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# Estimation of Japanese Steel Product Trade Elasticity of Substitution

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1. Introduction

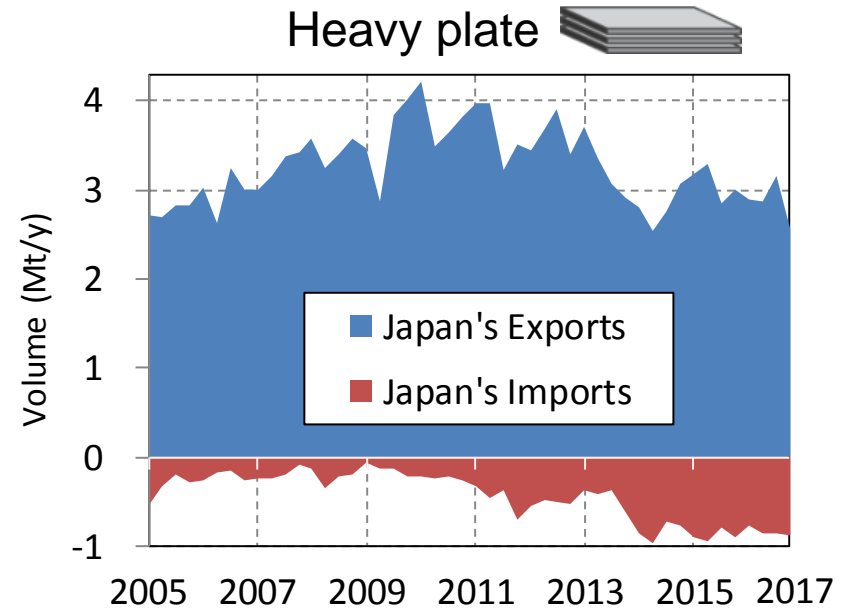
2. Analysis 1:

Price elasticity of substitution between Japan's export and Japan's import

3. Analysis 2:

Price elasticity of substitution between Japan's export and China's export

4. Summary

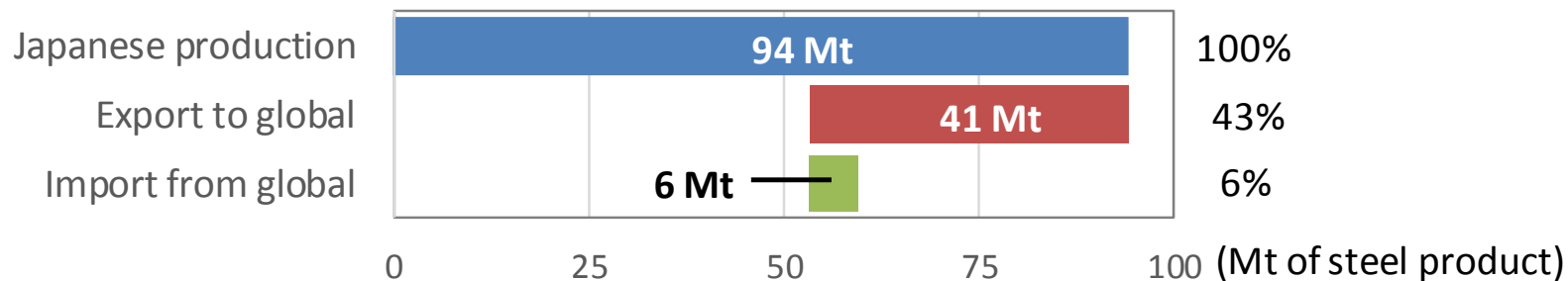


## 1. Steel is a carbon intensive material.

- ✓ Japanese steel industry emitted a 187 Mt of CO<sub>2</sub> in 2016, accounting for a 17% of Japan's energy-related CO<sub>2</sub> emissions.
- ✓ If an unilateral carbon tax, 30 US\$/tCO<sub>2</sub>, is adapted, steel production cost could rise by 66 US\$/t of steel (+11%).

