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Impact of market access and comparative advantage on regional distribution of manufacturing sector

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Abstract

Background: This paper discuss the effects of trade costs and comparative technology on industry location for the economy of China.

Methods: The model assumes differences in comparative technology and different intraregional and interregional trade costs, and argues how different factors influence the location of industrial value added.

Results: By processing the designed model, equations were set up to check whether the conclusions from our mathematical model are credible under panel data at the provincial level of China from 1995 to 2014. We found that the location of industrial value added in a region strongly related to infrastructure and local market size.

Conclusions: Geographical location of a region is an important factor for deciding which factor should be handled first (either intraregional or interregional).

Keywords: New economic geography, Comparative advantage, Market access

JEL classification: R12, O18, P25

Background

Why do some regions turn to prior locations for industries and others fail to attract? Many authors have tried to explain this by employing different techniques. Marshall (1890) emphasizes on spatial linkages that firms cluster to economize on the transport of goods, the labor market and the technological spillover. Jofre-Monseny et al. (2011) and Ellison et al. (2010) tested the Marshall theory of agglomeration in Spanish regions, and in the US and UK, respectively, and found strong evidence for all three factors.

The NEG (new economic geography) literature has tried to assess this question by considering the framework of increasing returns to scale and imperfect competitive markets (Dixit and Stiglitz 1977). Krugman (1991) assumed monopolistic competition with economies of scale and iceberg trade costs to explain the industrial input-output mechanism by differentiating between core-periphery conditions. Behrens et al. (2009) extended Krugman's model to multiple regions, where they allow three different factors, regional market access, size and competition; combined with geographical location of a region these play a radical role in determining regional income and expenditure level and volume of industrial produce; however, the authors ignored regional comparative advantage over others.

Regional infrastructure to the market is one of the determinants of the industrial location; Hanson and Song (1998) explored the US-Mexican economic ties and market access (NAFTA) and showed that increasing regional market access and economic integration cause falling trade costs between US and Mexico, and further effect the location choice of Mexican manufacturers. Davis and Weinstein (2003) also derived the same conclusion for the Organization for Economic Co-operation and Development (OECD) regions, i.e. that home market effect and regional trade costs stand as substantial forces to attract firms.

Most researchers consider interregional trade costs as the main determinant for the market access that further determines industrial location, profits and consumer utility level. The milestone NEG research work of Krugman (1991), the "core-periphery model", states that workers migrate in search of higher nominal wages, and in the end are repatriated to their region of origin, while a higher-than-threshold value will agglomerate all the labor into a single region. Therefore core-periphery analyses are based on interregional trade and its transaction costs, which exclude the trade inside a region and ignore non-zero intraregional trade costs that direct the industrial value added towards a certain region and demand for labor and produce (Behrens and Thisse 2007). The model of Martin and Rogers (1995) is among those that distinguish between intraregional and interregional trade costs. They report that developed countries will attract more industries by improving interregional transportation facilities, while intraregional improvement in infrastructure favors developing countries. Eventually, we will count on both kinds of trade cost as the determinants of the research problem.

Spatial infrastructure determines regional market access, wages, consumer utility and consequently the level of regional agglomeration that further determines the industrial location. Besides the quoted factors, comparative advantage in technology plays a radical role in spatial economic growth. Garau and Lecca (2013), conducted a study to understand the macroeconomic impact of the cost of innovation and technology spillover that determines wages and spatial economic growth.[1] Glasson (2001) and Audretsch and Feldman (2004) concluded the same and pointed out that educational institutes and research and development (R & D) laboratories increase spatial innovation, which significantly affects their surrounding industries and regions. Florax and Folmer (1992) have extensively distinguished between three approaches, while analyzing the regional impact of technology. First, decisions about industrial locations in terms of proximity to an innovative sector enhances production and innovation (Bania et al. 1992; Sivitanidou and Sivitanides 1995).

