Estimation of substitution elasticities for CGE models

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1. Introduction

Background

Many studies of climate policy are based on computable general equilibrium (CGE) modeling.

Criticism

The lack of the empirical evidence for the key parameters in CGE models

- The simulation results depend on the size of parameters specified.

- In particular, the substitution elasticities between production factors have a major influence.

2. Estimation of substitution elasticities

Estimation model

Three levels of nested CES

$$Q = \left[\alpha_{top} LKE^{\frac{\sigma_{top}-1}{\sigma_{top}}} + (1-\alpha_{top}) M^{\frac{\sigma_{top}-1}{\sigma_{top}}} \right]^{\frac{\sigma_{top}}{\sigma_{top}-1}}$$

$$LKE = \left[\alpha_{KE-L} L^{\frac{\sigma_{KE-L}-1}{\sigma_{KE-L}}} + (1-\alpha_{KE-L}) KE^{\frac{\sigma_{KE-L}-1}{\sigma_{KE-L}}} \right]^{\frac{\sigma_{KE-L}}{\sigma_{KE-L}-1}}$$

$$KE = \left[\alpha_{KE} K^{\frac{\sigma_{KE}-1}{\sigma_{KE}}} + (1-\alpha_{KE}) E^{\frac{\sigma_{KE}-1}{\sigma_{KE}}} \right]^{\frac{\sigma_{KE}}{\sigma_{KE}-1}}$$

The models to be estimated

$$\ln\left(\frac{LKE}{M}\right) = \beta_{top} + \sigma_{top} \ln\left(\frac{P_M}{P_{LKE}}\right)$$

$$\beta_{top} = \sigma_{top} \ln\left[\frac{1-\alpha_{top}}{\alpha_{top}}\right]$$

$$\ln\left(\frac{KE}{L}\right) = \beta_{KE-L} + \sigma_{KE-L} \ln\left(\frac{P_L}{P_{KE}}\right)$$

$$\beta_{KE-L} = \sigma_{KE-L} \ln\left[\frac{1-\alpha_{KE-L}}{\alpha_{KE-L}}\right]$$

$$\ln\left(\frac{E}{K}\right) = \beta_{KE} + \sigma_{KE} \ln\left(\frac{P_K}{P_E}\right)$$

$$\beta_{KE} = \sigma_{KE} \ln\left[\frac{1-\alpha_{KE}}{\alpha_{KE}}\right]$$

Role of substitution elasticity σ

Larger σ

The sigma is the degree of how easily they can buy energy efficient equipments when energy costs increase.

Lower cost of CO_2 emission reductions

Smaller economic impact by CO_2 emission reductions

The σ has a major influence on simulation results of CGE models and therefore policy designs.

