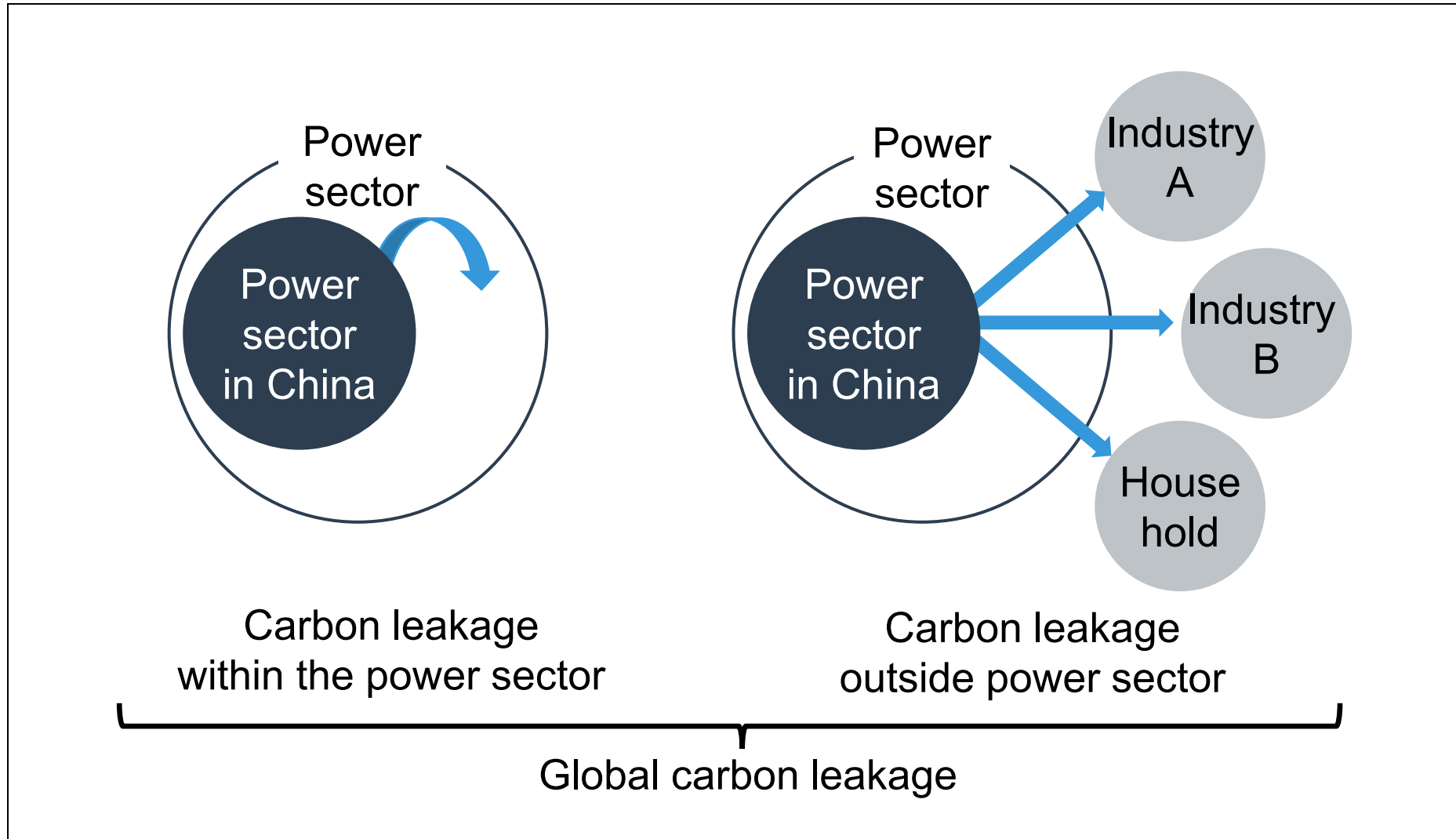


4. Country-specific carbon leakage (Wind)

- Most of the country-specific carbon leakage occurs in China.
- Country-specific carbon leakage occurs in 14/21 C/Rs.

	Electricity	Ene_Int	O_mnf	Services	ROI	HHs	Total	C_leakage
Oceania	0.02	0.11	0.02	-0.12	0.03	-0.08	-0.02	-0.02
China	-421.54	15.51	2.65	5.16	0.72	4.57	-392.92	28.62
Japan	0.06	0.21	0.05	0.04	0.01	0.04	0.41	0.41
Korea	0.02	0.08	0.01	0.05	0.00	0.05	0.21	0.21
Indonesia	-0.01	0.30	0.08	-0.10	0.01	-0.07	0.21	0.21
India	-1.29	0.68	0.08	0.11	0.01	0.09	-0.31	-0.31
N_Ame	-0.01	0.22	0.11	-0.20	0.07	-0.07	0.12	0.12
W_Euro	-0.13	0.17	0.05	-0.14	0.02	-0.01	-0.04	-0.04
ROW	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
World	-422.88	17.27	3.06	4.80	0.87	4.52	-392.36	29.18
S_leakage	-1.34	17.27	3.06	4.80	0.87	4.52	29.18	

4. Sector-specific carbon leakage



4. Sector-specific carbon leakage (Wind)

- Sector-specific carbon leakage occurs in all sectors except power.

	Electricity	Ene_Int	O_mnf	Services	ROI	HHs	Total	C_leakage
Oceania	0.02	0.11	0.02	-0.12	0.03	-0.08	-0.02	-0.02
China	-421.54	15.51	2.65	5.16	0.72	4.57	-392.92	28.62
Japan	0.06	0.21	0.05	0.04	0.01	0.04	0.41	0.41
Korea	0.02	0.08	0.01	0.05	0.00	0.05	0.21	0.21
Indonesia	-0.01	0.30	0.08	-0.10	0.01	-0.07	0.21	0.21
India	-1.29	0.68	0.08	0.11	0.01	0.09	-0.31	-0.31
N_Ame	-0.01	0.22	0.11	-0.20	0.07	-0.07	0.12	0.12
W_Euro	-0.13	0.17	0.05	-0.14	0.02	-0.01	-0.04	-0.04
ROW	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
World	-422.88	17.27	3.06	4.80	0.87	4.52	-392.36	29.18
S_leakage	-1.34	17.27	3.06	4.80	0.87	4.52	29.18	



5. Conclusion

- Carbon leakage with renewable energy shift in China
 - Power price rises while coal prices are falling. → Domestic CL
 - Outside of China, production of energy-intensive goods increase and coal prices decrease. → Transboundary CL
 - By sector, CL occurs in all sectors except the power sector.
- For global decarbonization
 - China's own actions is important
 - Commitment from trading partners is also important
 - Global cooperation to address the challenges of Transboundary CL.



Sectoral Aggregation

No.	Coad	Sector	No.	Coad	Sector
1	Primary	Agri, forestry, and fisheries	11	HydroB	Hydro power base load
2	Coal	Coal mining	12	OilB	Oil power base load
3	Oil	Crude oil mining	13	OtherB	Other base load (biofuels, waste, geothermal, and tidal technologies)
4	Gas	Gas manufacture, distribution.	14	GasP	Gas power peak load
5	P_C	Petroleum, coal products	15	HydroP	Hydro power peak load
6	TnD	Electricity trans and distribution	16	OilP	Oil power peak load
7	NuclearB	Nuclear power base load	17	SolarP	Solar power peal load
8	CoalB	Caol power base load	18	Ells	Energy intensive industries
9	GasB	Gas power base load	19	O_mfr	Other manufacturing industries
10	WindB	Wind power base load	20	Svc	Services

