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Does Transportation Infrastructure Technology Evolve to Improve Consumer Surplus?

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Abstract: Based on the existing research, this paper introduces the variable of transportation infrastructure technology evolution. Through model deduction, it is found that technology evolution accelerates knowledge spillovers among regions, and spillovers reduce the variable cost of technology in backward regions, which leads to the transfer of technical services from developed regions to backward regions, the increase of income (income effect) and the decrease of prices (price effect) in backward regions, and the increase of consumer surplus in backward regions.

1. Introduction

A large number of studies [1][2] have proved that the evolution of transportation infrastructure technology can stimulate the development of knowledge-intensive industries in cities along the route and upgrade the industrial structure. However, from the perspective of a country (region) [3] , the government is more concerned about how to maximize the welfare level of a country or region[4]. If the welfare level of cities along the route is obviously improved while promoting the upgrading of industrial structure, then the technological evolution has certain policy significance[5]. On the basis of the foregoing, this paper analyzes the changes of welfare level before and after technological evolution[6], and examines the impact of technological evolution on the welfare level of the two regions.

2. Theoretical Analysis

Consumers in two regions consume industrial products and agricultural products markets at the same time, and consumer surplus in backward regions is divided into two parts: consumer surplus in industrial products market and consumer surplus in agricultural products market. We will calculate and compare the regional consumer surplus before and after the technology evolution. G Regional consumer surplus, and be compared.

2.1 Consumer Surplus before Technology Evolution

Regional consumer surplus of industrial products: $Welfare_{con}^{I} = (w_u^* L_u^* / M)\int_{p_1}^{p_0} \alpha M / p dp$

(Region 1 in Figure 1), deduce:

$$Welfare_{con}^{I} = \alpha w_u^* L_u^* (\ln p^o - \ln p_I) \quad (1)$$

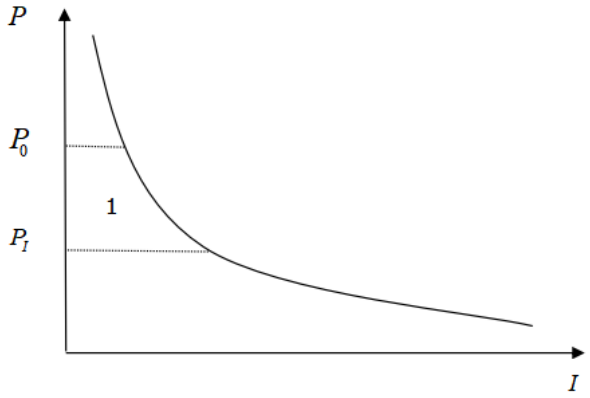

Figure 1: Consumer Surplus in Industrial Products Market before Technology Evolution

p^o Represents the price of industrial goods p_I upper bound; Because in the equilibrium state, the price of industrial goods is: $P_I = \int_0^{\tau_\theta} p^*(\tau) d\tau + \int_{\tau_\theta}^1 p(\tau) d\tau$, G The area in Stage $[0, \tau_\theta]$ of parts production, and D the area Stage $[\tau_\theta, 1]$ of parts production. The price of industrial goods is optimal, lower than all in G Regional production or all in the D Regional production, but p^o Indicates that all in the area G the price of industrial products produced in the region and all in the area.. Minimum value of regional production.

Similarly, G Regional agricultural products consumer surplus:

$$Welfare_{con}^{A} = (w_u^* L_u^* / M) \int_{p_A}^{p_A^0} (1-\alpha) M \Big/ p \, dp$$

(region 1 in Figure 2), deduce,

$$Welfare_{con}^{A} = (1-\alpha) w_u^* L_u^* (\ln p_A^0 - \ln p_A) \quad (2)$$

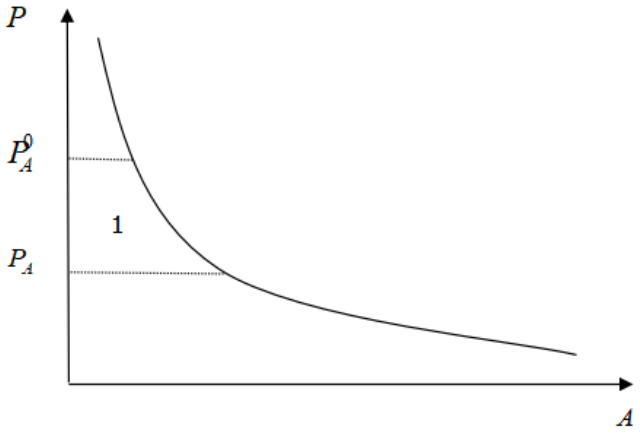

Figure 2: Consumer Surplus in Agricultural Products Market before Technology Evolution

2.2 Consumer Surplus after Technology Evolution

Consumer surplus of industrial products in the region G after technology evolution:

$$\overline{Welfare}_{con}^{I} = [(w_u^* L^* + tL_s^*)/M^{'}]\int_{p_I^{'}}^{p_0} \alpha M^{'}/p dp$$

simplified and available:

$$\overline{Welfare}_{con}^{I} = \alpha(w_u^* L^* + tL_s^*)(\ln p^o - \ln p_I^{'}) \quad (3)$$

G Regional Consumer Surplus of Agricultural Products:

$$\overline{Welfare}_{con}^{A} = (1-\alpha)(w_u^* L^* + tL_s^*)(\ln p_A^0 - \ln p_A) \quad (4)$$

Comparing formulas (1) and (3), after the technological evolution of transportation infrastructure, some technical services are transferred from region D to region G, which leads to the employment of D regional skilled labor and unskilled labor. Therefore, the income level of region G before technological evolution has been greatly improved. Therefore, $w_u^* L^* + tL_s^* > w_u^* L_u^*$, we call it the income effect of technological evolution, that is, region 3 in Figure 3.

