Pathways for Reducing CO2 Emissions Through Decoupling Processes: A Global Multi-Regional Structural Decomposition Analysis

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Author: Waka Nishifuji
Co-Authors: Shigemi KAGAWA

To combat climate change, it is crucial for governments to clarify the process of decoupling economic growth from greenhouse gas (GHG) emissions and to develop effective low-carbon pathways for the economy. Economists have sought to identify factors that influence GHG emissions alongside economic growth, such as changes in emission factors, production technology, consumption volumes, and preferences. While previous studies provide empirical results using structural or index decomposition analysis, they often fail to offer multi-country and multi-period comparisons of decomposition factors or to identify effective low-carbon development pathways for specific countries based on the time trends of decomposition effects observed in reference countries.

It is important to emphasize that a comprehensive and detailed structural decomposition analysis is essential for countries to develop effective decoupling policies. Currently, no studies provide sufficient guidance for global GHG reduction policies with a focus on decoupling processes. In particular, few studies have examined the role of global supply chains as a factor in decoupling economic growth from environmental impacts. This study addresses a wide range of economic factors, including global supply chains, and highlights pathways for reducing GHG emissions through degrowth.

This study employs structural decomposition analysis (SDA) using the Global Multi-Regional Input-Output (MRIO) database (World Input-Output Database) in constant 2014 prices to provide guidelines for reducing global CO2 emissions. The database spans a 15-year period (2000â€“2014) and includes data for 43 countries and regions. Using this database, we first calculated the annual average change rates of consumption-based CO2 emissions and GDP for each country during the study period. We then estimated decoupling indicators, defined as the ratio of the annual average change rate of a countryâ€™s CO2 emissions to that of its GDP. Based on the time series of decoupling indicators for the 43 countries and regions, we applied clustering analysis to identify patterns in the decoupling process. Subsequently, we decomposed changes in consumption-based CO2 emissions (i.e., carbon footprint) into six factors: emission factors, production technology, per capita final demand, consumption preferences, the trade structure of intermediate goods, and the trade structure of final goods.

The clustering results revealed eight distinct patterns in the decoupling processes of countries. While some countries reduced their carbon footprints, either relatively or absolutely, alongside economic growth, others increased their carbon footprints despite achieving similar levels of economic growth.

Examining the detailed SDA results for countries with comparable levels of economic growth during the study period, we identified key factors driving CO2 emission changes. We then compared these factors between countries that achieved decoupling and those that did not. The analysis identified changes in the trade structure of intermediate and final goods (i.e., global supply chains) as a critical factor in reducing a countryâ€™s carbon footprint while maintaining economic growth.

Conversely, in countries experiencing major economic growth, trade structure changes played a less significant role in achieving decoupling. Instead, changes in consumption preferences and per

capita final demand were found to be the primary drivers of decoupling in these cases.

In countries in the de-growth phase, changes in consumption preferences and per capita final demand contributed to emission reductions. However, changes in trade structure and production technology were found to contribute to increased emissions, thereby hindering efficient emission reductions.

The results of this study suggest that changes in trade structure play an important role in achieving decoupling. In order to implement effective policies, it is necessary to consider restructuring global supply chains and providing technical and financial support to countries that specialize in emission-intensive exports.