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Article

Geographic poverty caused by distance to market

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Abstract: Poverty is a key challenge to socioeconomic development globally. However, the degree to which distance from a market contributes to poverty remains unclear. To provide insights into this relationship, we quantified the relationships between distance from markets and the per capita income of rural and urban people in China based on data from 29 provinces and 2651 counties. Our results illustrate the existence of a "geographical curse"; that is, a large separation between producers and consumers can exacerbate poverty for less-affluent rural residents, who pay a larger proportion of their income to send their products to market and to purchase goods from those markets. Programs to alleviate poverty should therefore consider seeking solutions associated with reducing the impact of that distance, such as subsidizing the transport of goods, improving the transportation infrastructure, supporting innovative business practices, and balancing the locations of producers and their markets.

Keywords: geographical poverty traps; distance to market; travel distance threshold; remote regions; transaction cost

1. Introduction

Poverty has afflicted human civilization throughout history and around the world. It remains such a severe economic problem in the modern era that individual governments and international organizations have actively sought solutions (Chin, 2015; Serageldin, 2002). International organizations such as the World Bank and the United Nations World Food Programme, nongovernmental organizations such as Oxfam, as well as national governments have tried to fight poverty (Cuaresma et al., 2018; Guo et al., 2019; Hubacek et al., 2017). However, some of these efforts have succeeded while others have had little effect. For example, poverty has continued to be a factor for many countries in the sub-Saharan region of Africa despite a half century of ongoing efforts to resolve this problem (Hyden, 2007; Kates and Dasgupta, 2007). As a result, this region is home to the largest impoverished populations in the world (Collier, 2007). Accordingly, *Science* proposed the need to identify the causes of poverty in this region as being one of the 125 most challenging scientific issues globally (http://science.sciencemag.org/content/309/5731/78.2).

Poverty has many causes (Lade, 2017), including insufficient capital investment (Hassan and Birungi, 2011; Mabogunje, 2007), inadequate technology (Yunus, 1998), a lack of education (Krueger and Malečková, 2003; Zhang, 2014), inadequate access to information (Blumenstock, 2016), inadequate transportation (Grieco, 2015), primitive systems (Cao et al., 2009), natural disasters (Gray et al., 2005), environmental degradation and the remoteness resulting from distance (Barrett et al., 2011; Barrett and Bevis, 2015; Barbier and Hochard, 2018; Cao et al., 2017), and vulnerability to unwise or unequitable governance (Kroft et al., 2016). A long distance

between producers of products and potential purchasers of those products is a logical contributor to poverty; this has been called "geographic poverty" (Centers for Disease Control and Prevention, 2010). This is revealed in the Chinese proverb that "distant water does not quench near thirst". However, there is little quantitative study of this relationship and its impact. Therefore, we lack sufficient information about how the geographic distributions of producers and their markets affect access of remote residents to a country's market economy.

To find ways of improving access to markets for residents of impoverished remote regions, it's necessary to learn how the distance from markets contributes to poverty. It's also important to learn whether a threshold distance exists, such that markets can easily purchase from producers that are located closer than that distance. In this paper, we examined Chinese data from 29 provinces and 2651 counties based on the hypothesis that distance from markets was a key contributor to poverty. Based on this data, we attempted to quantify the extent to which this distance was related to poverty. To do so, we examined the relationship between a resident's location (thus, their distance to market) and the per capita income where they live to test whether there was a threshold beyond which the distance led to poverty. Moreover, China has geographically diverse regions in different stages of economic and social development, which provides an opportunity to explore the relationship between the distance to market and a resident's income in different regions, thus guiding important decisions such as how to invest in transportation infrastructure and where to locate new cities. Our results will provide guidance for efforts to combat poverty and improve socioeconomic development policies both in China and around the world.

