Developing renewable electricity with carbon tax recycling mechanisms in the East Asia region

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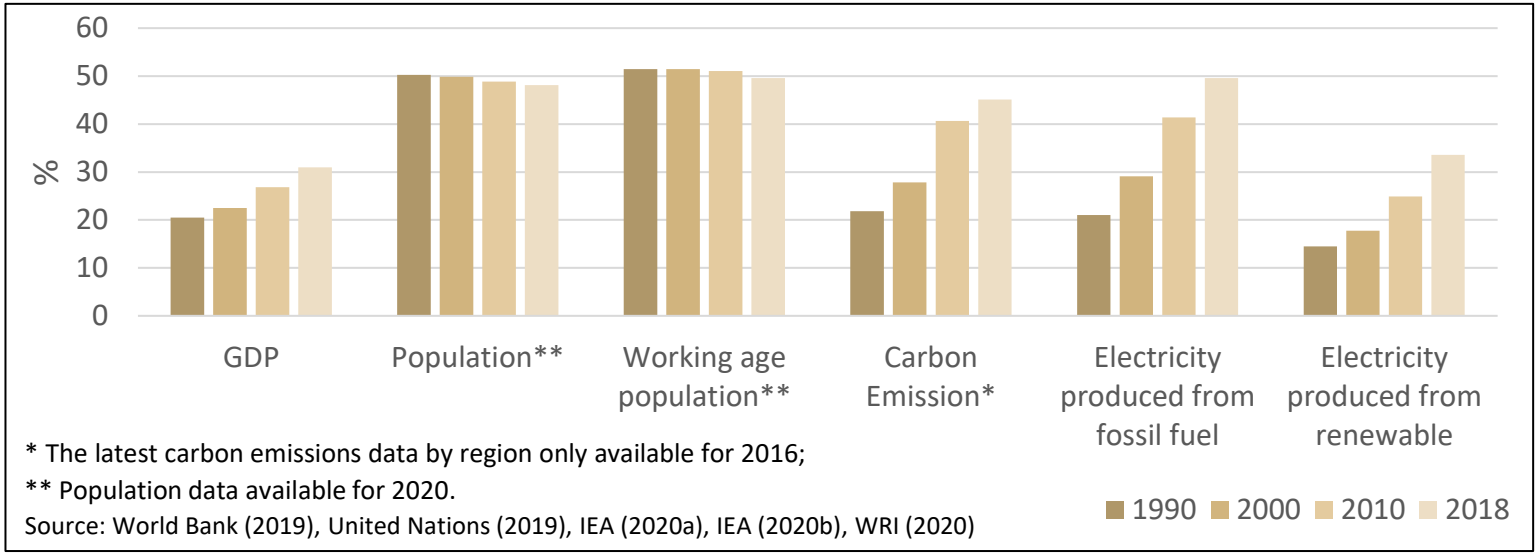
Introduction

The importance of East Asia region



* The latest carbon emissions data by region only available for 2016;
** Population data available for 2020.
Source: World Bank (2019), United Nations (2019), IEA (2020a), IEA (2020b), WRI (2020)

- East Asia region is becoming more important in term of the economy & population.
- However, its carbon emissions increasing since the region consumed more fossil fuel to generate more electricity.
- **How to produce enough electricity → enhance the economy with lower emissions?**

Introduction

Renewable electricity in East Asia

- There are still several barriers of renewable electricity development in developing countries, including East Asia.
  - ✓ fluctuate investment in renewable electricity
  - ✓ relatively cheaper price of fossil fuels
  - ✓ subsidised on-grid electricity tariff

    (ERIA 2020; IEA 2019b; REN21 2019; Burke et al. 2019).
- **How to overcome those barriers in developing renewable electricity?**

  Carbon tax as a solution:
  - ✓ increasing fossil fuels' prices, reduces demand on fossil fuels, reducing carbon emissions
  - ✓ additional revenue for government that can be recycled back into the economy
- **However:**
  - ✓ There is a limited study on developing renewable energy using recycling carbon mechanism
  - ✓ There is an unclear distributive impacts on the household expenditure

Introduction

Objective of this study

- Analyse implications of methods in developing renewable electricity:
  - ✓ indirect tax reduction for renewable electricity sectors, and
  - ✓ subsidy for the household to consume more renewable electricity

  utilising carbon tax recycling mechanisms in East Asian countries.

