Journal of Economic Statistics

Impact of Industrialization on Household Income in Rural China, 1988-2018

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ABSTRACT

This paper uses China Household Income Project rural household survey data spanning 30 years (1988-2018) to study the impact of China's industrialization on rural household income. In the semiparametric regression model, we use the rural households' distance to the manufacturing hub to analyze the spillover effect of industrialization on their income and the spatial attenuation. The results show that the income gap between rural households in Guangdong and other provinces increased from 1988 to 2002, but continuously decreased from 2002 to 2018; the rural households' distance to the Pearl River Delta or the Yangtze River Delta, the two international manufacturing hubs, has a significant impact on their income, which has been increasing from 1988 to 1995, but has been decreasing since the new century. On the contrary, the influence of the rural households' distance to the provincial capital on their income has been increasing since the new century.

KEYWORDS

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1. Introduction

Since the reform and opening up in the late 1970s, with the successful industrialization, China has witnessed an economic miracle, the substantial increase of rural household income and the rapid decline of rural poverty rate (Wen, 2016). Specifically, China's reform and opening up started from the rural areas. The Chinese government returned the land to rural households on long-term lease, which injected great vitality into the rural economy and greatly improved the productive efficiency. As a result, the grain output soared from 300 million tons in 1978 to 450 million tons in 1990 (National Bureau of Statistics, 1991). However, the share of the primary industry, including agriculture, forestry, animal husbandry, fishery and mining, in China's GDP gradually dropped from 27.7% in 1978 to 7.2% in 2018, while the share of the tertiary industry increased steadily from 24.6% to 52.2% in the same period, and the share of industrial output maintained at about 45% except for a slight decline in recent years.[1] Excluding price effect, the annual growth rate of value added of China's primary industry was about 4.38% during the period from 1978 to 2018, far lower than GDP's annual growth rate of 9.45%, while the annual growth rate of non-farm sectors' value added reached 10.52%.[2] Therefore, farming development played an extremely limited role in promoting economic growth and rural household income (Zhang et al., 2012). That is to say, in order to get rid of poverty and realize continuous increase of income, the rural households in China cannot merely rely on farming, but have to engage in non-farm activities in local areas and migrant work in the city, or more precisely, to rely on the continuous industrialization.

At the beginning of reform and opening up, the Chinese government decided in 1980 to establish four special economic zones respectively in Shenzhen, Zhuhai, Shantou and Xiamen, mainly to attract investment from Hong Kong, Macao and Taiwan-funded enterprises and to expand exports through the international sales network of these enterprises. In the early 1980s, as a result, Shenzhen and Zhuhai's Special Economic Zones in Guangdong Province became the forefront of China's opening up. Hong Kong, Macao and Taiwan-funded enterprises took the lead in relocating to the Pearl River Delta of Guangdong Province to engage in the "three processing and one compensation" business (processing with supplied materials, processing according to investors' samples, assembling with imported parts, and compensation trade), which set off a high tide of the industrialization of labor-intensive textile and light industrial products aiming at the international market, attracting a large number of migrant workers from Hunan, Jiangxi, Sichuan, etc. After the initial success of the special economic zones, in particular Shenzhen Special Economic Zone, in 1984, the Chinese government decided to open up Hainan Island and 14 coastal port cities, namely Dalian, Qinhuangdao, Tianjin, Yantai, Qingdao, Lianyungang, Nantong, Shanghai, Ningbo, Wenzhou, Fuzhou, Guangzhou, Zhanjiang and Beihai, and established Hainan Special Economic Zone in 1988 and Pudong New District in 1992. As a result, the Pearl River Delta industrial zone with Shenzhen, Guangzhou, Dongguan and Foshan as the center, and the Yangtze River Delta industrial zone with Shanghai as the center and Jiangsu and Zhejiang as the hinterland were gradually established (Lin and Zhang, 2019). From the perspective of China's industrialization process, in the early stage of reform and opening up, the Chinese government first implemented the regional development strategy of making southeast coastal areas pioneers in development, and gave priority to these areas in the system building and the allocation of capital, technicians and labor force (Huang, 2018, Liu et al., 2008, Yuan and Fan, 2003). In the middle and late 1990s, the Chinese government implemented major strategies such as boosting coordinated regional development, developing the western region, promoting the rise of the middle region,

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[1] The data of industrial structure are worked out by the author according to the value added of primary, secondary and tertiary industries issued by the National Bureau of Statistics over the years.

[2] Based on Lv Feng's method (2016), this paper calculates the per capita value added of manufacturing and service industries in various provinces at the constant price in 2018 by using the value-added growth index of manufacturing and services issued by the National Bureau of Statistics over the years, and obtains the value added of non-farm industries after summing them up.

and revitalizing the old industrial bases in the Northeast China. The labor intensive manufacturing sector in the southeast coastal areas are gradually relocated to the middle and western regions (Huang, 2018). At the turn of the century, the State-Owned Enterprises in China rapidly upgraded the economic infrastructure such as transportation (high-speed rail, highway network, ports and terminals, aviation), communication, energy and electricity (Wen, 2016). Since the beginning of the 21st Century, the Pearl River Delta with Shenzhen as the center has grown into the forefront of international information technology manufacturing industry, and the Yangtze River Delta has become the manufacturing hub of China and even the world. Driven by urban State-Owned Enterprises and private enterprises, rural township and village enterprises and foreign-funded enterprises, China's industrialization has rapidly been developed. In 2010, China surpassed Japan to become the second-largest economy and the number one manufacturing hub in the world.

It can be seen that since the reform and opening up, the industrialization in China has been extremely unbalanced. To make clear the industrial development track of various regions in China, we compared the industrialization levels of various provinces in 1980, 1988, 1995, 2002, 2007, 2013 and 2018 (corresponding to CHIP data targeting years). According to the standard of RMB 50 billion yuans of non-farm output value in 1980, RMB 100 billion yuans in 1988, RMB 200 billion yuans in 1995, RMB 500 billion yuans in 2002, RMB one trillion yuans in 2007, RMB two trillion yuans in 2013 and RMB 2.5 trillion yuans in 2018 (Figure 1), the provinces in the forefront of industrial development can be roughly divided into four economic zones, namely the Pearl River Delta Economic Zone (Guangdong Province), the Yangtze River Delta Economic Zone (Shanghai, Jiangsu, and Zhejiang), the Circum-Bohai Sea Economic Zone (Liaoning, Hebei, Beijing, Tianjin, and Shandong), and the middle reaches of the Yangtze River Economic Zone (Hunan, Hubei, Henan, Sichuan, and Chongqing).[3] Fujian entered the ranks of provinces with relatively developed industry and commerce in 1995. In 2018, Anhui's non-farm output value was close to the above-mentioned standard, and it seems that Anhui could be included in the Yangtze River Delta Economic Zone. The development level of township enterprises in the above four economic regions is also relatively high. The most prominent provinces of non-farm output value in 2018 are Guangdong (more than RMB 9 trillion yuans), Jiangsu (close to RMB 9 trillion yuans), Shandong (more than RMB 7 trillion yuans), and Zhejiang Province (more than RMB 5 trillion yuans) (Figure 1). Since the reform and opening up, the output value of township enterprises in the above four provinces has also ranked in the forefront of all provinces in China. In addition, despite their smaller area and lower output value, all four municipalities directly under the central government (Beijing, Tianjin, Shanghai, and Chongqing) are classified into corresponding economic zones due to their developed industry and commerce, advanced education and science and technology. In summary, China's industrialization is basically dominated by coastal provinces and the provinces along the Yangtze River. The above analysis is only based on the non-farm output value of provinces and economic regions. From the perspective of FDI and export [4] (or internationalization), only the Pearl River Delta Industrial Zone and the Yangtze River Delta Industrial Zone can be classified as China's industrialization, high-tech and internationalization frontier. In recent years, however, Anhui, Hunan, Hubei, Henan, Sichuan and Shandong have witnessed a rapid growth of exports.

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[3] Source of the data of 1988-1992:   the statistical data of "60 Years of New China"; Source of the data of 1993-2018: the website of National Bureau of Statistics, http://data.stats.gov.cn/easyquery.htm?cn=E0103. According to Lv Feng's method (2016), we adjust all data to constant prices in 2018.

[4] Source of the data of 1988-2007:   the statistical data of "60 Years of New China"; Source of the data of 2013-2018: the website of National Bureau of Statistics http://data.stats.gov.cn/easyquery.htm?cn=E0103.
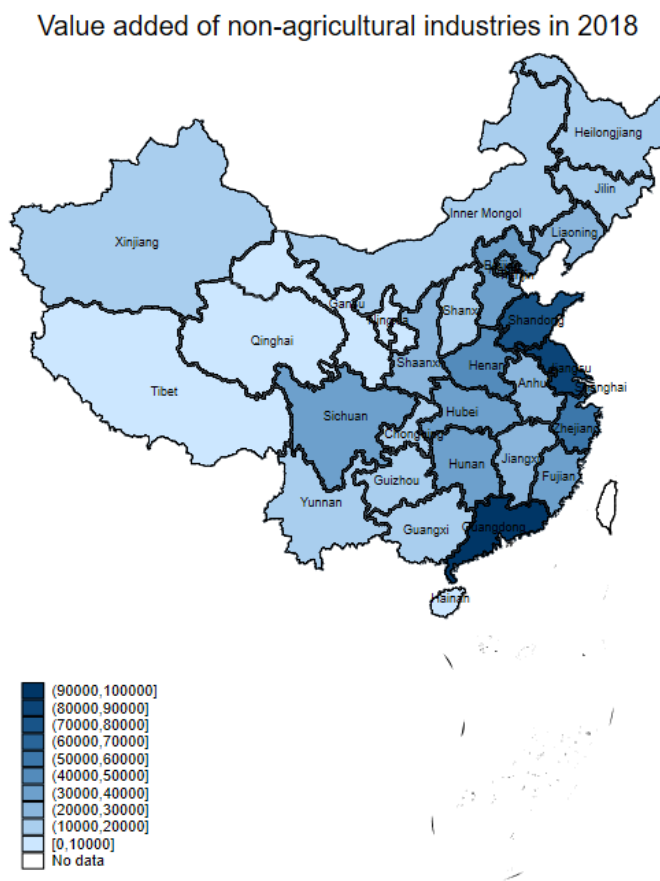
Figure 1. Value added of Non-farm Industries by Province in the Year of 2018 in China, unit: RMB100 million yuans.

Source: the National Statistical Bureau of China.

In the process of rapid industrialization, a large number of rural workers began to work in cities or even across provinces, in addition to working in the nearby township enterprises. In 1984, the Chinese government began to allow rural workers to work in cities. In 1990, there were 15 million migrant workers, and this figure reached 98 million in 2003 (Information Office of the State Council of the PRC, 2004). By the end of 2019, there were a total of 291 million migrant workers in China, including 135 million worked in cities.[5] It can be said that migrant work has gradually become the main employment of rural labor force. According to the National Report on Migrant Worker Monitoring and Survey, the proportion of migrant workers absorbed by the southeast coastal areas has gradually decreased in the past decade, while this proportion in the middle and western regions has steadily increased. In 2009, the migrant workers in the eastern, middle and western regions accounted for 67.80%, 16.00% and 15.30% respectively. In 2019, the proportion of migrant workers in the eastern regions dropped to 54.00%, while that in the middle and western regions rose to 21.40% and 21.20% respectively. The Yangtze River Delta and the Pearl River Delta are the most attractive areas for migrant workers. In 2009, the migrant workers in the Yangtze River Delta and the Pearl River Delta accounted for 24.14% and 21.40% respectively. In recent years, the number of migrant workers in these two regions has decreased slightly, but the total proportion of migrant workers there remains above 30%. In 2019, the proportion of migrant workers in the Yangtze River Delta and the Pearl River Delta was 18.54% and 15.19% respectively. It shows that employing a large number of migrant workers is a main channel

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[5] Source: the website of National Bureau of Statistics,
http://www.stats.gov.cn/tjsj/zxfb/202004/t20200430_1742724.html.

for the Yangtze River Delta and the Pearl River Delta to play a positive role in driving the economic development of other provinces.[6]

The radiation effect of manufacturing hubs on rural household income is mainly achieved through the following ways: Firstly, rural workers from various regions work in manufacturing hubs. However, due to their low education level, it is difficult for migrant workers to get high-tech jobs. In other words, most rural workers are engaged in low-skilled and unskilled jobs. Secondly, the upgrading of manufacturing sector in the southeast coast regions leads to the reallocation of labor-intensive industries to other inland provinces. Thirdly, with the development of manufacturing hubs, the land price, rent and other prices in the surrounding areas continue to rise, so the local rural household income from land transfer, housing rental and farming product sales has been increasing constantly. Generally speaking, the distance from the manufacturing hubs affects their migrant workers' commuting or mobility cost, the degree of technology spillover and knowledge spillover, the cost of information, and the market demand of farming products (Fujita et al., 2001; Hering and Poncet, 2010). In other words, the radiation effect of manufacturing hubs on rural household income in other provinces vary with rural households' distance to manufacturing hubs. A longer distance raises the labor mobility cost, weakens information and technology transmission and reduces industry relocation. At the same time, the process of industrialization may also lead to the outflow of farming resources, which has a negative effect on the welfare of rural households near the manufacturing hubs (Wu et al., 2017). In addition, we propose the following hypotheses:

I.   In the first decade of reform and opening up (i.e. the 1980s), the rapid development of township enterprises and private businesses in the process of China's industrialization provided more non-farm employment opportunities for rural labor force, broadened their employment channels, and directly increased rural households' income (Wen, 2016). Provinces with developed township enterprises, such as Guangdong, Jiangsu and Zhejiang, have increased the income of rural residents by employing a large number of nearby rural laborers.

