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Japan and China's Energy-related CO_2 Emissions: What can China learn from Japan?

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Abstract. In this paper, China's energy-related CO_2 emissions in 1995, 2000 and 2005 are calculated, and inter-, intra- country structural decomposition analyses with results of study on Japan are conducted. The results show that: (i) Japan's emission slightly grew from 1107 million tons in 1995 to 1134 and 1163 million tons in 2000 and 2005 respectively. While China's emission decreased in the first five-year period from 2106 to 1694 and then surged to 2686 million tons in 2005; (ii) High emission and emission-intensive sectors in both countries are recognized; (iii) Technological effect was the main factor offsetting emission increments in both countries; (iv) Quantitative comparison by structural decomposition analysis reveals that technological, economic system efficiency, structural and population effects contributed to China's excessive emissions over Japan. However, as scale effect is an important indicator in global equity, Japan also needs to spare efforts boosting its low-carbon consumption.

Keywords: China, Energy-related CO_2 Emission, Japan, Structural Decomposition Analysis

1. Introduction

As Oliver et al. (2012)[1] assessed, the top 5 emitters are China (share 29%), the US, the European Union, India, the Russian Federation and Japan (4%). It is note worthy that, from 2006, China's CO_2 emissions ranked the first in the world. [2] It's CO_2 emission per capita increased by 9% to 7.2 tons in 2011, being approximate to the European level. [1] While in 2009, China's government committed to reduce its emission intensity by 40-45% by the year 2020. Therefore, China's emission performance has considerable impact on the global mitigation of climate change. Meanwhile, as another main CO_2 emitter, Japan has a significant emission amount as well. Especially after the Tohoku-Pacific Ocean Earthquake, Japan faces more severe challenge reducing its CO_2 emissions. Apart from the emission performance, China and Japan have many other important features in common, most crucially: enormous economic aggregate, and being low in natural resources per capita. On this background, it is of great significance to make in-depth comparative analysis between these two countries to derive appropriate policy implications for both of them to draw on.

Many scholars have examined the energy-related CO_2 emissions of China. [3-10] To analyse the driving factors, two methods are widely used. Most of the previous studies adopted index decomposition method. Only a few of them [11-12] applied structural decomposition analysis (SDA). However, it is indicated SDA is capable of revealing the indirect demand effects adopting input-output model, which makes it more reliable. [13] With respect to Japan's case, there are fewer related studies. It is worthy noting that Keisuke and Yuichi (2012) [14] accounted the energy-related CO_2 emissions of Japan within the input-output framework, Shigemi and Hajime (2001) [15] proposed a structural decomposition of energy consumption based on a hybrid rectangular input-output framework and applied it to Japan's case. Shinichiro and Makoto

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(2007) [16] applied a multiple calibration decomposition analysis on the energy consumption and CO_2 emission in the Japanese economy. DhakalIn et al. (2003) [17] considered Tokyo as a good model in emission control for other Asian megacities. Shigemi and Hajime (2004) [18] conducted intra- and inter-country analysis on energy demand of Japan and China. After then, few studies ensued in comparative analysis between Japan and China's emission performance due to the data availability limitation and difficulties in data management.

In this paper, emission trajectories and features are examined in Japan and China from 1995 to 2005. Then SDA within the input-output framework is conducted using time-serial data to reveal the driving factors of CO_2 emission changes of each country and adopting cross-sectional data to examine the main impact factors of the CO_2 emission difference between the two countries during the ten-year period. The remaining of this paper is organized as follow: method, data and data management are presented in detail in Section 2, then the results derived are demonstrated in Section 3. Finally, in Section 4, the results are discussed and appropriate policy implications are derived.

