Economic Opening and Industrial agglomeration in China

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Abstract:
This paper explores the causes of industrial agglomeration in China using the provincial panel data during 1987-2001, focusing on the effects of economic opening. The determinants of industrial agglomeration are tested by controlling three types of factors, those of economic policies, economic geography and new economic geography, respectively. In summary, we find: (1) Economic opening, which is also related with geography and history encourages industrial agglomeration; (2) Large market size, effects of forward and backward linkage, high level of urbanization, better infrastructure and less involvement of local government tend to facilitate industrial concentration; (3) Costal regions have geographical advantage in attracting firms. These findings not only support the new economic geography theory from evidence within China, but also emphasize the important role that policies like economic opening might directly play in industrial agglomeration. The most important policy implication of this paper is that by quickening up the step of integrating into world economy and deregulating, even those less developed regions might accelerate industrial agglomeration and thus decrease regional disparity.

Key words: Industrial Agglomeration, Economic opening, New Economic Geography, Provincial Panel Data

JEL classification: L60; O18

1. Introduction

Since the launching of economic reform in the late 1978 China has been fast integrating into the world economy at a pace as remarkable as its economic growth. While the role of opening-up in growth and inequality in China has widely been studied (Kanbur and Zhang, 2005; Wei and Wu, 2003; Zhang and Zhang, 2003; Wan, Lu and Chen, 2004), there is little publication on how openness and industrial agglomeration is related in China. However, focusing on industrial agglomeration in China requires little justification. Industrial agglomeration has significance for economic efficiency and regional development. In addition, given the fact that regional disparity is now a great concern in China, the pattern and causes of industrial agglomeration would have great policy implications to policy makers.

This paper draws some new light on how Chinese industries have been gradually relocating and concentrating with economic forces and relevant policies, particularly, economic opening. Fujita and Hu (2001) and Kim and Knaap (2001) both investigated some potential factors that relate to China's industrial agglomeration, however, neither of them did further econometric work. According to the new economic geography theory, Wen (2004) has investigated the determinants of industrial agglomeration in China in 1992. Apart from Wen's work, this paper uses provincial panel data and tries to investigate what potential factors contributed to the industrial agglomeration in China keeping eyes not only on new economic geography factors but also those of geography and policies, especially economic opening.

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Secondly, this study also relates to the heated debate on globalization and inequality. Different theories and empirical analysis often reach contrasting results about whether trade or economic liberalization leads to greater concentration of economic activity or greater disparity (Krugman, 1993; Venables, 1998; Sachs and Warner, 1995). Evidence from China and other transitional economies shows that globalization leads to increases in inequality. Wan, Lu and Chen (2004) provide evidence from China that economic opening results in dispersal in international trade and FDI, and thus regional disparity. Since higher regional share in industrial GDP always causes higher share of GDP (Wen, 2004), this paper suggests that trade may increase inequality by contributing to industrial agglomeration, which is less emphasized by existing literatures.

Finally, this paper contributes to the literature by drawing a picture of industrial agglomeration in China and exploring its causes using the provincial panel data during 1987-2001. To elaborate further, firstly our work provides some empirical evidence for the new economic geography theory. Since Krugman (1991), the framework of new economic geography has come into being, where standard building blocks of mainstream economics are used to model the trade-off between dispersal and agglomeration. New economic geography models stress the importance of transportation costs, "home market effect" and backward and forward linkages (Fujita 1988; Krugman, 1991). They have actually explained agglomeration in a theoretical framework that is tractable, has solid micro foundations, and makes testable empirical predictions. However, there is only a small number of empirical works that builds directly on the new economic geography framework. For example, Combes and Lafourcade (2000) use a data set from mainland France and find that when allowance is made for intermediate inputs, transport costs have a significant impact on specialization patterns in nearly all sectors.

The outline of the rest of the paper is as follows. Section 2 presents some stylized facts of economic opening and industrial agglomeration in China since 1987. Section 3 provides a framework to analyze three groups of factors contributing to industrial agglomeration, i.e. economic policies, economic geography and new economic geography respectively. Econometric model and data explanation are also presented in this section together with empirical results. Finally, policy implications are discussed in Section 4.

2. Economic opening and industrial agglomeration in China: some stylized facts[1]

Since China launched economic reform in the late 1978, its economy has gradually opened up to the rest of the world with increasing foreign capital inflow and international trade. Meanwhile, China's industries have relocated from a political-oriented pattern into a market-oriented one and there does exist a trend of industrial agglomeration since the reform.

Growing international trade

Before 1979, international trade was under the plan of the central government, which controlled more than 90% of trade by monopolizing the imports and exports of over 3000 kinds of commodities. However, international trade was liberalized step by step during reform. By 1991, almost all exports were deregulated, with only 15% controlled by specially appointed trading companies. Imports have also been deregulated. The proportion of plan-commanded imports in the total import volume was reduced from 40% in 1985 to 18.5% in 1991[2]. By 1994, almost all planning on imports and exports were abolished with a few exceptions.

In pre-reform China, tariff was high and represented the only form of protection. When China initiated

[1] Most of this section is written based on Wan, Lu and Chen (2004).
[2] Commodities under control can be classified into two categories: plan-commanded goods (both the value and volume of trade were strictly controlled) and plan-guided goods (only the value of trade was controlled).

significant trade reforms in 1992, the rates of tariff remained high, averaged at 44.05%. Since 1992, China has cut its tariff rates substantially every year. The average tariff rate fell to 17.1% in 1998 (Yin 1998, p. 126). On the other hand, non-tariff barriers were introduced in the early 1980s. Subsequently, an increasing number of goods were placed under licensed trading and quota. In 1992, some 25% of imports and 15% of exports were managed under licenses. However, the scope of license and quota management has been narrowed down since 1992. By 1997, only 384 categories of imports, a mere 5% of the total, were managed under quota and licenses (Yin 1998, p. 129).

Due to the trade liberalization, both exports and imports have experienced remarkable growth. The growth trend was maintained even during the Asian financial crisis. In 1978, China ranked 32nd in the world in terms of international trade. The ranking improved to 15th in 1989, 10th in 1997 and 6th in 2001. The ratio of international trade to GDP also rose from 9.80% in 1978 to as high as 49.03% in 2002. In 2002, total trade exceeded US$600 billion, representing about 50% of China's GDP.[1] This places China as the 5th largest trader in the world. The same also happens to export. The ratio of export to GDP rose from 4.62% in 1978 to 25.72% in 2002. In passing, it is noted that export of manufactured goods has accounted for a larger and larger share since the mid-1980s, while the corresponding import has declined though at a slow rate. Clearly, China has been industrializing and is becoming a major exporter of manufactured commodities.

[Figure 1 about here]

Increasing cross-boarder capital flows

In 1979, three Special Economic Zones (SEZs) were set up in Guangdong for attracting FDI.[2] However, not until 1984 did FDI start to pour in when twenty-four additional SEZs were opened. Since that time, more and more SEZs are developed to attract FDI and technology transfer, and to enhance exports. The second wave of FDI inflow occurred in 1992 when Deng Xiaoping made the well-known tour of South China.

For many years China was the largest recipient of FDI among developing countries, and the second largest in the world since 1993, next to the United States. In 2002, China attracted US$52.743 billion of FDI and became the number one in the world. The ratio of FDI to GDP was as high as more than 4% in 2002. Actually FDI closely relates to import and export in China since many foreign invested firms are export-oriented and sometimes involve in importing from overseas markets. Meanwhile, a large amount of foreign loans has been utilized in various areas of development.[3] Also, China has seen an impressive growth of capital outflows in recent years, owing to the rapid growth of domestic enterprises. China's investment abroad nearly tripled from US$2562.49 million in 1997 to US$6885.398 million in 2001.

