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Regional Inequality, Industry Agglomeration and Foreign Trade

The Case of China

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Abstract

How do foreign trade and foreign direct investment affect regional inequality? Foreign trade and investment may affect internal economic geography, and the resulting industry agglomeration may contribute to regional inequality. This paper provides empirical evidence supporting this linkage. The results indicate that the increasing regional inequality in China has been accompanied by an increase in the degree of regional specialization and industry agglomeration. Foreign trade and foreign investment are closely related to industry agglomeration in China. Industries dependent on foreign trade and FDI are more likely to locate in regions with easy access to foreign markets, and exporting industries have a higher degree of agglomeration.

Keywords: trade, production, industry, inequality, regions, China

JEL classification: R12, F15

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UNU-WIDER held an essay competition on Inequality and Poverty in China that attracted over 300 entries and was judged by a selection committee headed by Anthony Shorrocks with members John Bonin, Fang Cai, Shi Li, Justin Lin, and Guanghua Wan. This is one of the prize winning papers.

Acronyms

CPI consumer price index

FDI foreign direct investment

GDP gross domestic product

SSB State Statistical Bureau of China

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1 Introduction

Substantial regional disparity, especially the increasing income gap between coastal and interior areas, is one of the most significant features of the economic development process in China. Most empirical studies on this topic have focused on inter-provincial income inequality (see, e.g., Tsui 1991, 1993, 1996; Chen and Fleisher 1996; World Bank 1997; Kanbur and Zhang 1999). The general trend is that regional inequality decreased in the early stages of economic reform (from the beginning year of economic reform, 1978, to the end of the 1980s), and significantly increased in the 1990s.

There are several important explanations for the increase in regional inequality, for example, economic decentralization, biased regional policies and market fragmentation. Openness to foreign trade and foreign investment is one of the competing explanations. The previous literature has identified a significant and positive effect of foreign trade and foreign investment on regional income growth, controlling for other regional characteristics. For example, Chen and Fleisher (1996) test the conditional convergence of per capita GDP across China's provinces from 1978 to 1993 and show that foreign direct investment (FDI) had a positive effect on regional growth. Gao (2004) finds that exports and foreign direct investment have strong positive effects on regional industrial growth. Fu (2004) investigates the spillover and migration effect of exports and FDI and shows that exports and FDI have played an important role in increasing regional disparities in China. Wan, Lu and Chen (2004) estimate the important contribution of globalization to regional income inequality in China. Kanbur and Zhang (2005) show a positive relationship between trade openness and interregional inequality.

The purpose of this paper is to examine empirically one potential channel through which foreign trade and investment may affect domestic regional inequality. New economic geography theories have shed some light on the linkage between globalization and domestic inequality: openness to foreign trade may affect internal economic geography, and foster a spatial concentration of industry. With a fragmented factor market, an unbalanced geographical distribution of industry may translate into a regional income inequality. (See, e.g., Fujita, Krugman and Venables 1999; and Venables, 2000). Hu (2002) develops an economic geographic model to link foreign trade, industrial agglomeration and increasing regional income disparity in China. According to his spatial agglomeration model, 'With a geographic advantage in international trade, the coast becomes the initial location for industrial agglomeration and its leadership becomes strengthened by the positive feedback mechanism from the increasing return to scales' (Hu 2002: 311). This implies a potential linkage between regional inequality, industry agglomeration and foreign trade: external trade liberalization affects the internal geography, and the resulting industry agglomeration contributes to the rise in regional inequality.

This paper provides empirical evidence supporting this linkage: First, we show that the increasing regional inequality is accompanied by significant increases in the degree of regional specialization and industry agglomeration. Decomposition of regional inequality shows that regional disparity in the production structure is an important source of regional inequality. Second, we test both the determinants of industry location and the determinants of industry concentration in China. The results indicate that foreign trade and FDI significantly affect industry location and are positively related to industry agglomeration. Industries relying heavily on foreign trade and FDI are more likely to locate in regions with easy access to sea transportation, and exporting industries have a higher degree of agglomeration. Our results also led some support to the resource endowment theory: agriculture endowment and skill endowment are important concerns in making decisions regarding location.

The remainder of this paper is organized as follows: Section 2 introduces the data set. Section 3 discusses the linkage between regional inequality and industry agglomeration. The effect of foreign trade and investment on industry location and agglomeration are examined in section 4, and section 5 concludes this paper.

2 Data

This study uses province-level data and disaggregated industrial data for the period 1990 to 1999. The year 1985 is also included in this study to examine the consistency of the patterns over time. The major data sources are various provincial statistics yearbooks, industry economy statistics yearbooks, and the second and third national industrial censuses. The information concerning the provincial nominal gross domestic product (GDP), the population and consumer price index (CPI) in the period 1990-98 was compiled from *Comprehensive Statistical Data and Materials on 50 Years of New China* (State Statistical Bureau 1999).[1] This book summarizes various provincial economic indicators from complete volumes of provincial statistics yearbooks. The 1999 data were compiled from various provincial statistics yearbooks (2000). We use the provincial CPI to convert the nominal value of GDP into 1990 constant prices. The education level of the provincial population in 1995 was compiled from 'The 1 per cent Population Sample Survey in 1995,' *Population Statistical Yearbook* of *China* (State Statistical Bureau 1997c). The information on the education level of the provincial population in 1982 was compiled from 'The Population Census in 1982,' *Almanac of China's Population* (Population Research Centre 1985). The distances between the provinces and the shortest distance of each province from the coast were obtained from a map of China.

Following the official definition, twenty-seven provinces and three municipalities have been divided into three geographic areas according to the location of each province.[2] The data from each area are aggregated from provincial data.