II. At the forefront of China's reform and opening up and industrialization, the Pearl River Delta and the Yangtze River Delta have attracted tens of millions of migrant workers for a long time. Thus, the high-quality rapid economic growth in these two regions has resulted in the increase of rural household income. In addition, with the WTO entry in 2001, China has attracted a large sum of foreign investment and its exports have increased by a large margin. With the acceleration of China's economic internationalization at the turn of the century, the Pearl River Delta and the Yangtze River Delta upgraded to the hubs of China's manufacturing and high-tech industries, thus boosting the development of China's economy and employment, in particular for rural workers. There are many Hong Kong, Macao and Taiwan-funded enterprises, foreign-funded businesses and domestic high-tech enterprises in the Pearl River Delta and the Yangtze River Delta, so the labor productivity and the wage level are relatively high and these two regions are attractive to the technical and non-technical labor force nationwide. China has a vast territory. The closer to these two regions, the lower the cost of transportation and home visits are. As a result, many rural households in the nearby provinces come to work here. In other words, the ability of the Pearl River Delta and the Yangtze River Delta to attract migrant workers and increase their income will decline with the increase of geographical distance.

III. With the upgrading of industrial technology in the southeast coastal areas such as the Pearl River Delta and the Yangtze River Delta, the rise of the cost of living (and level of wages) in these areas and the improvement of environmental awareness, many medium- and low-tech enterprises have to move

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[6] Source: the monitoring and investigation reports of migrant workers in 2009 and 2019,
http://www.stats.gov.cn/ztjc/ztfx/fxbg/201003/t20100319_16135.html,
http://www.stats.gov.cn/tjsj/zxfb/202004/t20200430_1742724.html.

westward into the middle and western provinces, thus promoting migrant workers' employment in local provinces. In addition, the rise of the Yangtze River Economic Zone, including Anhui, Hunan, Hubei, Henan and Sichuan, has also promoted the employment and income growth of migrant workers in local and nearby provinces.

Since the reform and opening up, the greatest achievement of China's economic development is the successful industrialization and the substantial increase of the income of rural residents. This paper, therefore, attempts to study the impact of the rapid development of China's industrialization on rural household income since the reform and opening up by using the rural household survey data of CHIP (China Household Income Project) during the three decades from 1988 to 2018. First of all, it attempts to study the impact of industrialization on rural household income by analyzing the gap between the other province and the Guangdong Province (the Pearl River Delta) in CHIP data of 1988, 1995, 2002, 2007, 2013 and 2018 as well as the trends. Secondly, this paper attempts to study the impact of industrialization levels in various provinces on local rural household income by calculating the correlation coefficient between the provincial dummy variables' regression coefficient (with Guangdong Province or the Pearl River Delta as the base) and the corresponding provincial industrialization level variable in the above-mentioned years. Thirdly, in the above-mentioned years, this paper constructs the variables of rural households' railway time or distance to manufacturing hubs to study the radiation effect of manufacturing hubs on rural household income and its attenuation. Finally, as the relationship between the rural households' railway travel time or distance to the manufacturing hubs and their income may be nonlinear, we use the Generalized Additive Models (GAMs) to further study the non-linear radiation effect of manufacturing hubs on rural household income and its attenuation.

The structure of this paper is as follows: Part II summarizes the existing literatures on the impact of industrialization on rural economic development and rural household income. Part III presents the theoretical model. Part IV introduces the data and models used in this paper and describes the situation of rural households' income in detail. Part V discusses the measurement results of this paper, and Part VI is the conclusion.

2. Literature Review

According to the development economic theory, the growth of non-farm industries or industrialization is the main channel to absorb rural surplus labor. Lewis (1954) put forward the theory of dual economy, that is: the surplus labor in the farming sector is unlimitedly supplied for the urban industrial sector. When the wage level of the industrial sector is higher than that of the farming sector, the surplus labor in the farming sector will flow into the urban industrial sector. Gustav and Fei (1961) believed that farming development provided labor and surplus for the sustainable development of industrial sector. Todaro (1969) argued that the decision of rural labor transfer is based on the expected wage gap between farming and non-farm sectors, and emphasizes the significance of industrial sector in absorbing rural labor and increasing rural household income. After investigating the industrialization process of some countries, Austin & Sugihara (2010) found that the early industrialization of many countries was labor-intensive, thus absorbing a large number of laborers; in the middle and later stages of industrialization, however, the industrial sector has a higher demand for the quality of labor force, leading to a higher capital - labor ratio and a higher capital-output ratio as well.

There are also a number of studies on the relationship between industrialization and rural household income in China. Chen and Hu (1994) proposed China's ternary economic structure based on the dual economic theory and China's reality, and emphasized the important role of rural non-farm development in absorbing rural surplus labor. Jin & Qian (1998), Yao (2000) and Cai (2007) believed that before the mid-1990s, township enterprises were the main contributors of rural non-farm employment, which helped increasing rural per capita income and reducing rural poverty. Wen (2016) argued that after the reform and opening up, the explosive development of rural industry

represented by township enterprises has absorbed a large number of rural laborers and increased rural household income, thus provided market demand for the various consumer products supplied by the labor-intensive firms in both urban and rural areas. The expansion of the township enterprises is, Zhong (2011) pointed out, conducive to increasing rural household income, but the rural industrialization lacks the advantages of scale economy after the 1990s, so the rural industrialization played a limited role in increasing rural households' welfare. CSLS (2003) argued that China's industrialization has absorbed rural surplus labor and increased rural household income. Li and Han (2007), Zhang and Hu (2007) found that industrialization has short-term and long-term impact on rural household income. Based on the income structure, Che (2013) found that industrialization had no significant impact on rural household income (such as farming income, household business income and wage income). Based on the data of prefecture-level cities in China in 2010 and 2015, using spatial econometrics, Qian and Mo (2018) found that rural industrialization significantly increases rural household income, but the industrialization level of surrounding areas has no significant impact on rural household income.

By analyzing household data, Berdegue et al. (2001), de Janvry et al. (2005), Yue and Luo (2010), Möllers & Buchenrieder (2011) found that non-farm employment helps increase rural household income and reduce rural poverty. Lanjouw & Lanjouw (2001) found that low-income workers generally have low education levels, thus usually engaging in non-farm activities with low productivity. Low-income families tend to, Zhu (2005) pointed out, enter the industries with low thresholds and low wages, such as labor-intensive activities, while high-income families may be more interested in non-farm own-account business. Zhang et al. (2012) studied the impact of industrialization on rural poverty by analyzing the proportion of rural households' labor time spent on non-farm activities, and found that the penetration effect of industrialization is conducive to lifting rural households out of poverty, and allowing rural surplus labor to transfer to the industrial sector is the key to poverty reduction. Partridge & Dan (2008) found that the weak rural labor market is not conducive to increasing wage of migrant workers, and the rural workers' distance to urban areas affects their commuting and migration costs. The empirical results show that the farther away from large cities, the higher the poverty rate in rural areas. The rural households' distance to the market has, according to the research findings of Jonasson & Helfand (2010), Duvivier et al. (2013) and Sarit &Vasilescu (2017), a significant negative correlation with their non-farm employment possibilities and non-farm earnings; with the increase of average income and the expansion of population size, central cities will have a larger demand for farming products and rural labor of the surrounding areas, thus promoting the increase of rural household income.

3. Theoretical framework

The focus of this paper is to examine the impact of the rural households' distance to manufacturing hubs on their non-farm employment and income. Based on Dxiit-Stiglitz-Krugman model (Dixit and Stiglitz, 1977; Krugman, 1992), market access and market size have a great influence on wages in the industrial sector (Fujita, Krugman and Venables, 2001; Head and Mayer, 2004; Hering and Poncet, 2010). If industrial products in area r will be sold to area j (j=1...N), the wage function of the industrial sector in area r is as follows:

$$w_r = \left(\sum_{j=1}^{N} T_{rj}^{1-\sigma} G_j^{\sigma-1} E_j \right)^{\frac{1}{\sigma}} = \left(\sum_{j=1}^{N} \phi_{rj} m_j \right)^{\frac{1}{\sigma}} \tag{1}$$

where σ is the elasticity of substitution between any pair of products, E_j is location j's total expenditure on manufactured goods, G_j is the CES price index for manufactured goods and m_j is the market capacity of region j, $m_j = G_j^{\sigma-1} E_j$. T_{rj} means that if a unit of industrial product produced in region r is shipped to region j, only $1/T_{rj}$ of the original unit arrives. We follow the literature in referring to $\phi_{rj} = T_{rj}^{1-\sigma} = 1/d_{rj}$ as the "phi-ness" of trade,

where d_{rj} is the distance between region r and region j (Baldwin et al., 2003, Head and Mayer, 2004).

We assume that there is an economic center O, the region where the labor is located is region R, the distance between the two places is D; and there is a region s between the two places, the distance between the economic center and region s is ds, and the distance between the region R and region s is D-ds. Industrial products produced by industrial sectors in regions that are not economic centers (such as region R, region s) will be sold locally or sold to economic center O. Labors in region R can be employed in industrial sectors in any region[7]. Therefore, the wage function of the industrial sector in s area is:

$$w_s = (m_s + d_s^{-1} m_O)^{\frac{1}{\sigma}} \qquad (2)$$

We abbreviate ds as d and ws as w, then Eq.2 can be rewritten as:

$$w = (C_0 + d^{-1} C_1)^{\frac{1}{\sigma}} E \qquad (3)$$

where $C_0 = m_s$ and $C_1 = m_O$. This yields:

$$w' = \frac{\partial w}{\partial d} = -\frac{1}{\sigma}(C_0 + d^{-1} C_1)^{\frac{1-\sigma}{\sigma}} d^{-2} C_1 < 0$$

$$w'' = \frac{\partial^2 w}{\partial d^2} = -\frac{C_1}{\sigma}\left\{(C_0 + d^{-1} C_1)^{\frac{1-\sigma}{\sigma}} d^{-2}\left[\frac{\sigma-1}{\sigma}(C_0 + d^{-1} C_1)^{-1} d^{-1} C_1 - 2\right]\right\} > 0$$

We assume that the utility function is $u(c,l) = c^\alpha l^\beta$, where c is the consumption, l is the leisure, $\alpha > 0$ and $\beta > 0$. The individual has a unit of time, then the non-farm employment time of labor is 1-l. If the laborer in the region R chooses to work in the region s, the wage is given by Eq.2 and the transportation cost $k(D - d_s)$ is required[8]. (Similarly, d_s is abbreviated as d, and G_s is abbreviated as G). The laborer chooses commodities, leisure and non-farm employment locations under budget constraint to maximize utility:

$$\max u(c,l) = c^\alpha l^\beta$$
$$\text{s.t.} \ Gc + k(D - d) \le w(d)(1 - l)$$

The first order condition (FOC) implies that:

$$\alpha c^{\alpha-1} l^\beta - \lambda G = 0 \qquad (4)$$
$$\beta c^\alpha l^{\beta-1} - \lambda w(d) = 0 \qquad (5)$$
$$\lambda[w'(1 - l) + k] = 0 \qquad (6)$$

where λ is Lagrange multiplier. Eq.4, Eq.5 and Eq.6 imply that $Gc = \frac{\alpha w l}{\beta}$ and $l = 1 + \frac{k}{w'} > 0$. The budget constraint can be rewritten as:

$$\frac{\alpha + \beta}{\beta} kw + \frac{\alpha w w'}{\beta} + kw'(D - d) = 0 \qquad (7)$$

Differentiating with respect to the distance(D) yields:

$$\left[\frac{\alpha}{\beta} w'(k + w') + \frac{\alpha}{\beta} w w'' + kw''(D - d)\right]\frac{\partial d}{\partial D} = -kw'$$

which implies $\frac{\partial d}{\partial D} > 0$.