Second, it will cause forward linkage through more clustering and agglomeration, while strengthening innovative activities in the specified region (Saxenian 1994; Feldman 1999). Finally, innovation will explain differences in regional production and income, where knowledge transfer is easier with geographic proximity to a specified sector. Pavitt (1998) states that: "the link between basic research and technological practice is geographically constrained". Ultimately, it points to the fact that proximity to vertical industries leads other similar ones to locate to the location concerned.

We combine some of the previous research experience in a single dynamic platform, whereby first, well-established infrastructure creates a suitable trade environment (Chiambaretto et al. (2013)). Second, market access and its size directly affect intraregional economic growth (Jofre-Monseny et al. 2011 and Ellison et al. 2010). We used the model of Martin and Rogers (1995) and added some extra features of intraregional trade costs and the comparative advantage of technology between the two regions and tried to analyze which factors make a region comparatively more attractive for industries than others. We based our analysis on China as one of the world's fastest-growing economies, using provincial data to unveil the driving forces of industrial value added inside the country within last two decades.

The subsequent text of this paper is organized as follows. The next section describes how we developed our model. In section 3, we present the implication of empirical analysis on Chinese industrial distribution. The last section contains our concluding remarks.

Methods

NEG theory has three main forces to explain industrial agglomeration; these are the market access effect, the cost of living effect and the market crowding effect. The first two are agglomeration forces and the third is known as a dispersion force; in our model we count on the first two. Therefore, we are using the technique of Martin and Rogers (1995) and assuming that there are two regions ℓ_1 and ℓ_2 for comparative analyses, with each region composed of two sectors, agriculture A and manufacturing M. The agriculture sector uses labor L to produce while the manufacturing sector uses both of the factors labor L and capital K combined with the level of technology in the particular region. The level of infrastructure has a direct impact on the regional trade costs and production of goods in both regions. Consequently, the level of infrastructure and technology is the ultimate source of agglomeration to the location that is comparatively more advantageous (see Martin 1995; Martin 1999).

Consumer behavior

For comparative analyses, a representative consumer in location ℓ_1 has the utility function:

$$U = C_M^{\mu} C_A^{1-\mu}$$

consisting of the consumption C of the agriculture sector and manufacturing sector, where:

$$C_M = \left(\int_0^{n^w} {c_i}^{(\sigma-1)/\sigma} di \right)^{\sigma/(\sigma-1)}$$

represents consumption of the manufacturing sector at ratio μ.

The process of maximization subject to the expenditure function:

$$E = p_A c_A + P_M C_M$$

determines the level of consumer expenditure in each sector:

$$C_A = (1 - \mu)E/p_A, \quad c_i = \mu E({p_i}^{-\sigma}/P_M^{1-\sigma})$$

where c_i under constant elasticity of substitution factor σ represents consumption of manufacturing goods produced by industry i at the price:

$$P_M = \left(\int_0^{n^w} p_i di\right)^{1/(\sigma-1)}$$

The agriculture sector is the same in all regions and has no impact on the regional economy, while the number of producers in the manufacturing sector is the direct source of regional growth. Therefore:

$$n + n^* = n^w$$

will represent the total number of firms n^w in regions $\ell_1 and\ \ell_2$, and the asterisk (*) represents ℓ_2. One can follow the same process to calculate the consumer demand of region ℓ_2 and the industrial price of the goods produced in ℓ_2.

Production sector

We assume that the agriculture sector produces homogenous goods in both regions, which are transported to perfectly competitive markets at the same price in both regions. Therefore, wages in the agriculture sector and revenues equate with each other:

$$p_A x_A = a_A w_A$$

where a_A represent the labor used per unit of output x_A, while receiving w_A amount of wages that are spent on agriculture produce at price p_A. Because of the perfect competition, price is equal to the marginal costs, therefore agriculture goods play the role of numeraire, therefore through standardization we assume that $a_A = 1$ and $w_A = 1$, that is that $p_A x_A = a_A w_A = 1$, and ℓ_2 follows the same process and equates to the price and wage markets $p^*_A = a^*_A w^*_A = 1$. Consequently, perfect competition equates to the labor productivity and wages in the agriculture sector in both regions.