The information concerning provincial employment and GDP for four aggregate sectors (agriculture, manufacturing, construction, and the service sectors) was compiled from the *China Statistical Yearbooks* (State Statistical Bureau 1991-2000a). The data for provincial employment, gross value of output and value added for 25 disaggregated manufacturing industries from 1990 to 1999 were compiled from the *China Industry Economy Statistical Yearbook* (State Statistical Bureau 1991-2001b).[3] The information

1 There were 27 provinces and 3 municipalities in China before 1997. In 1997, Chongqing City became the fourth municipality. For consistence, we still treat Chongqing as part of the Sicuan province after 1997.

2 The details of division and description of three geographic areas are provided in the data appendix.

3 We exclude all industries of mining, utility and construction in our study. The information on eight manufacturing industries in 1999 is not reported in the *China Industry Economy Statistical Yearbooks*. We have collected the information on these industries instead from various provincial statistical yearbooks (2000).

for 1985 was compiled from *The Second National Industrial Census of the People's Republic of China in 1985* (State Statistical Bureau 1987a). The classifications for manufacturing industries have been adjusted slightly to enable a comparison over time.[4] The information on industrial foreign investment, and the education level of employees in the manufacturing industries was compiled from the second and third industrial census for 1985 and 1995. The information on the inter-industry input-output linkage and export share in total output was compiled from the *Input-Output Table* in 1987 and 1995 (SSB 1987b and 1997b)

3 Regional inequality and industry agglomeration

3.1 Decomposition of regional inequality

A large body of empirical studies indicates that China has experienced a significant increase in regional inequality since the 1990s.[5] Tsui (1991) describes the trend of inter-provincial disparities in China from the 1950s to the mid-1980s. Tsui (1993) decomposes China's regional inequality into intra-provincial, inter-provincial, intra-rural, intra-urban, and rural-urban components. Tsui (1996) explores the trend of inter-provincial inequality and the factors behind the dynamics of inequality from 1978 to 1994. Chen and Fleisher (1996) find the increasing income gap between the coastal and inland areas. Kanbur and Zhang (1999) use the consumption expenditure of household data to study regional income inequality in China. They find that while the contribution of rural-urban inequality to the overall regional inequality is much higher than that of the inland-coast inequality, the contribution of the latter has increased dramatically. In this paper, we do not use direct measures of regional income, but focus on the regional aggregate labour productivity, which is measured by the regional value added divided by regional employment.[6]

The aggregate interregional productivity inequality comes from two main sources: the interregional productivity disparity within the same sector, and the regional production structure differential (or industry mix).

> A particular region can have an aggregate productivity per worker above the mean because of two reasons (or a combination of both). On the one hand, it can be that in all, or most, a sector in this region has productivity per worker above the mean. On the other hand, it can be the case that sectoral productivity is not different from mean, but that this region is specialized in those sectors with higher productivity per worker (Esteban 2000: 356).

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4 The details are in the data appendix.

5 Regional GDP, gross value of output or national income are widely used as the measures of income. However, Kanbur and Zhang (1999) argued that these measures are not reflecting living standards and differ from commonly used measures of income. The income or consumption expenditure from household data is a better measure of standards of living.

6 We use the provincial consumer price index to convert nominal value added into the constant 1990 price. The better measure of productivity is total factor productivity (TFP), which is usually estimated from a production function or directly calculated from the Divisia index. Due to data limitations, we only use labor productivity.

Using the method of shift-share analysis developed by Esteban (2000), we are able to estimate the contributions of these two sources on the interregional production inequality. The key idea of the shift-share analysis is to decompose the variation of regional aggregate labour productivity into three terms: (i) the industry-mix component μ_i, which measures the differential productivity accruing from the deviation of province *i*'s industrial structure from the national industrial structure; (ii) the productivity differential component π_i, which measures the contribution of within-sector productivity differences to regional inequality; (iii) the allocative component α_i, which measures the efficiency of each province in allocating resources.[7] Following Esteban (2000), we use p_i^j to denote sector *j*'s employment share in province *i*; p^j to denote sector *j*'s employment share at the national level; x_i^j to denote the labour productivity in sector *j* and province *i*; x^j to denote the labour productivity in sector *j* at the national level. We have the following equalities: the aggregate labour productivity in province *i*, x_i, is equal to $\sum_j p_i^j x_i^j$, and the national labour productivity, x, is equal to $\sum_j p^j x^j$. Therefore, we can decompose $x_i - x$ into three components:

$$x_i - x = \sum_j (p_i^j - p^j)x^j + \sum_j p^j (x_i^j - x^j) + \sum_j (p_i^j - p^j)(x_i^j - x^j) = \mu_i + \pi_i + \alpha_i \qquad (1)$$

where the industrial mix component $\mu_i = \sum_j (p_i^j - p^j)x^j$; the productivity differential component $\pi_i = \sum_j p^j (x_i^j - x^j)$; and the allocative component $\alpha_i = \sum_j (p_i^j - p^j)(x_i^j - x^j)$.

To measure the contribution of each component on the interregional productivity inequality, we decompose the variance of $(x_i - x)$ into the variances and covariance of three components:

$$\mathrm{var}(x_i - x) = \mathrm{var}(\mu_i) + \mathrm{var}(\pi_i) + \mathrm{var}(\alpha_i) + 2\,\mathrm{cov}(\mu_i, \pi_i) + 2\,\mathrm{cov}(\mu_i, \alpha_i) + 2\,\mathrm{cov}(\pi_i, \alpha_i) \quad (2)$$

According to Equation 2, the relative weight of the variance of each component in the overall variance will indicate the role played by each component in explaining the interregional productivity disparity. The results are reported in Table 1. The third and fourth rows in Table 1 show the variance structure for four sectors: agriculture, manufacture, construction and the service sectors. The sixth and seventh rows in Table 1 show the variance structure for twenty-eight sectors: agriculture, construction, service and 25 manufacturing sectors. As Table 1 shows, both the industry mix component and the productivity differential component play important but not dominant roles in explaining the interregional productivity disparity. About a 40 per cent variation in the interregional aggregate productivity is attributable to the covariance between the industry mix component and the productivity differential component; about a 30 per cent to 40 per cent variation is attributable to a pure within-sector productivity differential; about a 10 per cent to 20 per cent variation is attributable to pure industrial

[7] See Esteban (2000) for details.