Therefore, the effect of increasing the distance between region R and the economic center on wage is:

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[7] According to the new economic geography theory, the wage is lower in regions farther from the economic center, and considering transportation costs, under the assumptions of this paper, labor will only choose to work in the region between region O and region R.

[8] If the labor is employed in the local industrial sector, the wage is $w_R = (m_R + D^{-1} m_O)^{\frac{1}{\sigma}}$, and the transportation cost is zero.

$$\frac{\partial w(1-l)}{\partial D} = [w'(1-l) - wl']\frac{\partial d}{\partial D} \tag{8}$$

In other words, when the laborer's distance to the economic center increases, they can reduce transportation costs by choosing to work in a location closer to the hometown to maximize utility under budget constraint, but at the same time, the wage decreases. On the other hand, the laborer can increase working hours to increase income, that is $\frac{\partial(1-l)}{\partial D} = -\frac{\partial\frac{k}{w'}}{\partial D} > 0$. However, in real life, the laborer is restricted by regulations, time endowment, and cannot increase working time arbitrarily. So we expect that when the laborer's distance to the economic center increases, income will decrease.

4. Research methods and data description

4.1. Econometric models and data used

4.1.1. Basic Econometric Model

In the process of industrialization, the main factors affecting the Chinese rural household income include: the rural household laborers' productive and non-productive characteristics (including proportion of non-farm employment, gender and average age, average education), household structure (including family size, number of workers, gender of the household head, and ethnic minority or not), household land area per capita, and location (province a household belongs to). Other control variables include the proportion of civil servants in the total workers of a household, and the proportion of Party members in a household population. Although there may be endogenous problems in the model, it is difficult to find a perfect tool variable for each year's data because of the long-time span of the data used in this paper. If different instrumental variables were used, we would not be able to judge whether the differences of conclusions result from the change of instrumental variables or from the impact of control variables. Therefore, this paper does not use instrumental variables, but tries to control variables that may affect rural household income to reduce endogeneity. The rural household income generation function can be written as:

$$lny_i = \alpha_0 + \beta_1 r_i + \beta_2 X_i + \varepsilon_i \tag{9}$$

where lny is the logarithm of household income per capita, r is the indicator of the proportion of non-farm employment in the household workers, X are the other control variables mentioned above, and ε is the error term.

Considering that manufacturing hubs can absorb rural surplus labor and affect rural household income, the rural households' distance to China's economic engines, Shanghai (representing the Yangtze River Delta Economic Zone) and Guangdong (representing the Pearl River Delta Economic Zone) is also added to the equation (9). The rural household income generation function is further given by:

$$lny_{ij} = \alpha_1 + \beta_3 r_{ij} + \beta_4 X_{ij} + \gamma_1 lnD_j + \theta_1 \Phi_j + \epsilon_{ij} \tag{10}$$

where lnD_j is the logarithm of the distance between the location j of rural household i and the manufacturing hubs (Shanghai, Guangzhou), Φ_j are the control variables at the regional level, including non-farm industry development, industrial structure, the degree of openness, fixed-asset investment as percent of GDP and road density. It should be noted that all the regional control variables lag behind by a year to avoid potential endogeneity.

4.1.2. Semi-Parametric Regression

In this paper, an important hypothesis is that distance will affect the allocation of resources between the manufacturing center and surrounding areas, labor migration costs, information costs, and the strength of technology spillover effects. It is an important factor affecting the radiation effect of the manufacturing hubs on

rural household income. Under the radiation effect, we expect that the relationship between the rural households' distance to manufacturing hub and their income may be nonlinear. Therefore, this paper employs the semiparametric regression model proposed by Hastie & Tibshirani (1986), that is, generalized additive models (GAMs) to perform a nonlinear regression analysis. The biggest advantage of the GAMs is that the model allows both linear explanatory variables and nonlinear explanatory variables in a regression. In order to examine whether the impact of the rural households' distance to manufacturing hub on their income has nonlinear effect, we assume that this variable is a nonlinear variable, and other explanatory variables are treated as linear explanatory variables. the rural household income function is given by:

$$g\left(E(lny_{ij}|r_{ij}, X_{ij}, D_j)\right) = \alpha_2 + \beta_5 r_{ij} + \beta_6 X_{ij} + f(lnD_j) + \theta_2 \Phi_j \tag{11}$$

where $g(\cdot)$ is link function, assuming its form is $g\left(E(lny_i|r_i, X_i, D_i)\right) = E(lny_i|r_i, X_i, D_i)$, $f(\cdot)$ is the non-parametric smoother.

4.2. Data Description

The household characteristic variables and income variable used in this paper are from the CHIP rural household survey data, which have a detailed classification of rural household income sources, and the surveys cover most of provinces and are nationally representative. By utilizing the CHIP rural household survey data of the six years of 1988, 1995, 2002, 2007, 2013 and 2018[9], covering the most important stage of China's rapid industrialization, this paper aims to stduy the impact of industrialization on the rural household income. Compared with other years, the definition of income in the CHIP data of the year of 2007 is more general, including only personal non-farm wage income, family wage income, family business income, family property income and family transfer income, and there are no more detailed data on the source of income. Therefore, the statistical caliber of this year's data may be different from that of other years. The rural households' railway distances to their own provincial capital city, Shanghai and Guangzhou are derived from Baidu map. Considering the different road networks in different years, this paper also collects the rural households' railway travel time to their own provincial capital city, Shanghai and Guangzhou in the year before the survey. All the data are from the "National Railway Passenger Train Timetable" over the years. For the train running time, we first select the shortest running time among the direct trains between the two regions. If there is no direct train, we choose the shortest time in the transfer route. Other macroeconomic variables are from the statistical yearbooks and statistical bulletin of various provinces (municipalities). In addition, all price data in this paper are adjusted to comparable prices in 2018.

Table 1 shows the descriptive statistics of some control variables. From the perspective of rural household members' employment, from 1988 to 2018, the proportion of non-farm employment in the household' total workers gradually increased. It was 10% in 1988, increased to 17% in 1995, and further increased to 37%, 41%, 52% and

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[9] There are slight differences in the provinces sampled in the survey of CHIP data. Specifically, 28 provinces (municipalities) were surveyed in 1998, namely Beijing, Tianjin, Hebei, Shanxi, Inner Mongolia, Liaoning, Jilin, Heilongjiang, Shanghai, Jiangsu, Zhejiang, Anhui, Fujian, Jiangxi, Shandong, Henan, Hubei, Hunan, Guangdong, Guangxi, Hainan, Sichuan, Guizhou, Yunnan, Shaanxi, Gansu, Qinghai and Ningxia. 19 provinces (municipalities) were surveyed in 1995, namely Beijing, Hebei, Shanxi, Liaoning, Jilin, Jiangsu, Zhejiang, Anhui, Jiangxi, Henan, Hubei, Hunan, Guangdong, Sichuan, Guizhou, Yunnan, Shaanxi and Gansu. 21 provinces (municipalities) were surveyed in 2002, namely Beijing, Hebei, Shanxi, Liaoning, Jilin, Jiangsu, Zhejiang, Anhui, Jiangxi, Shandong, Hubei, Hunan, Guangdong, Guangxi, Sichuan, Chongqing, Guizhou, Yunnan, Shaanxi, Gansu and Xinjiang. The surveyed provinces (municipalities) in 2007 include Hebei, Jiangsu, Zhejiang, Anhui, Henan, Hubei, Guangdong, Sichuan and Chongqing. 15 provinces (municipalities) were surveyed in 2013, namely Beijing, Shanxi, Liaoning, Jiangsu, Anhui, Shandong, Henan, Hubei, Hunan, Guangdong, Sichuan, Chongqing, Yunnan, Gansu and Xinjiang. 15 provinces (municipalities) were surveyed in 2018, namely Beijing, Shanxi, Inner Mongolia, Liaoning, Jiangsu, Anhui, Shandong, Henan, Hubei, Hunan, Guangdong, Sichuan, Chongqing, Yunnan and Gansu.

60% in the years of 2002, 2007, 2013 and 2018 in that order. That is to say, more half of the workers of rural households engages in non-farm work. It also shows that with the deepening of industrialization, non-farm sector provides more and more employment opportunities for rural workers. In addition, the railway travel time from various regions to Shanghai and Guangdong has been reduced significantly. China's railway experienced six large-scale speed-up respectively in1997, 1998, 2000, 2001, 2004 and 2007. The first high-speed train was put into operation in 1997, and extra express trains and direct trains were added in 2001 and 2004. The Beijing-Shanghai High-speed Railway and the Beijing-Guangzhou High-speed Railway were put into operation successively in 2011 and 2012. So far, China's "eight-vertical and eight-horizontal" high-speed railway network has been set up and put into operation. The high-speed railways in the Yangtze River Delta, the Pearl River Delta, Beijing, Tianjin and Hebei have been connected into a network, and high-speed rail interconnection has been realized in the eastern, central, western and northeastern regions. The rapid development of railway transportation reduces the migration cost of migrant workers, and helps migrant workers achieve cross-provincial non-farm employment.

Table 1. Descriptive statistics.

	1988	1995	2002	2007	2013	2018
The proportion of non-farm employment	0.11	0.18	0.37	0.41	0.52	0.60
	(0.24)	(0.27)	(0.36)	(0.37)	(0.39)	(0.37)
Road density	31.42	28.64	39.73	110.80	123.90	130.30
	(39.42)	(11.45)	(18.06)	(35.03)	(48.51)	(53.35)
Value added of tertiary industry/ added value of secondary industry	76.11	76.03	99.23	80.53	77.67	110.40
	(41.16)	(37.14)	(34.81)	(26.44)	(39.49)	(47.26)
Foreign direct investment (% of GDP)	0.61	3.84	1.63	2.49	1.87	1.42
	(1.04)	(5.24)	(2.35)	(2.78)	(1.70)	(1.62)
Fixed-asset investment (% of GDP)	21.81	24.36	29.94	49.96	70.80	85.78
	(10.20)	(16.88)	(12.26)	(18.42)	(29.26)	(33.54)
Non-farm value added per capita	7.54	8.22	8.81	9.57	10.25	10.62
	(0.57)	(0.72)	(0.78)	(0.71)	(0.64)	(0.62)
Logarithm of highway distance between the rural households' location and the provincial capital	5.20	5.06	5.11	5.11	5.05	5.21
	(0.84)	(0.91)	(0.95)	(0.68)	(0.87)	(0.86)
Logarithm of highway distance between the rural households' location and Shanghai	6.92	6.92	7.01	7.06	6.93	6.91
	(0.74)	(0.73)	(0.77)	(0.52)	(0.79)	(0.74)
Logarithm of highway distance between the rural households' location and Guangdong	6.97	6.93	7.03	6.65	6.99	7.02
	(0.73)	(0.68)	(0.72)	(0.75)	(0.66)	(0.61)
Logarithm of railway travel time from the rural households' location to the provincial capital	7.18	7.13	7.15	6.98	7.10	7.18
	(0.61)	(0.83)	(0.87)	(0.70)	(0.84)	(0.71)
Logarithm of railway travel time from the rural households' location to Shanghai	7.20	7.20	6.96	6.59	6.59	6.19
	(0.85)	(0.80)	(0.77)	(0.89)	(0.87)	(0.70)
Logarithm of railway travel time from the rural households' location to Guangdong	7.53	7.41	7.10	6.88	6.85	6.24
	(0.63)	(0.85)	(0.79)	(0.91)	(1.06)	(0.95)
Observations	9718	7966	9002	7691	9585	8224

Notes: The data comes from CHIP, statistical yearbooks, " National Rail Passenger Timetable " and Baidu map. Standard deviations are in parentheses.

