REGIOANL-SCALE DECOMPOSITION ANALYSIS OF CO_2 EMISSIONS OF THE MANUFACTURING INDUSTRY IN JAPAN

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Overview

Japan has made efforts in reducing GHG emissions, particularly CO_2, as a member country of the UNFCCC and the Kyoto Protocol, and the country ratified the Paris Agreement aiming to reduce emissions 26% by 2030 compared with the 2013 level. Because the Paris Agreement refers to the role of non-state actors, effort at the local level is essential. Prefectures in Japan are obliged to set targets and action plans for GHG emission reduction. To achieve these targets, identifying factors of the emission reduction in prefectures is important. The purpose of this study is to analyze factors of CO_2 emission change between 1990 and 2013 in the Japanese manufacturing industry, the largest emitter, via a decomposition approach.

Methods

This study used the logarithmic mean Divisia index (LMDI) approach (additive decomposistion) for decomposing CO_2 emissions of the manufacturing industry in 47 prefectures from 1990 to 2013. The manufacturing industry is classified into eight sectors (food, textile, pulp & paper, chemistry, cement & ceramics, metal, machinery, and others). This study used the carbon intensity, energy intensity, structure, and activity effects as decomposition factors. Equation 1 shows the difference in emissions between two periods (t0 and t1). Equation 2 is an example (carbon intensity effect) of calculating the impact of a factor on total changes in CO_2 emissions. Similar equations were used for the other three factors. These equations were applied to each prefecture.

$$\Delta T\_Ems_t = T\_Ems_{t1} - T\_Ems_{t0} = \Delta T\_Ems_{cint,t1} + \Delta T\_Ems_{eint,t1} + \Delta T\_Ems_{pstr,t1} + \Delta T\_Ems_{T\_prd,t1} \quad (1)$$

$$\Delta T\_Ems_{cint,t1} = \sum_i \frac{Ems_{i,t1} - Ems_{i,t0}}{\ln Ems_{i,t1} - \ln Ems_{i,t0}} \ln\left(\frac{cint_{i,t1}}{cint_{i,t0}}\right) \quad (2)$$

where *i*: industry sector; *t*: year; *T_Ems*: total CO_2 emissions from manufacturing industry (ktC); *Ems*: sectoral CO_2 emissions (ktC); *cint*: carbon intensity; *eint*: energy intensity; *pstr*: production share of sector *i* in the manufacturing industry; ΔT_Ems_x: changes in total CO_2 emissions by factor *x*.

The data for the decomposition were from the following sources. CO_2 emissions and energy consumption were from Energy Consumption Statistics by Prefecture. Production, measured by gross prefectural production (GPP) by sector, was from the Prefectural Accounts.

Results

Patterns of the factors of emission change varied by prefecture (Figure 1). Overall, the carbon intensity effect was negative, meaning that the energy mix in the entire manufacturing industry has changed toward low carbon during the last quarter century in many prefectures.

Directions of changes (increase/decrease) in the other three factors differed by prefecture, although the number of prefectures with negative changes was larger. The contribution of the energy intensity effect to an increase in CO_2 emissions was largest, and energy intensity increased in 23 prefectures. Large increases were observed in Hyogo and Oita. In contrast, that effect was the most important factor for emission reduction in Wakayama and Yamaguchi.

The structure and activity effects are related to production in the manufacturing industry. The prefectures that had greatly increased emissions from the structure effect were Chiba and Tokyo (e.g., the increase was 3,478 ktC in Chiba). This means that in these prefectures, the share of sectors with relatively high carbon intensity increased. In contrast, the structure effect was negative in Hyogo and Aichi. This means that the share of sectors with relatively high carbon intensity decreased in these prefectures. The impact of the activity effect on increasing emissions was powerful in Mie and Yamaguchi (e.g., 2,250 ktC in Mie), meaning that production of the manufacturing industry greatly increased in these prefectures. In contrast, the impact was strongly negative in Kanagawa and Osaka. In these prefectures, decreases of GPP in the manufacturing industry contributed to reducing the emissions.

