Estimation of Japanese Steel Product Trade Elasticities of Substitution

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Abstract

This paper empirically examined Japan's steel product trade elasticity of substitution. The overall results indicate relatively large Elasticity and minus time trends, which means that price competition for export opportunity is very intensive and Japanese steel industry is losing the share of steel export in the global market. If the estimated elasticity (-3.34) between Japan's export and China's export of flat-rolled steel products for the global market is simply combined with hypothetical one-sided Japan's carbon tax, e.g., 30$/t$CO_2$, Japan's export price could rise by 66 US$/t (+11%), Japan's export volume could decrease by 4.2 Mt/y (-15%), and Japan's CO_2 emissions could decrease by 9.3 MtCO_2/y. In the case, China's export volume increase by 4.2 Mt/y (+9%), and China's CO_2 emissions increase by 10.6 MtCO_2/y. As a result, net global CO_2 emissions increase by 1.3 MtCO_2/y.

Keywords: Steel product, elasticity of substitution, trade elasticity, climate policy, flat-rolled steel.

1. Introduction

The steel industry is a key sector both for economic competitiveness and for climate policy. The Japanese steel production was 94.1 Mt of steel products in 2016. The CO_2 emissions from the Japanese steel industry would be around 187 MtCO_2 in 2016, which accounted for 17% of total energy-related CO_2 emissions in Japan.

Steel product is a typical tradable commodity. In 2016, the Japanese steel industry directly exported 40.7 Mt of steel products (Fig. 1), and imported 6.1 Mt of steel products. The net exported steel products were 34.6 Mt, which accounted for 37% of the total production in 2016 (JISF, 2017). In 2015, unit price of China's steel export was very low. For example, the cold-rolled strip reached around 320 US$/t in 2015Q4 (cf. Japan's export price was 520 US$/t in 2015Q4). The Chinese Central Government already stated the overcapacity of steel production in 2005-2007. We can reconfirm the degree of the overcapacity from the export prices over the last few years.

The given overcapacity of steel production on a global scale, combined with increasingly stringent climate policies within Japan, could have great impact on the Japanese steel trade (export and import). If an additional explicit carbon pricing (e.g., carbon tax) is adopted in Japan, the relatively deteriorated price competitiveness would reduce the Japan's steel export and increase the import. In other words, Japan would reduce their production-based CO_2 emissions and the other exporting countries would increase their production-based CO_2 emissions. The degree of the "carbon leakage" due to the one-sided carbon pricing depends on the elasticity of substitution as well as the cost pass-through rate (NERA, 2016).

This paper focuses on the observation of time series variation in Japan's steel product export and import, i.e., weight (tons) and unit price (US$/t) based on Trade Statistics of Japan (Ministry of Finance, 2017), etc. We empirically estimate Japanese steel product trade elasticity of substitution.

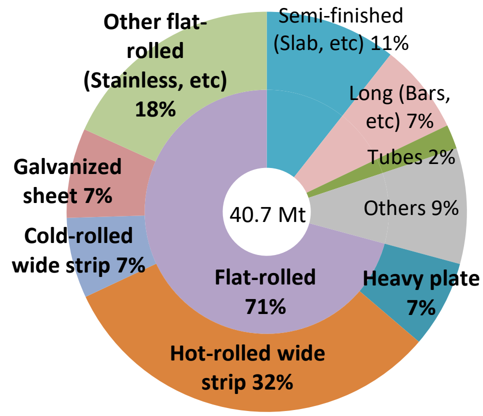

Fig. 1. Japan's steel product export in 2016
Source: Japan Iron and Steel Federation (2017)

2. Elasticity of substitution between Japan's export and import

2.1 Methods

Estimating trade elasticity is a classical framework, and empirical literature goes back to at least Orcutt (1950). Armington (1969) developed a measure of the degree of substitution between domestic and imported goods. Hoshino (2001) focused on Japanese semi-conductor trade and empirically estimated the elasticity between Japan's export and import using the methodology of Armington (1969) and Hansson and Lundberg (1989).

