A study on the impacts of decarbonisation by the technology innovation and carbon pricing into industry transition and GHG reduction in the NE Asia

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東アジアの持続可能な発展のためのエネルギー・環境財政のグリーン改革

東アジア環境政策研究会

Contents

Information & News

ケンブリッジ・エコノメトリックスでE3MEモデルセミナー開催（2016年10月31日～11月３日）

名城大学の李秀澈教授、龍谷大学の李態妍教授、長崎大学の松本健一准教授、尚絅学院大学の東愛子准教授とともに、イギリスのケンブリッジ・エコノメトリックスでHector氏、Unnada

Contents

1. Introduction

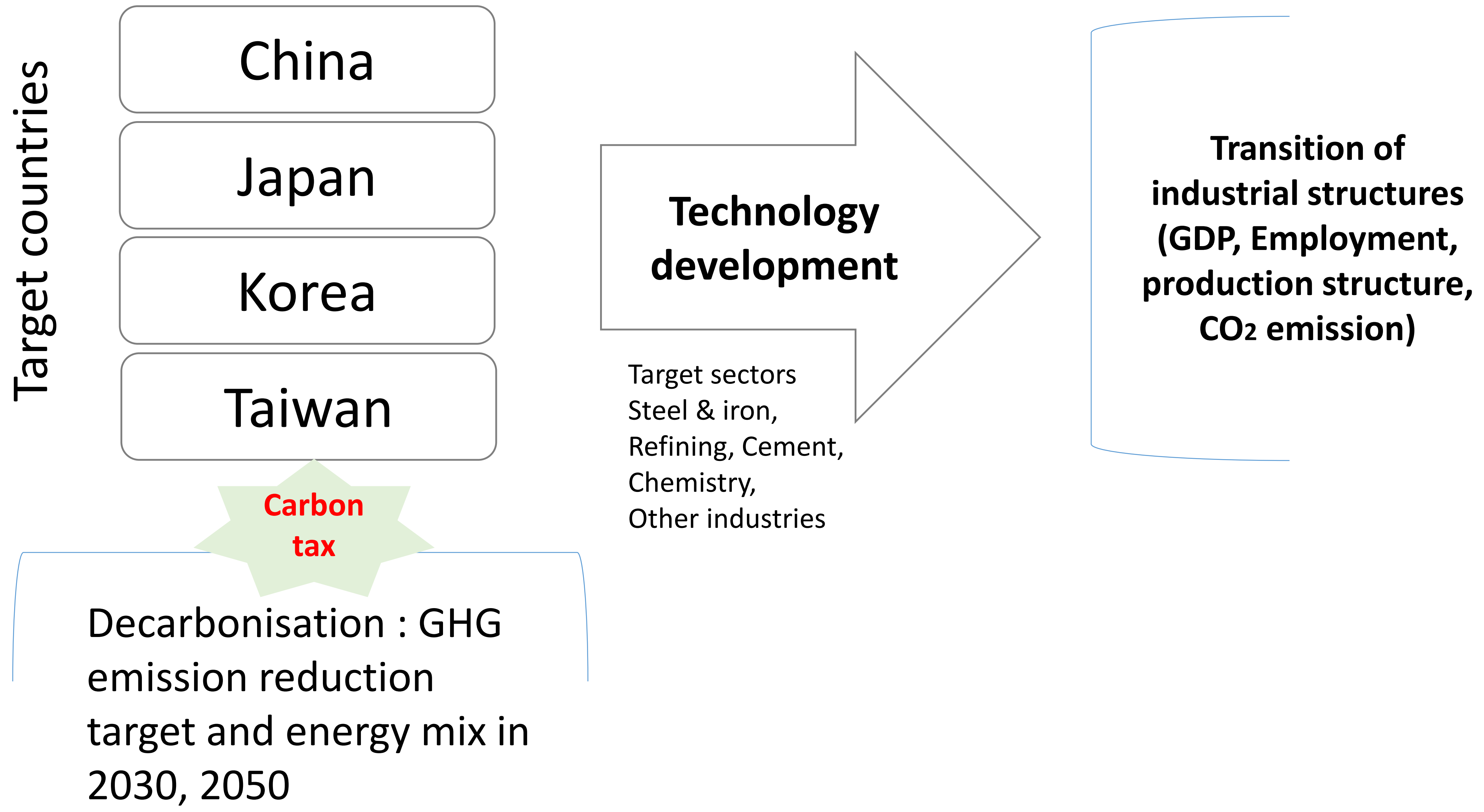
- The low-carbon technology innovation or a broader concept of technology innovation for climate change mitigation, attracts increasing attention from both entrepreneurs and policymakers (IEA2016), since the accelerated technology development may reduce the costs for achieving the stringent climate goals (McJeon et al. 2011).
- Carbon pricing is focused as a key measure. The pricing of carbon emission would induce the profit-oriented business to adopt low carbon technology (Tran, 2012).

2. Study objectives and concept framework

Objective:

- To investigate the transition of industrial structures under decarbonisation for GHG emission reduction target and energy mix in 2030, 2050 and CO_2 emission thereby focusing on the main polluters (metals, cement, refineries, chemicals, papers & pulps etc.;
- To analysis the influence of carbon tax in a different policy scenarios for revenue recycling

Concept framework



3. Policy Scenarios and Methodology

3.1 Policy Scenarios

Scenario	Description
Baseline	Technology development at the same rate with the past (reference scenario of IEEJ)
Scenario 1	• Carbon tax to be imposed to meet 2030 INDCs and 2°C in 2050 (WEO 450PPM values) • All carbon tax revenues are recycled via lump sum payment to households
Scenario 2	• Carbon tax to be imposed to meet 2030 INDCs and 2°C in 2050 (WEO 450PPM values) • 10% of carbon tax revenues are recycled to energy efficient (EE) investment in industries and 90% of carbon tax revenues are recycled to lump sum payment to households

IEEJ: The Institute of Energy Economics

3.2 Estimated carbon tax rates

The carbon tax rate estimates the carbon tax rates required to meet NDC targets by 2030.

