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Energy Market Integration in China

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1. Introduction

Oil prices have been closely scrutinized by the applied economics literature during the past three decades (Lanza, Manera and Giovannini, 2005). Many applied research and policy studies have examined the role played by the price of oil in determining economic growth or inflation rates both in developed and developing countries (Adrangi et al., 2001; Asche et al., 2003; Stern, 2000; Girma and Paulson, 1999; Gjolberg and Johnsen, 1999; Serletis, 1994; Shaked and Sutton, 1982).

Examining energy price movements can help to reveal whether local protectionism has resulted in significant barriers to international trade and to provide more empirical evidence on the extent of market economy in China. This study will investigate energy price movements in China with a data set that consists of 4 energy types (coal, gasoline, electricity and diesel) in 35 cities (all of which are provincial or autonomous regions and municipal cities) over a maximum of 132 months (from 1995 to 2005) and using time series methods which focus upon non-stationary and cointegration.

The ongoing transition of former communist countries from planned to market economies has been one of the most important economic phenomena in the last few decades. Therefore, it is interesting to discern whether the liberalization of domestic trade prompts major shifts in price structures that were highly distorted under central planning.

Among the transitional economies, China seems to have been the centre of attention in the recent economic literature. In particular, as highlighted by some recent work (Lau, Qian and Roland, 2000; Young, 2000; Poncet, 2003 and 2005), whether China's gradualist reform has been successful is still subject of great interest and intense debate. Even since China embarked on its economic reform and adopted an open door policy in the late 1970s, its economic development has been greatly fuelled by its active participation in international trade. In recent years, China's major trading partners have strongly urged it to open its domestic market further to the outside world, especially after it has admitted to the World Trade Organization. However, even if Chinese government removes the barriers to international trade significantly, the effectiveness of this policy might be extremely affected by regional trade barriers within China itself (Fan and Wei, 2006).

China's economic reforms have been maintained and the purpose of these policy changes is to promote the formation of an integrated market in China. It is thus interesting indeed important to test for the spatial market integration, which can provide important information on how the market works (Zhang, Wan and Chen, 2000). Such information may help government to decide the extent to which it should intervene in the market (Wyeth, 1992).

The energy market integration has been extensively investigated worldwide since the 1990s (Asche, Osmundsen and Tveteras, 2002; Asche, Osmunddsen and Sandssmark, 2006; Bachmeier and Griffin, 2006; De Vany and Walls, 1999; Narayan and Smyth, 2005; Adrangi, Chatrath, Raffiee and Ripple, 2001; Asche, Gjolberg and Volker, 2003; Gjolberg and Johnsen, 1999; Serletis, 1994; Weiner, 1991). Recent work sees only one study, Fan and Wei (2006), which tests for The Law of One Price in China, covering 72 time series (in detail, 41 variables from industrial products, 20 variables from agricultural products, 13 variables from other consumer goods and 18 variables from service products, but it includes only two fuel variables (gasoline and diesel). To the best of our knowledge, there has been no specific study on energy market integration using data from China.

This study has two major goals. The first goal is to investigate energy market integration across major cities in China. The second goal is to estimate the rate at which relative prices converge to their long-run values across cities and to examine causality relationship across cities to observe how prices change between cities. The rest of paper is organized as follow. The next section presents our empirical methodologies, followed by data description. Section 4 discusses the estimated results and provides main findings. The section 5 concludes.

2. Methodologies

A common approach to investigate market integration is to apply the unit root test to examine whether price differential series are stationary. The rejection of the unit root hypothesis implies that the time series of relative price are stationary, so that relative prices will converge in the long run. Otherwise, if the tests fail to reject the null hypothesis, the relative price series are will follow a random walk (Fan and Wei, 2006).

This paper starts an empirical investigation by carrying out the Augmented Dickey-Fuller (ADF) tests for four kinds of energy products and over all cities to examine whether their relative price series [$p_{ijt} = \ln(g_{ij,t} / g_{j.t})$] are stationary. The regression takes the follow form:

$$\Delta p_{ij,t} = c_{ij} + \alpha_{ij} p_{ij,t-1} + \sum_{h}^{k} \beta_{ijh} \Delta p_{ij,t-h} + \varepsilon_{ij,t} \qquad (1)$$

Where Δ is the first-difference operator; ε is an identically independently distributed (*i.i.d*) error term; *i*, *j* and *t* stand for city, product and time. The ADF unit root test is simply the test on whether α_{ij} is negative and statistically significant using some modified critical values for the t-test provided by McKinnon. The number of lags, *k*, to be included in equation (1) for each product and city series is determined individually by using modified Hannan-Quinn criterion on a city-by-city and product-by-product bases.

All the ADF specifications include an intercept term in order to capture city-specific fixed effects. Such effects may cover, for instance, city-specific transportation, income levels, and local non-traded costs. The inclusion of the intercept term is to demonstrate whether prices converge to absolute price parity (zero mean) or relative price parity (nonzero mean).

It is convenient using one city as a benchmark ($g_{j.t}$) to generate relative price series to conduct the ADF unit root tests. Theoretically, it is possible that all of the ADF unit root tests will reject null hypothesis no matter which city is chosen as a benchmark ($g_{j.t}$) if the energy market is completely integrated. Meanwhile, there may be apparent difference across energy products in the degree of market integration. Therefore, it may be a good way to first conduct the ADF unit root tests using one city as a benchmark to see how many tests reject null. If the ADF unit root tests show almost all of them reject unit root hypothesis for some energy products, it may not be necessary to further conduct the ADF unit root tests of pairs of relative price series on city-by-city basis.

However, there may be more likely the second scenario that most of the ADF unit root tests do not reject null hypothesis. In this case, it can be explained that one city (or call regional market) is not integrated with benchmark city (or region), but it does not mean this city (or regional market) is not integrated with some other cities (or regional markets). Therefore, we may need to conduct the ADF unit root tests on a city-by-city basis under this circumstance. This implies that the markets of some products may not be integrated nationally, but it can be integrated regionally due to, for example, transportation cost or network connection (especially for power supply market).

Since the appearance of the papers by Levin and Lin (1992, 1993), the use of panel data unit root tests has become very popular among empirical studies with access to a panel data set. It bas been generally accepted that the traditionally used unit root tests, such as the Dickey-Fuller (DF), augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) tests, lack power in distinguishing the unit root null hypothesis from stationary alternatives. Consequently, using panel data unit root tests is one way of increasing the power of unit root tests based on a single time series (Banerjee, 1999; Maddala and Wu, 1999). There are many various versions of panel unit root test, which has both advantages and disadvantages. For detail of panel data unit root test approach, an overview and a comparison can be referred to Banerjee (1999) and Maddala and Wu (1999), respectively. In this empirical study, we simply present all kinds of test results estimated by various panel unit root test approach employing EView6.0 software.

It is interesting to see the rate at which the relative price series converge to their long-run values. Like in Ceglowski (1999), the rates, half-lives, are estimated by the expression $\ln(0.5)/\ln(1+\alpha_{ij})$, where α_{ij} is the parameters to be estimated in equation (1). Since the energy spot prices are recorded based on every 10-day interval, the final half-lives are expressed in months by dividing the expression by 3.

It is also interesting to establish the direction of flows of information between energy markets. The following regression can be estimated:

$$\begin{aligned}\Delta P_{it} &= \theta_{11}\Delta P_{i,t-1} + \cdots + \theta_{1n}\Delta P_{i,t-n} \\ &\quad + \theta_{21}\Delta P_{j,t-1} + \cdots + \theta_{2n}\Delta P_{j,t-n} \\ &\quad - \gamma_1(P_{it-1} - \alpha P_{jt-1} - \delta) + \varepsilon_{1t}\end{aligned} \tag{2}$$

$$\begin{aligned}\Delta P_{jt} &= \theta_{31}\Delta P_{jt-1} + \cdots + \theta_{3n}\Delta P_{jt-n} \\ &\quad + \theta_{41}\Delta P_{it-1} + \cdots + \theta_{4n}\Delta P_{it-n} \\ &\quad - \gamma_2(P_{it-1} - \alpha P_{jt-1} - \delta) + \varepsilon_{2t}\end{aligned} \tag{3}$$

The causality tests can be undertaken with the following null hypotheses:

$$\theta_{21} = \cdots = \theta_{2n} = \gamma_1 = 0 \quad (4)$$

Which implies there is no causality from p_j to p_i.

$$\theta_{41} = \cdots = \theta_{4n} = \gamma_2 = 0 \quad (5)$$

Which implies there is no causality from p_i to p_j.

3. Data

The data set used in this empirical study is a panel data set of monthly price for four energy fuels in 35 major Chinese cities.[1] The price data are collected by the China Price Information Center (CPIC) – a division of the State Development Planning Commission (SDPC) of People's Republic of China. The data are initially collected every ten-day interval (e.g., three times a month) for the period January 1995 to January 2006. Like in Fan and Wei 2006, we first aggregate these ten-day data sets into monthly data sets by simply taking the average of three observations within each month.[2] Unlike other market price data, fuel price data set has no missing information during the study period because fuels are extensively used in all cities. Empirically, this study includes four major fuel products, which are coal, electricity, gasoline and diesel.