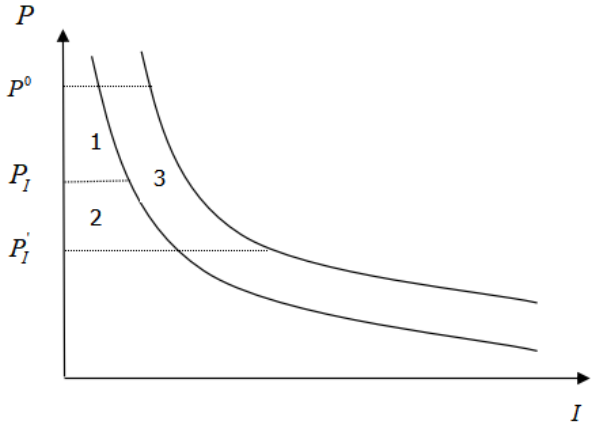

Figure 3: Consumer Surplus in Industrial Products Market after Technology Evolution

Not only that, but the technological evolution has also reduced the variable cost of technology in the region G, a new critical point of division of labor $\tau_\theta^{'} > \tau_\theta$. In equilibrium, the price of industrial products is equal to its cost: $P_I^{'} = \phi + \frac{T_A - T_A^*}{T_A T_A^*}\tau_\theta^{'} + \Gamma^{'}\tau_\theta^{'2}$ .Thereinto, $\Gamma^{'} = \frac{\varphi}{2} + \frac{c^*\omega^*\left(1+tT_A^*\right)}{2\lambda T_A^* n^{*\frac{(1-\lambda)}{\lambda}}} - \frac{c\omega\left(1+tT_A\right)}{2\lambda T_A n^{\frac{(1-\lambda)}{\lambda}}}$ .Obviously, due to the progress of G regional production technology, the price of technical services is lower than the import price, while the prices of parts and industrial products are equal to their costs,so $P_I^{'} < P_I$ that $\ln p^o - \ln p_I^{'} > \ln p_A^0 - \ln p_A$, which is called the price effect of technological evolution (region 2 in Figure 4). According to $w_u^* L^* + tL_s^* > w_u^* L_u^*$, $\ln p^o - \ln p_I^{'} > \ln p_A^0 - \ln p_A$ and $Welfare_{con}^{I} < \overline{Welfare}_{con}^{I}$, the evolution of transportation infrastructure technology improves the consumer surplus of G regional industrial products market.

Comparing formulas (2) and (4), similarly, due to the employment of skilled and unskilled laborers caused by technological evolution, the income effect will lead to an increase in consumer surplus (Figure 4, Region 2). However, as agricultural products belong to a perfectly competitive market, the prices of agricultural products p_A remain unchanged, and technological evolution fails

to trigger the price effect of agricultural products market.Overall $Welfare_{con}^{A} < \overline{Welfare}_{con}^{A}$.

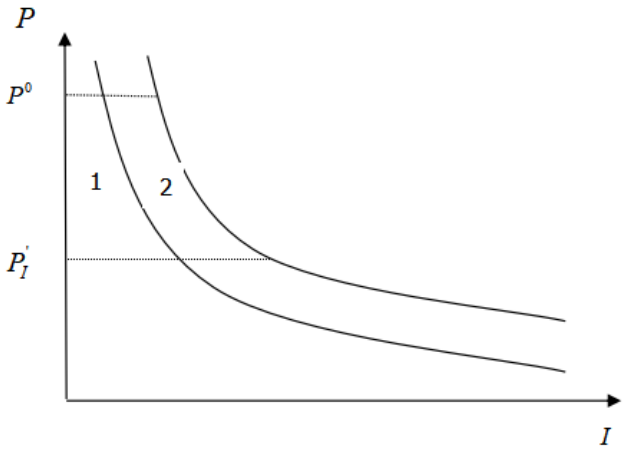

Figure 4: Consumer Surplus in Agricultural Products Market after Technology Evolution

Whether it is the industrial product market or the agricultural product market, the consumer surplus in the region G has been significantly improved after the technology evolution. The reasons are as follows: on the one hand, the technology evolution has accelerated the knowledge spillovers among regions, and reduced the variable cost of technology in the region G, thus prompting some D regional technical services to be transferred to the region G, improving the employment of local skilled and unskilled labor, and increasing the income level (income effect) of the region D. On the other hand, the reduction of the variable cost of technology in the region G reduces the price of industrial products, increases the output of industrial products, and increases the consumer surplus (price effect) in the region D, thus obtaining proposition five:

Proposition: Technological evolution reduces the variable cost of technology in backward areas, which leads to the increase of income (income effect) and the decrease of price (price effect) in backward areas, and increases the consumer surplus in backward areas.

3. Conclusion

Based on the intra-product division of labor model, this paper establishes a theoretical model including technological evolution and industrial structure. Through mathematical model deduction, we find that the consumer surplus in both regions has improved significantly after technological evolution. The reasons are as follows: on the one hand, technological evolution has accelerated the knowledge spillovers between regions, reduced the variable cost of technology, thus improving the employment of local skilled and unskilled labor and increasing the income level of backward regions. On the other hand, the reduction of technology variable cost in developed areas reduces the price of industrial products, increases the output of industrial products, and increases the consumer surplus in backward areas.

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