Energy Taxation and the Double Dividend Effect in Taiwan's Energy Conservation Policy – An Empirical Study Using a Computable General Equilibrium Model

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Introduction

- **Double Dividend**
  - **Originally came from Tullock (1967) but was first proposed by Pearce (1991)**
- **Pigouvian effect (first dividend):**
  - **This effect uses economic incentives as a tool to reduce pollutants produced by the polluter until the marginal external cost is equal to the pollution tax rate.**

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Introduction

- **Revenue effect (second dividend):**
  - **The revenue collected from levying environmental taxes could reduce the inefficiency of distortionary taxes (such as an income tax or social welfare tax) on the market so as to increase household income.**

Introduction

- **Argument:**
  - **The second effect of the double dividend was questioned by some economists:**
    - Bovenberg and Mooij (1994a), Parry (1995), Oates (1995), Parry, Williams, and Goulder (1999), Lomborg (2001)
  - **Other empirical studies in the literature have adopted a more positive view about the second effect of the double dividend**
    - Terkla (1984) , Repetto, Dower, Jenkins, and Geoghegan (1992), Larsen (1992), Barker, Baylis, and Madsen (1993) , Mckitrick (1997)

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Introduction

- **In spite of the double dividend of green tax reform remaining a contentious issue, European countries, including Denmark, Finland, the Netherlands, Norway, and Sweden, as early as the 1990s launched the green tax reform:**
  - **levied of a tax**
  - **alleviated the burden of social welfare taxes**
- **Years after such green tax policies were implemented, it is undoubtedly evident to the world that both their economic development and public welfare have improved as a result.**
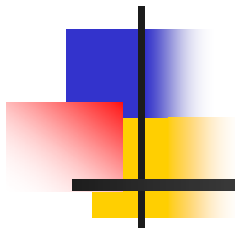
Introduction

- **How about the positive external effect of the mitigation of pollution on society and the bio-system?**
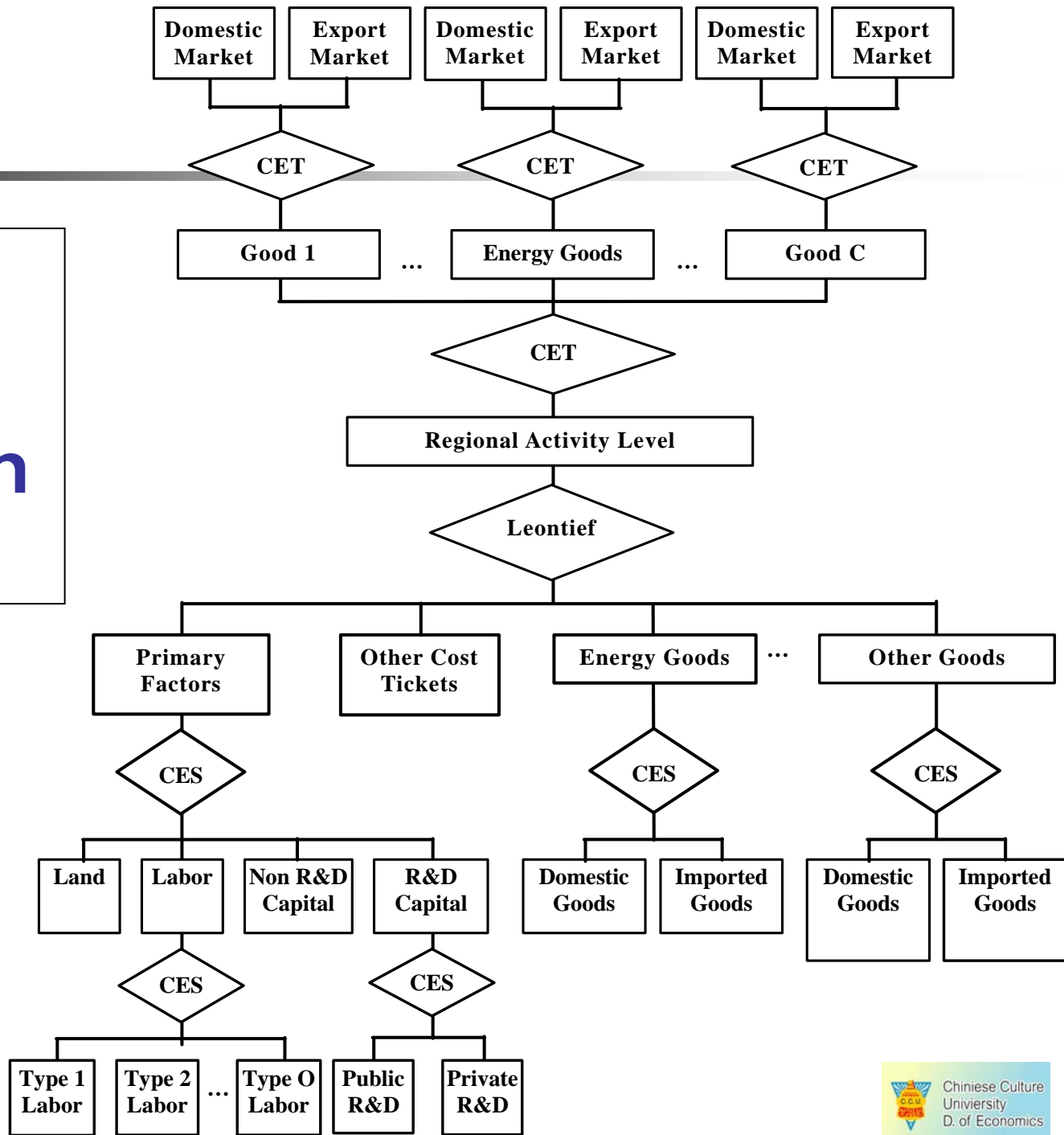 - **which was indeed a fundamental issue related to the environmental problem**

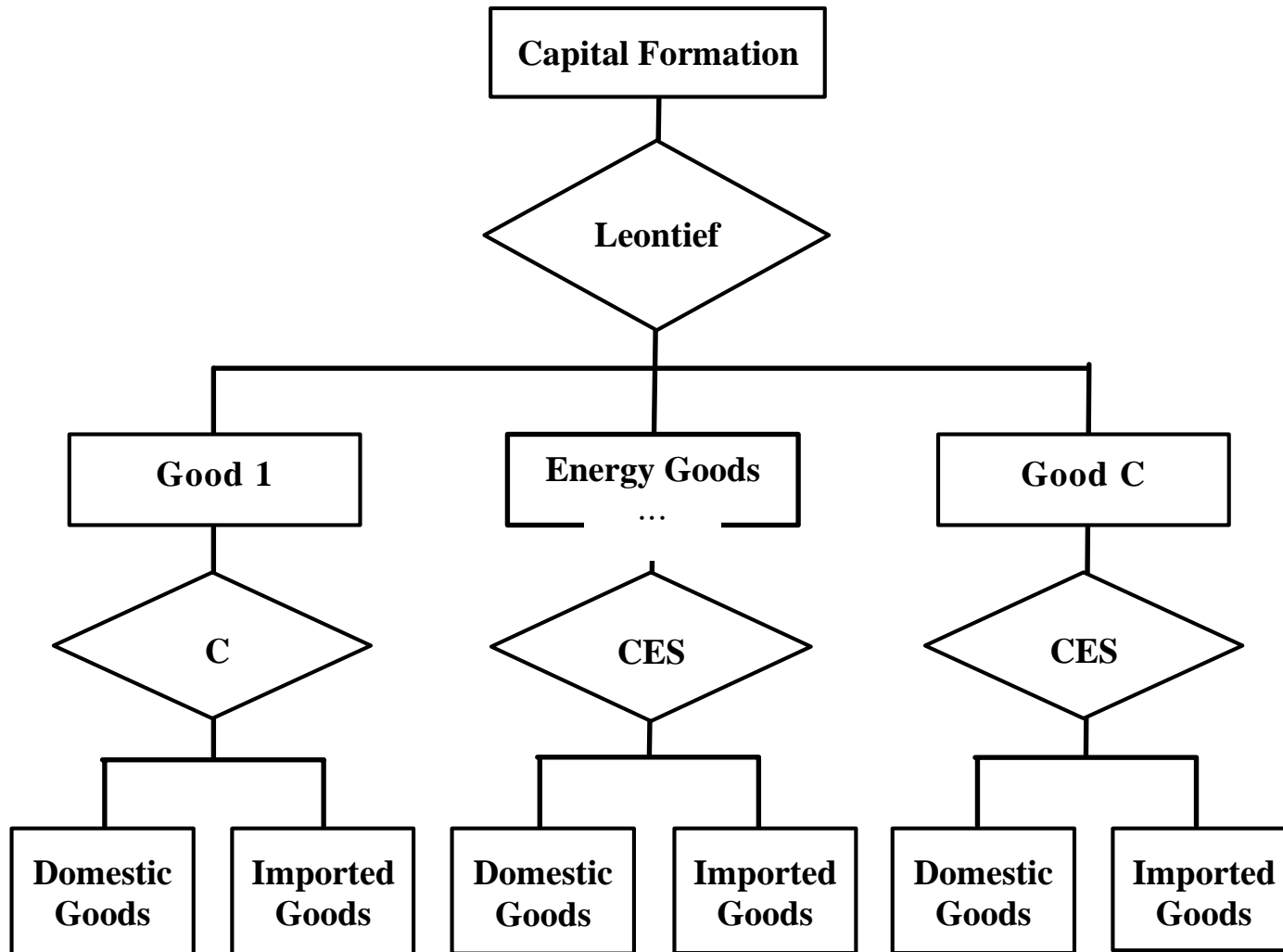Chiniese Culture Univiersity D. of Economics