- The observed indicators are broadly categorized as:
  - ✓ sectoral impacts: sectoral price and total output changes,
  - ✓ macroeconomics impacts: carbon emission and GDP changes,
  - ✓ microeconomics impacts : household expenditure and poverty incidence changes.

Introduction

Contributions

- One of the few research on developing renewable electricity:
  - ✓ Carbon tax recycling mechanism for renewable electricity development
- Develop CGE with a flexible electricity inputs production function:
  - ✓ Sector can substitute between different sources of electricity (renewable electricity or fossil fuel electricity)
- Covers East Asia region (East Asia Energy Market Integration 2005):
  - ✓ Australia (AUS), China (CHN), Japan (JPN), South Korea (KOR), and India (IND), as well as ASEAN countries, namely Indonesia (IDN), Malaysia (MYS), the Philippines (PHL), Singapore (SGP), Thailand (THA), Vietnam (VNM), and rest of ASEAN (XSE).

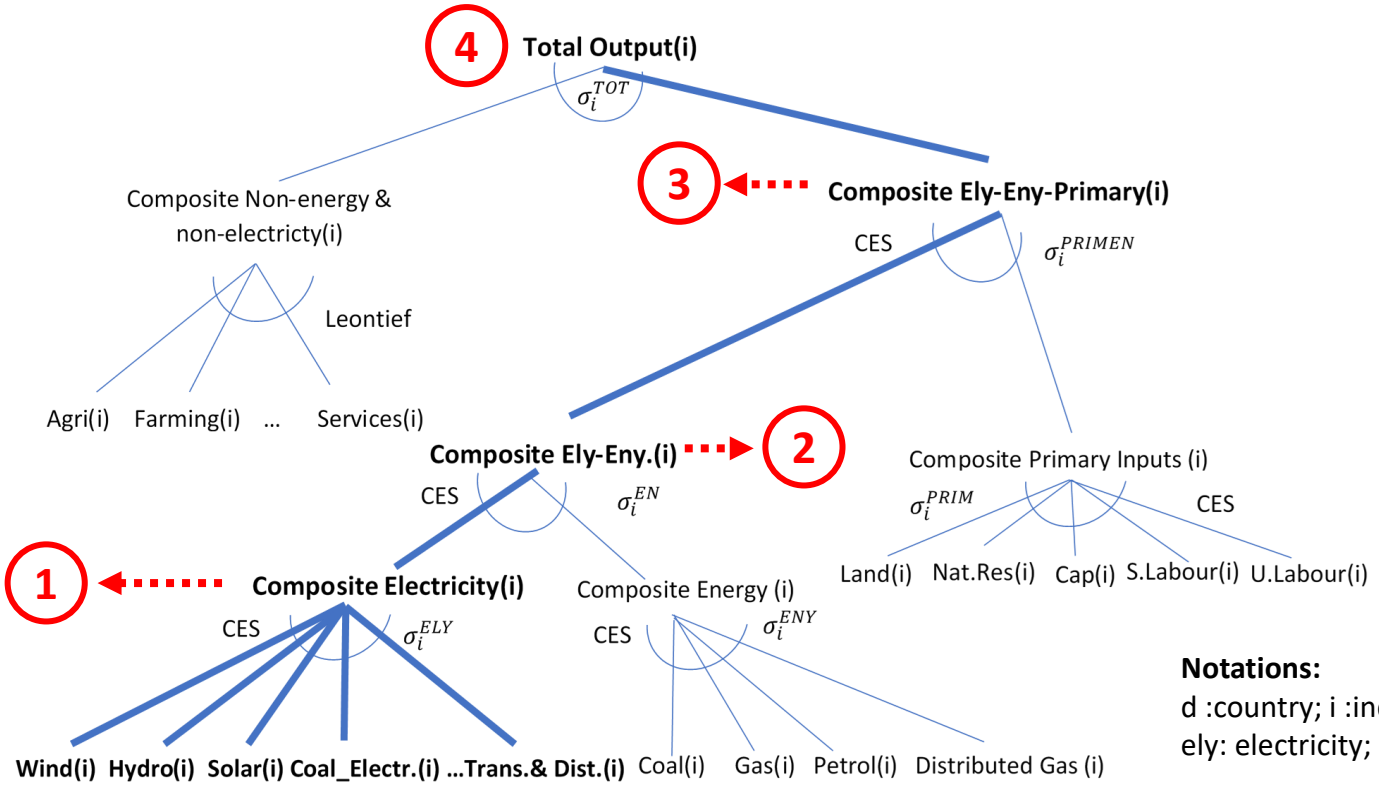
Methodology

The inter-regional system of analysis for East Asia (IRSA-EA) model

- This paper develops an inter-regional CGE model based on IRSA-Indonesia5; and IRSA-ASEAN (Resosudarmo *et al.* 2008; Nurdianto & Resosudarmo 2016; Resosudarmo *et al* 2020)
- The inter-regional system of analysis for East Asia (IRSA-EA):
  - ✓ a comparative static multi-country CGE model;
  - ✓ 33 sectors, including 8 disaggregated electricity sector: coal, oil, gas, wind, hydro, solar, other electricity (nuclear) & transmission and distribution sectors.
- Analysis in this paper is a short-term analysis:
  The closure on production factors:
  - ✓ labours are mobile → labour can move into other sectors
  - ✓ non-labour inputs are immobile → cannot move across the industry.
- The carbon emission and household income analysis are kept separate from the main model
  - ✓ Carbon emission and household income analysis use the results of IRSA-EA directly.
  - ✓ Poverty incidence is computed using a microsimulation model (Yusuf & Resosudarmo 2015)

Methodology

Flexible production structure of IRSA-EA



Notations:

d :country; i :industry;

ely: electricity; eny: energy.

Methodology

Recycling mechanisms to develop renewable electricity

1 **Total carbon tax revenue**

$$TCTR_d = TCG_d + TCI_d + TCH_d$$

$TCTR_d$: additional revenue from carbon tax; TCG_d : additional spending by the government; TCI_d : indirect tax reduction for renewable electricity sectors; TCH_d : subsidies for renewable electricity consumption by households.

2 **Reduction of the indirect tax rate**

$$\boldsymbol{ritxr_{ren,d}} = \frac{shxtot_{ren,d} \,.\, TCI_d}{PDOM_{ren,d} \,.\, XTOT_{ren,d}}$$

$$\forall\, ren \in c = \{wind, hydro, solar\}$$

$$\left(1 - itxr_{i,d} + \boldsymbol{ritxr_{i,d}}\right) PDOM_{i,d}.XTOT_{i,d} = PPRIMEN_{i,d}.XPRIMEN_{i,d} + PQ\_SC1_{i,d}.XINT\_SC1_{i,d}$$

3 **a direct subsidy on renewable electricity consumption for urban and rural households**

$$\boldsymbol{tren_{ren,h,d}} = \frac{shxhous_{ren,h,d} \,.\, TCH_d}{PQ\_S_{ren,d} \,.\, XHOUS\_S_{ren,h,d}}$$

$$XHOU\_S_{c,h,d} = \frac{\beta_{c,h,d}}{\left(1 + stx_{c,d}\right).\left(1 - \boldsymbol{tren_{c,h,d}}\right).PQ\_S_{c,d}} . EH_{h,d}$$