4.3. Per Capita Income of the Chinese Rural Households

The Chinese rural household income can be classified into farming income, non-farm earnings[10] and other

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[10] The farming income defined in this paper includes the wage income of farming employment, the net income of farming operation and the income from self-marketing. The non-farm earnings mainly include the wage income of non-farm employment and the net income of non-farm operation.

income according to the income sources in order to facilitate the discussion of the change in rural household income structure from 1988 to 2018.[11]

From 1988 to 2018, the rural household income per capita increased more than five times, rising from RMB 2715 yuans to RMB 15625 yuans, while the rural household farming income per capita increased rather slowly from RMB 1593 yuans in 1988 to RMB 3460 yuans in 2018, rising by only 117.2%, and its proportion in the rural household income per capita dropped from 59% to 22%. The rural household non-farm income per capita, however, increased 11 times from RMB 568 yuans to RMB 6873 yuans in the same period, and its proportion in the rural household income per capita increased from 21% to 44%. It can be said that the increase of the rural household non-farm income per capita is the main source of the increase in the rural household income per capita. With industrialization, the market demand for labor increased, so a large number of rural laborers began to work in cities, and the remittance from migrant workers has also increased year by year.
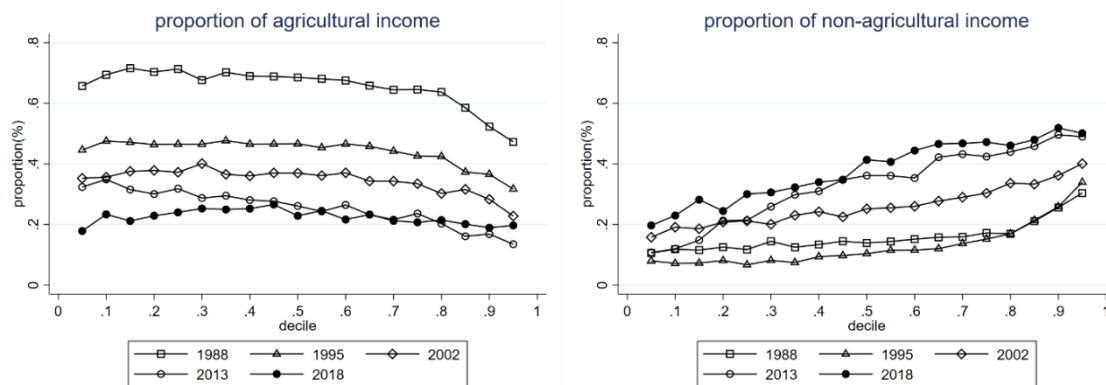
Table 2. Rural household income per capita.

	1988	1995	2002	2007	2013	2018
Per capita income(yuan)	2715	5132	6495	7229	13831	15625
Standard deviation of per capita income	2183	4563	4692	6364	12914	15380
Proportion of income						
Per capita farming income (%)	58.67	39.69	31.05	-	20.49	22.14
Per capita non-farm income (%)	20.93	21.01	30.76	34.95	40.01	43.99
Per capita non-farm income (plus income remitted by migrant workers) (%)	22.01	23.32	31.66	-	45.30	51.71
Per capita income from the manufacturing sector(%)	8.67	10.71	15.08	-	18.97	19.04
Per capita income from the service sector(%)	11.68	10.10	15.69	-	21.04	24.94

In terms of the change in sources of rural household income per capita at the selected percentiles, in 1988 and 1995, farming income was the main income source for rural households, but the proportion of farming income dropped gradually with income at the same year (Figure 2). In fact, in 1995, the farming income at the 75th percentile of rural household income per capita accounted for only about 43% of the household income. From 2002 to 2013, the proportion of farming income further dropped, and this proportion for middle- and high-income households declined more significantly than that of low-income families; compared with the proportion of farming income of low-income families in 2013, it dropped further a bit in 2018, while this proportion for high-income families rose slightly. From the perspective of non-farm earnings, the proportion of it gradually rose with income at the same year. In 1988 and 1995, there was no significant difference in the proportion of non-farm earnings among high-income groups, but the average proportion of it for middle- and low-income families in 1995 was slightly lower than that in 1988. In 2002, the proportion of non-farm earnings in the whole distribution of rural household income per capita rose significantly compared with that in 1995; in 2013, the proportion of it for low-income families was slightly lower than that in 2002, while this proportion for middle- and high-income families increased; in 2018, the proportion of non-farm earnings at all percentiles was further enhanced, and for more than half of the rural households the share of non-farm earnings accounted for more than 40% of their total revenue. Comparing the sources of income over the years, we found that until 2002, farming income remained the main source for most families (middle- and low-income families). At and after 2013, non-farm earnings replace farming as the main revenue source for the middle- and high-income rural families. However, for low-income families, farming income

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[11] There is no price of farming products in the data of 2002, so this paper uses the price data of 1995 to adjust the price index and estimates the income of self-marketing in 2002. As the income data of 2007 is not classified in detail, we do not discuss the data in 2007 here. In addition, we believe that most of the long-term migrant workers (peasant workers) are engaged in non-farm work in non-local areas, so we redefine the per capita non-farm earnings of the second type of family, which includes the income remitted home by long-term migrant workers.

still accounts for more than 30% of their total revenue, exceeding the proportion of non-farm earnings. In 2018, non-farm earnings became the number one source of income for most of the rural households.

Figure 2. Income resource by decile.

According to the analysis on the income structure of rural households in various provinces, in 1988, farming income accounted for more than 50% of rural families' per capita income in most provinces, and this proportion in Inner Mongolia, Anhui, Sichuan and Ningxia even exceeded 70%. However, the proportion of non-farm earnings of rural households in Beijing, Shanghai, Jiangsu, Zhejiang and Guangdong was 38.9%, 37.0%, 30.7%, 31.2% and 27.9% respectively, all above 27%. In 1995, non-farm earnings became the main source of income of rural households in Beijing, Zhejiang and Jiangsu, accounting for 51.6%, 37.9% and 32.6% respectively, while this proportion in Guangdong dropped to 25.3%.[12] In 2002, the proportion of non-farm earnings of the rural households exceeded 40% in Beijing, Hebei, Jiangsu and Zhejiang, and remained above 30% in Shandong, Hunan and Guangdong. The main source of rural household income in other provinces is still farming. With the rapid industrialization in the middle and western provinces, in 2013 and 2018, the proportion of non-farm earnings of rural families in almost all the provinces covered by CHIP was higher than that of farming income (except Inner Mongolia and Xinjiang), but the level of industrialization between regions remains unbalanced, and the absolute value of non-farm earnings and its proportion in family revenue vary greatly among provinces. In 2018, for example, the proportion of non-farm earnings of rural households in Beijing, Jiangsu and Guangdong remained high, up to 60.7%, 50.6% and 50.5% respectively, while the corresponding proportion of Sichuan, Yunnan and Gansu was 38.5%, 38.1% and 29.0% respectively. In addition, Anhui, Henan, Hubei, Hunan, Sichuan and Gansu are the main provinces providing migrant workers, so the proportion of their long-term migrant workers' income remitted home is also high.

For the period from 1988 to 2018, despite the rapid industrialization in various provinces of China, the development between regions remains unbalanced. Industrialization developed first in the Pearl River Delta (Guangdong), the Yangtze River Delta (Shanghai, Jiangsu and Zhejiang), and then other coastal areas in the east also achieved rapid industrialization. Despite the rapid increase of the per capita value added of non-farm industries in the middle and western regions after 2002, the level of industrialization in the middle and western regions lags 5-10 years behind that in the eastern regions. The correlation coefficient between the rural household income per capita by province (CHIP data) and the per capita value added of the primary industry in corresponding provinces (official statistics) is not statistically significant. Township enterprises developed rapidly in the 1980s and 1990s, absorbing a large number of rural labors. The correlation coefficient between the rural household income per capita by province (CHIP data) and the per unit output value of township enterprises in corresponding province has been decreasing year by year since 1988, dropping from 0.75 in 1988 to 0.70 in 1995, and then to 0.68 in 2002. This

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[12] However, if the income from migrant work is classified as non-farm employment income, the proportion of non-farm earnings in the per capita income of rural households in Guangdong Province would increase to 28.81% in 1995.

correlation coefficient was not statistically significant in 2007, and was 0.67 in 2013.[13] Further calculation shows that from 1988 to 2018, the correlation coefficient between the rural household income per capita by province (CHIP data) and the per capita value added of non-farm industries in corresponding provinces showed an upward trend. It was 0.87 in 1988, slightly increased to 0.89 in 1995, then decreased to 0.71 in 2002, and soared to 0.91 in 2007, 0.96 in 2013 and 0.93 in 2018. Specifically, the correlation coefficient between the rural household income per capita by province (CHIP data) and the per capita value added of manufacturing industry in corresponding provinces dropped significantly after reaching the peak in 2007. It was 0.89 in 1988, 0.90 in 1995, 0.91 in 2002 and 0.95 in 2007, and declined to 0.70 in 2013 and 0.52 in 2018. The correlation between the rural household income per capita by province (CHIP data) and the value added per capita of the service sector in corresponding provinces is on the rise. The correlation coefficient was 0.82 in 1988, 0.85 in 1995, and dropped sharply to 0.58 in 2002, but rose to 0.83 in 2007, and maintained an upward trend in 2013 and 2018, reaching 0.92 and 0.94 respectively. In addition, the correlation between the rural household income per capita by province (CHIP data) and the total export per capita in corresponding province has been on the decline since 1988, while the correlation with per capita foreign direct investment has been fluctuating, rising from 0.77 in 1988 to 0.83 in 2018.

Table 3. The correlation between the per capita income of rural households and the per capita value added of each industry.

	1988	1995	2002	2007	2013	2018
Per capita value added of primary industry	-0.270	0.173	0.192	0.141	-0.291	-0.441*
Output value of township enterprises per unit	0.748***	0.702***	0.680***	0.412	0.670***	-
Per capita value added of secondary industry	0.889***	0.904***	0.912***	0.950***	0.702***	0.519**
Per capita value added of secondary industry	0.822***	0.846***	0.582***	0.831***	0.920***	0.942***
per capita non-farm value added	0.872***	0.886***	0.711***	0.906***	0.963***	0.929***
Per capita foreign direct investment	0.772***	0.812***	0.766***	0.865***	0.610**	0.830***
per capita total exports	0.810***	0.759***	0.716***	0.743**	0.700***	0.613**

*Notes: ***,** and * indicate significance at the 1%,5% and 10% levels, respectively.*

5. Results of Econometric Analysis

5.1. Linear Regressional Analysis of The Impact of Industrialization on Rural Household Income

5.1.1. Linear Regression Results of Basic Variables in Linear Regression Equation of Rural Household Income

Before studying the impact of manufacturing hubs on rural households' income, we first provide the regression results of basic variables affecting rural household income (Table 4)[14]. It can be seen from Table 4 that the increase in the proportion of non-farm employment of the workers in rural families will significantly increase the per capita income of rural household. For every 10% increase in this proportion, the per capita income of rural households would increase by about 5.44% in 1988 and 6.54% in 1995. After that, this rate kept dropping, declining to 2.35%, 2.04%, 2.00% and 1.22% respectively in 2002, 2007, 2013 and 2018. In the 1980s and 1990s, there were a large number of surplus labor in rural China, so the rapid rise of township enterprises, and non-state-owned industrial and commercial businesses in urban areas provided many employment opportunities for the rural surplus labor.

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[13] Since 2015, "China Farming Yearbook" no longer publishes the relevant data of township enterprises.
[14] Since there is no data on the cultivated land area of Party members and rural households in 2007, the results are only used for a robustness test in the following part of this paper.

The rural laborers with strong ability and good physical conditions were transferred to the industrial sector, of which the wage was generally higher than that of the farming sector. Therefore, the increase in the proportion of non-farm employment in rural families would significantly increase the per capita income of rural households. With the advance of industrialization, however, the labor force has been further transferred from the farming sector to the non-farm sector, the marginal income of non-farm employment has been reduced, and rural households have got more sources of income increase, reducing the impact of the proportion of non-farm employment on rural per capita income.