Introduction

- **In this study, the EnFore - CGE model has been used for incorporating relevant modules such as the public finance and public R&D investments to investigate the double dividend effect of energy tax and its complementary measures in Taiwan.**
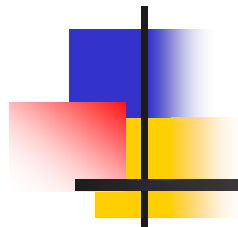
EnFore - CGE Production Structure

Domestic Market	Export Market	Domestic Market	Export Market	Domestic Market	Export Market

CET — CET — CET

Good 1 ... Energy Goods ... Good C

CET

Regional Activity Level

Leontief

Primary Factors	Other Cost Tickets	Energy Goods	...	Other Goods

CES (Primary Factors) — Land | Labor | Non R&D Capital | R&D Capital

CES (Energy Goods) — Domestic Goods | Imported Goods

CES (Other Goods) — Domestic Goods | Imported Goods

CES (Labor) — Type 1 Labor | Type 2 Labor | ... | Type O Labor

CES (R&D Capital) — Public R&D | Private R&D

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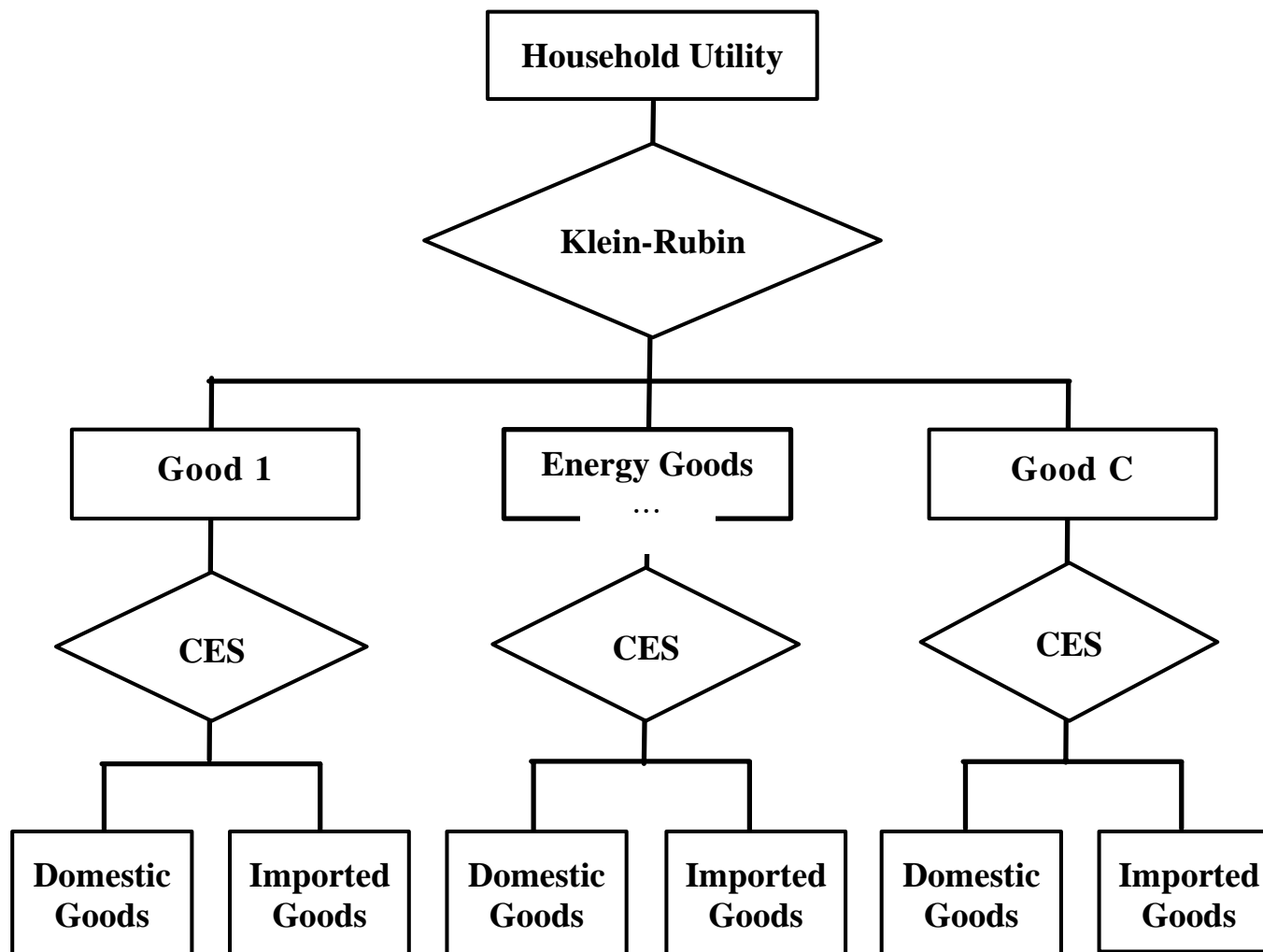# EnFore - CGE Capital Formation

EnFore – CGE Closure

25,099 equations 7,244 exogenous variables

Exogenous Variables	Description
Real GDP Supply Side	
x1lnd x1rad	Land and R&D Capital
a1cap a1lab_o a1lnd	Technology Changes
a1prim a1tot a2tot a1rad_s	Technology Changes
faccum	Capital Shift Variable
delfwage	Real Wage Rate Shift Variable
Real GDP Expenditure Side	
f3tot	Ratio of Consumption/GDP
f5tot2	Ratio between Shift of Government Expenditure/Household Consumption
invslack	Investment Slack Variable for Exogenous Investment
fx6	Capital Stock Shift Variable
Foreign Condition	
pf0cif	Import Price
f4p f4q	Export Price and Demand Shift Variables
f4p_ntrad f4q_ntrad	Collective Nontrade Export Price and Demand Shift Variables
Investment	
finv2	Exogenous Investment Shift Variable
finv4	Long Run Investment Shift Variable
Taxation	
delPTXRATE f3tax_cs f0tax_s	Changes in Production Tax and Household Tax Rates, Sale Tax Shifter
f5tax_cs t_lab t_busi t_rad	Changes in Government Usage Tax, Income Taxes, and Investment Taxes
f4tax_ntrad f1oct f4tax_trad	Changes in Nontrade Export Tax, Other-Costs Tax, and Trade Export Tax
f1tax_csi f2tax_csi t0imp	Changes in Intermediate Tax and Investment Tax, Tariff
Others	
phi	Exchange Rate
q	Household
emptrend	Long-term Employment Rate
delUnity	Dummy Variable
rnorm	Nominal Rate of Return
gtrend	Long-run Ratio of Investment/Capital