(unit: US$/$CO_2$t)

	Scenarios	2030	2050
China	S1	102	1032
	S2	70	400
Japan	S1	35	1032
	S2	25	400
Korea	S1	42	1032
	S2	30	400
Taiwan	S1	74	1032
	S2	50	400

Common carbon taxes were set and estimated to approximate for the achievement of the 2C degree target by 2050.

3.2 Methodology

- The E3ME model, a computer-based model of the world's economic and energy systems and the environment, is employed.
- E3ME stands for "Energy, Environment and Economy Model"

E3ME (version 6.0)

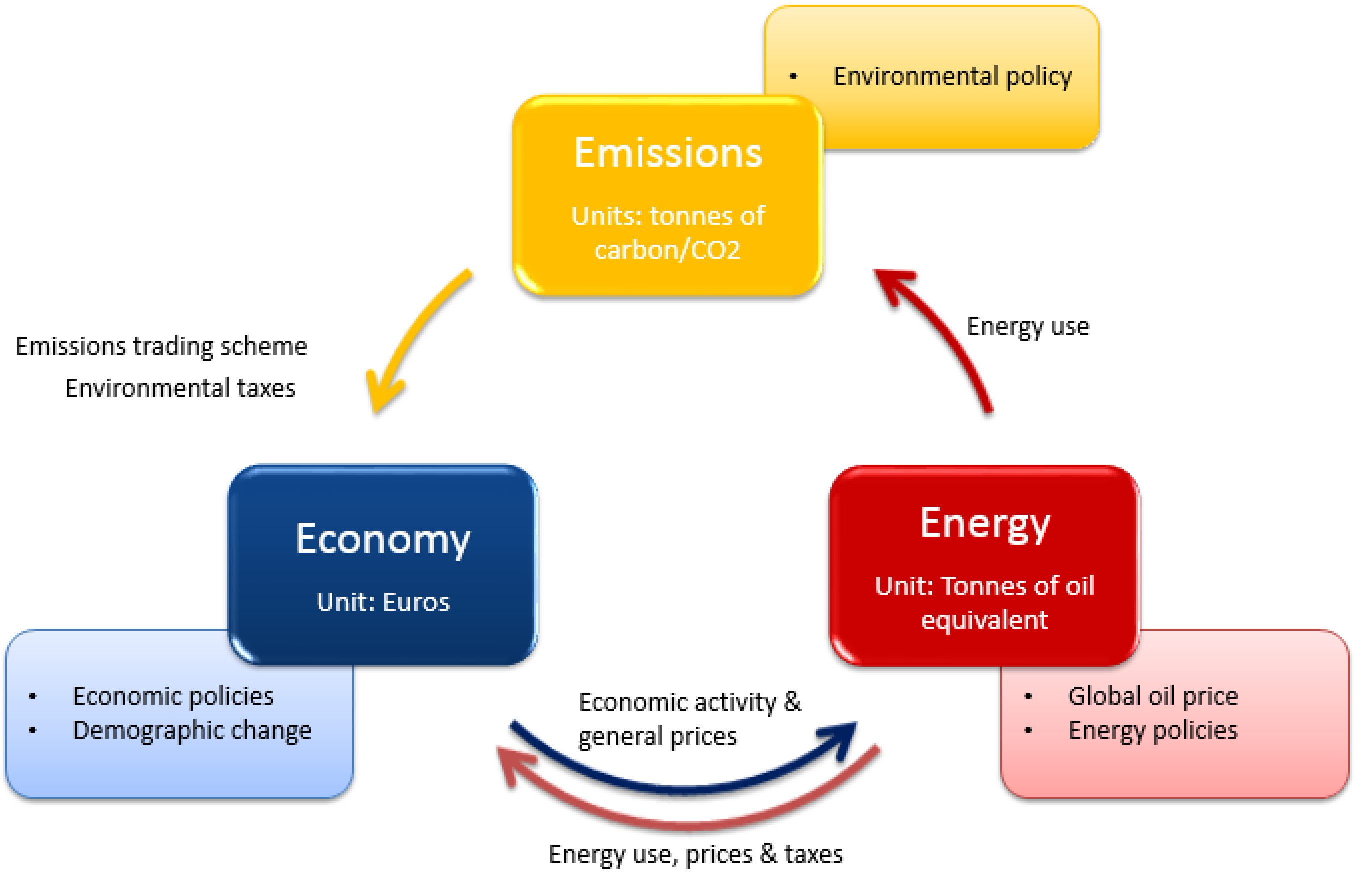
- The model is based on post-Keynesian economic theory, with an input-output core supported by econometric equations for final demand, prices, the labor market, energy demand and materials demand.
- The basic economic structure of E3ME is based on the system of national accounts. Input-output ratios determine linkages between sectors and bilateral trade data provide links between regions.
- There are further linkages to energy demand and environmental emissions through matching economic and physical data sets. The labor market is also covered in detail, including both voluntary and involuntary unemployment.
- In total there are 33 sets of econometrically estimated equations, also including the components of GDP (consumption, investment, and international trade), prices, energy demand and materials demand. Each equation set is disaggregated by the 59 countries and 43 sectors.
- The model is usually applied for scenario-based policy analysis.
- The current version of E3ME can be described as top-down in its energy modelling, with a bottom-up sub-model of the electricity supply sector.