2. Methods

The data we used were obtained from China's statistical yearbooks for each province (National Bureau of Statistics, 1953–2017), the Statistical Communiqué of the People's Republic of China on the National Economy and Social Development for each county (National Bureau of Statistics, 2017), the Ministry of Transport of the Government of the People's Republic of China (http://www.mot.gov.cn/), and China Railway (http://www.china-railway.com.cn/). Based on historical administration boundaries, we merged Hainan Province with Guangdong Province and merged Chongqing City with Sichuan Province. The result was data from a total of 29 provinces or merged regions from 1952 to 2016. In addition, we obtained data from a total of 2651 counties from these provinces or regions in 2016, which provides high geographic resolution; as a result, our analysis strongly represents actual Chinese conditions. To the best of our knowledge, this paper represents the first use of our approach (using a large dataset that covered almost all of China's large area over a long period of time). We divided the 2651 counties into three major geographic regions (**Figure 1**).

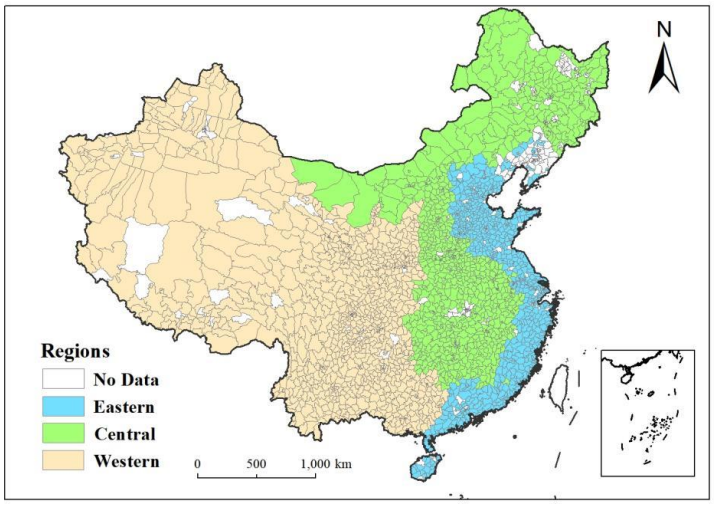

Figure 1. The 2651 counties were divided into three major geographic regions: The eastern, central, and western regions.

To determine the relationship between market distance and poverty, we selected the market distance and per capita income as indicators. Specifically, the domestic market distance equaled the distance between the capital of every province or the geographic center of each county and Wuhan City, in Hubei Province. We chose this city because Wuhan is regarded in China as the domestic market center, as it is the city closest to China's geographic center, at about 31° N and 113° E, and its population center of gravity. International market distance is the distance between the capital of each province or the geographic center of each county and the main coastal port or frontier with another country (to represent access to the international market). To calculate market distance, we divided the market distance into the domestic market distance and the international market distance, then combined the two distances using weights equal to the proportions of domestic and international trade.

We used the railway transportation distance to represent the combination of all kinds of market distances (to the domestic market center or international ports), because railway transportation has advantages over other transportation methods based on the rail network's high transportation capacity and low cost. However, because road transportation is also important in many regions, we integrated road and railway distances by converting the road distance into a railway distance based on the proportions of each province's total transportation cost (obtained from the abovementioned Ministry of Transport Web site) accounted for by road and railway transportation when there was no railway between the two areas and transport was only possible by road. To calculate per capita income, we combined the per capita income of both urban and rural people into a weighted per capita income, with the weights equal to the respective proportions of the population from urban and rural areas in each province or county.

To account for the effects of inflation on the per capita income, we used the retail price index (*RPI*), because data for the consumer price index (*CPI*) is only available starting in 1978. We selected 2016 as the base year, and we calculated the real per capita income in each year as follows:

$$RPCI_k = NPCI_k \times \prod_k^{2016} (1 + RPI_k)$$

where $RPCI_k$ represents the real per capita income in year k; $NPCI_k$ represents the unadjusted per capita income in year k; and RPI_k is the retail price index of China in year k.

We used the SPSS software (https://www.ibm.com/analytics/spss-statistics-software) to calculate Pearson's correlation coefficient (r) for the relationship between per capita income and market distance. In addition, we developed a threshold model to quantify the relationship between per capita income and the market distance for each province during three different periods: 1952–1977 (before China opened up to the West), 1978–2016 (after China opened up to the West), and 1952–2016 (the entire period following the Chinese Revolution). We repeated this analysis for all counties combined in 2016.