Data

Macro, micro, and parameter datasets

- **Macro dataset:**
  East Asia IRSAM - inter-regional Social Accounting Matrix for East Asia → constructed based on modified GTAP Power 9 Database, the base year is 2011
- **Micro dataset**: share of urban and rural HHs' expenditures on each commodity:

Indonesia	2012 Socio-economic Survey (SUSENAS);
the Philippines	2011 Annual Poverty Indicators Survey (APIS);
Thailand	2011 Household Socio-Economic Survey (SES);
Vietnam	2014 Vietnam Household Living Standards Survey (VHLSS);
China	2012 China Family Panel Survey (CFPS);
Australia	2009-2010 Household Expenditure Survey;
Japan	2009 Family Income and Expenditure Survey;
India	2011-2012 Household Consumer Expenditure NSS-68th Round.

- **Parameters of IRSA-EA come from various studies:** Resosudarmo (2002); Yusuf and Resosudarmo (2015); & GTAP.

Policy simulations

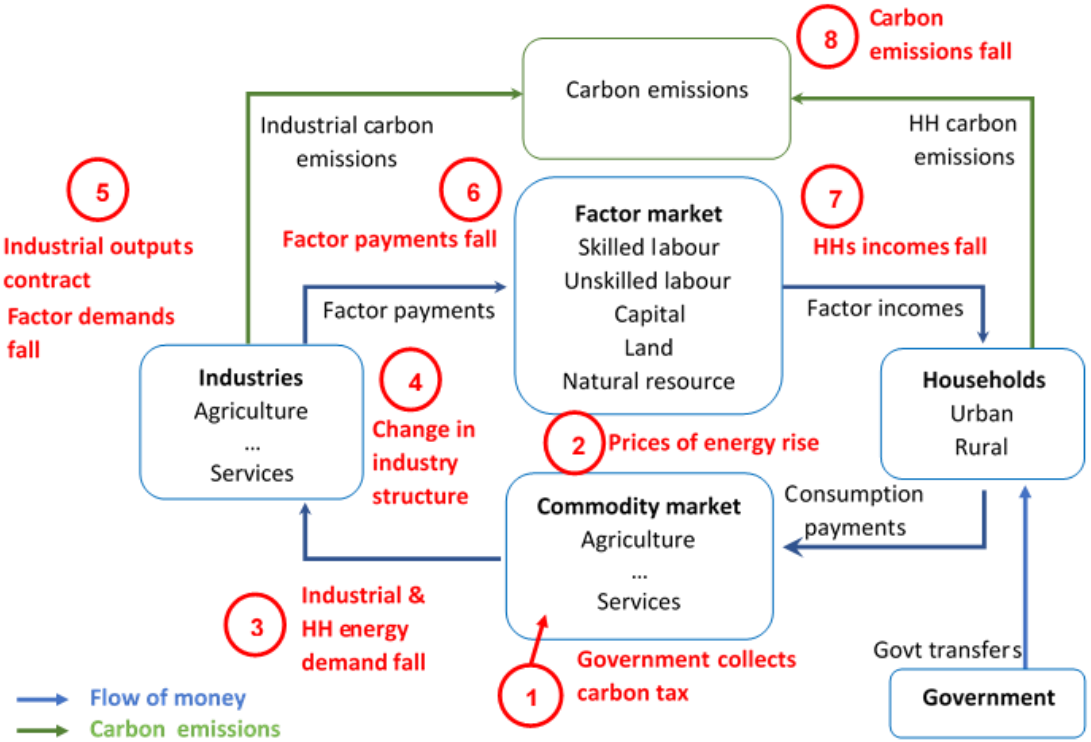
Three simulations on developing renewable electricity

Scenarios	Government redistributes 100% of the carbon tax revenue to …
SIM1	increase government spending
SIM2	indirect tax reduction for the renewable electricity sectors.
SIM3	subsidy for the renewable electricity consumption of the households.