Data source of the model

Main data sources	Eurostat, AMECO, IEA, OECD (new sources for non-EU regions)
Accounting system	ESA95
Number of stochastic equation sets	29

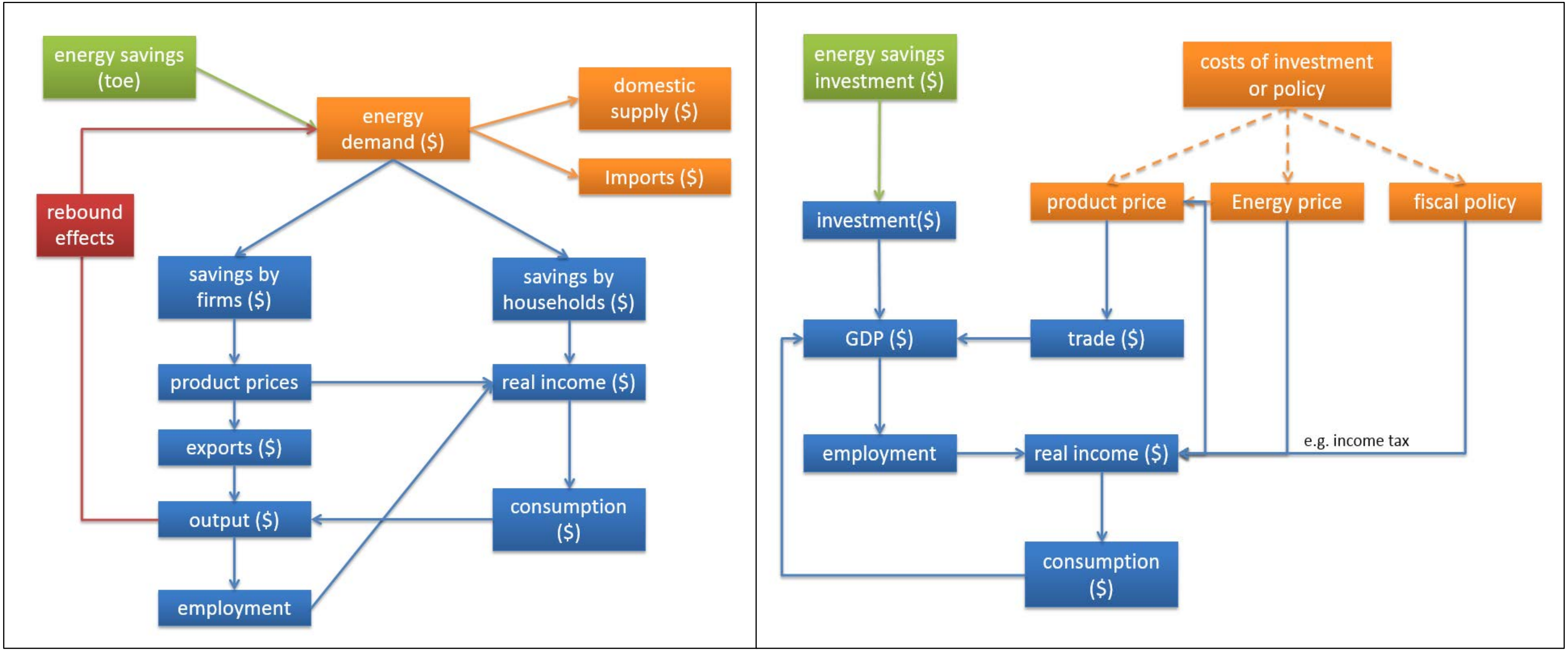
For energy data, the main data source is the IEA. Gaps in historical data are estimated using customized software algorithms (never replacing actual data.

E3 linkages in E3ME



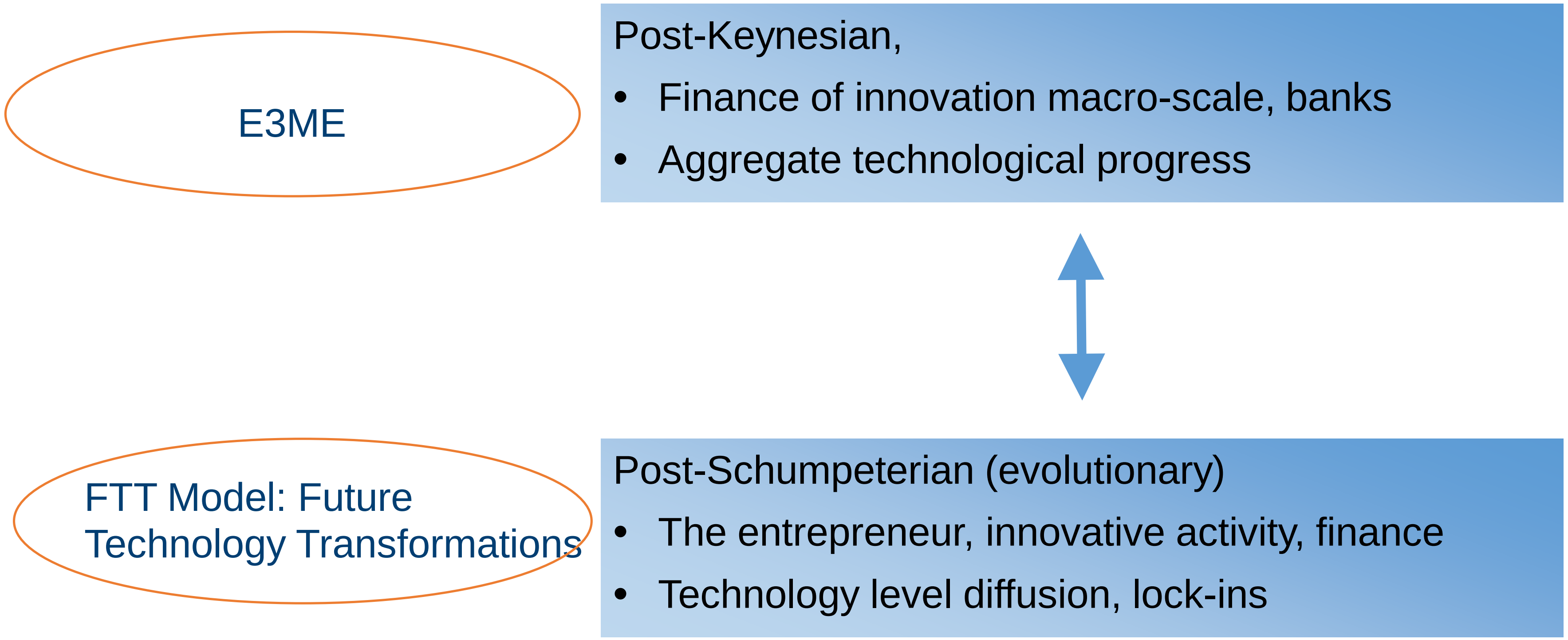
3.E3ME Modelling of Energy Efficiency (3/3):