Further opening up after WTO accession

Since becoming a member of the WTO, China has taken several steps to promote economic opening. The first day of 2002 saw China cut average tariff rate to 12% from a level of 15.3% in 2001. Particularly, the rate for manufacturing goods was reduced from 14.7% to 11.3%. At the same time, China abolished quota and license arrangement for grains, wool, cotton, chemical fertilizers, and so on. Looking into the future, the tariff rate will be cut further and non-tariff barriers will be removed for most manufacturing goods.

In addition, laws and regulations are abolished, modified or newly issued in accordance with rules of

[1] Unless indicated otherwise, data quoted in this section are all from the State Statistics Bureau of the PRC(SSB) (various years).
[2] See Table 3 in Démurger *et al.* (2002) for the timeline of policy initiatives.
[3] Stock market represents another avenue for attracting foreign capital.

WTO. Small-and medium-sized enterprises and foreign-owned companies are now entitled to participate directly in international trade. Laws on anti-dumping and anti-subsidy have been implemented since 1 January 2002. New laws and regulations concerning service trade, covering legal service, telecommunication, financial institution, insurance, audio and video products, tourism and so on have been issued around China's entry into the WTO. Also, measures have been taken to ensure compliance with rules of the WTO on intellectual property, foreign investment, and information transmission.

While China is fast integrating into the world economy, different regions are not doing the same job due to significant regional heterogeneity. Actually, export or trade increases faster in costal regions in general during the reform. This is shown in Figure 2 with the ratio of regional export/GDP (or trade/GDP) to the national average in selected years, which is a proxy for openness in this paper. Next, we investigate this regional disparity in more details by looking into the evolution of industrial agglomeration in different regions.

[Figure 2 about here]

Regional industrial agglomeration during reform

The following historical comparison of the regional share in industrial GDP might help us draw a picture of the extent of industrial agglomeration since economic reform and get to know how industries have been relocating from former industrial bases to new industrial cores.

In 1987 when the reform in industry sector was launched, the coefficient of variance of regional share in industry was 0.026, which increased to 0.030 in 2001, suggesting that industries have become more geographically concentrated following the economic reform. However, the industrial cores today are not the same when the reform began. The following four graphs illustrate the spatial characteristics of the regional share in industrial GDP in China in 1978, 1987, 1995 and 2001 respectively.[1] A trend of agglomeration could also be seen in the figure; however, there are more details to tell. As figure 3(a) shows, in the beginning of the reform Chinese industry was not as concentrated as that in 2001 particularly in following four aspects. (1) The industrial shares of some costal provinces, such as Zhejiang and Fujian were very low, both less than 4%. (2) Two western provinces, Gansu and Shaanxi both had more than 2% in industrial GDP, which made them be in the same group with most eastern provinces at that time. (3) In 1978, the Chinese industry was also highly geographically concentrated in three northeastern provinces, Heilongjiang, Jilin and Liaoning, especially in the Eastern Liaoning Peninsula. (4) The three autonomous municipal cities had high share in industrial GDP relative to their territories. To large extent, this is the consequence of historic events and development strategies with political concerns. The impact of Japanese occupation of the northeastern China and the effect of leasing territories to foreigners in some costal areas might explain the higher level of industrial agglomeration in northeastern China, Shanghai, Shandong and Tianjing. The inland development policies with political concerns adopted in the first five-year plan might explain why some western provinces like Gansu and Shaanxi had higher share in Industrial GDP than some costal provinces at that time.

However, China's industrial location has substantially changed since the economic reform with open-door policies. This process can be seen from the following four figures and especially figure 3(d). Compared with figure 3(a), figure 3(d) shows that shares in industrial GDP in costal provinces significantly increased. Particularly, industry shares in Guangdong, Jiangsu, Shandong and Zhejiang have increased to 11.20%, 10.11%, 9.69% and 7.35% respectively in 2001. Meanwhile, shares in

[1] Taiwan and Tibet are blank because data are unavailable. Industrial GDP of Chongqing is merged into that of Sichuan in figure 3(d), thought we have not done so in the following descriptions and econometric analysis since data of Chongqing before 1997 are not available.

industrial GDP in northeastern and western China and three autonomous municipal cities [1] have decreased except Sichuan. In short, the trend of agglomeration could be indicated by the fact that in 1978, there were only 11 provinces with less than 2% share in industrial GDP and 2 regions with more than 8%, yet in 2001, the numbers became 16 and 3 respectively.

[Figure 3 about here]

It is also shown by figure 3 that during the reform, more and more industries have relocated into Yangtse River Delta, Pearl River Delta and Bo Hai belt.[2] Table 1 shows that the first four provinces with highest share in industrial GDP are all within the above mentioned 3 great regions. However, within these regions, Guangdong seems to be the most attractive location due to the impact of Hong Kong and its earlier open-door policies, while Liaoning has been replaced by Shandong as a leading industrial base in Bo Hai belt. And the Yangtse river delta is keeping its role as the largest industrial base in China, which is leading in both light and heavy industries including textile, garment, machinery, electron, steel, automobile and petrochemical. Wen(2004) has sorted those cities with the first and second highest share in industrial GDP in the twenty five industrial sectors in 1995, roughly half of them are in the Yangtse river delta. Actually, in 2001 30.23% of total industrial output in China was conducted in Yangtse river delta. In brief, more industries were concentrated in fewer and geographically closer regions in 2001, which indicates the trend of industrial agglomeration in China during the reform.

[Table 1 about here]

3. Determinants of the agglomeration of Chinese industry

Different factors might explain the substantial changes of spatial location of Chinese industries. In this section, we will discuss three groups of factors respectively and test some related hypotheses to find out the determinants of industrial agglomeration in China. Particularly, we will test if economic opening plays a significant role in shaping industrial agglomeration.

3.1 Economic policies, economic geography and new economic geography

According to traditional economic geography theory, geographical factors play the main role in determining industrial agglomeration. For instance, those close to natural resources and major ports will probably become industrial centers with higher level of industrial agglomeration. We can find such cases in China. Say, Liaoning and Shanxi used to be two important industrial centers in China because of their abundant natural resources.

However, traditional economic geography theory cannot explain some important findings about industrial localization. First, some regions with less geographical advantage may attract more industries. Second, those with similar geographical conditions might be substantially different as far as agglomeration is concerned. For instance, Zhejiang has no advantage in resource endowment compared with Fujian, however, its share in industrial GDP is keeping increasing much faster than that of Fujian. Similarly, Guangdong and Guangxi are very alike geographically, however Guangdong has become an important industrial center during the reform while Guangxi is far lagged behind.

Economic policies might be one of the explanations for such kind of observation. When industrial reform as well as open-door policies began in China, priority was given to some costal regions by

[1] As mentioned above, Chongqing, the newly established autonomous municipal city, is calculated together with Sichuan in 2001.
[2] Yangtse River delta includes Jiangsu, Zhejiang and Shanghai. Pearl River Delta includes Guangdong. Bo Hai belt includes Beijing, Tianjing, Hebei, Liaoning and Shandong.

establishing four special economic zones in Guangdong and Fujian in 1980 and 14 open coastal cities later on. Consequently, these regions attracted not only early foreign investment but also domestic investment, which result in fast increase of shares in industrial GDP. Economic opening might also contribute to industrial agglomeration indirectly. For instance, local infrastructure will probably be much improved in order to attract more FDI, which consequently make it more attractive for firms. What's more, economic opening always bring better management and technology to local firms through FDI, which also help attract more firms. The extent that local government interferes in the market might also have impact on industrial concentration. The more local government interferes, especially in pre-reform economies like China, the less attractive the region is to investment, and consequently the less industrial concentration there will be. We will test such kind of hypothesis in this section. Some existing literatures also indicate that economic policies do have impact on regional development in China, though agglomeration is not investigated in these studies (see Kanbur and Zhang, 2005; Démurger et al., 2002).