EnFore-CGE Closure and Simulation

Historical Simulation

Historical Simulation
Calibration

Baseline Forecast →→ Policy Simulation

2002   2007   2009   2019

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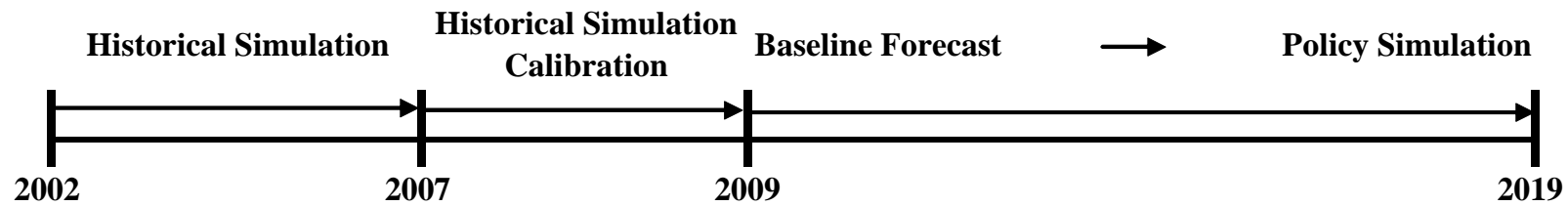
EnFore – CGE Simulation Calibration and Baseline Forecast

Real GDP Change Rate (%)

Historical Simulation Calibration

Historical Simulation

Baseline Forecast

Year

◇ **Real Data** □ **Simulation Data**

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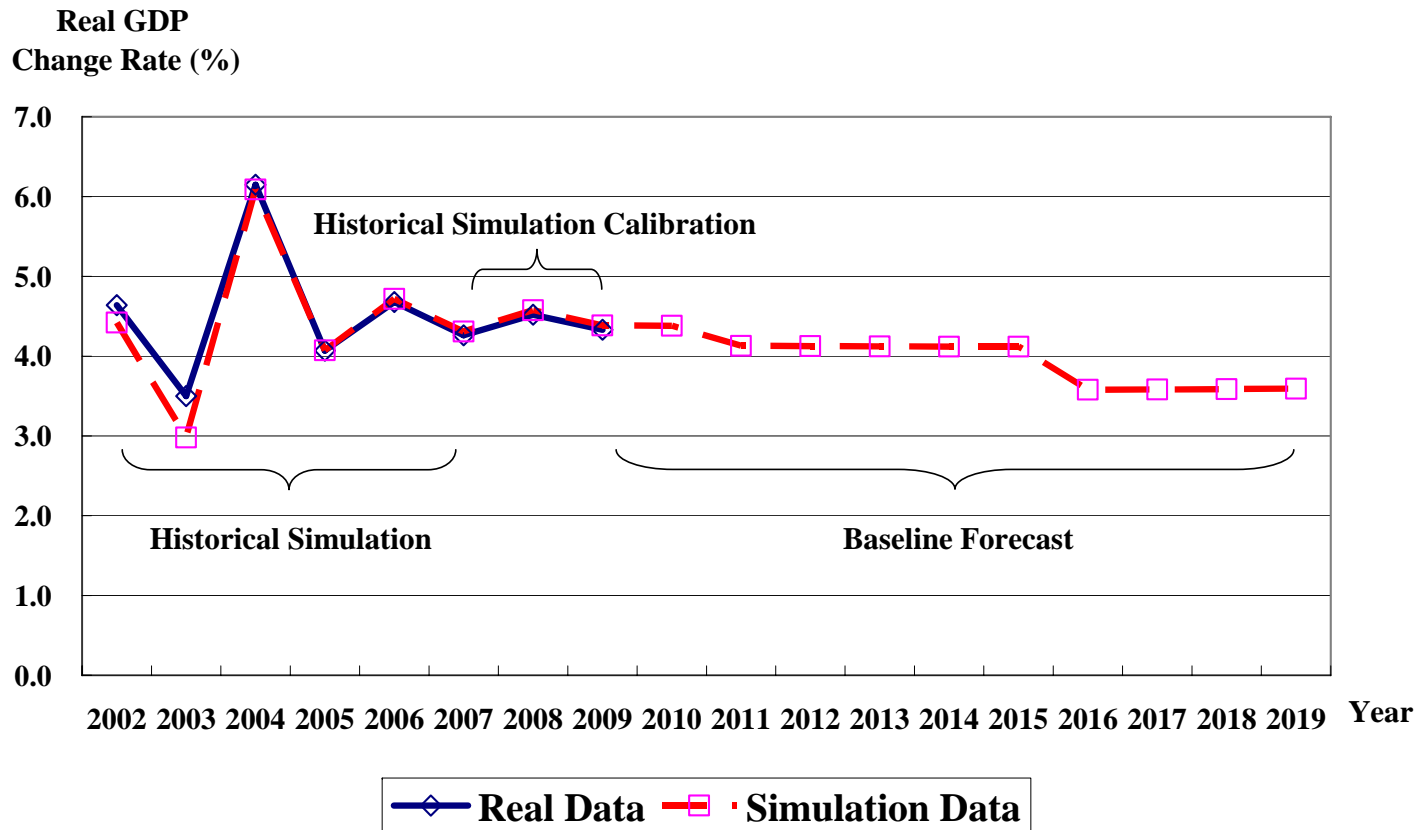
EnFore – CGE Data Structure

			Output					
			1	**2**	**3**	**4**	**5**	**6**
			Producers	**Investment**	**Household**	**Export**	**Government**	**Stock**
		Size	**I**	**I**	**1**	**1**	**1**	**1**
	Basic Flows	**C×S**	**V1BAS**	**V2BAS**	**V3BAS**	**V4BAS**	**V5BAS**	**V6BAS**
	Margins	**C×S×M**	**V1MAR**	**V2MAR**	**V3MAR**	**V4MAR**	**V5MAR**	**n/a**
	Taxes	**C×S**	**V1TAX**	**V2TAX**	**V3TAX**	**V4TAX**	**V5TAX**	**n/a**
I n p u t	**Labor**	**O**	**V1LAB**					
	Individual Income Tax	**O**	**V1LABTAX**					
	Capital	**1**	**V1CAP**					
	Business Income Tax	**1**	**V1CAPTAX**					
	Land	**1**	**V1LAD**					
	Production Tax	**1**	**V1PXT**					
	Other Cost Tickets	**1**	**V1OCT**					

	Joint Production Matrix
Size	**I**
C	**MAKE**

	Tariffs
Size	**1**
C	**V0TAR**

21 industries
48 commodities

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Simulation Scenario Design

- **Scenario 1: Levying an energy tax without any complementary measures (basic scenario)**
- **Scenario 2: New energy tax revenue that is all used for reducing individual income tax (green tax reform)**
- **Scenario 3: New energy tax revenue that is all used for reducing business income tax (green tax reform)**
- **Scenario 4: New energy tax revenue that is half used for reducing business income tax and half used for reducing individual income tax (green tax reform)**
- **Scenario 5: One-third of the new energy tax revenue is used for reducing business income tax; one-third is used for reducing individual income tax; and one-third is used for subsidizing public transportation (green tax reform plus fiscal policy)**
- **Scenario 6: One-fourth of new energy tax revenue is used for reducing business income tax; one-fourth is used for reducing individual income tax; one-fourth is used for subsidizing public transportation; and one-fourth is used for R&D investment (green tax reform plus fiscal policy)**

Energy Tax Rates

(%)

Items	Unit	Ad-Valorem Tax Rate									
		2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Gasoline	NT$/L	51.07	51.07	57.01	68.42	79.37	90.31	101.26	113.57	129.99	146.41
Diesel	NT$/L	30.48	30.48	41.64	52.75	63.85	74.96	86.06	101.33	117.99	134.65
Kerosene	NT$/L	14.05	14.05	17.36	20.66	25.62	32.23	38.84	45.45	52.07	58.69
Jet Fuel	NT$/L	2.93	2.93	10.14	19.76	29.38	38.99	48.61	58.22	67.84	77.42
Solvent Oil	NT$/L	2.60	2.60	8.02	15.25	22.47	31.61	42.45	53.29	64.13	72.25
L.P.G.	NT$/L	3.40	3.40	12.31	22.16	32.00	43.70	56.01	68.32	60.63	89.86
Fuel Oil	NT$/L	1.06	1.06	5.80	13.54	21.28	29.01	36.75	44.49	52.22	59.96
Coal	NT$/Kg	0.00	0.00	5.63	13.13	20.63	28.13	35.63	43.13	50.63	58.13
Natural Gas	NT$/$M^3$	0.00	0.00	5.45	12.73	20.00	27.27	34.55	41.82	49.09	56.36