The quality of Chinese data is often criticised because data reporting in China is likely affected by political factors (Rawski, 2001). However, we believe that the data for specific product prices collected by local government agencies under strict government mandates are unlikely subject to manipulation. Central government specifies the collection of prices for specific products at fixed dates and locations and these price data are also available to the public so that local officials would find it hard to report false data. Unlike macro-economic data (such as GDP growth and employment rates), these micro

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[1] The cities are Beijing, Tianjin, Shijiazhuang, Taiyuan, Huhehaote, Shenyang, Changchun, Harbin, Shanghai, Nanjing, Hangzhou, Hefei, Fuzhou, Nanchang, Jinan, Zhengzhou, Wuhan, Changsha, Guangzhou, Nanning, Haikou, Chongqing, Chengdu, Guiyang, Kunming, Lhasa, Xian, Lanzhou, Xining, Yinchuan, Wulumuqi, Qingdao, Dalian, Xiamen, Ningbo. They include four municipalities and all the capital cities for the 31 provinces and autonomous regions in mainland China.

[2] The price data are collected to provide price information to the central and local governments for macroeconomic management. According to State law, the local price bureaus in 36 major cities are obligated to report price information for a specified list of products to the Price Information Center. The price information must be collected from fixed local markets. The fuel price information is collected three times a month, on the 5th, the 15th and the 25th day of the month. The fuel names are uniform across all cities, and all prices must be market prices.

data for prices could hardly serve as indicators in assessing the performance of local officials and hence local officials have no incentives to falsity them.

The data used in this study are spot prices regularly collected on a ten-day interval (the 5th, 15th and 25th of each month) from local markets by governmental agencies. This is in contrast with most of the empirical studies, which employ price index or lower frequency (such as annual) data. The monthly frequency of our price data corresponds well to the time needed for domestic price arbitrage because lower frequency (annual) price index data are not as appropriate as high frequency (monthly) specific product price data for examining price convergence (Taylor, 2001). Further more, monthly spot prices are not nearly as rich a data source as daily spot prices, particularly if one wants to measure the half-life of subsequent adjustment following the single day response (Bachmeier and Griffin, 2006). This implies that 10-day interval spot prices used in this study are better suited to test for market integration than monthly spot prices. These panel data sets are also truly nationally representative because it covers main fuel components (e.g., coal, electricity, gasoline and diesel), all provincial capitol cities of mainland China, and a longer period from 1995 to 2005.

It should be noted that the market prices collected by CPIC are list prices. To the extent that in some markets prices paid may be different from the list prices, the use of list prices may result in measurement error problems. However, such measurement errors, if they exist, should be random across different cities so that effects on fuel market integration are not serious (Fan and Wei, 2006).

4. Results and discussions

As a rule, we first conduct the ADF unit root tests to observe whether our raw price data series contain unit root. The unit root test results are displayed in Appendix 1 for level data series and Appendix 2 for the first difference series. The ADF unit root tests show that each of 35 city raw price data series for four energy products exhibit unit root and integrated of order one. All testes suggest that the first differences of the series are stationary.

Having established that raw price series each contain a unit root, we first conduct the ADF unit root test for relative price series using Shanghai as a benchmark to examine whether energy prices of all other cities converge with that of Shanghai and the test results are shown in Table 1. It can be seen from Table 1 that of 35 relative price series there are 11 at 5% significant level and 2 at 10% level for coal. Even less number of relative price series with significant level above 10% for electricity (only 3 at 10% significant level and 3 at 5% significant level). However, there is extremely opposite scenario for gasoline and diesel. For example, all of the ADF unit root tests show a 5% significant level for gasoline relative price series (except for six insignificant series: Tianjin, Hangzhou, Nanning, Chongqing, Lhasa and Ningbo). The same can be observed for diesel (except for six insignificant series: Huhehaote, Hefei, Guangzhou, Kunming, Lhasa and Wulumuqi, among which there are still two series at 10% significant level).

The primary conclusion we can make is that most of gasoline and diesel prices of other cities are convergent with that of Shanghai. If taken account of some special and remote regions (e.g., Lhasa, Wulumuqi, Kunming), almost all prices series are convergent each other. Therefore, gasoline and diesel markets of Mainland China should be treated integrated. Generally, this finding is consistent with that in Fan and Wei (2006). Only difference is that this study has found prices of more cities to be convergent, which can be due to more frequency and more updated prices used in current study. As for coal and electricity prices, we need to further conduct the ADF unit root tests on city-by-city basis because it is possible for those insignificant to be convergent with that of its neighbours in stead of convergent with Shanghai.

Following the ADF unit root tests above, we have collected t-statistic of intercept term in equation (1) and calculated half-lives only for those convergent prices. The results are shown in Table 2. It can be seen from Table 2 that coal prices more likely converge to relative price parity (nonzero mean) because almost all of relative price series found to be convergent have significant intercept term. As expected, there are not any intercept terms to be found significant, not any even at 10% significant level for electricity market. Meanwhile, it can be found that gasoline market prices more likely converge to relative price parity than diesel prices because more significant intercept terms have been found for gasoline (9 pairs of relative price series) than for diesel (only 4 pairs of relative price series).

Turn to half-lives estimated, it can be seen that the estimated half-lives for coal and electricity (2.7 and 2.9 months, respectively) are longer than those of gasoline and diesel (1.6 and 1.8 months, respectively). It also finds that the half-lives are not only dependent upon the distance but transportation and communication facilities and other factors as well. For example, it takes 2.4 months for the diesel relative price to converge to its long run value in Nanjing (closer to Shanghai), but it only takes 0.9 months in Zhengzhou (far from Shanghai).

No matter how many relative price series have been found to have rejected null hypothesis, whether or not energy markets are integrated is still unknown. Therefore, next step, we turn to conduct panel unit root test to answer whether energy markets in Mainland China are integrated as a whole. Various panel unit root tests are displayed in Table 3. It can be seen from Table 3 that all kinds of panel unit root tests for gasoline and diesel have rejected null hypothesis, which means that both gasoline and diesel prices are convergent, in other words, gasoline and diesel markets in Mainland China are integrated. This finding is fundamentally consistent with that of traditional ADF unit root tests.

However, all of coal panel unit root tests reject null hypothesis and also more than half of electricity panel unit root tests reject null hypothesis. These panel unit root test results contradict with those based on the traditional ADF unit root tests (see Table 1). Interestingly, some literatures also present the same contradictive scenarios. For example, In Fan and Wei (2006), there are 7 convergent cities out of 31 cities for tin, 9 convergent cities out of 31 cities for cast pig iron, 4 convergent cities out of 25 cities for caustic soda, 6 convergent cities out of 35 cities for sulfuric acid and only 2 convergent cities out of 23 cities for refrigerator, and 5 convergent cities out of 35 cities for corn flour, etc, but all of their panel unit root tests reject null hypothesis. This contradiction also urges us to conduct further traditional ADF unit root tests on city-by-city basis. Therefore, we will next focus on only coal and electricity prices.

The ADF unit root test results on city-by-city basis are presented in Table 4, which clearly displays how coal price in each city converges that in other city. It can be seen that there are 111 pairs rejecting null hypothesis, accounting for 24% of total (465) pairs of relative price series. There are 16 pairs of relative price series rejecting null hypothesis for Nanning and Chongqing. There are 10-13 pairs of relative price series rejecting null hypothesis for 8 cities (Beijing, Shijiazhuang, Huhehaote, Shanghai, Hefei, Wuhan, Chengdu and Xian). It is very interesting g to find that only two pairs of relative coal price series reject null for Taiyuan (Shanxi province) considered it is most important coal production base and accounts for approximate 20% of national coal supply.

As for electricity, less pairs of relative price series reject null hypothesis (see Appendix 3). It can be seen that there are 81 pairs rejecting null hypothesis, accounting for 17% of total (465) pairs of relative price series. There are 9-13 pairs of relative price series rejecting null hypothesis only in 7 cities (Shijiazhuang, Huhehaote, Nanchang, Zhengzhou, Haikou, Chengdu and Lhasa).

Using the expression $\ln(0.5)/\ln(1+\alpha_{ij})$ and the estimated α_{ij} from equation (1), we calculate half-lives for those relative price series that reject null hypothesis. The results are shown in Table 5 (for coal) and in Appendix 4 (for electricity). For coal market, the average is about 4.6 months, which means it takes 4.6 months for coal relative prices to converge to their long-run values. The estimated half-lives do not vary much and most of them range from 3.3 to 4.5 months (if dropping two extremely values for Lhasa (7.4) and Wulumuqi (8.5)). For electricity market, it takes only 2.9 months (average in Appendix 4) for electricity relative prices to converge to their long-run values. Likewise, there is no much variation in estimated half-lives across cities.

Causality relationship between each pair of the markets where the relative prices significantly converge to long-run value is also analyzed for coal and electricity. Firstly, according to the results in Table 6, some cities have double-direction causality relationship with others, among them Shanghai has double-direction causality relationship with 18 cities. And then come Taiyuan (with 12 cities), Nanjing (with 10 cities), and Xining (with 14 cities). Second, causality most likely originates from Shijiazhuang and Yinchuan (causing 20 other city price change), Shanghai (causing 18 other city price change), Wuhan and Kunming (causing 21 other cities price change), and Guangzhou (causing 22 other city price change). In addition, causality also likely originates from Beijing, Taiyuan, Hangzhou, Jinan, Haikou and Xining (causing about 15 other cities price change). Third, the results show that causality originates not only from supply regions (e.g., Taiyuan, Xian and Zhengzhou) but from demand regions (Shanghai, Guangdong, Yinchuan, Kunming and Wuhan). However, it seems that price change signals more likely originate from demand regions. Finally, it is no doubt that Guiyang, Lhasa, Lanzhou and Wulumuqi have less causality relationship with outside, but it seems strange for Tianjin and Nanjing not to have much causality relationship with outside.