However, there is another possible explanation that can never be neglected, which is emphasized by new economic geography theory. By assuming increasing returns, which borrows from the new international trade theory, the new economic geography theory does tell us a story different from the traditional one. Giving two geographically similar regions, it implies that industrial concentration might begin by chance in one region, and because of the increasing return it will continue to attract industries as long as the inter-regional transaction cost is not high enough to segment the two regions and thus result in industrial agglomeration. According to the framework of new economic geography, following factors are essential to industrial agglomeration. (1) Number of firms. Because of the forward and backward linkage, the larger number of firms in one region, the greater the firms can benefit from easy access to raw materials and local markets. So, firms tend to cluster geographically. (2) Local stock of human capital. The more stock of human capital, the less cost needed to invest in R&D and the easier to gain from innovation. (3) Market size. Firms tend to agglomerate where the regional market size is large. Other things equal, the size of the local market will be larger, given the higher per capita income and the larger population size. (4) Trade costs. Trade costs are one of the core parameters in new economic geography theory. Lower trade costs, such as lower transaction or transportation costs will encourage industrial concentration.

What should be emphasized is that new economic geography theory does leave space for other factors such as economic policies and geography to play their roles. As stated by Neary (2001), when trade costs are in certain range, both agglomeration and diversification are possible equilibriums, so history and policy have a potential role in influencing which equilibrium prevails. Accordingly, in this paper we will test the roles of both policies and history in influencing agglomeration, which have not been given enough emphasis to in recent studies, for example, in Wen (2004). In more details, the open-door policies implemented in Pearl River delta at the early stage of the reform might explain why the two geographically similar provinces, Guangdong and Guangxi, could be totally different in attracting industries. The urban preferential policies result in more education and infrastructures in eastern China, which has higher level of urbanization, and consequently, eastern China might attract more industries than elsewhere. A similar case is Mexico during the North American Free Trade Agreement (NAFTA) period, which saw a trend of industrial concentration towards regions bordering the USA (Rodríguez-Pose et al, 2003).

In the next sub-section we will test the impact of economic policies, economic geography and new economic geography on industrial agglomeration in China. Before that, it is worth mentioning that economic policies might affect industrial agglomeration both directly and indirectly. As far as economic opening is concerned, preferential policies in those open costal cities would probably directly help attract firms. What's more, economic opening might also help lower transaction cost and enlarge market size thus help attract firms indirectly through the mechanism of increasing returns in new economic geography theory. And since economic policies are usually self-enforcing once implemented, such kind of impact will not disappear in short run. For instance, since the early

marketization process, further privatization and deregulation have never been stopped in Zhejiang province, which continuously encourage the private sector and hence stimulate industrial agglomeration.

3.2 Econometric model and data explanation

The model we use adopts the following form:

$$Y_{it} = \alpha_0 + \alpha_1 X1_i + \alpha_2 X2_{i,t-1} + \alpha_3 X3_{i,t-1} + \varepsilon_{it} \quad (1)$$

where Y_{it} is the regional share in industrial GDP for region i in year t, which measures regional industrial agglomeration as in Wen (2004). Vector $X1_i$, $X2_i$ and $X3_i$ represent three types of factors affecting industrial agglomeration in China, economic policies, economic geography and new economic geography respectively. To minimize the simultaneity error, $X1_i$ and $X3_i$ are both made pre-determined before realization of Y_{it} by lagging one year. α_0, α_1, α_2, α_3 and ε_{it} are constant, vectors of coefficient and error term respectively.

The provincial panel data we use in this paper are compiled from *Comprehensive Statistical Data and Materials for 50 Years of New China*, as well as various issues of *China Statistical Yearbook*, both published by the State Statistics Bureau of the PRC (SSB). Please see the Appendix for details on data construction. Largely due to the incompleteness of some data, the modeling exercise is confined to the period of 1987-2001. With Taiwan, Hong Kong and Macao excluded, there are 31 provinces or regions in China, including four autonomous municipal cities. Tibet and Chongqin are excluded because of lack of complete data. Therefore, a total of 29 regions will be covered in this study. Other variables are grouped into three types as follows.

(1) Economic policies

As argued above, economic polices have their spatial impacts in China. Particularly, we will test the impact of two types of policies on industrial agglomeration, economic opening and the local government involvement in economic activities. Regional economic opening is represented by *export* (or *trade*), which is the ratio of regional export/GDP (or trade/GDP) to the national average. Obviously, *export* or *trade* is expected to encourage regional industrial agglomeration. The ratio of regional share of government expenditure[1] in GDP to the national average (*gov*) serves as a proxy of local government involvement in economic activities, which we expect to discourage regional industrial agglomeration, since the government involvement in the planned economy has distorted resource allocation as described in section 2.[2]

It is worthwhile to explainthat although the variance of the above mentioned policy proxies among regions and periods make panel data ideal for testing the impact of policies, those proxies might be the result of some unobserved variables other than policy itself. In order to minimize the estimation bias from such kind of endogeneity problem, *export* and *trade*, which are proxies of economic opening, are instrumented in our estimation. Two instrumental variables are used. One is the ratio of regional export/GDP (or trade/GDP) to the national average in 1978 (*export78* or *trade78*). The other

[1] In the economic growth literature, the government consumption is represented by the share of government expenditure excluding education and defense fees in GDP. Here we use the similar definition, except that defense fee is not included in the local government expenditure and expenditures for culture, education, science and healthcare instead of education are excluded, which we believe are very similar.

[2] Privatization is also a great issue during China's reform, which according to existing theories is not certainly related to regional industrial agglomeration. However, in this study we do have tested the impact of the privatization of SOEs on industrial agglomeration, which is represented by the ratio of regional share of workers in non-state owed enterprises to the national average. However, it is not significant and the regression result will not change without this variable. So, it's not included in our report.

is the distance from provincial center to Shanghai or Hongkong[1] (*port*), whichever is the nearer. These two instrumental variables catch the impact of history and geography on openness respectively, and actually reflect the indirect impacts of history and geography on regional industrial agglomeration.

(2) Economic geography

We will control economic geography by two dummy variables. The region dummy *Coast* is used to distinguish costal regions from the others. The *city* dummy is used to distinguish three autonomous municipal cities[2] from provinces. As in most of the studies on regional disparity in China, we use dummy to distinguish costal and inner regions rather than eastern, central and western regions. This is because as far as geography, history and policy preference are concerned, there exists significant difference between costal and inner regions, however western and central regions are very similar. We expect costal regions to have higher level of industrial agglomeration. Since autonomous municipal cities serve as political or commercial centers compared with other regions, we expect the *city* dummy negatively relates to regional share in industrial GDP.

(3) New economic geography

The new economic geography theory challenges neoclassical economics by stressing the importance of externality based on industrial backward and forward linkages, human capital accumulation (Henderson, 1974) and "home market effect" (Fujita 1988; Krugman, 1991) in the trade off between agglomeration and dispersal. In order to test these factors that all base on increasing returns, we include the following variables into the econometric model: (i) The regional share in manufacturing firms (*firm*), which measures relative industrial externality; (ii) The ratio of regional average years of schooling to the national average (*edu*), which serves as a proxy for regional comparative advantage in human capital. Since the incompleteness of the data, we use the estimated regional average years of schooling in Wan, Lu and Chen (2004); (iii) The ratio of the logarithm of regional per capita GDP to the national average (*pergdp*), which measures the relative capacity of local market[3]; (iv) Urban development. Here we use the ratio of share of nonagricultural population to its national average (*urban*) as a proxy, which we think better represents the regional infrastructure than number of the cities in the region does in Wen (2004); (v) Transaction cost, which in this study is represented by two variables. One is the ratio of the share of regional transportation, post, storage and telecommunication in GDP to the national average (*com*), which captures development of information and communication service. The other is regional share in length of highway[4] (*road*), which measures condition of transportation. Since lower transaction cost helps attract firms, these two variables should be positively related to regional share in industrial GDP.

