



# The emergence and evolution of regional convergence clusters in China's energy markets

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## ABSTRACT

Employing the new regression tests for *Convergence*, *Club Convergence* and *Clustering* proposed by Phillips and Sul (2007), this paper models and analyses the behaviour of China's energy sectors. Energy market 'convergence clusters' are identified using new price data, and their regional spatial distributions are mapped for four major fuel types: coal, gasoline, diesel and electricity. The findings are as follows: i) as yet, there are no fully integrated national energy markets in China, as more than one convergence cluster is identified for all four fuels; ii) some regional energy markets can be regarded as 'quite mature,' as evidenced by the existence of some highly concentrated convergence clusters connected geographically; iii) some regional markets remain in a 'state of transition,' as witnessed by convergence clusters that are scattered geographically and that are growing in membership; iv) it seems that there is more regional-based integration for coal and electricity than for gasoline and diesel, as more convergent clusters were identified for coal and electricity than for gasoline and diesel; and v) overall, China still appears to be in the process of energy market integration, as demonstrated by the number and evolution of convergence clusters over time.

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## 1. Introduction

Although China has been praised for promoting market competition among the state-owned, collective and private sectors (Qian and Xu, 1993), assessments of its performance have been mixed. Many authors who have studied China's market economy have concluded that some of China's markets are integrated. Rozelle et al. (1997), for example, investigated market integration in China's rural sectors in the late 1990s and found evidence in favour of such a transition. Zhou et al. (2000), Park et al. (2002), Huang and Rozelle (2006), and Awokuse (2007) investigated market integration in China's agricultural commodity markets, and all found that the grain markets were well integrated. Fan and Wei (2006) conducted tests for price convergence amongst 96 commodities and concluded that prices had converged to the 'Law of One Price' in China for an overwhelming majority of goods and services. However, some authors argue that changing patterns of provincial economic structure suggest that China's markets have become *less* rather than *more* nationally integrated during much of the reform period. Young (2000) argues that China's economic reform has actually led to the fragmentation of

domestic markets. Poncet (2005) measured China's domestic market disintegration and identified its determinants and concluded that China is a 'fragmented economy'. Therefore, whether China's reforms have led to a more integrated internal market remains inconclusive (Lan and Sylwester, 2010). However, perhaps this is not surprising given that substantial differences in regional, location-specific advantages and central government preferential policy have resulted in economic development disintegration in China (Demurger et al., 2002).

Based on the above discussion, it might be reasonable to expect that China is not yet a completely integrated market economy and that it is still essentially in a 'state of transition'. In fact, empirical studies have suggested that regional markets are highly fragmented due to interregional protection in China (Li et al., 2003). The final outcome may be the formation of powerful, geographically disconnected (or partially connected), regionally based growth zones. However, a rejection of convergence for the country as a whole does not imply there is no evidence of convergence within regional subgroups. Examples include the possible existence of 'convergence clusters' around separate points of equilibria or steady state growth paths and cases in which there may be both convergence clusters and divergent members in the full panel of regions or sectors. Demurger et al. (2002) demonstrated the relative contributions of location and preferential policies in China's regional development; as expected, these convergence clubs will be geographically linked, i.e., coastal, east–west, north–south, or natural resource based. If local equilibria

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or club convergence clusters exist, then it is of considerable interest as to where they are, what sectors they are in and whether they have/are evolving over time. In separate work, Ma et al. (2009b) and Ma and Oxley (2010) have investigated the convergence of major energy fuel price series using traditional unit root and panel cointegration methods. They found that energy price series are not convergent as a whole and regional energy price series display a differing convergent pattern; this finding implies that there might be some regional energy markets in China.

Given the above discussion of China's market performance, it seems important to investigate whether there is any empirical evidence for convergence clusters for specific commodities and how the clusters evolve over time. Therefore, several questions and issues are worth considering. Firstly, testing for the existence of convergence clusters and determining how regional markets have evolved in China can help us understand the process of China's market economic development and may provide useful insights for policy makers and academics. Secondly, given the concerns and doubts about China's economic reforms (Demurger et al., 2002; Poncet, 2005; Young, 2000), such tests can add to the evidence regarding China's market development and integration. Thirdly, although some studies have investigated China's market integration, most have focused on agricultural commodity markets (Awokuse, 2007; Huang and Rozelle, 2006; Park et al., 2002; Zhou et al., 2000) and aggregate commodity markets (Fan and Wei, 2006; Poncet, 2005). Thus, few regional commodity markets have been investigated and identified, particularly the potential convergence clubs that might exist in regional energy markets. Finally, and perhaps most importantly, given the substantial differences in regional, location-specific advantages, central government preferential policy and economic reforms, it may be advantageous to investigate regional market formation and evolution rather than to simply determine whether China has a market economy as a whole.