For electricity, it seems there are more cities having double-direction causality relationship with outside (see Appendix 5). For example, Tianjin, Zhijiazhuang, Harbin, Shanghai, Fuzhou, Chengdu, Kunming and Lanzhou have significant double-direction causality relationship with 17-19 outsiders. Causality most likely originates from Shijiazhuang, Shanghai, Wuhan, Guangdong, Kunming and Yinchuan. The electricity price changes in Huhehaote, Taiyuan, Harbin, Shanghai, Changsha, Nanning, Xian and Xining are most likely caused by outsiders.

5. Findings and conclusions

This paper investigates market integration in Mainland China by employing common ADF unit root test and familiar causality test using unique highest frequency energy price data sets (ten-day interval spot prices). Meanwhile the paper has estimated the rates at which relative prices converge to their long-run values and observed the flow of energy price between cities. The major findings are as follow:

First of all, both common ADF unit root test and panel unit root test have shown that gasoline and diesel markets are fundamentally integrated because almost all tests reject unit root hypothesis. Taking into some special and remote cities (some western and southwestern small cities, such as Lhasa, Wulumuqi, Guiyang and Lanzhou), it may be safe to conclude that gasoline and diesel markets are fairly integrated. This finding is consistent with international literatures (Fan and Wei, 2006; Panagiotidis and Emilie, 2007).

Although all tests disclose that coal and electricity markets in mainland China seem not well integrated as gasoline and diesel markets, this may be most partly due to bulk of coal and non-storability of electricity and power network disconnection. As a consequence, panel unit root tests rejected null hypothesis, which may imply that coal and electricity markets in Mainland China are still quite integrated as a whole.

Second, there are not any significant intercept terms, electricity prices empirically and theoretically converge to absolute price parity due to no more transportation cost once started. However, coal and gasoline prices more likely converge to their relative price parities due partly to significant transportation cost.

Third, the rates at which relative prices converge to their long-run values are very close between each relative price series within the same energy product and also fairy short compared with those internationally.

Fourth, there are rich causality relationships between cities for coal and electricity. Causality not only originates from supply cities but from demand cities as well.

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Table 1. Unit root tests for relative price series (Shanghai is used as a benchmark)

	Coal		Electricity		Gasoline		Diesel	
City	t-stat.	Prob.*	t-stat.	Prob.*	t-stat.	Prob.*	t-stat.	Prob.*
Beijing	-2.8089	0.0579	-1.6798	0.4408	-3.1360	0.0248	-3.2065	0.0204
Tianjin	-1.0854	0.7227	-1.5906	0.4864	-2.3647	0.1526	-2.8677	0.0501
Shijiazhuang	-3.9503	0.0019	-1.9243	0.3210	-5.2085	0.0000	-2.7239	0.0709
Taiyuan	-1.8693	0.3468	-1.2036	0.6741	-4.2926	0.0005	-4.2398	0.0006
Huhehaote	-3.5428	0.0074	-2.6304	0.0877	-3.9871	0.0016	-2.6634	0.0814
Shenyang	-1.3012	0.6302	-1.3786	0.5933	-3.2547	0.0177	-5.1200	0.0000
Changchun	-1.9807	0.2954	-2.8305	0.0549	-3.5845	0.0065	-3.4023	0.0115
Harbin	-2.3477	0.1576	-2.6673	0.0807	-3.6311	0.0056	-3.7728	0.0035
Shanghai	-	-	-	-	-	-	-	-
Nanjing	-1.0223	0.7464	-2.2971	0.1735	-3.2032	0.0206	-2.8618	0.0509
Hangzhou	-2.1609	0.2212	-1.9748	0.2980	-2.5622	0.1018	-2.6073	0.0923
Hefei	-2.0499	0.2655	-1.3108	0.6257	-3.9787	0.0017	-2.2758	0.1804
Fuzhou	-1.1292	0.7053	-1.7744	0.3931	-3.7725	0.0035	-3.5680	0.0068
Nanchang	-2.2404	0.1924	-1.5696	0.4972	-5.1085	0.0000	-3.8377	0.0028
Jinan	-3.7008	0.0044	-2.9385	0.0419	-3.7040	0.0044	-2.7994	0.0593
Zhengzhou	-3.3462	0.0136	-1.5293	0.5178	-5.5169	0.0000	-3.5539	0.0072
Wuhan	-4.7670	0.0001	-1.6823	0.4395	-3.4729	0.0092	-3.3640	0.0129
Changsha	-2.5393	0.1070	-2.3117	0.1688	-2.8242	0.0558	-4.0787	0.0012
Guangzhou	-2.3736	0.1500	-1.8966	0.3338	-3.8072	0.0031	-2.1359	0.2308
Nanning	-3.5707	0.0068	-1.3635	0.6006	-2.2276	0.1969	-2.7380	0.0686
Haikou	-1.7268	0.4170	-3.8405	0.0028	-5.5661	0.0000	-3.3795	0.0123
Chongqing	-3.4382	0.0103	-1.8192	0.3710	-2.4931	0.1179	-4.4552	0.0003
Chengdu	-2.9288	0.0430	-2.4557	0.1273	-3.6815	0.0047	-2.7844	0.0614
Guiyang	-1.3498	0.6072	-2.0704	0.2570	-3.8648	0.0025	-4.6588	0.0001
Kunming	-3.0916	0.0280	-1.5782	0.4928	-3.7133	0.0043	-2.2736	0.1812
Lhasa	-0.9005	0.7877	-2.2667	0.1835	-1.8779	0.3427	-2.0313	0.2734
Xian	-2.5751	0.0990	-1.8184	0.3714	-3.2284	0.0191	-3.1258	0.0255
Lanzhou	-1.5278	0.5186	-1.7631	0.3987	-5.5932	0.0000	-3.2995	0.0156
Xining	-2.5098	0.1139	-1.2791	0.6404	-4.8597	0.0001	-4.2277	0.0007
Yinchuan	-2.5679	0.1004	-1.3733	0.5959	-4.8815	0.0000	-3.9251	0.0021
Wulumuqi	-2.2598	0.1858	-1.4958	0.5349	-3.2153	0.0199	-2.6049	0.0928
Qingdao	-0.9005	0.7877	-1.9639	0.3029	-3.7738	0.0035	-3.6466	0.0053
Dalian	-2.5179	0.1119	-1.4077	0.5790	-3.0487	0.0315	-3.6199	0.0058
Xiamen	-3.0152	0.0344	-3.2314	0.0190	-6.1913	0.0000	-4.4798	0.0002
Ningbo	-3.0791	0.0290	-2.1150	0.2389	-2.4159	0.1380	-3.4713	0.0093
Proportion of rejecting null	-	12/35	-	6/35	-	30/35	-	30/35

*MacKinnon (1996) one-sided p-values.
Null hypothesis is that each series contains a unit root.
ADF is the Augmented Dickey-Fuller test.
Critical values: -3.44 (1% level), -2.87 (5% level) and -2.57(10% level).
Lag length is based on modified Hannan-Quinn, Minlag=0 and Maxlag=16.

Table 2. t-statistic of intercept term (c_{ij}) and estimated half-lives(months) (Shanghai=benchmark)

	Coal		Electricity		Gasoline		Diesel	
City	t-stat.	Half-life	t-stat.	half-life	t-stat.	Half-life	t-stat.	Half-life
Beijing	**-2.4112**	3.2	-0.9410	-	-0.5922	2.1	-0.1350	2.5
Tianjin	-1.2147	-	-0.8333	-	-1.4732	-	-0.9380	1.9
Shijiazhuang	**-3.6953**	2.1	-1.1904	-	-1.6415	1.1	0.4642	2.6
Taiyuan	-1.3700	-	-0.9222	-	**-3.2811**	1.7	**-2.0968**	1.3
Huhehaote	**-3.3651**	1.9	-0.1226	4.9	0.4155	1.7	1.2779	-
Shenyang	-0.8118	-	-0.9593	-	-1.6579	1.6	0.4353	1.2
Changchun	-1.0081	-	0.5779	2.6	**-2.1446**	1.1	-0.4314	1.2
Harbin	-2.2787	-	-1.5648	1.6	-0.2146	1.3	0.7789	1.7
Shanghai	-	-		-	-	-	-	-
Nanjing	-0.9961	-	-0.1489	-	**-2.4543**	0.6	**-2.1295**	2.4
Hangzhou	-0.5096	-	-0.3650	-	-1.5899	-	-1.4990	2.5
Hefei	-0.9377	-	-0.8756	-	**-2.6712**	4.2	-1.4016	-
Fuzhou	-0.6796	-	-0.0188	-	1.2249	1.6	0.9691	2.3
Nanchang	-0.3825	-	-1.2497	-	**-2.1650**	2.0	-1.7190	1.5
Jinan	**-3.0756**	1.8	-1.3835	3.0	-1.8154	1.2	-0.6936	2.8
Zhengzhou	**-3.1233**	2.3	-1.1954	-	-1.4192	0.8	-0.0858	0.9
Wuhan	**-3.0093**	1.4	-0.7554	-	-0.6876	1.6	-1.2069	1.5
Changsha	-0.8963	-	-1.2247	-	-1.6494	1.3	**-2.1896**	1.1
Guangzhou	1.8567	-	0.9078	-	**-2.5306**	2.4	-1.0520	-
Nanning	**-3.2645**	2.2	-0.8465	-	-0.7599	-	-1.1172	2.9
Haikou	-0.9377	-	-1.4232	1.6	0.7021	0.9	0.2576	1.4
Chongqing	**-3.6202**	2.8	-1.3072	-	-0.2944	-	-1.4175	1.8
Chengdu	-1.8167	3.6	-1.5120	-	-1.1144	2.3	0.1895	2.7
Guiyang	-1.1842	-	-0.9969	-	-0.8605	2.0	0.8879	1.2
Kunming	**-2.8105**	2.6	-1.1546	-	0.8252	2.1	0.9746	-
Lhasa	-1.5589	-	-1.6127	-	1.4600	-	1.6305	-
Xian	**-2.6090**	4.2	-1.3695	-	-1.7526	0.9	-0.3896	1.4
Lanzhou	-1.8306	-	-1.4771	-	**-2.6298**	1.1	0.7910	2.0
Xining	-2.6001	-	-0.9562	-	0.0469	1.3	-0.1378	1.2
Yinchuan	**-2.3656**	4.3	-1.0515	-	-1.4649	1.2	0.5330	1.4
Wulumuqi	-2.6444	-	-1.1612	-	**-2.5337**	1.7	-1.1290	-
Qingdao	-1.5589	-	-1.3564	-	**-2.1278**	2.4	-1.0060	2.3
Dalian	-0.8386	-	-0.5147	-	-0.0851	1.6	1.4608	0.8
Xiamen	-0.2111	2.4	1.0365	3.4	0.2743	0.9	-1.2533	1.4
Ningbo	**-2.1394**	2.4	-0.4992	-	-1.4040	-	**-2.2566**	2.5
Average	-	2.7	-	2.9	-	1.6	-	1.8