3.3 empirical results

Table 2 reports the results of determinants of regional share in industrial GDP for the period during

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[1] Only two ports are included here because they are the two largest and most important ports in China. Shenzhen is not included because it actually borders Hongkong. Such kind of instrumental variable is also used by Wei and Wu (2001).

[2] Beijing, Tianjin and Shanghai.

[3] Regional population is another important factor that determines local market size according to new economic geography theory. However, in our data set, local population is significantly correlated with the other two explanatory variables, *road* and *firm*, (the correlation coefficients are 0.7024 and 0.7196 respectively). If we include regional population into the control variables in the basic regression equation shown in table2, *firm* will become insignificant because of the multicollinearity problem. Since *firm* here is an irreplaceable explanatory variable, which we use to test industrial externality and population could to large extent be replaced by *pergdp* to test the home market effect, we have dropped population in the equation.

[4] The length of railway is not included here, since the data unreasonably fluctuates due to serious measurement errors.

1987-2001 on three types of explanatory variables. Five models are performed. The first two models include all the independent variables and are estimated by random effects and fixed effects respectively. According to the Hausman test, the random effects assumption could be accepted here. In addition, *export* is a proxy for economic opening in both two models, and we will use *trade* instead of *export* later to do a robust test in model 5. Model 3 is estimated by radon effects, where *export* is instrumented by *export78* and *port*. However, no significant endogeneity bias is found according to Hauseman test. In model 4 where the insignificant variable (*edu*) is not included, all other independent variables still remain significant and keep their coefficients almost unchanged. In addition, according to the Hausman test, the random effects assumption is still acceptable and there does not exist significant endogeneity bias with *export*. In model 5, economic opening is measured by *trade* rather than *export*, where random effects model is again accepted and no significant endogeneity bias is found. Interestingly, when checking whether *trade78* and *port* could serve as efficient instrumental variables for economic opening (*trade*) in combination with other variables, we found that *port* is no longer significantly related with *trade*. That is to say, export rather than trade that includes both export and import, is closely related with the distance to major ports.

The models in table 2 indicate that the result of estimation in model 1 is robust. According to model 1, industrial agglomeration may be well explained together by economic geography, new economic geography and economic policies. That also implies industrial development and agglomeration is a compound process and a reliable empirical study should consider all these factors. The results of estimation are concluded as follow.

(1) Economic policies

The two variables of economic policies have robust and significant coefficients in model 1. The positive coefficient of economic opening, whether measured by *export* or *trade*, implies that the export-orientated development policy in developing economies may encourage industrial agglomeration. When using instrumental variable, we found that industrial agglomeration is indirectly and significantly related with history and geography through economic opening. That is to say, openness in the beginning of the reform (*export*78 or *trade78*) as a historical factor has significant effect on economic opening measured by *export* or *trade* respectively. In addition, *port* as a geographical factor has significant effect on economic opening measured by *export*.[1] However, *port* has no significant effect on economic opening measured by *trade*. This is probably because export and export-oriented industries, rather than import are closely related with geographical factor, or because historical factor has too strong influence on trade, and geography plays a less important role in determining openness in such a short period sine the reform. As we have expected, local government involvement in economic activities has significant yet negative influence on industrial agglomeration.

(2) Economic geography

According to regression 1, costal regions tend to have higher industrial share, which is probably because those regions are closer to international markets. In addition, since the autonomous municipal cities have entered the post industrialization era, they tend to have lower level of industrial agglomeration.

(3) New economic geography

[1] In the study of the history of city development in Japan, Davis and Weinstein (2002) found that basically economic agglomeration and size of cities are determined by geographical factors (mainly location) and even great shocks in short run (like the change of city size due the blast from A-bomb in world war II) have no significant impact on city size in long run. Similarly, as to our study, geography might be the overwhelming factor that determines regional openness in the long run.

Our study does confirm new economic geography theory in explaining China's industrial agglomeration during 1987 to 2001. The positive effects of per capita GDP and number of firms on regional industrial share are both highly significant. Hence, per capita GDP as potentials of market size (the "home market effect" in Krugman (1991)) and number of firms as industrial externality are both determinants of industrial agglomeration. The effect of regional human capital on industrial agglomeration is insignificant though not negative in our regressions. This might because, generally speaking, industrialization in China is still at the initial stage, which is not strongly subject to human capital stock. Finally, improved urban development, better transportation condition and intensive use of information all have positive and significant effect on industrial agglomeration.

[Table 2 about here]

4. Conclusions and Policy implications

There is an evident trend of industrial agglomeration in China since economic reform, which is a result of economic geography, new economic geography and economic policies as well. Our estimation of determinants of industrial agglomeration in China indicates that: (1) Economic opening, which is also related with geography and history encourages industrial agglomeration; (2) Large market size, effects of forward and backward linkage, high level of urbanization, better infrastructure and less involvement of local government tend to facilitate industrial concentration; (3) Coastal regions have geographical advantage in attracting firms.

These findings not only support the new economic geography theory from evidence within China, but also emphasize the important role that policy itself might directly play in industrial agglomeration. Since to large extent industrial concentration among regions causes regional disparity, our study provides the government with some policy suggestion. For instance, by improving condition of transportation and facilities of information and communication, local government might attract more firms and hence develop local industries. More importantly, by quickening up the step of integrating into world economy and deregulating, even those less developed regions might accelerate industrial development and thus decrease regional disparity.

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Data appendix:
(1) Unless indicated otherwise, data for the period 1987-1998 are all from *SSB* (1999). Data for years 1999-2002, unless indicated otherwise, are from *China Statistical Yearbook, 2000 - 2003* (SSB, various years).

(2) *export* = $\dfrac{\text{export}_i / \text{GDP}_i}{\frac{1}{29}\sum_i \text{export}_i / \text{GDP}_i}$ i = 1, 2, …, 29

(3) *trade* = $\dfrac{\text{trade}_i / \text{GDP}_i}{\frac{1}{29}\sum_i \text{trade}_i / \text{GDP}_i}$ i = 1, 2, …, 29

(4) *gov* = $\dfrac{\text{government expenditure / GDP in region } i}{\frac{1}{29}\sum_i \text{government expenditure / GDP in region } i}$ i = 1, 2, …, 29

Expenditures for culture, education, science and healthcare are not included in the government expenditure.

(5) *port* = min{distance from provincial center to Shanghai, distance to Hongkong}
Distance from provincial center to Shanghai and Hongkong are from *China electronical map for transportation & tour* (Beijing: Tuling software technology company)

(6) *coast*
Tianjing, Hebei, Liaoning, Shanghai, Jiangsu, Zhejiang, Fujian, Shandong, Guangdong, Hainan and Guangxi are coastal cities. Beijing is also treated as coastal city in this paper since Beijing is very close to Tianjing port and has many preferential policies as the capital city. Others are inner *provinces*, including Shanxi, Inner Mongolia, Jilin, Heilongjiang, Anhui, Jiangxi, Henan, Hubei, Hunan, Sichuan, Guizhou, Yunnan, Shaanxi, Gansu, Qinghai, Ningxia and Xinjiang.