Expected impacts from reduction in energy used and EE investment

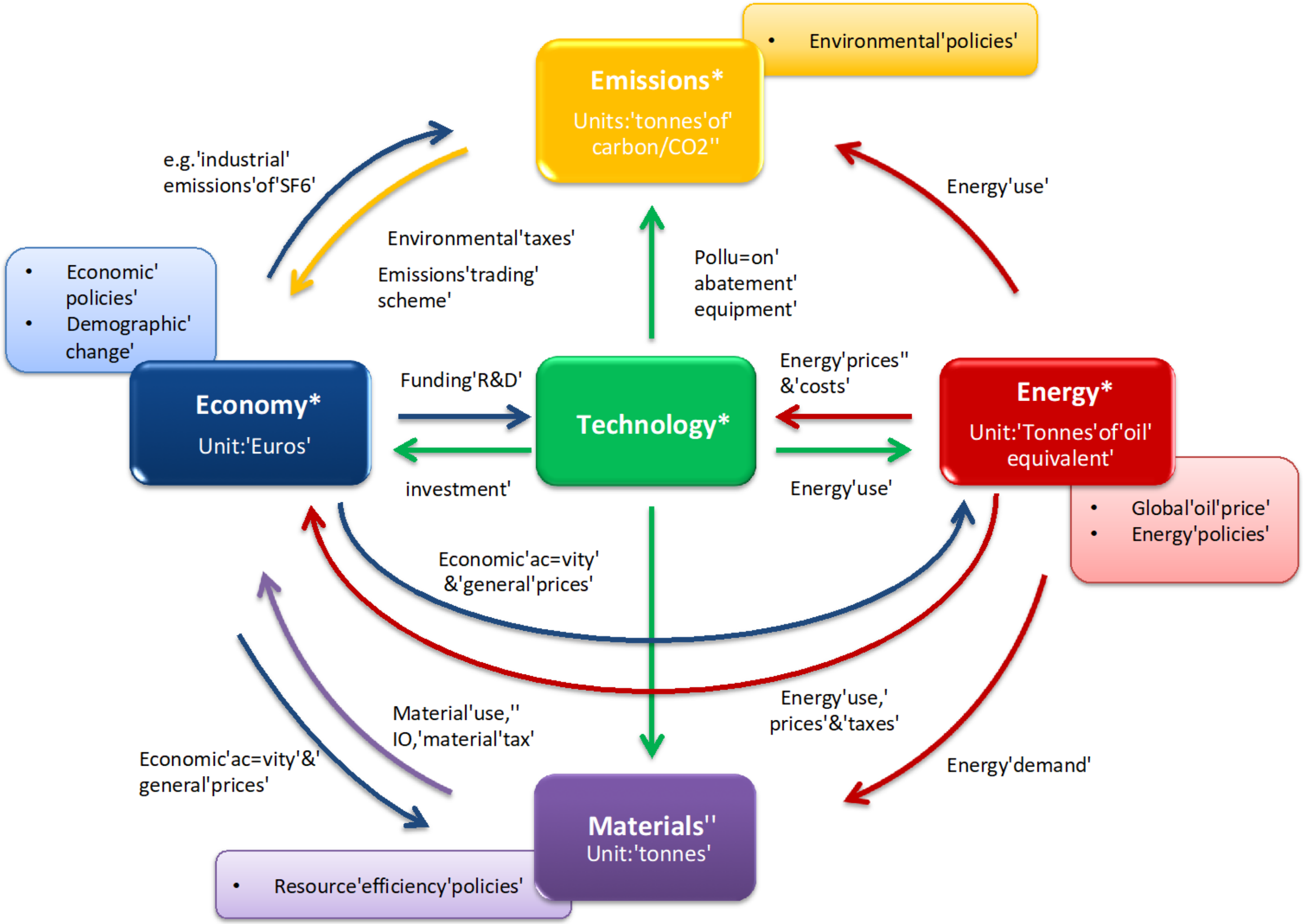


Model linkage

- Bottom-up Schumpeterian meeting Top-down Post-Keynesian
- Two sides of the same coin, from micro to macro



E3ME-FTT Industry Linkages



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cambridge econometrics

4. Analysis results

5.1 GDP, Employee and CO_2

5.2 Impact on the industrial structure change

5.3 Impact of CO_2 reduction by sector

4.1 GDP, Employee and CO_2

(1) GDP

(2) Employment

(3) CO_2

(1) GDP

Lump-sum recycling and 10% of tax revenue recycling for energy efficiency improve GDP by a little in 2030 rather than in 2050.

