Decomposing aggregate CO_2 emission changes with heterogeneity: An extended production-theoretical approach

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Executive summary

Quantifying the driving forces behind changes in aggregate CO_2 emissions provides valuable information for supporting policy in climate change. We study this issue using the production-theoretical decomposition analysis (PDA) methodology, which is established within the production theory framework and based on nonparametric frontier models. From a production system viewpoint, PDA helps to understand the driving forces of CO_2 emissions with a focus on technical efficiency and production technology. Since agents in energy demand and CO_2 emissions behave heterogeneously, heterogeneities in energy consumption and emission patterns, whether by sector or by geographical region, can be prevalent. For the purposes of policy making, it is logical to conduct decomposition analysis that accounts for heterogeneities to provide targeted insights at sectoral and regional levels where possible. This study extends the conventional PDA approach to account for the heterogeneities.

We propose an extended PDA approach and apply it to examine China's aggregate CO_2 emission changes in its 11th five-year plan (FYP) period (2005-2010). It is found that production technology improvement helped to reduce the aggregate emissions significantly, while the impact of technical efficiency change was marginal. The results imply that the technological progress taken place in China has been driving the low-carbon development and suggest the need to keep improving technical efficiencies. On the other hand, both the potential carbon factor and potential energy intensity deteriorated during the 11th FYP. A possible reason is the widespread use of coal, which has a relatively low energy conversion efficiency in production. The energy mix became more carbon-intensive in the period, leading to worsening of the potential energy intensity. China's economy structure also became more carbon-intensive, and further efforts in adjusting the economy structure will be needed. At the regional level, the technical efficiencies of the four Chinese economic regions studied, except the western region, improved. The western region's worsening technical efficiencies in energy utilization and emission suggest the importance of accelerating technology diffusion to narrow the technology and efficiency gaps among regions. At the sectoral level, aggregate emissions could be substantially reduced by improving the potential carbon intensity and technical efficiencies in energy use and emissions of the industry sector.

The proposed extended PDA approach can be generally applied at the economy-wide level and at any disaggregation level as data permits. For instance, emissions of a multi-country region can be first divided by country and then by sector within each country. Where geographical and/or sectoral heterogeneities exist, application of the proposed approach will reveal the additional

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driving forces behind emissions and insights which the traditional PDA approach is unable to provide.

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