(7) *firm* = $\dfrac{\text{number of firms in region}_i}{\sum_i \text{number of firms in region}_i}$ i = 1, 2, …, 29

Data for the number of firms are from *China Statistical Yearbook* in each year.

(8) *edu* = $\dfrac{\text{average years of schooling in region } i}{\frac{1}{29}\sum_i \text{average years of schooling in region } i}$ i = 1, 2, …, 29

China Population Yearbooks report regional population by education attainment from 1987. Unfortunately, such data were not published for 1989, 1991 and 1992, and data for 1987 and 1988 are incomplete as illiterate population are not reported. Also, unlike data for other years, the 1994 data did not consider population below the age of 15. To estimate data for these years, we compute average years of schooling (education) using data for the other years and then fit the model:

$$\ln(\text{education}) = f(\cdot) + \mu,$$

where edu is per capita years of schooling, $f(\cdot)$ is simply a linear function of time trend and regional dummies, μ the error term. This model is estimated by GLS technique, allowing for heteroskedasticity in the panel data. The R^2 of the estimated equation is 0.966. Denote the predicted value by ^, we have:

$$\hat{\text{education}} = \exp[\ln(\hat{\text{education}})]\exp(0.5\hat{\sigma}^2),$$

where $\ln(\hat{\text{education}})$ denotes the predicted values of $\ln(\text{education})$ and $\hat{\sigma}^2$ is the estimated variance of μ. Data for 1987-89, 1991, 1992 and 1994 are estimated by the above model.

(9) *pergdp* = $\dfrac{\text{per capita GDP}_i}{\frac{1}{29}\sum_i \text{per captia GDP}_i}$ i = 1, 2, …, 29

Regional per capita GDP is the weighted average of urban and rural per capita GDP, with non-agricultural and agricultural population shares as weights. Both urban and rural GDP are deflated by regional urban and rural CPIs. For Shanghai, Beijing and Tianjin, urban and rural CPIs are the same.

(10) *urban* = $\dfrac{\text{urbanization in region } i}{\frac{1}{29}\sum_i \text{urbanization in region } i}$ i = 1, 2, …, 29

Urbanization is defined as the proportion of non-agricultural population in the total in each region. Except for Hebei, Heilongjiang and Gansu, 1999-2001 data of agricultural and non-agricultural population are from provincial statistical yearbooks. Total population of Hebei, Heilongjiang and Gansu in 2000 are from *China Statistical Yearbook, 2001*. For these three regions, the 1999 population data are the averages of the neighbouring two years, and the 2001 data are forecast based on data in 2000 and the growth rate during 1999-2000.

(11) *com* = $\dfrac{\text{GDP of transportation, post, storage and telecommunication /GDP in region } i}{\frac{1}{29}\sum_i \text{GDP of transportation, post, storage and telecommunication /GDP in region } i}$ i = 1, 2, …, 29

(12) *road* = $\dfrac{\text{lenth of highway in region } i}{\sum_i \text{lenth of highway in region } i}$ i = 1, 2, …, 29

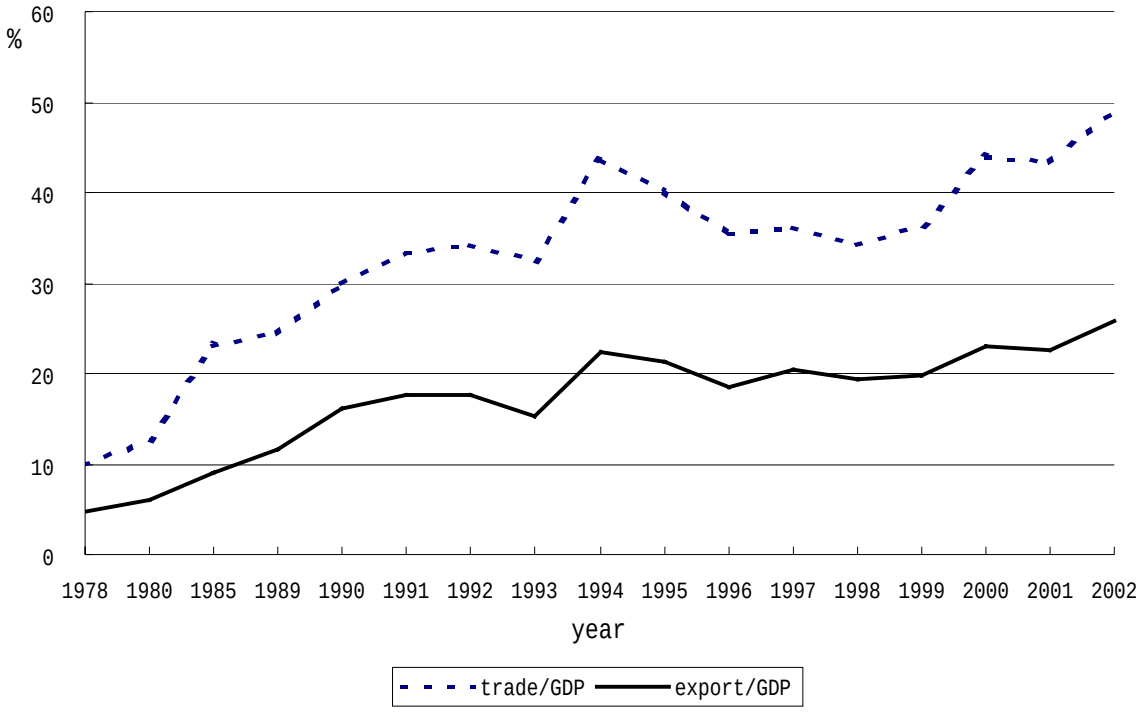

Figure 1 ratio of trade (or export) to GDP, various years.

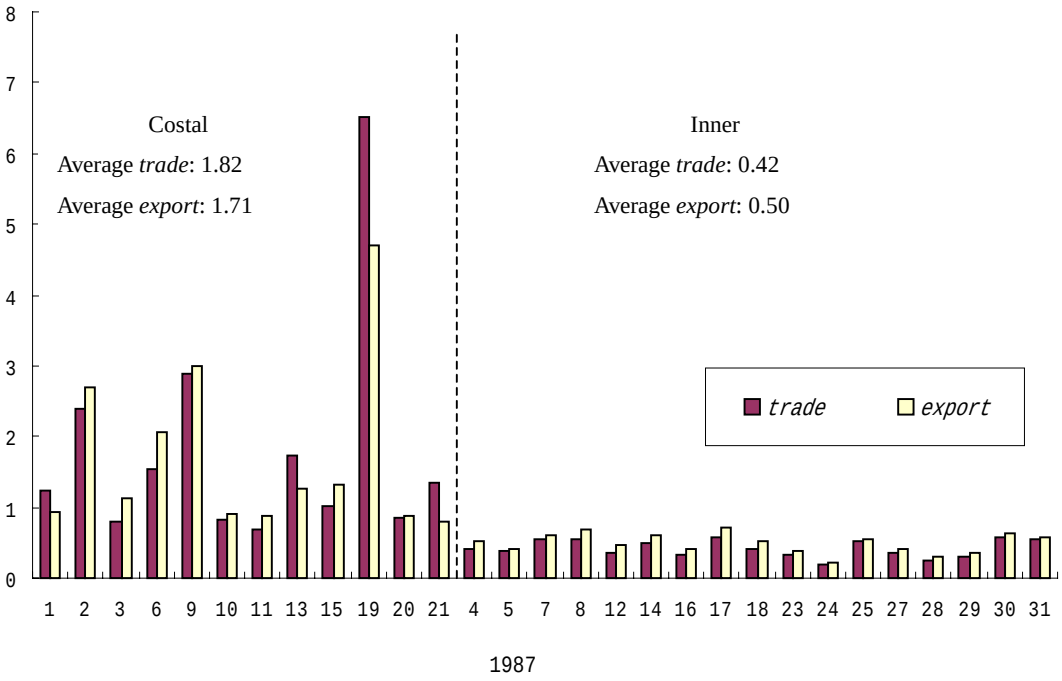

Figure 2(a) ratio of regional export/GDP (trade/GDP) to the national average, 1987

