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Price convergence and geographic pattern of market integration: Evidence from China

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Abstract

This study analyses the level and geographic dimension of China's market integration. The objective is to provide a broad characterization of China's market integration by performing a variety of empirical tests and providing comparisons to other studies on the same topic. The models tested are grounded in the law of one price. Price convergence is analysed with univariate time series methods, where linear and non-linear cointegration models refer to convergence in the short run and in the long run, respectively. The non-linear model is considered a good fit for analysing transitional economies, because the non-linear trend variable in the model indicates whether there is movement towards integration in the long run. Convergence of prices is first analysed by comparing city-level prices with China's national average price level and then by dividing China into three regional clusters. The estimation results suggest that the level of integration across Chinese cities is fairly high by international standards. The great majority of price series trending towards integration are services. The geographic pattern of China's market integration did not turn out as expected. Eastern cities are among the least integrated cities in the nationwide examination. Relatively high levels of integration were detected from several central and south-eastern cities. Furthermore, the cluster convergence approach to analyse China's market integration did not augment the eastern cities' level of convergence.

Keywords: China, market integration, law of one price, price dispersion, regional clusters, convergence
JEL Classification: C12, C32, P22, R10.

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Tiivistelmä

Tässä tutkimuksessa analysoidaan Kiinan hyödykemarkkinoiden integraation astetta ja maantieteellistä ulottuvuutta. Teoreettisesti testattavat mallit perustuvat yhden hinnan lakiin. Markkinoiden integraatiota tutkitaan yksiulotteisella aikasarja-analyysilla, jossa lineaarinen yhteisintegroituvuutta mittaava malli viittaa konvergenssiin lyhyellä aikavälillä ja epälineaarinen malli pitkällä aikavälillä. Epälineaarisen mallin katsotaan soveltuvan erityisesti siirtymätalouksien tarkasteluun, sillä siihen kuuluvan asymptoottisesti pienenevän trendimuuttujan tulkitaan merkitsevän hintojen käynnissä olevaa konvergenssiprosessia. Kaupunkien hintakehitystä verrataan sekä Kiinan keskimääräiseen hintatasoon että maan sisäisiin klustereihin nähden. Tutkimustulokset osoittavat, että Kiinan markkinoiden integraatio on kehittyneiden maiden tasolla. Konvergoitumassa olevista aikasarjoista suurin osa koskee palveluja. Markkinoiden maantieteellinen integraatio ei osoittautunut ennalta oletetun kaltaiseksi. Kiinan keskimääräiseen hintatasoon suhteutettuna maan itäosan kaupungit kuuluvat heikoiten integroituneiden joukkoon. Pisimmällä integraatio on useissa maan keski- ja kaakkoisosan kaupungeissa. Itäisten kaupunkien vähäistä integroituneisuutta ei selitä markkinoiden jakautuminen alueellisiin klustereihin.

Asiasanat: Kiina, markkinoiden integraatio, yhden hinnan laki, hintojen hajonta, alueelliset klusterit, konvergenssi.

1 Introduction

Empirical findings generally suggest that the law of one price (LOP) rarely holds in international examinations as volatile exchange rates along with other factors cause cross-country prices to deviate from parity. As a consequence, interest in price determination has shifted from the international to the intranational context, so that currency fluctuations and, to some extent, also cultural heterogeneity can be implicitly controlled for. (Engel & Rogers 2001)

Economies in transition constitute an interesting strand to the literature of the law of one price. Specifically, these countries provide a unique environment for studying how fast new institutions are able to absorb crucial mechanisms and adapt to new conditions by responding effectively to signals of demand and supply through prices. China's economic transformation was accomplished over the course of several decades. China allowed the planned system to function alongside an advancing market system that gradually assumed a bigger role in the economy (Naughton 1995). OECD (2005) estimates indicate that a significant share of commodities was actually sold through the planned system in the early 1990s.

The dynamics of China's transformation period raises several interesting questions that are inextricably connected to the discussion of market integration and the law of one price. What is the present level of integration of Chinese commodity markets? Is the integration moving ahead, and is it regional rather than national in nature? What is the geographic dimension of China's market integration? This study aims to shed some light on these matters by analysing the behaviour of a set of disaggregated goods and services prices. First we analyse convergence of city-level prices to the national price level in the short and long run. Then the markets are split into three geographic parts in order to capture the characteristics of integration between remote and central regions. Such a cluster convergence approach should be fruitful, considering China's size and decentralized nature of government's policy-making in the last 30 years.

The methodological approach employed here is closely related to that of Gluschenko (2006), who analysed the integration of Russian commodity markets. The state of integration of China’s commodity markets is analysed by a linear cointegration model in the short-run. Non-linear cointegration tests then shed light on the issue of long-run con-

vergence. Estimation of the two models leads to three alternative outcomes: 1) integrated cities, i.e. those in the steady state, where prices have reached equality, 2) non-integrated cities that are trending to integration, i.e. those in which prices are converging to common levels in the long-run, 3) non-integrated cities not displaying such a trend. This paper contributes to the previous literature in two aspects. Firstly, the geographic pattern of market integration has not been analysed earlier in the literature on China's market integration. Secondly, the results of this study provide up-to-date information on the issue as the study covers the years 2005 - 2007. To our knowledge, data sets of previous studies extend at most to the start of 2003.

The remainder of the paper is organized as follows: subsections 1.1 and 1.2 lay out the theoretical framework of the law of one price and present the cluster convergence approach to analyse geographic market integration. Chapter 2 briefly discusses the previous empirical studies on price convergence within national borders. After that, in chapter 3 an insight into the basic principles of China's reformation mechanisms is provided and key policies that have contributed to growing imbalances within the country are analysed. The data set, methodology and some descriptive statistics are presented in chapter 4. Chapter 5 presents main results as well as findings of additional tests and robustness checks, and chapter 6 concludes with suggestions for further study.

1.1 Underlying theories of market integration

The law of one price (LOP) proposes that in an efficient market all identical goods must have the same price, so that in the absence of transportation costs and trade restrictions, perfect commodity arbitrage insures that goods are uniformly priced throughout the world. Model (1.1) represents the original theory of the law of one price in the short-run (the long-run price parity condition is presented below). A series of relative prices of two homogeneous commodities in different locations, is equal to one, i.e. the prices at the two locations are identical.

$$p_{i,k,t} / p_{i,c,t} = 1 \qquad (1.1)$$

$p_{i,c,t}$ price of product i in city c at time t

$p_{i,k,t}$ price of product i in city k at time t

t = 0,..., T.