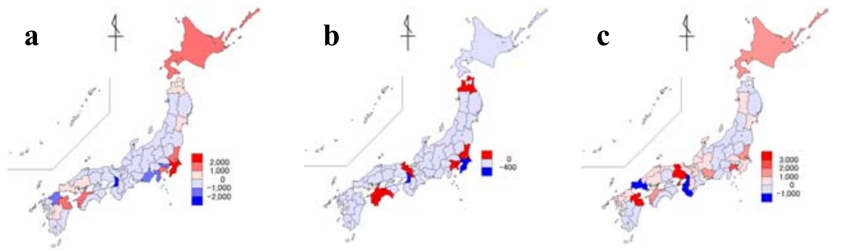
Comparing the four factors, the contribution of the carbon intensity effect on changes of CO_2 emissions was much smaller. The largest changes were −665 (negative) and 390 (positive) for carbon intensity, and −1,820 to −5,591 (negative) and 2,250 to 3,894 (positive) for the others. Among the three other factors, the number of prefectures whose energy intensity and activity effects were negative or positive was nearly equal (24 negative and 23 positive). However, on average, the positive effect was stronger for energy intensity, and the negative effect stronger for the activity effect. For the structure effect, although it was negative in 32 prefectures, it was a factor that increased emissions on average.

Among the eight sectors, overall, chemistry and metal were the two most influential. On average, chemistry was the only sector that had an increase in carbon intensity, although its magnitude was small. Although carbon intensity in the chemistry sector improved in some prefectures, there were increases in a greater number of prefectures and their magnitudes were large, particularly in Ehime and Ibaraki. Among the other sectors, the contribution of the metal sector to emission reduction was the maximum. Although there were prefectures that had an increase of carbon intensity in the metal sector, the increases were small, and there were more prefectures that improved carbon intensity with larger magnitudes, such as Chiba and Osaka. Such differences in carbon intensity change in each sector by prefecture might have occurred because of changes in structure and technology within the sector.

For energy intensity effect, in contrast with carbon intensity, metal was a sector that increased emissions. The increases were particularly large in Hyogo and Oita. The chemistry sector had an average negative effect, which was especially large in Chiba and Okayama. The reasons behind these results might be changes in the structure of energy-intensive or less energy-intensive products in each sector.

Observing the structure effect, the chemistry and metal sectors were the two most influential sectors; chemistry contributed to an increase in emissions and metal to a decrease. In particular, the chemistry sector in Chiba, and Kanagawa, and the metal sector in Chiba and Okayama had powerful impacts on the changes.

Overall, impacts of the chemistry and metal sectors were strong among the three effects. In the aggregated CO_2 emissions, the impact of the metal sector was weaker. However, contributions of the other sectors to changes in emissions were much smaller among the three factors.



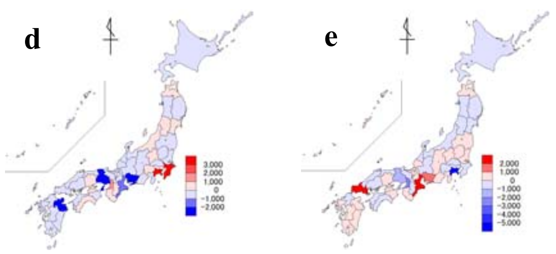


Figure 1: Changes in CO_2 emissions (a) and four factors (b: carbon intensity effect, c: energy intensity effect, d: structure effect, e: activity effect) by prefecture (total of manufacturing industry;

Conclusions

The chemistry and metal sectors were the main causes of CO_2 emission increases from the manufacturing industry, with positive changes for each factor. Thus, reducing the factors from these sectors and making them negative are essential to decrease emissions from the manufacturing industry toward the emission reduction target of the Paris Agreement and further reduction in the long term. Because increases in production contribute to economic development, the priority is to address carbon and energy intensity. Among the two aforementioned sectors, there were prefectures that greatly decreased carbon and/or energy intensity in the last quarter century. Thus, diffusion of technology and knowledge to reduce carbon and energy intensity aids emission reduction in the two sectors.