(% difference from baseline)

	China		Japan		Korea		Taiwan		CJKT	
Year	2030	2050	2030	2050	2030	2050	2030	2050	2030	2050
S1	0.3	-1.5	0.3	-0.5	0.0	-1.4	0.5	-0.6	0.2	-1.3
S2	0.6	-1.5	0.3	-0.7	-0.1	-1.4	0.6	-0.4	0.5	-1.3

(2) Employment

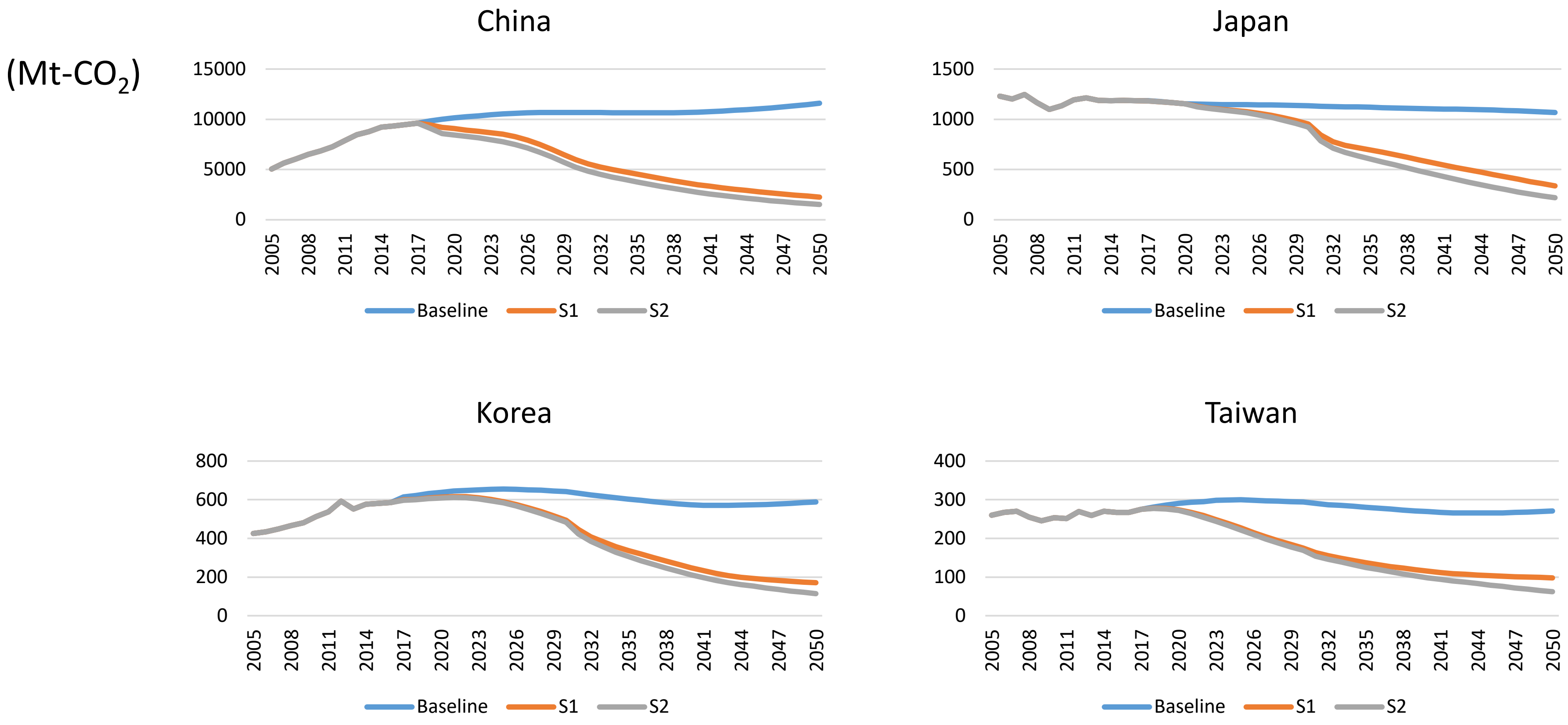
The impact to employment vary in each country. Similar with GDP, its impact to 2030 is better that 2050.

(% difference from baseline)