Convergence in the long-run can be depicted by model (1.2), where the prices in two cities approach each other so as to fulfil the parity condition as t approaches infinity.

$$p_{i,k,t} / p_{i,c,t} = 1+\gamma e^{\delta t} \qquad (1.2)$$

δ Speed of convergence, when the parameter gets values smaller than zero.

γ Direction of convergence.

(Other components of the model presented in connection with model 1.1)

Model (1.2) is non-linear, which is expressed by including an asymptotically subsiding trend variable (Gluschenko 2006). Both equations (1.1) and (1.2) represent the absolute versions of the price parity theorems meaning that eventually prices in two locations end up at precisely the same level.

1.2 Cluster convergence

A lack of market integration across regions as a whole might suggest that certain geographic locations follow their own pattern of price convergence and so form clusters within the area. The hypothesis of cluster convergence, originally postulated in connection with endogenous growth studies, states that the long-run growth path of each region/country is precisely given by the area's structural characteristics and that the initial GDP per capita functions as a threshold value that defines the convergence club of the country/region (Sorensen & Whitta-Jacobsen 2005). From the vast empirics related to the subject it appears that the fundamental motive for economic growth convergence studies is to explain why poor countries as a group are not catching up with the rich countries in the same way that, for example, the low-income states in the United States have been catching up with the high income states (Romer 1994).

The hypothesis is interesting from the viewpoint of price convergence, since it allows a fraction of geographic locations to acquire their own price equilibrium. Neverthe-

less, it is obvious that nearly all the economic, socio-demographic and political factors that are reasonable explanatory variables for examining endogenous growth mechanisms fail to qualify as determinants of price movements. Factors that could generally explain patterns of goods market clustering have been analysed quite extensively in the literature (Goldberg & Knetter (1997), Frankel et al. (1994), Engel & Rogers (1996)). In China's case the cluster approach can be justified by the cultural heterogeneity, geographic scope and transformation history.

2 Literature review

Overall, the number of intranational price convergence examinations is modest compared to the vast amount of cross-country studies on the same subject. Examinations cover, by and large, the U.S., Canada, some of the European countries and the former Soviet Union countries. The number of empirical analyses on China is relatively modest partly due to a lack of qualified price information.

Parsley and Wei's (1996) study on the U.S. markets is one of the most relevant price convergence analyses in intranational context. The authors use actual goods prices instead of indexes and test the absolute versions of parity theorems. The data set of the study consists of 51 final goods and services prices, sampled quarterly from 48 U.S. cities over the period 1975 - 1992. The authors first measured price variability and mean absolute deviations for the observations. After that, they tested for stationarity of the time series with panel unit root tests and estimated the convergence rates. As a result, Parsley and Wei found that convergence of tradables was significantly faster than the typical estimates for the speed of convergence to purchasing power parity in cross-country studies. Half-lives of deviations were also found to be longer for services than for goods. When it comes to the transportation costs, the findings suggest that distance alone cannot explain the higher convergence in the U.S. than in the case of multiple countries.

Engel and Rogers (1996) examined price patterns in Canada and in the U.S. versus cross-border prices in order to analyse the importance of border effects between the two countries. Consumer price data was disaggregated into 14 categories of goods. The results

indicate that both the distance between cities and the border between the countries explain a notable share of the price disparity.

Cecchetti et al. (2002) also deal with price convergence across commodity markets in the United States. Their data set represents a panel of consumer price indexes from 19 cities over the period 1917–1995. The authors applied panel unit root methods to determine the state of market integration, and managed to reject the unit root hypothesis of non-stationarity in a majority of cases. Half-lives of convergence were found to be considerably larger than in the literature in general. The slow speed of convergence was explained by transportation costs, differential speeds of adjustment to shocks, and inclusion of prices of non-traded goods in the overall price index.

Another interesting study on North-American market integration is provided by Ceglowski (2003). She analysed the integration of Canadian commodity market using semi-annual retail price data for the period 1976 through 1993. The data set consists of a panel of 45 consumer goods collected from 25 Canadian cities. Estimation results rejected the unit root null at the 10 % level for roughly half of the price series. The speeds of convergence vary from less than a quarter to eight quarters, with a median value of half a year. Ceglowski concluded that Canadian retail prices exhibit relative price parity as the long-run characteristics.

Gluschenko (2006) analyses the geographic structure of market integration on Russia, which requires univariate time series analysis instead of methods introduced for panel data. Gluschenko established 75 relative price series for the period 1994–2000, so that each of the 75 regional price series was proportioned to the national average price level. Price representative of the analysis is the cost of a basket for 25 consumer food items. As a result Gluschenko discovered that, of 75 Russian regions, 36 % were integrated with the national market while 44 % were non-integrated and were integrating at varying speeds of convergence. Regions classified as non-integrated were located in remote areas.

To the author's knowledge, the study of Chen et al. (2008) is the only one to apply the methods of the endogenous growth literature to analyse price dynamics. The authors rely on the Hobijn-Franses (2000) approach to distinguish convergence clusters, albeit this is somewhat problematic in that the grouping is not based on geographic or cultural factors. Instead, Hobijn and Franses propose a methodology in which country grouping is based solely on long-run log per capita income levels. Chen et al. (ibid.) determine clusters

by price level movements in 11 countries. They find 5-7 clusters, implying that price levels vary considerably within the sample and do not support the hypothesis of general price level or cluster price level convergence.

Fan and Wei (2006) are among the few to examine the state of market integration in China. Interest to shed light on the success of China's gradual reform policy is the major motivation for the study. The authors utilized monthly panel data on some 80 goods and services and found evidence of long-run price parity. The data cover 36 Chinese cities over the period 1990–2003. Fan and Wei apply ADF tests in order to determine the stationarity of the time series. Then they analyse whether distance and coastal location operate as major drivers of price dispersion. As a result, Fan and Wei managed to reject the null hypothesis of a unit root for 40% of all the cities at the 5 % level. Results presented on a more detailed basis show that services are least likely to experience price convergence. Interestingly, non-perishable consumer goods represented the lowest level of convergence of all goods categories. Moreover, less than half of prices converge to relative, rather than absolute, parity. The mean and median of deviation half-lives were 2.4 and 2.3 months, respectively. As for the coastal dummy, the results are mixed, as the coefficient signs vary across categories of goods and services.