The manufacturing sector faces imperfect competition - as explained by Dixit and Stiglitz (1977) - and the problem of profit maximization $p_M x_j - c_M$, therefore, production of product x produced by industry j needs to pay wages w to labor "a_m" used per unit of production and profits π to capital, as:

$$c(x_j) = w a_m x_j + \pi.$$

Consumption of goods in a region faces intraregional (D) and interregional (I) iceberg trade costs τ as:

$$x_j = \tau_D c_i + \tau_I c_i *$$

where demand:

$$c_i = p_i^{-\sigma} \mu E \Big/ \Delta n^w$$

in market:

$$\Delta n^w = \int_0^{n^w} p_i{}^{1-\sigma} di$$

faces domestic price:

$$p_i = \sigma w a_m / (\sigma - 1)$$

for domestic production and interregional price:

$$p_i = \sigma w a_m^* / (\sigma - 1)$$

for imports to ℓ_1, while:

$$a_m^* = \delta a_m$$

is the factor to count on the interregional comparative advantage of technology of ℓ_1 over ℓ_2. The difference in regional trade costs and comparative advantage will result in four different prices, whereby the first region pays a lesser transaction cost than the second region because of the comparative disadvantage of the latter region in technology:

$$p_i^{\text{intra}} = \tau_D p = \tau_D \qquad p_i^{\text{inter}} = \tau_I p = \tau_I \tag{1.1_1.2}$$

$$p_i^{\text{intra}*} = \tau_D^* p^* = \tau_D^* \delta \qquad p_i^{\text{inter}*} = \tau_I p^* = \tau_I \delta \tag{1.3_1.4}$$

$$a_m{}^* = \delta a_m \qquad p_i^* = \sigma w^* a_m^* / (\sigma - 1) = p^* \qquad p^* = \delta p \text{ where } 0 < \delta < 1$$

Eq 1.1 and 1.2 represent consumer prices for the first region while 1.3 and 1.4 represent the prices for the second region; $^{\text{intra}}$ represents the intraregional and $^{\text{inter}}$ represents the interregional final consumer prices, as explained through Fig. 1.

The equilibrium condition

The manufacturing sector uses capital as the fixed cost that is derived through the sales divided by σ. Therefore, through the Mill pricing and demand function we derived eq. 2.1 and 2.2 to distinguish between core-periphery regions:

$$\pi = \frac{px}{\sigma} = bB\frac{E^w}{n^w}, \qquad \pi^* = \frac{p^* x^*}{\sigma} = bB^* \frac{E^w}{n^w}, \qquad b = \mu/\sigma \tag{2.1_2.2}$$

Extending the regional market to the opponent region will change the market price to:

$$\Delta n^w = \int_0^n p_f^{\text{intra}^{1-\sigma}} di + \int_0^{n^*} p_f^{\text{inter}*^{1-\sigma}} di$$

for the consumption of goods in ℓ_1 in the intraregional and interregional consumption market while:

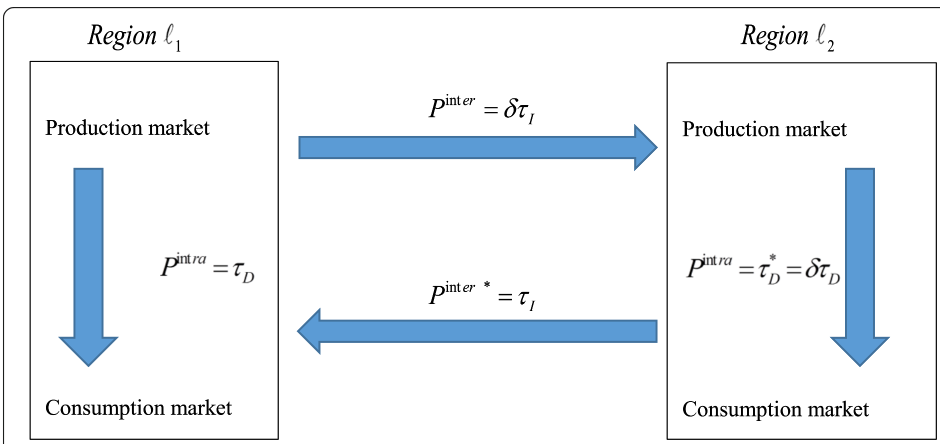

Fig. 1 Regional comparative advantage and trade costs

$$\Delta^* n^w = \int_0^{n^*} p_f^{\text{intra}*^{1-\sigma}} di + \int_0^{n} p_f^{\text{inter}^{1-\sigma}} di$$

For the consumption of goods in ℓ_2 in both regions.