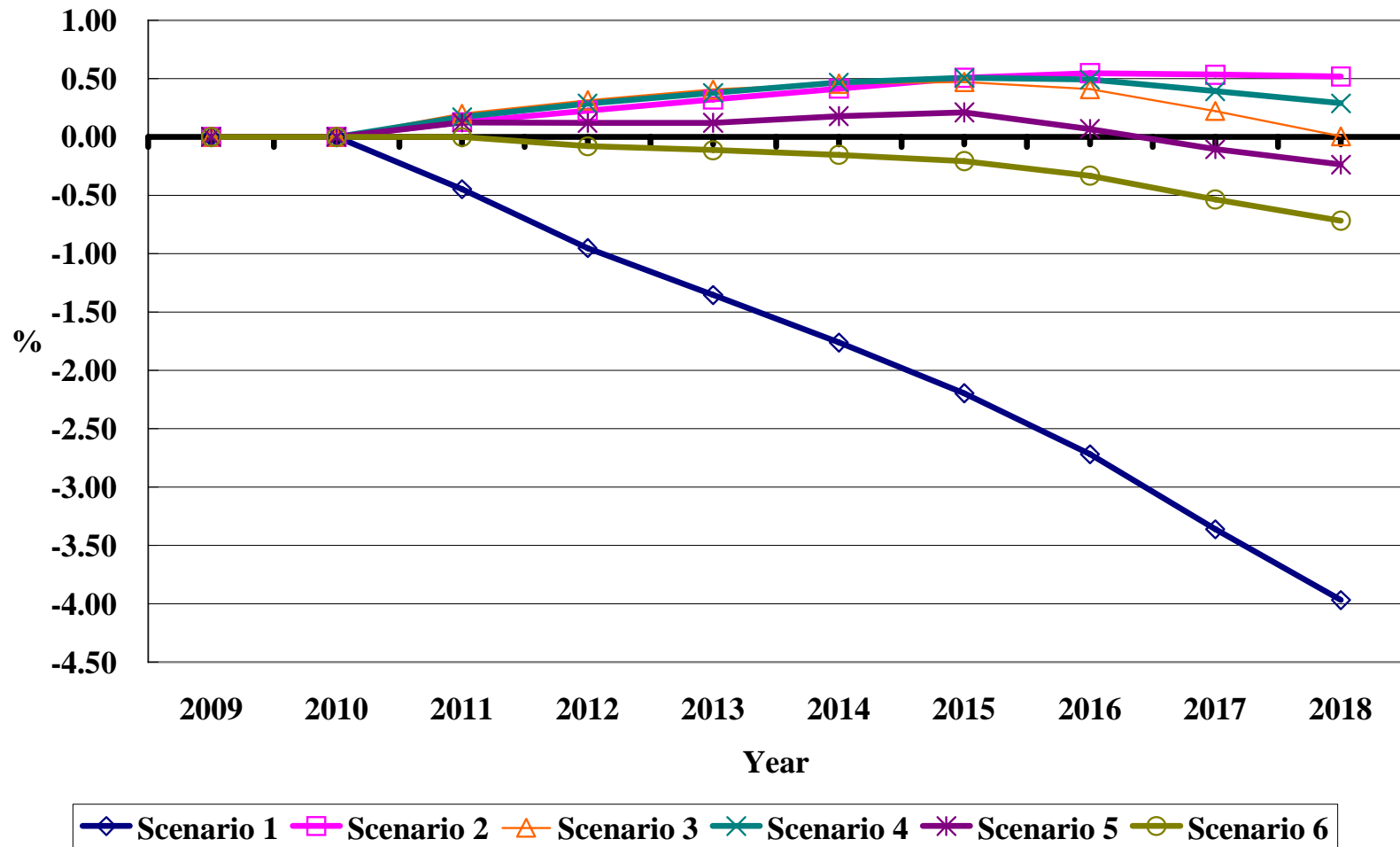Source: Based on the Draft of the Energy Tax Bill proposed by Legislator Min-Jen Chen, Legislative Yuan, Taiwan 2007

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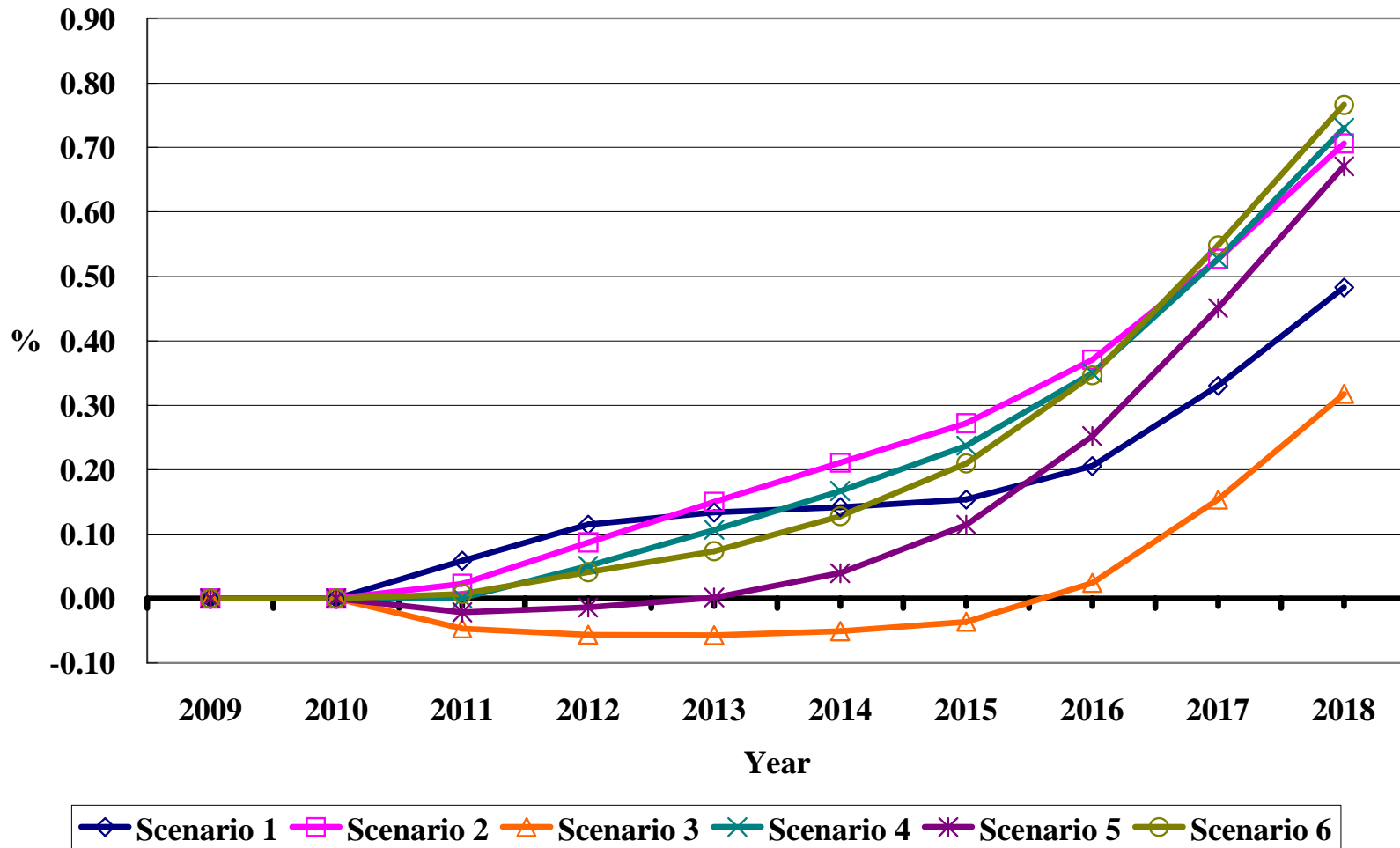16

