The Decomposition of Carbon Productivity Under the Context of International Trade

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1. Introduction

Carbon productivity, which is defined as the amount of gross domestic product (GDP) produced per metric ton of carbon emissions, has been regarded as an important indicator of a country's performance in mitigating global warming.

The Kaya identity and its extensions about carbon productivity address decomposition with domestic economic factors. However, noting the growing importance of global trade, we propose a new decomposition of carbon productivity: *Carbon Productivity = Consumption-based labor productivity × Population-sustaining power of CO_2 × Labor exploitation × Carbon emissions exploitation × Trade surplus*. We divide carbon productivity into the part of true carbon productivity and the part with the nature of zero-sum games. The labor and carbon emissions exploitation and trade surplus represent the zero-sum part and consumption-based labor productivity and population-sustaining power of CO_2 are the parts that represent real improvement when their value increases.

This study synthesizes the fields of footprint analysis, labor exploitation and carbon productivity to provide a new perspective on decomposing carbon productivity on the back of international trade so as to reveal the impacts of exploitation and the true direction of national and international policies.

2. Methodology

Our decomposition is formally expressed as:

$$\frac{Y}{E_p} = \frac{D}{L_c}\frac{L_p}{E_c}\frac{L_c}{L_p}\frac{E_c}{E_p}\frac{Y}{D}.$$

Here Y represents GDP. E_p and E_c are production-based and consumption-based carbon emissions respectively. Similarly, L_p and L_c are production-based and consumption-based employment respectively. Consumption-based carbon emissions refer to the carbon emissions embodied in the final demand of a country through domestic production and international trade. The first and last

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components contain D, which is the total final demand of a country, including domestically produced and imported final consumption products. The fraction of Y to D represents the trade surplus ratio. We use global multi-regional input-output (GMRIO) tables to generate consumption-based indicators and construct monetary GDP and final demand indexes including each year's currency exchange rates. Based on the new decomposition model, we further decompose the change in carbon productivity into five effects by using the Logarithmic Mean Divisa Index (LMDI) method addressing two different periods: 1995-2006 and 2006-2018.

3. Main Results

By analyzing 66 countries/regions and the rest of the world in 2018, we find that excluding the exploitation part the difference in carbon productivity among countries, especially between developed and developing countries shrinks. Analysis for selected economies/countries (EU15, EU13, the United States, Japan, China, and India) from 1995 to 2018 reveals that international exploitation of labor and carbon emissions has deepened from 1995 to 2006, and weakened from 2006 to 2018, but the structure of exploitation has been maintained through the entire period; the consumption-based labor productivity and population-sustaining power of CO_2 effects are the principal driving factors of change in carbon productivity. The growth in true carbon productivity increased in the last half of the period, but the improvement is still quite modest.

4. Conclusion

We revealed the complex relationship between trade, economic growth and the environment by proposing a new decomposition of carbon productivity. Consumption-based labor productivity and population-sustaining power of CO_2 represent real improvement, while exploitation at the global level do not. The stable structure of labor and carbon emissions exploitation indicates the decrease in the discrepancy between the two regions was caused mainly by the contraction of the difference in true carbon productivity. Developing countries such as China have shown an increase faster than EU15 and Japan. If the labor productivity for developing countries will also become closer to that of developed countries, the world can tackle the climate issue cooperatively to increase the population-sustaining power of CO_2.