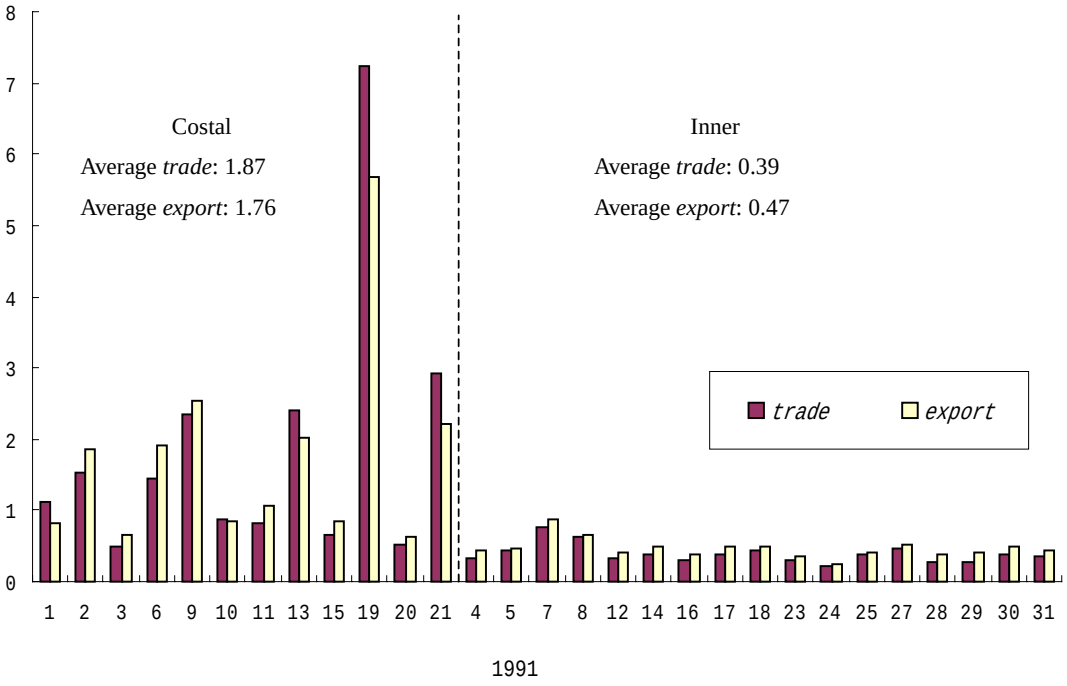

Figure 2(b) ratio of regional export/GDP (trade/GDP) to the national average, 1991

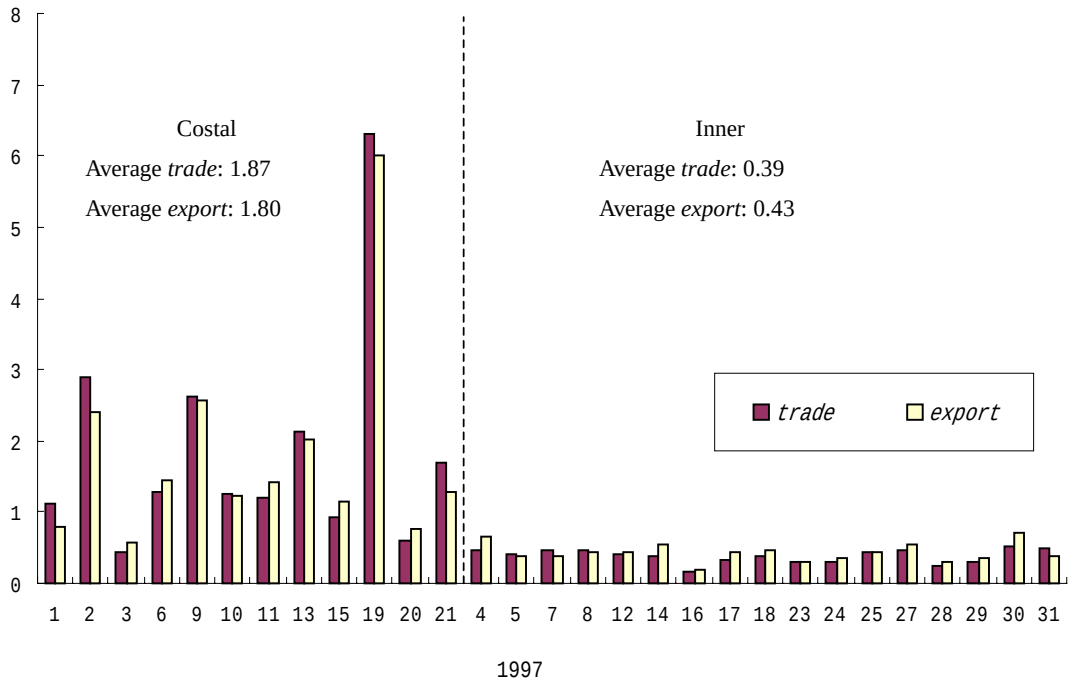

Figure 2(c) ratio of regional export/GDP (trade/GDP) to the national average, 1997

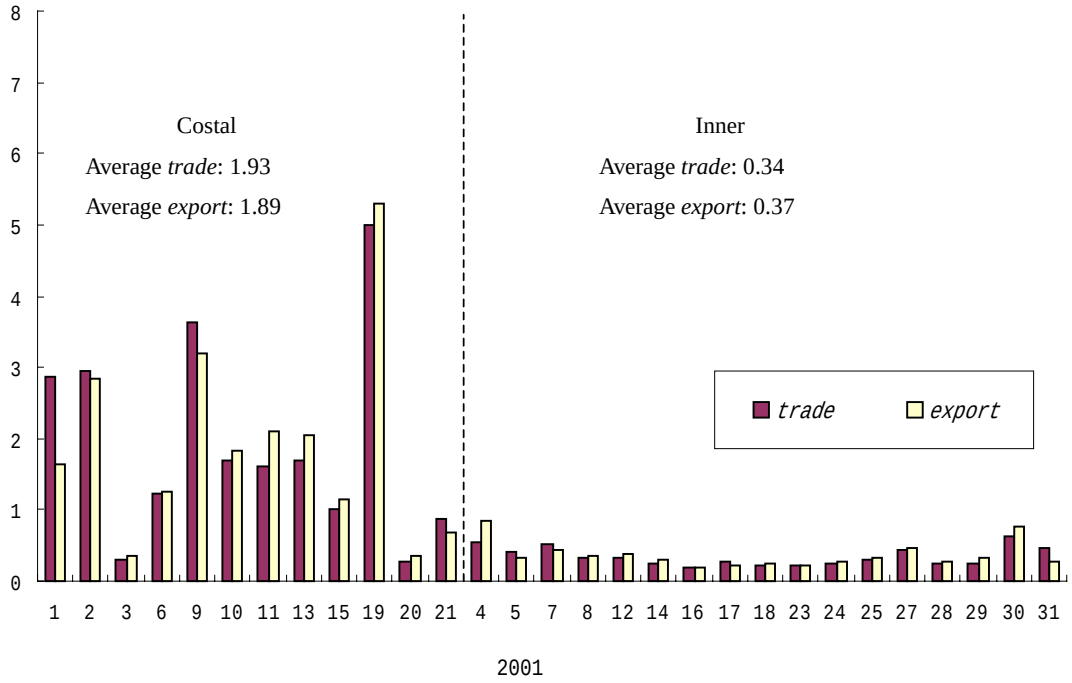

Figure 2(d) ratio of regional export/GDP (trade/GDP) to the national average, 2001

