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A welfare economics analysis of China's industrial layout restructuring

Welfare
economics
analysis

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Abstract

Purpose – At present, China's industrial spatial layout faces the predicament of over-agglomeration of Eastern China industries and the near disintegration of industrial structure in the central and western regions. The paper aims to discuss this issue.

Design/methodology/approach – Based on the perspective of differentiated inter-regional labor mobility, this paper constructed a model framework of quadratic sub-utility quasi-linear preference utility function, and conducted model deduction and numerical simulation on causal factors of this spatial imbalance along the two dimensions of individual and regional welfare.

Findings – The study finds that in the long run, industrial spatial layout imposes a certain threshold limit on the portfolio proportion of differentiated labor. The dilemma of China's industrial spatial layout is attributable to the deviation of the market's optimal agglomeration from the social optimal agglomeration, and to the disfunction of Eastern China's role as an intermediary between the global and the domestic value chain.

Originality/value – To resolve this predicament of industrial layout, the unitary welfare compensation based on fiscal transfer payment has to be switched to a more comprehensive approach giving consideration to industrial rebalancing.

Keywords Industrial layout, Industrial rebalancing, Differentiated labour, Welfare compensation

Paper type Research paper

1. Introduction

Since the reform and opening up, China's domestic and international market-oriented industries have, invariably, agglomerated primarily in the eastern coastal areas, where the industrial development is, in a sense, primarily achieved with the assistance of a mass of immigrants from the central and western regions. However, the huge influx of young and middle-aged laborers with relatively higher skills in the Midwest into the eastern coastal areas has given rise to, on the one hand, the phenomenon of “left-behind elderly, women and children,” which is unique to Midwest China at the present stage; on the other hand, behind the veil of prosperity, the long-term aggregation of a large number of migrant workers with relatively low labor skills in the eastern coastal areas. The above phenomena may be related either to China's specific topography and landforms[1] or to the strong attraction of the urban “conviviality effect” in the eastern coastal areas[2]. At present, due to the excessive agglomeration of population and industries, the eastern coastal areas not only carry huge pressures on resources and the environment, but are also faced with the turbulent changes in the situation around the western Pacific, which are not conducive to China's development.

A large number of high-quality resources and elements are mainly concentrated in the eastern core area where the modern industrial sector is highly aggregated. The traditional



industrial sector can only passively choose to migrate to the periphery, resulting in the headquarters of large enterprises being clustered in the core area, leaving only manufacturing factories in the periphery, thus forming a spatial separation between the headquarters economy and the factory economy. Since the corporate operating income and tax accounting mainly occur in the core area of the headquarters, the finance and taxation in headquarters area are relatively unfair relative to the factory area. Therefore, the imbalance of industrial spatial layout will inevitably lead to unfair inter-regional welfare[3]. The cause for the persistence of this kind of architecture that separates the headquarters space from the factory space lies in that: first, it enjoys the preferential foreign investment policy that China has long encouraged to attract foreign investment and processing trade. Second, it has the advantage of continuously reaping cheap labor and resources in the central and western regions. The imbalance of industrial distribution, manifested in the over-agglomeration in eastern region and the near disintegration of industrial structure in the central and western regions, is still continuing, resulting in the dual differentiation of individual welfare and regional welfare. The academic community is also very concerned about such problems, and put forward the policy proposition of industrial transfer, but it is still limited to the cognitive and qualitative analysis stage of the phenomenon, and the government's solution to this problem relies mainly on transfer payment.

Having experienced the “growing pains (problems incidental to growing up)” such as the sharp decline in cultivated land, environmental pollution, energy dilemma, and rising costs, and the “restriction pains” in various aspects, in order to alleviate the predicament of over-concentration of industrial layout, some provinces in the eastern coastal areas endeavor to “vacate cage to change bird Turning cages for birds,” namely, to transfer some traditional industries to the central and western regions through the “double transfer” approach: industrial transfer and labor transfer. However, this transfer is, for the Midwest, mostly passive acceptance. Before the tide of immigration to the eastern coastal areas in the central and western regions is effectively alleviated, the dilemma of China's industrial spatial layout will continue, and the spatial mismatch and inconsistency in terms of talents and industries will continue. Judging from the implementation effect, the central government's transfer payment by means of “blood (fiscal) transfusion” is not only difficult to compensate for the huge demand gap of transfer payments in the central and western regions, but also unsustainable. The method of industrial transfer of vacating-cage-for-bird-type is merely based on the industrial layout of developed regions, without considering the actual situation and willingness of underdeveloped regions, thus lacking a comprehensive view of industrial linkages.

From the perspective of welfare economics, the imbalance of industrial layout is mainly due to the large deviation between the market's optimal agglomeration and the social optimal agglomeration. The so-called market optimal agglomeration refers to the equilibrium result of the industrial spatial layout under long-term stability under the free operation of the market; and the social optimal agglomeration refers to the industrial spatial distribution state corresponding to the maximization of social welfare.

Then, given the imbalance of industrial spatial layout and the resulting inequity of inter-regional welfare unfair, how should they be coordinated? Will excessive agglomeration of industries in the core area bring new inefficiencies, and should it be promoted or limited? Which areas can benefit from agglomeration, which areas are damaged from it, and can the beneficiary be able to and required to compensate for the maleficiary? Can the free operation of the market form the optimal agglomeration scale? If these problems cannot be given theoretical solutions, they will affect not only the major decisions of the industrial spatial layout, but also the smooth realization of the strategic goals for regional coordinated development. Based on the perspective of welfare economics of inter-regional mobility of differentiated labor, this paper studies the dilemma and rebalancing of China's industrial spatial layout.

The research in this paper also stems from the following concerns: since the reform and opening up, many foreign-invested OEM enterprises in the eastern region have integrated

into the manufacturing labor-division system dominated by multinational corporations through processing trade at the expense of regional imbalances. On the one hand, most of the profits reaped by multinational corporations have flowed back to their home countries, and even the profits of local enterprises that have contracted foreign OEM have flowed overseas through disguised channels. On the other hand, regarding the global value chain and the domestic value chain, the eastern region has not played a good role as a “converter” in introducing, digesting and absorbing foreign advanced technology, and has not fulfilled its function as an intermediary that transfers industries to the central and western regions. On the contrary, it has become a conveyor belt for siphoning the cheap resources and elements of the Midwest and then transporting wealth and talents incessantly overseas.

The structure of the rest of the paper is as follows: the second part, based on the relevant theoretical literature, proposes the breakthrough point of the research; the third part constructs the theoretical model to analyze the proportional constraint of the differentiated labor in the industrial layout; the fourth part introduces trade cost, scale economies effect and degree of differentiation, and based on the interpersonal and inter-regional two-dimensional vision, analyzes the dilemma of China’s industrial spatial layout; the fifth part, based on the perspective of market optimum and social optimum deviation, analyzes the principle and mechanism of unitary transfer payment shifting to industrial intervention and industrial rebalancing; the last part constitutes the research conclusion and policy revelation.

2. Literature review

Researches on the imbalance of industrial spatial layout and regional industrial transfer are not uncommon. The representative research results primarily encompass: Lu (2002) analysis of the Changing trends and environmental variations of industrial structure in the western region and counter-measures; investigations by Guo *et al.* (1994) on the economic development of the six central provinces; Fan (2004) analysis of market integration, regional specialization and the trend of industrial agglomeration; analysis made by Cai *et al.* (2009). on China’s Flying Geese Model for industrial upgrading. Lu (2002) believes that although the process of industrial structural change in the western region has accelerated significantly since the 1990s, the level of specialization has also increased, but the industrial competitive advantage is still weak, the overall quality of industrial structure is generally low, and the gap relative to the eastern region continues to widen. He also believes that, judging from the external reasons, with the deepening of reform and opening up, elements with strong liquidity such as capital and talents have rapidly flowed to areas with high returns, and the industrial layout has undergone major restructuring with market efficiency as the orientation. These causes have accelerated, in effect, the gradual disintegration of the industrial structure of the western self-contained system.

Guo *et al.* (1994) have, from the perspective of China’s productivity distribution and industrial structural linkages, advocated that each region should proceed from the local actual situation and seek the best goals conducive to national productivity and overall development. Fan (2004) found that China’s industrial layout has undergone fundamental changes since the reform, and most of the industries have moved to the eastern coastal areas. However, at this stage, it is still in a situation of high agglomeration of industry and low specialization of the region. The overall level of integration of the domestic market is still low, and lags behind that of the external market, rendering the manufacturing industry with excessive agglomeration in the eastern coastal areas unable to transfer to the central region. This has led to an ever widening regional gap.