Half-Lives are estimated by the expression $\ln(0.5)/\ln(1+\alpha_{ij})$ and α_{ij} come from equation (1).
The averages are only for those rejecting null hypothesis.

Table 3. Panel data unit root tests (Shanghai is used as a benchmark)

Tests (assumption)	Coal		Electricity		Gasoline		Diesel	
	Statistic	Prob.**	Statistic	Prob.**	Statistic	Prob.**	Statistic	Prob.**
1. Exogenous variables: none								
Null: Unit root (common unit root process)								
Levin, Lin & Chu	-5.2813	0.0000	-8.3938	0.0000	-17.4462	0.0000	-16.5273	0.0000
Null: Unit root (individual unit root process)								
ADF - Fisher Chi-square	159.277	0.0000	174.399	0.0000	506.333	0.0000	432.368	0.0000
PP - Fisher Chi-square	297.000	0.0000	1179.48	0.0000	1477.50	0.0000	1663.73	0.0000
2. Exogenous variables: individual effects								
Null: Unit root (common unit root process)								
Levin, Lin & Chu	-2.1169	0.0171	-0.5589	0.2881	-6.0979	0.0000	-3.2672	0.0005
Null: Unit root (individual unit root process)								
Im, Pesaran and Shin	-6.12602	0.0000	-3.1879	0.0007	-15.007	0.0000	-12.2398	0.0000
ADF - Fisher Chi-square	167.603	0.0000	95.8128	0.0148	418.868	0.0000	312.278	0.0000
PP - Fisher Chi-square	461.094	0.0000	1066.03	0.0000	1471.41	0.0000	1630.46	0.0000
3. Exogenous variables: individual effects and linear trend								
Null: Unit root (common unit root process)								
Levin, Lin & Chu	-3.7303	0.0001	1.2507	0.8945	-10.7295	0.0000	-5.2583	0.0000
Breitung	-3.8288	0.0001	-2.2417	0.0125	-11.6367	0.0000	-11.6871	0.0000
Null: Unit root (individual unit root process)								
Im, Pesaran and Shin	-4.4451	0.0000	1.7358	0.9587	-14.1982	0.0000	-9.9196	0.0000
ADF - Fisher Chi-square	127.0280	0.0000	48.327	0.9660	366.820	0.0000	237.374	0.0000
PP - Fisher Chi-square	491.1880	0.0000	1081.25	0.0000	1447.20	0.0000	1596.12	0.0000

** Probabilities for Fisher tests are computed using an asymptotic Chi-square distribution. All other tests assume asymptotic normality.
Lag length is based on modified Hannan-Quinn, Minlag=0 and Maxlag=16.

Table 4. Unit root tests for pairs of coal price series for 31 cities (null hypothesis unit root, * and ** stand for 10% and 1% significant level, respectively)

City	Beijing	Tianjin	Shijiazh	Taiyuan	Huhehao	Sheny	Changch	Harbin	Shanghai	Nanjing	Hangzh	Hefei	Fuzhou	Nanch	Jinan	Zhengzh
Beijing	-	-	**	-	*	-	-	*	*	-	-	**	-	-	*	**
Tianjin	-	-	-	-	-	-	-	-	-	*	-	-	**	-	-	-
Shijiazh	**	-	-	-	**	**	-	-	**	-	-	**	-	-	-	**
Taiyuan	-	-	-	-	*	-	-	-	-	-	-	-	-	-	-	*
Huhehao	*	-	**	*	-	-	**	-	**	-	-	*	-	-	**	-
Sheny	-	-	**	-	-	-	-	**	-	-	**	*	-	*	-	-
Changch	-	-	-	-	**	-	-	-	-	-	-	-	-	-	-	-
Harbin	*	-	-	-	-	**	-	-	-	-	-	-	-	*	-	-
Shangh	*	-	**	-	**	-	-	-	-	-	-	-	-	-	**	**
Nanjing	-	*	-	-	-	-	-	-	-	-	-	-	**	-	-	-
Hangzh	-	-	-	-	-	**	-	-	-	-	-	*	-	-	-	-
Hefei	**	-	**	-	*	*	-	-	-	-	*	-	-	-	-	*
Fuzhou	-	**	-	-	-	-	-	-	-	**	-	-	-	-	-	-
Nanch	-	-	-	-	-	*	-	*	-	-	-	-	-	-	-	-
Jinan	*	-	-	-	**	-	-	-	**	-	-	-	-	-	-	*
Zhengzh	**	-	**	*	-	-	-	-	**	-	-	*	-	-	*	-
Wuhan	*	-	**	-	**	-	-	*	**	-	-	-	-	-	**	**
Changsh	-	-	-	-	**	-	-	-	-	-	-	-	-	-	**	-
Guangzh	*	-	**	-	*	-	-	-	-	-	-	-	-	-	-	-
Nann	**	-	**	-	*	**	*	**	**	-	**	**	-	**	-	-
Haikou	-	*	-	-	-	-	-	-	-	-	*	-	**	-	-	-
Chongq	**	-	**	-	**	*	-	**	**	-	-	**	-	*	**	**
Chengd	**	-	**	-	-	*	-	-	**	-	-	**	-	**	-	-
Guiy	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Kunm	-	-	-	-	**	-	-	-	**	-	-	-	-	-	**	**
Lhasa	-	*	-	-	-	-	-	-	-	-	-	-	*	-	-	-
Xian	**	-	**	-	-	**	-	*	-	-	**	*	*	-	-	-
Lanzh	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Xining	-	-	-	-	-	-	-	-	-	-	**	-	*	**	-	-
Yinch	-	-	-	-	-	-	-	-	*	-	-	-	-	-	-	-
Wulumu	-	-	-	-	-	-		-	-	-	-	*	-	-	-	-

Table 4: continued

City	Wuhan	Changsh	Guangzh	Nanning	Haikou	Chongq	Chengdu	Guiyang	Kunm	Lhasa	Xian	Lanzhou	Xining	Yinch	Wulumu
Beijing	*	-	*	**	-	**	**	-	-	-	**	-	-	-	-
Tianjin	-	-	-	-	*	-	-	-	-	*	-	-	-	-	-
Shijiazh	**	-	**	**	-	**	**	-	-	-	**	-	-	-	*
Taiyuan	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Huhehao	**	**	*	*	-	*	-	-	**	-	-	-	-	-	-
Sheny	-	-	-	**	-	*	*	-	-	-	**	-	-	-	-
Changch	-	-	-	*	-	-	-	-	-	-	-	-	-	-	-
Harbin	*	-	-	**	-	**	-	-	-	-	*	-	-	-	-
Shangh	**	-	-	**	-	**	**	-	**	-	-	-	-	*	-
Nanjing	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Hangzh	-	-	-	**	*	-	-	-	-	-	**	-	**	-	-
Hefei	-	-	-	**	-	**	**	-	-	-	*	-	-	-	*
Fuzhou	-	-	-	-	*	-	-	-	-	*	*	-	*	-	-
Nanch	-	-	-	**	-	*	**	-	-	-	-	-	**	-	-
Jinan	**	**	-	-	-	**	-	-	**	-	-	-	-	-	-
Zhengzh	**	-	-	-	-	**	-	-	**	-	-	-	-	-	-
Wuhan	-	**	**	**	-	**	-	-	*	-	-	-	-	-	-
Changsh	**	-	-	-	-	**	**	-	-	-	-	-	-	-	-
Guangzh	**	-	-	**	-	*	-	-	*	-	**	-	-	-	-
Nann	**	-	**	-	-	**	**	-	-	-	**	-	*	-	-
Haikou	-	-	-	-	-	-	-	-	-	-	-	**	-	-	-
Chongq	**	**	*	**	-	-	**	-	-	-	-	-	**	-	-
Chengd	-	**	-	**	-	**	-	-	*	-	-	-	-	-	-
Guiy	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Kunm	*	-	*	-	-	-	*	-	-	-	-	-	-	-	-
Lhasa	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Xian	-	-	**	**	-	-	-	-	-	-	-	-	**	-	-
Lanzh	-	-	-	-	**	-	-	-	-	-	-	-	-	-	-
Xining	-	-	-	*	-	**	-	-	-	-	**	-	-	-	-
Yinch	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Wulumu	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Table 5. The estimated half-lives for coal (months) for those rejecting null hypothesis (unit root)