## 2. Steel is a tradable commodity.

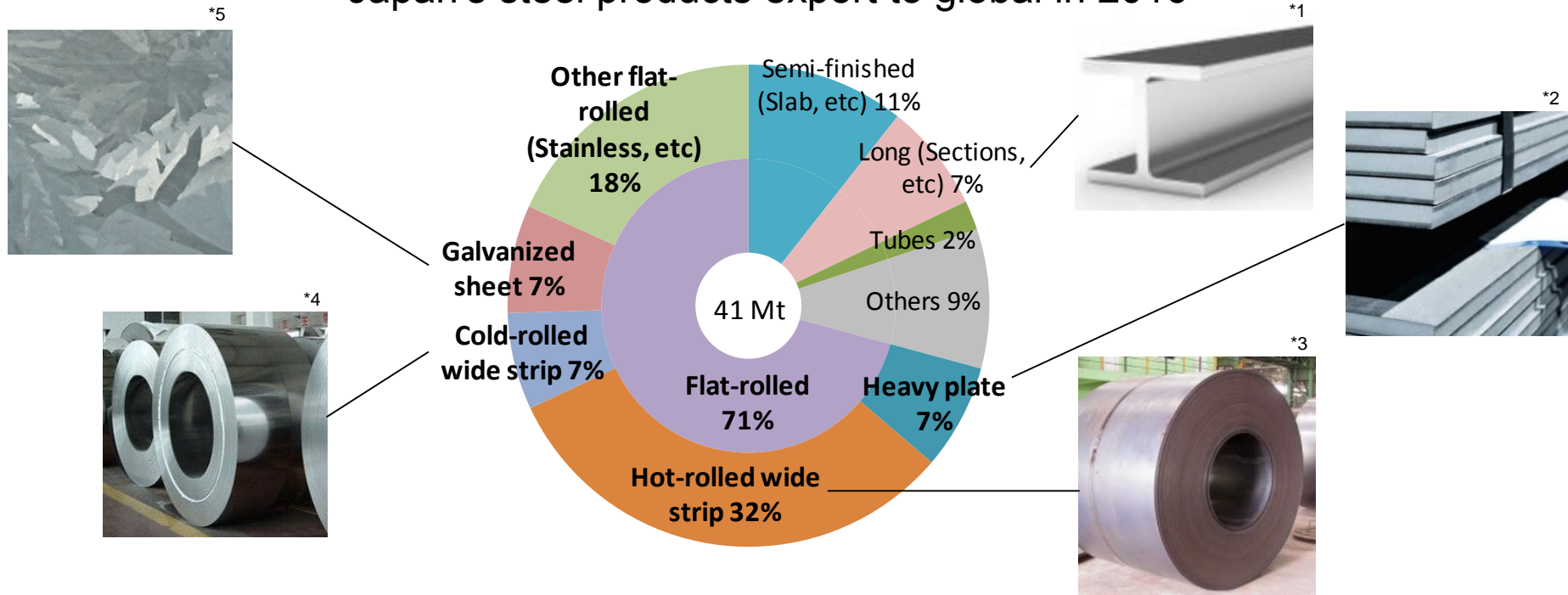
- ✓ Japan directly exported 41 Mt of steel products in 2016.



## 3. The increase in production cost can lead to carbon leakage.

Elasticity is one of the key parameters for the significance of carbon leakage.

## Japan's steel products export to global in 2016



✓ This study focuses on flat-rolled steel products as follows:

	Analysis 1	Analysis 2
Flat-rolled steel products	✓	✓
Heavy plate	✓	
Hot-rolled wide strip	✓	
...	...	

\*1) <http://www.retainingwallsteelqld.com.au/products.php>

\*2) <https://www.thyssenkrupp-steel.com/en/products/heavy-plate/heavy-plate-overview.html>

\*3) [http://www.yogsunsteel.com/fl at\\_products.php](http://www.yogsunsteel.com/fl at_products.php)

\*4) <http://japanese.galvanized-steelcoils.com/sale-5372291-astm-a1008-din16723-en10130-cold-rolled-steel-plate-sheet-for-oil-drum.html>

\*5) [https://en.wikipedia.org/wiki/Hot-dip\\_galvanization](https://en.wikipedia.org/wiki/Hot-dip_galvanization)

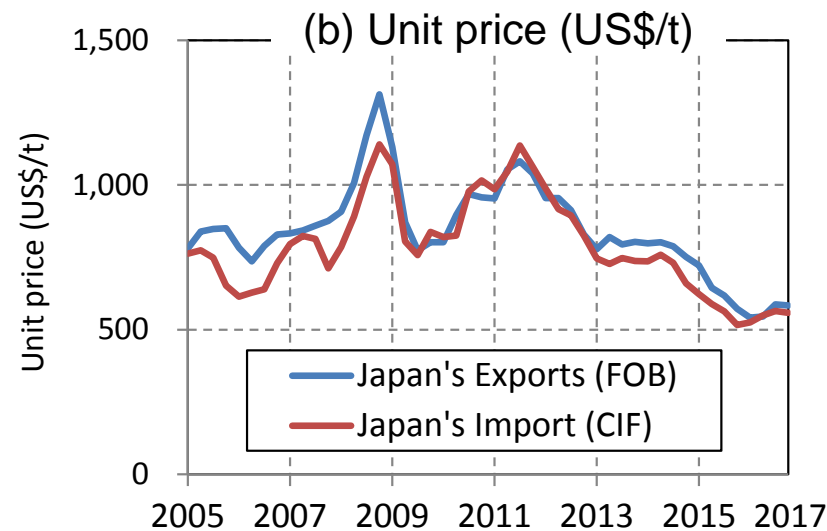
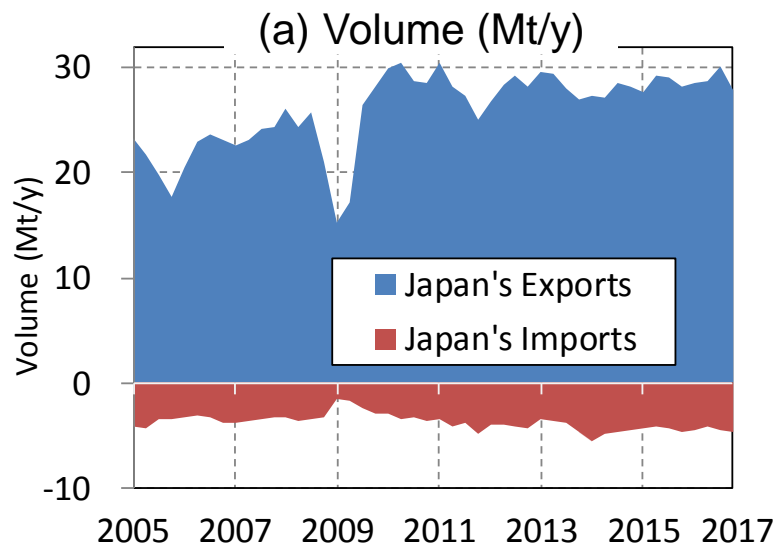
## Methodology