This paper applies the analysis frameworks of Hoshino (2001) shown in Eq.1 to the Japan's steel product export and import.

$$\ln\left(\frac{E}{M}\right) = c + s \cdot \ln\left(\frac{PE}{PM}\right) + g \cdot TIME \tag{1}$$

where E is weight (tons) of Japan's steel export to foreign countries; M, weight (tons) of steel import from foreign countries; PE, FOB price (US$/t) of Japan's steel export; PM, CIF price (US$/t) of steel import; c, constant term; s, elasticity between Japan's steel product export and import; and g, time trend variable. The time trend variable represents non-price factors, such as relative degree of overcapacity of steel production. Noted that energy cost (purchase cost of coal) of Japan's integrated steel mills was 75 US$/t of cold-rolled strip in 2015Q4.

2.2 Data

Time-series steel products trade data is requisite for this empirical analysis. In order to estimate elasticity of substitution between Japan's export and import, this paper referred to the Trade statistics of Japan (Ministry of Finance, 2017).

This paper focuses on so-called flat-rolled steel products which accounted for 71% of Japan's steel export in 2016 (Fig. 1). Category of flat-rolled steel products was divided into five categories: (i) heavy plate, (ii) hot-rolled wide strip, (iii) cold-rolled wide strip, (iv) galvanized sheet, and (v) other flat-rolled steel products.

Figs. 2-7 show the volume and unit price of the Japan's export to the global market and Japan's import from the global suppliers. The original data is monthly basis, and this paper converted it into quarter basis only for purposes of simplified illustration in these figures. Unit price is nominal basis, not real basis, and we referred to market exchange rate for each quarter.

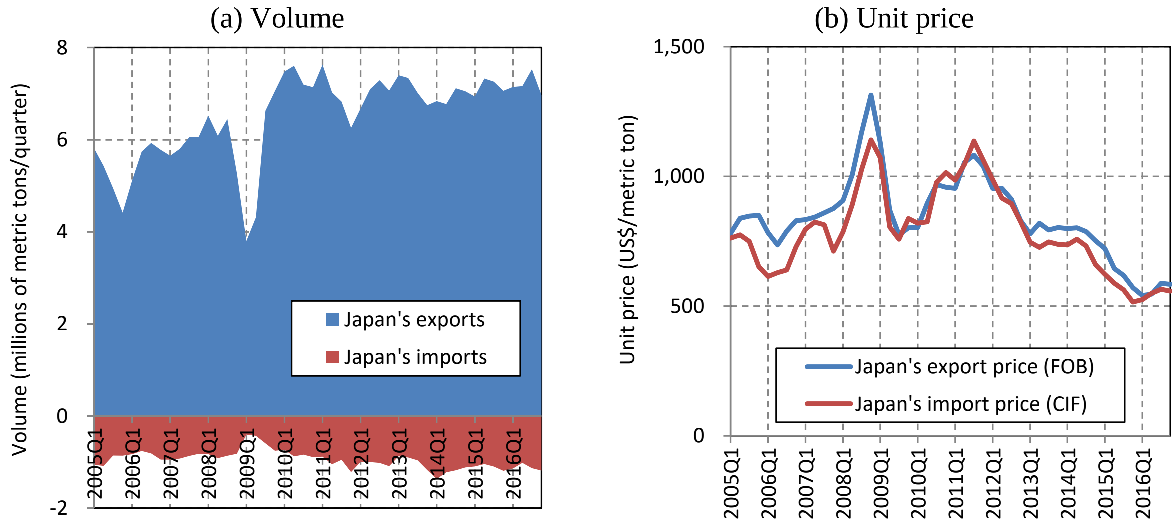

Fig. 2. Japan's export and import of flat-rolled steel products
Source: Estimates based on Ministry of Finance (2017)

