International Comparison of trade embodied CO2 emissions

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1. Introduction

The Kyoto Protocol adopted in 1997 calls for capturing Green House Gas (GHG) emissions at the source country. However, mitigation policies designed to reduce GHGs domestically can cause GHG sources to be shifted from countries with mitigation policies to those without: a phenomenon known as carbon leakage (Wyckoff *et al*., 1994).

Consequently, greater attention has been given in recent years to the concept of capturing GHG emissions at the country of consumption rather than at the country of origin, which marks a departure from the Kyoto Protocol. This has given rise to the new concept of GHG emissions embodied in trade. This concept aims to include the GHG emissions resulting from the production of goods created in the original producing country in the calculation for GHG emissions in the importing country. This report refers to such emissions as GHG emissions embodied in trade. Since the 1990s, several experimental studies of GHG emissions embodied in trade have been conducted using various methodologies (Cosbey, 2008).

Calculations for GHG emissions embodied in trade include bottom-up approaches that use macroeconomic statistics, trade statistics, and industrial reports to analyze particular countries or industrial sectors, as well as bottom-up approaches that look at specific products. Bottom-up approaches include life cycle analysis, carbon footprint analysis, and hybrid life cycle analysis, and generally are used to assess a specific product since these analyses require a large amount of data and effort.

Top-down methods are appropriate for country-level calculations. Recent calculation methods have been offered by Shui & Harriss (2006), Weber & Matthews (2007), Helm *et al*. (2007), RITE (2008), Honma *et al*. (2008), and Peter & Hertwick (2008).

In this report, we focused on the period after the year 2000, when drastic changes in trade structure has taken place since BRICS countries have emerged. We estimated net imports of CO2 emission embodied in trade after the year 1991 based on aggregate data of each country, Japan, US, UK and China.

2. Methodology

We used the method proposed by Helm *et al*. (2008). In Helm *et al*. (2007), GHG emissions embodied in trade were estimated for England's net imports using macroeconomic and trade statistics, and not an inter-industry

relations table. Helm *et al*. used an approach to estimating GHG emissions whereby a basic unit of GHG emissions per unit of GDP is found, and then emissions are estimated based on the level of imports and exports. While this approach provides only an approximation, it is possible to estimate GHG emissions embodied in trade, which also partially account for indirect emissions from other sectors.CO_2 emissions embodied in imports are found by using equation (1); the standard unit of CO_2 emissions per unit of GDP for each country of origin is multiplied by the amount of exports (calculated in GDP) for each country of origin's export destination. Next, the net amount of CO_2 emissions embodied in imports is found by using equation (2), which sums the results from all importing countries found in equation (1) and subtracts the amount of CO_2 emissions due to exports.

Amount of CO_2 emissions embodied in exported goods from country *j* to country *i*:

$$CY_j \times E_j \times \left(M_{ij} / Mw_j\right) \quad (1)$$

Net amount of CO_2 emissions embodied in imports to country *i*:

$$\sum_j \left\{CY_j \times E_j \times \left(M_{ij} / Mw_j\right)\right\} - CY_i \times E_i \quad (2)$$

Here, M_{ij} is the value of imports from country *j* to country *i*; Mw_j is the value of global imports from country *j*; E_i, E_j is the real exports from countries *i* and *j*; M_i, M_j is the real imports for countries *i* and *j*; and CY_i and CY_j are the CO_2 emissions in countries *i* and *j* in terms of units of real GDP.

Moreover, while Helm *et al*. (2007) included the financial and services sectors in trade balance calculations, services were removed from the calculation in the present research, and only CO_2 was considered among GHGs. This was done because the aim of this research was to clarify the international shift in CO_2 emissions caused particularly by shifts in manufacturing production to overseas.

Data sources were the OECD and International Trade by Commodity Statistics databases for data on country of origin, and the World Development Report by the World Bank and Chinese Statistical Yearbooks for data on GDP, deflation statistics, import-to-GDP ratios, exchange rates, and CO_2 emissions statistics.

3. Estimation Results

Figure 1 shows the yearly change in CO_2 emissions embodied in net imports.