To calculate the distance threshold (DT) for poverty, we developed a threshold model based on Hansen's (1999) approach. This model can be written as follows:

$$y_{it} = \begin{cases} \beta_0 + \beta_1 x_{it} + e_{it} & q_{it} \le \gamma \\ \beta_0 + \beta_2 x_{it} + e_{it} & q_{it} > \gamma \end{cases}$$

where y is the per capita income, x is the market distance, e is residual error, i is the individual, t is the time, q is the threshold variable, and γ is the threshold value. Obviously, when the threshold variable q is less than the threshold value γ, the influence of x on y is caused by β_1; in contrast, when the threshold variable q is greater than γ, the influence of x on y is caused by β_2.

3. Results

The per capita income was significantly negatively correlated (r = −0.272) with the distance to market for rural and urban areas combined. The impact of this negative correlation was consistent for residents of rural areas (r = −0.271) and urban areas (r = −0.282). There appears to be a threshold distance of 403 km between people and their markets (**Figure 2** and **Table 1**). However, the threshold was much lower for rural residents (at nearly half the urban value). When the distance was greater than this threshold, then with few exceptions, the per capita income was low and was unlikely to increase with increasing distance.

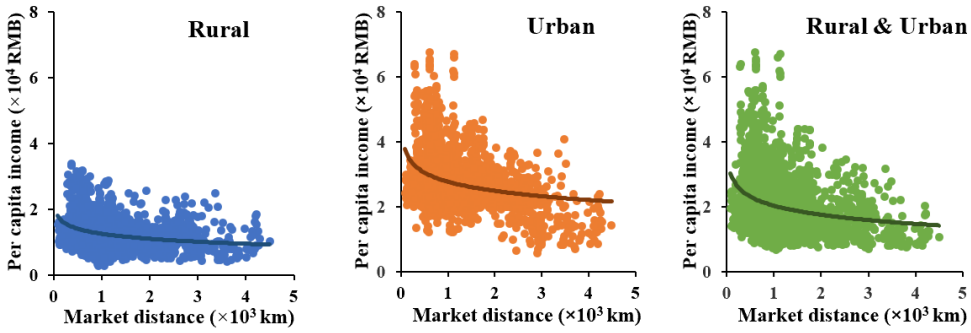

Figure 2. Regression analysis results of the relationship between per capita income and the distance to market based on data from 2651 counties.

Table 1. Correlation analysis (Pearson's *r*) results for rural, urban and rural and urban combined areas based on data from 2651 counties.

	r	***p***	***DT***
Rural	−0.271	<0.001	219
Urban	−0.282	<0.001	405
Rural and Urban	−0.272	<0.001	403

To further explore the differences in the threshold distance, we repeated our analysis for the Eastern, Central, and Western regions shown in **Figure 1**. The results differed significantly among the three regions. When we combined rural and urban data, the threshold distance averaged 1415 km, 83 km, and 349 km for the Eastern, Central, and Western regions, respectively (**Figure 3** and **Table 2**). The threshold distances were much lower for rural residents.

Table 2. Correlation analysis (Pearson's *r*) results for rural, urban and rural and urban combined areas divided into three major geographic regions of China based on data from 2651 counties.

		r	***p***	***DT***
Rural	Eastern	−0.438	<0.001	804
	Central	−0.066	0.050	67
	Western	−0.076	0.020	62
Urban	Eastern	−0.367	<0.001	1345
	Central	−0.116	<0.001	96
	Western	−0.540	<0.001	667
Rural and Urban	Eastern	−0.339	<0.001	1415
	Central	−0.085	0.010	83
	Western	−0.267	<0.001	349