1. Previous work for estimating trade elasticity
  - ✓ Armington (1969): substitution between domestic and imported goods
  - ✓ Hoshino (2001): semi-conductor trade elasticity in Japan
2. Based on Hoshino (2001), Analysis 1 applies the following:

$$\ln \left( \frac{\text{Japan's export vol. [t]}}{\text{Japan's import vol. [t]}} \right) = c + \text{elasticity} \cdot \ln \left( \frac{\text{Japan's export price [US\$/t]}}{\text{Japan's import price [US\$/t]}} \right) + g \cdot \text{year}$$

## Data

### Flat-rolled steel products



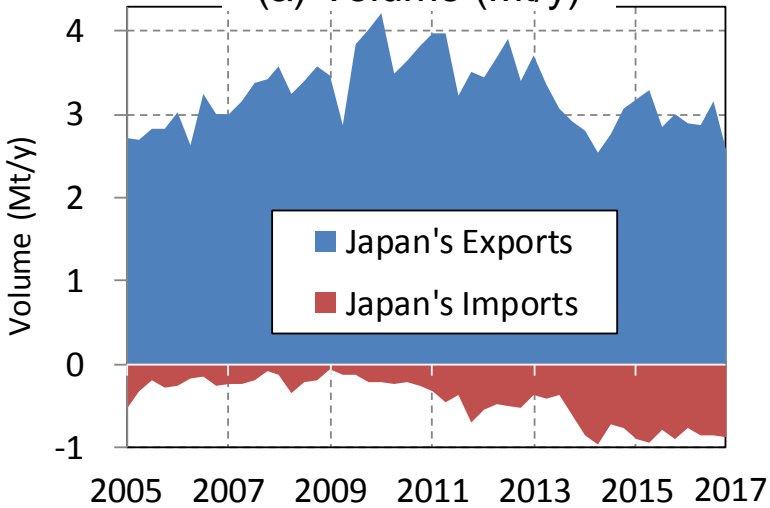
# Analysis 1: Data (1/2)

## Heavy plate

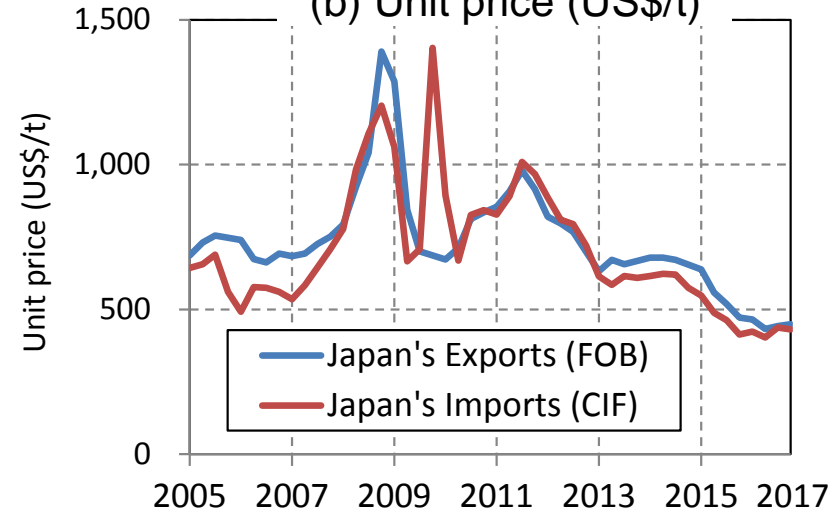


\*2

(a) Volume (Mt/y)



(b) Unit price (US\$/t)