The market size:

$$\Delta = n\phi_D + n * \phi_I \eta, \ \ \Delta^* = n\phi_I + n^* \phi_D^* \eta$$

of a region is based on the level of trade freeness:

$$\phi_D = \tau_D^{1-\sigma}, \ \ \phi_D^* = \tau_D^{*1-\sigma}, \ \ \phi_I = \tau_I^{1-\sigma}$$

where ϕ represents the level of market freeness and $\eta = \delta^{1 - \sigma}$ is the level of comparative advantage.

Meanwhile ℓ_1 faces lower trade costs than ℓ_2, therefore $\phi_D > \phi_D^* > \phi_I$ represents the freeness of trade in the first region rather than the second; it is reasonable because more developed regions with better infrastructure further provide more favorable conditions to intraregional and interregional trade. Meanwhile ℓ_1 already utilizes the required technology level whereby it can transport produce at lower costs, which is evident from market equations 3.1 and 3.2. We standardized the number of firms in this economic system to one, that is:

$n^w = n + n^* = 1$, then $s_n + s_n^* = 1$ and $s_E + s_E^* = 1$

$$B = \frac{s_E \phi_D}{\Delta} + \frac{(1-s_E)\phi_I}{\Delta^*} \quad \text{While} \quad B^* = \frac{(1-s_E)\eta\phi_{D^*}}{\Delta^*} + \frac{s_E \eta \phi_I}{\Delta} \qquad (3.1\_3.2)$$

The expression of s_n and s_E represents the spatial distribution of the manufacturing sector and market size when $s_n = 1$, it means all firms will agglomerate to ℓ_1, and vice-versa. An objective of this paper was to identify the effect of regional trade costs and the comparative advantage of technology on regional distribution of the manufacturing sector in a single model. First, we solved the economic system in a steady state $\pi = \pi^*$. Processing the steady state of the system will result in a number of regional firms s_n (the spatial industrial distribution in ℓ_1). Basically, s_n has two parts, first eq. 3.1 and 3.2 show that both intraregional[2] and interregional trade costs have an impact on the local market. The second part shows the importance of intraregional trade costs in the opponent region, which is a technologically disadvantaged region, which means that ℓ_1 industrial distribution in this model depends on its regional market size and the comparative disadvantage in technology in ℓ_2: if $T = \left(\phi_D^* \eta - {\phi_I}^2\right)\left(\phi_D - \phi_I \eta\right)$ and $T > 0$, then:

$$s_n = \frac{\eta}{T}\left[s_E\left(\phi_D \phi^*{}_D - {\phi_I}^2\right) - \phi_I^2\left(\phi_D^* \eta - \phi_I\right)\right] \qquad (4)$$

Eq.4 reflects the industrial share s_n of region ℓ_1, which is being decided by market size s_E, comparative advantage η, and different domestic $\phi_D and \phi^*{}_D$ and foreign ϕ_I level of trade freeness. If the regional market size s_E is not large enough as compared to interregional trade freeness ϕ_I, then the regional market has to depend on importing - to satisfy domestic consumers' demands for manufacturing produce - from the opponent region that will transpose the sign of the regional industrial value added s_n to negative. Further, we will discuss the relationships between s_n and the other four research variables one by one to find out the mechanism of the ℓ_1 economy. The second-order condition of Eq. 4 will explain the share of each factor included on the right of s_n:

$$\frac{\partial s_n}{\partial s_E} = \frac{\eta}{T}\left(\phi_D {\phi^*}_D - {\phi_I}^2\right) > 0 \tag{5}$$

As reported by the previous researchers Li et al. (2012) and Kang et al. (2012), the industrial distribution and regional numbers of firms are direct functions of the market size and possible regional market access: Eq.4 explains the same concept by indicating the importance of comparative advantage, while dealing with the distribution of the manufacturing sector in a two-region model.