In order to study the impact of industrialization level on the rural household income, this paper also employs conditional quantile regression for estimation.[15] It can be seen that in the regression results of 1988 and 1995, despite slight differences in the coefficient of non-farm employment proportion at different quantiles, there is no significant difference between them according to the statistical test results. In 2002, the contribution of the proportion of non-farm employment to the increase of rural household income decreased with the increase of revenue. For every 10% increase in the proportion of non-farm employment in the 25th percentile of per capita income, the per capita income would increase by 2.49%; while for the rural households at the 75th percentile income per capita level, the per capita income only increased by 1.99%. In the quantile regression results of 2007, 2013 and 2018, the contribution of the proportion of non-farm employment of rural households to the increase of rural household income has a similar trend. It shows that since the beginning of the new century, the increase in the proportion of non-farm employment plays a greater role in increasing the income of middle- and low-income rural families.

Table 4. Ordinary least-squares estimator of the proportion of non-farm employment.

	1988	1995	2002	2007	2013	2018
Proportion of non-farm employment	0.544***	0.654***	0.235***	0.204***	0.200***	0.122***
	(0.031)	(0.024)	(0.015)	(0.019)	(0.018)	(0.023)
Control variables	YES	YES	YES	YES	YES	YES
Province	YES	YES	YES	YES	YES	YES
Observations	9,718	7,966	9,002	7,691	9,585	8,224
Adj. R-squared	0.304	0.331	0.344	0.273	0.273	0.216

*Notes: Standard errors in parentheses. ***,** and * indicate significance at the 1%,5% and 10% levels, respectively.*

5.1.2. The Impact of Manufacturing Hubs on Rural Households' Income from the Perspective of Inter-Provincial Income Gap

After controlling the variables of occupation, human capital and family structure, the provincial variable coefficients in the estimated rural household income function of the CHIP data in each year (OLS) indicates the gap in the rural household income per capita between other provinces and Guangdong Province (the Pearl River Delta). We attempt to analyze the change of provincial variable coefficients from 1988 to 2018 in term of the impact of the rural households' distance to the Pearl River Delta on their income.

Guangdong, Jiangsu and Zhejiang, where the Pearl River Delta and the Yangtze River Delta are located, can be called a core economic circle. Jiangsu Province, which faces the sea to the east, is the hinterland of Shanghai and a part of the Yangtze River Delta. It has industrial cities (Nanjing, Suzhou, Nantong, Wuxi, Yangzhou, etc.) and its economic development level is not lower than that of Guangdong. In 1988, the rural household income per capita in Jiangsu was 21.4% lower than that of Guangdong. In 1995 and 2002, the coefficient was not statistically significant (meaning no difference with Guangdong). In 2013, the rural household income per capita in Jiangsu was 10.5% higher than that of Guangdong, and 20.4% higher in 2018. Like Jiangsu Province, Zhejiang is also the

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[15] Due to space limitation, quantile regression results were omitted. If you need them, please contact the author.

hinterland of Shanghai and a part of the Yangtze River Delta. It faces the sea in the east, has developed port trade, and has a cluster of industrial cities (Hangzhou, Ningbo, Wenzhou, Shaoxing, etc.). Its economic development level is not lower than that of Jiangsu. In 1988, the rural household income per capita in Zhejiang was 13% higher than that of Guangdong, but it was 19% lower than that of Guangdong in 1995, then became basically the same in 2002 and 2007.[16] In the early stage of the period from 1988 to 2018, the rural household income per capita in Jiangsu and Zhejiang was lower than that in Guangdong, but the gap then narrowed and the rural household income per capita in Jiangsu and Zhejiang even exceeded that in Guangdong in the later stage.

The adjacent provinces of the Pearl River Delta and the Yangtze River Delta include Hunan, Fujian, Jiangxi, Anhui, etc., forming the second economic circle of the manufacturing hubs. Being separated from Guangdong by mountains, Hunan is an inland province and belongs to the middle region in term of China's economic development level. In 1988, there was no gap between the rural household income per capita in Hunan and that in Guangdong. In 1995, however, the rural household income per capita in Hunan was 35% lower than that in Guangdong. The gap remained stable at 34% in 2002 and 2013, and was then reduced to 29% in 2018. The situation in Jiangxi is similar.[17] In 1988, the rural income gap between Anhui Province and Guangdong was 33%. In 1995, 2002 and 2007, the gap widened to 40%, 45% and 51% respectively. In 2013, however, the gap narrowed to 33%, and then to 26% in 2018. The gap between Hunan/Anhui and Guangdong has been continuously decreasing.

Shandong, Hubei and Henan are a little bit far away from the manufacturing hubs of the Yangtze River Delta and the Pearl River Delta, constituting the third economic circle of the manufacturing hubs. Shandong is a coastal province with developed township enterprises and export trade (Korea, Japan). In 1988, the per capita income of rural households in Shandong was 32.9% lower than that in Guangdong. In 1995 and 2002, the gap widened to 34.0% and 38.6% respectively. In 2013, however, the income gap narrowed to 12.9%[18], and then to 10.5% in 2018. As an inland province, Hubei straddles the Yangtze River and has a metropolitan city of Wuhan, which is the thoroughfare of nine provinces. In 1988, there was no difference in the rural household income per capita between Hubei and Guangdong. In 1995, however, the income of rural households in Hubei was 31% lower than that in Guangdong, and the gap widened to 34% and 38% in 2002 and 2007 respectively, and then narrowed to 25% and 30% respectively in 2013 and 2018. Henan Province, through which the Yellow River flows, is the birthplace of the Chinese civilization, known as China's most populous province. In 1988, the rural household income gap between Henan and Guangdong was 58%, and then it continuouly narrowed down. In 1995, 2002, 2007 and 2013, the gap narrowed to 45%, 52%, 48% and 26% respectively. In 2018, the gap disapeared. It can be seen that the living conditions of Henan's rural households have been greatly improved. By contrast, we can see that the household income gap between the third economic circle and Guangdong is far greater than that between the core /second economic circle and Guangdong.

Sichuan, Hebei, Shanxi and Liaoning constitute the fourth economic circle of the manufacturing hubs of the Yangtze River Delta and the Pearl River Delta. Sichuan is an inland province with a large population and inconvenient traffic. In 1988, the rural household income gap between Sichuan and Guangdong was 23%. In 1995, 2002 and 2007, the gap expanded to 40%, 48% and 58% respectively, but it narrowed to 40% in 2013, and then to 35% in 2018. The rural household income gap between Hebei and Guangdong gradually narrowed from 64% in 1995 to 32% in 2007.[19] The area along the Yellow River in Southeast Shanxi Province is also the birthplace of Chinese civilization, and Shanxi is rich in coal resources. The rural household income gap between Shanxi and Guangdong was 51% in 1988, widened to 94% in 1995, and then narrowed to 57%, 58% and 27% respectively in

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[16] The CHIP data of 2013 and 2018 do not cover Zhejiang Province.
[17] The CHIP data does not cover Jiangxi Province.
[18] The CHIP data of 2007 do not cover Shandong Province.
[19] The CHIP data of 1988, 2002, 2013 and 2018 do not cover Hebei Province.

2002, 2013 and 2018. Liaoning Province is located in the southernmost part of Northeast China, bordering on the Bohai Sea and the Yellow Sea. Before the reform and opening up, Liaoning was the heavy industry base of the new China and had a series of heavy industrial cities as Shenyang, Anshan, Fushun, Benxi, Jinzhou and Dalian. The rural household income gap between Liaoning and Guangdong was 26% in 1988, widened to 50% and 49% in 1995 and 2002 respectively, and then narrowed to 32% in 2013 and 13% in 2018. In a word, compared with the core, the second and third economic circles of the manufacturing hubs, the fourth economic circle has a wider rural income gap comparing with Guangdong, but the gap has also narrowed in the new century.

The last economic circle of the manufacturing hubs of the Yangtze River Delta and the Pearl River Delta include southwest and northwest provinces of China, such as Yunnan, Guizhou, Shaanxi, Gansu, Inner Mongolia, Qinghai and Xinjiang. Yunnan is located in the southwest border of China and has many ethnic minorities, bordering Vietnam and Myanmar. The gap between rural household income of Yunnan and that of Guangdong was 7% (only significant at the statistical level of 10%) in 1988, then expanded to 35% and 60% respectively in 1995 and 2002, and narrowed to 23% in 2013 and 20% in 2018. Gansu is located in the northwest of China, and the Yellow River flows through it. In 2018, its income of rural households was 41% lower than that of Guangdong. The gap expanded to 54% in 1995, and then widened to 61% and 62% respectively in 2002 and 2013, but it narrowed to 53% in 2018. The income gap between Gansu and Guangdong is a reflection of the economic situation in northwest provinces of China.

Beijing, as the capital, is the political, economic and cultural center of China. High-tech enterprises, financial businesses, universities and research institutions gather here. Its rural household income per capita was 28.8% higher than that in Guangdong in 1998, but was then 13.0% and 20.8% lower than that in Guangdong respectively in 1995 and 2002. In 2013, however, its per capita income of rural households was 15.7% higher than that in Guangdong. Then the gap further increased to 46.4% in 2018. Despite their incomplete data, according to the existing data, Shanghai and Tianjin also have the characteristics of Beijing. The conditional quantile results show that before 2002, the rural household per capita income gap between middle/western provinces and Guangdong gradually widened, especially for the low-income families, and then the income gap narrowed in 2013, which is first reflected in the narrowed gap of low-income families. In 2018, the income gap of high-income families of the two regions also narrowed to some extent.[20]

To sum up, after controlling rural households' occupation, human capital and family structure, the rural household income gap between other provinces and Guangdong expanded from 1988 to 2002, but gradually narrowed from 2002 to 2018. The main factors causing this phenomenon in the new century are as follows: since the beginning of the new century, coastal labor-intensive enterprises have gradually reallocated to the middle and western regions, and the rural household per capital income gap between Guangdong and the middle/ western provinces such as Anhui, Chongqing, Sichuan, Yunnan and Gansu began to narrow in 2013, which preliminarily verified the third hypothesis of this paper, that is, the shift of China's labor-intensive industries to the middle and western provinces in the new century caused the rise of income of local rural areas. In addition, there is still a "cascade" difference in the rural household per capita income across China. Taking the Yangtze River Delta and the Pearl River Delta as the center, the farther away a provinces is, the lower its rural household per capita income is. To a large extent, the radiation effect of the manufacturing hubs of the Pearl River Delta and the Yangtze River Delta is declining in space.

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[20] Due to space constraints, the results of this part are not reported in this paper. If you are interested in that, please contact the author.

Table 5. Ordinary least-squares estimator of provincial dummy variables.

	1988	1995	2002	2007	2013	2018
Beijing	0.288*** (0.067)	-0.130** (0.054)	-0.208*** (0.041)		0.157*** (0.041)	0.464*** (0.061)
Tianjin	0.133** (0.064)					
Hebei	-0.428*** (0.037)	-0.639*** (0.031)	-0.444*** (0.031)	-0.324*** (0.035)		
Shanxi	-0.507*** (0.043)	-0.941*** (0.036)	-0.570*** (0.031)		-0.584*** (0.035)	-0.273*** (0.048)
Inner Mongolia	-0.482*** (0.045)					-0.149*** (0.052)
Liaoning	-0.260*** (0.045)	-0.496*** (0.037)	-0.494*** (0.031)		-0.321*** (0.036)	-0.126** (0.049)
Jilin	-0.403*** (0.047)	-0.503*** (0.038)	-0.618*** (0.032)			
Heilongjiang	-0.769*** (0.043)					
Shanghai	0.448*** (0.069)					
Jiangsu	-0.214*** (0.040)	-0.056* (0.031)	-0.025 (0.029)	-0.105*** (0.028)	0.105*** (0.031)	0.204*** (0.042)
Zhejiang	0.133*** (0.041)	-0.186*** (0.033)	0.025 (0.028)	0.047* (0.028)		
Anhui	-0.330*** (0.040)	-0.400*** (0.032)	-0.452*** (0.029)	-0.512*** (0.028)	-0.329*** (0.031)	-0.257*** (0.044)
Fujian	-0.284*** (0.045)					
Jiangxi	-0.303*** (0.043)	-0.296*** (0.034)	-0.347*** (0.029)			
Shandong	-0.329*** (0.037)	-0.340*** (0.029)	-0.386*** (0.027)		-0.129*** (0.030)	-0.105** (0.042)
Henan	-0.577*** (0.037)	-0.445*** (0.028)	-0.516*** (0.028)	-0.483*** (0.027)	-0.260*** (0.029)	-0.029 (0.039)
Hubei	-0.003 (0.039)	-0.311*** (0.033)	-0.343*** (0.028)	-0.376*** (0.027)	-0.245*** (0.032)	-0.304*** (0.042)
Hunan	-0.010 (0.039)	-0.350*** (0.031)	-0.339*** (0.029)		-0.342*** (0.031)	-0.291*** (0.043)
Guangxi	-0.124*** (0.044)		-0.539*** (0.031)			
Hainan	0.214*** (0.058)					
Chongqing			-0.582*** (0.038)	-0.621*** (0.033)	-0.393*** (0.037)	-0.201*** (0.051)
Sichuan	-0.229*** (0.036)	-0.404*** (0.028)	-0.481*** (0.028)	-0.575*** (0.027)	-0.399*** (0.031)	-0.354*** (0.042)
Guizhou	-0.360*** (0.045)	-0.525*** (0.038)	-0.764*** (0.031)			
Yunnan	-0.074* (0.043)	-0.349*** (0.037)	-0.602*** (0.037)		-0.229*** (0.035)	-0.197*** (0.046)
Shaanxi	-0.406*** (0.043)	-0.742*** (0.036)	-0.756*** (0.030)			
Gansu	-0.409*** (0.045)	-0.544*** (0.037)	-0.613*** (0.033)		-0.622*** (0.033)	-0.533*** (0.044)
Qinghai	0.135** (0.065)					
Ningxia	-0.169*** (0.065)					
Xinjiang			-0.179*** (0.035)			

Notes: Standard errors in parentheses. ***,** and * indicate significance at the 1%,5% and 10% levels, respectively.