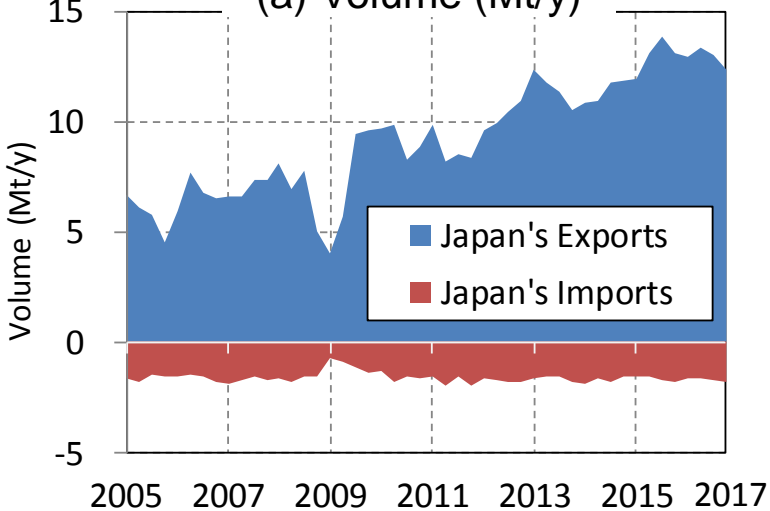


## Hot-rolled wide strip

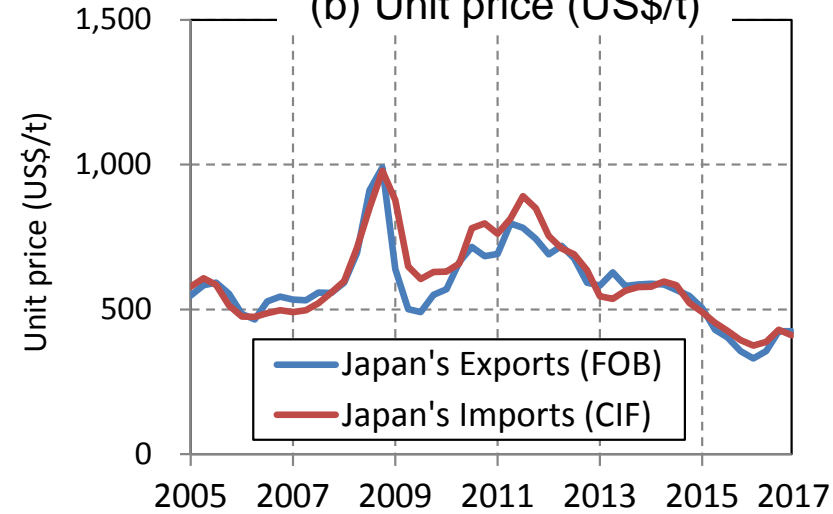


\*3

(a) Volume (Mt/y)

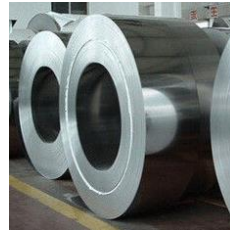


(b) Unit price (US\$/t)



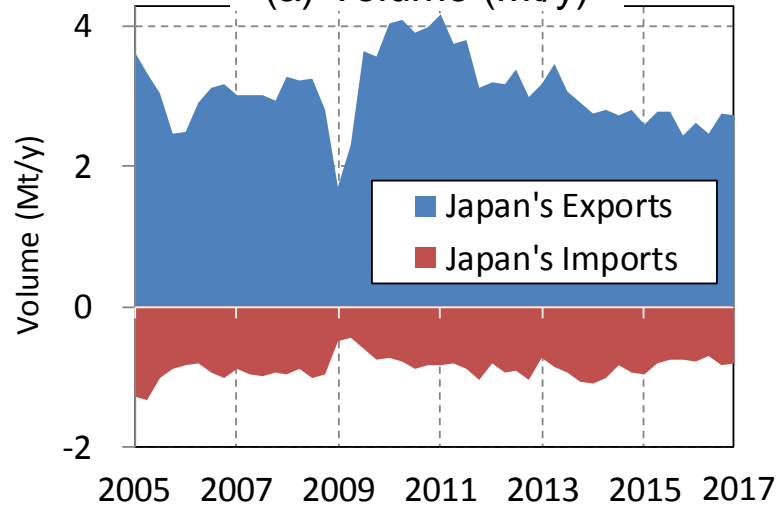
# Analysis 1: Data (2/2)