From the perspective of industrial security, Cai *et al.* (2009) believe that the impact of the financial crisis on China is related to the structural problems of various regions, industries and even firms themselves. Under crisis conditions, outdated growth patterns, industrial structures and technology choices were the first to be affected. The key to getting over the

crisis and achieving sustained economic growth is to reshape the regional development model. Under the background of the financial crisis and the assumption of big countries, this paper extends the interpretation and prediction range of the Flying Geese Model, and empirically demonstrates the characteristics of the changes in manufacturing growth and productivity growth in China since the turn of the century, which is primarily manifested in that coastal areas have faster rates of increase in total factor productivity and contribution rates. Through the re-deployment of industries in the East, West and Central China regions, namely, the industrial upgrading and transfer of coastal areas and the industrial OEM undertaking of the central and western regions, it is possible to reclaim the labor-rich comparative advantages in the central and western regions while maintaining labor-intensive industries in China.

In addition, the researches of Pan and Li (2007), as well as Wu and Zhu (2008), etc., are also representative. These studies are all based on the perspective of input industry for quantitative analysis of the spillover effects and feedback effects of industrial linkages between different regions of China. Based on the two-region input-output model, Pan Wenqing and Li Zinai concluded that the spillover effects of China's coastal economic development on inland areas are not obvious, and even less than the spillover effects of inland areas on coastal areas. Wu Fuxiang and Zhu Lei extended the two-region input-output model, and measured the forward and backward linkages of the multiplier effect, inter-regional spillover and feedback effect in China's eastern, central and western regions. It is found that the spillover effect of the eastern region on the central and western regions is less significant than that of the latter on the former, and the central region has not played a nexus role in the regional economy, this has largely limited the role-play of regional coordination. Therefore, to achieve industrial coordination and inter-regional welfare compensation in the three major regions of eastern, central and western China, it is necessary to accelerate industrial transfer and expand the efficiency of inter-regional public knowledge spillovers.

With differentiated opinions, the above-mentioned researches are not only concerned with the risk of the gradual disintegration of the industrial structure of the self-contained system in the western region under the international background of reform and opening up, but also emphasizes that in view of the excessive concentration of manufacturing in the eastern coastal areas, it is impossible to transfer industries to the central region. As a result, the regional gap has been widening, and it is called for to proceed from the goal of optimal productivity and comprehensive development of China, to promote the comparative advantage of reclaiming the labor force in the central and western regions, and to maintain labor-intensive industries in China. The focus of previous research and analysis is mainly limited to a unitary dimension, or the regional industry dimension, or the labor dimension, to analyze the inter-regional industrial transfer and industrial linkage issues. In fact, if we can start from the two dimensions of industry and labor simultaneously to perform quantitative analysis of the regional and labor welfare status in the wake of the inter-regional imbalance of industrial spatial layout, it may be of more theoretical significance and practical value for improving regional economic analysis methods.

To a certain extent, the introduction of welfare economics analysis methods into regional issues may be an important theoretical issue that endeavors to innovate China's regional economics research methods, and it is also an important practical issue that desiderates to be resolved in the coordinated development of China's regional economy. This paper breaks through the limitations of a unitary perspective. From the two dimensions of individual welfare and regional welfare, on the one hand, it compensates for the shortcomings of previous academic researches; on the other hand, it reveals the principle and mechanism, the objective conditions and possible paths of the rebalancing of China's industrial spatial layout. It reflects not only the innovation in the research methods of China's regional economic problems, but also the innovation in the research perspective.

The differentiated labor force referred to in this paper is mainly divided into two categories: skilled labor and unskilled labor. The Turing analysis method used in this paper refers to, simply put, the graphical illustration of the method of intuition with spatial visualization of the simulation results through numerical simulation. In addition, the logical starting point of the analysis of welfare economics in this paper is the welfare economic theorem[4]. The framework of modeling follows the analytical framework of linear model of spatial economics. Through the welfare matrix of interpersonal and inter-regional dimensions, the analysis seeks to find the equilibrium point between social optimum and market optimum of industrial spatial layout relative to inter-regional income redistribution, to highlight the two perspectives of equity and efficiency in welfare analysis. We conducted welfare analysis in the order of “equity first, efficiency second.” The so-called equity perspective refers to the comparison of welfare in different agglomeration states; the so-called efficiency perspective refers to the comparison between the market optimum and social optimum effects under different trade costs. The former corresponds to transfer payment, and the latter corresponds to the industrial balance[5]. In this paper, the proposal of welfare compensation mechanism under different agglomeration states is mainly based on the comparison of the above two perspectives.

In contrast to the theoretical system of Western welfare economics, if the compensation measures used in the past are mainly transfer payments, which mainly addresses the problem of inter-regional inequality, then the actual situation in China should be based, furthermore, on efficiency, namely, considering the coordination of regional welfare by rebalancing the inter-regional industrial location. The design of the welfare compensation mechanism from an equity perspective primarily tries to reveal whether the beneficiaries under the change of industrial locations can compensate the maleficiaries, the amount of compensation, and how the nature and intensity of economic variables can affect them. The corresponding compensatory device is, principally, the potential transfer payment based on the Karldor Hicks Principle[6]. From the efficiency perspective of welfare compensation mechanism, researchers tried to examine what kind of industrial layout adjustment between specific trade cost zones can improve market efficiency and balance equity, whether the benefit entity can compensate the damaged entity, and whether the agglomeration formed under market conditions is optimally consistent with social standards. If the objectives are inconsistent, is the agglomeration excessive or insufficient? Especially when the market is found to be over-aggregated, the devices of compensation based on industrial transfer and rebalancing of industrial location will not only improve the overall welfare level of the economy, but also reduce the inter-regional welfare differences.

Charlot *et al.* (2006) tentatively gave three different evaluation methods to compare the requirements of industrial agglomeration or dispersion for two welfare compensation devices[7]. According to Charlot *et al.* (2006), the potential transfer payment method of the first welfare compensation mechanism may be the only way to compensate for the loss of the underdeveloped areas due to insufficient agglomeration. However, as far as China's actual situation is concerned, such conditions are not currently available. There are also many operational difficulties in terms of the second compensation mechanism for balancing industrial locations with a focus on industrial transfer. The main reason is that although the initial population size of the Eastern China is much larger than that of the central and western regions, through the effective intervention of the government's industrial policies, the promotion of production factors from the eastern region to the central and western regions, and thus the promotion of industrial transfer, may achieve the two-way advancement of regional equity and welfare. However, under the existing fiscal decentralization model, local differentiation makes it impossible for the central government to adopt a “one size fits all” approach to this kind of decentralization and compensation. The imbalance of inter-regional industrial development will almost

certainly strengthen the new core-peripheral structure, which will undoubtedly directly affect the central government's policy of decentralization and incentives to localities. The next analysis in this paper is mainly based on the trade-off between the above-mentioned inter-regional equity and efficiency. Based on the model of Ottaviano *et al.* (2002) and Ottaviano and Thisse (2002), new model variables are introduced and a model framework of quasi-linear preference utility function including quadratic sub-utility is constructed, which focuses on the second welfare compensation path to examine the rebalancing of social optimality and market optimality of the industrial spatial layout.

3. The proportional constraint of differentiated labor in the industrial layout

This section first proposes the basic framework of the model, and then conducts long-term equilibrium analysis to reveal the requirements of the industrial spatial layout for the optimal combination ratio of skilled labor and unskilled labor.

3.1 The basic framework of the model

The idea of this model is to first set the consumer's utility function, the initial factor endowment and the production function of the enterprise, to assume, without losing generality, that there is only one product in the economic system, and the manufacturer uses only one factor (labor). Then, based on utility and profit maximization, the commodity demand, factor supply, commodity supply and factor demand are solved separately. Finally, based on the simultaneous clearing conditions of the commodity and factor market, the general equilibrium's price ratio, distribution ratio and welfare function matrix are solved.

Assume that the economic system contains two regions, two sectors, and two types of labor. The areas consist of Region A (core area) and Region B (peripheral area) with core-peripheral structure; the sectors are, respectively, the traditional sector "a" characterized by constant returns to scale and perfect competition, and modern sector "m" characterized by increasing returns to scale, i.e., monopolistic competition. The two types of labor are skilled labor ($n = L_S$) and the unskilled labor ($n = L_U$), the skilled labor is only employed in the modern sector "m," with higher inter-regional mobility, and the unskilled labor is mainly employed in the traditional sector "a," with lower inter-regional mobility. The spatial distribution of skilled labor in the model is an endogenous variable, and the inter-regional mobility is mainly determined by the difference in inter-regional real labor rates. The output of industrial products in the modern sector of Region A and Region B is, respectively, n_A and n_B , and the total amount of industrial products in the economy is $n = n_A + n_B$.