Table 1
The shift-share analysis

Year	$\frac{\mathrm{var}(\mu_i)}{\mathrm{var}(x_i)}$	$\frac{\mathrm{var}(\pi_i)}{\mathrm{var}(x_i)}$	$\frac{\mathrm{var}(\alpha_i)}{\mathrm{var}(x_i)}$	$\frac{2\,\mathrm{cov}(\mu_i,\pi_i)}{\mathrm{var}(x_i)}$	$\frac{2\,\mathrm{cov}(\mu_i,\alpha_i)}{\mathrm{var}(x_i)}$	$\frac{2\,\mathrm{cov}(\alpha_i,\pi_i)}{\mathrm{var}(x_i)}$
	4 sectors					
1990	0.2124	0.3149	0.0175	0.3971	0.0322	0.0258
1999	0.1199	0.2855	0.0461	0.2933	0.0911	0.1640
	28 sectors					
1990	0.1433	0.3419	0.0274	0.3901	0.0375	0.0599
1999	0.1682	0.3642	0.0067	0.4054	0.0286	0.0269

structure differentials; and other components have a modest weight. The shift-share analysis shows that both the within-sector productivity gap and the disparity of regional industrial structures jointly determine interregional inequality. This is quite different from the case of Europe (Esteban 2000) where most of the interregional inequality is attributed to pure within-sector productivity differentials.

Industry agglomeration may affect these two sources of interregional inequality. First, industry agglomeration directly contributes to the increasing regional inequality by increasing the regional disparity in the industry structure. Section 3.2 shows the trend of increasing regional specialization and industry concentration in China. According to the new economic geography literature (see, e.g., Fujita, Krugman and Venables 1999), however, the regional disparity in the industry structure may not automatically translate into a regional income inequality. A free movement of factors may eliminate the regional factor price difference. Only when there are factor-market fragmentations, an unbalanced geographical distribution of industry will contribute to regional income inequality. The previous literature has shown the existence of factor market fragmentation within China. For example, Boyreau-Debray and Wei (2005) provide evidence for the segmentation of the internal capital market due to local government interference and misallocation of capital. Labour-market fragmentation within China due to a government policy of restricting migration has been widely observed and well documented in the previous literature. Chan and Zhang (1999) report the process of rural-urban migration and the operation of China's *hukou* (household or residential registration) system, which is a major mechanism for internal migration control. Wang (2004) summarizes the recent reform of the *hukou* system. During the economic reform, the internal migration control has been relaxed and localized, resulting in an increased mobility of the population. Lin, Wang and Zhao (2004) calculate the inter-provincial migration rate from the population census and show that it increased from 1.11 per cent during the 1985 to 1990 period to 2.35 per cent in the 1995 to 2000 period. However, the migration-control function of the hukou system remains fundamentally unchanged. The *hukou* system has not been abolished but has been adjusted to monitor and regulate the population mobility effectively. As the internal migration is still regulated and restricted by the government, the speed of industry agglomeration may overtake the speed of migration, and thus contribute to increasing regional inequality.

Second, industry agglomeration may also contribute to increasing regional inequality by enlarging the within-sector productivity gap. Industry agglomeration may generate positive externalities and improve local productivity. There are several potential sources of increasing return to scale (or agglomeration economies) such as knowledge spillovers, labour-market pooling, input sharing and home-market effect. A large body of empirical studies has shown the existence of agglomeration economies: agglomeration may improve productivity (Henderson 2003), encourage employment growth (Glaeser *et al.* 1992; Henderson, Kuncoro and Turner 1995), contribute to a spatial wage disparity (Wheaton and Lewis 2002) and to a land-rent disparity (Dekle and Eaton 1999). Due to data limitations, however, the hypothesis that industry agglomeration in China contributes to a within-sector productivity disparity is not tested in this paper. It is an interesting topic for future study.

3.2 Increasing regional specialization and industry agglomeration

The unbalanced geographic distribution of production has been well observed and documented in the literature. Most empirical studies concerning the pattern of production agglomeration focus on the cases of the United States and Europe (see, e.g., Krugman 1991; Ellison and Glaeser 1997; Kim 1995; Brulhart 1998; Amiti 1999; Midelfart-Knarvik *et al.* 2000). Only a few empirical studies have examined the patterns of regional specialization and industry agglomeration in China, and these patterns still remain ambiguous and controversial. One view is that local protection (interregional trade barriers) prevents regional specialization and causes a duplication of the regional production structure. Young (2000) studies the provincial output structure and claims that local protection has led to a fragmentation of the domestic market and a duplication of the regional production structure. Another view is that the degree of regional specialization and industry agglomeration has increased over time. Manufacturing industries tend to be concentrated in the eastern coastal area. Bai *et al.* (2004) find that local protection did discourage industry agglomeration, but that the overall degree of industry agglomeration increased. Gao (2003) shows that there was a geographic shift in industry toward the south-east coast of China between 1985 and 1998. Wen (2004) finds that the Chinese manufacturing industry became more geographically concentrated following the economic reform and that many industries were highly concentrated in coastal areas.

