A structural and dynamic approach to measuring rebound effect in China

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Overview

In a simplified term, energy rebound effect refers to additional energy consumption due to a reduction in the unit cost of energy usually brought about by an elevated level of energy efficiency. The rebound effect has been studied at the economy level as well as sectors of the economy. A recent study by Shao et al (2014) attempted to measure China's economy-wide rebound effect following the logic that an energy efficiency improvement results in improved productivity (at least that of energy) which should accelerate economic growth which, in turn, calls for an increase in energy consumption. The rebound effect is determined by technological progress rate conditional on energy intensity and economic growth, which suggests that there will not be any rebound effect if there is a lack of technological progress, or the rebound effect is bound to arise regardless of the nature of technological progress. The state space model of technological progress in the study, which is estimated by the Kalman filter algorithm, also implies that technological progress is autonomous and exogenous. It is more appropriate to regard technological progress as an endogenous factor in studies of energy efficiency since technological innovations for better use of fossil fuels and clean energy are strongly influenced by government policies.

It is clear that the rebound effect is otherwise completely observable had the technological progress rate been available. Thus, how to measure the rebound effect boils down to how to measure technological progress rate. Like the Shao study, the present paper measures rebound effect from the perspective that technological progress results in energy efficiency improvement which, in turn, may spark additional energy consumption. Unlike Shao et al, the present paper incorporates structural information in estimating the technological progress rate using time series data by way of an instrumental variable estimator. Compared with the Kalman filter algorithm, the IV estimator recognises sectoral differences in responding to technological shocks. The estimates are total factor productivity growth (TFPG) which the Shao et al study termed technological progress rate. The data employed are output, measured as gross value of output and value-added, and input of labour, capital and energy by 12 subsectors which make up China's industrial sector. The use of the subsectoral panel data has made this exercise possible.

The modelling results show that rebound effects did exist in the 12 subsectorsin varying amounts over the 21 years from 1986 to 2006. *Chemical Industrial Products* experienced the most number of years of rebound effect, which is 15. This is compared to 9, the least number of years of rebound effect for *Food and Tobacco* and *Electronics and Instruments*. The maximum rebound effect of about 840% is found in *Timber, Printing and Paper* in 1998. "False" rebound effect existed in 1997 in energy production and other manufacturing in the sense that the energy intensities in these two subsectors actually rose which invalidates the premise of the rebound effect.

Methods

As outlined above, the modelling part of the analysis is to estimate technological progress rate proxied by TFPG. Specifically, the production possibility sets of the subsector gross output are assumed a function of the inputs of capital, labour, energy and materials. Since data on materials are not available, subsector value-added is used as the dependent variable of a production function for productivity estimation. Specifically, it is assumed that the value-added (Y) of subsector *i* in year *t* is generated according to a Cobb-Douglas production function that depends on capital (K) and labour (L), namely,

$$Y_{it} = A_{it}(K_{it})^{\alpha}(L_{it})^{\beta} \quad (1)$$

Using lower cases to denote the logarithms of the variables,

$$a_{it} = y_{it} - \alpha k_{it} - \beta l_{it} \quad (2)$$

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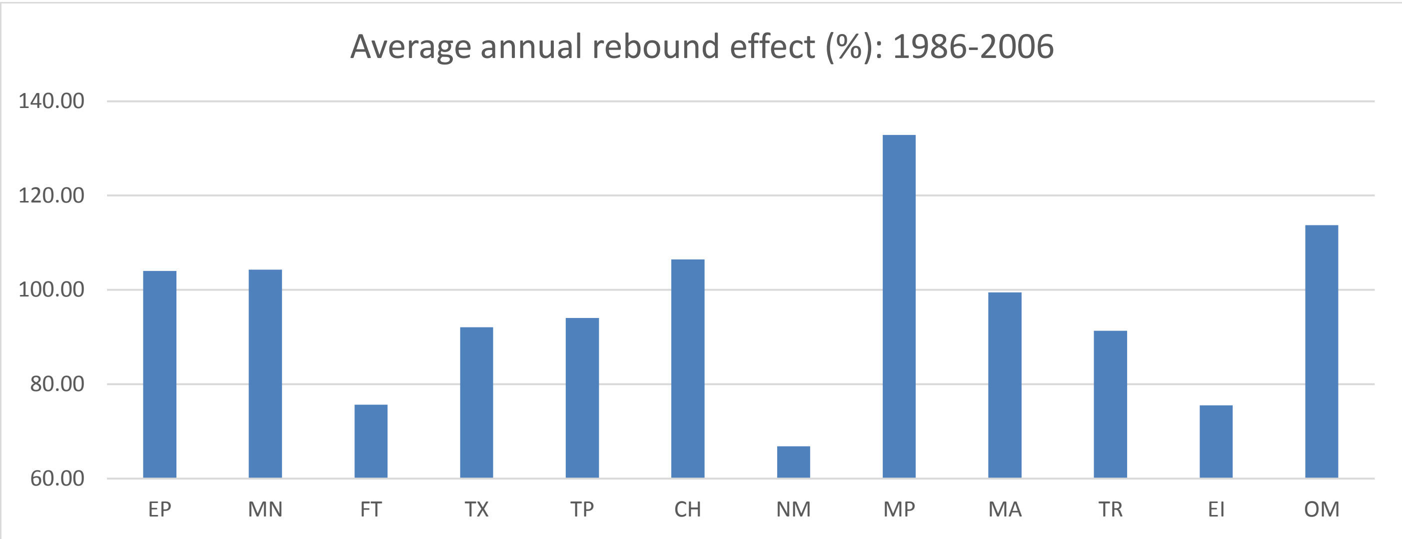
where A_{it} is the total productivity of subsector *i* in year *t*. Using lower cases to denote the logarithms of the variables. Eq. (2) is estimated in the first-difference form to obtain observation-specific TFP growth rates. Instrumental variables for Eq. (2) are based on input-output relationships as documented in Shea (1993) and Conley and Dupor (2003). Next, the rebound effects by year and by subsector are calculated as per the Shao et al study. Some of the graphs below summarise the empirical results.

Results

The subsectors are: Energy Production (EP), Mining (MN), Food and Tobacco (FT), Textile (TX), Timber, Paper and Printing (TP), Chemical Industrial Products (CH), Non-metallic Mineral Products (NM), Metal Products (MP), Machineary (MA), Transportation equipment (TR), Electronics and Instruments (EI) and Other Manufacuring (OM). The graph below shows the main results from the modelling analysis.



Conclusions

Rebound effect, as a possible consequence of energy efficiency improvement, has been widely studied. The present study investigates rebound effect in the 12 subsectors which make up China's industrial sector. Using longitudinal data sets, like the one used in this study, offers more options, and indeed better alternatives, to estimate technological progress which is a key component in evaluating the rebound effect. The study found that rebound effects were most significant in high energy intensities, to curb rebound effects, energy efficiency initiatives and measures should be complemented with taxes. Most of the subsectors that experienced large rebound effects (backfire) are those that used bigger shares of energy than the others. The study period witnessed the start of China's energy price reforms. However, energy prices, such as, the coal and electricity prices, were still controlled and relatively low. A complete marketization of energy prices should help alleviate the rebound.

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