Guangdong as the control group.

5.1.3. The Impact of Industrialization on Rural Household Income from the Perspective of the Correlation between the Provincial Variable Coefficients and the Level of Industrialization in the Corresponding Provinces

Guangdong (The Pearl River Delta) is the default province of the provincial dummy variable group in the estimated rural household income function, so the coefficient of dummy variable for a certain province represents the relative gap between the province's rural household income and that of Guangdong. To explore the relationship between the a province's rural household per capita income gap with Guangdong and the economic development level of corresponding province, we've calculated the correlation coefficient between the provincial variable coefficients in the regression equation of rural household income function and the per capita farming or non-farm output value of the corresponding provinces in 1988, 1995, 2002, 2007, 2013 and 2018. First of all, we worked out the correlation coefficients between the provincial variable coefficients in the above OLS regression and the below economic indicators of corresponding provinces: per capita value added of agriculture and animal husbandry and fishery and mining, per unit output value of township enterprises, per capita value added of non-farm industries, per capita value added of manufacturing industry, per capita value added of service industry, per capita foreign direct investment and per capita export (Table 6).[21] In 1988, 1995, 2002, 2007, 2013 and 2018, the correlation coefficient between the provincial variable coefficients and the per capita farming value added of corresponding provinces is not statistically significant. In other words, the rural household income gap between Guangdong and other provinces has nothing to do with the farming production status of the provinces.

In the 1980s, township enterprises witnessed rapid development and attracted a large number of rural laborers for non-farm employment, becoming the main force of rural economic development. Except for 2007, the correlation coefficient between the provincial variable coefficient and the per unit output value of township enterprises in the corresponding province is statistically significant, which was 0.47 in 1988, increased to 0.55 in 1995, and declined slightly to 0.53 in 2002. By 2007, this correlation coefficient is not statistically significant anymore, which means that the impact of township enterprises on rural household income was greatly weakened. However, this coefficient rose to 0.59 in 2013, which may be because the higher the level of industrialization, the more developed the rural township enterprises.[22] According to quantile regression analysis, in 1988, 1995 and 2002, the correlation coefficient between the provincial variable coefficients of high-income rural households and the per unit output value of township enterprises in the corresponding provinces was higher than that of low-income families, the correlation coefficients of the 25th quantile were 0.44, 0.52 and 0.48, and the correlation coefficients corresponding to the 75th quantile were 0.48, 0.64 and 0.55 respectively. In 2013, however, the correlation coefficient decreased with income, and the correlation coefficients corresponding to the 25th and 75th percentile were 0.59 and 0.55 respectively. It also verifies the first hypothesis proposed in this paper to a certain extent, that is, the development of township enterprises in early stage led to the increase of rural household income. Even in today's successful catch-up industrialization in China, township enterprises still play a significant role in increasing rural household income.

The correlation coefficient of the provincial variable coefficients and its corresponding province's per capita value added of non-farm industries is statistically significant. It was 0.62 in 1988, slightly decreased to 0.48 in 1995 and 0.57 in 2002, soared to 0.92 in 2007, dropped to 0.83 in 2013, and rose to 0.90 in 2018, indicating the less

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[21] The coefficients of dummy variables in OLS estimation results represent the difference between the per capita income of rural households in this province and that of rural households in Guangdong. In the correlation analysis with macro variables, however, we directly use the absolute value of macro data of each province after price adjustment because it is equal to the correlation coefficient calculated with the relative figure of macro data of Guangdong Province.
[22] In 2019, the Statistical Year of China published by the National Statistical Bureau of China did not report the output of rural township enterprises for the year of 2018.

developed of non-farm industries of a sample province, the larger the rural household income gap between the province and Guangdong. Conversely, the more developed of non-farm economic activities in a province, the smaller the rural households income gap between the province and Guangdong. The provincial per capita non-farm value added can further be divided into per capita value added of manufacturing sector and per capita value added of service sector. Among them, the correlation coefficient of provincial variable coefficients and the per capita value added of manufacturing sector in corresponding provinces reached the peak in 2007. It was 0.60 in 1988, 0.50 in 1995, 0.76 and 0.96 in 2002 and 2007 respectively, and then dropped to 0.69 in 2013 and nearly 0.59 in 2018. Except for 1995, the correlation coefficient between the provincial variable coefficients and the per capita value added of service sector of the corresponding provinces is statistically significant. The correlation coefficient was 0.61 in 1988, decreased to the lowest level of 0.46 in 2002, and then showed an overall upward trend, rising to 0.84 in 2007, 0.76 in 2013, and 0.86 in 2018. The above findings indicate that the impact of a province's development level of the non-farm industries and of them the service sector on its rural household income had steadily been increasing for the whole period from 1988 to 2018, and the impact of manufacturing sector had been increasing from 1988 to 2007 but since then it had been decreasing.

According to the quantile results, in 1988, 1995 and 2002, the correlation coefficient between the provincial variable coefficients and the per capita value added non-farm industries of corresponding provinces at the same year increased with the income. The correlation coefficient of the 25th quantile was 0.56, 0.49 and 0.48 in 1988, 1995 and 2002 respectively, and the correlation coefficient corresponding to the 75th quantile was 0.63, 0.57 and 0.63 respectively. It means that in this stage, high-income families were more involved in non-farm employment or own-account business, and the main source of their family income was non-farm earnings, so they had a higher correlation with the development of non-farm industries. With the significant advance of industrialization, after 2007, the correlation between the provincial variable coefficients and the per capita value added non-farm industries of corresponding provinces become highly significant, while this correlation coefficient is lower for the high-income families than for the low-income ones. In 2007, 2013 and 2018, the correlation coefficients between the provincial variable coefficients at the 25th percentile and the local per capita non-farm value added of corresponding provinces were 0.94, 0.84 and 0.90 respectively, and the corresponding correlation coefficients at the 75th percentile were 0.89, 0.80 and 0.89 respectively.[23]

Table 6. The correlation between the real income gap of rural households and macroeconomic variables.

	1988	1995	2002	2007	2013	2018
Per capita value added of primary industry	-0.035	0.438*	0.383*	0.221	0.014	-0.371
Output value of township enterprises per unit	0.473**	0.550**	0.533**	0.441	0.592**	-
Per capita value added of secondary industry	0.598***	0.494**	0.759***	0.959***	0.690***	0.594**
Per capita value added of secondary industry	0.606***	0.457*	0.460**	0.835***	0.760***	0.875***
per capita non-farm value added	0.619***	0.480**	0.571***	0.915***	0.833***	0.903***
Per capita foreign direct investment	0.636***	0.591***	0.638***	0.842***	0.526*	0.788***
per capita total exports	0.621***	0.426*	0.672***	0.897***	0.794***	0.801***

*Notes: ***,** and * indicate significance at the 1%,5% and 10% levels, respectively.*

In the early stage of opening up, China mainly exported labor-intensive products. Due to the low wage level and high labor quality, foreign investors, mainly overseas Chinese businessmen from Hong Kong, Macao and Taiwan,

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[23] Due to space limitation, the results of this part are not provided here. If you are interested in them, please contact the author.

founded a large number of labor-intensive manufacturing enterprises (Lin and Zhang, 2019). After China joined the WTO in 2001, many foreign businessmen flowed into China. The expansion of exports and FDI led to a larger market demand for rural surplus labor. To study the impact of internationalization on the rural household income, we also calculated the correlation coefficients between the provincial dummy variable coefficients and the per capita foreign direct investment or per capita export of the corresponding provinces. In terms of the correlation coefficient between the provincial dummy variable coefficients and the per capita FDI of the corresponding provinces, except for 2013, the correlation coefficients are statistically significant in other five CHIP survey years, up to 0.64, 0.59, 0.64, 0.84 and 0.79 in 1988, 1995, 2002, 2007 and 2018 respectively. In terms of the correlation coefficient between the of provincial variable coefficients and the per capita export of the corresponding provinces, except for 1995, the correlation coefficients of the other five years are statistically significant, reaching 0.62, 0.67, 0.90, 0.80 ad 0.80 in 1988, 2002, 2007, 2013 and 2018 respectively. From 1988 to 2007, the impact of FDI and export on rural households' income had been increasing, and then began to decline. It can be seen that the financial crisis in the United States and other western countries from 2007 to 2009 led to the global demand downturn, thus reducing FDI and hindering export growth. At the same time, to reduce the negative effects of the western financial crisis on China's economy during that period, China issued a four trillion yuans investment plan and implemented large-scale infrastructure construction such as high-speed railway and highway building, leading to an increase in total domestic demand. In addition, in 1988, 1995 and 2002, the correlation coefficient between the provincial variable coefficients and the level of internationalization (export per capita and FDI per capita) of corresponding provinces significantly increased with income at the same year. Taking the export per capita as an example, the correlation coefficient at the 25th percentile was 0.58, 0.45 and 0.58 in 1988, 1995 and 2002 respectively, and that at the 75th quantile was 0.60, 0.49 and 0.73 respectively. In 2007, the correlation coefficient between the provincial variable coefficients at middle and low income rural households and the level of internationalization (export per capita and FDI per capita) of corresponding provinces was slightly higher than that of high-income families. However, in 2013 and 2018, this correlation coefficient is higher for high-income families.

To sum up, the impact of manufacturing sector on the rural household income tends to weaken, whereas that of the service sector is getting more important. All these show that the rural household income is closely related to the industrialization level of corresponding provinces, which verifies the second hypothesis of this paper, that is, the rapid industrialization in China leads to the increase of rural household income; the internationalization level of a province represented by FDI and export is highly related to its rural household income, and that the provincial variable coefficients for the rural high-income households is more closely related to the level of internationalization of corresponding provinces than for those low-income ones.

5.2. Parametric and Semi-Parametric Regression Analysis on the Radiation Effect of Manufacturing Hubs on Rural Household Income

As the forefront of China's industrialization and the manufacturing hub, in response to the policy of taking the lead in boosting the development of southeast coastal areas in the early stage of reform and opening up, the Yangtze River Delta and the Pearl River Delta gathered technical elements and labor factors, and especially absorbed a large number of migrant workers from other provinces. With the coordinated economic development of various regions, the shift of labor-intensive industries from the southeast coast areas to the middle and western regions was facilitated by the industrial upgrading and knowledge spillover and technology diffusion in the Yangtze River Delta and the Pearl River Delta, affecting the industrialization process of surrounding provinces and thus increasing the latter's rural household income. Therefore, we attempt to discuss the radiation effect of the Yangtze River Delta and the Pearl River Delta on rural household income from the perspective of micro data.

Referring to the relevant concepts of regional economics, this paper defines the positive impact of the

development of industrialization center on the per capita income of surrounding rural households as "radiation effect", and vice versa as "siphon effect". The coefficient of distance variable reflects the externality of manufacturing hub to rural households to a certain extent. A positive distance coefficient tells us that the manufacturing hub has a net siphon effect on the rural households, while a negative coefficient means that the manufacturing center has a net radiation effect on the rural households.[24] To analyze the externality of the development of manufacturing hub in their own province on rural households, we also examine the impact of the rural households' travel distance to their own provincial capital on their income. The rapid development of China's transportation since the beginning of this century, especially the large-scale use of high-speed rail has greatly shortened the travel time of ordinary people, but the rural households' geographical distance to manufacturing hubs remains unchanged. To reflect this change, we also use the rural households' railway travel time to the manufacturing hub in the rural household income function to explore the radiation impact of manufacturing hub on the rural household income.