## Cold-rolled wide strip

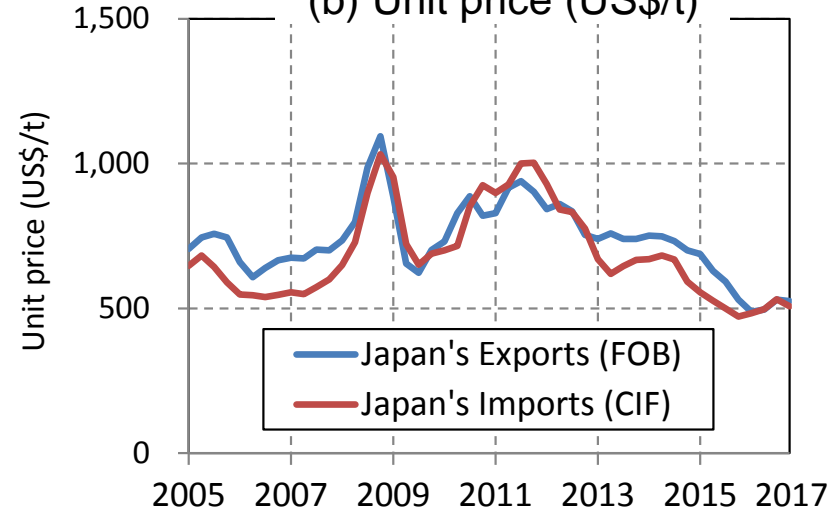


\*4

(a) Volume (Mt/y)



(b) Unit price (US\$/t)

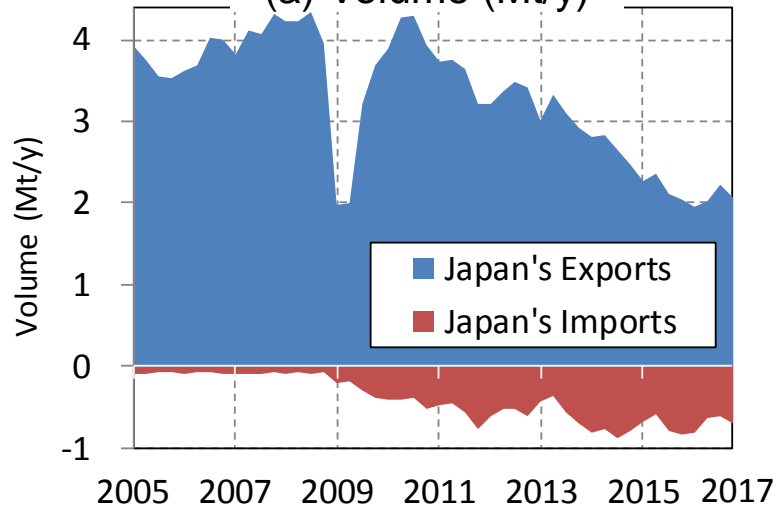


## Galvanized sheet

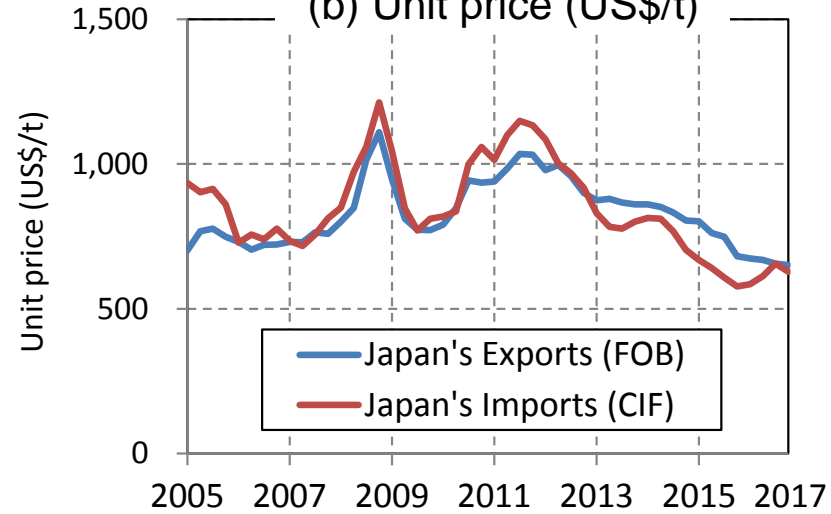


\*5

(a) Volume (Mt/y)



(b) Unit price (US\$/t)



# Analysis 1: Regression results

[Monthly data basis]	12 years (Jan. 2005—Jan. 2017)			4 years (Jan. 2013—Jan. 2017)		
	elasticity	<i>g</i> , time trend	R <sup>2</sup> adj	elasticity	<i>g</i> , time trend	R <sup>2</sup> adj
Flat-rolled steel products	-0.66**	-1%/y	0.05	N/A		
Heavy plate	-1.18**	-17**%/y	0.53	-1.83**	-24**%/y	0.50
Hot-rolled wide strip	-0.64**	7**%/y	0.59	N/A		
Cold-rolled wide strip	-0.99**	-1%/y	0.13	N/A		
Galvanized sheet		N/A		-1.16**	-23**%/y	0.50

Note) “N/A” means that we can’t observe statistically significant results.  
 \* denotes significance level < 10%. \*\* denotes significance level < 5%.