Young (2000) examined China's state of market integration and found evidence conflicting with Fan and Wei's results even though some of the data sets of the two studies were collected from the same source. Young simply analyses trends in the standard deviations of log relative prices, which might have caused the apparent inconsistency. The results show that prices increasingly diverged from parity in the late 1980s and then fluctuated without trending during the 1990s. Furthermore, he concluded that varying dispersions are consistent with the trade wars that were periodically interrupted and suppressed by the government.

3 What's special about China?

China's reform process, often referred as a dualistic transformation or a dual-track system, is generally considered to have contributed to the dynamics of China's regional development. The dual track refers to two coordination mechanisms (plan track and market track) in an economy. On the first track, production and prices are restricted to a predetermined

level so that in any situation a certain fraction of total production is reserved for the command track with frozen prices. The second track entails producers as profit seekers; prices are determined by market demand, and free market transactions are permitted (Roland 2000). An important aspect of the approach is its implicit growth mechanism, which gradually increases the importance of the market track versus the planned production.

Even though several researchers share the view of China's advantageous transformation (see e.g. Branstetter & Lardy 2006), some opposing opinions have been presented as well. Young (2000) argues that the price reform resulted in significant rent seeking opportunities in the plan part of the economy, where distortions continued to prevail. The attempts to control them only created another set of distortions. Lee (1998) acknowledges the same problem and argues that the persistence of price distortions contributed to a renewal of regional protectionism starting at the end of the 1980s, mostly on the initiative of interior provinces. Customs barriers, whether or not tariff-based, impeded interregional trade and thereby weakened the least advanced regions' possibilities for development. Table 1 illustrates the extensive regulation of prices, which affected several materials and commodities until the early 1990s.

Table 1. Share of transactions conducted at market prices (% of transaction volume).

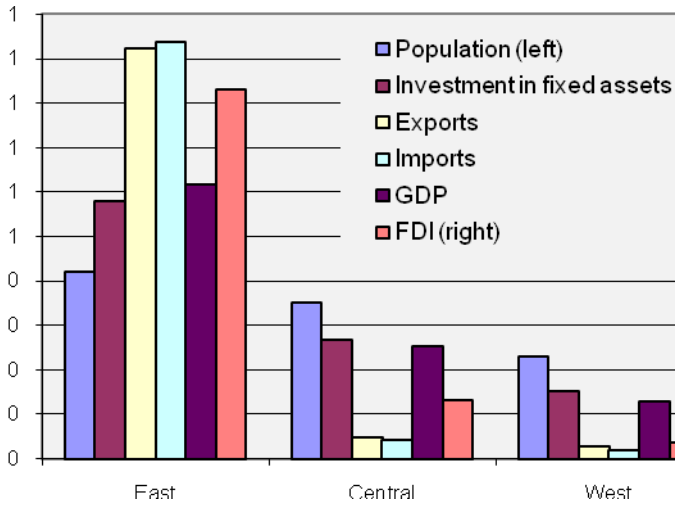
	1978	1985	1991	1995	1999	2003
Consumer goods and services						
Market prices	3	34	69	89	95	97
State guided	0	19	10	2	1	1
State fixed	97	47	21	9	4	3
Industrial materials						
Market prices	0	13	46	78	86	87
State guided	0	23	18	6	4	3
State fixed	100	64	36	16	10	10
Agricultural materials						
Market prices	6	40	58	79	83	97
State guided	2	23	20	4	7	2
State fixed	93	37	22	17	9	2

Sources: OECD 2005, Wei & Fan 2006.

The steep east-west slope of economic development in China derives partly from the dual track transformation, which finally spread over almost every aspect of policy-making, from sector-specific reforms to price deregulation. Provinces located in China's eastern coast belt experienced the most dynamic growth processes while the central, and

even more so the western, provinces lagged behind (OECD 2002). Figure 1 highlights the highly unbalanced regional distribution patterns of foreign investments. Imports and exports of the east constituted over 90 % of China's total imports and exports in 2006. More than 80 % of foreign direct investment and over 90 % of foreign trade is concentrated in China's coastal provinces even though the central and western regions account for 65 % of China's total population.

Figure 1. China's regional shares of population, investment in fixed assets, imports, exports and GDP in 2006, %



Sources: National Bureau of Statistics (2007), China Data Online.
Regional division performed by the OECD (2002)1.

Table 2 portrays China's level of infrastructure by showing the development gap between the eastern and inland provinces. As the volumes of trade flows depend on distribution channels, the differences between areas are intuitively reasonable. On the other hand, the gap could also be explained by the high density of cities in the east relative to other parts of the country. Nevertheless, according to the underlying assumptions of the LOP theory, infrastructure together with economic activity correlates positively with the level of market integration. Therefore, the level of market integration of the three clusters – east, central and west – along with the whole of China, are analysed here.

[1] **Eastern regions:** Liaoning, Hebei, Beijing, Tianjin, Shangdong, Jiangsu, Shanghai, Zhejiang, Fujian, Guangdong, Guangxi and Hainan. **Central regions:** Jiangxi, Heilongjiang, Jilin, Nei Mongol, Shanxi, Henan, Anhui, Hubei, and Hunan. **Western regions:** Shaanxi, Gansu, Ningxia, Sichuan, Yunnan, Guizhou, Qinghai, Xinjiang, Tibet and Chongqing.

Table 2. China's internal infrastructure in 2006.

	National total	East	Central	West
Railway (km/10^4 km^2)	71	184	115	30
Highway (km/10^4 km^2)	3197	8272	4658	1568
Navigable inland waterways (km/10^4 km^2)	114	447	146	35

Sources: National Bureau of Statistics (2007).

4 Data and methodology

4.1 Data

The data source for this study is the China Price Journal, maintained by the China Price Information Centre, a division of the State Planning Committee of the People's Republic of China. The sample is a monthly series covering 31 months over the period 2005:2–2007:8. The data set is disaggregated and consists of 19 commodities and services. It is collected on the 20th of each month and includes prices of 36 Chinese cities. The cities represent all of China's provinces[2]. In this study, the commodities are split into four categories in accord with Parsley and Wei (1996). Table 3 presents the breakdown along with the goods and commodities included in the analysis.

Table 3. Breakdown of commodities and services into four categories.