City	Beijing	Tianjin	Shijiazh	Taiyuan	Huhehao	Sheny	Changch	Harbin	Shanghai	Nanjing	Hangzh	Hefei	Fuzhou	Nanch	Jinan	Zhengzh
Beijing	-	-	3.6	-	3.4	-	-	4.4	3.2	-	-	3.1	-	-	9.2	3.3
Tianjin	-	-	-	-	-	-	-	-	-	5.1	-	-	3.5	-	-	-
Shijiazh	3.6	-	-	-	3.1	3.7	-	-	2.1	-	-	2.8	-	-	-	3.4
Taiyuan	-	-	-	-	3.8	-	-	-	-	-	-	-	-	-	-	5.9
Huhehao	3.4	-	3.1	3.8	-	-	3.2	-	1.9	-	-	3.7	-	-	3.0	-
Sheny	-	-	3.7	-	-	-	-	2.1	-	-	5.2	4.1	-	2.5	-	-
Changch	-	-	-	-	3.2	-	-	-	-	-	-	-	-	-	-	-
Harbin	4.4	-	-	-	-	2.1	-	-	-	-	-	-	-	3.3	-	-
Shangh	3.2	-	2.1	-	1.9	-	-	-	-	-	-	-	-	-	1.8	2.3
Nanjing	-	5.1	-	-	-	-	-	-	-	-	-	-	3.1	-	-	-
Hangzh	-	-	-	-	-	5.2	-	-	-	-	-	5.0	-	-	-	-
Hefei	3.1	-	2.8	-	3.7	4.1	-	-	-	-	5.0	-	-	-	-	5.5
Fuzhou	-	3.5	-	-	-	-	-	-	-	3.1	-	-	-	-	-	-
Nanch	-	-	-	-	-	2.5	-	3.3	-	-	-	-	-	-	-	-
Jinan	9.2	-	-	-	3.0	-	-	-	1.8	-	-	-	-	-	-	5.9
Zhengzh	3.3	-	3.4	5.9	-	-	-	-	2.3	-	-	5.5	-	-	5.9	-
Wuhan	4.8	-	4.3	-	1.9	-	-	7.4	1.4	-	-	-	-	-	6.2	4.0
Changsh	-	-	-	-	2.1	-	-	-	-	-	-	-	-	-	3.7	-
Guangzh	4.6	-	3.2	-	3.7	-	-	-	-	-	-	-	-	-	-	-
Nann	2.2	-	1.7	-	4.7	1.7	4.3	2.8	2.2	-	1.9	2.0	-	2.6	-	-
Haikou	-	5.5	-	-	-	-	-	-	-	-	4.6	-	3.7	-	-	-
Chongq	4.4	-	5.6	-	3.8	7.0	-	5.9	2.8	-	-	3.5	-	6.7	6.6	4.3
Chengd	3.0	-	5.3	-	-	7.0	-	-	3.6	-	-	3.1	-	3.9	-	-
Guiy	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Kunm	-	-	-	-	5.1	-	-	-	2.6	-	-	-	-	-	5.0	4.5
Lhasa	-	10.0	-	-	-	-	-	-	-	-	-	-	4.7	-	-	-
Xian	5.3	-	4.9	-	-	4.2	-	3.5	-	-	1.8	4.2	4.1	-	-	-
Lanzh	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Xining	-	-	-	-	-	-	-	-	-	-	2.5	-	3.9	3.1	-	-
Yinch	-	-	-	-	-	-	-	-	4.3	-	-	-	-	-	-	-
Wulumu	-	-	-	-	-	-	-	-	-	-	-	8.0	-	-	-	-

Table 5: continued

City	Wuhan	Changsh	Guangzh	Nanning	Haikou	Chongq	Chengdu	Guiyang	Kunm	Lhasa	Xian	Lanzhou	Xining	Yinch	Wulumu
Beijing	4.8	-	4.6	2.2	-	4.4	3.0	-	-	-	5.3	-	-	-	-
Tianjin	-	-	-	-	5.5	-	-	-	-	10.0	-	-	-	-	-
Shijiazh	4.3	-	3.2	1.7	-	5.6	5.3	-	-	-	4.9	-	-	-	9.0
Taiyuan	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Huhehao	1.9	2.1	3.7	4.7	-	3.8	-	-	5.1	-	-	-	-	-	-
Sheny	-	-	-	1.7	-	7.0	7.0	-	-	-	4.2	-	-	-	-
Changch	-	-	-	4.3	-	-	-	-	-	-	-	-	-	-	-
Harbin	7.4	-	-	2.8	-	5.9	-	-	-	-	3.5	-	-	-	-
Shangh	1.4	-	-	2.2	-	2.8	3.6	-	2.6	-	-	-	-	4.3	-
Nanjing	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Hangzh	-	-	-	1.9	4.6	-	-	-	-	-	1.8	-	2.5	-	-
Hefei	-	-	-	2.0	-	3.5	3.1	-	-	-	4.2	-	-	-	8.0
Fuzhou	-	-	-	-	3.7	-	-	-	-	4.7	4.1	-	3.9	-	-
Nanch	-	-	-	2.6	-	6.7	3.9	-	-	-	-	-	3.1	-	-
Jinan	6.2	3.7	-	-	-	6.6	-	-	5.0	-	-	-	-	-	-
Zhengzh	4.0	-	-	-	-	4.3	-	-	4.5	-	-	-	-	-	-
Wuhan	-	4.2	3.2	3.8	-	4.9	-	-	4.8	-	-	-	-	-	-
Changsh	4.2	-	-	-	-	5.5	6.2	-	-	-	-	-	-	-	-
Guangzh	3.2	-	-	2.8	-	5.8	-	-	3.4	-	4.6	-	-	-	-
Nann	3.8	-	2.8	-	-	4.4	3.4	-	-	-	2.6	-	2.0	-	-
Haikou	-	-	-	-	-	-	-	-	-	-	-	3.1	-	-	-
Chongq	4.9	5.5	5.8	4.4	-	-	4.3	-	-	-	-	-	5.5	-	-
Chengd	-	6.2	-	3.4	-	4.3	-	-	6.7	-	-	-	-	-	-
Guiy	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Kunm	4.8	-	3.4	-	-	-	6.7	-	-	-	-	-	-	-	-
Lhasa	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Xian	-	-	4.6	2.6	-	-	-	-	-	-	-	-	2.0	-	-
Lanzh	-	-	-	-	3.1	-	-	-	-	-	-	-	-	-	-
Xining	-	-	-	2.0	-	5.5	-	-	-	-	2.0	-	-	-	-
Yinch	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Wulumu	-	-	-	-	-	-	-	-	-	-	-	-		-	-

Table 6. Causality among coal price series (<> stands for column and row causes each other, > stands for column causes row and < stands for row causes column)

City	Beijing	Tianjin	Shijiazh	Taiyuan	Huhehao	Sheny	Changch	Harbin	Shanghai	Nanjing	Hangzh	Hefei	Fuzhou	Nanch	Jinan	Zhengzh
Beijing	-	-	<	>	<>	>	-	>	<>	-	<	>	-	>	<	>
Tianjin	-	-	-	-	<	-	-	-	-	-	-	-	>	-	-	-
Shijiazh	>	-	-	>	>	>	-	<>	<>	-	>	<>	-	>	<	<>
Taiyuan	<	-	<	-	>	<>	<>	<>	<>	-	<>	<>	<	<>	<	<>
Huhehao	<>	>	<	<	-	<	<>	>	<>	>	<>	<	-	<>	<	<
Sheny	<	-	<	<>	>	-	>	>	<>	-	>	>	-	<>	<	-
Changch	-	-	-	<>	<>	<	-	>	>	-	-	<	-	<	<	-
Harbin	<	-	<>	<>	<	<	<	-	<>	-	<	<	-	<>	<	<
Shangh	<>	-	<>	<>	<>	<>	<	<>	-	-	<>	<>	-	<>	<>	<>
Nanjing	-	-	-	-	<	-	-	-	-	-	-	-	>	-	-	-
Hangzh	>	-	<	<>	<>	<	-	>	<>	-	-	>	>	>	<	<>
Hefei	<	-	<>	<>	>	<	>	>	<>	-	<	-	<>	<>	<	>
Fuzhou	-	<	-	>	-	-	-	-	-	<	<	<>	-	-	>	-
Nanch	<	-	<	<>	<>	<>	>	<>	<>	-	<	<>	-	-	-	<
Jinan	>	-	>	>	>	>	>	>	<>	-	>	>	<	-	-	>
Zhengzh	<	-	<>	<>	>	-	-	>	<>	-	<>	<	-	>	<	-
Wuhan	>	-	<	>	>	>	>	>	>	-	>	>	-	>	>	>
Changsh	<>	-	<>	<>	>	<	<>	>	<>	-	<>	<	-	<	<	<
Guangzh	>	-	<>	<>	<>	>	-	<>	<>	>	>	>	-	>	>	>
Nann	<>	-	<>	<>	<	<	<>	<	<>	>	<>	<	-	<>	<	<
Haikou	>	<	-	-	>	-	-	>	-	-	>	>	-	<	-	>
Chongq	<>	-	<	<	>	>	>	>	>	-	>	>	<	>	<	-
Chengd	<	-	<	>	>	>	>	<>	<>	-	<	<>	<	<>	<	<>
Guiy	-	-	-	>	-	-	-	-	-	-	-	-	>	-	>	-
Kunm	>	-	<>	>	>	>	-	>	<>	-	>	>	-	>	>	>
Lhasa	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Xian	<>	<>	<	-	<	<	<>	-	<>	-	<>	<>	-	-	<>	>
Lanzh	>	-	-	-	-	-	-	-	-	-	-	-	-	<	-	-
Xining	<>	-	<	<	<>	<>	-	<>	<>	-	<	<>	-		<	<>
Yinch	<>	-	<	<>	>	<>	>	>	>	-	<>	>	<	>	>	>
Wulumu	-	<	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Table 6: continued