According to the assumption of monopolistic competition and increasing returns to scale, each manufacturer produces only one differentiated product, and the total number of modern sector manufacturers in both regions is also n . The total number of laborers in the economy is $L = L_U + L_S$. The unskilled labor is initially distributed symmetrically in the two regions ($L_U/2$). The skill labor force has proportion of θ in Region A, $n = \theta L_S$, and a proportion of $(1-\theta)$ in Region B, $n = (1-\theta)L_S$. It is assumed that each manufacturer needs to use f units of skilled labor when producing differentiated industrial products. The nominal wage of the skilled labor force in Region A is w_A , and the nominal wage of Region B is w_B , then there is $n = L_S/f$. It is also assumed here that the marginal cost of the manufacturer is a_m , and that a unit industrial product has a linear inter-regional transportation cost of τ .

Similar to the construction method of the model of Ottaviano *et al.*, the personal preference of the author is also given by the quasi-linear preference containing the quadratic sub-utility. Different from the Ottaviano text, this paper introduced the marginal cost variable of industrial production, added the Turing analysis of numerical simulation, constructed the interpersonal and inter-regional two-dimensional welfare function matrix, and based on the efficiency and equity principle, analyzed the inter-regional and

interpersonal welfare in multiple equilibriums of industrial spatial layout. The utility functions of the two-region consumers constructed in this paper are:

$$U = \alpha \int_0^n c_i di - \frac{\beta - \delta}{2} \int_0^n c_i^2 di - \frac{\delta}{2} \left(\int_0^n c_i di \right)^2 + C_a; \alpha > 0, \beta > \delta > 0, \quad (1)$$

where c_i is the consumption of differentiated industrial products by the consumers in the modern sector, and C_a is the consumption of traditional products by all consumers in the region. α represents consumers' preference for differentiated industrial products and δ reflects the substitutability of differentiated products. $\beta > \delta$ is the condition for the quasi-linear preference quadratic sub-utility function to satisfy the convexity. $\beta > \delta$ also denotes that when consumers face the physical constraints of differentiated industrial products, for a given β value, the larger the δ value, the stronger the substitutability between products.

Assuming that savings, initial profit sharing and transfer payments are not considered, the consumer's income is all used for purchasing expenses, that is, to meet economic constraints of $\int_0^n p_i c_i di + C_a = w$, where p_i denotes the price of the i th industry product, the price of the traditional sector product is set to 1. The first-order condition is obtained according to physical and economic constraints, and the demand function of the differentiated product can be obtained:

$$c_i = a - (b + cn)p_i + cP, \quad (2)$$

where $a = \alpha / (\beta + (n-1)\delta)$, $b = (a/\alpha)$, $c = \delta / ((\beta - \delta)[\beta + (n-1)\delta])$. The composite price index of the product is $P = \int_0^n p_i di$. If the nominal price levels of the Regions A and B are, respectively, indicated by P_A and P_B , then there is $P_A = \int_0^n p_i di = n_A p_{AA} + n_B p_{BA}$, $P_B = \int_0^n p_i di = n_B p_{BB} + n_A p_{AB}$. Here, p_{rs} is the price ($r, s = A, B$) of the product made in Region r and sold in Region s .

In the Walrasian equilibrium system, the consumer of the product is also the supplier of the production factor, so the quantity of the consumer ($L_U + L_S$) can derive the supply of products in the corresponding area (A and B):

$$M_A = \frac{1}{2} L_U + \theta L_S, \quad M_B = \frac{1}{2} L_U + (1 - \theta) L_S.$$

First, solve the profit maximization conditions for manufacturers located in Regions A and B. Take Region A as an example, and B is similar:

$$\text{Max } \pi_A = \pi_{AA} + \pi_{AB} - f w_A \quad (3)$$

where $\pi_{AA} = (p_{AA} - a_m)[a - (b + cn)p_{AA} + cP_A]M_A$, $\pi_{AB} = (p_{AB} - a_m - \tau)[a - (b + cn)p_{AB} + cP_B]M_B$. π_{AA} and π_{AB} are, respectively, the operating profit when manufacturers in Region A are equalized in two markets.

Pursuant to the first-order condition of profit maximization, we solve the partial derivative of π_A and π_B relative to the corresponding price, and obtain:

$$\begin{aligned} p_{AA} &= \frac{2[a + a_m(b + cn)] + c\tau n_B}{2(2b + cn)}, p_{BA} = p_{AA} + \frac{\tau}{2}, \\ p_{BB} &= \frac{2[a + a_m(b + cn)] + c\tau n_A}{2(2b + cn)}, p_{AB} = p_{BB} + \frac{\tau}{2}. \end{aligned} \quad (4)$$

It is not difficult to see from Equations (3) and (4) that in the linear model, the manufacturer implements pricing including transportation costs and related to spatial distribution. The condition of product trade is that the sales price of the manufacturer in any region suffices to cover its transportation costs to another counterpart region. Assuming the linear

transportation cost per unit of product is τ , the condition can be written as:

$$\left. \begin{aligned} p_{AA} - a_m - \tau > 0 &\Rightarrow p_{AA} > a_m + \frac{\tau}{2} \Rightarrow \tau < \frac{2(a - a_m b)}{2b + cn_A} \\ p_{BA} - a_m - \tau > 0 &\Rightarrow p_{AA} > a_m + \frac{\tau}{2} \Rightarrow \tau < \frac{2(a - a_m b)}{2b + cn_B} \end{aligned} \right\} \Leftarrow \tau < \tau^{trade} = \frac{2(a - a_m b)}{2b + cn}. \quad (5)$$

Trade can only happen when $\tau < \tau^{trade}$ is met. As for τ^{trade} , there is $\tau^{trade} = 2(a - a_m b)/(2b + cn) > 0$, that is, the marginal cost of the enterprise needs to be within the following range: $0 < a_m < a/b$. This condition can be further relaxed to $\tau < \min(2(a - a_m b)/(2b + cn_A), 2(a - a_m b)/(2b + cn_B))$. In fact, when the inter-regional product trade cost is positive, if there is no increasing returns to scale (i.e. $f=0$), or products show homogeneity ($c=\infty$), the inter-regional product trade will hardly occur, because Equation (5) does not hold at the moment. Otherwise, both regions either produce differentiated industrial products, or each is self-contained or self-satisfied.

The following is an analysis of the impact of market size and differentiation on product flow. Since $c = \delta/((\beta - \delta)[\beta + (n-1)\delta])$, there is $dc/d\delta = \beta^2 + (n-1)\delta^2/((\beta - \delta)^2[\beta + (n-1)\delta])^2 > 0$. The larger the δ , the stronger the product substitutability, therefore the larger the c , the stronger the product homogeneity is. The smaller the c , the greater the degree of differentiation. By separately solving the first-order partial derivative of τ^{trade} relative to f and c , we obtain the expression $d\tau^{trade}/df = 2(a - a_m b)cL_S/(2bf + cL_S)^2 > 0$, $d\tau^{trade}/dc = -2(a - a_m b)fL_S/(2bf + cL_S)^2 < 0$.

According to the solution result, the following proposition can be obtained:

P1. In the inter-regional flow model of differentiated labor, there is a critical point where the symmetric spatial distribution is broken, which divides the agglomeration and diffusion of the industrial layout. At the same time, trade costs also have strict threshold limits on market size and product differentiation, with both the trade costs are negatively correlated within the critical value range.

Further, the profit of the manufacturer in Region A in the equilibrium state can be obtained, and the case of Region B is similar:

$$\pi_A^* = \pi_{AA}^* + \pi_{AB}^* - fw_A = (b + cn)[(p_{AA} - a_m)^2 M_A + (p_{AB} - a_m - \tau)^2 M_B] - fw_A. \quad (6)$$

3.2 Proportional constraints on factors

It is assumed that the profit of the manufacturer will eventually be converted into the nominal gross income of the consumer, and each manufacturer hires f units of skilled labor, then we get the nominal wage level W of Region A, and the situation of Region B is similar:

$$w_A = (\pi_{AA}^* + \pi_{AB}^*)/f = (b + cn)[(p_{AA} - a_m)^2 M_A + (p_{AB} - a_m - \tau)^2 M_B]/f. \quad (7)$$

Without the loss of generality, assume that the nominal wage level of the unskilled labor force is 1. Since the consumer surplus is the area between the demand curve and the market price curve in the long-term equilibrium, the consumer surplus of the Regions A and B can be calculated in Equation (4) for equilibrium price, to derive:

$$C_A(\theta) = \frac{a^2 L_S}{2bf} - a[\theta p_{AA} + (1 - \theta)p_{BA}]n + \frac{b + cn}{2}[\theta p_{AA}^2 + (1 - \theta)p_{BA}^2]n - \frac{c}{2}[\theta p_{AA} + (1 - \theta)p_{BA}]^2 n^2, \quad (8)$$

$$C_B(\theta) = \frac{a^2 L_S}{2bf} - a[(1 - \theta)p_{BB} + \theta p_{AB}]n + \frac{b + cn}{2}[(1 - \theta)p_{BB}^2 + \theta p_{AB}^2]n - \frac{c}{2}[(1 - \theta)p_{BB} + \theta p_{AB}]^2 n^2. \quad (9)$$