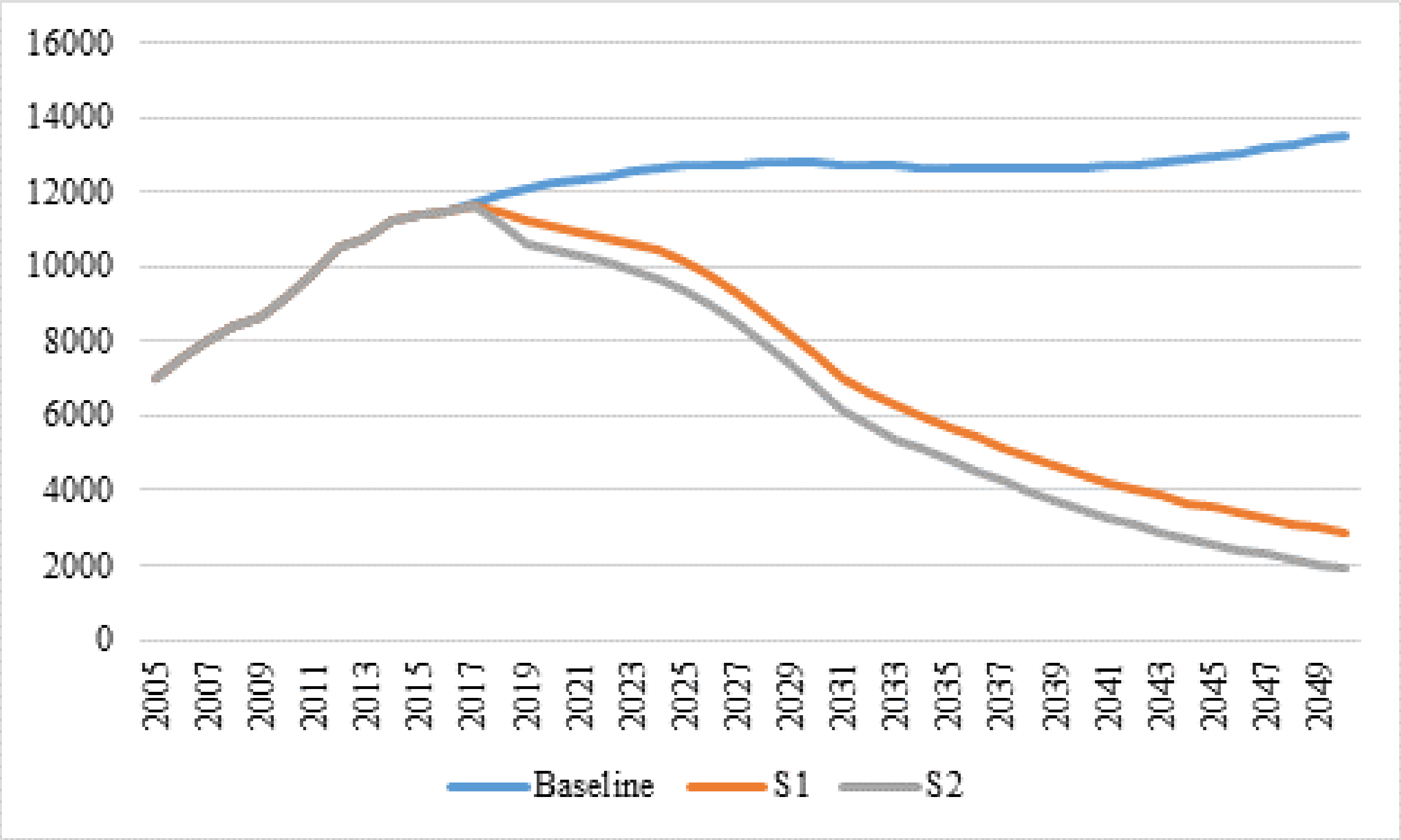
	China		Japan		Korea		Taiwan		CJKT	
	2030	2050	2030	2050	2030	2050	2030	2050	2030	2050
S1	-0.09	-1.12	0.03	-0.37	-0.31	-2.64	0.08	-0.49	-0.09	-1.08
S2	-0.12	-1.12	0.01	-0.56	-0.50	-2.92	0.09	-0.54	-0.12	-1.12

(3) CO_2

The CO_2 emissions show much bigger decrease with EE investment (S2) from these decarbonisation scenarios.

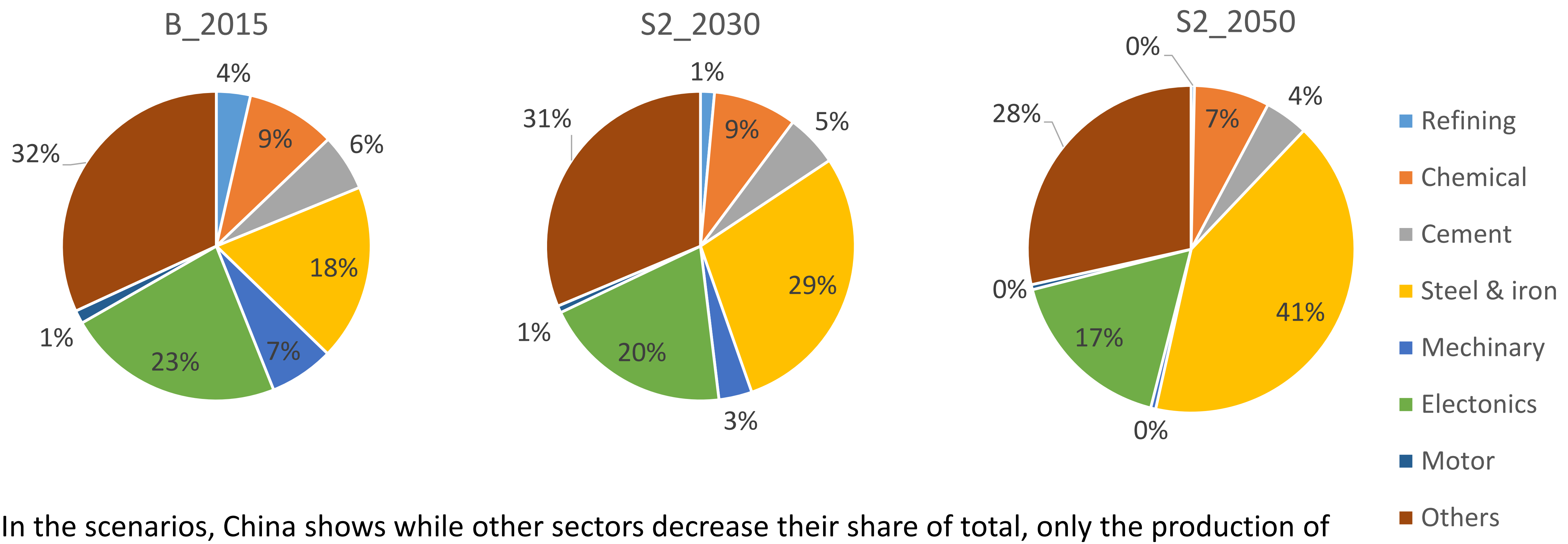


CO_2 emission in China, Japan, Korea and Taiwan (Mt-CO_2)