Tradables			**Non-tradables (services)**
Perishables (500 g):	**Non-perishables:**		
	Agriculture (500 g):	**Industry**	
Cucumber	Rice	Steel	Tuition fee high school (per term)
Tomato	Pepper	Fertilizer	Kindergarten (per month)
Cabbage	Flour premium quality	Cement	Stay in hospital (per day)
Eggplant	Flour standard quality		Surgery (appendix cut)
Pork	Peanut oil		
Egg			
Milk			

[2] **List of cities:** Beijing, Tianjin, Shijiazhuang, Taiyan, Hohhot, Shenyang, Dalian, Changchun, Harbin, Shanghai, Nanjing, Hangzhou, Ningbo, Hefei, Fuzhou, Xiamen, Nanchang, Jinan, Qingdao, Zhengzhou, Wuhan, Changsha, Guangzhou, Shenzhen, Nanning, Haikou, Chongqing, Chengdu, Guiyang, Kunming, Lhasa, Xi'an, Lanzhou, Xining, Yinchuan and Urumqi.

Commodities that were found non-identical across cities observed on the grounds of the data (e.g. televisions and mobile phones) have been excluded from the study. In addition, some of the commodities in the data set were eliminated because their prices are known to be controlled by either the central or local government (e.g. fuel, gas and electricity). It is noteworthy that, even though the price of steel should be essentially determined by market mechanisms (not being controlled by the government), China's largest (sixth largest in the world) steel producer, Baosteel, has in fact substantial price-setting power.

The prices are from 36 cities for most of the commodities, so that at most a total of 630 city-pairs can be constructed per commodity. A standard way of reducing such a huge number of relative prices is to choose one city as a benchmark as in Parsley and Wei (1996). In this study, China's average prices serve as benchmarks for city-level prices. Hence, for the purpose of the study city–national relative price series was constructed. The cluster estimations are then conducted by comparing city–regional average prices. The data set lacks about 3 % of the observations (June 2006 and some sporadic observations). The missing observations have been interpolated accordingly: p_t is the arithmetic mean of the nearest known preceding price, p_{t-1}, and nearest known succeeding price, p_{t+1}.

Before presenting the estimation results it is useful to look at some descriptive statistics for the data set. Relative time series were constructed in order to perform the requisite calculations. Here, a relative time series is a series of log-differences between the price of product k in city i and the national price level, c: $P_{i,k,t} = \ln (p_{i,k,t}/ p_{i,c,t})$. Thus $P_{i,k,t}$ measures the percentage difference in the price of product i as between the city in question and the national average. When absolute price parity holds $P_{i,k,t}$ must be zero.

Appendix A-1 presents the absolute price differentials and standard deviations product-by-product. Mean absolute differentials were calculated by averaging absolute price differentials, $|P_{i,k,t}| = |\ln (p_{i,k,t}/ p_{i,c,t})|$, for every city-national price series. Minimum and maximum absolute price differentials shed additional light on the magnitude of differentials by representing maximum and minimum percentage differences in prices across all the price series. Standard deviation is a gauge of variability of relative prices. It was calculated for each city-national pair over time, i.e. the standard deviation over time for $P_{i,k,t} = \ln (p_{i,k,t} / p_{i,c,t})$. For each commodity and service it was then attained by averaging city-national standard deviation on a product-by-product basis.

The mean absolute differentials average 24 % with services varying the most, by about 50 %, and industrial products the least, by roughly 10 %. Variation across products and product categories appears to be relatively large. The Fan-Wei (2006) study also found the service prices varied in absolute terms by nearly 50 % on average. Their explanation for the huge variation was China's underdeveloped service sector, which is thus reflected in large price variations in their data set.

Excluding the services category, the mean absolute differential is 17 %. Ceglowski (2003) and Parsley and Wei (1996) measured absolute price differentials for the Canadian and the U.S. commodity markets, respectively. Ceglowski found an average of 12 % for absolute price differentials, whereas Parsley and Wei's differentials averaged roughly 12-15 % depending on the commodity category. Absolute price differences across China's commodity markets thus seem to be considerably greater than those of Canada or the United States, especially if the services category is taken into account.

The standard deviations vary considerably across products as do the mean absolute price differentials. However, unlike in the case of mean absolute price differentials, the services posted the smallest mean standard deviation of the commodity categories. Hence, even though representing values which are furthest from absolute price parity, service price variation appears to be increasingly stable. Generally, for other commodity categories, there seems to be a positive correlation between mean standard deviations and mean absolute price differentials, meaning that the further the relative price from absolute price parity, the greater the price volatility.

4.2 Estimation models

A linear cointegration model is used to test the state of integration of China's commodity market in the short run. A non-linear cointegration model is used to study whether prices are trending towards integration in the long run. This subsection presents both approaches.

1) Short-run cointegration

Linear price parity holds only if the relative price series is a stationary process[3]. In

[3] The concept of stationarity refers generally to a stochastic process whose probability distribution at a fixed time or position is the same for all times or positions. If the hypothesis of a unit root (non-stationarity) is rejected, the time series is considered integrated, otherwise not integrated.

this paper, the absolute linear price parity was measured by the following general AR(1) (first-order autoregressive) process:

$$P_{i,k,t} = V_t,\ V_t = (\lambda + 1)V_t{-}1 + \varepsilon_{i,k,t}. \qquad (4.1)$$

$$\Delta P_{i,k,t} = \lambda P_{i,k,\,t}{-}1 + \varepsilon_{i,k,t}. \qquad (4.2)$$

$P_{i,k,t}$ The log-difference in the price of product k in city i relative to the national price level.

$V_{i,k,t}$ Stochastic disturbance term.

$\varepsilon_{i,k,t}$ Random error, with zero-mean.

λ Rate at which deviations from the trajectory caused by random shocks die out.

$t = 1,\ldots,T.$

Model (4.2) is reformulated from expression (4.1). When $\lambda = 0$ random shocks never disappear and there is a unit root in the estimated equation. Hence the unit root hypothesis $H_0 = 0$ is tested against $\lambda < 0$. The Phillips-Perron test is used to determine whether there is a unit root in the time series. Furthermore, to eliminate serial correlation from residuals, the Newey-West automatic bandwidth selection method with Bartlett spectral kernel is employed (Gluschenko 2006).

Equation $\theta = \ln(0.5)/\ln(1 + \lambda)$ which defines the half-live of a deviation, was also calculated, along with the actual model. With $\lambda = 0$, i.e. in the case of a unit root, $\theta = \infty$. Thus, random shocks never die out and there is no return to trajectory. On the contrary, when $\lambda = -1$ (and hence $\theta = 0$), the return to trajectory is immediate.