> Statement 1: if one region improves its market access, ultimately improves its home market endogenously and exogenously by reconsidering trade costs, the region will become more attractive for firms to locate, which further helps the region to extract its market power and size.

Intraregional trade costs seem meaningless in economic geography for many authors and are neglected, whereas the model of Martin and Rogers (1995) is an exception as it makes the distinction between intraregional and interregional trade costs; however, it still fails to consider the regional comparative advantage and its role in determining trade costs. To determine impact of market access on the regional distribution of the manufacturing sector, we have assumed that ℓ_1 has the comparative advantage of technology between the two regions. Therefore, combining regional trade costs with the comparative advantage we took technology as the factor of development to explain the spatial distribution of the manufacturing sector. The impact of intraregional trade freeness of regions ℓ_1 and ℓ_2 are explained in Eqs. 6.1 and 6.2. The right-hand side of both of the equations show that intraregional trade costs in one region are dependent on the market size in the other region that is further exposed to interregional trade costs and, particularly, to comparative advantage:

$$\frac{\partial s_n}{\partial \phi_D} = \frac{\phi_I \eta}{\left(\phi_D - \phi_I \eta\right)^2} * (1 - s_E) > 0 \tag{6.1}$$

$$\frac{\partial s_n}{\partial \phi_D^*} = -\frac{\phi_I \eta}{\left(\phi_D^* \eta - \phi_I\right)^2} * s_E < 0 \tag{6.2}$$

As we assume that $\phi_D > \phi_D^* > \phi_I$, therefore $\phi_D - \phi_I\eta > 0$, and ${\phi^*}_D\eta - \phi_I > 0$.[3] The improvement in trade openness is favorable and lesser trade costs will attract more firms to the specific region.

> Statement 2: when a region improves its intraregional infrastructure level to improve trade, it will result in higher production, ultimately increase the market size and consequently decrease the market size in the opponent region. If this improvement is done in the less developed region, it will decrease the development gap.

The impact of the traditional trade openness factor ϕ_I on the regional distribution of the manufacturing sector is quoted in Eq. 6.3, which further includes regional comparative advantage or disadvantage over other regions as an important determinant:

$$\frac{\partial s_n}{\partial \phi_I} = \frac{\eta}{T^2}\left[2s_E\left\{\phi_I^2(\phi_I\eta - \phi_D) + \left(\phi_D\phi_D^* - \phi_I^2\right)\left(\phi_D^*\eta^2 + \phi_D\phi_I\right)\right\} - \left(\phi_D^*\eta - \phi_I\right)\begin{Bmatrix} 4\phi_I^2\eta + 2s_E\phi_I^2 \\ -\phi_D\phi_D^* \end{Bmatrix} + \phi_D\phi_I^2\right] \tag{6.3}$$

Interregional trade between two regions is subject to the market size in both regions:

$$s_E = 1 - s_E$$

therefore, the symbol of Eq.6.3 is dependent on s_E. If s_E is > 1/2 then $\partial s_n/\partial \phi_I > 0$, which means that the lower trade costs for ℓ_1 to export to ℓ_2 as ℓ_1 has a larger market size than ℓ_2, while the opposite is true for ℓ_2 to export to ℓ_1 when s_E is < 1/2, then $\partial s_n/\partial \phi_I < 0$.

Statement 3: trade openness between two regions is directly exposed to the size of the regional market that is less beneficial for comparatively smaller markets. Therefore, a larger market will attract more producers from the opponent region.