In this study, we focus on the manufacturing sector. We exclude agriculture, mining, and the utility and service industries because agriculture and mining rely heavily on local natural endowment, while the utility and service industries rely heavily on local demand. The manufacturing industries are the so-called ‘footloose’ industries; most of the industrial relocation and agglomeration are expected to be within the manufacturing sector. We use both employment and output data of disaggregate manufacturing industries to answer two related questions: First, does the regional production structure become more diverse over time? And second, is there a trend of increasing geographic concentration in each manufacturing industry?

We use production data of disaggregate manufacturing industries to investigate the change in the regional specialization in China. Two indicators are applied in our study. The first one is Hoover’s coefficient of specialization (Hoover and Giarratani 1984). This coefficient is defined as: $\frac{1}{2}\sum_{k=1}^{25}\left|\frac{\sum_i E_i^k}{\sum_i \sum_k E_i^k} - \frac{E_i^k}{\sum_k E_i^k}\right|$, where E_i^k is employment (or output) in manufacturing industry k for region i. It measures the difference between the industry structure of a particular region and the national production structure.

The coefficients of specialization are reported in Table 2. The patterns of employment and output structures are similar. There are two basic messages: first, the western area has the highest degree of specialization, and the eastern coastal area the most diversification. Second, for each area there is an upward trend in regional specialization between 1985 and 1999. The manufacturing production structure of each area is increasingly different from the national structure.

The second indicator is the Krugman specialization index (Krugman 1991), which is defined as: $K_{ij} = \sum_k \left| \frac{E_i^k}{\sum_k E_i^k} - \frac{E_j^k}{\sum_k E_j^k} \right|$, where E_i^k and E_j^k is employment (or output) in the manufacturing industry k for region i and j, respectively. This index is used to compare bilaterally the disparity in the production structure between two regions.

Table 3 shows a comparison of the production structure among three geographical areas. The results suggest that, first, the east-west disparity is the largest, and the central-west structure is the smallest. Second, the manufacturing-production structures of the coastal and interior areas have diverged over time. The disparity in the structure between the central area and the western area has also increased over time.

We also calculate the Hoover coefficients for each individual province.[8] Both employment and output data show a similar trend: for most provinces, the manufacturing structure is increasing differently from the national structure. The

Table 2
Hoover's coefficients of specialization for three geographical areas, 1985-99

Region	1985	1990	1994	1999	Change 1985-99(%)
	Employment structure				
Eastern	0.099	0.109	0.109	0.162	63.6
Central	0.123	0.137	0.165	0.267	117.1
Western	0.167	0.170	0.187	0.310	85.6
	Output structure				
Eastern	0.103	0.100	0.110	0.140	35.9
Central	0.178	0.190	0.250	0.384	115.7
Western	0.195	0.235	0.262	0.439	125.1

Table 3
Krugman's specialization index for three geographical areas, 1985-99

Region	1985	1990	1994	1999	Change, 1985-99 (%)
	Employment structure disparity				
Eastern-Central	0.218	0.243	0.271	0.424	94.5
Eastern-Western	0.241	0.261	0.264	0.457	89.6
Central-Western	0.157	0.157	0.200	0.200	27.4
	Output structure disparity				
Eastern-Central	0.272	0.288	0.361	0.523	92.3
Eastern-Western	0.294	0.308	0.365	0.567	92.9
Central-Western	0.148	0.202	0.247	0.366	147.3

8 The results are not reported here but are available upon request.

average coefficient of specialization increased more than 50 per cent from 1985 to 1999, and the average degree of specialization of the eastern coastal provinces is less than that of the interior provinces. These results indicate that the interior area was more specialized than the eastern area, and regional specialization has significantly increased over time.

There are various measures of industry concentration. One popular index is the locational Gini coefficient (Krugman 1991). The Gini coefficient defines on the localization quotient of province *i* for industry *k*: $g^k = Gini^k(r_i^k)$. The localization quotient r_i^k is defined as: $r_i^k = \left(\frac{E_i^k}{\sum_k E_i^k}\right) \Big/ \left(\frac{\sum_i E_i^k}{\sum_i \sum_k E_i^k}\right)$, where E_i^k is employment (or output) in manufacturing industry *k* for region *i*. It is a measure of regional specialization in industry *k* relative to the employment share of the industry for the entire country. If r_i^k is greater than one, then region *i* has a higher percentage of industry *k* compared to its proportion of total industry employment. The higher the Gini index, the stronger is the industry agglomeration. The disadvantage of this index is that it is not derived from a theoretical locational choice model and that it does not control for the size distribution of plants. Based on an underlying locational choice model of

Table 4
Geographic concentration of manufacturing employment, 1985-99

Manufacturing industries	1985	1990	1994	1999	Change 1985-99 (%)
Food manufacturing	0.249	0.285	0.258	0.275	10.4
Beverage manufacturing	0.297	0.258	0.235	0.257	-13.5
Tobacco processing	0.540	0.523	0.555	0.594	10.0
Textiles	0.194	0.211	0.233	0.294	51.5
Garments & other fibre products	0.163	0.243	0.338	0.513	214.7
Leather, furs and down	0.254	0.284	0.363	0.558	119.7
Timber processing	0.472	0.509	0.564	0.532	12.7
Furniture manufacturing	0.227	0.277	0.474	0.426	87.7
Paper making & paper products	0.201	0.214	0.220	0.271	34.8
Print & record medium reproduction	0.223	0.216	0.163	0.301	35.0
Stationery, educational, sport goods	0.466	0.517	0.552	0.648	39.1
Petroleum processing & coke product	0.323	0.399	0.493	0.554	71.5
Chemicals	0.160	0.168	0.195	0.216	35.0
Medical & pharmaceutical products	0.149	0.192	0.233	0.207	38.9
Chemical fibres manufacturing	0.480	0.409	0.353	0.424	-11.7
Rubber products	0.189	0.302	0.291	0.323	70.9
Plastic products	0.265	0.211	0.199	0.341	28.7
Non-metal mineral products	0.140	0.168	0.152	0.220	57.1
Smelting & pressing of ferrous metals	0.320	0.336	0.350	0.394	23.1
Metal products	0.123	0.125	0.181	0.262	113.1
Machinery manufacturing	0.133	0.158	0.200	0.244	83.5
Transportation equipment	0.309	0.307	0.289	0.334	8.1
Electric equipment	0.213	0.222	0.254	0.258	21.1
Electronic and telecommunications	0.377	0.383	0.412	0.462	22.5
Instrument meters, cultural machinery	0.342	0.350	0.342	0.370	8.2
Average	0.27	0.29	0.32	0.37	37.0