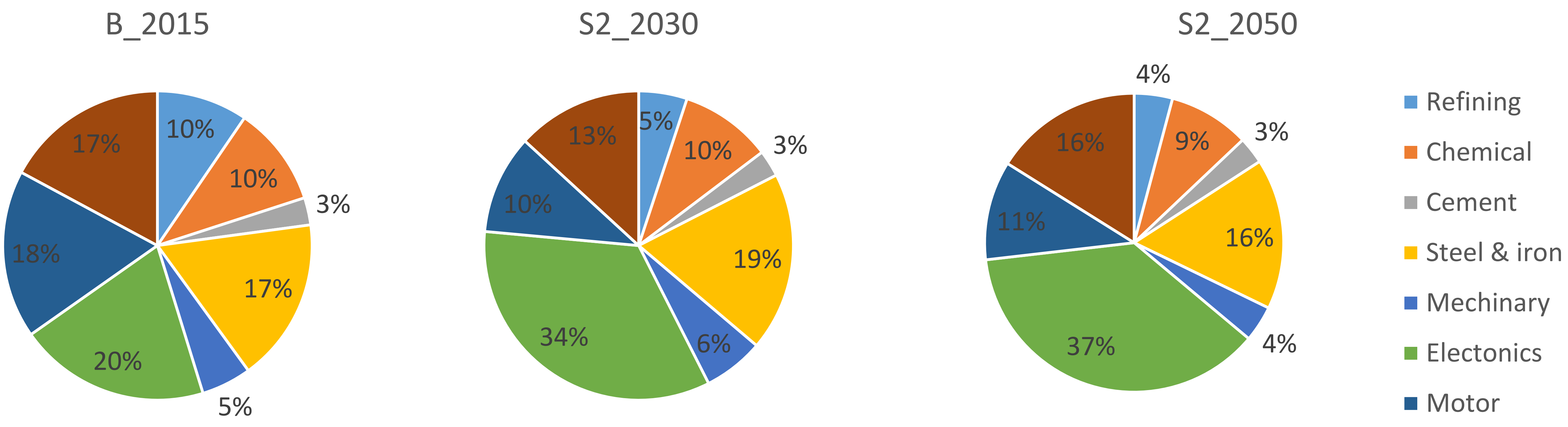
5.2 Impact on the industrial structure change

(1) China



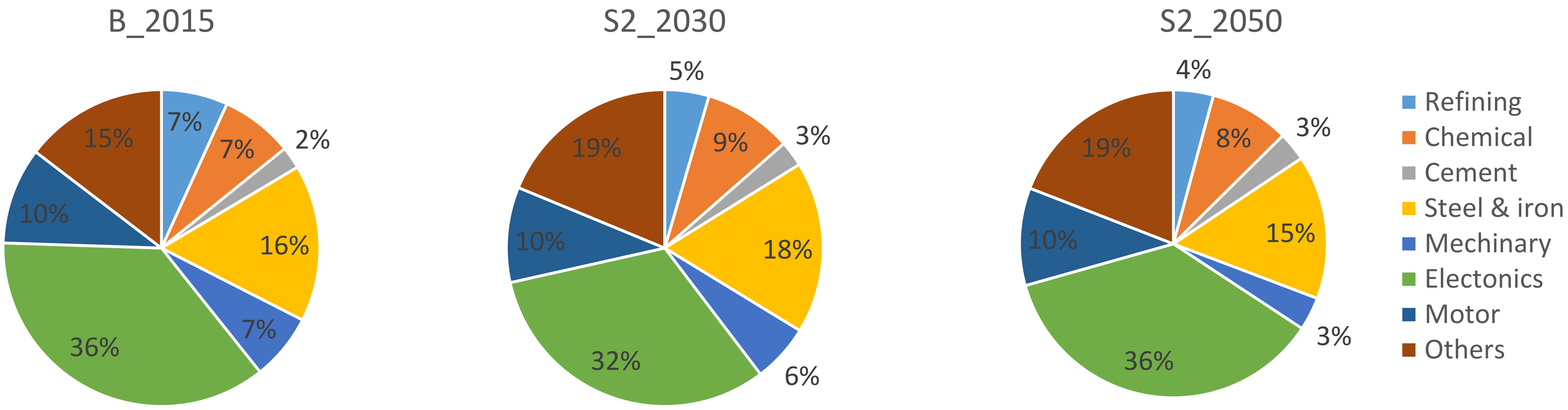
In the scenarios, China shows while other sectors decrease their share of total, only the production of steel & iron will be increased largely up to 40% in 2050