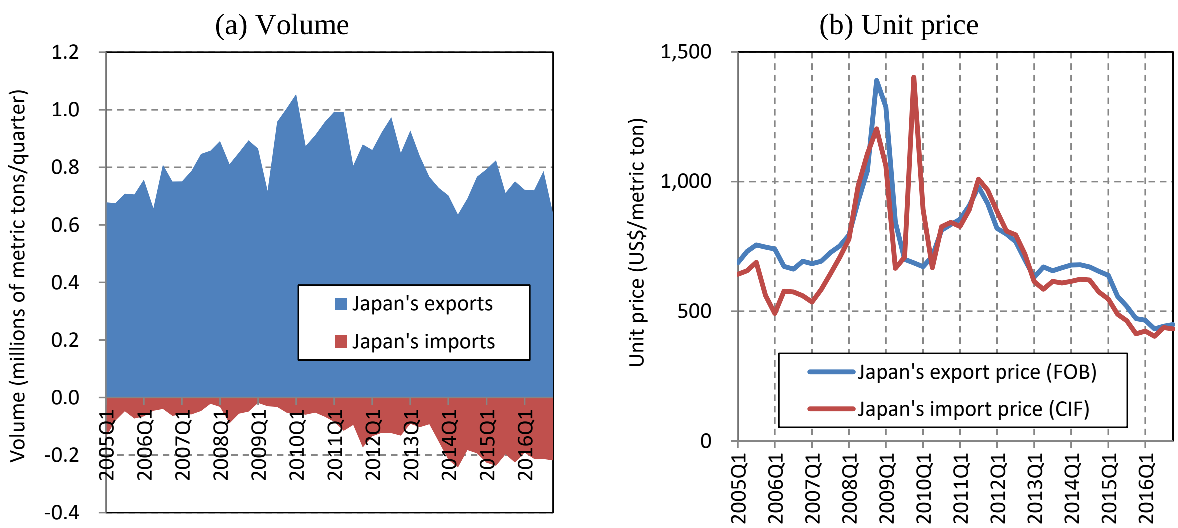

Fig. 3. Japan's export and import of heavy plate

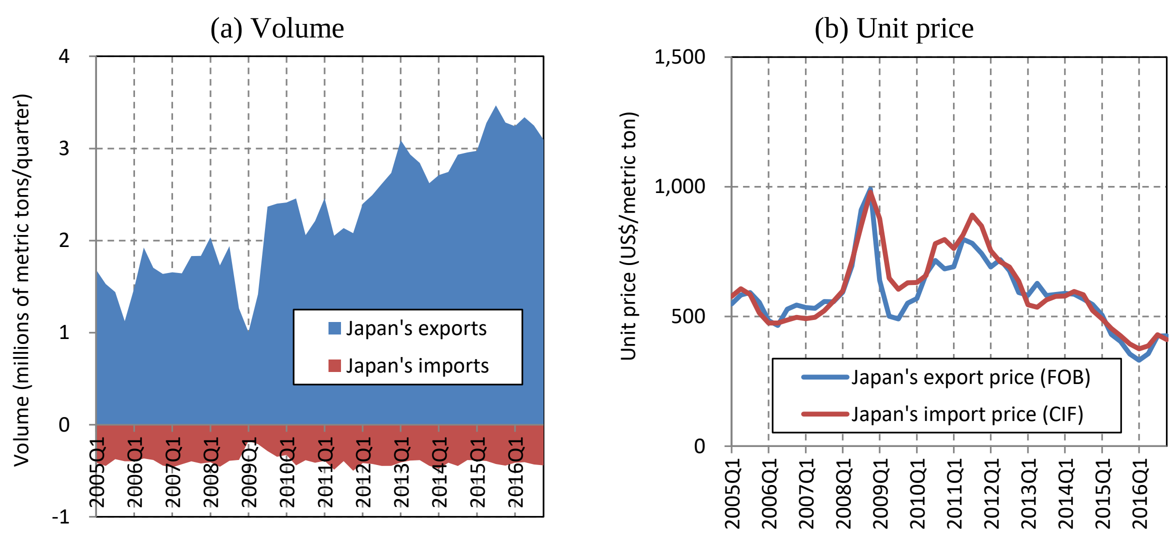

Fig. 4. Japan's export and import of hot-rolled wide strip

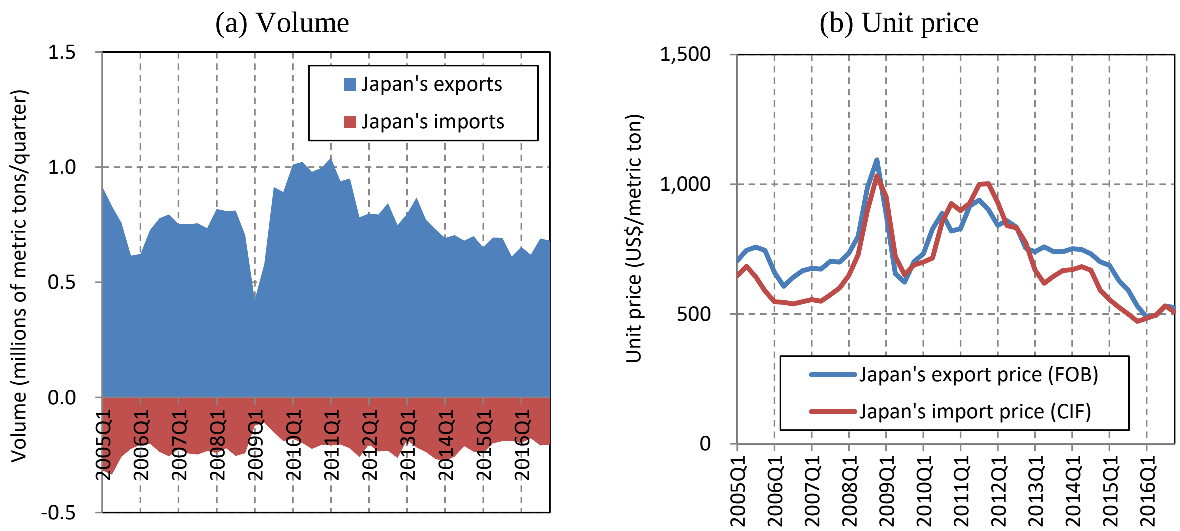

Fig. 5. Japan’s export and import of <u>cold-rolled wide strip</u>

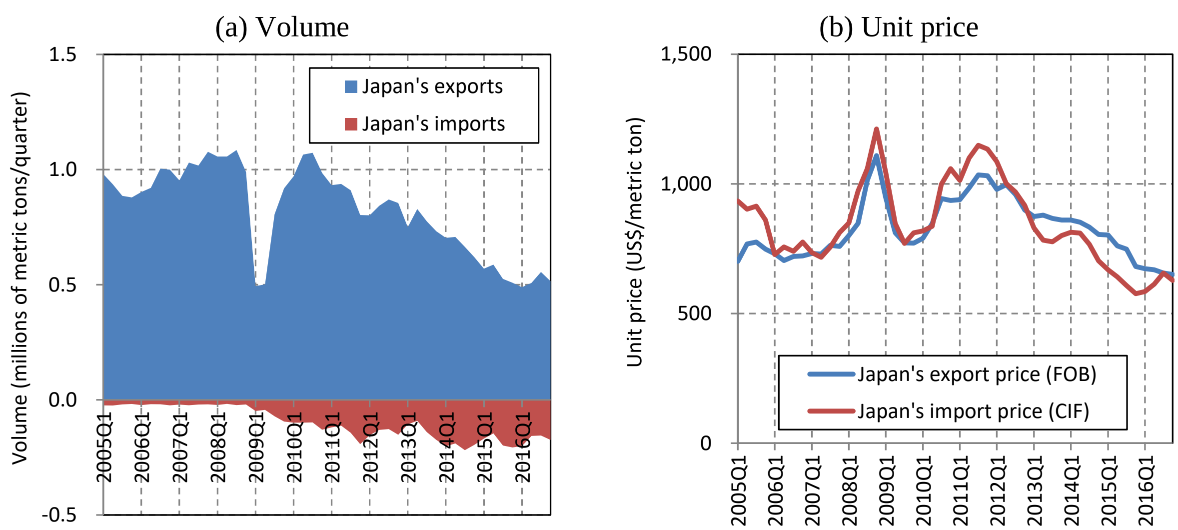

Fig. 6. Japan’s export and import of <u>galvanized sheet</u>

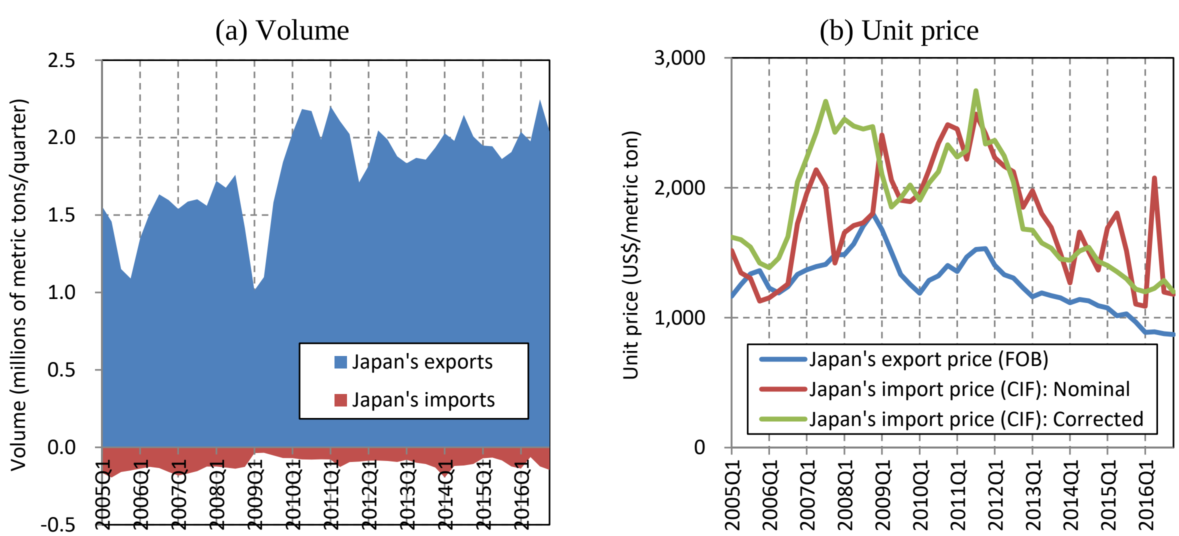

Fig. 7. Japan’s export and import of <u>other flat-rolled steel products</u>

In terms of the volume of Japan's steel net exports, hot-rolled wide strip and other flat-rolled steel products increased for the 12 years. Galvanized sheet decreased, and heavy plate and cold-rolled wide strip have no clear time trend. In terms of the unit price, Figs. 2-7 generally indicate strong correlation between export and import prices. In more detailed, Fig. 6 shows the lower import price than export price and decreasing export volume during the period from 2013Q1 to 2016Q1. Fig. 6 suggests the existence of an elasticity of substitution between Japan's export and import.