Looking at countries other than England, we can see that both the United States and Japan have positive net imports of CO_2 emissions, with the ratio in 2005 of imported emissions amounting to 20% of total emissions in the United States, and 40% of total emissions in Japan.

The increase is particularly significant from 2000 onward, with steady increasing trends observed in both England and the United States. On the other hand, the figures point to an overrun of CO_2 exports in China. Information on China was only available up to 2004 because of issues data availability, but compared with the year 2000, exports of CO_2 emissions increased 211% during those four years. The CO_2 emissions embodied in exports in 2004 constituted slightly less than one-third of all CO_2 emissions in China in that year.

The adequacy of the results was assessed by comparing them with results for England from Helm *et al*. (2007).

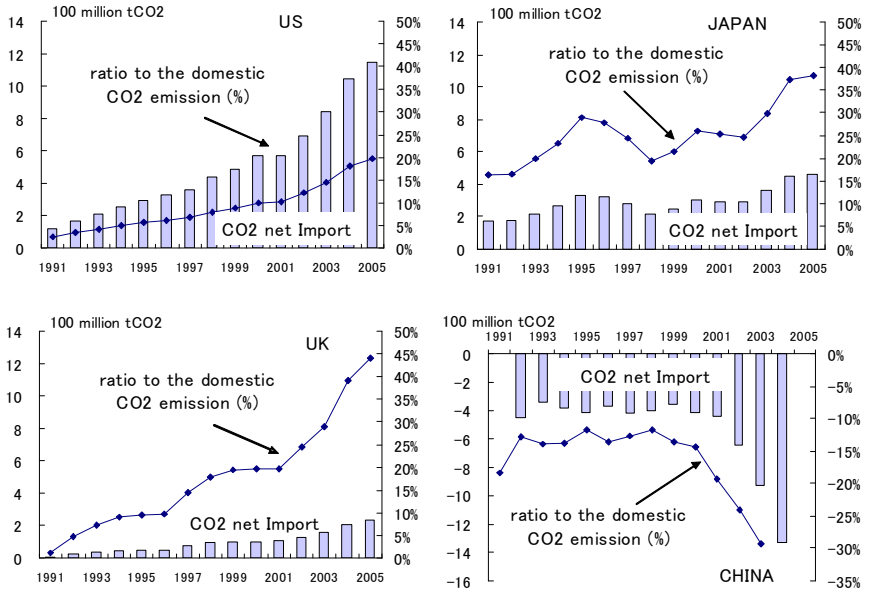

Figure 1 The yearly change in CO_2 emissions embodied in net imports

Results under this assessment of CO_2 emissions embodied in net imports for the year 2005 were found to be 230 million tons CO_2. This figure amounts to approximately 70% of the value calculated by Helm *et al.* (2007) for 2006: 340 million tons of CO_2. In consideration of the different scope of GHGs used in each assessment (i.e., all GHGs or only CO_2), as well as the different methods and data used, it was concluded that the results of this research were reasonable.

4. Conclusion

This research was conducted under the premise that, compared with in the past, increasing globalization demands increased awareness of addressing problems due to CO2 emissions from not only the country where production occurs, but also the country where consumption occurs.

In developed countries, although the decline in manufacturing has suppressed domestic emissions, emissions in other countries due to imports to satisfy domestic consumption have been increased to levels that amount to a sizable proportion of domestically occurring emissions.

In the debate about reduction targets for greenhouse gas emissions, a wide gap in opinion persists between developed and developing countries. However, framing the argument in terms of CO2 emissions embodied in trade can facilitate mutual understanding of the problem for both developed and less-developed countries.

As the world economy continues to globalize and relationships of economic interdependence strengthen accordingly, the world economy is reaching a stage where the international division of labor cannot be simply turned back. The concept of CO2 emissions embodied in trade examined in this research can help to provide perspective in the debate on where to count GHG emissions. We hope that this concept will help foster awareness of the limitations involved in arguing about GHG reductions targets in terms of national borders. On

this basis, a more productive debate on policy collaboration between developed and developing countries is possible in regard to the prevention of global warming.

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