City	Wuhan	Changsh	Guangzh	Nanning	Haikou	Chongq	Chengdu	Guiyang	Kunm	Lhasa	Xian	Lanzhou	Xining	Yinch	Wulumu
Beijing	<	<>	<	<>	<	<>	>	-	<	-	<>	<	<>	<>	-
Tianjin	-	-	-	-	>	-	-	-	-	-	<>	-	-	-	>
Shijiazh	>	<>	<>	<>	-	>	>	-	<>	-	>	-	>	>	-
Taiyuan	<	<>	<>	<>	-	>	<	<	<	-	-	-	>	<>	-
Huhehao	<	<	<>	>	<	<	<	-	<	-	>	-	<>	<	-
Sheny	<	>	<	>	-	<	<	-	<	-	>	-	<>	<>	-
Changch	<	<>	-	<>	-	<	<	-	-	-	<>	-	-	<	-
Harbin	<	<	<>	>	<	<	<>	-	<	-	-	-	<>	<	-
Shangh	<	<>	<>	<>	-	<	<>	-	<>	-	<>	-	<>	<	-
Nanjing	-	-	<	<	-	-	-	-	-	-	-	-	-	-	-
Hangzh	<	<>	<	<>	<	<	>	-	<	-	<>	-	>	<>	-
Hefei	<	>	<	>	<	<	<>	-	<	-	<>	-	<>	<	-
Fuzhou	-	-	-	-	-	>	>	<	-	-	-	-	-	>	-
Nanch	<	>	<	<>	>	<	<>	-	<	-	-	>	-	<	-
Jinan	<	>	<	>	-	>	>	<	<	-	<>	-	>	<	-
Zhengzh	<	>	<	>	<	-	<>	-	<	-	<	-	<>	<	-
Wuhan	-	>	>	>	<	>	>	-	<>	-	>	-	<>	>	-
Changsh	<	-	<>	>	<	<	<	-	<	-	>	-	<>	<	-
Guangzh	<	<>	-	<>	>	>	>	-	<>	-	>	-	>	<>	-
Nann	<	<	<>	-	<	<	<>	-	<	-	<	-	<>	<	-
Haikou	>	>	<	>	-	-	-	-	>	-	<>	>	<>	>	<
Chongq	<	>	<	>	-	-	<	-	<	-	>	-	>	<	-
Chengd	<	>	<	<>	-	>	-	-	<	-	<	-	>	<	-
Guiy	-	-	-	-	-	-	-	-	-	-	-	-	-	>	-
Kunm	<>	>	<>	>	<	>	>	-	-	-	>	-	<>	<>	-
Lhasa	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Xian	<	<	<	>	<>	<	>	-	<	-	-	-	<>	<	<
Lanzh	-	-	-	-	<		-	-	-	-	-	-	<	-	<>
Xining	<>	<>	<	<>	<>	<	<	-	<>	-	<>	>	-	<>	-
Yinch	<	>	<>	>	<	>	>	<	<>	-	>	-	<>	-	-
Wulumu	-	-	-	-	>	-	-	-	-	-	>	<>	-	-	-

Appendix 1. Unit root tests for raw price series (level)

City	Coal		Electricity		Gasoline		Diesel	
	t-stat.	Prob.*	t-stat.	Prob.*	t-stat.	Prob.*	t-stat.	Prob.*
Beijing	-0.7111	0.8413	-0.8501	0.8031	0.2324	0.9743	-0.6390	0.8587
Tianjin	-2.5085	0.1142	-0.3834	0.9090	0.2995	0.9781	-0.3007	0.9219
Shijiazhuang	-0.9082	0.7853	-1.5534	0.5055	0.4333	0.9841	-0.6984	0.8444
Taiyuan	-0.3815	0.9093	-0.1914	0.9366	-0.0143	0.9558	-0.4964	0.8888
Huhehaote	0.0050	0.9576	-2.1534	0.2241	0.1948	0.9720	-0.6603	0.8537
Shenyang	-1.1487	0.6974	-1.2734	0.6430	0.1670	0.9702	-0.8209	0.8117
Changchun	-0.4688	0.8940	-1.7094	0.4257	-0.2018	0.9353	-0.7102	0.8415
Harbin	-1.1522	0.6959	-1.7861	0.3872	0.2318	0.9743	-0.9639	0.7669
Shanghai	-0.9926	0.7570	-1.8937	0.3352	-0.0283	0.9545	-0.4736	0.8931
Nanjing	-2.2767	0.1801	-1.6780	0.4417	0.1521	0.9692	-0.5747	0.8729
Hangzhou	-0.6981	0.8445	-2.6612	0.0818	0.2811	0.9771	-0.3506	0.9143
Hefei	-0.2278	0.9320	-0.1669	0.9396	0.6058	0.9898	-0.1082	0.9463
Fuzhou	-2.6298	0.0878	-1.9420	0.3128	0.1455	0.9687	-0.7348	0.8352
Nanchang	-1.3158	0.6233	-1.9699	0.3002	0.1047	0.9658	-0.0387	0.9535
Jinan	-0.1991	0.9357	-1.8333	0.3641	0.0907	0.9647	-0.3799	0.9096
Zhengzhou	0.1423	0.9685	-1.9818	0.2949	0.1895	0.9717	-0.1209	0.9449
Wuhan	-0.0130	0.9559	-1.2208	0.6666	0.7009	0.9921	-0.2193	0.9331
Changsha	0.5424	0.9880	-1.7209	0.4199	0.1321	0.9678	-0.6408	0.8583
Guangzhou	-0.2689	0.9264	-1.9592	0.3050	0.2082	0.9729	-0.6715	0.8510
Nanning	-0.7997	0.8177	-1.2259	0.6644	0.2867	0.9774	-0.4870	0.8906
Haikou	-1.7279	0.4164	-1.7476	0.4065	0.2313	0.9743	-0.7176	0.8396
Chongqing	-1.5995	0.4819	-2.0324	0.2729	0.2932	0.9777	-0.1028	0.9469
Chengdu	-0.6962	0.8450	-1.4898	0.5379	-0.2050	0.9349	-0.2684	0.9265
Guiyang	-1.5445	0.5101	-2.4010	0.1421	-0.0220	0.9551	-0.5347	0.8812
Kunming	-0.5576	0.8765	-0.7192	0.8392	-3.8494	0.0027	-0.9199	0.7815
Lhasa	-	-	-1.8935	0.3353	-0.3646	0.9121	-1.2808	0.6396
Xian	-2.1419	0.2285	-2.9816	0.0375	0.2149	0.9733	-0.7097	0.8416
Lanzhou	-2.0630	0.2600	-2.2784	0.1796	0.6075	0.9898	-0.4177	0.9032
Xining	0.2378	0.9747	-0.5791	0.8720	-4.7267	0.0001	0.1242	0.9672
Yinchuan	0.5328	0.9877	-0.8353	0.8075	0.4174	0.9835	-0.6191	0.8632
Wulumuqi	-2.1408	0.2289	-2.2128	0.2021	0.3810	0.9820	-0.5325	0.8817
Qingdao	-	-	-1.9543	0.3072	0.2390	0.9747	-0.2759	0.9254
Dalian	-1.8626	0.3500	-1.1018	0.7163	0.0941	0.9650	-1.3019	0.6299
Xiamen	-1.2446	0.6561	-1.9759	0.2975	-0.0286	0.9545	-0.7937	0.8194
Ningbo	-0.8790	0.7944	-1.8593	0.3516	0.2716	0.9766	-0.2602	0.9276

*MacKinnon (1996) one-sided p-values.
Null hypothesis is that each series contains a unit root.
ADF is the Augmented Dickey-Fuller test.
Critical values: -3.44 (1% level), -2.87 (5% level) and -2.57(10% level).
Lag length is based on modified Hannan-Quinn, Minlag=0 and Maxlag=16.