Noted that Japan's import volume and nominal price of other flat-rolled steel products were not stable but fluctuated as shown in Fig. **7**. This is because the ratio between commodity steel (low price) and stainless steel (high price) was not stable. Japan constantly imported stainless steel (high price) every month, and occasionally imported commodity steel products (low price) by month. Fig. 8 indicates the nominal relationship between Japan's import volume and price of other flat-rolled steel products by month over the last four years. Nominal price depends on the volume (composite of other flat-rolled steel products) rather than the price level of same/similar steel product.

In order to avoid the apparent effect of composite of other flat-rolled steel products import, this paper developed a corrected price index based on the price trajectory of the 14 steel products, accounting for 66% of import volume of other flat-rolled steel in 2013. The corrected import price and the export price have a correlation as shown in Fig. 7.

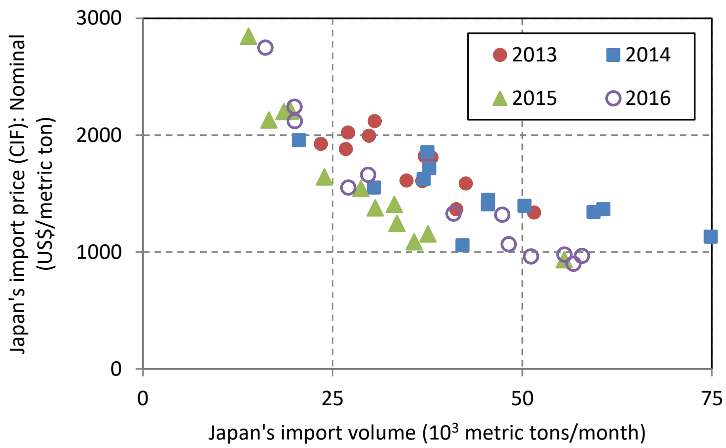

Fig. 8. Japan's import of other flat-rolled steel products by month

2.3 Results

We applied Eq.1 to the Japan's export and import by steel product category. Table 1 shows the results of estimated elasticity and time trend variables. This paper examined two periods: (i) 12-years period from Jan. 2005 to Jan. 2017, and (ii) four-years period from Jan. 2013 to Jan. 2017. The 12-years period includes the 2008 Financial Crisis and the 2011 earthquake. The estimated elasticity of hot-rolled wide strip is relatively small and the time trend is plus, which is consistent with the active overseas production of Japan's steel and car companies, e.g., in Thailand. Since the category of flat-rolled steel products is the aggregated one as shown in Fig. 1, the composite change inside the category affects the results and the adjusted R^2 is very low (0.05), which makes it difficult for us to discuss on the results of flat-rolled steel products.