Substituting the equilibrium price Equation (4) and the wage Equation (7) into Equation (1), the indirect utility function of the labor force can be obtained. Of course, this

indirect utility function can also be obtained by adding the consumer surplus to the nominal wage level, i.e.:

$$\omega_A = C_A(\theta) + w_A, \quad (10)$$

$$\omega_B = C_B(\theta) + w_B. \quad (11)$$

The prices of industrial products in Equations (8) and (9) are the prices that consumers can purchase locally. The migration decision of skilled labor is largely due to the difference in real labor rates, and Equations (10) and (11) can represent the level of indirect utility. In order to achieve long-term equilibrium in each sub-regional market, it is necessary to satisfy the three basic conditions of maximizing consumer utility, maximizing profit of the manufacturer and clearing the market. Since each manufacturer only produces one modern industrial product, and uses f units of skilled labor, the number of manufacturers in Region A is thus $n_A = \theta L_S f$, the number of manufacturers in Region B is $n_B = ((1-\theta)L_S)/f$, and the total number of the manufacturers in the two areas is $n = L_S f$. Without loss of generality, it is possible to set the appropriate unit of measure for the skilled labor, namely, by simplifying the model via standardizing n . Let $L_S = f$, and therefore $n = 1$, $n_A = \theta$, and $n_B = 1 - \theta$.

In the standard linear model, it is generally assumed that the skilled labor force has strong mobility to pursue higher real wages (nominal wages are converted through the price index). The strength of mobility mainly depends primarily on the difference between the two regions, and the entire regional economic system will not reached a long-term equilibrium until they are the same. The flow equation for labor can be written as:

$$\dot{\theta} = (\omega_A - \omega_B)\theta(1 - \theta). \quad (12)$$

The long-term equilibrium conditions are: when $0 < \theta < 1$, $\omega_A = \omega_B$; when $\theta = 1$, $\omega_A > \omega_B$ and when $\theta = 0$, $\omega_A < \omega_B$.

Using the derived manufacturer's profit and price formula, combined with Equations (10) and (11), we can get the long-term equilibrium equation that determines the difference between the actual labor rate of the skilled labor inter-regional flow and the flow barrier:

$$\omega_A - \omega_B = \Theta(\tau^* - \tau)\tau\left(\theta - \frac{1}{2}\right), \quad (13)$$

where $\Theta = ((b+c)((6b(b+c)+c^2)L_S + c(2b+c)L_U)/(2L_S(2b+c)^2)) > 0$, and $\tau^* = (4L_S(3b+2c)(a-a_m b))/((6b(b+c)+c^2)L_S + c(2b+c)L_U)$.

Equation (13) shows that to maintain the long-term equilibrium of labor inter-regional flows, the inter-regional real labor rates must be equal. From this formula, it can be seen that no matter how big the obstacles of inter-regional factors flow, when $\theta = 1/2$, it is a point of equilibrium. According to the standardized initial setting $n_A = \theta = 1/2$, the regional spatial structure is a symmetric distribution structure[8].

Is this symmetrical structure composed of two regions stable and can the equilibrium point be maintained? The result depends mainly on the size of τ^* and τ . It is not difficult to find from Equation (13), when $\tau < \tau^*$, $\omega_A - \omega_B$ and $n_A - (1/2)$ have the same symbol; on the contrary, when $\tau > \tau^*$, their symbols were different. Equation (13) reveals that when the degree of regional integration is high, there is a positive feedback mechanism in the economic system. The slight deviation of the symmetric distribution leads to the widening of the inter-regional real labor rate and the further deviation of the symmetric spatial distribution, forming a "black hole" phenomenon in which the skilled labor is fully concentrated in the core area. On the contrary, when the degree of regional integration is

low, the economic system has a negative feedback mechanism, and the symmetric distribution is relatively stable.

What is the relationship between τ^* and τ^{trade} ? The conclusion is that if $\tau^* > \tau^{trade} > \tau$, agglomeration always occurs and is persistent and stable. In fact, if $\tau^* < \tau^{trade}$, it is very similar to the “non-black hole condition” in the core-peripheral model, which is:

$$\tau^* = \frac{4L_S(3b+2c)(a-a_mb)}{[6b(b+c)+c^2]L_S+c(2b+c)L_U} < \tau^{trade} = \frac{2(a-a_mb)}{2b+cn}$$

$$\Rightarrow \frac{L_U}{L_S} > \frac{6b^2+3c^2+8bc}{c(2b+c)} > \frac{3c^2+6bc}{c(2b+c)} = 3. \quad (14)$$

This inequation shows that the number of unskilled labor must be more than three times that of skilled labor regardless of agglomeration equilibrium or dispersion equilibrium. This shows that although the skilled labor force is very important for industrial agglomeration, it must be supported by the corresponding unskilled labor force. If Formula (14) is not satisfied, then $\tau^* > \tau^{trade}$. The symmetric distribution is unstable while the agglomeration state is stable. The following propositions can thus be obtained:

- P2. In the inter-regional mobility model of differentiated labor, regardless of the industrial distribution pattern, the number of unskilled labor is at least three times that of the skilled labor. The upkeep of industrial agglomeration in the core area requires the continued supply of peripheral skilled labor. The smaller the trade cost, the more aggregated the industrial distribution will be.

4. The dilemma of industrial spatial layout from the two-dimensional perspective of labor and regions

This section expands the above basic model and performs numerical simulations to reveal whether the welfare conditions of the individual and regional dimensions are consistent with the optimal ratio requirements in the actual situation in China. This section will also introduce variables such as location conditions, market size, trade costs and marginal manufacturing costs to compare individual and regional welfare.

From the perspective of welfare, it is necessary to consider not only whether the industrial distribution can improve the welfare level of the entire economic system, but also whether the interpersonal and inter-regional distribution of welfare levels is appropriate. The former involves the efficiency of welfare and the latter involves the equity of welfare. The calculation results of the labor and regional two-dimensional welfare function matrix are shown in Table I, where W_s represents the welfare of skilled labor, and W_u represents that of unskilled labor.

To facilitate the simulation, we first assign values to related parameters. Considering that in Equation (5), $\tau^{trade} = 2(a-a_mb)/(2b+cn) > 0$, further let $a=b=c=1$, $L_S=L_U=f=1$, then $\tau^{trade} = 2/3(1-a_m) > 0$, $0 < a_m < 1$. This means that higher marginal costs will lead to the decrease of τ^{trade} , trade costs are forced to compress, and terms of trade become more demanding.

Table I.
Two-dimensional
welfare matrix by
labor and region

	Skilled labor (S)	Unskilled labor (U)
Region A	$W_S^A(\theta) = \theta L_S[C_A(\theta) + w_A(\theta)]$	$W_U^A(\theta) = (1/2)L_U[C_A(\theta) + 1]$
Region B	$W_S^B(\theta) = (1-\theta)L_S[C_B(\theta) + w_B(\theta)]$	$W_U^B(\theta) = (1/2)L_U[C_B(\theta) + 1]$
Note: The welfare function matrix of this table is calculated according to the corresponding formula		

4.1 The welfare of differentiated labor

First, we examine the welfare of the unskilled labor force. Combining Equations (7) and (4), we get:

$$C_A = \frac{2}{9} - \frac{4}{9}(1-\theta)\tau + \frac{1}{4}(1-\theta)\tau^2 - \frac{1}{36}(1-\theta)^2\tau^2 - \frac{4}{9}a_m + \frac{2}{9}a_m^2 + \frac{4}{9}a_m(1-\theta)\tau.$$

In the same way, we get:

$$C_B = \frac{2}{9} - \frac{4}{9}\theta\tau + \frac{1}{4}\theta\tau^2 - \frac{1}{36}\theta^2\tau^2 - \frac{4}{9}a_m + \frac{2}{9}a_m^2 + \frac{4}{9}a_m\theta\tau, \text{ and } 0 < a_m < 1.$$

Solve the first-order partial derivative of C_A relative to θ , we get $(\partial C_A / \partial \theta) = -[(2\theta+7)/(36)\tau - (4/9)(1-a_m)]\tau$, and $(\partial C_A / \partial \theta) > 0 \Leftrightarrow \tau < (16)/(2\theta+7)(1-a_m)$. Consider again $1/2 \leq \theta \leq 1$ (because the core area has an agglomeration effect), therefore $(16/9)(1-a_m) < (16/(2\theta+7))(1-a_m) < 2(1-a_m)$. According to Equation (5), $0 < \tau < \tau^{trade} = (2/3)(1-a_m)$, and there is $(2/3)(1-a_m) < (16/9)(1-a_m)$, and therefore $\tau < (16/(2\theta+7))(1-a_m)$, there is thus $(\partial C_A / \partial \theta) > 0$, and $(\partial W_U^A / \partial \theta) > 0$. The inequation shows that with the increase of the degree of agglomeration, the welfare level of the unskilled labor force in the core area rises, indicating that the unskilled labor force in the core area always prefers the structural model of agglomeration. The reason is that the agglomeration of the modern industrial sector not only allows them to benefit from lower industrial product prices, but also to enjoy what is commonly referred to as the “Marshall Pecuniary Externality” advantage[9]. Similarly, we solve the first-order partial derivative of consumer surplus C_B of the unskilled labor force relative to θ , and get $(\partial C_B / \partial \theta) = [(9-2\theta/(36))\tau - (4/9)(1-a_m)]\tau < 0$, that is, $(\partial W_U^B / \partial \theta) < 0$, indicating that the unskilled labor force in the peripheral region is more inclined to the industrial distribution under the dispersed structural model. Further analysis found that the aggregated welfare increased with the expansion of the market size and the expansion of product categories.