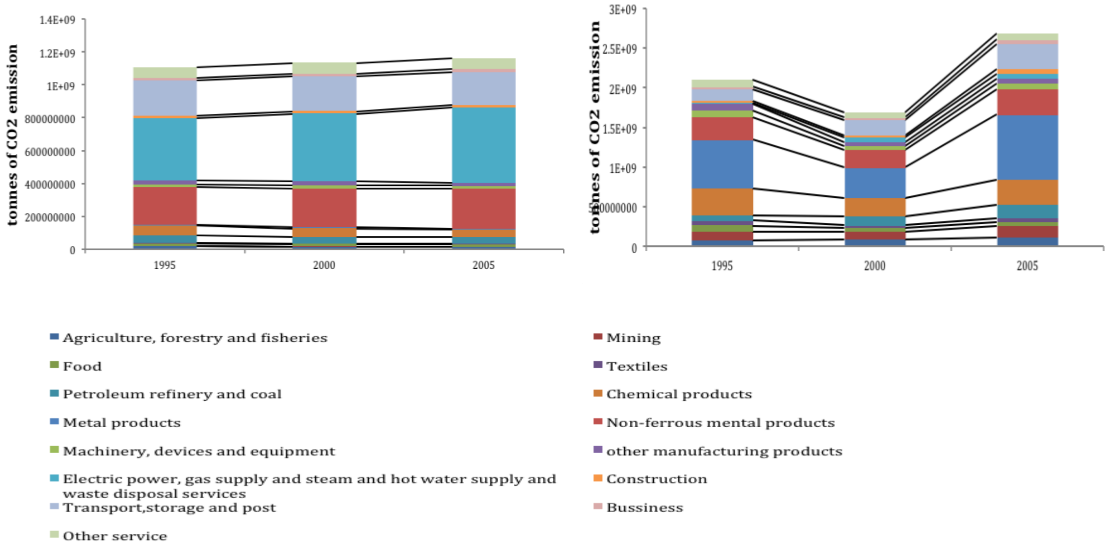

Fig. 1: Japan (left) and China's CO_2 emission amount in 1995, 2000 and 2005

2. Method and Data

Direct emissions are calculated according to the IPCC Guidelines and Tie 2 approach is adopted. [19] Moreover, according to IPCC (2006), CO_2 contributes the most to global climate change and is mainly generated from energy activities. Therefore, only energy-related CO_2 emissions are taken into account in this paper. Then SDA within input-output framework is conducted. [20] Population effect, technological effect, economic system efficiency effect, structural effect and scale effect are selected as potential driving factors. The decomposition can be presented as in Eq. (1):

$$\Delta E = \Delta P\times EI\times L\times F_{str}\times F_{vol} + P\times \Delta EI\times L\times F_{str}\times F_{vol} + P\times EI\times \Delta L\times F_{str}\times F_{vol} + P\times EI\times L\times \Delta F_{str}\times F_{vol} + P\times EI\times L\times F_{str}\times \Delta F_{vol} \quad (1)$$

Where: Δ refers to change of a factor; P is a scalar representing population; EI is the CO2 emission row vector depicting the technological effect (15×1); L is the Leontief inverse matrix economic system efficiency effect (15×15); F_{str} is a column vector representing per capita household consumption structure as structural effect (1×15) and F_{vol} is a scalar representing the per capita consumption volume indicating the scale effect. In SDA, it is possible to evaluate different terms at the start of the end point of the time period. [21] To avoid this bias, the weighted average of all possible first-order decompositions is adopted. [22]

Required data are extracted from various sources. [14], [23], [24] And the 1995, 2000 and 2005 input-output tables of China are from Chinese Input-output Association, Japan's are from the Statistic Bureau of Japan. The population data is from World Bank. To conduct the spatial SDA, the sector classification of the six input-output tables are combined based upon the "Sector Classifications" provided by the Statistics Bureau of Japan and China's "National Industries Classification".

3. Results

3.1. Emission features and trajectories

Japan's emission grew slightly from 1107.2 million tons in 1995 to 1135.0 and 1163.1 million tons in 2000 and 2005 respectively. While China's CO_2 emission declined from 2105.9 million in 1995 to 1693.9 million tons in 2000, but then sored to 2685.7 million tons in 2005. China's decline in energy consumption and related CO_2 emission in the late 1990s is also confirmed and discussed by many others [3-10].