Data

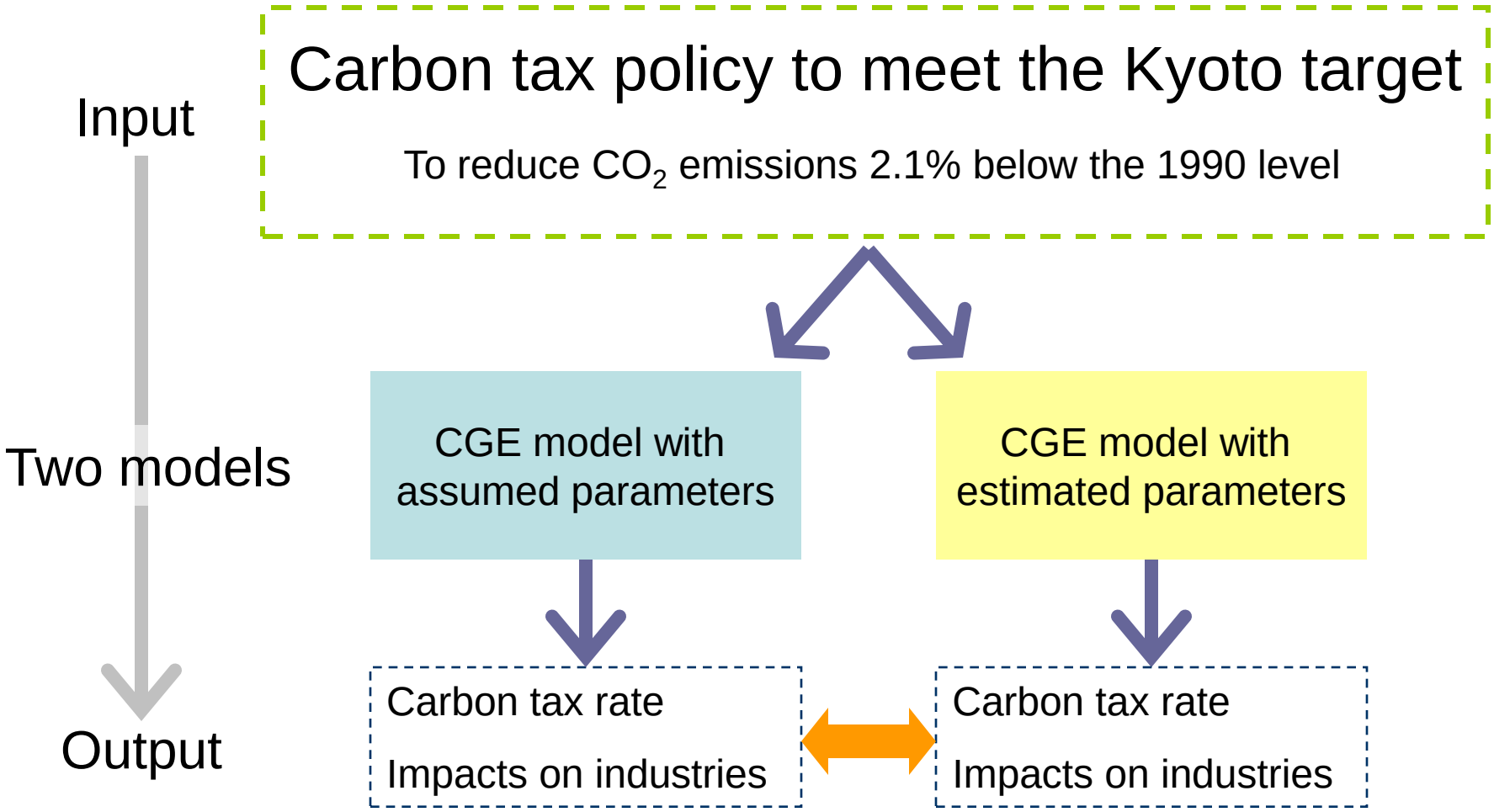
- Panel data analysis
  - Period: 1995-2004
  - OECD 14 countries
    - Austria, Belgium, Denmark, Spain, Finland, France, Germany, Italy, Japan, Luxemburg, Netherlands, Sweden, UK, US
  - 18 industries
    - Agriculture, Mining, Food, Textile, Wood, Paper & pulp, Chemical, Non-ferrous metal, Machinery, Electrical equipment, Transport equipment, Other manufacturing, Electricity-water-gas distribution, Construction, Transportation, Telecom, Financial service, Personal service
  - Formed by EU-KLEM project (European committee)

Estimation results

	assumed parameters		estimated parameters
	σ top		
Chemical	0.00	<	0.81
Iron & Steel	0.00	<	1.05
Machinery	0.00	<	1.15
Electrical equipment	0.00	<	0.75
Transport equipment	0.00	<	1.04
Transport	0.00	<	1.05
Construction	0.00	<	0.97
	σ KE-L		
Chemical	0.80	>	0.34
Iron & Steel	0.80	>	0.00
Machinery	0.80	>	0.08
Electrical equipment	0.80	>	0.33
Transport equipment	0.80	>	0.43
Transport	0.80	>	0.47
Construction	0.80	<	0.94
	σ KE		
Chemical	0.10	>	0.04
Iron & Steel	0.10	<	0.29
Machinery	0.20	>	0.12
Electrical equipment	0.20	<	0.25
Transport equipment	0.20	>	0.09
Transport	0.10	<	0.45
Construction	0.20	>	0.11