(2) Japan



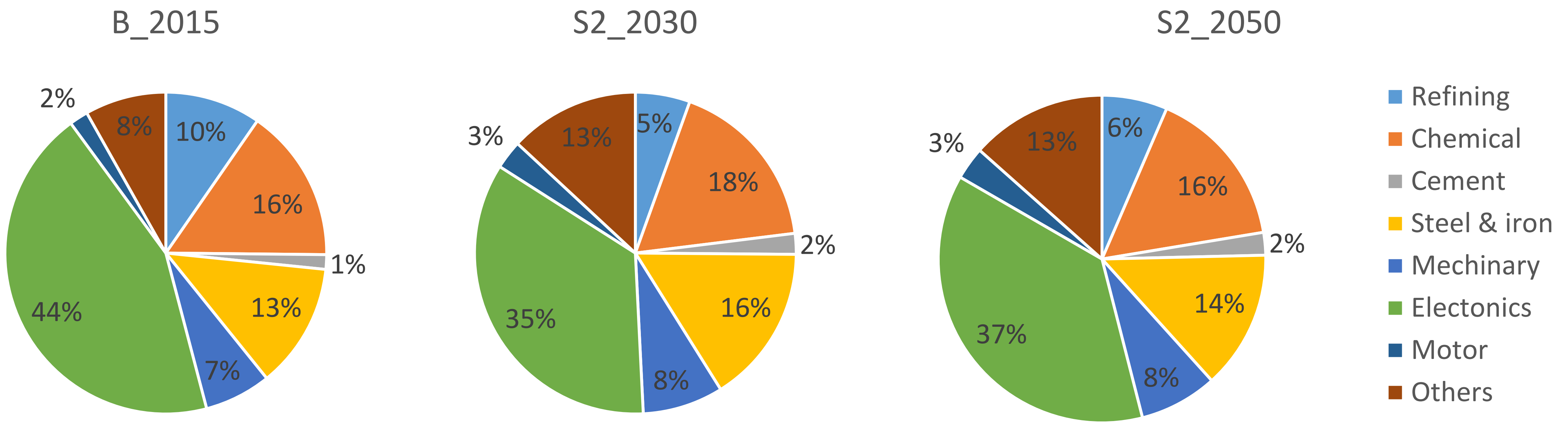
In Japan, by recycling the carbon tax revenue for EE, most the share of production by energy intensity sectors will shrink but that of Electronics will take over the place in 2050.

(3) Korea



The most changes of industry production among the sectors are from Refining and Machinery in Korea while other sectors will experience little changes comparing 2015 under the S2.

(4) Taiwan



Different from Japan, the share of Electronics sector in 2050 will be decreased.

5.3 Impact of CO_2 reduction by sector

Emissions by fuel user (%diff from baseline)

Fuel user	Years	Japan		China		Korea		Taiwan	
		S1	S2	S1	S2	S1	S2	S1	S2
Iron & steel	2030	-17.7	-21	-48.6	-85.8	-14.8	-21.4	-2.6	-11.7
	2050	-54.6	-87.8	-75.3	-100	-58.7	-95.1	-13.5	-62.7
Non-ferrous metals	2030	-8.6	-25.5	-32.6	-57.4	-7.4	-56.2	-2.5	-7.7
	2050	-57.6	-89.5	-69.4	-100	-22.2	-98.9	-14.4	-49
Chemicals	2030	-15.2	-17.3	-24.3	-37.7	5.5	-1.5	-27.4	-32.1
	2050	-60.4	-72.7	-66.5	-100	-27.6	-65.9	-77.9	-94.8
Non-metallics nes	2030	-4.2	-6.2	-38.5	-45	-15.2	-17.8	-88.3	-91
	2050	-38.1	-61.1	-66.9	-86.4	-35.7	-70	-99	-100
1Paper & pulp	2030	-39.1	-42.1	-39.6	-50.2	-18.1	-25.1	-24.8	-30.6
	2050	-91.9	-96.2	-78	-97.5	-38.1	-81.6	-80.7	-94.2
Engineering etc	2030	-7.2	-22.6	-30.1	-45.3	-10.3	-23.9	-2.3	-27.7
	2050	-56.4	-92.1	-63.9	-88.9	-28.7	-82.8	-3.8	-62.6
Other industry	2030	-25.6	-51.5	-31.6	-59.7	-24.1	-34.3	-42.1	-90.8
	2050	-64.3	-90.5	-73.3	-93.2	-55.3	-84.3	-85.4	-100

10% of revenues to increase EE in industries can almost result in 100% decarbonisation.

6. Summaries

- This study quantitatively analyzed the trends of industrial structure and CO_2 emissions in the major industries in four East Asian countries by 2050 under the assumption that carbon taxes introduced to achieve the 2030 NDC and 2050 WEO 450 scenarios.
- As an analytical method in this study, E3ME is used to analyse impacts of carbon taxes on the East Asia industries and how different the impacts are if some of carbon tax revenues are used to invest in industries' low carbon technology measures.
- A good mix of policies must therefore be included to make sure the power sector continues to invest in renewables technologies despite reduction in electricity demand.

- This research has several challenges. Our approach is simplistic as it used existing top-down estimates of amount of energy savings per dollar as exogenous assumption to E3ME and we assumed only carbon price is used to achieve the NDC and WEO 450 targets.
- In this paper, we did not include policies such as production taxes, subsidies, regulations, and many more to promote decarbonization in other sectors. In an upcoming paper, we will look at all sectors in parallel to produce the most comprehensive analysis of decarbonization policies in East Asia to date.

- In the near future, a Future Technology Transformation (FTT) model for energy intensive industries will be available. The FTT: industry model will provide a bottom-up approach to take ups of new technologies in industries.
- While most existing models reflect the potential for breakthroughs in low-carbon technology innovation by 2050 by an extension of past technological innovations (by default), the FTT model reflects the endogenous estimation of the progress of possible future technological innovations. In other words, this model can infer the future industrial structure under decarbonization policy more realistically.
- The carbon tax rate applied in this study was estimated based on the premise that low carbon technology innovation is underestimated and there is no other capacity, but if the FTT model is used, the more realistic carbon tax rate will be estimated by reflecting the endogenous low carbon technology innovation of the model.

Thank you very much