Appendix 2. Unit root tests for coal and electricity raw price series (first difference)

	Coal		Electricity	
City	t-statistic	Probability*	t-statistic	Probability*
Beijing	-4.9295	0.0000	-29.6549	0.0000
Tianjin	-19.7731	0.0000	-32.8642	0.0000
Shijiazhuang	-14.0624	0.0000	-9.8271	0.0000
Taiyuan	-22.0608	0.0000	-33.2201	0.0000
Huhehaote	-9.1967	0.0000	-30.4496	0.0000
Shenyang	-11.3690	0.0000	-11.1330	0.0000
Changchun	-4.5155	0.0002	-33.5161	0.0000
Harbin	-21.3610	0.0000	-27.7364	0.0000
Shanghai	-21.0599	0.0000	-31.2860	0.0000
Nanjing	-20.8885	0.0000	-29.6326	0.0000
Hangzhou	-5.7025	0.0000	-30.5004	0.0000
Hefei	-18.4661	0.0000	-33.1374	0.0000
Fuzhou	-10.0311	0.0000	-32.6083	0.0000
Nanchang	-23.3857	0.0000	-11.5107	0.0000
Jinan	-5.5255	0.0000	-27.1770	0.0000
Zhengzhou	-19.8551	0.0000	-6.9812	0.0000
Wuhan	-8.1037	0.0000	-28.8355	0.0000
Changsha	-12.1084	0.0000	-23.6189	0.0000
Guangzhou	-19.4356	0.0000	-29.3376	0.0000
Nanning	-20.4704	0.0000	-26.8992	0.0000
Haikou	-10.9325	0.0000	-32.7681	0.0000
Chongqing	-7.8832	0.0000	-10.9079	0.0000
Chengdu	-6.9323	0.0000	-32.2002	0.0000
Guiyang	-6.7335	0.0000	-28.9132	0.0000
Kunming	-14.1332	0.0000	-26.0395	0.0000
Lhasa	-	-	-11.2821	0.0000
Xian	-26.1758	0.0000	-34.1028	0.0000
Lanzhou	-6.6617	0.0000	-30.6707	0.0000
Xining	-19.2009	0.0000	-35.0401	0.0000
Yinchuan	-8.1284	0.0000	-21.5598	0.0000
Wulumuqi	-27.7271	0.0000	-31.0831	0.0000
Qingdao	-	-	-19.8212	0.0000
Dalian	-7.8436	0.0000	-30.6524	0.0000
Xiamen	-10.0988	0.0000	-28.3606	0.0000
Ningbo	-21.2195	0.0000	-31.3287	0.0000

*MacKinnon (1996) one-sided p-values.
Null hypothesis is that each series contains a unit root.
ADF is the Augmented Dickey-Fuller test.
Critical values: -3.44 (1% level), -2.87 (5% level) and -2.57(10% level).
Lag length is based on modified Hannan-Quinn, Minlag=0 and Maxlag=16.

Appendix 3. Unit root tests for pairs of electricity price series for 31 cities (null hypothesis unit root, * and ** stand for 10% and 1% significant level, respectively)

City	Beijing	Tianjin	Shijiazh	Taiyuan	Huhehao	Sheny	Changch	Harbin	Shanghai	Nanjing	Hangzh	Hefei	Fuzhou	Nanch	Jinan	Zhengzh
Beijing	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*
Tianjin	-	-	*	-	*	-	-	-	-	-	-	-	-	-	-	*
Shijiazh	-	*	-	-	**	-	-	-	-	-	-	-	-	*	-	**
Taiyuan	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Huhehao	-	*	**	-	-	-	-	-	*	**	-	-	-	**	-	**
Sheny	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Changch	-	-	-	-	-	-	-	-	*	-	-	-	-	**	-	**
Harbin	-	-	-	-	-	-	-	-	*	*	-	-	-	-	**	-
Shangh	-	-	-	-	*	-	**	*	-	-	-	-	-	-	**	-
Nanjing	-	-	-	-	**	-	-	*	-	-	-	-	-	-	-	-
Hangzh	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Hefei	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Fuzhou	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nanch	-	-	*	-	**	-	**	-	-	-	-	-	-	-	**	*
Jinan	-	-	-	-	-	-	-	**	**	-	-	-	-	**	-	*
Zhengzh	*	*	**	-	**	-	**	-	-	-	-	-	-	*	*	-
Wuhan	-	**	*	-	**	-	-	-	-	-	-	-	-	-	-	-
Changsh	*	-	**	-	**	-	**	-	-	*	-	-	-	**	-	*
Guangzh	-	-	-	-	-	-	-	-	-	*	-	-	-	-	-	-
Nann	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Haikou	-	-	*	-	*	-	**	**	**	-	-	-	-	**	-	**
Chongq	-	-	-	-	-	-	-	-	-	-	-	-	-	*	*	*
Chengd	-	-	**	-	**	-	-	-	-	-	-	-	-	**	-	**
Guiy	-	*	-	-	-	-	-	-	-	-	*	-	**	-	-	-
Kunm	-	-	-	-	*	-	-	-	-	-	-	-	-	*	-	*
Lhasa	-	-	*	-	*	-	**	-	-	*	-	-	-	**	**	**
Xian	-	*	-	-	-	-	-	-	-	-	*	-	*	-	-	-
Lanzh	-	-	-	-	*	-	-	-	-	-	**	-	-	-	-	-
Xining	-	-	-	**	-	*	-	-	-	-	-	-	-	-	-	-
Yinch	-	-	-	-	-	**	-	-	-	-	-	-	-	-	-	-
Wulumu	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Appendix 3: continued

City	Wuhan	Changsh	Guangzh	Nanning	Haikou	Chongq	Chengdu	Guiyang	Kunm	Lhasa	Xian	Lanzhou	Xining	Yinch	Wulumu
Beijing	-	*	-	-	-	-	-	-	-	-	-	-	-	-	-
Tianjin	**	-	-	-	-	-	-	*	-	-	*	-	-	-	-
Shijiazh	*	**	-	-	*	-	**	-	-	*	-	-	-	-	-
Taiyuan	-	-	-	-	-	-	-	-	-	-	-	-	**	-	-
Huhehao	**	**	-	-	*	-	**	-	*	*	-	*	-	-	-
Sheny	-	-	-	-	-	-	-	-	-	-	-	-	*	**	-
Changch	-	**	-	-	**	-	-	-	-	**	-	-	-	-	-
Harbin	-	-	-	-	**	-	-	-	-	-	-	-	-	-	-
Shangh	-	-	-	-	**	-	-	-	-	-	-	-	-	-	-
Nanjing	-	*	*	-	-	-	-	-	-	*	-	-	-	-	-
Hangzh	-	-	-	-	-	-	-	*	-	-	*	**	-	-	-
Hefei	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Fuzhou	-	-	-	-	-	-	-	**	-	-	*	-	-	-	-
Nanch	-	**	-	-	**	*	**	-	*	**	-	-	-	-	-
Jinan	-	-	-	-	-	*	-	-	-	**	-	-	-	-	-
Zhengzh	-	*	-	-	**	*	**	-	*	**	-	-	-	-	-
Wuhan	-	-	-	-	-	-	-	*	-	-	**	**	-	-	-
Changsh	-	-	-	-	-	-	**	-	-	-	-	-	-	-	-
Guangzh	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nann	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Haikou	-	-	-	-	-	**	-	-	-	**	-	-	-	-	-
Chongq	-	-	-	-	**	-	**	-	-	-	-	-	-	-	-
Chengd	-	**	-	-	-	**	-	-	-	**	*	-	-	-	*
Guiy	*	-	-	-	-	-	-	-	-	-	**	**	-	**	-
Kunm	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Lhasa	-	-	-	-	**	-	**	-	-	-	-	-	-	-	-
Xian	**	-	-	-	-	-	*	**	-	-	-	**	-	-	-
Lanzh	**	-	-	-	-	-	-	**	-	-	**	-	-	-	-
Xining	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Yinch	-	-	-	-	-	-	-	**	-	-	-	-	-	-	-
Wulumu	-	-	-	-	-	-	*	-	-	-	-	-	-	-	-

Appendix 4. The estimated half-lives for electricity (months) for those rejecting null hypothesis (unit root)

City	Beijing	Tianjin	Shijiazh	Taiyuan	Huhehao	Sheny	Changch	Harbin	Shanghai	Nanjing	Hangzh	Hefei	Fuzhou	Nanch	Jinan	Zhengzh
Beijing	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4.3
Tianjin	-	-	3.6	-	3.5	-	-	-	-	-	-	-	-	-	-	3.4
Shijiazh	-	3.6	-	-	2.2	-	-	-	-	-	-	-	-	3.2	-	2.4
Taiyuan	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Huhehao	-	3.5	2.2	-	-	-	-	-	4.9	4.2	-	-	-	2.4	-	2.3
Sheny	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Changch	-	-	-	-	-	-	-	-	2.6	-	-	-	-	1.5	-	1.9
Harbin	-	-	-	-	-	-	-	-	1.6	4.2	-	-	-	-	2.9	-
Shangh	-	-	-	-	4.9	-	2.6	1.6	-	-	-	-	-	-	3.0	-
Nanjing	-	-	-	-	4.2	-	-	4.2	-	-	-	-	-	-	-	-
Hangzh	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Hefei	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Fuzhou	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nanch	-	-	3.2	-	2.4	-	1.5	-	-	-	-	-	-	-	5.7	2.4
Jinan	-	-	-	-	-	-	-	2.9	3.0	-	-	-	-	5.7	-	5.8
Zhengzh	4.3	3.4	2.4	-	2.3	-	1.9	-	-	-	-	-	-	2.4	5.8	-
Wuhan	-	2.3	4.1	-	3.4	-	-	-	-	-	-	-	-	-	-	-
Changsh	3.5	-	2.5	-	2.4	-	2.3	-	-	2.1	-	-	-	4.0	-	3.9
Guangzh	-	-	-	-	-	-	-	-	-	3.4	-	-	-	-	-	-
Nann	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Haikou	-	-	1.8	-	2.8	-	1.3	1.8	1.6	-	-	-	-	1.5	-	2.2
Chongq	-	-	-	-	-	-	-	-	-	-	-	-	-	3.4	6.0	2.6
Chengd	-	-	1.3	-	3.2	-	-	-	-	-	-	-	-	1.7	-	1.8
Guiy	-	4.5	-	-	-	-	-	-	-	-	4.1	-	3.1	-	-	-
Kunm	-	-	-	-	2.9	-	-	-	-	-	-	-	-	5.1	-	3.9
Lhasa	-	-	4.6	-	3.0	-	2.0	-	-	4.4	-	-	-	1.7	5.6	2.7
Xian	-	2.9	-	-	-	-	-	-	-	-	2.8	-	2.7	-	-	-
Lanzh	-	-	-	-	2.9	-	-	-	-	-	1.6	-	-	-	-	-
Xining	-	-	-	1.2	-	2.3	-	-	-	-	-	-	-	-	-	-
Yinch	-	-	-	-	-	3.1	-	-	-	-	-	-	-	-	-	-
Wulumu	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Appendix 4: continued