Notes:
1 = Beijing, 2 = Tianjin, 3 = Hebei, 4 = Shanxi, 5 = Inner Mongolia, 6 = Liaoning, 7 = Jilin, 8 = Heilongjiang, 9 = Shanghai, 10 = Jiangsu, 11 = Zhejiang, 12 = Anhui, 13 = Fujian, 14 = Jiangxi, 15 = Shandong, 16 = Henan, 17 = Hubei, 18 = Hunan; 19 = Guangdong, 20 = Guangxi, 21 = Hainan, 23 = Sichuan, 24 = Guizhou, 25 = Yunnan, 27 = Shaanxi, 28 = Gansu, 29 = Qinghai, 30 = Ningxia; 31 = Xinjiang.

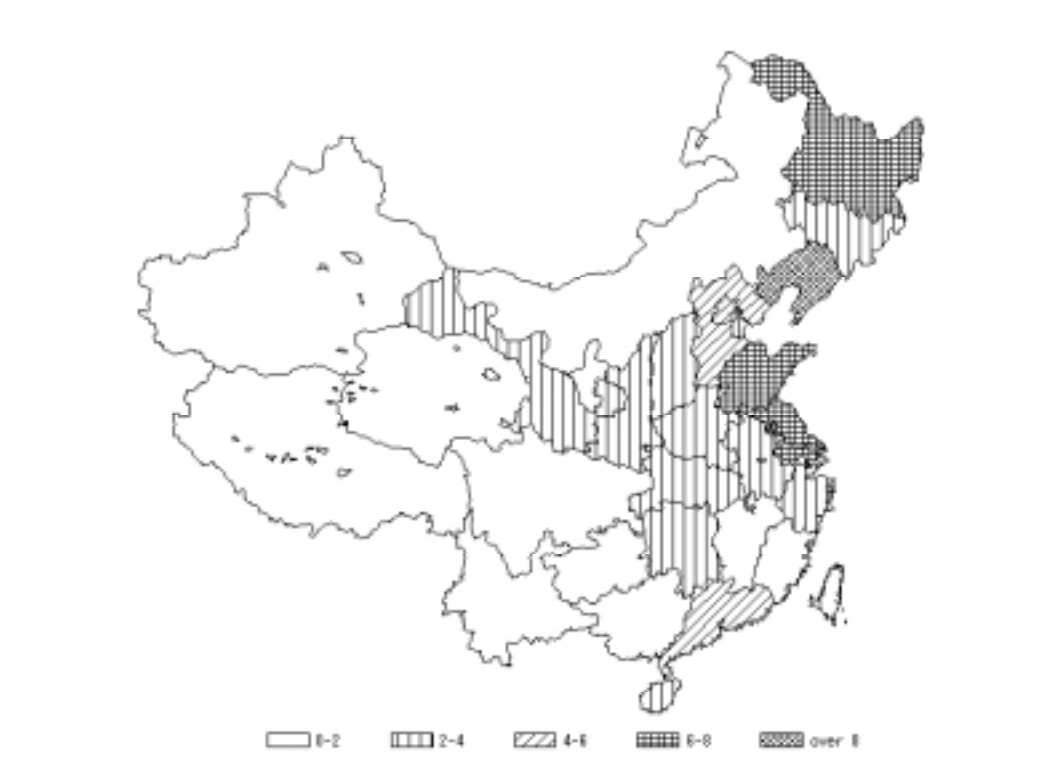

Figure 3(a) regional share of industrial GDP in 1978

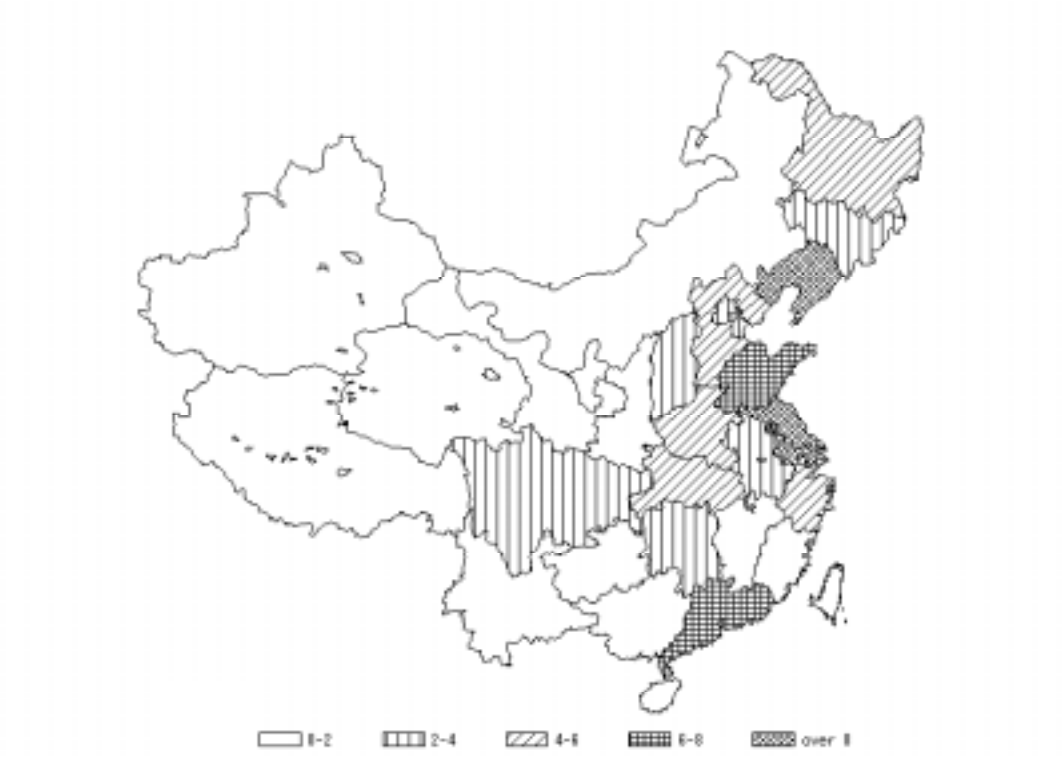

Figure 3(b) regional share of industrial GDP in 1987

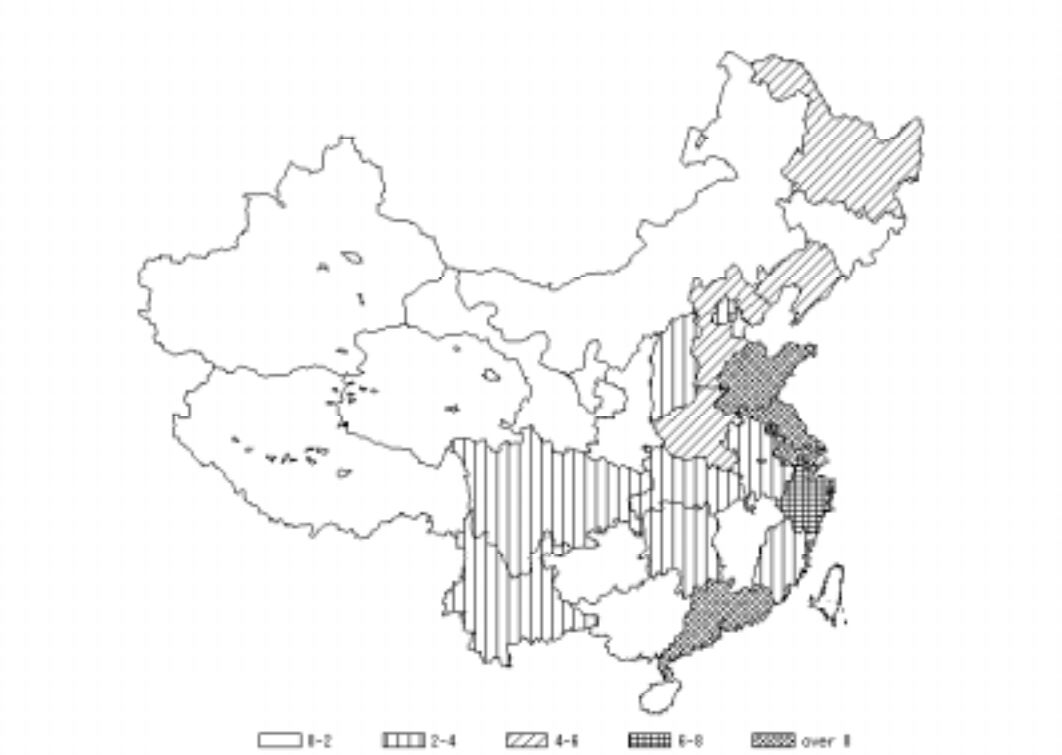

Figure 3(c) regional share of industrial GDP in 1995

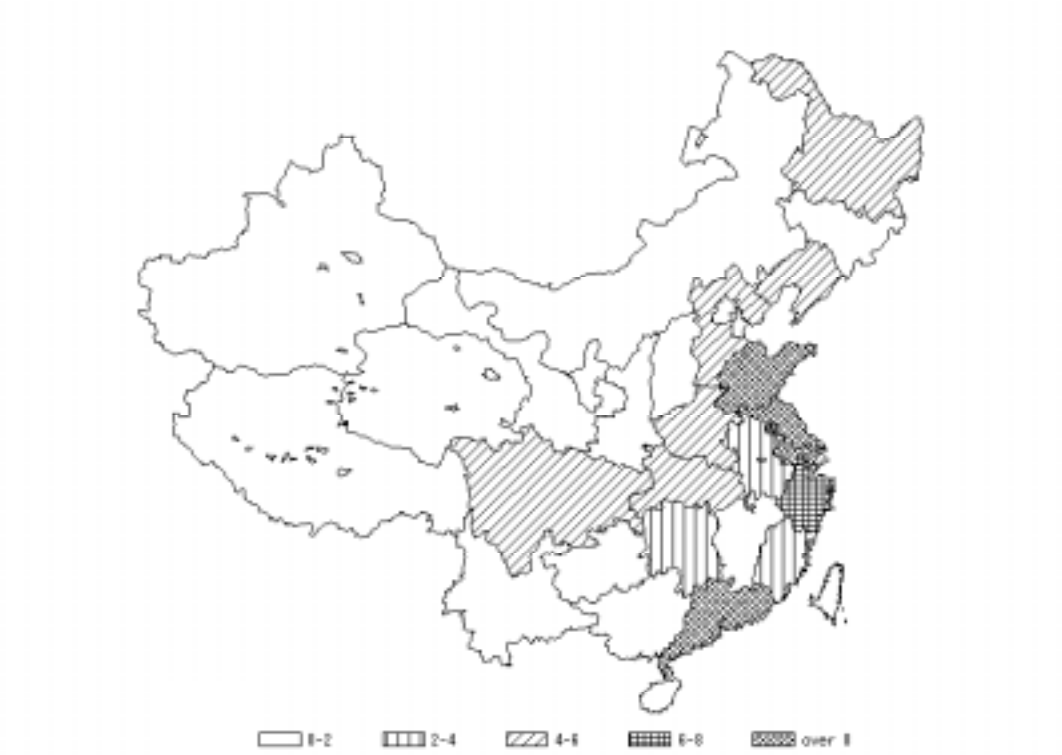

Figure 3(d) regional share of industrial GDP in 2001

Table 1 the first four provinces with highest share of industrial GDP

rank \ year	1981	1986	1991	1996	2001
1	Shanghai	Jiangsu	Jiangsu	Guangdong	Guangdong
2	Liaoning	Liaoning	Guangdong	Jiangsu	Jiangsu
3	Jiangsu	Shanghai	Shandong	Shandong	Shandong
4	Shandong	Shandong	Liaoning	Zhejian	Zhejian

Source:

The Leading Body of National Industrial Census of the State Council (LBNICSC), *The Data of the 1985 Industrial Census of the People's Republic of China*, vol. 4. China Statistical Publishing House, Beijing, 1986.

The State Statistics Bureau of the PRC, *China Statistical Yearbook of Industrial Economy*, China Statistical Publishing House, Beijing, 1997, 1999-2002.

Table 2 determinants of industrial agglomeration

Dependant variables	Regional share of industrial GDP				
	(1)RE	(2)FE	(3)IVRE	(4)RE	(5)RE[2]
Economic policies					
export(trade)	0.624 ***	0.659 ***	1.176 ***	0.623 ***	0.202 ***