Source: SSB (1991-2001b).

Table 5
Geographic concentration of manufacturing output, 1985-99

Manufacturing industries	1985	1990	1994	1999	Change 1985-99 (%)
Food manufacturing	0.222	0.257	0.252	0.276	24.3
Beverage manufacturing	0.287	0.262	0.297	0.339	18.1
Tobacco processing	0.560	0.574	0.679	0.709	26.6
Textiles	0.247	0.276	0.332	0.404	63.6
Garments & other fibre products	0.124	0.251	0.431	0.522	321.0
Leather, furs and down	0.276	0.305	0.410	0.549	98.9
Timber processing	0.432	0.498	0.406	0.503	16.4
Furniture manufacturing	0.285	0.262	0.388	0.387	35.8
Paper making & paper products	0.257	0.265	0.262	0.294	14.4
Print & record medium reproduction	0.282	0.288	0.270	0.368	30.5
Stationery, educational, sport goods	0.523	0.537	0.571	0.706	35.0
Petroleum processing & coke products	0.526	0.514	0.511	0.527	0.19
Chemicals	0.214	0.199	0.237	0.255	19.2
Medical & pharmaceutical products	0.190	0.234	0.231	0.400	110.5
Chemical fibres manufacturing	0.501	0.483	0.404	0.512	2.2
Rubber products	0.306	0.355	0.423	0.461	50.7
Plastic Products	0.261	0.250	0.302	0.386	47.9
Non-metal mineral products	0.160	0.258	0.247	0.280	75.0
Smelting & pressing of ferrous metals	0.329	0.362	0.394	0.442	34.3
Metal products	0.149	0.163	0.231	0.309	107.4
Machinery manufacturing	0.157	0.196	0.234	0.351	123.6
Transportation equipment	0.355	0.363	0.387	0.422	18.9
Electric equipment	0.247	0.232	0.282	0.345	39.7
Electronic and telecommunications	0.410	0.436	0.538	0.606	47.8
Instrument meters, cultural machinery	0.377	0.354	0.378	0.461	22.3
Average	0.307	0.327	0.364	0.433	41.0

Source: SSB (1991-2001b).

firm behaviour, Ellison and Glaeser (1997) construct a more theoretically motivated measure of geographic concentration. This index compares the sectoral structure with the total manufacturing structure, conditional on the size distribution of plants. As detailed information concerning the establishment of each plant is not available in our study, we use the locational Gini coefficient as a proxy of industry concentration.

Table 4 reports locational Gini indices for employment in 25 manufacturing industries among 30 provinces, and Table 5 reports the indices for output. Both tables show similar trends. The locational Gini indices of all manufacturing industries are increasing over time, except for employment in the beverage and chemistry fibbers manufacturing. The average change in the degree of concentration within 15 years is substantial, 37 per cent for industrial employment and 41 per cent for industrial output, which implies that the manufacturing industries are distributed more unevenly across regions. These results indicate that the degree of industry agglomeration for most manufacturing industries has increased over time during the period 1985 to 1999. These pieces of evidence are consistent with the findings in Bai *et al.* (2004) and Wen (2004).

4 Industry agglomeration and foreign trade

4.1 Determinants of industry location

Midelfart-Knarvik *et al.* (2000) study the industry locations in European countries and regress the industrial regional share on the interaction terms between industry characteristics and regional characteristics. Midelfart-Knarvik *et al.* (2002) develop economic geographic models in which the industry location is decided jointly by factor endowments, increasing return-to-scales and transport costs. The empirical evidence shows that endowments of skilled and scientific labour are important determinants of industrial structure in European countries, as are also forward and backward linkages to industry.

Based on the specification in Midelfart-Knarvik *et al.* (2000), we assume that the location of an industry depends on both industry characteristics and provincial characteristics, with the form of interaction between these effects. We focus on three groups of interaction: first, to investigate the impact of foreign trade and foreign investment on industry location, we introduce the interaction between regional access to foreign markets (or access to sea transportation) and the industrial dependence on foreign investment and foreign trade. The key hypothesis is that industries relying heavily on foreign investment and foreign trade will tend to locate in regions with easy access to foreign markets. Second, the comparative advantage theory emphasizes the important effect of endowment on industry location. We include the interaction between regional endowment abundance and industrial endowment intensity in the regression, and expect that industries with a high agricultural (skill) intensity will tend to locate in regions with a high agricultural (skill) endowment. Third, forward and backward linkages are emphasized by the new economic geography theory. To minimize transportation costs, industries that rely heavily on intermediate inputs will tend to locate close to other industries (forward linkage), and industries with a high share of sales to other industries will locate close to customers (backward linkage). To test the hypothesis that industries with strong backward and forward linkages tend to locate in central regions with high market potential, we also include the interaction between domestic market potential and interindustry linkage in the regression. The specification is the following:

$$\ln(s_i^k) = \alpha + \beta \log(pop_i) + \sum_j \beta[j](X_i[j] - \gamma[j])(Y^k[j] - \varphi[j]) + \varepsilon_i^k \qquad (3)$$

where s_i^k is the industrial share of province *i* in total output of industry *k*. The independent variables are six pairs of interaction terms between the provincial characteristics and the industry characteristics: *X* is the province characteristics and *Y* is the industry characteristics. *X*[1] is agriculture endowment, which is defined as the share of agricultural production in provincial GDP; *Y*[1] is agriculture intensity, which is defined as the use of agricultural input as the share of industrial output; *X*[2] is skill endowments, which is defined as the fraction of personnel with at least 16 years of education (college and above) in regional population; *Y*[2] is skill intensity, which is defined as the fraction of non-manual workers among industrial employees; *X*[3] and *X*[4] are market potential, which is defined as the sum of provincial GDP (excluding own province) inversely weighted by distance: $\sum_{j \neq i} GDP_j / D_{ij}$ where D_{ij} is the shortest distance between the capital cities of province *i* and province *j*; *Y*[3] is intermediate intensity, which is defined as the use of intermediate inputs as share of total inputs; *Y*[4] is sales to industry, which is defined as the percentage of output sold to domestic industry (excluding own industry) as intermediates and capital goods; *X*[5] and *X*[6] are access to foreign markets, which is measured by the proximity to the coast (sea transportation): 1 divided by the shortest distance from the provincial capital city to the coast (set as 10 if the capital city is a port city); *Y*[5] is industrial dependence on export, which is defined as the percentage of export in total output; *Y*[6] is industrial dependence on foreign investment, which is defined as the share of foreign capital in total capital. pop_i is the total population of province *i*; α is the constant term and ε_i^k is the error term. $\beta, \beta[j], \gamma[j]$ and $\varphi[j]$ are coefficients to be estimated in this model. The definitions of variables measuring province characteristics and industry characteristic are reported in Table 6 (Panel A), and the summarized statistics are reported in Table 6 (Panel B).

Table 6
Summary of statistics of provincial and industrial characteristics

Panel A: Definition of variables

Provincial characteristics	
Agricultural endowment	The share of agricultural production in provincial GDP
Skill endowment	The fraction of personals with at least 16 years education (college and above) in total population
Market potential	$\sum_{j \neq i} GDP_j / D_{ij}$ where D_{ij} is the shortest distance between the capital cities of province *i* and province *j* (million *yuans*/km)
Access to foreign market	1/ the shortest distance from the provincial capital city to coast (1/100km) (set as 10 for port city)
Industrial characteristics	
Agricultural intensity	Use of agricultural input as share of industrial output
Skill intensity	The fraction of non manual workers in industrial employees
Scale	The average number of employees (1000 persons) per firm
Intermediate share	Use of intermediate inputs as share of total inputs
Sales to industry	Percentage of output sold to domestic industry (exclude own industry) as intermediates and capital goods
FDI	The share of foreign capital in total capital
Export	Percentage of export in total output

Panel B: Summary of statistics

	Mean	S.D.	25%	Media	75%	Observations
Agricultural endowment	0.230	0.090	0.165	0.231	0.292	30
Skill endowment	0.028	0.028	0.013	0.019	0.029	30
Market potential	63.140	22.189	46.931	59.922	83.113	30
Access to coast	1.178	2.538	0.148	0.237	0.641	30
Agricultural intensity	0.06	0.13	0.0	0.02	0.06	21
Skill intensity	0.34	0.10	0.26	0.35	0.40	27
Scale	0.21	0.16	0.10	0.17	0.25	27
Intermediate share	0.66	0.07	0.60	0.64	0.69	21
Sales to industry	0.45	0.22	0.33	0.46	0.69	21
FDI	0.20	0.11	0.12	0.20	0.26	27
Export	0.14	0.09	0.07	0.13	0.20	21

Table 7
Determinants of industrial location

Dependent variables	$LOG(s^k_{i,1995})$			$LOG(s^k_{i,1996})$	$LOG(s^k_{i,1985})$
Constant	7.393**	9.478**	9.525**	8.650**	-0.350
	(2.05)	(2.59)	(2.57)	(2.28)	(-0.05)
Log (Population share)	1.467***	1.467***	1.467**	1.482**	1.851***
	(11.50)	(11.61)	(11.59)	(10.38)	(11.02)
Agricultural endowment * Agricultural intensity	13.204***	13.475***	13.698**	13.055**	7.764**
	(3.37)	(3.63)	(3.64)	(3.30)	(2.09)
Skill endowment * Skill intensity	36.255**	40.586**	38.833**	51.950**	83.156**
	(2.13)	(2.27)	(2.20)	(2.79)	(2.40)
Market potential * Intermediate share (forward linkage)	0.050	0.055	0.056	0.048	-1.306*
	(0.81)	(0.89)	(0.90)	(0.73)	(-1.94)
Market potential * Sales to industry (backward linkage)	0.007	0.007	0.006	0.005	0.017
	(0.43)	(0.44)	(0.41)	(0.30)	(0.10)
Access to coast * FDI		0.085**	0.096**	0.103**	
		(2.21)	(2.16)	(2.29)	
Access to coast * Export	0.042**		-0.027	-0.037	0.033***
	(1.96)		(-0.86)	(-1.18)	(2.60)
Agricultural endowment	-12.561***	-12.577***	-12.591**	-12.617**	-8.460***
	(-9.90)	(-9.97)	(-9.96)	(-9.06)	(-5.75)
Skill endowment	-8.341	-9.809	-9.215	-15.743**	-1.628
	(-1.31)	(-1.48)	(-1.40)	(-2.25)	(-0.28)
Market potential	-0.022	-0.025	-0.025	-0.016	1.035*
	(-0.51)	(-0.59)	(-0.60)	(-0.37)	(1.85)
Access to coast	-0.001	-0.012	-0.010	-0.009	-0.010***
	(-0.21)	(-1.15)	(-1.05)	(-0.90)	(-2.60)
Agricultural intensity	-2.968***	-2.334***	-2.498**	-1.871*	-4.086***
	(-3.36)	(-2.83)	(-2.45)	(-1.65)	(-3.58)
Skill intensity	-3.496***	-3.332***	-3.396**	-4.039**	-18.668***
	(-2.88)	(-2.87)	(-2.47)	(-2.94)	(-3.39)
Intermediate share	-3.683	-6.544	-6.476	-5.634	11.713
	(-0.77)	(1.36)	(-1.37)	(-1.12)	(1.49)
Sales to industry	-0.792	-0.579	-0.647	0.027	-2.967
	(-0.64)	(-0.49)	(-0.50)	(0.02)	(-1.31)
FDI		-4.433***	-4.417**	-4.836**	
		(-5.14)	(-4.84)	(-5.00)	
Export	-3.124***		-0.230	0.869	-3.449***
	(-4.32)		(-0.15)	(0.44)	(-2.80)
R-square	0.653	0.660	0.661	0.628	0.552
Observations	630	630	630	630	580