Other results reveal that the elasticity is relatively large (from -0.76 to -1.83), which means that price competitiveness is very intensive. Even after the remove of price effects, the most time trend variables are minus, which means that Japan's export has been relatively decreasing during the analysis period. Especially for the last four years (from Jan. 2013 to Jan. 2017), the elasticity is relatively large (-1.83 and -1.16) and the time trends are minus (-0.24 and -0.23), which suggests that price competitiveness is intensive due to the stagnant steel demand and surplus capacity of steel production especially in China.

Table 1. Estimated elasticity between Japan's export and import and time trend variables (monthly)

	12 years (from Jan. 2005 to Jan. 2017)			Four years (from Jan. 2013 to Jan. 2017)		
	s, elasticity	*g* (/y), time trend	R^2adj	*s*, elasticity	*g* (/y), time trend	R^2adj
Flat-rolled	-0.66**	-0.01	0.05		N/A	
Heavy plate	-1.18**	-0.17**	0.53	-1.83**	-0.24**	0.50
Hot-rolled wide strip	-0.64**	0.07**	0.59		N/A	
Cold-rolled wide strip	-0.99**	-0.01	0.13		N/A	
Galvanized sheet		N/A		-1.16**	-0.23**	0.50
Other flat-rolled†	-0.76**	0.07**	0.31		N/A	

Note) N/A means that we can't observe significant results.
* denotes significant level < 10%. ** denotes significant level < 5%.

3. Elasticity of substitution between Japan's export and China's export

3.1 Methods

Next, we focus on flat-rolled steel products for the global market and elasticity between Japan's export and China's export. The equation used is as follows:

$$\ln\left(\frac{E_{Japan}}{E_{China}}\right) = c + \sigma \cdot \ln\left(\frac{PE_{Japan}}{PE_{China}}\right) + g \cdot TIME \qquad (2)$$

where E_{Japan} is weight (tons) of Japan's export to the global market; E_{China}, weight (tons) of China's export to the global market; PE_{Japan}, unit price (US$/t) of Japan's export; PE_{China}, unit price (US$/t) of China's export; and σ, elasticity between Japan's export and China's export. The structure of Eq.2 is similar to the Eq.1; however, the elasticity in the Eq.2 is expected to be higher than that in Eq.1, because the Eq.2 calculates the elasticity between the same/similar steel products category. The time trend variable represents non-price factors, such as relative degree of overcapacity of steel production in Japan and China.

3.2 Data

In terms of Japan's export, this paper referred to the Trade statistics of Japan (Ministry of Finance, 2017). The category of flat-rolled steel products is same as Figs.1, 2, and Table 1. In terms of China's export, this paper referred to worldsteel (2016) for volume and World Steel Dynamics Inc. (2017) for unit price. Due to data availability, this paper referred to yearly data and the time period from 2001 to 2015 as shown in Fig. 9. The unit price is nominal basis, and we referred to yearly average market exchange rate for each year.

Fig. 9 indicates that China's export volume was drastically increasing while Japan's export volume was approximately constant. Relative China's export price compared to Japan's export price was low especially in 2014 and 2015.