Then we examine the impact of marginal cost a_m on consumer surplus and welfare for unskilled labor. Taking Region A as an example, we first solve the first-order partial derivative of C_A relative to a_m , and get $(\partial C_A / \partial a_m) = (4/9)(1-\theta)[\tau - (1-a_m)/(1-\theta)]$. Since $(1/2) \leq \theta \leq 1$, there is $(1-a_m)/(1-\theta) > 2(1-a_m)$, and $2(1-a_m) > (2/3)(1-a_m) = \tau^{trade} > \tau$, thus $(1-a_m)/(1-\theta) > \tau$, and therefore $(\partial C_A / \partial a_m) < 0$, and $(\partial W_U^A / \partial a_m) < 0$. By the same token, seeking the first-order partial derivatives of C_B relative to a_m , there is $(\partial C_B / \partial a_m) = (4/9)\theta[\tau - (1-a_m)/\theta]$, similarly, there is $(\partial C_B / \partial a_m) < 0$, and $(\partial W_U^B / \partial a_m) < 0$. Similar to the above conclusions, be it the core area or the periphery, the marginal cost is invariably reduced, this will increase the consumer surplus of the unskilled labor and improve the overall welfare of the group.

The change in the welfare of skilled labor is more complicated than the relevant discussion of unskilled labor in that consideration has to be made on the changes in wage levels, and investigations and comparison of the industry’s spatial agglomeration (θ), trade costs (τ), and the marginal cost of the enterprise (a_m).

Now we look at the overall welfare status W_S^A and W_S^B of the skilled labor. Note that $0 < \tau < (2/3)(1-a_m)$ and $0 < a_m < 1$, first we set different marginal costs to determine the upper boundary and lower boundary of trade costs τ ; then select representative critical points, and within the allowable range of τ , take the critical points close to the upper and lower boundaries for simulation (Figure 1).

Observing Figure 1, it is not difficult to find: skilled labor will benefit from the agglomeration in a certain region; the reduction of trade costs and marginal cost will lead to the decline of the overall welfare of skilled labor in the region; the reduction in trade costs and marginal costs has a huge impact on the welfare level of skilled labor in different regions. Observing (a), (b), (c) and (d), (e), (f) in Figure 1, respectively, it can be found that given a marginal cost, a small change in trade costs has less impact on welfare; but an

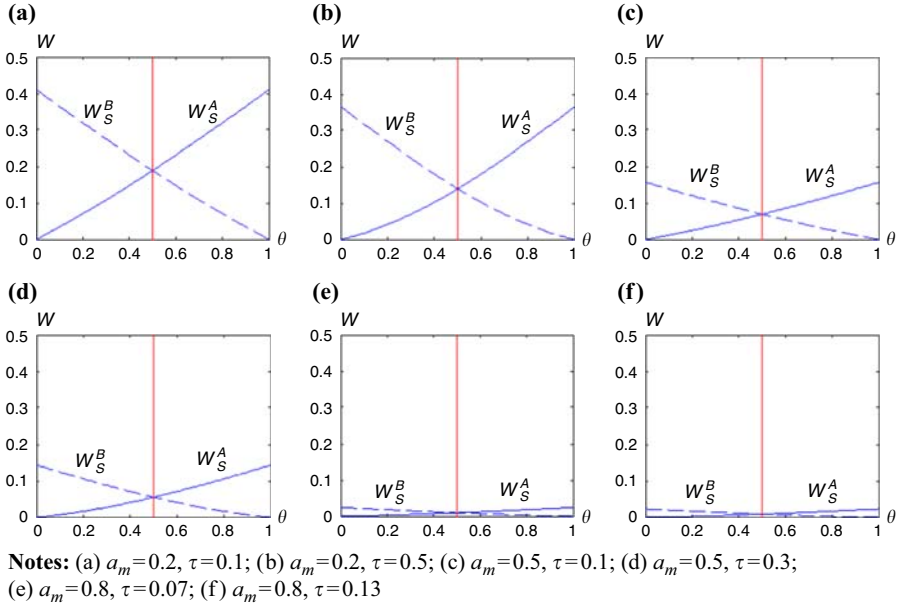


Figure 1.
Changes in the
welfare level of inter-
regional skilled labor
under different costs

observation of (a), (c), (e) and (b), (d), (f) in Figure 1 shows that the increase in marginal cost causes a significant decline to W_S^A and W_S^B . It can be seen that the impact of trade costs on the welfare level of skilled labor is much less than that of the marginal costs.

The partial derivatives of W_S^A and W_S^B with respect to the marginal cost a_m are solved, respectively, taking $\tau < (2/3)(1-a_m)$, we obtain $(\partial W_S^A / \partial a_m) < 0$, $(\partial W_S^B / \partial a_m) < 0$ and $(\partial^2 W_S^A / \partial a_m^2) = (4/3)\theta$, $(\partial^2 W_S^B / \partial a_m^2) = (4/3)(1-\theta)$, indicating that the second order derivative of W_S^A relative to a_m has a uniform increase-decrease characteristic with θ , while the second order derivative of W_S^B relative to a_m is opposite to the increase-decrease characteristic of θ . It can be seen that under different industrial distribution patterns, the welfare of skilled labor has higher sensitivity with respect to marginal cost and changes with the variation of agglomeration degree θ . This leads to the following proposition:

P3. In the differentiated labor inter-regional mobility model, skilled labor can always benefit from the two models. When trade costs rise, welfare levels rise; when marginal costs rise, welfare levels fall. Relative to the cost of trade, marginal cost has a higher sensitivity to the impact of skilled labor welfare, and is enhanced with the increase of industrial concentration in the core areas. On the contrary, unskilled labor has the opposite situation in the two regional models. When it is in the core area, the welfare is improved, and when it is in the peripheral area, the welfare suffers.

4.2 Comparison of welfare in interpersonal dimension

The overall welfare of the skilled labor and unskilled labor are expressed, respectively, as follows:

$$W_S = \theta L_S [C_A + w_A] + (1-\theta) L_S [C_B + w_B], \quad (15)$$

$$W_U = \frac{1}{2} L_U [C_A + 1] + \frac{1}{2} L_U [C_B + 1]. \quad (16)$$

First, we examine the impact of industrial distribution on the welfare of differentiated labor. The partial derivatives of W_S and W_U relative to θ are solved, combining the constraints we

obtain $(\partial W_S/\partial \theta) = (2\theta - 1)[(16/9)(1 - a_m) - (53/16)\tau]\tau$. When $\theta > (1/2)$, $(\partial W_S/\partial \theta) > 0$; when $\theta < (1/2)$, then $(\partial W_S/\partial \theta) < 0$. In the same way, we get $(\partial W_U/\partial \theta) = (1/18)((1/2) - \theta)\tau^2$. When $\theta > 1/2$, $(\partial W_U/\partial \theta) < 0$; when $\theta < 1/2$, then $(\partial W_U/\partial \theta) > 0$. Therefore, agglomeration increases the overall welfare of the skilled labor, but may reduce the overall welfare of the unskilled labor.

Second, we examine the impact of marginal cost on differentiated labor welfare. The partial derivatives of W_S and W_U relative to a_m are solved, combining the constraints we obtain $(\partial W_S/\partial a_m) < 0$, $(\partial^2 W_S/\partial a_m^2) > 0$, and $(\partial W_U/\partial a_m) < 0$, $(\partial^2 W_U/\partial a_m^2) > 0$. Therefore, the reduction in marginal cost will increase the overall welfare of the two types of labor, and this effect will gradually increase.

Finally, we examine the impact of trade costs on differentiated labor welfare. The partial derivatives of W_S and W_U relative to trade costs are solved, combining the constraints we obtain $(\partial W_S/\partial \tau) < 0$, $(\partial W_U/\partial \tau) < 0$. It shows that when trade costs rise, all labor welfares decline.