We assume that ℓ_1 enjoys comparatively better technology, which is explained through Eq.6, where the size and access to the market play an important role:

$$\frac{\partial s_n}{\partial \eta} = s_E\left[\phi_I\eta - \phi_D^*\left(\phi_D^2 - \phi_I^2\eta^2\right)(\phi_D - \eta)\right] + 2\phi_D^*\phi_I\eta\left[\phi_I(\phi_D + \eta) - \phi_I\eta(\phi_I + \eta) - \eta\left(\phi_D + \phi_D^*\eta\right)\right] - \phi_D(s_E - \phi_I)\left(\phi_D^{*2}\eta^2 - \phi_I^2\right) < 0 \tag{7}$$

while:

$$\frac{\partial \eta}{\partial \delta} = (1-\sigma)\delta^{-\sigma} > 0$$

that is:

$$\frac{\partial s_n}{\partial \delta} > 0$$

Improvement in technological level is beneficial for both regions as Eq.6 shows:

$$\frac{\partial s_n}{\partial \delta} > 0$$

but comparatively backward regions enjoy more than developed regions, which is evident in the last part of the equation, where market size and interregional trade openness decide the power of intraregional trade openness. While Eq.7 is the ultimate source of agglomeration in our model, a comparatively well-established region has more power to attract firms towards the specific region.

Statement 4: comparative advantage in technology proves the power of agglomeration; higher comparative advantage leads to more producers, and consequently leads to a greater development gap between the two regions.

Results and discussion

Research analyses are conducted at the provincial level in China from 1995 to 2014, where the main source of data is the Chinese Statistical Bureau. We followed the generalized regression model, whereby manufacturing value added is strongly correlated with regional market and intraregional trade costs, whereas interregional trade costs are strongly correlated with regional technology. Our econometric model includes all the necessary variables to explain Chinese industrial distribution over the last two decades.

The market price of the regional industrial value added represents regional advancement in the industrial share (*K*) Chow (1993, 2010), which is further determined by the regional market size (*MSz*) measured through the regional gross domestic product, intraregional trade costs (*IntraTC*) as the cost borne for the transportation of passenger and freight volume, interregional trade costs (*InterTC*) as the flow of foreign direct investment and comparative advantage (*CAd*) as the average ratio of productivity per unit of labor in each region, (Ciccone 2002; Zhang and Zhang 2003; McCann and Shefer 2003). Each variable is averaged for the annual outcome of each region, which helps us to check all the regions in a single platform and find the regional comparative advantage over others:

$$K_{gt} = \beta_0 + \beta_1 MSz_{gt} + \beta_2 CAd_{gt} + \beta_3 InterTC_{gt} + \beta_4 IntraTC_{gt} + e_{gt}.$$

According to the *Natural Resource Defense Council (NRDC)*, we classify mainland China into seven parts as mentioned in Table 1, which helps us to observe the industrial distribution in China. Most of the border regions are less productive and lack proper infrastructure, except the coastal regions, while northeastern and northwestern regions are distant and therefore have insignificant results for most variables.

The panel data results are included in Table 2. First, the central provinces of China are close to all parts of the country and have better infrastructure for transportation both inside and outside. Regional technology or wages negatively affect industrial distribution up to 143%, while the interregional transaction cost is more beneficial (70%) than the intraregional one (18%), as per Eqs. 6.1, 6.2 and 6.3. The market effect is comparatively higher than other factors, as per Eq.7.

Second, eastern regions consist of a set of provinces like Fujian, Shandong and Zhajiang etc., which add more to domestic value-added production. The eastern region includes six provinces with well-established intraregional infrastructure resulting in a 17% (Eq. 6.1) effect on industrial production. Comparative technology and interregional

Table 1 Regional distribution of China

Region	Provinces
Center	Hubei, Hunan, Henan, Jianxi
East	Anhui, Fujian, Jiangsu, Shanghai, Shandong, Zhejiang,
North	Beijing, Tianjin, Hebei, Shanxi, Inner-Mongolia
South	Guangdong, Guangxi, Hainan
Southwest	Sichuan, Yunnan, Guizhou, Chongqing
Northeast	Heilong Jiang, Liaoning, Jinan
Northwest	Ningxia, Xinjiang, Qinghai, Shan'xi, Gansu

Natural Resource Defence Council (NRDC)[4]

Table 2 Estimated model: generalized regression for industrial distribution across Chinese regions from 1995 to 2014