Energy Tax Revenue

(Million NT$)

Tax Revenue	2011	2012	2013	2014	2015	2016	2017	2018
Energy Goods	38,067	94,520	154,661	222,359	297,505	383,822	485,541	589,825
Other Goods	4,574	11,264	18,868	26,616	34,404	41,093	46,328	51,949
Intermediate Goods Subtotal	42,641	105,784	173,529	248,975	331,909	424,914	531,869	641,775
Business Income Tax	-2,185	-5,354	-8,726	-12,521	-16,734	-21,532	-27,053	-32,705
Individual Income Tax	-2,341	-5,531	-8,690	-12,146	-15,928	-20,224	-25,246	-30,262
Total	38,114	94,899	156,113	224,308	299,247	383,158	479,570	578,807

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Impacts of Energy Tax on GDP

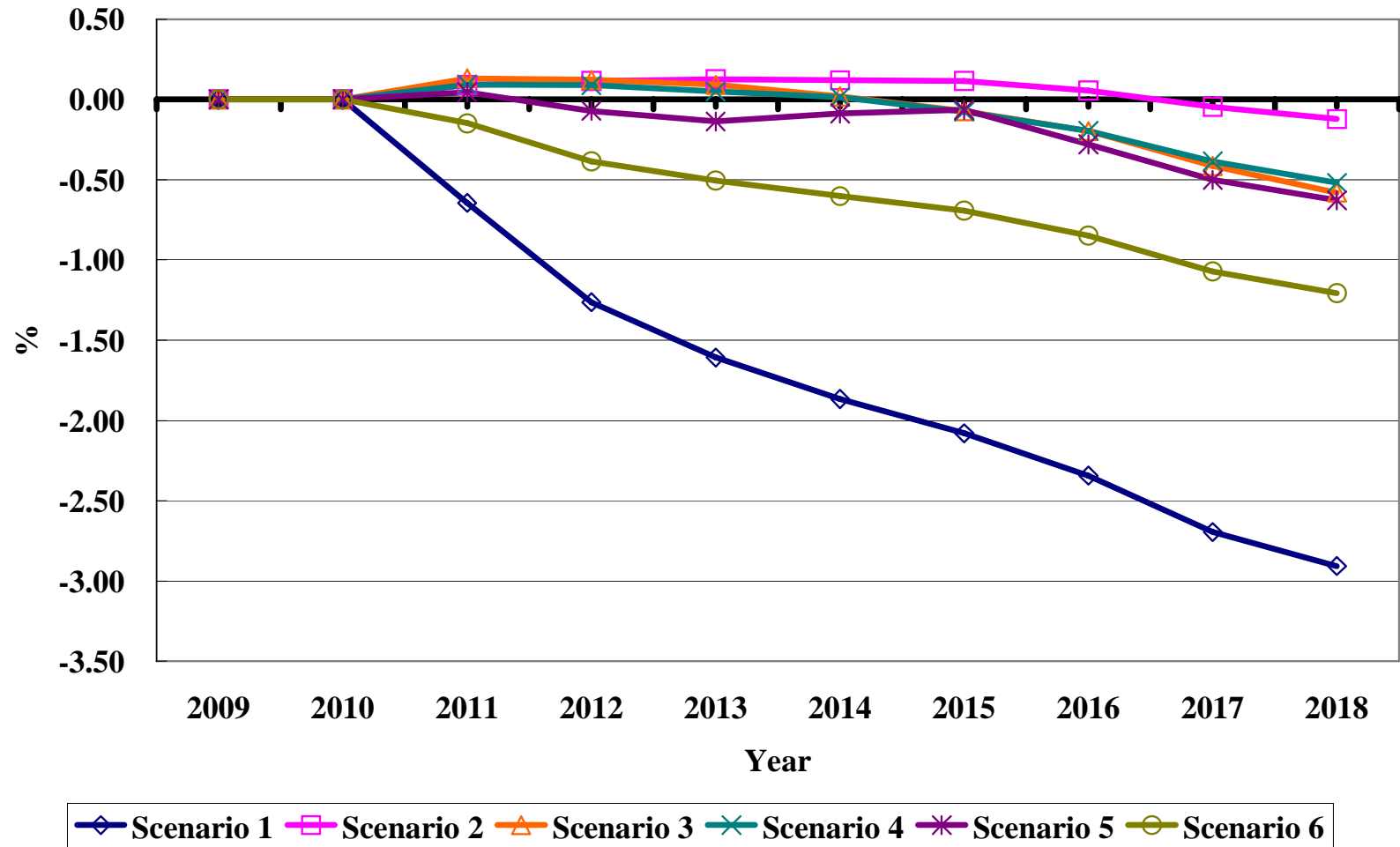Chiniese Culture
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Impacts of Energy Tax on the Price Level (CPI)

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Impacts of Energy Tax on the Real Wage Rate

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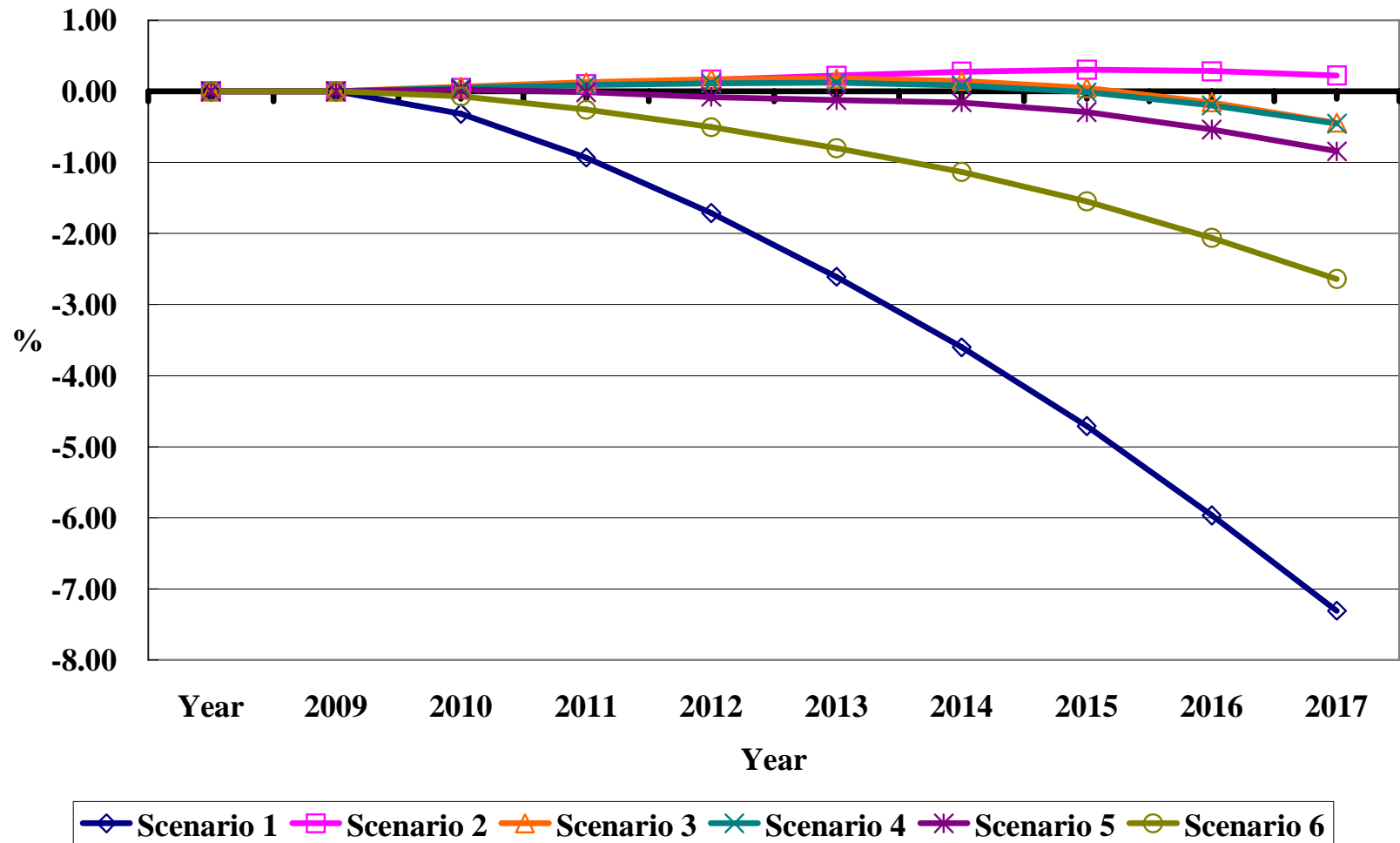
Impacts of Energy Tax on Employment