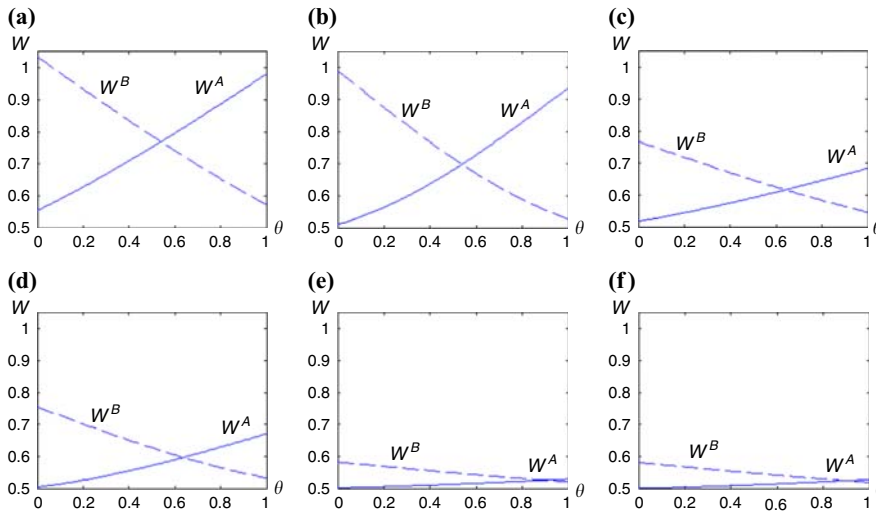
4.3 Comparison of welfare in the inter-regional dimension

Divided by the inter-regional dimension, the welfare levels of the two regions can be expressed as follows:

$$W^A(\theta) = W_S^A(\theta) + W_U^A(\theta) = \theta L_S[C_A(\theta) + w_A(\theta)] + \frac{1}{2}L_U[C_A(\theta) + 1], \quad (17)$$

$$W^B(\theta) = W_S^B(\theta) + W_U^B(\theta) = (1 - \theta)L_S[C_B(\theta) + w_B(\theta)] + \frac{1}{2}L_U[C_B(\theta) + 1]. \quad (18)$$

Give different marginal costs first, and then we simulate within the value range of trade costs (Figure 2).



Notes: (a) $a_m = 0.2$, $\tau = 0.1$; (b) $a_m = 0.2$, $\tau = 0.5$; (c) $a_m = 0.5$, $\tau = 0.1$; (d) $a_m = 0.5$, $\tau = 0.3$; (e) $a_m = 0.8$, $\tau = 0.07$; (f) $a_m = 0.8$, $\tau = 0.13$

Figure 2.
Comparison of
inter-regional welfare
levels under different
freight rates and
marginal costs

The following proposition can be drawn from Figure 2:

- P4.* In the differentiated labor inter-regional flow model, when the location conditions are improved, the industrial agglomeration is enhanced, the welfare of the core area will be increased, but the welfare of the peripheral areas will be uncertain or even decreased. When trade costs rise, welfare in core areas rises; when marginal costs rise, welfare in core areas falls.

Figure 2 and *P4* show that although industrial agglomeration and location improvement can enhance the welfare of the core area, the core area has insufficient drive for regional integration. The reason is that rising degree of integration means that the cost of trade has fallen, the threshold for entry has decreased, the monopoly position of the core area has declined, and the welfare has, on the contrary, declined.

5. Transition from unitary transfer payment to industrial intervention and industrial balance

The results of the previous analysis show that, in the long run, the welfare of the core area tends to rise in the core-peripheral structure, whereas the welfare of the peripheral area tends to decline. So, how should the core area compensate the periphery for welfare? There are currently no established criteria and answers to this issue. Even with interpersonal compensation standards, welfare economists have different theoretical perspectives and policy claims. For example, Kaldor (1939) compensation principle is concerned with the compensation after the change, and believes that if the beneficiaries still get benefits after fully compensating the maleficiaries, then the social welfare is improved. Hicks (1940) made some amendments on the basis of the kaldor standards, and believed that the criteria for judging social welfare should be observed in the long run. If the maleficiaries cannot benefit from the social beneficiaries from the changes contrary to social conditions, such compensation is an improvement in social welfare. Scitovsky (1941) combines the above two viewpoints and believes that the forward test or the reverse test alone cannot be used as a basis for judging whether social welfare is improved. Only by making two-way tests at the same time can we correctly analyze changes in social welfare, that is, only when the kaldor and Hicks standards are met simultaneously, can we confirm that social welfare is improved or not.

5.1 Transfer payment from an equity perspective

First of all, in theory, the above transfer payment from the perspective of welfare economics is a potential one based on certain value judgments. The special meaning of "potential" here is that the premise of this transfer payment lies in the confirmation that agglomeration is superior to dispersion in terms of efficiency, which determines that when the economic entity changes from dispersion to agglomeration, it can obtain potential Pareto improvements in the sense of kaldor-Hicks compensation. Therefore, this potential transfer payment is a kind of welfare compensation that balances equity and efficiency.

Assuming that the transfer payment plan is (c, t) , c denotes the per capita payment required in the peripheral area, and t denotes the core area per capita payment. The welfare results of various groups in the two states of agglomeration and dispersion are shown in Table II.

First, according to the Pareto standard of equity perspective, when the industrial distribution shifts from dispersion to agglomeration, there is $\widehat{W}_U^A > \overline{W}_U^A$ and $\widehat{W}_S^A > \overline{W}_S^A$, but $\widehat{W}_U^B < \overline{W}_U^B$. Therefore, both types of labor in Region A must provide transfer payment to the unskilled labor of Region B, so that the unskilled labor's welfare (\widehat{W}_U^B) after

compensation is not less than that in the dispersed state (\overline{W}_U^B), namely, after compensation, at least $\widehat{W}_U^B(c) = \overline{W}_U^B$ is met. Thus there is:

$$\frac{1}{2} \cdot (\overline{C}_B + 1) \leq \frac{1}{2} (\hat{C}_B + 1 + c), \text{ with solution } c \geq \frac{2}{9} (1 - a_m) \tau - \frac{5}{48} \tau^2. \quad (19)$$

Second, according to the principle of welfare compensation, after paying compensation in the agglomeration state, the personal utility level of all residents in Region A should be at least not lower than that in the dispersed state. That is:

$$\begin{cases} \hat{V}_S^A \geq \overline{V}_S^A \\ \hat{V}_U^A \geq \overline{V}_U^A \end{cases}, \text{ simplified as } \begin{cases} t \leq \frac{4}{9} (1 - a_m) \tau - \frac{53}{144} \tau^2 \\ t \leq \frac{2}{9} (1 - a_m) \tau - \frac{17}{144} \tau^2 \end{cases}. \quad (20)$$

Again, the transfer payment shall ensure that the total income and expenditure of the two regions are equal, thus:

$$c \left(\frac{1}{2} L_U \right) = t \left(L_S + \frac{1}{2} L_U \right), \text{ simplified as } c = 3t. \quad (21)$$

Finally, the transfer payment scheme (c, t) must meet the clearing conditions after agglomeration, which is reflected in Equation (3). Consistent with the foregoing, the marginal cost is set to three values, respectively, $a_m = 0.2$, $a_m = 0.5$ and $a_m = 0.8$. Combined with Equations (19)–(21), the Turing analysis corresponding to the transfer payment scheme (c, t) can be given as shown in Figure 3.