The impact of the rural households' rail travel distance to manufacturing hubs on their income may be nonlinear. Therefore, we use generalized additive models (GAMs) to conduct semi-parametric regression analysis on rural household income function of the above-mentioned years. In accordance with the original linear model, on the basis of controlling household and regional characteristic variables, we take the impact of logarithm of distance (or railway travel time) between rural households' residing location and Guangdong or Shanghai or their provincial capitals on rural household income as a nonlinear relationship for semi-parametric regression. Table 7 shows the significance test of nonparametric variables (EDF value and significance).[25] The results show that in all survey years of CHIP, the EDF values of all nonparametric variables are significantly greater than 1, which means that the distance between rural households and manufacturing hubs has a significant nonlinear effect on the per capita income of rural households.

Table 8 shows the estimated results of the model after taking into account the rural households' rail travel distance to Guangdong or Shanghai or their provincial capitals as well as other control variables. Table 9 shows the estimated results of the model after taking into account rural households' travel time to Guangdong or Shanghai or their provincial capitals as well as other control variables. Figure 4 and Figure 5 are the fitting graphs of the nonlinear relationship between the variable of the rural households' rail travel distance to the manufacturing hub, or the variable of the rural households' railway travel time and logarithum of their income per capita in the semi-parametric regression equation of the rural household income function[26].

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[24] The radiation effect and siphon effect discussed in this paper are relative concepts. For example, if the distance coefficient is positive, it means that the development of manufacturing center has a greater positive effect or a smaller negative effect on the income of rural households within a short distance. An insignificant coefficient does not absolutely mean that the development of manufacturing center has no significant impact on the income of rural households, but indicates that there is no significant difference in the impact of manufacturing center's development on income of rural households in different distances.

[25] In the result of the generalized additive model regressions, Effective Degree of Freedoms (EDF) is the main indicator of testing whether the supposed non-linear variable is really non-linear; the null hypothesis is that the variable is linear; if the statistic is statistically significant, it implies that the null hypothesis should be rejected, i.e., the effect of the variable on the explained variable is non-linear (Harezlak et al., 2018).

[26] This paper mainly talks about the impact of the Pearl River Delta and the Yangtze River Delta on the income of rural households in relatively backward provinces. Referring to the rural households'rural households' income comparison between Guangdong and other provinces, the rural households'rural households' income in Beijing, Tianjin, Shanghai, Jiangsu and Zhejiang is higher than that in Guangdong in some years, and the rural households'rural households' income in Beijing, Tianjin and Guangdong is higher than that in Shanghai, Jiangsu and Zhejiang in some years. Therefore, in the regression of rural households'rural households' income function of the distance and travel time from rural households to Guangzhou, we remove the rural households'rural households' observation values of Beijing, Tianjin, Shanghai, Jiangsu and Zhejiang in order to study the radiation effect of the Pearl River Delta on the relatively backward provinces. In the regression of rural households'rural households' income function of the distance and travel

Table 7. Results of effective degree of freedoms of semi-parametric regression.

	1988	1995	2002	2007	2013	2018
Logarithm of highway distance between the rural households' location and Guangdong	8.54 ***	8.67 ***	8.41 ***	6.72 ***	8.87 ***	8.40 ***
Logarithm of highway distance between the rural households' location and Shanghai	8.52 ***	8.77 ***	8.80 ***	8.76 ***	7.87 ***	8.77 ***
Logarithm of highway distance between the rural households' location and the provincial capital	8.39 ***	8.69***	8.80***	7.92***	7.87***	8.50***
Logarithm of railway travel time from the rural households' location to and Guangdong	8.21***	8.71***	8.80***	7.75***	8.15***	7.96***
Logarithm of railway travel time from the rural households' location to and Shanghai	7.98***	7.89***	7.90***	6.78***	8.43***	7.28***
Logarithm of railway travel time from the rural households' location to the provincial capital	8.59***	8.55***	8.73***	3.22***	7.88***	8.08***

Notes: ***,** and * indicate significance at the 1%,5% and 10% levels, respectively.

Table 8. The impact of the distance from the manufacturing center on the per capita income of rural households.

	1988	1995	2002	2007	2013	2018
Logarithm of highway distance between the rural households' location and Guangdong	-0.177*** (0.011)	-0.111*** (0.009)	-0.021*** (0.008)	-0.106*** (0.018)	-0.117*** (0.008)	-0.046*** (0.013)
Logarithm of highway distance between the rural households' location and Shanghai	-0.086*** (0.011)	-0.210*** (0.012)	-0.157*** (0.010)	-0.098*** (0.020)	-0.110*** (0.014)	-0.055*** (0.020)
Logarithm of highway distance between the rural households' location and the provincial capital	-0.021** (0.008)	-0.016** (0.007)	0.034*** (0.006)	-0.007 (0.012)	-0.054*** (0.008)	-0.067*** (0.011)
Control variables	YES	YES	YES	YES	YES	YES

Notes: ***,** and * indicate significance at the 1%,5% and 10% levels, respectively.

Table 9. The impact of the railway travel time from the rural households' location to the manufacturing center on the per capita income of rural households.

	1988	1995	2002	2007	2013	2018
Logarithm of railway travel time from the rural households' location to and Guangdong	-0.169*** (0.011)	-0.080*** (0.009)	-0.033*** (0.009)	-0.057*** (0.014)	-0.077*** (0.007)	-0.040*** (0.010)
Logarithm of railway travel time from the rural households' location to and Shanghai	-0.044*** (0.010)	-0.146*** (0.010)	-0.146*** (0.010)	-0.004 (0.017)	-0.106*** (0.012)	-0.156*** (0.018)
Logarithm of railway travel time from the rural households' location to the provincial capital	-0.024*** (0.005)	-0.005 (0.006)	0.040*** (0.005)	0.004 (0.008)	-0.006 (0.006)	-0.042*** (0.008)
Control variables	YES	YES	YES	YES	YES	YES

Notes: ***,** and * indicate significance at the 1%,5% and 10% levels, respectively.

First, we investigate the impact of the rural households' rail travel distance or railway travel time to the Pearl

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time from rural households to Shanghai, we do not use the rural households'rural households' observation values of Beijing, Tianjin and Guangdong in order to study the radiation effect of the Yangtze River Delta on the relatively backward provinces.

River Delta on their income. In the linear regression equation of rural household income function, the coefficient of logarithmic variable of distance between rural households and Guangdong decreased from -0.177 in 1988 to -0.111 (absolute value) in 1995, further dropped to -0.021 in 2002, rebounded to -0.106 and -0.117 in 2007 and 2013 respectively, and then declined to -0.046 again in 2018. In the linear regression equation of rural household income function, the coefficient of logarithmic variable of travel time from the rural households to Guangdong shows almost the same trend. It changed from - 0.169 in 1988 to - 0.080 in 1995, further dropped to - 0.33 in 2002, rebounded to - 0.057 and - 0.077 in 2007 and 2013 respectively, and then declined to - 0.040 in 2018. It indicates that the impact of the rural households' rail travel distance to the Pearl River Delta on the their income was in a downward state from 1988 to 2002, slightly increased from 2002 to 2013, but decreased again from 2013 to 2018. According to the quantile regression results of the rural households' income function (figures in the first row, Figure 3), the impact of the distance or travel time on rural households' income decreases slightly with the increase of rural households' income. In other words, the impact on low-income rural families is greater. In the graphic results of semi-parametric regression function of rural household income, in order to improve the robustness of the results, we mainly discuss the nonlinear fitting part with more sample observations and smaller confidence interval. It can be seen from the top rows of Figure 4 and Figure 5 that in 1988, 1995, 2002, 2007, 2013 and 2018, with the increase of the rural households' distance or travel time to Guangdong, the per capita income of rural households showed a downward trend, which implies a negative effect and is consistent with the change characteristics described in the "center-periphery" theory in the new economic geography (Fujita, et al. 2001).

Second, analyze the impact of the rural households' distance or travel time to the Yangtze River Delta on their income. The coefficient of logarithmic variable of distance increased from -0.086 in 1988 to - 0.210 (absolute value) in 1995, and then decreased all the way. It was -0.157, - 0.98, - 0.110, - 0.055 respectively in 2002, 2007, 2013 and 2018. The coefficient of logarithmic variable of travel time showed the same trends from 1988 to 2002, and then changed somehow. Specifically, the coefficient changed from - 0.044 in 1988 to -0.146 and -0.146 in 1995 and 2002 respectively. The coefficient in 2007 is not statistically significant, and then decreased to -0.106 in 2013 and rose to -0.156 in 2018. The quantile results of the two figures on the second row in Figure 3 show that in the first four years from 1988 to 2007, the impact of the distance or travel time on the rural households' income decreased slightly with the increase of rural households' income. In other words, the impact on low-income rural families was greater. In 2013 and 2018, however, the impact decreased significantly with the improvement of rural households' income level. In other words, the impact on middle- and high-income rural families was greater. According to the estimation result that the impact of the rural households' distance or travel time to the Pearl River Delta on their income has been declining since the beginning of the new century, it is more reasonable to believe that the impact of the rural households' distance or travel time to the Yangtze River Delta on their income has been declining since the beginning of the new century. After the development of Pudong New District in Shanghai in the early 1990s, the Yangtze River Delta's radiation effect on the economy of the surrounding areas has increased, which is reflected in the greater impact on the income of rural households from 1988 to 1995. It can be seen from the middle row of Figure 4 that from 1988 to 2018, there was a negative correlation between the rural households' distance to Shanghai and their income. Except for the year of 2017, the relationship between the rural households' distance to Shanghai and their income is similar.

Finally, we discuss the impact of the rural households' distance or travel time to their own provincial capital on their income. Provincial capitals are generally large cities with convenient traffic and developed economy. Many migrant workers who have no way to work in Beijing, Shanghai and Guangzhou tend to work or engage in own-account business in their own province's capitals or major cities, so provincial capital cities often have a certain radiation effect on the economic development of surrounding urban and rural areas. In addition, migrant workers usually take long-distance bus in the province, so the rural households' rail travel time to the provincial capitals is less relevant to their income. The coefficient of the logarithm of the rural households' distance to the provincial capital was -0.021 in 1988, changed to -0.016 in 1995 and 0.034 in 2002. It was not statistically significant in 2007, and was -0.054 in 2013 and -0.067 in 2018. The coefficient of the logarithm of the rural households' travel time to their provincial capitals is roughly the same. From 1988 to 2002, the radiation effect of provincial manufacturing