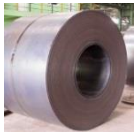
- ✓ Negative time trends imply that Japanese steel industry was losing market share.
- ✓ Large elasticity implies that price competitiveness was very intensive.



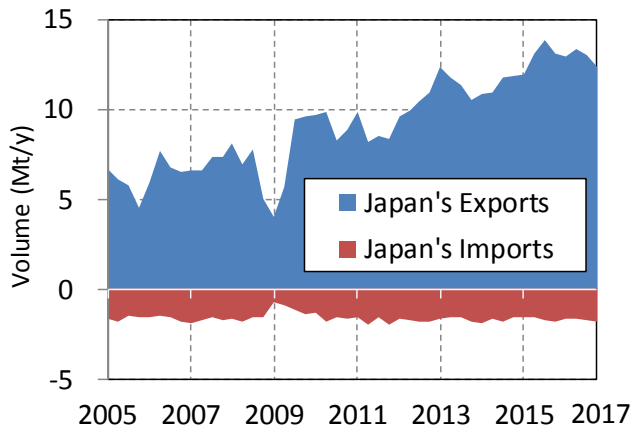
# Analysis 1: Discussion

[Monthly data basis]	12 years (Jan. 2005—Jan. 2017)			4 years (Jan. 2013—Jan. 2017)		
	elasticity	g, time trend	R <sup>2</sup> adj	elasticity	g, time trend	R <sup>2</sup> adj
Hot-rolled wide strip	-0.64**	7**%/y	0.59	N/A		
Galvanized sheet		N/A		-1.16**	-23**%/y	0.50

Hot-rolled wide strip, HRS (Mt/y)



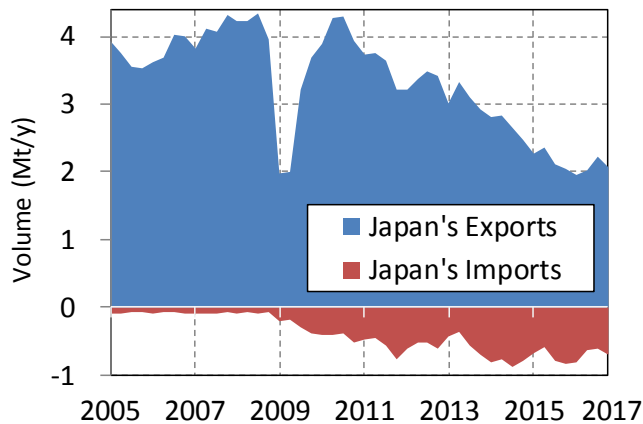
\*3



Galvanized Sheet, GS (Mt/y)



\*5



Hot-rolled wide strip (Mt/y)

2000'

Japan's steel makers

GS



Thai car companies

e.g., Toyota Motor Thailand

2010'

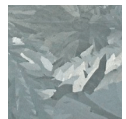
Japan's steel makers

HRS



Thai re-rollers

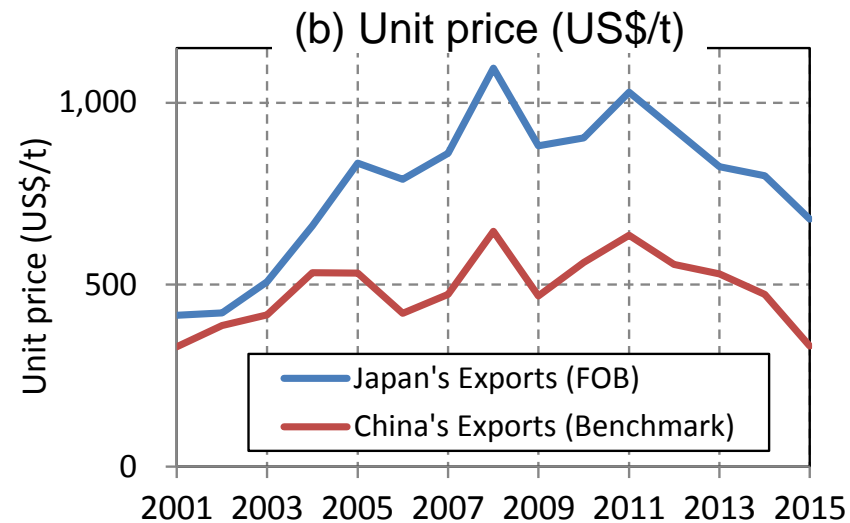
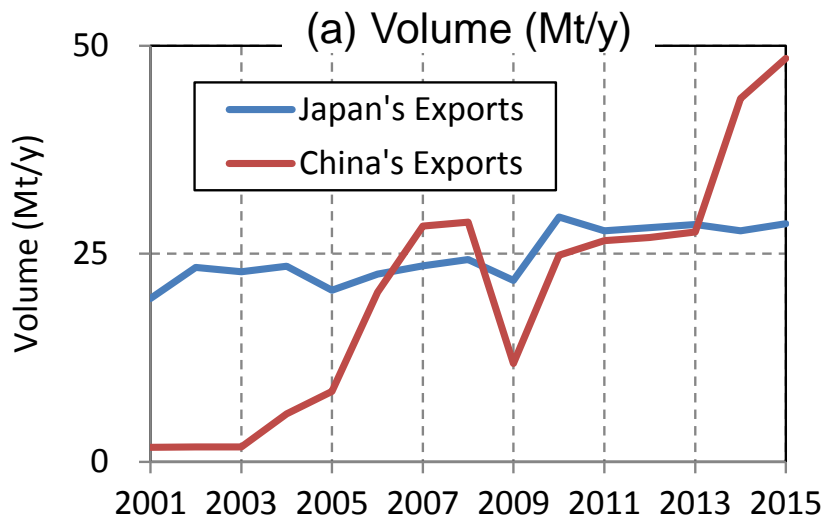
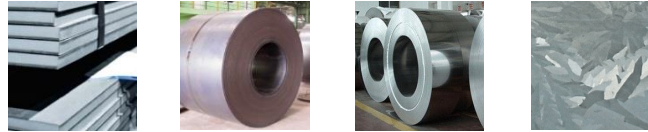
GS