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Industrial Structural Change under Scenario 2

(%)

Industries	2011	2012	2013	2014	2015	2016	2017	2018
Energy-intensive Industries								
Petrochemical	-0.14	-0.42	-0.70	-0.99	-1.28	-1.62	-1.99	-2.35
Oil and Coal	-2.21	-4.54	-6.31	-7.80	-9.07	-10.35	-11.66	-12.79
Non-metallic	-0.91	-2.34	-3.87	-5.49	-7.14	-8.89	-10.72	-12.43
Metallic	-0.28	-0.84	-1.53	-2.44	-3.52	-4.75	-6.13	-7.38
Water, Electricity, Gas	-0.06	-0.20	-0.33	-0.47	-0.60	-0.79	-1.02	-1.23
Nonenergy-intensive Industries								
Agriculture	0.04	0.08	0.09	0.09	0.06	-0.09	-0.32	-0.61
Mining	-0.63	-1.66	-2.87	-4.26	-5.68	-7.23	-8.82	-10.23
Food	0.06	0.11	0.13	0.12	0.09	-0.06	-0.30	-0.60
Tobacco & Wine	0.05	0.07	0.09	0.10	0.11	0.09	0.02	-0.06
Textile & Leather	0.29	0.46	0.54	0.56	0.51	0.34	0.06	-0.38
Wood & Bamboo	0.55	1.22	1.88	2.59	3.32	4.00	4.64	5.21
Paper and Printing	0.25	0.48	0.70	0.92	1.14	1.32	1.46	1.58
Machinery	0.35	0.73	1.08	1.38	1.63	1.78	1.83	1.83
Electric Machinery	0.50	1.11	1.72	2.34	2.96	3.55	4.11	4.64
Information & Computer	0.49	1.14	1.86	2.69	3.60	4.59	5.65	6.73
Electronic	0.36	0.84	1.39	2.03	2.75	3.55	4.44	5.37
Other Manufactories	0.88	2.00	3.16	4.41	5.74	7.08	8.45	9.77
Construction	0.10	0.20	0.26	0.26	0.19	-0.03	-0.40	-0.85
Commercial	0.18	0.35	0.51	0.67	0.83	0.92	0.94	0.94
Transportation	0.04	0.03	0.00	-0.04	-0.08	-0.24	-0.50	-0.79
Other Services	0.18	0.35	0.53	0.71	0.90	1.05	1.15	1.26

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Industrial Structural Change under Scenario 3

<div align="right">(%)</div>

Industries	2011	2012	2013	2014	2015	2016	2017	2018
Energy-intensive Industries								
Petrochemical	-0.07	-0.34	-0.63	-0.97	-1.34	-1.76	-2.30	-2.85
Oil and Coal	-2.14	-4.45	-6.23	-7.75	-9.10	-10.47	-11.94	-13.24
Non-metallic	-0.74	-2.03	-3.44	-4.98	-6.58	-8.30	-10.15	-11.93
Metallic	-0.17	-0.68	-1.36	-2.31	-3.47	-4.82	-6.39	-7.88
Water, Electricity, Gas	0.01	-0.10	-0.22	-0.39	-0.58	-0.84	-1.20	-1.56
Nonenergy-intensive Industries								
Agriculture	-0.05	-0.20	-0.39	-0.63	-0.92	-1.35	-1.91	-2.54
Mining	-0.66	-1.82	-3.21	-4.79	-6.42	-8.20	-10.06	-11.73
Food	-0.01	-0.11	-0.28	-0.52	-0.81	-1.25	-1.82	-2.47
Tobacco& Wine	0.11	0.20	0.27	0.33	0.37	0.37	0.31	0.23
Textile & Leather	0.06	-0.22	-0.64	-1.20	-1.90	-2.75	-3.83	-5.05
Wood & Bamboo	0.43	0.80	1.12	1.39	1.60	1.71	1.64	1.47
Paper and Printing	0.23	0.35	0.43	0.47	0.47	0.40	0.23	0.01
Machinery	0.50	0.97	1.38	1.69	1.91	2.01	1.93	1.76
Electric Machinery	0.31	0.57	0.80	0.98	1.12	1.20	1.16	1.09
Information & Computer	0.65	1.49	2.43	3.48	4.66	5.94	7.31	8.71
Electronic	0.66	1.53	2.55	3.73	5.08	6.59	8.24	9.97
Other Manufactories	0.60	1.14	1.62	2.05	2.40	2.66	2.74	2.72
Construction	0.24	0.48	0.70	0.79	0.72	0.47	-0.06	-0.73
Commercial	0.27	0.48	0.67	0.80	0.90	0.90	0.76	0.57
Transportation	0.15	0.22	0.25	0.24	0.18	0.00	-0.34	-0.74
Other Services	0.28	0.53	0.76	0.97	1.17	1.30	1.34	1.35

Tax Burden in Major Energy-intensive Industries

(Million NT$)

Year	2011	2012	2013	2014	2015	2016	2017	2018
Petrochemical								
Scenario 1	-142	-354	-584	-845	-1,137	-1,465	-1,836	-2,221
Scenario 2	-32	-88	-150	-220	-295	-377	-466	-559
Scenario 3	-2,166	-5,226	-8,486	-11,999	-15,767	-20,001	-24,684	-29,480
Scenario 4	-1,513	-3,303	-5,471	-7,903	-10,500	-13,313	-16,466	-19,660
Scenario 5	-749	-1,796	-2,928	-4,288	-5,633	-7,115	-8,758	-10,431
Scenario 6	-571	-1,407	-2,326	-3,345	-4,446	-5,630	-6,923	-8,214
Metallic								
Scenario 1	-254	-639	-1,076	-1,610	-2,233	-2,931	-3,722	-4,505
Scenario 2	-72	-208	-388	-639	-950	-1,308	-1,719	-2,115
Scenario 3	-2,625	-6,427	-10,561	-15,087	-19,971	-25,390	-31,332	-37,382
Scenario 4	-1,865	-4,138	-6,938	-10,128	-13,564	-17,244	-21,324	-25,418
Scenario 5	-940	-2,301	-3,818	-5,677	-7,571	-9,654	-11,954	-14,266
Scenario 6	-708	-1,765	-2,948	-4,312	-5,833	-7,488	-9,321	-11,152
Transportation								
Scenario 1	-224	-555	-913	-1,310	-1,743	-2,243	-2,817	-3,406
Scenario 2	-5	-23	-48	-83	-126	-197	-299	-414
Scenario 3	-4,358	-10,261	-16,290	-22,559	-29,068	-36,292	-44,106	-51,896
Scenario 4	-3,047	-6,462	-10,459	-14,787	-19,252	-24,011	-29,231	-34,364
Scenario 5	-1,492	-3,489	-5,568	-7,989	-10,279	-12,768	-15,472	-18,148
Scenario 6	-1,064	-2,533	-4,071	-5,720	-7,461	-9,345	-11,406	-13,445