Region	Center	East	North	South	Southwest	Northwest	Northeast
MSz	2.140947 (.287356)*	2.765489 (.1024622)*	2.368863 (.1770392)*	1.454354 (.0839593)*	1.34885 (.1577469)*	.4577651 (.1161277)*	.4369391 (.214675)*
CAd	- 1.435096 (.8828371)**	.0039425 (.1123031)**	-.7632607 (.1699287)*	.9912443 (.4243256)*	.9714682 (.2596577)*	.2322001 (.0663806)*	-.1224958 (.4769336)***
InterTC	.7003798 (.174558)*	.002214 (.0209503)***	-.0093017 (.0277309)***	.0883141 (.0210309)*	.1850768 (.0388763)*	.0075077 (.0158179)***	.0313649 (.0704416)***
IntraTC	.1799575 (.1157521)**	.1672521 (.0511079)*	-.3021995 (.0924854)*	.1003722 (.0383487)*	.089857 (.0492795)*	.6906011 (.0447454)*	.7657295 (.0867046)*
Constant	.0172112 (.0219723)***	-.0213503 (.0042008)*	.0337041 (.0059889)*	-.0314977 (.0106556)$^{-}$	-.0306712 (.0073523)*	-.008505 (.0022426)*	.0045645 (.010956)***
Number of provinces	4	6	5	3	4	5	3
Number of observations	80	120	100	60	80	100	60
Wald chi-square (4)	220.85	1766.83	382.81	13980.19	692.28	2835.86	598.30
Log likelihood	284.5811	416.0149	368.3247	261.9177	342.9367	523.2777	249.453

MSz regional market size, *CAd* comparative advantage, *InterTC* interregional trade costs, *IntraTC* intraregional trade costs. $^{***}p < 0.01$, $^{**}p < 0.01 \le p < 0.05$, $^{*}p < 0.05 \le p < 0.10$, standard errors are included within parentheses trade costs have almost the same significant effect, whereas the market effect on regional industrial value added is much higher than in the other regions (276%).

Third, the northern region includes comparatively more developed provinces in China and is comparatively more populated than other regions, as evident from its market share (236%) and non-significant effect from all the other factors, where the effect of comparative technology on industrial distribution is much higher than in other parts of the country. Because of the larger market share, regional technology was not significant, which means that further increase in market size will increase the negative impact on industrial production.

Fourth, the south and southwest regions include seven provinces for which the results were almost the same. The south has a comparatively higher market effect than the opponent. Therefore, the market effect leads both regions to have an opposite response to interregional and intraregional trade costs, where because of the larger market share of the southern provinces (up to 145%), focusing on intraregional trade costs will be more beneficial, while the latter region, because of the comparatively lower market share interregional trade costs, will benefit the regional industrial value added. Regional technology significantly affects both regions.

Fifth, the northeast and northwest regions include distant and dry border regions, resulting in limited regional markets and have bad interregional infrastructure. Comparatively, intraregional trade costs have a larger impact on industrial value added than interregional trade costs, while the results for regional technology are different for both regions as there was a negative effect on industrial production in the northeast compared to the positive effect in the northwest region. The intraregional transaction effect was higher for the northeast (76%) than for the northwest (69%).

In these analyses we found that market effect plays a significantly positive role in all the seven regions in terms of industrial value added, throughout the country. Regional technology is more related to regional market size and regional expenditure as evident from the central, northern and northeastern regions, while the results for regional technology were opposite to the constant factors. Furthermore, less developed regions comparatively rely more on their intraregional transaction than any other factor to attract producers to the specific regions, while comparatively developed regions are more concerned about their interregional transactions, whereas the northern region had exceptional results because of the heavily populated provinces. The market size effect is further affected by the proximity to comparatively agglomerated regions.

Table 3 presents the macroeconomic results for China during the specified period, which strongly support our model. The regional market (at 221%) affected industrial production more than the other factors, while intraregional trade costs positively affected regional industrial value added as compared to the negative impact of interregional trade costs. Regional technology or the regional wage market has a positive effect on industrial value added (13%), which means there is still space for the Chinese government to take measures in accordance with wages to increase the aggregate share of industrial value added. This ultimately points towards the importance of market share, intraregional trade costs and regional technology for the economy of China.