Figure 3 reflects the core-to-peripheral transfer payment scheme at dispersion to agglomeration transition. The shaded parts in (a), (c) and (e) of the figure indicate the per capita payment to be obtained in the periphery, and the shaded parts in (b), (d) and (f) indicate the per capita payment to be paid by the core area. Given the marginal cost a_m , the trade cost range is $\tau < \tau^{trade} = (2/3)(1 - a_m)$. The vertical red line in Figure 3 represents the upper bound of the trade cost range, i.e., τ^{trade} . An observation of Figure 3 leads to the following proposition:

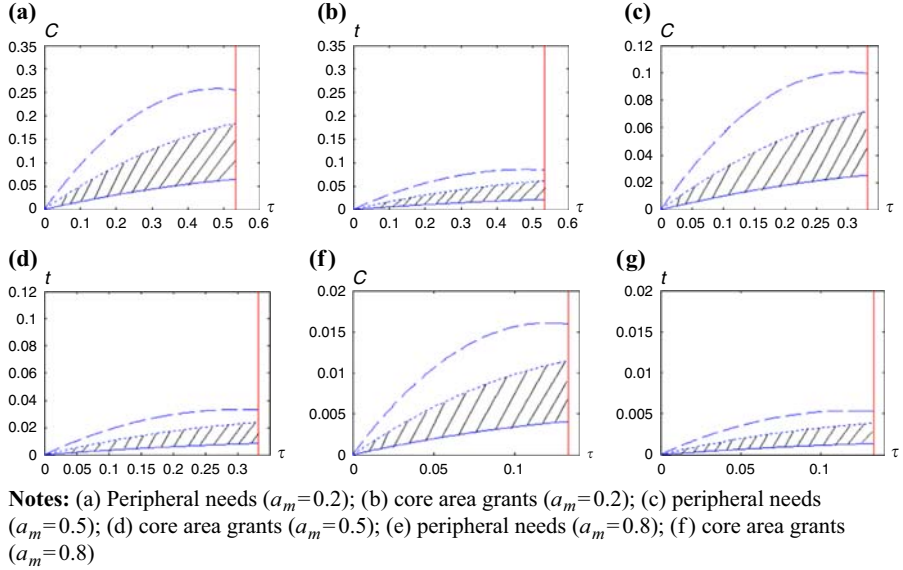
- P5. In the inter-regional mobility model of differentiated labor, the industrial distribution shifts from dispersion to agglomeration, objectively requiring the core area to support the periphery with corresponding welfare compensation, the intensity of which rises with the increase of inter-regional trade costs, and falls with the decline of the marginal manufacturing costs.

The proposition reveals that the size of inter-regional transfer payments depends mainly on the welfare losses and mobility willingness of the peripheral unskilled labor force when the regional economic system shifts from dispersion to agglomeration. On the one hand, rising

Dispersion equilibrium	Skilled labor (S)	Unskilled labor (U)
Region A	$\overline{W}_S^A = (1/2)L_S[C_A + w_A]$	$\overline{W}_U^A = (1/2)L_U[C_A + 1]$
Region B	$\overline{W}_S^B = (1/2)L_S[C_B + w_B]$	$\overline{W}_U^B = 1/2L_U[C_B + 1]$
Agglomeration equilibrium	Skilled labor (S)	Unskilled labor (U)
Region A	$\widehat{W}_S^A = L_S[C_A + w_A]$	$\widehat{W}_U^A = (1/2)L_U[C_A + 1]$
Region B	$\widehat{W}_S^B = 0$	$\widehat{W}_U^B = (1/2)L_U[C_B + 1]$

Note: The welfare function matrix of this table is calculated on the basis of Table I

Table II.
Welfare matrix of two
types of labor in
agglomeration and
dispersion equilibrium



trade costs have forced firms in the peripheral areas to bear higher import prices of industrial products, resulting in greater welfare losses, and forcing the core areas to provide more welfare compensation. On the other hand, the increase in marginal cost has led to the compression of the space for transfer payments. The peripheral skilled labor force, attracted by the “conviviality effect” in the core area, will choose to flock to there at the expense of large-scale immigration, resulting in excessive agglomeration and crowding.

5.2 Industrial balancing from the perspective of efficiency

Different from the transfer payment compensation method from the equity perspective, the inter-regional welfare compensation can also be realized by balancing the industrial locations across regions, that is, through industrial transfer and industrial intervention. The fundamental reason for its implementation lies in the deviation of the market's optimal agglomeration relative to that of the society. There are two potential inefficiencies in the regional economic system when the market is free to operate[10]. If the social welfare levels of the two regions are aggregated, the overall welfare can be “optimal.” At the same time, as an economic planner, if the central government can force the manufacturers in the region to price according to the marginal costs, the economic system can thus achieve the “sub-optimal” situation. Under such circumstances, the central government has sufficient information and adjusts the regional industrial layout according to the overall optimal agglomeration level of the whole society. Not only can the market efficiency be greatly improved, but also the regional gap can be narrowed. Compared with the potential transfer payment, the method of balancing the regional industrial location via global welfare analysis with utilitarian standards may also achieve the purpose of balancing equity and efficiency and realizing inter-regional welfare compensation through completely different compensation methods.

In order to give a utilitarian social welfare function, the two regional social welfare functions are summed up to:

$$W(\theta) = \frac{1}{2}L_U[C_A(\theta) + 1] + \theta L_S[C_A(\theta) + w_A(\theta)] + \frac{1}{2}L_U[C_B(\theta) + 1] + (1 - \theta)L_S[C_B(\theta) + w_B(\theta)]. \quad (22)$$

Since the manufacturer is pricing according to the marginal cost, there is $p_{AA}^0 = p_{BB}^0 = a_m$, $p_{AB}^0 = p_{BA}^0 = a_m + \tau$, that is, the difference between the profits of the manufacturers in the region is zero, and the difference in the nominal wage of the labor is also zero, $w_A(\theta) - w_B(\theta) = 0$ and it holds for all θ . The modified Equation (22) formula can solve the regional industrial distribution state at the social optimal agglomeration:

$$\begin{aligned} W &= (1-a_m)^2 + \left(2\theta^2 - 2\theta - \frac{1}{2}\right)(1-a_m)\tau + \left(-2\theta^2 + 2\theta + \frac{1}{4}\right)\tau^2 + 1 \\ &= 2\tau[\tau^0 - \tau]\theta(\theta-1) + \text{constant}, \tau^0 = 1-a_m. \end{aligned} \quad (22)$$

Combined with the actual labor rate difference of Equation (13), the industrial distribution under the optimal market condition can be obtained:

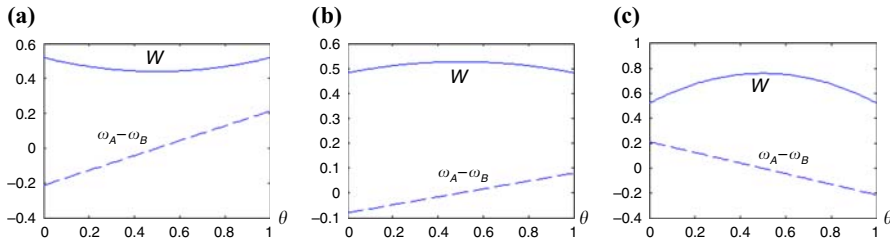
$$\omega_A - \omega_B = \frac{16}{9}(\tau^* - \tau)\tau\left(\theta - \frac{1}{2}\right), \quad \tau^* = \frac{5}{4}(1-a_m). \quad (12)$$

First, we examine the impact of trade costs on social optimal and market optimal industry distribution. Since the trade costs in Equations (22) and (12) have two critical values: $\tau^0 = 1-a_m$ and $\tau^* = 5/4(1-a_m)$, for each given marginal cost a_m , the trade cost parameters can be selected in three representative intervals for numerical simulation. We might as well set $a_m = 0.2$, then $\tau^0 = 0.8$, $\tau^* = 1$. Taking three representative trade cost parameters, the Turing analysis of numerical simulation is as shown in Figure 4.

Observing Figure 4 and combining the characteristics of long-term equilibrium, it is not difficult to find out: when the degree of regional integration is low, social optimality and market optimality are consistent when the industry is highly dispersed (corresponding to $\theta = 0.5$); when the degree of regional integration is at a higher level, social optimality still favors dispersion in industries, while market optimization requires a spatial distribution of agglomeration; when the regional integration is very high, social optimality and market optimality invariably tend to form in core areas an industrial distribution of complete agglomeration, where the market optimality and social optimality are inherently consistent.

At present, China is in the second stage of the above three situations, that is, the stage of low trade cost and high degree of regional integration, corresponding to the market optimal agglomeration is higher than the social optimal agglomeration. This means that the “laissez-faire” of spontaneous role of market forces would incur excessive agglomeration of industries. The reason is that although the degree of regional integration in China is gradually increasing, the current market is not yet fully mature. As reflected in Figures 3 and 4, the payment for compensation in the peripheral areas is much higher than that the core area is willing to pay.

The impact of marginal cost a_m on overall social welfare is also in line with expectations. For example, the partial derivative of Equation (22) on the marginal cost a_m and the



Notes: (a) $\tau = 0.2 < \tau^0 < \tau^{trade}$; (b) $\tau^0 < \tau = 0.9 < \tau^{trade}$; (c) $\tau^0 < \tau^{trade} < \tau = 1.2$

Figure 4.
Inter-regional
welfare compensation
path under
balanced industrial
location models

combination of constraints derive $(\partial W/\partial a_m) = -2[(1-a_m)+(\theta^2-\theta-(1/4)\tau)] < -2(\theta^2-\theta-(5/4))$ $\tau < 0$, denoting that through the means of economies of scale or technological progress, and reducing the marginal cost, the overall welfare of the whole society can be escalated.

