MARGINAL ABATEMENT COST OF CO_2 IN CHINA: APPLICATION OF CONVEX QUANTILE REGRESSION

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Overview

Shadow prices and marginal abatement costs of bad outputs are critically important for cost efficient environmental policy and management. The Chinese government applies emission trading scheme (ETS) for carbon dioxide (CO_2) emissions regulation in order to achieve the emission target with minimum costs. Although emission permits are already traded in some limited capacity, the trading scheme will extend to cover more industries and regions in the near future. To anticipate the regional impacts of expanding ETS scheme, it is interesting and relevant to evaluate the marginal abatement cost (MAC) of CO_2 using historical data (e.g., Zhou et al., 2015).

In this paper we estimate the MAC of CO_2 using a panel data of Chinese provinces in years 1997-2015. The MAC estimates are compared with the market price of CO_2 in order to analyze the expected effects of expanding emission trading. Based on the MAC estimates, a cost-efficient allocation of permits is calculated. We also discuss how extension of trading and limiting permits would affect prices of permits and optimal allocation across provinces.

Methods

We estimate MAC using convex quantile regression recently proposed by Kuosmanen et al. (2015). Our formulation of convex quantile regression combines the directional distance function formulation of convex regression (Kuosmanen and Johnson, 2017) with quantile regression (Wang et al., 2014). This method allows us to gain insights on MAC not only on the efficient frontier, but also in the interior of the production possibility set (cf. Lee at al., 2002).

To estimate the MAC, we consider not only the weak disposal of CO_2 by scaling down the good output, but also the possibility to increase the fixed inputs (capital investment) or the variable inputs (e.g., fuel switch), and evaluate MAC based on the least cost alternative.

Results

First, we estimate the MAC of CO_2 for each province in China for years 1997-2015 using convex quantile regression. This allows us to identify the provinces in which the MAC of CO_2 is lowest. We also analyze the development of MAC over time.

Second, the MAC estimates are compared with estimates obtained with more conventional frontier estimation techniques such as data envelopment analysis (DEA). We show that the convex quantile regression that takes inefficiency explicitly into account and allows for increase in input resources yields systematically lower MAC estimates than the conventional DEA methods.

Third, the MAC of CO_2 is compared with the market price of CO_2 in ETS. This comparison allows us to analyze the effects of expanding emission trading and propose a cost-efficient allocation of permits, which can be interpreted as the expected market outcome when the ETS expands to cover all provinces.

Conclusions

Motivated by the expansion of ETS to cover more industries and provinces, in this paper we estimated the MAC of CO_2 using a panel data of Chinese provinces in years 1997-2015. We showed that the novel convex quantile regression approach yields systematically lower MAC estimates than the conventional DEA method. Comparing the estimated MAC with the observed market price of CO_2 in ETS, we analyze the possible effects of expanding ETS scheme to cover all industries and provinces.

References

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