3.2. Driving factors of the intra-country emission changes

According to results of SDA, from 2002 to 2007, Japan's technological effect was the main factor offsetting its emission increments, which is consistent with Shinichiro and Makoto (2007). [16] Interestingly, the economic system efficiency effect was one of the main offsetting factors from 1995 to 2000, but reversed and became the main driver in the next five years. With respect to China, consistent with conclusions by previous studies, in late 1990s, due to the Southeast Asia economic crisis, China's economic growth slowed down, and together with technological advancement, the emission intensities of China's sectors decreased significantly, then consequently led to emission decline. Since 2000, along with the accelerating economic development and reversed emission intensity change, China's emission grew at full speed. For both countries, structure effect and population effect were mainly positive but not remarkable.

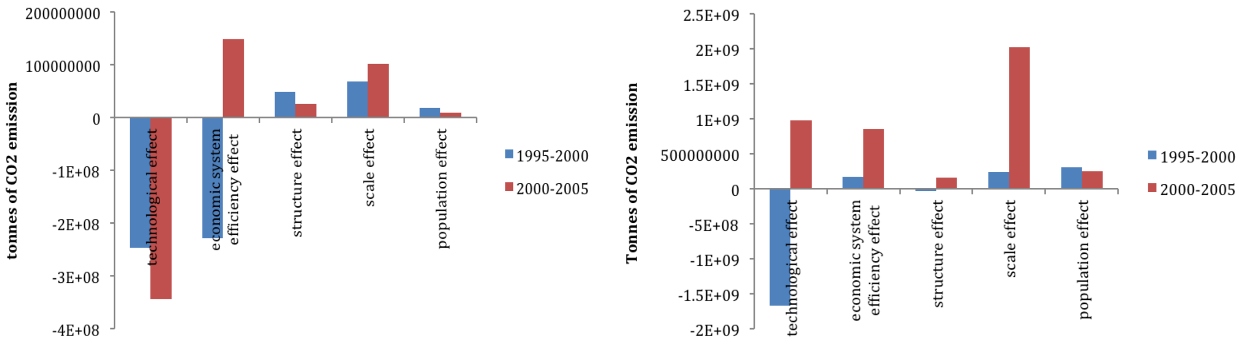

Fig. 2: Driving factors of the emission changes during periods 1995-2000 and 2000-2005 in Japan (left) and China

3.3. Impact factors of the inter-country emission difference

To understand what can both the two countries learn from each other, it is important to look at the difference between the emission performance of Japan and China and the underlying impacting factors behind it. Therefore, a spatial SDA adopting the cross-section data is conducted. According to the results, only scale effect (final demand per capita) contributed to the curling of China's excess. Apart from that, all other four factors justified that why China emitted much more than Japan.

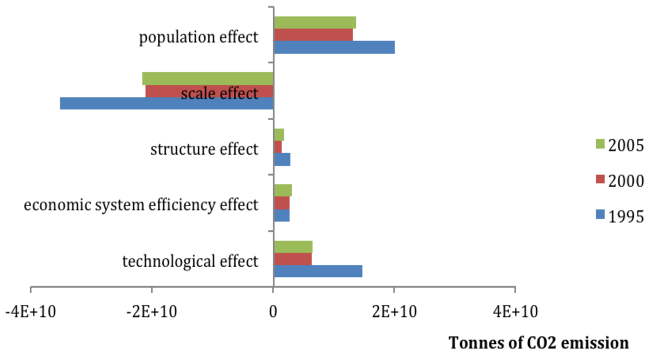

Fig. 3: The driving factors of the inter-country CO_2 emission (t CO_2) difference between Japan and China in 1995, 2000 and 2005 (If the factor's effect is positive, means it contributes to the China's surpassing amount than Japan, vice versa)