It is worth noting that the two thresholds (critical values) $\tau^0 = 1-a_m$ and $\tau^* = 5/4(1-a_m)$ of trade costs have subtle links with marginal costs. The increase of marginal cost a_m makes both thresholds decrease, and the market optimal and social optimal ideal state in the fully agglomerated state will be more difficult to achieve, because the range of values accompanying trade costs τ is compressed, and the requirements for τ are more demanding. Conversely, lower marginal costs will relax the range of trade costs. Under ideal conditions, there is a trade-off interaction between these two costs.

5.3 Extended discussion of industrial layout

In the model framework of this paper, the initial assumption is that the ratio of the number of skilled labor to unskilled labor is 1:1. However, according to the ratio requirement of Equation (14), in the composition of the two types of labor, the proportion of skilled labor to the total labor force cannot exceed 0.25. This means that in a regional economic structure with a core-peripheral structure, the number of skilled labor is much less than that of unskilled labor. Now suppose that the ratio of the skilled labor to the unskilled labor is $\lambda:1$ ($0 < \lambda < 1$), then the increase of λ means that the proportion of skilled labor in the economic system rises. Of course, for China in a transition period, among the many factors that measure the overall economic development driven by industrialization and urbanization, the proportion of skilled labor as a representative of high-tech and high-level labor is undoubtedly an important factor with a crucial impact on the overall welfare of the whole society.

Assume that the overall welfare of society can be written in the form of $W = \lambda \cdot W_S + W_U$. According to the conclusions of Equations (15) and (16), W_S is a parabola with an opening upward relative to θ , and W_U is a parabola with an opening downward relative to θ . However, the final opening direction of W mainly depends on the size of λ . When λ is larger, it represents a developed regional economic structure, which is dominated by W_S with an open side up parabola of W ; when λ is smaller, it represents an underdeveloped regional economic structure dominated by W_U and with an open-side-down parabola of W . The Turing analysis results of W are shown in Figure 5.

A closer look at Figure 5 reveals that when the proportion of skilled labor in the economic system is high, the industrial distribution in the agglomerated state can optimize the overall welfare of the society; and when the proportion of skilled labor in the economic system is low, the scattered industrial distribution is more conducive to the improvement of the overall welfare level of the society.

6. Conclusions and revelations

Based on the perspective of differentiated labor inter-regional mobility, this paper constructs a model framework consisting of quasi-linear preference functions of quadratic sub-utility, and theoretically analyzes the rebalance of China's industrial spatial layout.

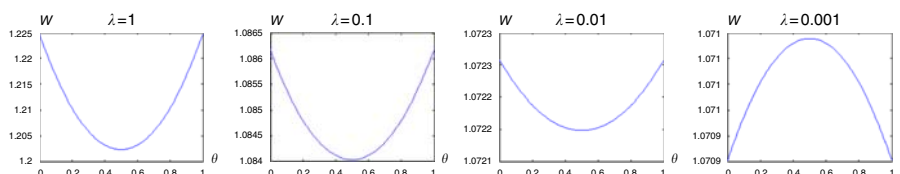


Figure 5.
Total social welfare of
skilled labor at
different scales

The main conclusions are as follows: first, in the long-term state, the industrial spatial layout has a certain threshold limit on the portfolio proportion of the differentiated labor force. The dilemma of China's industrial spatial layout stems from the deviation of market's optimal agglomeration from social optimal agglomeration, and from the disfunction of Eastern China's role as an intermediary between the global and the domestic value chain. Second, at this stage, because the market's optimal agglomeration is always higher than the social optimal agglomeration, it is objectively determined that the imbalance of industrial spatial distribution in China will persist in the long run. Third, the sustainability of high-end industrial agglomeration in the core region needs to be up-kept by the continuous supply of skilled labor in the peripheral regions. At the same time, it is necessary to have as guarantee a welfare compensation mechanism matching social optimum with market optimum.

The enlightenment significance of this paper is that, first, in order to fundamentally alleviate the imbalanced dilemma of China's industrial spatial layout and the phenomenon of regional left-behind due to long-term migration of the central and western labor force, it is necessary to realize a transition from a unitary regional transfer payment strategy to industry relocation and industry rebalancing strategy. Second, under open conditions, the connotation and standards of regional equity are dynamically changing, and the corresponding welfare compensation measures should also be adapted to local conditions. For example, interest groups in the core areas often have the stronger floor and vote decisions, now that they do not expect to obtain more inter-regional transfer payments; they are naturally reluctant to assume more compensation obligations. Therefore, copying the theory of Western economics does not help solve the practical problems in China. An obvious example is that the Western standard welfare economics theory generally believes that the most effective way to compensate for inter-regional welfare under market conditions is transfer payments, but for the actual situation in China, the conditions for doing so are not met. On the contrary, compared with the compensation devices of potential transfer payment, those devices balancing the regional industrial location via global welfare analysis with utilitarian principle may be an effective means to achieve the optimal welfare compensation of the whole society in China. To this end, the central government as an economic planner needs to scientifically balance the industrial location, and consciously plan new industries and projects in the peripheral areas through industrial transfer, industrial intervention and industrial support. In the regional counterpart support and assistance action plan, in view of the long-term siphoning of the skilled labor force in the peripheral areas by the core areas, it is necessary to escalate the system constraints to block the "allee couverte" of abnormal backflow of industry, capital and labor to the core areas. Third, the breakthrough in the predicament of regional industrial spatial layout must not only have an open vision, but also strive to achieve a reasonable balance and trade-off between equity and efficiency. First, based on the openness of the economic system, it is necessary to fundamentally change the traditional practice of maintaining the participation of foundry OEM enterprises in the international division of labor system by means of cheap energy and factor subsidies; second, it is necessary to fundamentally reverse the welfare inequity as a consequence of the deviation of market optimality from society optimality in industrial spatial layout. The spatial matching prowess of talents and industry shall be improved by beefing up the strategic investment on labor talents in general.

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Notes

1. As early as 1935, Chinese geographer Hu Huanyong proposed the famous “Hu’s line (Heihe-Tengchong Line),” which reveals that on the land map of China, the 45-degree diagonal line north from Heilongjiang Heihe River (Henan) and south to Yunnan Tengchong divides the proportion of land area in China into 64 percent in the northwest and 36 percent in the southeast, with a corresponding population ration of 4 and 96 percent, respectively. This pattern of asymmetric distribution of population has not changed even when Hu studied the topic again in 1987. See Hu (1935).
2. The so-called “birth effect” denotes that the more people there are, the greater the potential of social interaction. However, the 2009 World Development Report repeatedly mentioned in terms of the research on China’s immigration, growth and welfare that the southeast coast of China is not only a gathering place for large population migration, but also an agglomeration area with high poverty rate in China. For example, in the early days of reform and opening up in 1980, the population of Shenzhen was only about 30,000. In 1988, it soared up to 800,000, and in 2000, to 7m. See The World Bank (2009).
3. According to the utilitarian principle of social welfare function theory, the ideal state is the maximization of total social welfare, and the core categories are Pareto’s “optimality” and Marshall’s “consumer surplus.” The premise of fair global optimality is to rationally distribute welfare among regions, the necessary condition is economic efficiency, and the sufficient condition is reasonable distribution.
4. The first theorem of welfare economics states that competitive equilibrium has Pareto efficiency. The second theorem emphasizes that to satisfy the competitive equilibrium, appropriate welfare compensation must be applied to specific groups. The third theorem, namely, the Arrow’s theorem, purports that there is no Arrow social welfare function that satisfies simultaneously the universality, Pareto compatibility, independence, and Non-Dictorship. However, Mori’s theorem states that the “Arrow’s impossibility theorem” only applies to the collective selection rule such as in voting, its essence is the defect of the new welfare economics derived from the ordinal utility. The use of the cardinal utility can derive the relevant information for comparison of interpersonal utility. This article uses this as a starting point.
5. At the theoretical level, the current research on such issues is mainly represented by Charlot *et al.* (2006).
6. This is a transfer payment in the sense of obtaining potential Pareto improvements.
7. The first constitutes the Pareto improvement standard and considers that there is no situation in which certain group welfare is better without making any group welfare worse. The second constitutes the utilitarian welfare function standard, which considers the ideal state is to maximize the total social welfare; the third constitutes the Rawlsian welfare function standard, which believes that the level of social welfare depends mainly on the welfare level of the group with the lowest utility in society. Two devices are transfer payments and industrial transfers.
8. Of course, if we consider the influence of restrictions on population mobility such as household registration, we may maintain a symmetric structure of scattered distribution.
9. The so-called “Marshall Pecuniary externality” is essentially Marshall’s principle of external economy, which mainly includes the localization and urbanization effects brought by the knowledge spillover, labor union and factor sharing to the cluster of SMEs.
10. First, whilst the price index in the core region declined, and the price index in the peripheral region rose, which brought negative externalities to the peripheral residents. Second, if the monopolistic pricing of the manufacturers was higher than the marginal cost, unnecessary loss of consumer surplus would ensue.

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