2) Long-run cointegration

Linear cointegration does not reveal whether prices are trending to convergence in the long run, because it does not provide information on non-stationary processes that become stationary over a certain time span. Time series which are on a process of convergence were estimated using a non-linear cointegration model. In order to estimate the model, stochastic disturbances were again taken into account:

$$P_{i,k,t} = \ln(1 + \gamma e^{\delta t}) + V_{i,k,t},\ V_{i,k,t} = (\lambda + 1)\nu_{i,k,t-1} + \varepsilon_{i,k,t}. \quad (4.3)$$

$$\Delta P_{i,k,t} = \lambda P_{i,k,t-1} + \ln(1 + \gamma e^{\delta t}) - (1 + \lambda)\ln(1 + \gamma e^{\delta (t-1)}) + \varepsilon_{i,k,t}. \quad (4.4)$$

γ Direction of convergence.

δ Speed of convergence.

(Other components of the model presented in connection with model 4.1)

Substituting the second equation in (4.3) into the first gives a non-linear model to be estimated and tested (Gluschenko 2006). As in model (4.2), equation (4.4) represents an AR(1), where the parameter λ should not be zero or the whole time series turns non-stationary. We thus test the time series $P_{i,k,t}$ to see that it does not have a unit root and so is stationary around a non-linear trend. The hypothesis to be tested is the same as for the linear model (4.2), H_0: $\lambda = 0$ (against $\lambda < 0$).

To test H_0 of the nonlinear model, the t-ratio of λ, denoted τ_{NL}, is the test statistic. Distribution of the statistic differs, though, from the ordinary Dickey-Fuller distributions, and has not been introduced in the literature. In order to provide a valid distribution $\tau_{N,}$ a large number of simulations were performed in the econometric calculations for t = 30[4].

If H_0 is rejected, the significance of the two other parameters, γ and δ will be tested: H_1: $\gamma = 0$ (against $\gamma \neq 0$) and H_2: $\delta \geq 0$ (against $\delta < 0$). If all three hypotheses are rejected,

[4] See Gluschenko (2006) for details.

the relative time series is trending to convergence with a subsiding trend. Because rejection of H_0 implies that the time series is stationary, the ordinary t-tests can be applied to test H_1 and H_2. If parameter $\delta \geq 0$ there is no ongoing integration process because the trend would not be subsiding. The sign of γ represents the initial deviation of prices from parity and shows the direction of convergence. If $\gamma = 0$ convergence is said to be completed and relative prices are equal, i.e. that absolute parity holds. (Gluschenko 2006)

Each time series is analysed according to the rules described above in the following order. At first model (4.4) is tested. When H_0, H_1 and H_2 are all rejected the times series trends to integration in the long run. If, though, one of the hypotheses is not rejected, the model is not accepted and the model (4.2) is tested. If the unit root hypothesis of model (4.2) is rejected, the times series is deemed stationary and hence the city in question is integrated with the national market. If the unit root hypothesis is not rejected at this stage, the city is considered to be non-integrated.

5 Empirical results

5.1 Main results

Appendix B-1 summarizes the results of cointegration tests for each commodity relative to national markets. Of all goods and services, 52 % and 9 % of the cities show convergence in the short and long run, respectively. Non-perishables have converged to absolute parity in roughly half of the cities, which is slightly less than for perishables (65 %). This is a surprising result since in general perishables should perish fairly quickly and so should not be as easily transported to distant locations as non-perishables. Fan and Wei (2006), who found a similar pattern for price disparities across product categories for China, explained their finding in terms of the prevailing imperfect competition in the markets for non-perishables.

Services show a significantly smaller degree of convergence compared to goods categories with 33 % of cities converged to absolute parity. However, the overwhelming majority of relative price series that trend to integration are services. The results change to an extent when the 5 % significance level is applied. More specifically, using critical values for the 5 % level, the unit root is rejected for 43 % of all relative time series in the ab-

solute short-run cointegration analysis. As regards the long-run estimations, the unit root is rejected and all the three parameters are found significant for 7 % of the relative price series.

Figure 2 and appendix B-2 summarize the estimation results for 36 Chinese cities, and shed light on the geographic dimension of market integration. Estimation results show that the eastern cities are not the most integrated cities in China; a majority of these showed a level of convergence of less than 60 %. As a matter of fact, the most integrated cities lie in the south-eastern and central parts of the country. This is a curious finding, given the strong prior of eastern cities being among the most integrated cities in China. Another fairly exceptional finding was that the integration levels of Shanghai and Shenzhen are about the same as that of Lhasa. This should not be seen as a sign of similar price levels in those cities but rather the reverse: prices in Shanghai and Shenzhen are higher than in China on average, whereas in Lhasa they are lower than China's general price level. Moreover, our results are not consistent with Gluschenko (2006), as the low level of integration in some of the Chinese cities could not be explained by their distant location in general. In our view, this provides a good reason to examine China's market integration further by means of the cluster convergence approach.

Figure 2. Market integration in 36 cities in China

Painted areas represent China's provinces.
Shenzhen, Xiamen and Dalian, which are not province capitals, are painted as points on the map.
Here by the state of integration it is referred to integration in the short- and in the long-run.

