A provincial analysis of economic transition and energy consumption in China

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Outline

- Background
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- Methods
- Regression Results
- Conclusions

Background: Decoupling GDP and energy consumption

- We must assess China's current energy demand under the economic "New Normal"
- Is the slowdown in energy consumption a temporary phenomenon or a long-term trend?
  - Significant shift in economic structure from industry to services
  - Reduction of overcapacity in major industries
  - Efficiency improvement
- Our goal is to understanding the impact of these transition characteristics on energy consumption, at both the national and the regional level

Literature Review

- There is a relationship between GDP and energy consumption in China in the long run (Herrerias, et al., 2013; Zhang and Xu, 2012; Li et al., 2011; Wang et al., 2011; Yu and Meng, 2008; Lin, 2003)
- There are regional and sectoral differences in the impacts of GDP and urbanization on energy consumption (Wang, et al., 2014; Zhang and Xu, 2012; Zhang and Lin, 2012; Li et al, 2011)
- Methods used in the literature:

  Panel co-integration (Wang, et al., 2014; Herrerias, et al., 2013; Zhang and Xu, 2012; Yu and Meng 2008; Lin, 2003)

  Stochastic Impacts by Regression on Population, Affluence, and Technology model (Zhang and Lin, 2012; Yang et al., 2017)

Literature Review

- Example: Li et al, 2011
  - Data: China (30 provinces), 1985-2007
  - Methods: panel unit root, panel co-integration, panel OLS, dynamic OLS
  - Positive long-run co-integrated relationship between GDP per capita and energy consumption
  - 1% GDP pre capita increase -> 0.48-0.50% energy consumption national average (east: 0.78-0.90%, west: 0.29-0.40%)
- Summary
  - There is much research in this area, but most studies focus on a single factor, such as GDP or urbanization
  - Few studies have looked into the key variables that can reflect current economic transition and quantify their impacts on energy consumption at both the national and provincial/regional level

Literature Review: Our Contribution

- National level and provincial/regional level analysis on the impacts of structural change on tertiary share, GDP per capita, heavy industry overcapacity reduction, and energy efficiency improvement
- Regional differences of these impacts provide policy implications for economic transition in different regions
- Panel co-integration estimation results have high performance in terms of model fitting and can be used to predict future energy demand

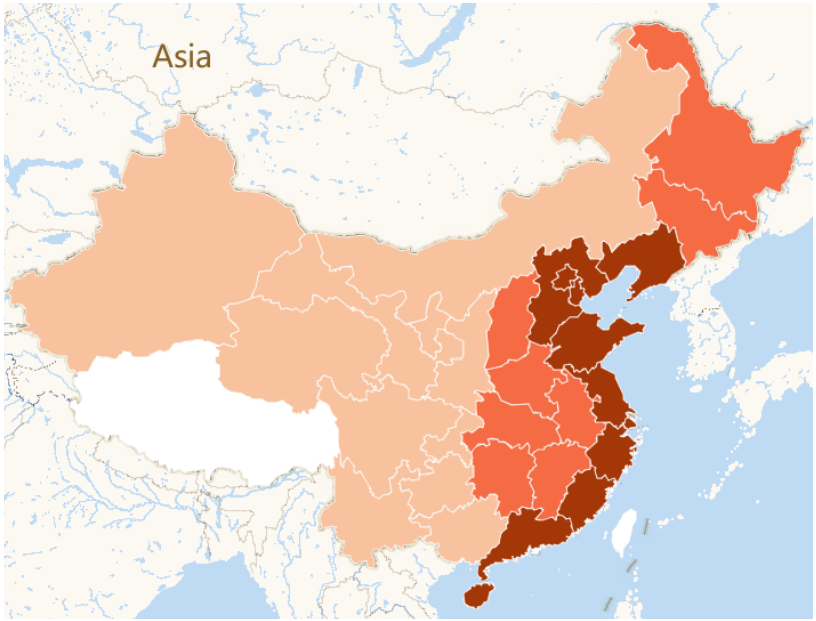
Methods: National Analysis and Regional Analysis

1. Estimate the whole sample

   30 provinces, 1995-2015

2. Estimate the sample by three regions based on geographic location and economic development stage:

Eastern (Beijing, Fujian, Guangdong, Hainan, Hebei, Liaoning, Jiangsu, Shandong, Shanghai, Tianjin, Zhejiang)
Central (Anhui, Heilongjiang, Henan, Hubei, Hunan, Jilin, Jiangxi, Shanxi)
Western (Chongqing, Gansu, Guangxi, Guizhou, Inner Mongolia, Ningxia, Qinghai, Shaanxi, Sichuan, Xinjiang, and Yunnan)