hubs on the rural household income gradually weakened; after 2007, the radiation effect increased, and the positive impact of provincial industrial hubs on nearby rural households' income increased gradually. This is because in the second decade of the new century, the manufacturing hubs in the Pearl River Delta and the Yangtze River Delta were upgraded rapidly, and many backward industries transferred to the middle and western provinces due to the higher housing price, higher living costs and higher labor wages in Beijing, Shanghai and Guangzhou. Foxconn, for example, moved from Shenzhen to Zhengzhou, Henan Province. Thus, it can be seen that the radiation effect of the provincial capitals on the surrounding areas increased from 2013 to 2018. According to the quantile regression results in the bottom row of Figure 3, in 2013 and 2018, the rural households' distance to provincial capitals had a greater impact on low-income rural households than on high-income ones. It can be seen from the bottom row of Figure 4 that in 1988, 1995, 2013 and 2018, there was a negative correlation between the rural households' distance to their provincial capitals and their income.
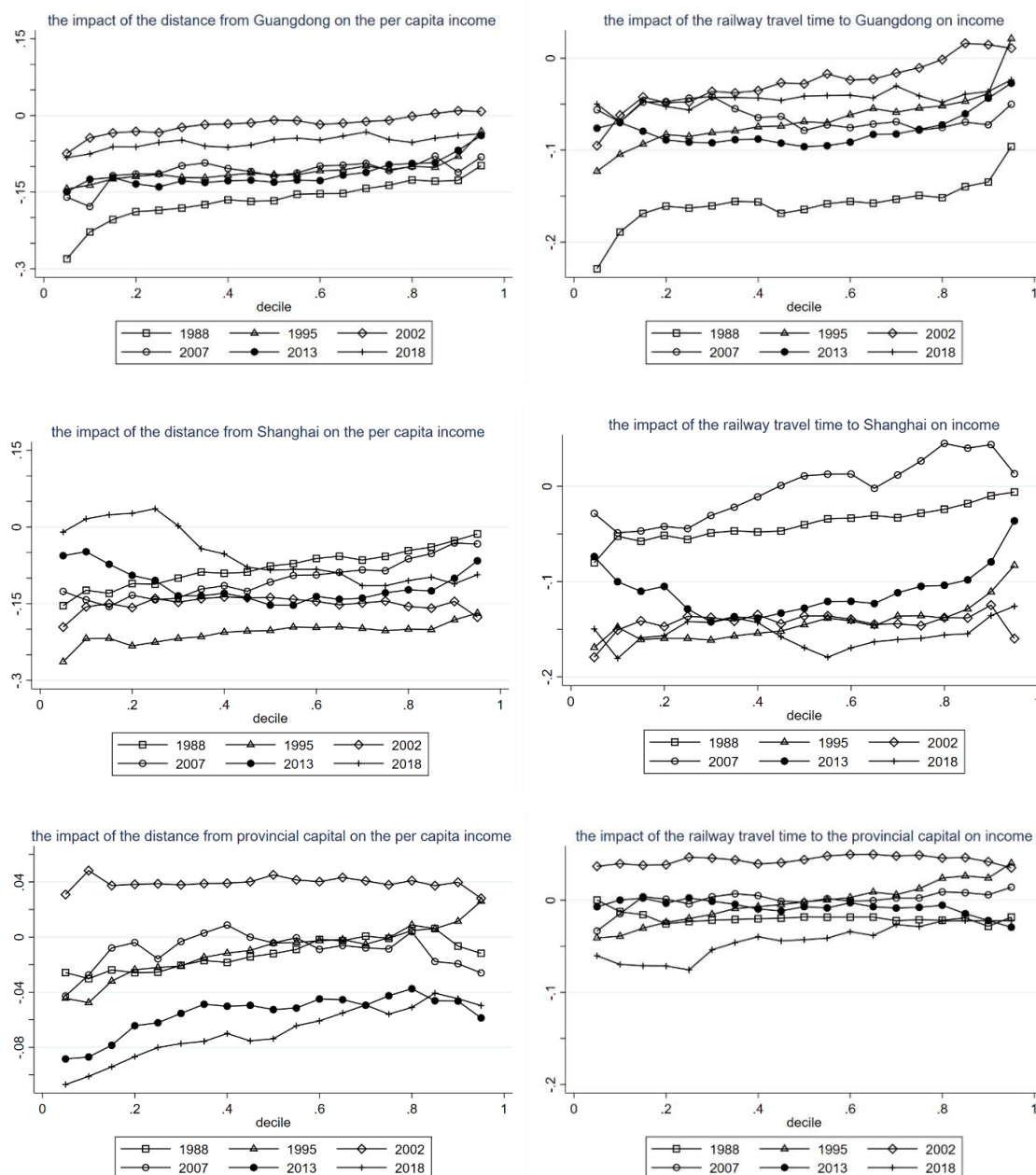
Figure 3. Quantile regression results of rural household income function.
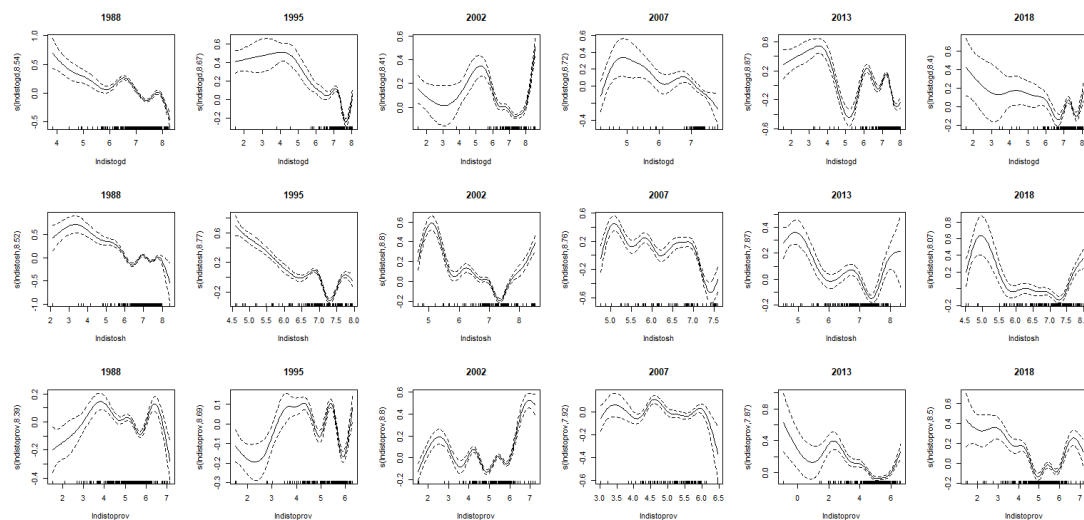
Notes: s(distance, edf) indicates the estimated smooth function (and its 95% confidence interval) of log(distance) and edf represents the estimated degree of freedom.

Figure 4. GAM partial residual smooth plots: the distance from the manufacturing center.
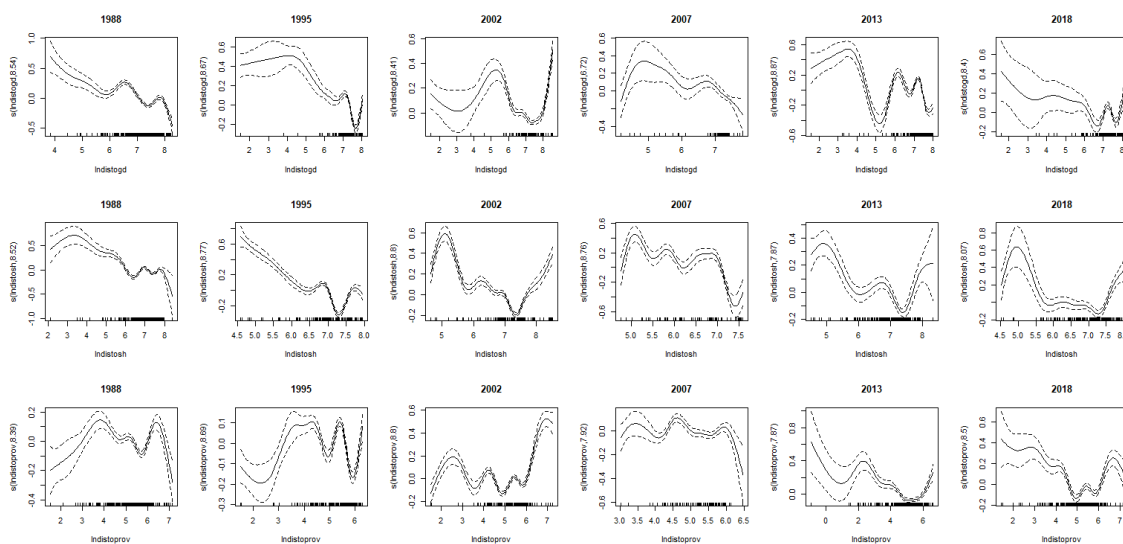
Notes: s(time, edf) indicates the estimated smooth function (and its 95% confidence interval) of log(time) and edf represents the estimated degree of freedom.

Figure 5. GAM partial residual smooth plots: the railway travel time to the manufacturing center.

To sum up, from 1988 to 2018, the radiation effect of the economic development of the Pearl River Delta and the Yangtze River Delta on the rural household income gradually weakened, while the radiation effect of local manufacturing hubs (provincial capitals) on rural household income significantly increased. It verifies the second and third hypotheses of this paper: in recent years, in fact, the Yangtze River Delta and the Pearl River Delta have been vigorously developing high-tech industries, and their demand for low-tech labor force has gradually decreased, so their impact on the rural household income is getting weaker and weaker; due to the industrial shift and the continuous industrialization in the middle and western provinces, more and more migrant workers have been employed by the local non-farm sector, so the local industrialization hubs have an increasing impact on the rural household income.

6. Conclusion

This paper utilizes the CHIP rural household survey data spanning 30 years (1988-2018) to study the impact of China's industrialization on rural household income. In the semi-parametric regression model, in particular, we examined the radiation effect of manufacturing hubs on rural household income and its spatial attenuation by putting the rural households' rail travel distance to manufacturing hubs in the rural household income function. The estimated results of the rural household income function in the six years of 1988, 1995, 2002, 2007, 2013 and 2018 show that the gap between the income of rural households in other provinces and that in Guangdong expanded from 1988 to 2002, but constantly narrowed from 2002 to 2018, which may be due to the gradual shift of coastal labor-intensive enterprises to the middle and western regions since the beginning of the new century. There is still a "cascade" difference in rural household income among provinces. The farther away from the Yangtze River Delta and the Pearl River Delta, the lower the per capita income of rural households. To a large extent, it indicates the fact that the radiation effect of manufacturing hubs of the Pearl River Delta and the Yangtze River Delta is declining in space.

In terms of the influential factors on the rural household income gap between Guangdong and other provinces, the provincial farming development level has no impact on the inter-provincial gap of rural household income, the impact of the provincial development level of township enterprises on the inter-provincial gap of rural household income showed an upward trend in the 1980s and 1990s, but has been weakening since the beginning of the new century; the impact of the provincial development level of manufacturing on the inter-provincial gap of rural household income kept expanding from 1988 to 2007, but weakened from 2007 to 2018; however, the provincial development level of service sector had an increasing impact on the inter-provincial gap of rural household income since the beginning of this century, and the impact of provincial FDI and export on the inter-provincial gap of rural household income had been constantly expanded from 1988 to 2007, and since then showed a downward trend. The above findings indicate that after China became the world's second largest economy and the number one manufacturing hub in 2010, the development level of service industry has a greater and greater impact on the increase of rural households' income. On the contrary, the impact of foreign investment and export on the increase of rural households' income shows a declining trend. In other words, the increase of rural households' income is increasingly dependent on China's domestic investment and consumption.

The impact of the rural households' travel distance to the two-international manufacturing hubs (the Pearl River Delta and the Yangtze River Delta) on their income kept increasing from 1988 to 1995, but has been decreasing since the beginning of this century. On the contrary, the impact of the rural households' travel distance to their provincial capitals on their income has been increasing in the new century. In the semi-parametric regression results of rural household income function, the estimated relationship between the rural households' distance to manufacturing hubs and their income also confirm this discovery. The main reason for this phenomenon is that since the beginning of the new century, labor-intensive manufacturing firms have been moving from the Pearl River Delta or the Yangtze River Delta to the middle and western provinces. As a result, migrant workers with low labor skills have gradually withdrawn from the southeast coastal areas and moved to the middle and western regions.

The core conclusion of this paper is that the income level of rural households in different regions of China is closely related to the level of local industrial development. The higher the development level of manufacturing, service industry, foreign-funded enterprises and export in a region, the higher the income of local rural residents, especially for rural low-income families. Since 2010, the labor-intensive industries in the Pearl River Delta and the Yangtze River Delta have been continuously shifting to the middle and western provinces, leading to the increasing impact of the provincial manufacturing hubs on the local rural households' income level. More and more migrant

workers choose to work in their own provinces. In the next three decades or so, therefore, the increase of rural household income in China will still rely on the enhancement of China's industrialization level.

Recently the United States and other developed countries with hollowed out industries have not only been striving to promote the return of manufacturing industry, but also trying to curb the upgrading of China's manufacturing sector by restricting high-tech exports to China. In the face of the containment of the United States and other western countries, China will spare no effort to establish its own high-tech industrial sector. At the same time, to avoid the mistake of industrial hollowing-out like that in western countries, China should gradually shift its labor-intensive industries to the middle and western provinces in an orderly manner, which is not only conducive to China's complete industrial system, but also conducive to the continuous increase of rural household income. Since the reform and opening up, 800 million poor people have been lifted out of poverty (Ryder, 2017; Xian et al., 2016). The main reason for this is China's successful industrialization. It will also be the core strategy of preventing the recurrence of poverty after 2020 to promote the industrialization in the relatively backward regions of the middle and western China.

Funding Statement

Conflict of interest

All authors declare that they have no conflict of interest.

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