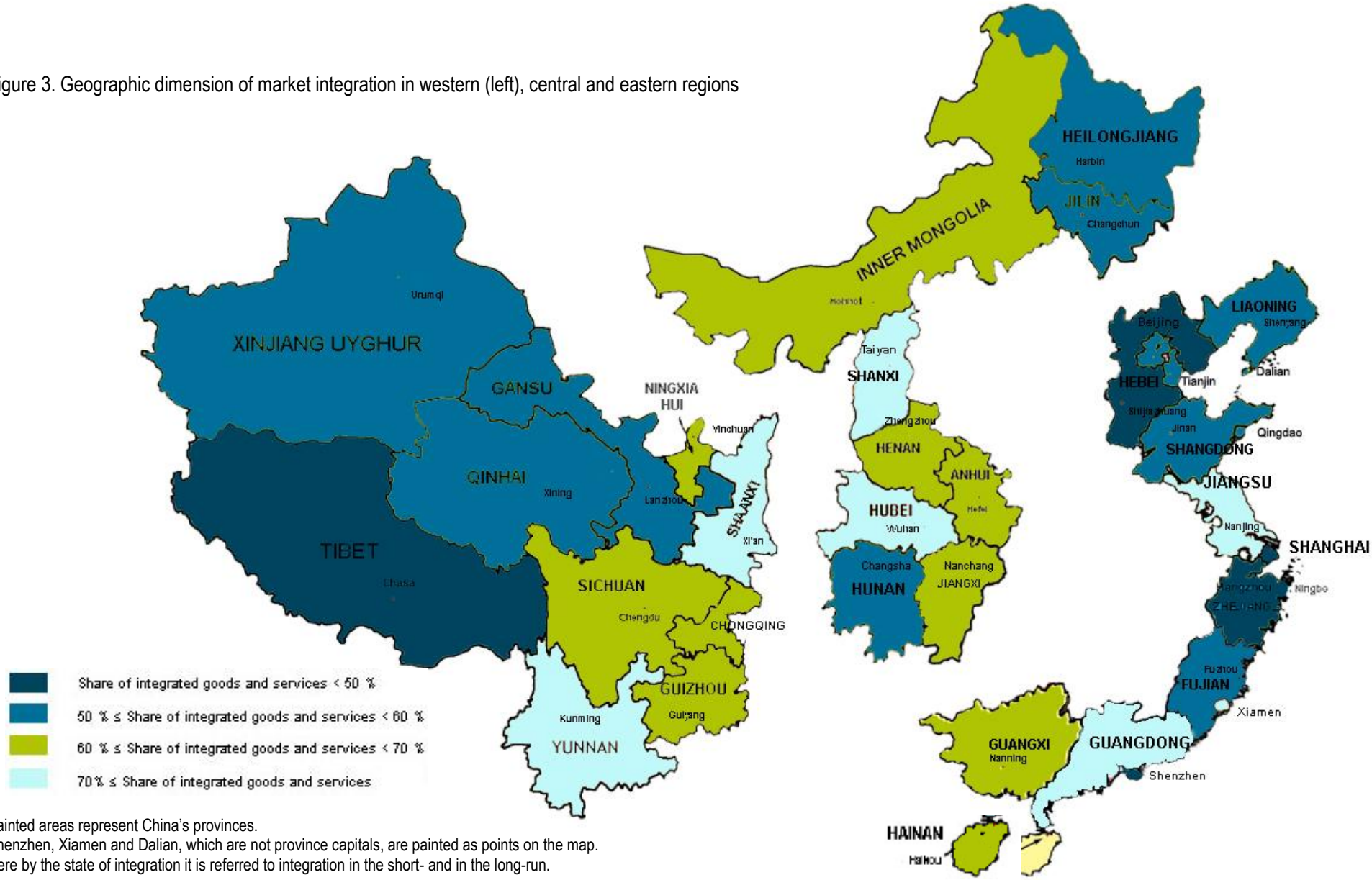
One can hardly draw unambiguous conclusions as to the geographic dimension of China's market integration on the basis of cointegration tests. In order to analyse the market's geographic structure more closely, China's provinces were divided into three groups - eastern, central, and western provinces - according to the principle presented in section 4. For each of the three groups, an average price level to replace the national prices was constructed by weighting each city by its population to proxy its size.

As in the previous results, summarized in appendix B-3, one can infer that regional market integration is greatest in China's central cities; a total of 57 % of regional relative price series were deemed stationary in the short-run analysis. However, for western and eastern regions, the level of integration remains slightly lower in regional testing, as compared to the nationwide analysis. The western and eastern areas, respectively, contain the largest and the smallest shares of cities that are trending to integration. Also noteworthy is that, of the time series for services, a small fraction (4 %) trend to integration in the east, whereas in the west the corresponding figure is 23 %. On the other hand, the east cluster accounts for the highest level of absolutely integrated services. As China's internal work-related migration is west-to-east, the tendency of prices to trend to integration across the west cluster might indicate an ongoing convergence of living standards within the cluster[5]. But this conjecture would require further empirical testing.

Figure 3 characterizes the geographic structure of integration for eastern, central and western clusters. Interpretations of eastern provinces' spatial structures remain ambiguous. The evidence strongly suggests the absence of effective arbitrage in the eastern and western cities and that price formation depends essentially on other factors which, unfortunately, have not been uncovered empirically in this study.

[5] I.e. Balassa (1964) argues that international equalization of service prices requires labour migration in response to intercountry differences in living costs.

Figure 3. Geographic dimension of market integration in western (left), central and eastern regions



Painted areas represent China's provinces.
Shenzhen, Xiamen and Dalian, which are not province capitals, are painted as points on the map.
Here by the state of integration it is referred to integration in the short- and in the long-run.

5.2 Additional tests and robustness checks

Rate of convergence

For the purpose of analysing how fast the price series actually converge to parity in China, half-lives of random shocks were estimated for all convergent log relative time series, and were then averaged for each commodity. The half-lives vary from a month (peanut oil) to 34 months (surgery) with an average of 8 months. This is slightly longer than that found in the Wei and Fan (2006) study, where the estimated average half-life was 2 months.

Several researchers report median instead of average half-lives in their estimation results. Ceglowski (2003) estimated median half-lives by employing both convergent and non-convergent relative price series. She found a median half-life of six months for a panel of Canadian goods' prices. When applying Ceglowski's method to this study, the median half-life including all goods and services changes to 3.5 months. For perishables, non-perishable agricultural products, industrial products and services estimations yield 2.4, 6.6, 3.5 and 63 months, respectively. In general, one can conclude that the time for deviations to die out are surprisingly small for China when services are excluded.

Relative price parity

Model (5.1) represents relative price parity where prices in different locations are allowed to converge to a value other than one. Hence, Ci,k must have significant values other than zero.

$$\Delta P_{i,k,t} = C_{i,k} + \lambda P_{i,k,\,t-1} + \varepsilon_{i,k,t} \qquad (5.1)$$

$C_{i,k}$ Constant term.
(Other components presented in connection with model 4.1)

For model (5.1), we test whether the H_0 of non-stationarity can be rejected and whether the constant term is significant at the 10 % significance level. Coefficient significance is tested with t-tests. Roughly 20 % of the time series, which were already found to be integrated in the short or long run in absolute terms, also had a significant constant term.

Theoretically, this is possible when the values of the constant term or non-linear trend variable are sufficiently close to zero and the significance level employed is low.

The share of significant constant terms in accordance with equation (5.1) is presented in table 4. Results reveal that the constant term is significant at the 10 % significance level for 29 % of the convergent and non-convergent relative time series. If relatively integrated time series were combined with absolutely converged price series, China's overall level of market integration would increase by nearly 10 percentage points to 61 %. The share of significant constants in all of the convergent relative price series would then average 21 % at the 10 % significance level. There is not much variation across regions in terms of the level of relatively integrated time series. It is however surprising that the share of relatively integrated cities is actually smaller in national markets than regionally. The presumption is the reverse because the constant term is generally thought to represent the gap between other factors across the cities.