According to Table 3, first, either refreshing or upgrading investment in technology will result into higher value added production. Increase in production is the ultimate source of further agglomeration, as derived in Eq. 7. Second, a larger market size with

Table 3 Generalized regression for industrial distribution across Chinese regions from 1995 to 2014

Variables	Coefficient
MSz	2.212617 (.0707419)*
CAd	.131022 (.0768181)**
InterTC	-.0457661 (.0141003)*
IntraTC	.080676 (.0345535)*
Constant	-.0084771 (.0023167)*
Number of provinces	30
Number of observations	600
Wald chi-squared (4)	5947.19

MSz regional market size, *CAd* comparative advantage, *InterTC* interregional trade costs, *IntraTC* intraregional trade costs. ***$p < 0.01$, **$0.01 \le p < 0.05$, *$0.05 \le p < 0.10$, standard errors are included within parentheses

higher technology is an incentive for new producers to add more value to domestic production, which will increase the number of consumption preferences for domestic consumers. Therefore, lower market size with greater technology combined with a larger population will lead to more profits for producers Third, being a developing country, the intraregional transaction costs in China have greater effect while interregional trade costs have negative significance for the value-added production, as derived in Eq.6.3; therefore, improving intraregional infrastructure is more beneficial for China. Fourth, sophisticated intraregional infrastructure will increase intraregional transaction costs and expand its market size (Eqs. 6.1 and 6.2) and a comparatively higher number of transactions will result in greater agglomeration power.

Conclusions

This paper considers the effect of regional transaction costs, comparative technology and market size on industrial value added. The methodology applied in this paper particularly accounts for imbalances in regional technology and the inclusion of intraregional transaction costs that affect regional value added, which was ignored in previous models of NEG. The designed model was used to analyze the economy of China over the last two decades through generalized regression.

The regression proves the specific effect of our key factors on regional value added with some exceptions for remote or overpopulated regions. Regional infrastructure determines the level of intraregional and interregional transaction, which further effect market access. The importance of regional market access varies for different regions according to their level of comparative advantage and the geographical location of the region. Dry border regions and distance from the center or comparatively developed regions has a comparatively lower effect on interregional transaction, whereas the intraregional transaction effect is comparatively more beneficial for less developed regions, as observed in Table 2.

First, the volume of industrial value added explains the agglomeration power based on the specified cost function. Second, industrial value added is directly affected by the market size, technology and regional infrastructure (Eq. 4). If a region has a comparatively limited market size than the region nearby then the intraregional transaction is more fruitful than the interregional transaction, while a larger market receives is affected more by interregional transaction, because of the circular effect of a larger market is obtained through the better market access, as per Eqs. 6.1 and 6.2.

Therefore, we utilized the same idea to find the factors that affect the regional industrial value added via the defined variables. Our equations of locations of interest indicate that the geographical location of a region is also important in explaining the regional distribution of production activity, where these factors can lead to the core-periphery situation (when the opponent region is comparatively well-developed). The intraregional trade cost shows the comparative advantage in favor of our region of interest, but improvement in infrastructure should be monitored according to regional location and nearby regions.

Going through the econometric model, we found that regional market size, interregional trade and intraregional trade possess a positive effect, while regional technology has a negative effect on regional value added. Considering these factors according to the location of a region will increase the regional value added and attract new producers. Therefore, the location of a region is more important in deciding the priority of different factors to increase regional production. Macroeconomic analyses of the Chinese economy fully support our designed model and point toward the importance of comparative advantage and intraregional transactions on the regional manufacturing sector.

Endnotes

[1]For knowledge spillover level and its impact see Ghosh (2007).

[2]The intraregional trade costs here are two different kinds of intraregional trade costs prevailing inside the two regions, that is $\tau_D\, and\, \tau_D^*$.

[3]To make sure firms can get profits from exporting to another region.

[4]For further details see Kang et al. (2012).

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Authors' contributions
All three authors equally contributed to this paper. All authors read and approved the final manuscript.

Competing interests
The authors declare that they have no competing interests.

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