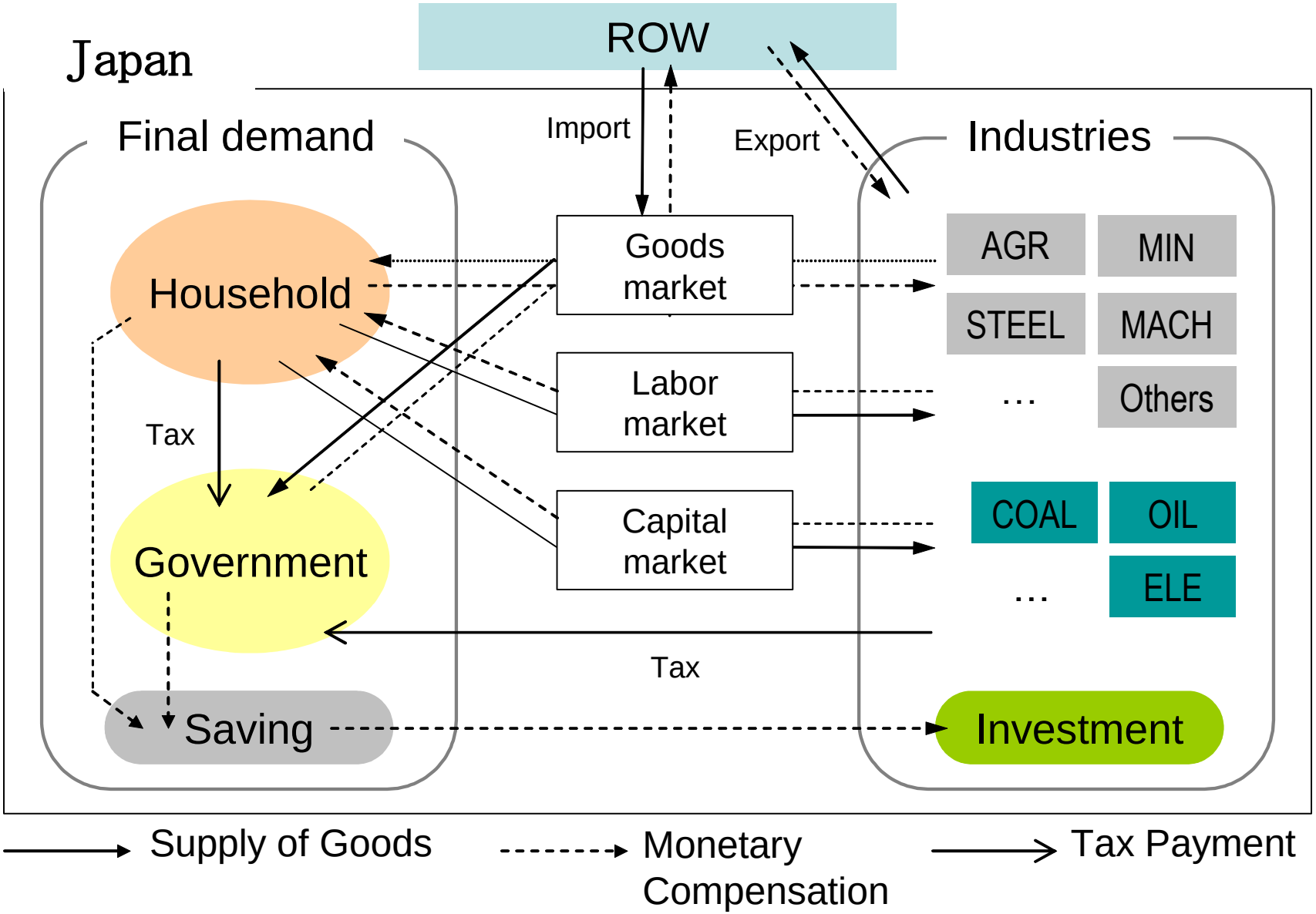
3. Policy simulation using estimated parameters

Comparison of different sigma



How different?

