Estimating China’s Energy and Environmental Productivity Efficiency: A Parametric Hyperbolic Distance Function Approach

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**Data**

A panel dataset including 32 provinces in China from 2000 to 2007: 
- Innominate capital stock (Lk), labor, energy consumption (Et) 
- Output: real GDP (RGDP), SO2 emissions (SO2) 
- Using the methodology of Zhang et al. and their 2000 time data, provincial capital stock is estimated 
- All data are from the Chinese Statistical Yearbook (various years)

**Enhanced Hyperbolic Distance Function**

Let input vector \( x = (K, L, L) \) and \( T \) denotes the technology set 
\[ T = \{x, \text{RGDP}, \text{SO2}\} \] 

Following Zhang et al., the enhanced hyperbolic distance function \( D_h \) is defined as 
\[ D_h(x, \text{RGDP}, \text{SO2}) = \|x - T\|_2 \|x - T\|_2 \] 

The properties of the enhanced hyperbolic distance function \( D_h \) are stated:
- high average environmental efficiency 
- the presence of neutral technical inefficiency 
- inputs are measured as output and vice versa 

**Environmental Efficiency Measurement**

Through the stochastic frontier analysis (SFA), the estimated environmental efficiency for each province is measured as:
\[ -\ln(\text{BF}_h) = \text{Translog}\( (L, E, \text{SO}_2, \{\text{parameters}\}) \} \] 

Let \( t \in \{1, 2, \ldots, n\} \) is the model component that captures time varying inefficiency.

Finally, time-varying environmental (enhanced hyperbolic efficiency function) can be calculated for each province as 
\[ \frac{\text{BF}_h(t)}{\text{BF}_h(0)} \]

**Conclusions**

- China has a great potential for reducing \( \text{SO2} \) emissions and energy consumption. 
- During 2000 to 2007, average energy consumption in China declined by 12.58%, translating to reducing energy consumption from 40.31 to 34.66 million ton oil equivalent per year. 
- China has proportionally saved energy inputs by 82.36%, translating to reducing energy consumption from 37.72 to 66.53 million ton oil equivalent per year. 
- The average environmental TE increase over time with 3.84% annually going from 2007 to 2009. 
- The environmental TE varies across provinces: 
  - In Shenghai, the central region is the most efficient. 
  - In Guangdong, the central region is the least efficient.

**Further Research**

- Investigate how the industrial structure will affect environmental productivity efficiency. 
- Identify potential different contributions of productivity growth for each province in China. 
- Examine how the energy saving program will affect the environmental productivity growth for each province.

**References**


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