City	Wuhan	Changsh	Guangzh	Nanning	Haikou	Chongq	Chengdu	Guiyang	Kunm	Lhasa	Xian	Lanzhou	Xining	Yinch	Wulumu
Beijing	-	3.5	-	-	-	-	-	-	-	-	-	-	-	-	-
Tianjin	2.3	-	-	-	-	-	-	4.5	-	-	2.9	-	-	-	-
Shijiazh	4.1	2.5	-	-	1.8	-	1.3	-	-	4.6	-	-	-	-	-
Taiyuan	-	-	-	-	-	-	-	-	-	-	-	-	1.2	-	-
Huhehao	3.4	2.4	-	-	2.8	-	3.2	-	2.9	3.0	-	2.9	-	-	-
Sheny	-	-	-	-	-	-	-	-	-	-	-	-	2.3	3.1	-
Changch	-	2.3	-	-	1.3	-	-	-	-	2.0	-	-	-	-	-
Harbin	-	-	-	-	1.8	-	-	-	-	-	-	-	-	-	-
Shangh	-	-	-	-	1.6	-	-	-	-	-	-	-	-	-	-
Nanjing	-	2.1	3.4	-	-	-	-	-	-	4.4	-	-	-	-	-
Hangzh	-	-	-	-	-	-	-	4.1	-	-	2.8	1.6	-	-	-
Hefei	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Fuzhou	-	-	-	-	-	-	-	3.1	-	-	2.7	-	-	-	-
Nanch	-	4.0	-	-	1.5	3.4	1.7	-	5.1	1.7	-	-	-	-	-
Jinan	-	-	-	-	-	6.0	-	-	-	5.6	-	-	-	-	-
Zhengzh	-	3.9	-	-	2.2	2.6	1.8	-	3.9	2.7	-	-	-	-	-
Wuhan	-	-	-	-	-	-	-	4.3	-	-	2.5	1.5	-	-	-
Changsh	-	-	-	-	-	-	1.9	-	-	-	-	-	-	-	-
Guangzh	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nann	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Haikou	-	-	-	-	-	2.5	-	-	-	1.9	-	-	-	-	-
Chongq	-	-	-	-	2.5	-	2.4	-	-	-	-	-	-	-	-
Chengd	-	1.9	-	-	-	2.4	-	-	-	2.2	4.3	-	-	-	2.7
Guiy	4.3	-	-	-	-	-	-	-	-	-	2.9	3.0	-	3.3	-
Kunm	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Lhasa	-	-	-	-	1.9	-	2.2	-	-	-	-	-	-	-	-
Xian	2.5	-	-	-	-	-	4.3	2.9	-	-	-	1.3	-	-	-
Lanzh	1.5	-	-	-	-	-	-	3.0	-	-	1.3	-	-	-	-
Xining	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Yinch	-	-	-	-	-	-	-	3.3	-	-	-	-	-	-	-
Wulumu	-	-	-	-	-	-	2.7	-	-	-	-	-	-	-	-

Appendix 5. Causality among electricity price series (<> stands for column and row causes each other, > stands for column causes row and < stands for row causes column)

City	Beijing	Tianjin	Shijiazh	Taiyuan	Huhehao	Sheny	Changch	Harbin	Shanghai	Nanjing	Hangzh	Hefei	Fuzhou	Nanch	Jinan	Zhengzh
Beijing		>	<>	<>	<>		>			>	<>	>	<>	<		<>
Tianjin	<		<>	<>	>	<>		<		<	<>	<>	<>	<	<	<>
Shijiazh	<>	<>			>		>	<>	<>	<>	>	>	>	>	>	<>
Taiyuan	<>	<>			<>	<>	<>	<>	<>	<>		<>	<>	<	<	<
Huhehao	<>	<	<	<>				<			<>	<>	<>	<		<>
Sheny		<>		<>								<>				
Changch	<		<	<>							<>	>	<>	<>	<	<>
Harbin		>	<>	<>	>				<>		<>	>	<>	<>	<>	<>
Shangh			<>	<>				<>			<>		<>	<>	<>	<>
Nanjing	<	>	<>	<>							<>	<>	<>	<>	<	<>
Hangzh	<>	<>	<		<>		<>	<>	<>	<>		<>	<	<	<>	<
Hefei	<	<>	<	<>	<>	<>	<	<		<>	<>					<>
Fuzhou	<>	<>	<	<>	<>		<>	<>	<>	<>	>			<	<>	<
Nanch	>	>	<	>	>		<>	<>	<>	<>	>		>		>	>
Jinan		>	<	>			>	<>	<>	>	<>		<>	<		
Zhengzh	<>	<>	<>	>	<>		<>	<>	<>	<>	>	<>	>	<		
Wuhan	<	<>	<>	<>	>		>				<>	<>	<>	<		<>
Changsh	<>	<>	>	<>	<>		<>	<>	<>	<>	>	>	>	>	>	>
Guangzh	<>	>	<	<>	>	<	<>	<>	<>	<>	<>	<	<>	<	<	<
Nann	<>	<>	<	>	<>	>	<>	<>	<>	<>		>	<			
Haikou	<	<>	<	<>	>		>	<>	<>	>	<>		<>	<	<	<>
Chongq		>	<	>	>		<>	<>	<>	>	>	<	>	<		>
Chengd	<	>	<>	<>		<		<	<		<>	>	<>	<>	<>	<>
Guiy			>								<>	<	<>	>	<>	>
Kunm	<>	<>	<>	>	<>	<>	<>	<>	<>	<>	>	>	<>	<		>
Lhasa	>	>	<	>	>		>	>	<>	>	>		>	<>	>	>
Xian	<>	<>	<>		<>	<	<>	<>	<>	>	<	<	<>	<		<>
Lanzh	<>	<>	<	<>	<>	<>	<>	<>	<>	>		<	<>	<	<	<
Xining	<	<>	<>	<>	<>	<>	<>	<>	<>	>	>	<>		<	<	<
Yinch	<	<>			<	>						>	<>			
Wulumu	<>	<>	<	>	<>	<	<>	<>	<>	<>			<	<	<>	<

Appendix 5: continued

City	Wuhan	Changsh	Guangzh	Nanning	Haikou	Chongq	Chengdu	Guiyang	Kunm	Lhasa	Xian	Lanzhou	Xining	Yinch	Wulumu
Beijing	>	<>	<>	<>	>		>		<>	<	<>	<>	>	>	<>
Tianjin	<>	<>	<	<>	<>	<	<		<>	<	<>	<>	<>	<>	<>
Shijiazh	<>	<	>	>	>	>	<>	<	<>	>	<>	>	<>		>
Taiyuan	<>	<>	<>	<	<>	<	<>		<	<		<>	<>		<
Huhehao	<	<>	<	<>	<	<			<>	<	<>	<>	<>	>	<>
Sheny			>	<			>		<>		>	<>	<>	<	>
Changch	<	<>	<>	<>	<	<>			<>	<	<>	<>	<>		<>
Harbin		<>	<>	<>	<>	<>	>		<>	<	<>	<>	<>		<>
Shangh		<>	<>	<>	<>	<>	>		<>	<>	<>	<>	<>		<>
Nanjing		<>	<>	<>	<	<			<>	<	<	<	<		<>
Hangzh	<>	<	<>		<>	<	<>	<>	<	<	>		<		
Hefei	<>	<	>	<		>	<	>	<		>	>	<>	<	
Fuzhou	<>	<	<>	>	<>	<	<>	<>	<>	<	<>	<>		<>	>
Nanch	>	<	>		>	>	<>	<	>	<>	>	>	>		>
Jinan		<	>		>		<>	<>		<		>	>		<>
Zhengzh	<>	<	>		<>	<	<>	<	<	<	<>	>	>		>
Wuhan		<>	<	<>	>		>		<>	<	<>	<>	<>	>	<>
Changsh	<>		>	<>	<>		<>	<>	>			>	<>		>
Guangzh	>	<		<>	<	<	>		<>	<	<>	<>	<>	<	<>
Nann	<>	<>	<>		<		<>		<>		>	>	>	>	
Haikou	<	<>	>	>		<	<>	>	<>	<		<>	<>		<>
Chongq			>		>		<>			<	<>	<>	>		>
Chengd	<	<>	<	<>	<>	<>			<>	<>	<>	<>	<>	<>	<>
Guiy		<>			<				>		>	<			<>
Kunm	<>	<	<>	<>	<>		<>	<			<>	<>	>	<	<
Lhasa	>		>		>	>	<>				>	>	>		>
Xian	<>		<>	<		<>	<>	<	<>	<				<>	
Lanzh	<>	<	<>	<	<>	<>	<>	>	<>	<			<	<>	<>
Xining	<>	<>	<>	<	<>	<	<>		<	<		>		<	
Yinch	<		>	<			<>		>		<>	<>	>		
Wulumu	<>	<	<>		<>	<	<>	<>	>	<		<>			