Framework of our CGE model

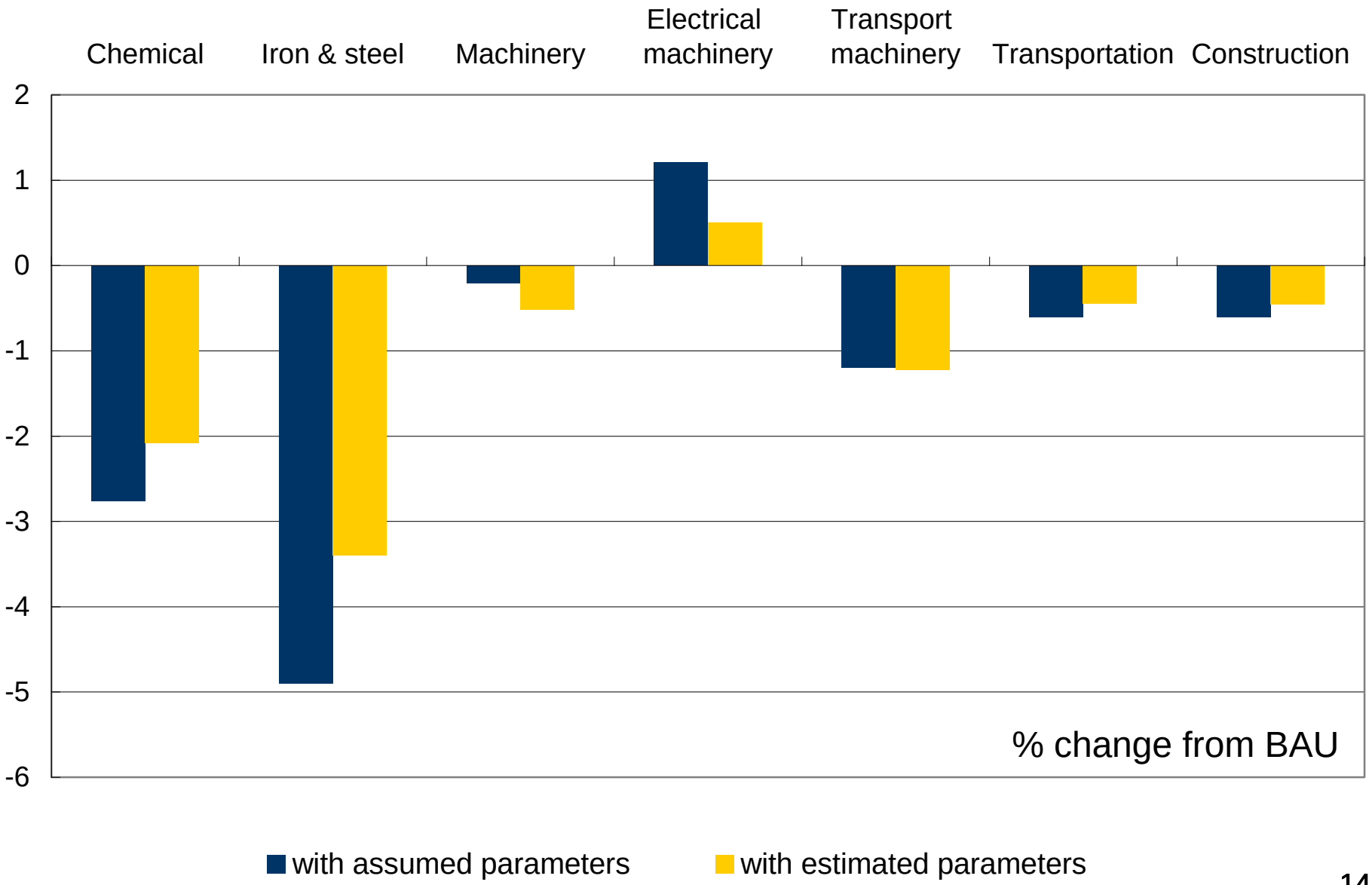


The results for macroeconomic impact

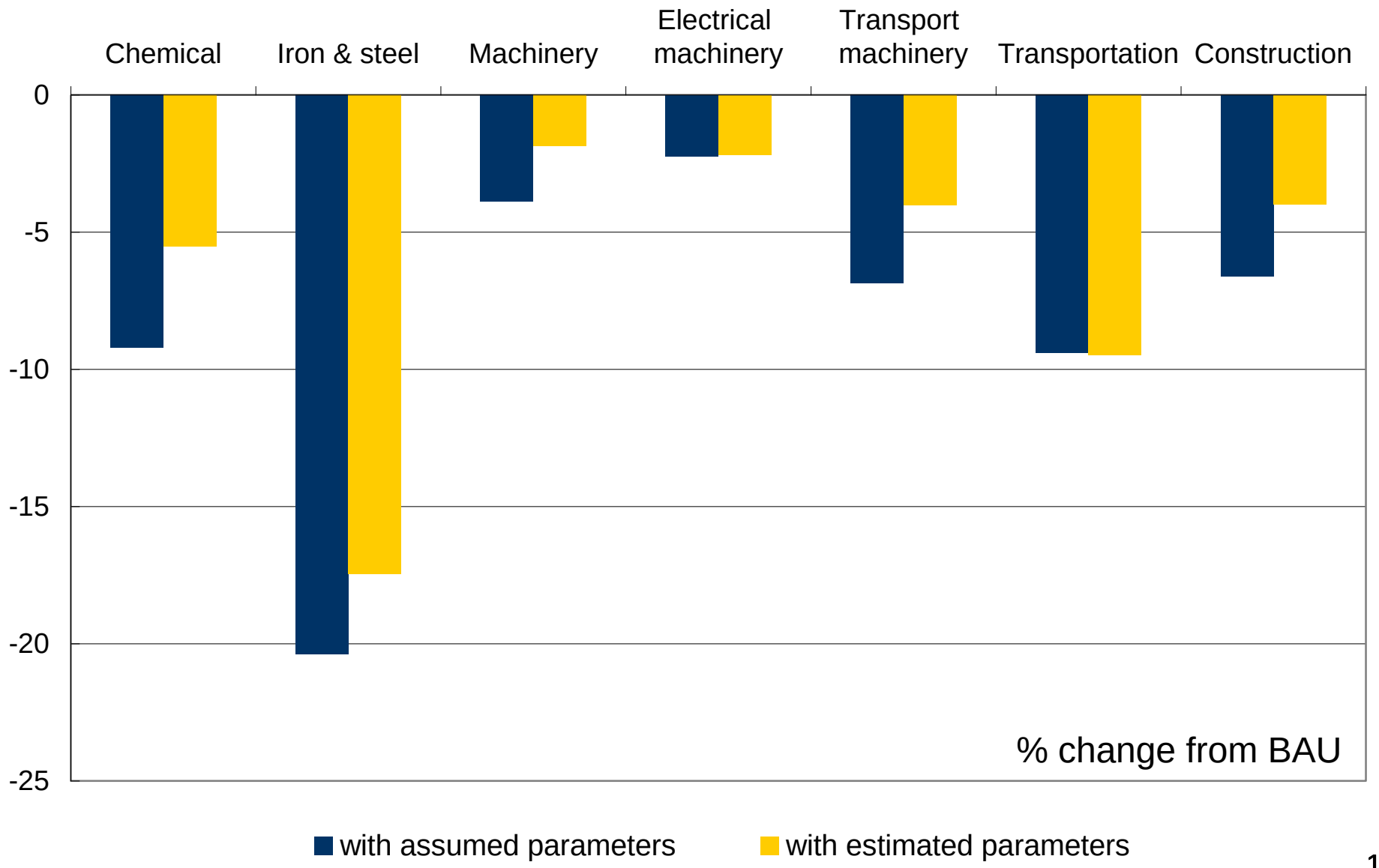
Model	with assumed parameters	with estimated parameters
CO2 reduction rate (%)	13.00	13.00
Carbon tax rate (yen/t-C)	18,766	13,075
GDP (%)	-1.10	-0.79
Equivalent Value (%)	-0.19	-0.16

Overestimation of the necessary carbon tax rate by 44% using assumed parameters

Industrial output change



Emission reduction



4. Summary

- We specified key parameters of CGE models by observation data.
  - Higher elasticities for energy intensive industries
  - Lower elasticities for non-energy intensive industries
- If we use conventional parameters, we could over-estimate the impacts of the climate policy.
  - 44% higher reduction costs for 1t of CO_2 emissions
  - Distribution of reduction costs of CO_2 emissions between industries

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