Impacts of Energy Tax on Gasoline Consumption

2008/9/2
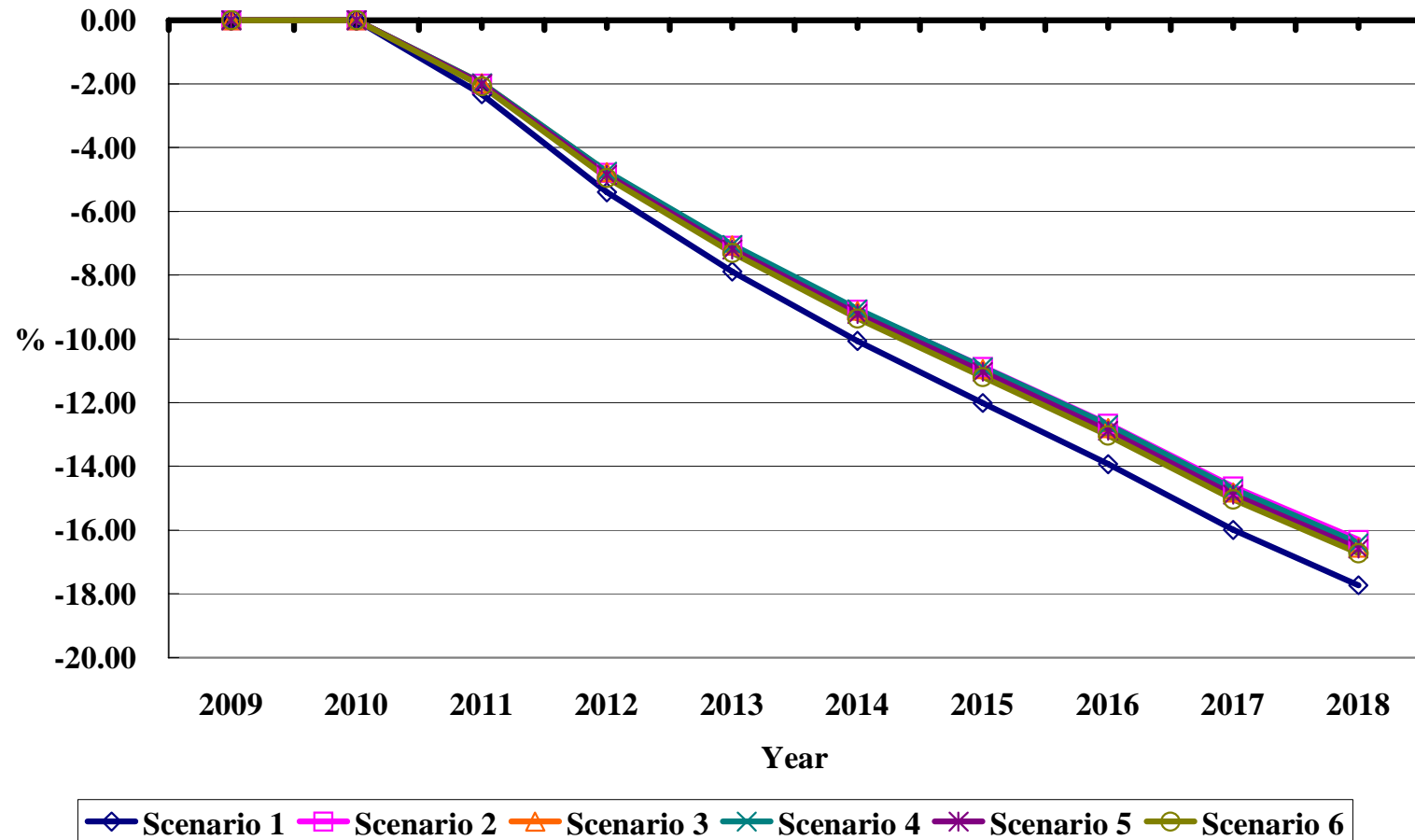
Impacts of Energy Tax on Diesel Consumption

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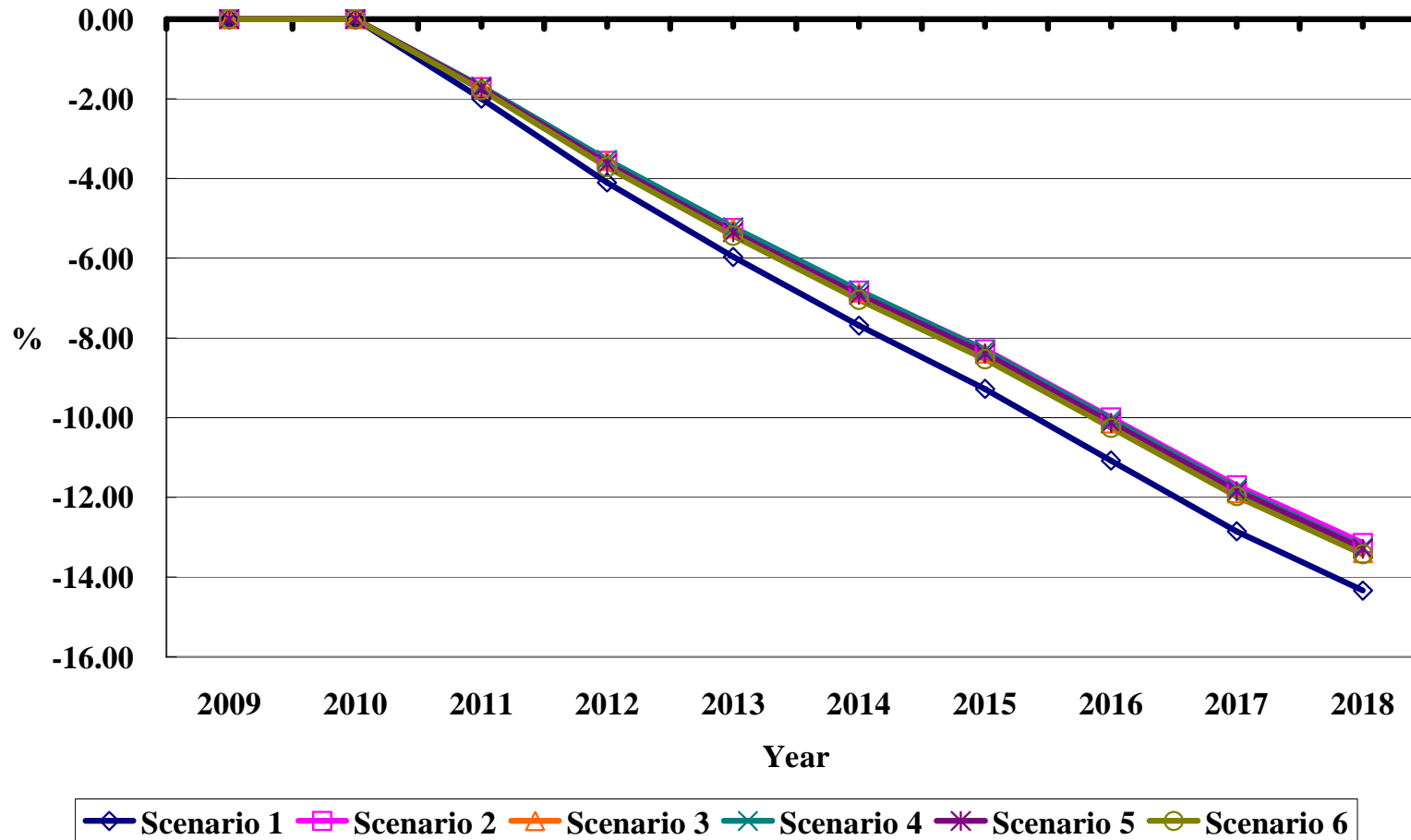
Impacts of Energy Tax on Fuel Oil Consumption