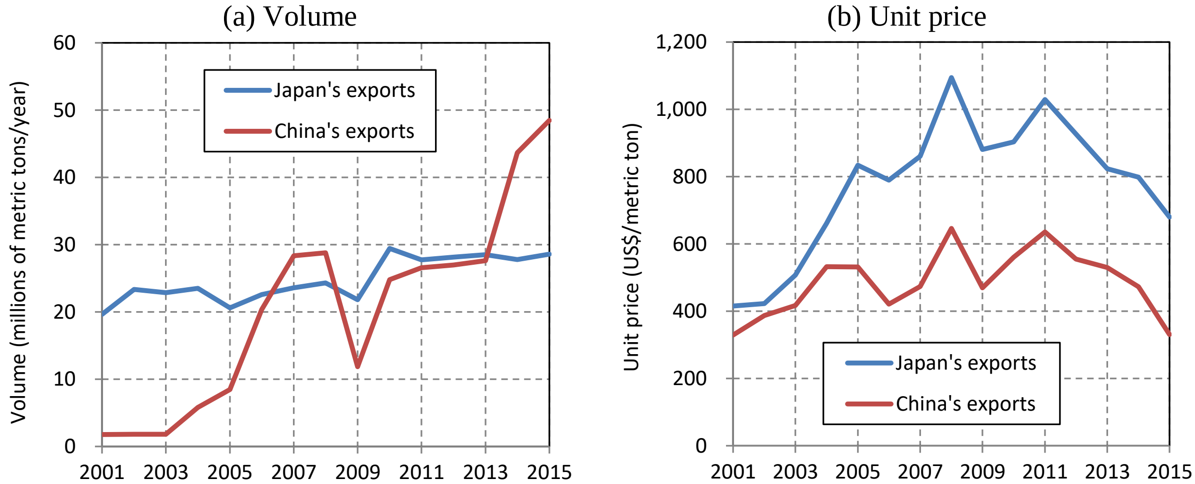

Fig. 9. Japan's export and China's export of flat-rolled steel products

3.3 Results

We applied Eq.2 to Japan's export and China's export. Table 2 shows the results of estimated elasticity and the time trend variable. Since availability of comparable price and volume data is limited, Table 2 referred to annual data of flat-rolled steel products and covered the period from 2001 to 2015. The estimated elasticity is large, -3.34, and the time trend is minus, -0.11, which means that price competition for export opportunity is very intensive and Japanese steel industry is losing global market share of steel export.

One-sided mitigation policies may lead to the re-allocation of production to regions, which is so-called carbon leakage. If the estimated elasticity, i.e., -3.34, is simply combined with hypothetical one-sided Japan's carbon tax, e.g., 30\$/tCO_2, Japan's export price could rise by 66 US\$/t (+11%), Japan's export volume could decrease by 4.2 Mt/y (-15%), and Japan's CO_2 emissions could decrease by 9.3 MtCO_2/y. In the case, China's export volume increase by 4.2 Mt/y (+9%), and China's CO_2 emissions increase by 10.6 MtCO_2/y. As a result, net global CO_2 emissions increase by 1.3 MtCO_2/y.

Noted that this example is illustrated based on the assumptions: (i) full cost pass-through rate of carbon cost, (ii) no price elasticity of global steel demand, (iii) market condition in 2015, (iv) difference of CO_2 intensity between Japan's integrated steel mills and China's integrated steel mills, and (v) only two exporters, i.e., Japan and China, in the market.

Table 2. Estimated elasticity between Japan's export and China's export and time trend variable (yearly)

	15 years (from 2001 to 2015)		
	σ, elasticity	g (/y), time trend	R^2adj
Flat-rolled steel products	-3.34**	-0.11**	0.87

Note) * denotes significant level < 10%. ** denotes significant level < 5%.

4. Conclusions

This paper empirically examined Japan's steel product trade elasticity of substitution. The overall results of elasticity between Japan's export and Japan's import indicate relatively large elasticity and minus time trends, which means that price competitiveness is very intensive and Japanese steel industry is losing global market share of steel products. Exceptionally, the estimated elasticity of hot-rolled wide strip is relatively small, which is consistent with the active overseas production of Japan's steel and car companies, e.g., in Thailand.

If the estimated elasticity (-3.34) between Japan's export and China's export of flat-rolled steel products is simply combined with hypothetical one-sided Japan's carbon tax, e.g., 30$/t$CO_2$, Japan's export price could rise by 66 US$/t (+11%), Japan's export volume could decrease by 4.2 Mt/y (-15%), and Japan's CO_2 emissions could decrease by 9.3 MtCO_2/y. In the case, China's export volume increase by 4.2 Mt/y (+9%), and China's CO_2 emissions increase by 10.6 MtCO_2/y. As a result, net global CO_2 emissions increase by 1.3 MtCO_2/y.

Further analysis including value-added steel (stainless steel, seamless pipe, etc.), explicit consideration of relative overcapacity of steel production by region, and multi-regional analysis remains as future work.

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