- Results are in real changes → computed at the original price.
- Results of each simulation is relative to the baseline

Policy simulations

How IRSA-EA works?



- Assume that a government aims to reduce carbon emissions by collects carbon tax from energy commodities, i.e. petroleum products.
- The economic impacts can be measured in changes in price and output, changes in demand, changes in factor payments, and changes in HH incomes (income distribution and poverty incidence).
- The environmental impacts can be measured in changes in carbon emissions.

Results

Sectoral output changes (%)

	SIM1						SIM2						SIM3					
	AGR	MNF	ENR	FFE	REE	SRV	AGR	MNF	ENR	FFE	REE	SRV	AGR	MNF	ENR	FFE	REE	SRV
AUS	-0.009	-0.012	-0.068	-0.167	-0.001	-0.011	-0.033	-0.087	-0.115	-0.464	0.172	0.015	0.022	0.055	-0.028	0.129	0.499	-0.038
CHN	-0.019	-0.076	-0.620	0.079	0.003	0.005	-0.037	-0.118	-0.652	-0.084	0.472	-0.013	0.020	0.051	-0.573	-0.071	0.276	-0.050
JPN	-0.011	-0.028	-0.208	0.094	-0.001	-0.003	-0.018	0.133	-0.177	-0.014	0.714	-0.008	-0.005	-0.183	-0.239	-0.190	1.345	-0.006
IND	-0.011	-0.084	-0.301	0.319	-0.017	-0.007	-0.001	0.719	-0.271	-0.021	0.638	-0.255	-0.013	-1.049	-0.309	-0.669	1.425	0.268
KOR	-0.014	-0.038	-0.230	0.178	0.000	-0.004	-0.013	0.026	-0.243	0.036	0.028	0.015	-0.004	-0.058	-0.196	-0.343	0.024	-0.039
IDN	-0.005	-0.043	-0.110	0.458	0.000	-0.008	-0.058	-0.766	-0.533	-0.525	0.113	0.210	0.052	0.621	0.280	-0.286	0.026	-0.224
MYS	-0.010	-0.030	-0.089	0.284	0.000	-0.010	-0.008	-0.034	-0.126	-0.284	0.003	-0.023	0.008	0.024	-0.034	-0.283	0.001	-0.031
PHL	-0.006	-0.019	-0.090	0.181	-0.006	-0.008	0.003	-0.001	-0.081	-0.155	0.539	-0.013	0.004	-0.017	-0.069	-0.256	0.983	-0.029
SGP	-0.009	-0.016	-0.224	0.082		-0.003	-0.008	-0.015	-0.356	-0.088		0.005	-0.010	0.003	-0.073	-0.080	0.000	0.000
THA	-0.026	-0.050	-0.129	0.099	0.000	-0.029	-0.025	-0.049	-0.151	-0.105	0.042	-0.038	0.005	0.033	-0.076	-0.070	0.005	-0.046
VNM	-0.008	-0.075	-0.119	0.244	-0.022	-0.025	-0.010	0.004	-0.120	-0.170	0.696	-0.065	0.012	-0.135	-0.104	-0.271	0.884	-0.158
XSE	-0.003	-0.010	-0.025	0.141	-0.001	-0.008	0.154	-0.631	0.749	-4.058	0.714	0.231	-0.101	0.445	-1.026	3.365	1.015	-0.219

- **SIM1:** increasing fossil fuel prices → price increase for sectors using fossil fuel, i.e. manufacturing & fossil fuel electricity sectors → producers will produce less → sectoral output contracted.
- **SIM2:** reducing indirect tax on producer price → producers produce more output → demands more inputs from other sector (spillover).

  SIM3: mainly channelled to consumer prices → consumer price is cheaper → boost demand for renewable electricity → producers produce more output → demands more inputs from other sector (spillover).