2008/9/2

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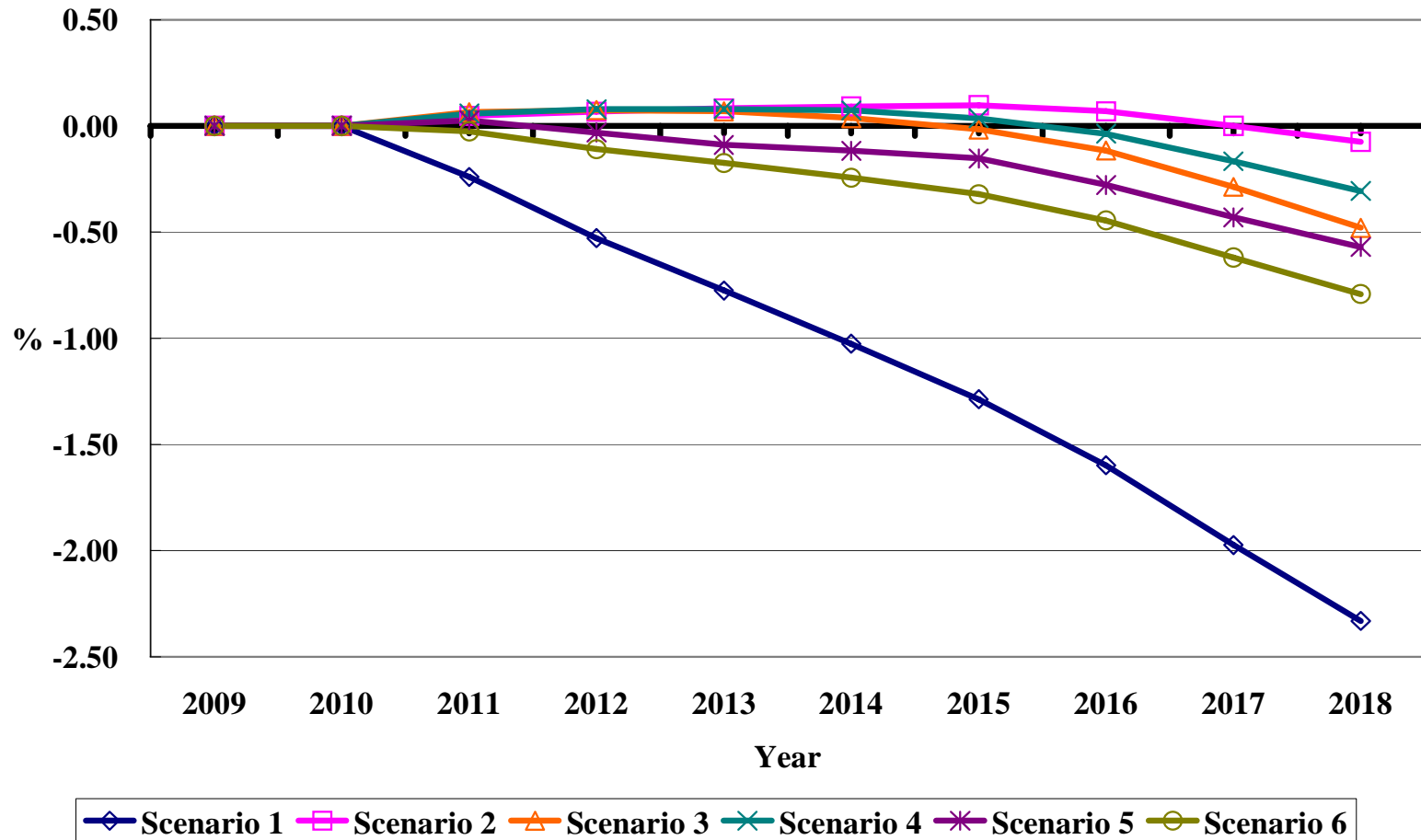
Mitigation of CO2 Emissions due to Energy Tax Policy

2008/9/2
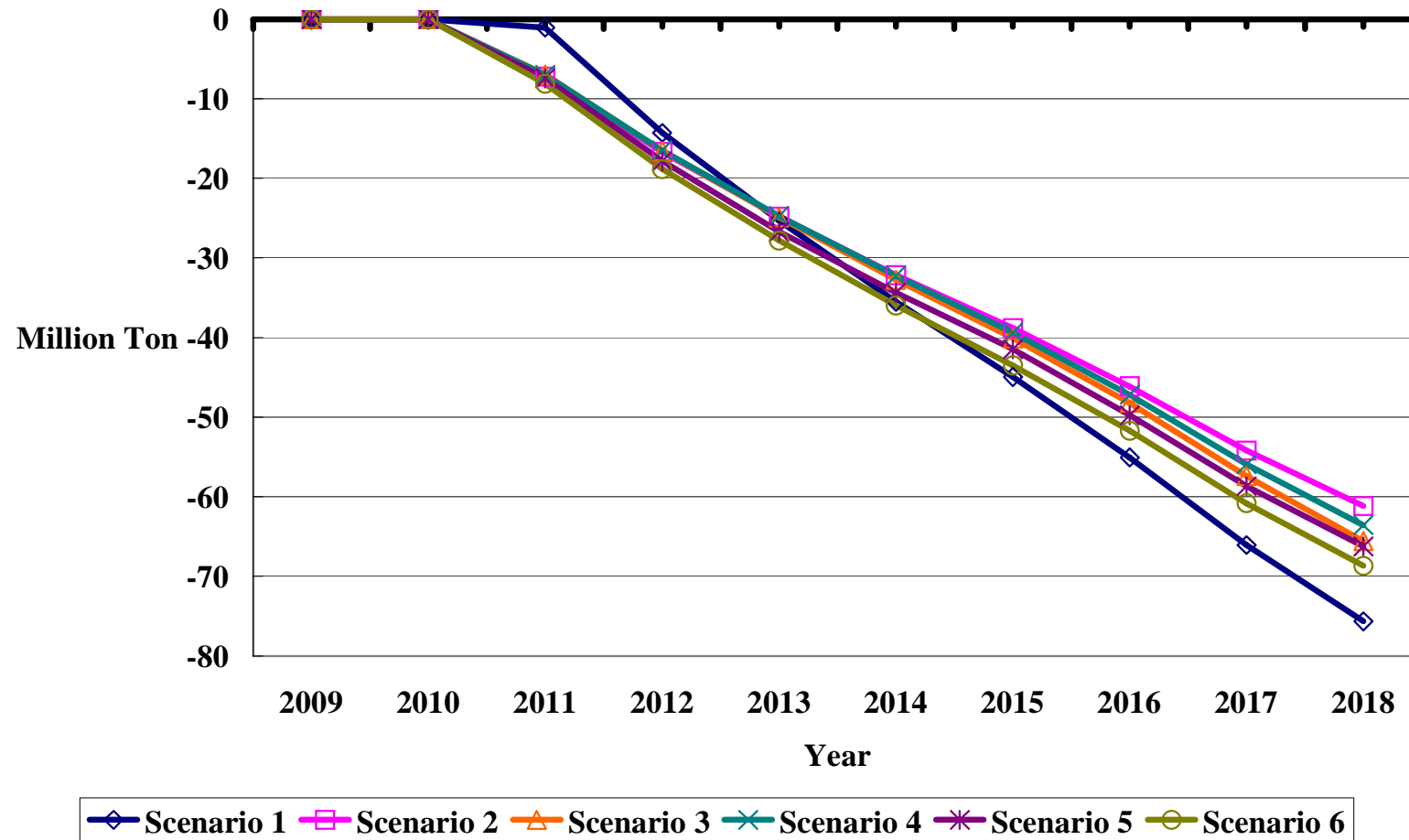
Benefit Estimation

- **By taking the benchmark EU carbon contract, for December 2008 delivery of EU allowances (EUAs), which closed at €27.54 on the European Climate Exchange (ECX)**

- **The converted monetary amounts in this study indicate that the energy-tax regime has generated the benefits of environmental protection at about:**

  - **€202 million in 2011 and €1.79 billion in 2018**
  - **Accounting for about 0.07% and 0.66% of real GDP in 2011 and 2018 for Taiwan, respectively**

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Concluding Remarks

- **The first dividend:**
  - **All types of energy consumption have consistently decreased under all scenarios, which indicates the positive effects of the policy in terms of energy saving and environmental protection**

Concluding Remarks

- **The second dividend:**
  - The measure of reducing both business and individual income taxes, due to its effect of encouraging investment and consumption, has not only offset the negative impact on real GDP but has even led to positive GDP growth

Concluding Remarks

- **From the industry perspective, due to the substitutive relationship or output effect between industries**
    - **Energy taxes will have negative impacts on energy-intensive industries such as:**
        - **Petrochemical, oil and coal, non-metallic, metallic, water, electricity, and gas industries, as well as transportation services**

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Concluding Remarks

- **When considering the net business tax burden**
  - Energy-intensive industries have still been able to enjoy the benefits of a lower tax burden under all scenarios
  - This will smooth over the objection lobby wave from those industries

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Concluding Remarks

- **The argument of a green tax reform is determined not by its compliance with the theory of internalizing externalities but by the design of the complementary fiscal measures**

Concluding Remarks

- **The authorities should design appropriate complementary measures that can generate the double dividend effect**

- **New evidence from this study**

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Thank you for your attention

Q and A Time