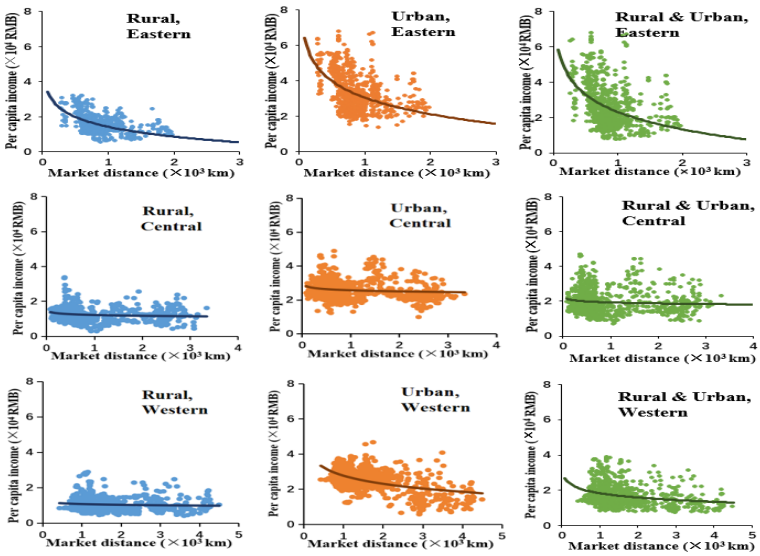

Figure 3. Regression analysis results of the relationship between per capita income and the distance to market based on data from 2651 counties.

The provincial-level data from 1952 to 2016 showed that per capita income was significantly negatively correlated with the distance to market for the study period as a whole (r = −0.226 to −0.203). The threshold distance between people and markets was 222 km for rural and urban residents combined (**Figure 4** and **Table 3**). The per capita income decreased significantly with increasing distance to market for the period from 1952 to 1977 (r = −0.218 to −0.142), which is the period when China's economic system was centrally planned, and the correlations were comparable from 1978 to 2016, the period after China's opening to the west and economic reforms to achieve a socialist market economy (r = −0.220 to −0.185). The threshold distance between producers and markets for urban and rural residents combined was 45 km during the period with a centrally planned economy and 185 km during the period with a market economy.

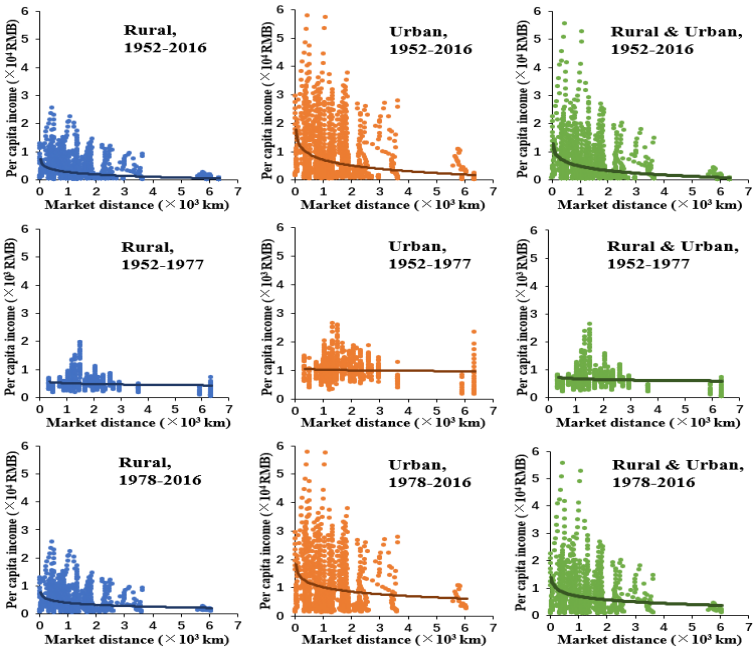

Figure 4. Regression analysis results of the relationship between per capita income and the distance to market based on data from 29 provinces.

Table 3. Correlation analysis (Pearson's r) results for rural, urban and rural and urban combined areas divided into three different periods based on data from 29 provinces.

		r	***p***	***DT***
1952 to 2016	Rural	−0.226	<0.001	123
	Urban	−0.203	<0.001	289
	Rural and Urban	−0.215	<0.001	222
1952 to 1977	Rural	−0.211	<0.001	42
	Urban	−0.142	<0.001	28
	Rural and Urban	−0.218	<0.001	45
1978 to 2016	Rural	−0.220	<0.001	101
	Urban	−0.185	<0.001	222
	Rural and Urban	−0.208	<0.001	185