Results

Macroeconomics indicators changes (%)

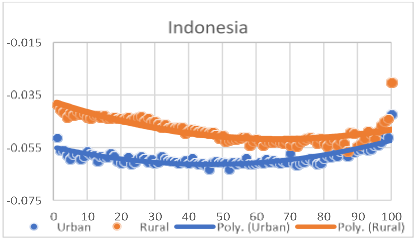
	SIM1			SIM2			SIM3		
	CO2	Real GDP	Carbon Intensity	CO2	Real GDP	Carbon Intensity	CO2	Real GDP	Carbon Intensity
AUS	-0.120	-0.006	-0.114	-0.236	-0.011	-0.225	0.010	-0.005	0.015
CHN	-0.194	-0.009	-0.185	-0.227	0.000	-0.227	-0.142	-0.032	-0.110
JPN	-0.110	-0.008	-0.101	-0.044	-0.008	-0.036	-0.172	-0.010	-0.162
IND	-0.193	-0.012	-0.181	-0.137	-0.046	-0.092	-0.199	0.007	-0.206
KOR	-0.141	-0.010	-0.132	-0.054	-0.023	-0.031	-0.198	-0.004	-0.193
IDN	-0.207	-0.003	-0.205	-0.386	0.001	-0.386	0.039	-0.072	0.111
MYS	-0.217	-0.006	-0.210	-0.273	0.000	-0.273	-0.129	-0.015	-0.114
PHL	-0.142	-0.008	-0.134	-0.115	-0.009	-0.107	-0.133	-0.009	-0.124
SGP	-0.076	-0.007	-0.069	-0.089	-0.008	-0.081	-0.060	-0.008	-0.052
THA	-0.162	-0.020	-0.142	-0.162	-0.021	-0.142	-0.121	-0.019	-0.103
VNM	-0.291	-0.022	-0.268	-0.199	-0.032	-0.167	-0.342	-0.030	-0.312
XSE	-0.143	-0.006	-0.137	-1.532	-0.025	-1.507	1.030	-0.045	1.076

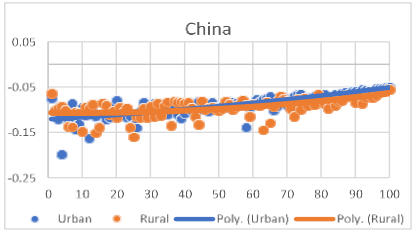
- **SIM1 :** output ↓→real GDP ↓→ carbon emissions ↓→ carbon intensity ↓.
- **SIM2:** environmental benefits only except for Indonesia (services sector rise).
- **SIM3:** three groups of country: rebound effect (AUS, IDN, XSE); env.benefit (CHN, JPN, KOR, MYS, PHL, SGP, THA, VNM); double dividend (IND)

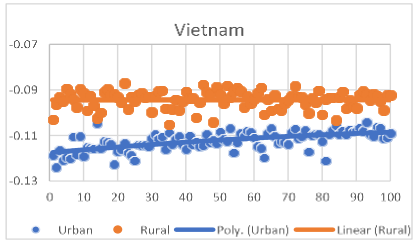
Results

Changes in HH expenditure per percentile (%)

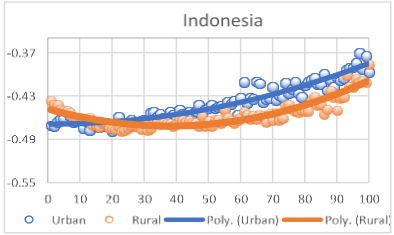
SIM1

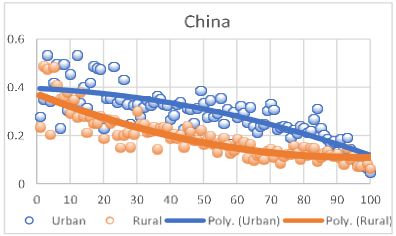


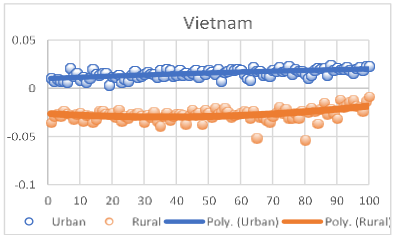




SIM3







SIM1

Indonesia

- a progressive pattern →carbon tax affects more on the richer HH

China

- a regressive pattern → the poor HH are more affected.