Thai car companies

## Data

### Flat-rolled steel products



Ref) World Steel Dynamics Inc. Steel Benchmarker (2017)

## Methodology

✓ Based on Hoshino (2001), Analysis 2 applies the following:

$$\ln \left( \frac{\text{Japan's export vol. [t]}}{\text{China's export vol. [t]}} \right) = c + \text{elasticity} \cdot \ln \left( \frac{\text{Japan's export price [US$/t]}}{\text{China's export price [US$/t]}} \right) + g \cdot \text{year}$$

- ✓ Negative time trend implies that Japanese steel industry is losing share of global market. Large elasticity implies that price competitiveness is very intensive.


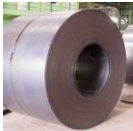
(Annual data basis)	15 years (2001—2015)		
	elasticity	g, time trend	R <sup>2</sup> adj
Flat-rolled steel products	-3.34**	-11**%/y	0.87

## Discussion

- ✓ Combining the estimated elasticity (-3.34) and an unilateral carbon tax (30 US\$/tCO<sub>2</sub>) can lead to carbon leakage.

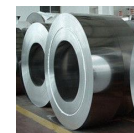
	Japan	China	Total (net)
Flat-rolled steel production	-4.2 Mt/y (-15%)	4.2 Mt/y (+9%)	0
CO <sub>2</sub> emission	-9.3 MtCO <sub>2</sub> /y	10.6 MtCO <sub>2</sub> /y	1.3 MtCO <sub>2</sub> /y
CO <sub>2</sub> intensity of BF steel mill	2.2 tCO <sub>2</sub> /t	2.5 tCO <sub>2</sub> /t	-

Note) Japanese steel production cost can rise by 66 US\$/t of steel (+11%) based on full cost pass-through rate of carbon cost. 2015 market condition basis.

- ✓ The results indicate large elasticity, which means that price competitiveness was very intensive.
- ✓ The results also indicate negative time trends, which means that Japan's steel industry was losing their market share.
- ✓ Analysis 1: Elasticity of substitution between Japan's export and Japan's import
  - Galvanized sheet [Jan. 2013—Jan. 2017]  \*5
    - Elasticity: -1.16
    - Time trend: -23%/y
  - Hot-rolled wide strip [Jan. 2005—Jan. 2017]  \*3
    - Elasticity: -0.64
    - Time trend: 7%/y

Note) This is consistent with active overseas production of Thai re-rollers and Thai car companies (e.g., Toyota Motor Thailand).

- ✓ Analysis 2: Elasticity of substitution between Japan's export and China's export
  - Estimated time trend: -11%/y
  - Estimated elasticity: -3.34
  - Combining the estimated elasticity (-3.34) and an unilateral carbon tax (30 US\$/tCO<sub>2</sub>) can lead to carbon leakage and net increase in global CO<sub>2</sub> emissions (1.3 MtCO<sub>2</sub>/y).



## Future work

- ✓ Comparison with the European studies done on trade impacts of EU ETS
- ✓ Explicit consideration of
  1. Value-added steel (stainless steel, seamless pipe, etc.)
  2. Overcapacity of steel production by region,
  3. Time lag and cumulative effect, and
  4. Multi-regional analysis.