Note: t-statistics are reported in parenthesis. ***, ** and * represent coefficient significant at the 1%, 5% and 10% level, respectively.

The intuition behind this specialization is the following: The variable of total regional population captures the regional size effect. The larger regions are expected to have a higher industry share. For interaction term *j*, we assume there is a cut-off level $\gamma[j]$ defining high and low abundance, and a benchmark level of $\varphi[j]$ defining high and low intensity. If $\beta[j]$ is positive, then the industries with a higher intensity (larger than $\varphi[j]$) will relocate into a region with a high abundance (larger than $\gamma[j]$), and out of the region with a low abundance (less than $\gamma[j]$).

Since information about industrial characteristics is not available for each year, we provide only the cross-section analysis on the determinants of industry location in 1985 and 1995. Expanding equation 3, we get the following estimating equation:

$$\begin{aligned}\ln(r_i^k) = \alpha + \beta\log(pop_i) + \sum_j \beta[j](X_i[j]Y^k[j]) - \sum_j \beta[j]\varphi[j]X_i[j] \\ - \sum_j \beta[j]\gamma[j]Y^k[j] + \sum_j \beta[j]\varphi[j]\gamma[j] + \varepsilon_i^k\end{aligned} \quad (4)$$

We estimate this equation by OLS, with White's heteroscedastic consistent error (White 1980). The results are reported in Table 7.

Columns 2 and 3 in Table 7 show the determinants of industry location in 1995 where foreign trade and foreign investment enter the regression separately. The sign of the estimated coefficients is the same as expected: The sign of the coefficients of industrial and regional characteristics is negative, and the sign of the coefficients of the interaction terms is positive. We are very interested in the coefficients of the interaction term between the share of foreign investment and access to foreign markets, and in the interaction term between export share and access to foreign markets. Both coefficients are positive and statistically significant at 5 per cent, which implies that industries that rely heavily on foreign trade and foreign investment tend to locate in regions with easy access to foreign markets. The coefficient of regional size is significant and positive, which implies that larger regions have a higher industrial share. The coefficient of the interaction term between agricultural intensity and agricultural abundance is significant and positive, which implies that industries with a high agricultural intensity tend to locate in regions with a higher agricultural endowment. The coefficient of the interaction term between skill intensity and skill abundance is significant and positive, which implies that industries with a high skill intensity tend to locate in regions with a high skill endowment. The coefficients of the interaction terms between domestic market potential and interindustry linkages are not significant.

When both export and foreign investment are included in the regression, export linkage becomes insignificant. The result is reported in Column 4 of Table 7. The coefficient of the interaction term between the distance to the coast and the export share in total output is negative and statistically insignificant after controlling for the effect of foreign investment. The reason might be that industries with a high share of foreign investment are also export oriented since FDI is the engine of export growth in China.[9] The correlation coefficient between the industrial export share and the foreign investment share is about 0.55, which implies a close link between FDI and exports.

There is a possible endogenous problem: first, if some omitted variables, such as policy variables, strongly affect both industry location and regional industrial characteristics, the coefficients estimated in the equation will be biased. Second, certain regional characteristics are possibly affected by the industry location. To mitigate this problem and to check the robustness of the result, we use the 1996 industrial provincial share as a dependent variable to estimate the same equation. The regional characteristics and industrial characteristics in 1995 could be treated as predetermined to the industry-location decision in 1996. The result is reported in Column 5 of Table 7. Compared to previous results, there is no change in the sign or significance of the

9 See Gao (2003) for details.

estimated coefficients. Three factors—agriculture endowment, skill endowment and access to foreign markets—have a positive and significant effect on the industrial provincial share.

As a robustness check, we perform the same exercise using the data for 1985. The results are reported in Column 6 of Table 7. Since the information on the industrial foreign investment share is not available for 1985, we only include the export linkage in the regression. The result is quite consistent with that of 1995 and supports our key hypothesis that industries with a high share of exports tend to locate in regions with easy access to foreign markets. Compared to China, a similar pattern is found in the case study of Mexico. For example, Hanson (1997, 1998) shows that foreign trade contributed to the breakup of the Mexico City manufacturing belt and to the formation of the new industry centres of the US-Mexico border. With trade liberalization, Mexican manufacturing industries were located toward northern Mexico with good access to the US market.