Table 4. The share of relatively converged time series

Relative Parity*	***China***	***East***	***Central***	***West***
Total	**0.289***	**0.292**	**0.321**	**0.317**
Tradables	0.324	0.330	0.288	0.341
Non-perishables:	0.267	0.252	0.211	0.388
Perishables	0.376	0.415	0.365	0.294
Non-tradables (services)	0.160	0.147	0.444	0.225

*Share of relatively integrated time series with respect to all time series.

Univariate ADF-tests

Univariate unit root tests of the main results are based on Phillips-Perron test statistics. However, as most researchers employ univariate augmented Dickey-Fuller tests, which are also based on a unit root null and an alternative of mean-stationarity, it is reasonable to analyse the test results also via this approach. The regression equation obtains the form

$$\Delta P_{i,k,t} = \lambda P_{i,k,\,t-1} + \sum_{m=1}^{s(k)} \beta_m P_{\,i,k,t-m} + \varepsilon_{i,k,t}. \qquad (5.2)$$

s(k) Lag-structure corresponds to possible serial correlation in the error term.

(Other components presented in connection with model 4.1)

The lag structure *s(k)* is introduced into the model to account for possible serial correlation in the error term. The length of the lag is determined for each individual relative time series by the Akaike information criterion (AIC), with seven as the maximum number of lags. It is worth noting that only the short-run convergence is detected by this estimation; the parameter representing an asymptotically subsiding trend differs from the ordinary Dickey-Fuller distribution, which makes the non-linear model incompatible for testing alongside the linear model.

The estimation results are presented in table 5 for the 10 % and 5 % significance levels. Switching methods from Phillips-Perron to the ADF approach affects estimation results to some extent. Namely, the share of absolutely integrated relative time series falls to 46 % at the 10 % significance level. At the 5 % level, the difference between the two methods is slightly smaller. These outcome differences between the two methods might indicate a type II error in the test results, meaning that a false null hypothesis is not rejected (Dougherty 2002).

Table 5. ADF-estimation results for absolute price parity

	10 %	***5 %***
Total*	***0.461***	***0.394***
Tradables	***0.508***	***0.431***
Non-perishables	**0.445**	**0.405**
Perishables	**0.579**	**0.462**
Non-tradables (services)	***0.287***	***0.252***

*The share of absolutely integrated time series with respect to all time series.

Panel unit root tests

Levin et al. (1992) have shown that panel data can greatly increase the power of unit root tests. Parsley and Wei (1996), as well as Cecchetti et al. (2002), tested the approach introduced by Levin et al. with price data and found it more difficult to reject a false unit root by the univariate approach than by panel estimations. This again concerns the type II error, which depends on the true, but unknown, value of the parameter to be tested. The regression takes the exact same form as in univariate ADF analysis:

$$\Delta P_{i,k,t} = \lambda P_{i,k,\,t-1} + \sum_{m=1}^{s(k)} \beta_m P_{\,i,k,t-m} + \varepsilon_{i,k,t}. \qquad (5.3)$$

s(k) Lag-structure corresponds to possible serial correlation in the error term. (Other components presented in connection with model 4.1)

The lag structure *s(k)*, used to account for possible serial correlation in the error term, is determined on a product-by-product basis as in the univariate ADF-testing presented above. Also the lag length is determined for each individual relative time series by the same method, i.e. using the Akaike information criterion (AIC). The estimation results show that at both the 5 % and 10 % significance levels, the unit root can be rejected for 74 % of all relative time series in absolute terms. More explicitly, at both significant levels the unit root was rejected for 86 % of perishables, 88 % of non-perishables and 0 % of services. Excluding the services' category, this is indeed a clearly higher estimation result than that for the univariate method. Moreover, China's market integration appears to be at the same level as the U.S. when the panel unit root estimation results are compared with Parsley and Wei's (2003) results.

6 Conclusions

The special characteristics of the China's price deregulation period and the generally increased interest among scholars in intranational price convergence provided the motivation to analyse patterns of price disparities in China. This study aimed at shedding light empirically on the matter by examining the level and geographic pattern of market integration across 36 Chinese cities. The general finding of the study was that China's level of market integration is highly comparable with the level of developed countries and, surprisingly, the eastern cities don't account for the highest level of convergence in the country. Performing estimations for China divided into three clusters did not improve the level of convergence across the eastern cities.

The mean and median half-lives of the price gap were found to be significantly smaller than those found in cross-country analyses. Also in intranational comparisons the

rate of convergence appears rather fast. The results also indicate that China's central and south-eastern cities show the highest levels of integration relative to the national markets. About a tenth of the relative time series was found to be trending to integration in the long run. The great majority of the series trending to integration was in services, which suggests convergence in general living standards across Chinese cities.

The estimations presented here are based on a relatively small number of services. Further analysis of the convergence patterns based on more detailed data would clearly be fruitful. Moreover, the methods introduced for cluster convergence in economic growth studies are not directly applicable to LOP examinations, which is why we composed the clusters by economic indicators published in the OECD country survey. As the chosen method will likely have a critical effect on estimation results, further analysis of the possibilities with endogenous or exogenous criteria for forming clusters should also provide ample motivation for further study.

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Appendix

A: Descriptive statistics

Table A-1. Absolute price differentials and standard deviations

	Absolute price differentials*			Standard deviation	Number of observations
	Mean	Min	Max		
Total	**0.240**	**0.000**	**3.168**	**0.138**	**20274**
Nonperishable agricultural products	**0.145**	**0.000**	**1.078**	**0.112**	**5022**
Flour Premium	0.156	0.000	0.710	0.060	1085
Flour	0.113	0.000	1.034	0.078	868
Rice	0.061	0.000	0.350	0.039	1085
Pepper	0.261	0.000	1.078	0.248	1116
Peanut Oil	0.136	0.000	0.883	0.135	868
Industrial products	**0.101**	**0.000**	**1.406**	**0.061**	**3162**
Fertilizer	0.073	0.000	1.406	0.045	1085
Steel	0.063	0.000	0.415	0.068	1054
Cement	0.166	0.000	0.883	0.071	1023
Perishables	**0.221**	**0.000**	**3.168**	**0.190**	**7626**
Cucumber	0.258	0.000	3.168	0.257	1116
Tomato	0.267	0.000	1.339	0.238	1116
Cabbage	0.320	0.000	1.419	0.307	1023
Eggplant	0.287	0.000	1.800	0.259	1116
Pork	0.118	0.000	1.329	0.097	1116
Egg	0.110	0.000	0.932	0.070	1116
Milk	0.184	0.000	0.920	0.102	1054
Services	**0.496**	**0.000**	**1.860**	**0.046**	**4433**
Tuition fee high school	0.563	0.008	1.707	0.087	1085
Kinderkarten	0.572	0.017	1.660	0.161	1116
Hospital	0.382	0.008	1.860	0.111	1116
Surgery	0.466	0.000	1.774	0.188	1116

The absolute percentage differences in prices so that 0.24 = 24 % etc.