Vietnam:

- relatively flat distribution
  - ✓ budget share on renewables
  - ✓ factor income distribution

  relatively similar.

SIM3

- the pattern of income distribution changes significantly.
- depends on whether the compensation to support development of renewable electricity > negative impacts of the carbon tax.

Results

Changes in percentage poverty incidence

	SIM1				SIM2				SIM3			
	Real HH Exp.		Poverty		Real HH Exp.		Poverty		Real HH Exp.		Poverty	
	Urban	Rural	Urban	Rural	Urban	Rural	Urban	Rural	Urban	Rural	Urban	Rural
CHN	-0.073	-0.080	0.000	0.035	-0.112	-0.127	0.000	0.049	0.212	0.135	0.000	-0.130
IND	-0.063	-0.065	0.015	0.195	-0.285	-0.389	0.101	0.443	0.407	0.527	-0.122	-1.570
IDN	-0.063	-0.065	0.122	0.025	0.452	0.490	-0.780	-0.309	-0.369	-0.368	1.323	0.390
MYS	-0.044	-0.044	0.003	0.005	-0.008	-0.016	0.001	0.002	0.105	0.028	0.000	-0.008
PHL	-0.037	-0.026	0.004	0.014	-0.009	-0.018	0.001	0.010	0.026	-0.001	-0.003	0.000
THA	-0.047	-0.068	0.267	0.118	-0.052	-0.073	0.274	0.123	0.108	0.015	-0.586	0.020
VNM	-0.117	-0.093	0.013	0.294	0.002	-0.060	0.001	0.077	0.096	0.038	-0.011	-0.032
XSE	-0.029	-0.033	0.005	0.113	1.016	0.923	-0.142	-0.685	-0.700	-0.656	0.099	1.793

- Real HH expenditure ← commodity prices and HH income.
- SIM1: poverty incidence rise
- SIM2: IDN and XSE experience poverty incidence reduction ← govt. transfer ← indirect tax and import tax
- SIM3: three groups of the country.
  - ✓ decreasing urban and rural poverty incidence → CHN, IND, MYS, PHL, VNM
  - ✓ increasing urban and rural poverty incidence → IDN, XSE.
  - ✓ increasing rural poverty incidence → THA.

Results

Sensitivity analysis

- Three parameters :
  - ✓ elasticity of substitution among electricity intermediate inputs ($\sigma_{i,d}^{ely}$)
  - ✓ elasticity of substitution between energy and electricity intermediate inputs ($\sigma_{i,d}^{en}$).
  - ✓ Carbon tax value
- The sensitivity analysis is done by:
  - ✓ randomly choosing parameters' value in a range of ±10% from the baseline parameters.
  - ✓ runs each simulation for 100 times.
  - ✓ for all simulations, the mean and standard deviation are computed.
- **the main results are relatively robust:**
  - ✓ the signs of sensitivity analysis results are all consistent with the main results.
  - ✓ the sensitivity analysis results have relatively lower standard deviation values.

Conclusions

- What is the best policy for each country to enhance development of renewable electricity?

Simulation / Objectives	SIM1	SIM2	SIM3
Economy (GDP rises)		IDN	IND
Environment (carbon emissions fall)	All East Asian countries	All East Asian countries	CHN,JPN, IND, KOR, MYS,PHL,SGP,THA, VNM
Equity (poverty incidence falls)		IDN,XSE	CHN,IND, MYS,PHL,VNM

Thank you

Terima kasih

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