4.2 Determinants of industry agglomeration

The previous study provides direct evidence of the linkage between foreign trade and industry location: the industries relying heavily on foreign trade and foreign investment tend to locate in regions with easy access to foreign markets. This introduces an additional question: Does foreign trade encourage domestic industry agglomeration?

To answer this question, we adopt a specification similar to previous studies (Kim 1995; Amiti 1999; Rosenthal and Strange 2001; Bai *et al*. 2004) to explain the cross-industrial variation in the degree of geographic concentration. The dependent variable is the locational Gini coefficient of each industry, which is defined and calculated in

Table 8
Determinants of industrial agglomeration, 1985 and 1995

Dependent variables	Location Gini coefficients
Constant	-0.051 (-0.30)
Agricultural intensity	0.003 (0.03)
Skill intensity	0.877*** (2.33)
Intermediate share	0.110 (0.47)
Sales to industry	0.089 (0.99)
Scale	0.173** (2.13)
Export	0.443** (2.04)
Year dummy	Yes
R-square	0.35
Observations	38

Note: t-statistics are reported in parenthesis. ***, ** and * represent coefficient significant at the 1%, 5% and 10% level, respectively.

section 3.2. The independent variables are various industrial characteristics including agricultural intensity, skill intensity, intermediate inputs share, sales to industry, scale of industry and export dependence.[10] Due to data limitations, our observations include only the years 1985 and 1995. We pool these two years and report the result of the original linear square (OLS) regression in Table 8.

The results in Table 8 show that the share of export in total output has a statistically significant influence on industry agglomeration. The more the industry relies on export, the more concentrated it appears, which stresses the importance of the role played by trade-related agglomeration. Skill intensity also has a strong and positive effect on the degree of industry concentration, which is consistent with the previous finding that skill-intensive industries are more likely to locate in skill-abundant regions. While agricultural endowment is an important factor in industry location, agricultural intensity has an insignificant effect on industrial agglomeration. Consistent with the findings in Bai *et al*. (2004), our results also show that the degree of concentration is higher for large-scale industries. The inter-industry linkages, however, are less important in explaining cross-industry variation of agglomeration.

However, due to a potential endogeneity bias, the result of OLS estimation cannot identify the direction of causality between foreign trade and industry concentration.[11] While the export-oriented industries may concentrate towards regions with easy access to foreign markets, industry agglomeration may also positively affect the export propensity of industry. The geographic concentration of exporters or multinational enterprises may reduce the cost of foreign-market entry for nearby domestic firms through several mechanisms such as spillovers of foreign market information and international business skills, and the construction of an export-related infrastructure. Self agglomeration may be generated from the spillovers: When the exporters locate toward regions with easy access to foreign markets, the concentration of exporters will attract more exporters to this location. This positive spillover effect is identified by several empirical studies. For example, Aitken, Hanson and Harrison (1997) find that the presence of multinational exporters in the same state and industry increases the probability of exporting by Mexican firms. Clerides, Lauch, and Tybout (1998) also find that the presence of other exporters in the same regions makes it easier for domestic firms to enter foreign markets. The spillover effect in the case of China, which is not tested in this paper, may be an interesting topic for future study.

5 Conclusion

Openness to foreign trade and foreign investment is one of the competing explanations for the rising regional inequality in China. Globalization may encourage export-oriented industries to concentrate in regions with easy access to foreign markets, and that industry agglomeration increases regional disparity. This paper provides empirical

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[10] The scale of industry is defined as the average number of employees (1000 persons) per firm. The definition and statistics summary of these variables are reported in Table 6.

[11] Due to data limitations, we are unable to find suitable instrumental variables to address the endogeneity bias. Since we only have two-year observations, we are unable to control for the unobservable individual fixed effect.

evidence for the close linkage between regional inequality, industry agglomeration and foreign trade in China. First, our study shows that cross-regional differences in the production structure are an important source of regional inequality. A rising regional income inequality is accompanied by an increase in industry agglomeration. Second, we provide a direct test on the linkage between industry agglomeration and foreign trade. The evidence indicates that industries relying heavily on foreign trade and foreign investment tend to locate in regions with easy access to foreign markets. Industries with a high export propensity have a high degree of agglomeration. To further explore this linkage, firm-level data are required to examine the response of firm location choice to trade liberalization, the effect of industry agglomeration on firm export decisions, and the effect of industry agglomeration on local productivity in China .

Data appendix

To maintain consistency over time, we make a slight adjustment in the classification of two-digit manufacturing industries. For the 1990 classification, we drop two industries: forage and art. For the 1994 and 1999 classification, we combine food manufacturing and food processing into one industry. We drop two industries: nonferrous metal products and special equipment. There are a total of 25 manufacturing industries in our sample.

The data for employment and output of eight manufacturing industries in 1999 are not reported in the *China Industry Economy Statistical Yearbooks*. These industries are garments and other fibber products, leather, furs and down, timber processing, furniture manufacturing, print and record medium reproduction, stationery, educational and sport goods, rubber and plastic products. We compile the information for industrial employment, output and value added from the provincial statistical yearbooks of 2000.

The three geographic zones are divided as follows: the eastern coastal area includes nine provinces: Liaoning, Hebei, Shandong, Jiangsu, Zhejiang, Fujian, Guangdong, Guangxi, Hainan, and three municipalities: Beijing, Tianjin and Shanhai. The central area includes nine provinces: Heilongjiang, Jilin, Inter-Mongolian, Shanxi, Henan, Hubei, Hunan, Jiangxi, Anhui. The western area includes nine provinces: Shanxi, Ningxia, Gansu, Xinjiang, Qinghai, Sichuan, Guizhou, Yunnan, Xizang. In 1997, Congqin City separated from Sichuan province as a fourth municipality. We still include it in Sichuan Province for consistency.

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