	(0.076) [1]	(0.074)	(0.452)	(0.075)	(0.062)
gov	-0.784 ***	-0.588 ***	-0.927 ***	-0.786 ***	-0.692 ***
	(0.149)	(0.143)	(0.210)	(0.148)	(0.159)
Economic geography					
coast	1.305 ***		0.778	1.324 ***	1.657 ***
	(0.472)		(0.698)	(0.472)	(0.480)
city	-5.516 ***		-5.543 ***	-5.446 ***	-5.623 ***
	(0.873)		(0.987)	(0.853)	(0.895)
New economic geography					
firm	4.248 ***	1.485	0.563	4.211 *	7.665 ***
	(2.443)	(2.350)	(3.667)	(2.439)	(2.575)
pergdp	15.557 ***	14.866 ***	13.583 ***	15.519 ***	17.172 ***
	(1.586)	(1.499)	(2.250)	(1.581)	(1.687)
edu	0.340	0.938	0.735		0.048
	(0.838)	(0.838)	(0.921)		(0.892)
urban	1.571 ***	2.107 ***	1.479 ***	1.591 ***	1.760 ***
	(0.327)	(0.333)	(0.371)	(0.324)	(0.347)
road	24.741 ***	21.439 ***	24.223 ***	24.812 ***	26.902 ***
	(4.917)	(4.921)	(5.197)	(4.905)	(5.257)
com	0.297 ***	0.434 ***	0.324 *	0.299 *	0.308 *
	(0.159)	(0.150)	(0.167)	(0.159)	(0.171)
constant	-15.127 ***	-15.758 ***	-13.525 ***	-14.783 ***	-16.646 ***
	(1.680)	(1.646)	(2.228)	(1.450)	(1.781)
R^2 (within)	0.568	0.577	0.537	0.568	0.496
R^2 (between)	0.604	0.237	0.547	0.606	0.623
Hausman test (FE vs. RE)		-5.69[3]		-50.75	-83.21
Instrumental variables			*export*78 *port*	*export*78 *port*	*trade*78
Hausman test P value (IVRE vs. RE)			0.981	0.953	0.972

(1) The numbers in brackets are standard errors. *, ** and *** denote significance higher than 0.10, 0.05 and 0.01 levels, respectively.
(2) Economic opening is measured by *trade* in regression (5) and by *export* in other regressions.
(3) According to *Stata Reference* 7, we could accept the estimation with random effects when the Hausman test is negative.