Methods: Panel Analysis

- Stochastic Impacts by Regression on Population, Affluence, and Technology

  $I_i = aP_i^b * A_i^c * T_i^d * \varepsilon_i$

  $LnI_{it} = a + bLnP_{it} + cLnA_{it} + dLnT_{it} + \varepsilon_{it}$

  Where

  I_{it} is total energy consumption of province *i* in year *t*;

  P_{it} is total population of province *i* in year *t;*

  A is Affluence: GDP per capita of province *i* in year *t;*

  T is Technology: tertiary share, crude steel production, cement production, and industrial electricity intensity of province *i* in year *t;*

- Estimation Methods
  - Provincial Fixed Effects with Driscoll-Kraay Standard Errors (robust to disturbances being heteroskedastic, autocorrelated, and cross-sectionally dependent (Hoechle, 2007))
  - Two-way fixed effects with robust standard errors

Methods: Data

Descriptive statistics of the variables:

Variable	Observations	Units	Mean	Std. Dev.	Min	Max
Provincial GDP	630	2005 100 million yuan	8382	9393	203	60524
Provincial GDP per capita	630	2005 yuan/capita	19870	17071	2316	110900
Energy consumption	627	10,000 tce	9140	7162	303	38899
Cement production	629	10,000 tons	3962	4095	64	19496
Steel production	621	10,000 tons	1336	2292	0.01	18850
Population	630	10,000 ppl	4300	2624	481	11430
Industrial Electricity Intensity	622	kWh/2005 yuan	0.28	0.22	0.08	1.32
Tertiary sector share	630	%	40%	8%	28%	80%
Electricity Price	630	2005 yuan/kWh	0.49	0.23	0.19	0.80

Methods: Dealing with Regression Issues

The overall goal is to examine the long-run relationship between energy consumption and the independent variables.

- Panel unit root test
- Panel co-integration test
- Panel co-integration estimation