4. Discussions and policy implications

Generally, such analyses could lay solid foundation for related policy formulation. For China's notable emission intensity decline in the late 1990s, several reasons were recognized. (i) China's Electric Power Law entered into force in 1996, which mandated the prohibition of new small-scale power plants and the closure of existing high emission, high pollution and low efficiency ones. Besides, Energy Saving Law went into force in 1998, therefore, fuel suppliers made effort to advance the fuel quality to meet the customer needs. [4,5]; (ii) From 1996 to 1999, China invested 539.3 million Yuan in constructing new power plants projects to reduce the losses in power transmission line and so on [4]; (iii) Nearly half of the changes in energy intensity and consumption were resulted from gains in energy efficiency at the firm level, and also from the relative prices and Research and Development as well; (iv) While the number of state-owned and collectively owned enterprises decreased, the enterprises fund by Hongkong, Macao, Taiwan and foreign countries have increased. [4] And the latter category is regarded to be more energy efficient.

The GDP growth rate of China reached 10%, 10.1% and 10.2% in 2003, 2004 and 2005 respectively after joining WTO in 2001. To boost the economy, China invested in many emission intensive sectors and expanded the demand for energy use. Peters et al. (2007) [11] pointed out that the growth in emissions from the production of high emission embodied exports were significant. Of course no country would sacrifice its development to reduce CO_2 emission, it is important for China to balance its economic growth and emission control. According to aforementioned discussions, some main measures could be: (1) Keep decreasing emission intensities, by implementing clean and advancer technologies, promoting R&D, investing in improving the efficiency in management and operation level; (2) Avoid expansion or investment in carbon intensive sectors, such as Non-ferrous Metal Products, Metal Products, Petroleum Refinery and Coal Products, Chemical Products, Transport, Storage and Post. Promote import instead export of these sectors; (3) Propel transition to a market-based economy to optimize the economic structure.

On the other hand, there are still some policy implications for Japan: (1) As the emission per capita is a very important indicator indicating the equity, it is noteworthy that the emission per capita of China is much lower than that of Japan. The spatial comparison shows the scale effect is the most important factor curling China's excess emission over Japan. Therefore, Japan's government should lead its citizen's consumption to low-carbon and green products in order to develop green consumption and economy. Measures like encouraging people to go to public bath instead of having bath in their own house and so forth could be adopted; (2) From 2005 to 2010, Japan's economic system efficiency was the biggest driver of Japan's emission growth. Therefore, the government should take efforts to improve its intermediate input structure; (3) Moreover, for China's 11th Five Year Plan (2006-2010), Chinese government made reduction in energy intensity a national development objective. Japan should pay extra more attention to its energy intensity control especially after the closure of nuclear power plants.

5. Conclusion

In this paper, China's direct CO_2 emissions in 1995, 2000 and 2005, are estimated and compared with results on Japan's case. Then intra-country decomposition analysis on the driving factors of the emission amount changes of both Japan and China from 1995 to 2005 is conducted, and then inter-country quantitative comparison to see what can the two countries learn from each other. Some main results are: (1) Japan's emission grew slightly from 1995 to 2005, while China's is characterized by relatively high emission in all the three years, decreasing from 1995 to 2000, then increasing till 2005; (2) As indicated by LC Liu (2007), energy intensity decline in heavy sectors will be greatly necessary to mitigate the growth of China's industrial CO_2 emission. The high emission and emission intensive sectors in both countries are recognized. Governments are suggested to avoid expansion and reduce export of these carbon intensive sectors; (3) Technological effect plays important role as negative effect in both countries. While China's technological effect reversed since 2000, and Japan's economic system effect reversed from negative to positive since 2000; (4) Quantitative comparison reveals that all the selected factors except scale effect contributed to China's excessive emission over Japan. However, as the energy consumption and emission per capita is an important indicator in global equity. Although China still has a long way to go on its CO_2 emission mitigation, Japan also needs to spare efforts boosting low carbon consumption.

At last, CO_2 emission could be generated from trans-boundary electricity and heat in other places, so the future studies could incorporate the other types of CO_2 emission source to derive more comprehensive results.

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