B: Estimation results of Phillips-Perron tests

Table B-1. Shares of integrated time series and average half-lives of deviations

	Absolute integration	*Trending to integration*	*Divergence*	*Non-integration*	*Half-life (months)***
Total	***0.521***	***0.089***	***0.016***	***0.374***	***8***
Tradables	***0.572***	***0.044***	***0.019***	***0.366***	***3***
Non-perishables:	**0.507**	**0.038**	**0.014**	**0.441**	**4**
Agricultural products	**0.501**	**0.043**	**0.017**	**0.439**	**2**
Rice*	0.286	0.057	0.029	0.629	2
Pepper	0.806	0.028	0.000	0.167	2
FlourP	0.200	0.057	0.057	0.686	3
Flour	0.393	0.036	0.000	0.571	2
Peanut Oil	0.821	0.036	0.000	0.143	1
Industrial products	**0.517**	**0.029**	**0.010**	**0.444**	**7**
Steel	0.735	0.000	0.029	0.235	16
Fertilizer	0.543	0.057	0.000	0.400	1
Cement	0.273	0.030	0.000	0.697	2
Perishables	**0.646**	**0.050**	**0.024**	**0.279**	**3**
Cucumber	0.889	0.000	0.000	0.111	10
Tomato	0.750	0.000	0.028	0.222	2
Cabbage	0.758	0.091	0.000	0.152	2
Eggplant	0.806	0.000	0.028	0.167	2
Pork	0.611	0.028	0.056	0.306	1
Egg	0.444	0.028	0.000	0.528	2
Milk	0.265	0.206	0.059	0.471	1
Non-tradables (services)	***0.328***	***0.260***	***0.007***	***0.405***	***25***
Tuition Fee Highschool	0.257	0.486	0.000	0.257	23
Kinderkarten	0.278	0.056	0.000	0.667	17
Stay in hospital per day	0.333	0.444	0.000	0.222	25
Surgery cost (appendix cut)	0.444	0.056	0.028	0.472	34

*Average share of cities by commodity and integration process.

** Average half-life of convergent time series.

Table B-2. Share of converged goods' and services' prices by city

	Perishables	Non-perishable agricultural products	Services	Industrial products	Average*	Number of estimated time series
Share of integrated goods and services < 50 %						
Shenzhen	0.286	0.400	0.500	0.333	0.368	(19)
Shanghai	0.333	0.000	1.000	0.333	0.467	(15)
Lhasa	0.333	0.800	0.500	0.000	0.471	(17)
Harbin	0.571	0.200	0.500	0.667	0.474	(19)
50 % ≤ Share of integrated goods and services < 60 %						
Shenyang	0.571	0.250	0.500	0.667	0.500	(18)
Hangzhou	0.429	0.500	0.750	0.333	0.500	(18)
Lanzhou	0.286	0.500	0.500	1.000	0.500	(18)
Shijiazhuang	0.833	0.250	0.500	0.333	0.514	(18)
Ningbo	0.571	0.200	0.750	0.667	0.526	(19)
Hefei	0.857	0.200	0.500	0.333	0.526	(19)
Dalian	0.571	0.333	0.500	0.667	0.529	(17)
Changchun	0.571	0.333	0.500	0.667	0.529	(17)
Fuzhou	0.571	0.333	0.750	0.333	0.529	(17)
Jinan	0.286	0.800	0.500	1.000	0.579	(19)
Yinchuang	0.857	0.200	0.500	0.667	0.579	(19)
Wuhan	0.714	0.800	0.500	0.000	0.588	(17)
60 % ≤ Share of integrated goods and services < 70 %						
Xining	0.857	0.500	0.500	0.333	0.611	(18)
Tianjin	0.714	0.400	0.500	1.000	0.611	(18)
Taiyan	0.714	0.600	0.500	0.667	0.632	(19)
Hohhot	0.857	0.600	0.500	0.333	0.632	(19)
Qindao	0.857	0.600	0.500	0.333	0.632	(19)
Haikou	0.429	0.800	0.750	0.667	0.632	(19)
Nanchang	0.857	1.000	0.500	0.000	0.647	(17)
Urumqi	0.714	0.750	1.000	0.000	0.667	(18)
Beijing	1.000	0.250	0.500	0.667	0.667	(18)
Nanning	0.714	0.800	0.500	0.667	0.684	(19)
Chengdu	0.857	0.800	0.500	0.333	0.684	(19)
Share of integrated goods and services ≥ 70 %						
Chongqing	0.857	0.400	0.500	1.000	0.684	(19)
Guangzhou	0.857	0.500	0.333	1.000	0.706	(17)
Xining	0.833	0.600	0.500	1.000	0.706	(18)
Zhengzhou	0.714	0.600	1.000	0.667	0.737	(19)
Xiamen	1.000	0.600	0.500	0.667	0.737	(17)
Changsha	0.857	0.400	0.750	1.000	0.765	(17)
Nanjing	0.857	1.000	0.750	0.333	0.740	(18)
Kunming	1.000	0.800	0.750	0.333	0.789	(19)
Guiyang	0.833	1.000	0.750	0.667	0.833	(18)

*Average share of converged goods and services by city.

Table B-3. Share of each cluster representing different types of integration processes

	Average**	Tradables	Non-perishables	Perishables	Non-tradables (services)
East					
Absolute integration	**0.503***	0.534	0.486	0.589	0.387
Trending to integration	**0.033**	0.030	0.057	0.000	0.044
Not integrating	**0.464**	0.439	0.462	0.411	0.569
Central					
Absolute integration	**0.574**	0.631	0.530	0.762	0.361
Trending to integration	**0.057**	0.027	0.046	0.000	0.167
Not integrating	**0.369**	0.341	0.424	0.238	0.472
West					
Absolute integration	**0.518**	0.623	0.527	0.717	0.125
Trending to integration	**0.085**	0.048	0.052	0.046	0.225
Not integrating	**0.397**	0.329	0.421	0.237	0.650

** Average share of goods and services by cluster.

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