4. Discussion

Producers living far from their markets must transport their products over long distances. This creates high transportation costs, which reduce their profits as well as the competitiveness of their products, particularly for perishable products such as fruits and vegetables (Konishi, 1999). Conversely, when residents of remote areas purchase goods from distant producers, the cost of their purchases include the high transportation costs to carry these products to them, thereby increasing their cost of living (Louveaux et al., 1982; Weinhold and Reis, 2008). The problem is exacerbated by a deficiency of demand, especially domestic demand, which reduces opportunities to ship products to a distant domestic market, and this has been identified as a key factor in poverty research (Murphy et al., 1989). Our results show that increasing distance between people and their markets can promote poverty (**Figure 2**; **Table 1**), and this suggests that governments must pay more attention to this issue, possibly by creating new institutions or modifying old ones. For example, it may be possible to create new transportation infrastructure such as railway lines that are more efficient than highway transportation, or to improve old infrastructure by upgrading gravel roads to high-speed paved roads. It should be emphasized that attention should be paid to the coordination of transportation infrastructure with the regional urban hierarchy when promoting transportation infrastructure (Baum-Snow et al., 2018).

Improving access to world markets can potentially overcome a deficiency of domestic demand, since a developing country has some competitive advantages compared with developed countries, and this increased demand can drive increases in per capita income (Chenery, 1986; Hanson, 2005; Ma et al., 2018; Okwi et al., 2007). The 2016 per capita income of rural people in China was equivalent to 36.8% of the income of urban people (National Bureau of Statistics, 2017). The distance threshold for rural people in 2016 was also much lower, at 219 km, which was equivalent to 54.1% of the 405 km value for urban people (**Figure 2**; **Table 1**). This suggests that the less affluent rural people (based on per capita income) will experience negative effects from distance to market at a shorter distance than for the more affluent urban people. Fortunately, the rapid development that has resulted from Chinese economic reforms since 1978 has led to an increase in per capita income to about 10.3 times the value during the Mao era from 1952 to 1977, accompanied by migration of many rural residents to urban areas since 2000 (National Bureau of Statistics, 1953–2017).

Similarly, the distance threshold in the Central and Western regions were 83 and 349 km, which were equivalent to 5.9% and 24.7% of the 1415 km for Eastern region in 2016 (**Figure 3**; **Table 2**). This suggests that people from the poorer Central and Western regions (whose per capita incomes were less than 30% of the eastern value) will be more likely to be adversely affected by the geographic curse. These results also suggest that socioeconomic development can effectively reduce the curse's impact. The low sophistication and size of the markets for a remote area's outputs constrains household economic activities (Berliant and Konishi, 2000; Howells, 2005; Partridge et al., 2007; Vinod, 2010; Yu and Luo, 2018). Balancing economic development so that products flow more often within than between regions can reduce the distance to market and help to overcome the geographic poverty effect. China's Western Development Plan (Zhang et al., 2019) and Targeted Measures in Poverty Alleviation

(Guo et al., 2019) recognize this effect, and include measures to help residents of impoverished regions overcome the geographic poverty trap. However, it is worth noting that the relationship between distance from markets and the per capita income, as well as its distance threshold, will change continuously in response to upgrading of technological development and transportation conditions. At the same time, the interaction between market distance and other influencing factors on geographic poverty should also be fully considered in future research. Finally, our analysis did not account for important geographic differences among counties and regions based on factors such as topography (e.g., transportation is more difficult in mountainous areas than in plains areas) and differences between regions in products and their markets.

Governments should take advantage of our findings to mitigate the geographic curse through development plans that improve market access and let residents of remote and impoverished areas benefit more from China's market economy. In some cases, infrastructure improvements (e.g., replacing highway transport systems with marine or railway transport systems) may be necessary. In other cases, subsidies to promote technological innovations such as the use of refrigerated transport vehicles for agricultural products may be important. Innovations such as the development of producer cooperatives can also help by letting producers share production and transportation costs among a larger number of producers, thereby reducing individual costs and increasing profitability. A final measure will be to guide the development of the urban layout during urbanization so that the huge numbers of people in modern Chinese cities will have easier access to markets for residents where they can both sell their goods and services, and buy the goods and services they need to live.

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