A limited number of studies have identified economic growth and the development of convergence clubs in China. For example, Maasoumi and Wang (2008) investigated regional economic reforms, economic growth economic development and convergence using a metric entropy-based measure. Their results show that there exist many small economic development convergence clubs in both the pre- and post-reform periods in China. Weeks and Yao (2003) discovered system-wide income divergence during the reform period (1978–1997) because the coastal provinces do not share a common initial technology progress rate with the interior provinces. However, these studies do not relate to specific commodity market convergence cluster tests; thus far, there have been few econometric tests of 'convergence clustering' for important, specific commodity markets in China. Therefore, the main objective of this paper is to identify the existence of regional convergence clusters and critically investigate the transitional dynamics of their formation using the new testing procedures of Phillips and Sul (2007) as they apply to China's four major fuel price series (coal, electricity, gasoline and diesel). Energy price reforms have perhaps had the most significant impact on the income transfer between the interior and coastal areas given that the interior provinces are the main suppliers of raw industrial materials.

The paper is organised as follows. Section 2 introduces China's major energy reforms to provide the historical background necessary to enable sensible interpretation of the results of the tests. Although econometrically powerful, the testing approach of Phillips and Sul (2007) is atheoretical because it requires no prior, specific inputs or assumptions regarding potential regional convergence club locations or associations. Section 3 outlines the testing approach and explained how it is applied to the data that are discussed in this section. Section 4 presents the empirical results and discussion. The final section presents some conclusions and possible policy implications.

## 2. China's major energy pricing reforms

China's energy reforms have recently been extensively documented. For example, refer to Ma et al. (2009a) for an overview of both energy industry deregulation and energy pricing decentralisation. Here we simply describe some of the major energy pricing reforms in China that may have led to significant changes in behaviour to demonstrate the effects of the gradual pricing reform process. Within the period of analysis, there were four major energy pricing reforms of fuel price changes (see Fig. 1). These major energy pricing reforms occurred approximately in 1997, 1999, 2002 and 2004.

Firstly, as more coal entered the 'free' market, the controlled low price of 'in-plan' coal was difficult to sustain. Consequently, coal prices were gradually relaxed, and for the first time in 1997, intense bargaining between coal companies and power plants was introduced (Hang and Tu, 2007). This bargaining has led to a sharp increase in the price of coal since March 1997. Meanwhile, a new scheme, 'operation-period price' and 'yardstick price',<sup>2</sup> was adopted to simplify the control of electricity pricing in 1997. The price under this scheme was based on an average social generation cost and a unified internal rate of return on capital over the remaining operation period. For plants already in existence, this is indeed an operation-period price; for new plants, the scheme actually specifies a unified yardstick price (Ma and He, 2008). This price reform led to a steady increase in the price of electricity after 1997, and prices became more volatile (Panel A of Fig. 1).

Secondly, domestic petroleum prices have been set in accordance with the international market since 1999 (Hang and Tu, 2007). The central government sets the regional prices of refined oil products according to the Singaporean oil market, and as a result, the 1998 reform resulted in domestic petroleum prices increasing substantially (Wu, 2003). As shown in Panel B of Fig. 1, spot prices of gasoline and diesel increased sharply, from approximately ¥2500/t in mid-1999 to more than ¥4000/t in October 2000, and then continuously regressed for one year until the beginning of 2002.

Thirdly, the system of government-guided coal pricing was abandoned, while electricity tariffs have remained regulated since 2002 (Wang, 2007). As a result, the coal price increased in 2000 from approximately ¥250/t to ¥270/t, while electricity prices maintained at or near their previous trends. Thus, bargaining between the two parties became more intense after 2002. Only 90 million metric tonnes of coal were contracted in that year; this amount was less than 37% of the total demand for coal by power generators. Faced with serious power shortages, the National Development and Reform Committee issued an order declaring that the price of coal to generators was to be set as the midpoint between the requirements of the two parties in 2003 (Wang, 2007). Coincidentally, petroleum prices had begun to rise, from ¥3000/t and ¥2700/t in early 2002 to ¥5700/t and ¥4700/t at the end of 2005 for gasoline and diesel, respectively.

Finally, the government introduced a new coal pricing policy called the 'co-movement' of prices of both coal and electricity in 2004 (Ma and He, 2008). The co-movement was not a free market adjustment but was regulated and determined periodically by the State Development and Reform Committee to avoid extreme price fluctuations. Adjustments would be made only if coal price fluctuations exceeded 5%; otherwise, the change would be accumulated to the next adjustment period. However, it seems that this reform might

<sup>2</sup> "Operation-period prices" and "yardstick prices" were a new pricing scheme and were implemented in 1997; this scheme in many respects mirrors the US introduction of incentive regulation programmes, or yardstick programmes, as alternatives to rate-of-return control since the late 1970s. Rate-of-return range programmes allow prices to fluctuate with changes in costs, while under yardstick competition programmes, a utility's price is based on the costs of comparable utilities. The change from 'repayment of principal and interest' to operation-period prices and yardstick prices in China serves a similar purpose (Ma and He, 2008).

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