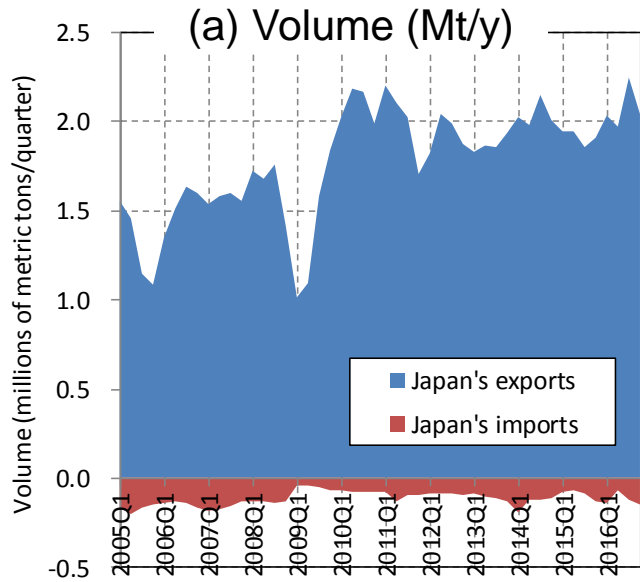
## General

- ✓ Elasticity and its determinants
  - MER
  - Transaction mode
    - Negotiation transaction
    - Selling at a store
  - Product differentiation
- ✓ Time trend and its determinants
  - Overcapacity of steel production, esp. in China
  - Supply chain dynamics
- ✓ Other factors (and error)
  - Anti-dumping, safeguard, and countervailing duties

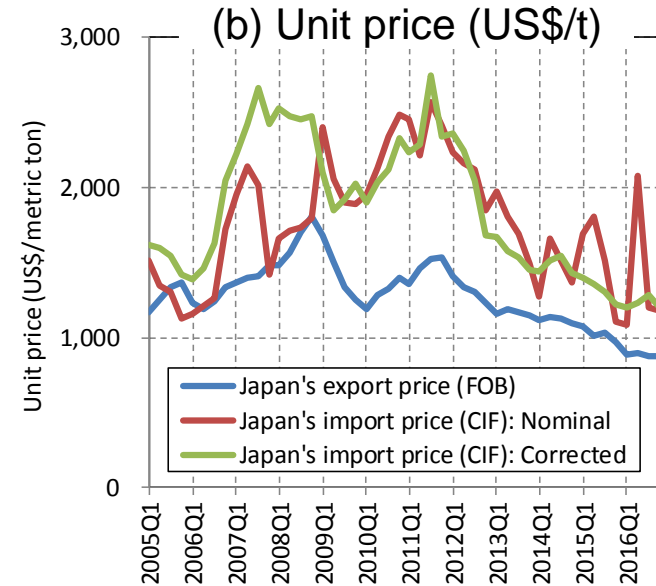
## Example

1. Japan's re-rollers tend to import hot-rolled coil in order to keep the bargaining power against domestic suppliers: NSSMC, JFE.
2. Thai car companies have been shifting "galvanized sheet import from Japan" to "galvanized sheet purchase from Thai re-rollers."
3. Japan import low-grade heavy plate, such as flooring in construction site.

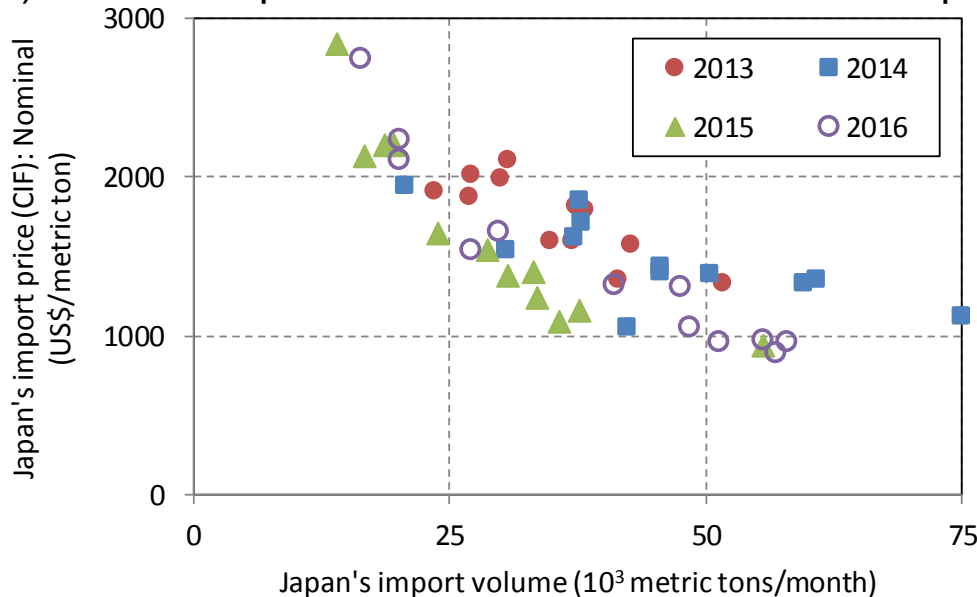




Ref) <http://sumitomothailand.co.th/>



(a+b) Relationship between volume and nominal unit price (monthly)



- ✓ Japan's import volume and nominal unit price of other flat-rolled steel were fluctuated.
- ✓ In order to avoid composite effect, this study developed a corrected price index based on price trajectory of 14 steel products.