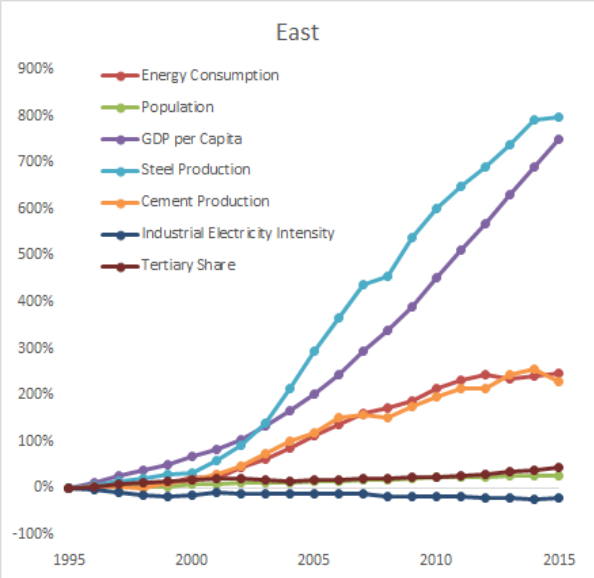
Results: National Level

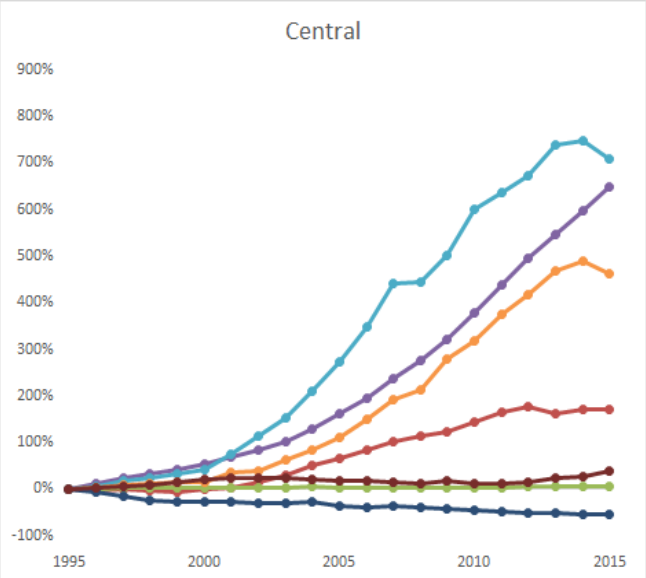
VARIABLES	Two-way Fixed Effects with Robust Standard Errors		Provincial Fixed Effects with Driscoll-Kraay Standard Errors		Panel Co-integration by Panel Fully Modified Least Squares
Provincial GDP per capita	0.731*** (0.076)	0.731*** (0.076)	0.741*** (0.042)	0.753*** (0.075)	0.760*** (0.028)
Tertiary Share	-0.702*** (0.057)	-0.702*** (0.057)	-0.846*** (0.074)	-0.852*** (0.066)	-0.870*** (0.058)
Population	0.801*** (0.089)	0.801*** (0.089)	0.847*** (0.064)	0.857*** (0.081)	0.801*** (0.071)
Steel Production	0.013** (0.006)	0.013** (0.006)	0.019** (0.007)	0.019** (0.008)	0.021*** (0.006)
Cement Production	0.070*** (0.024)	0.071*** (0.017)	0.070*** (0.024)	0.070*** (0.024)	0.063*** (0.020)
Electricity Price	/	0.037 (0.106)	/	0.013 (0.069)	/
Industrial Electricity Intensity	0.442*** (0.024)	0.442*** (0.024)	0.450*** (0.037)	0.450** (0.038)	0.478*** (0.027)
Observations	615	615	615	615	615
R-squared	0.991	0.991	Within 0.966	Within 0.966	
Number of Provinces	30	30	30	30	30

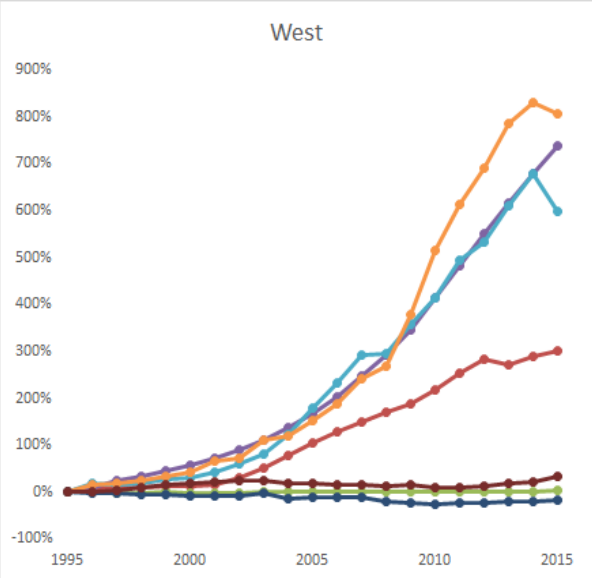
Results: Regional level

VARIABLES	Provincial Fixed Effects with Driscoll-Kraay Standard Errors			
	National	East	Central	West
Provincial GDP per capita	0.741*** (0.042)	0.830*** (0.031)	0.533*** (0.034)	0.730*** (0.065)
Tertiary Share	-0.846*** (0.074)	-1.18*** (0.105)	-0.613*** (0.068)	-0.768*** (0.093)
Population	0.847*** (0.064)	0.912*** (0.080)	-0.321 (0.481)	1.46*** (0.134)
Steel Production	0.019** (0.007)	0.015*** (0.003)	0.170*** (0.032)	-0.017 (0.013)
Cement Production	0.070*** (0.024)	0.044** (0.020)	0.120** (0.032)	0.070 (0.041)
Industrial Electricity Intensity	0.450*** (0.037)	0.600*** (0.054)	0.499*** (0.044)	0.273*** (0.043)
Observations	615	225	168	222
R-squared	Within 0.966	Within 0.977	Within 0.971	Within 0.966
Number of Province	30	11	8	11

Results: Economic transition is happening across China







Conclusions

- National level
  - population and affluence both have statistically significantly positive effects
  - structural shift to tertiary sector, reduction in cement and steel production, and decrease in electricity consumption per unit value added of industrial sector all have statistically significantly negative effects on energy consumption
  - Electricity price doesn't show a statistically significant effect
- Regional level
  - GDP per capita has a higher impact in the most developed region (i.e. the eastern region)
  - Tertiary sector share: eastern > western > central
  - Reduction in cement and steel production: central > eastern
  - Industrial electricity efficiency improvement: eastern > central > western
- Economic transition (including energy efficiency improvement) can help reduce energy consumption
  - Integrated thinking and management of the structural shift, electrification, and efficiency improvement are very important in order to achieve the maximum amount of energy reduction

Thank You!

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