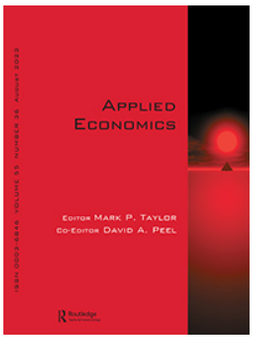

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"First Kilometer" to realize common prosperity: impact of public bus expansion into villages on farmers' income mobility

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ABSTRACT

Using data from the China Health and Nutrition Survey (CHNS) dated from 1991 to 2015, we assess the impact of public bus expansion into villages on income mobility of rural household, particularly, with low income. This paper finds that the income mobility of low-income households is suffered from the expansion of public buses in the rural areas. Due to the 'crowding out' effect, the low-income families are excluded from the non-agricultural employment brought by the public bus expansion, which nevertheless does not improve the agricultural production structure. This can explain why the low-income group has been marginalized during the process of urban-city integration in China. Improvement of the human capital can significantly alleviate the negative impact of public bus expansion on the low-income group in rural areas, while the child-care burden aggravates the issue. These results may also have policy implication for potential solutions to problems such as the 'First Kilometer' to realize common prosperity is not simply about the modernization in the infrastructure but also equalization of opportunities through cultivation of human capital.

KEYWORDS

Public bus expansion into villages; income mobility; non-agricultural employment; agricultural production structure

JEL CLASSIFICATION

R41; D31; D33

I. Introduction

'Building the road is the first step to become prosperous'. This slogan prevailing in China has also been supported by extensive academic research. Studies have shown that road construction can reduce labour costs and create non-agricultural jobs for rural households (Fan and Zhang 2004; Qiao et al. 2014; Qin, Wang, and Chen Zhuang 2016). Moreover, road construction has been noted for its contributions to strengthening market accessibility, opening up opportunities for agricultural products and lowering transportation costs (Zou, Zhang, and Zhuang 2008; Sekhon and Kaur 2016). Overall, road construction plays a critical role in boosting income for rural households in China.

The concept of common prosperity prioritizes long-term income growth and convergence rather than narrowing the income gap in the short term. Income mobility refers to the difference of the income level, either of an individual or of a household, at two different points of time (Fields 2010; Jarvis and Jenkins 2010; Gangadharan, Grossman, and Vecci 2021), which reflects the impact of equal access to opportunities on the income distribution in the long run. Gottschalk (2013) argue that a significant income gap may not necessarily lead to serious social problems as long as the income mobility is adequate to guarantee growth channels for households at the lower quantile. On the contrary, if the significant income gap exists along with a poor income mobility, the serious solidification of social stratification will undoubtedly fuel up social conflicts. Given the concerns above, this study adopts income mobility as an outcome variable so as to make up research gaps of absolute income and income gap and demonstrates how the transportation construction shapes the income level of different groups over time.

While there has been extensive research on the impact of infrastructure, limited attention has been paid to public services associated with public facilities. Gibson and Rozelle (2003) use household survey data in Papua New Guinea to investigate the impact of accessibility to roads on absolute poverty. They find that the closer residents were to a road, the less likely they were to experience

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absolute poverty. Zou, Zhang, and Zhuang (2008) compare the impact of roads and railways on economic growth and absolute poverty, and observed that increasing road density is more effective in alleviating absolute poverty. Aggarwal (2018), based on a survey of India, uncovered that improvement of road infrastructure can stimulate economic growth in rural areas and alleviate absolute poverty there. But all the analyses above focus on the conditions of infrastructures themself, leaving the services associated with the infrastructures untouched. The access to road is not equivalent to the access to the transportation. The effective supply of road infrastructure to rural households does not depend only on the availability of the road but also the transportation service that connects rural households and markets. Since the lack of private transportation among rural households, and their mobilizable radius keeps narrowing[1], the utilization of road infrastructure will decline if there is no convenient public bus connecting the residing location and the destination.

Based on the above analysis and discussions, this study proceeds from the perspective of public bus expansion into villages to examine income mobility of rural household. The contribution of this study mainly lies in three aspects. First, while existing literature on road infrastructure has mainly focused on its poverty alleviation effects (Warr 2008; Gibson and Olivia 2010; Aggarwal 2018), few scholars have looked into the causality between public bus expansion into villages and income mobility. Using data from the China Health and Nutrition Survey (CHNS) dated from 1991 to 2015, this study evaluates the impact of public bus expansion on income mobility among rural household, particularly, with low income. Second, previous research tends to evaluate the impact of road infrastructure using short panel or cross-section data (Agenor 2008), failing to consider the long-term impact of road infrastructure. In contrast, this study constructs an interaction variable between public bus expansion into villages and income level of the base period to analyse the long-term impact on income mobility of rural households. Third, we investigate mechanisms underlying the long-term impact of public bus expansion on mobility from the perspective of the non-agricultural employment and agricultural production structural adjustment.

The remainder of this study is organized as follows. Section II briefly reviews relevant literature and hypotheses of this study. Section III describes the research data, variables and model involved in this study. Section IV provides empirical results. Section V presents results of mechanism analysis and further analysis. Conclusions and policy suggestions are made at the end of this study.

II. Literature review and hypothesis development

Since Shorrocks (1984) and other scholars developed the concept of 'income mobility' and relevant measurement methods, there has been a growing research interest in this issue (Fields 2010).

Change trends of income mobility in China's rural areas

Research on the income mobility of rural households in China has yielded fruitful findings, despite the relatively late start. For instance, Ding and Wang (2008) find that high growth accompanied by exchange processes resulted in sustained high household income mobility 1989 to 2000. Shi, Nuetah, and Xian (2010) analyse four rounds of data from 1989 to 2006, and show that incomes in rural China are highly mobile. WenKai, XiangHong, and ChongEn (2014) examine the dynamics of income mobility in rural China from 2003 to 2006, and find it to be stable and relatively high, with higher mobility in the interior provinces than in the coastal provinces. Chen and Cowell (2017) analyse panel data from the CHNS and reveal a marked decline in rank mobility from the decade before to the decade after the millennium, indicating increased rigidity in China. On the time dimension, the changing trend of income mobility, as suggested by the above research findings, is logically consistent, with rising income mobility before 2010 and a decline thereafter, leading to increased class

[1]Source: 'Survey Report on Migrant Workers in 2020'.

solidification. Improving income mobility among low-income groups is critical to achieving common prosperity in rural China, as these groups have notably lower mobility than medium-income and wealthy groups (Zhao and Zhao 2021). Identifying these low-income groups is important but improving their income mobility is an even tougher challenge that must be addressed to promote rural revitalization.

Analysis of factors influencing income mobility

In the study of income mobility among rural households in China, various influencing factors have been explored from the perspective of macroeconomic growth, labour market development, and income distribution.These factors include income mobility, including human capital, household demographic features, non-agricultural employment, etc. (Shi et al., 2010; Qin, Wang, and Chen Zhuang 2016; He and Sun 2021). Among these factors, human capital is widely acknowledged as a key driver of income mobility differences among individuals, as individuals with higher educational attainment have greater opportunities to increase their income level (Qin, Wang, and Chen Zhuang 2016). The decrease of the household dependency ratio can boost the upward income mobility among rural residents (Woolard and Klasen, 2005; YingWei, Jun, and Zheng 2016). Income generated by non-agricultural employment plays a critical role in changing rural households' income level. Provided that rural households can make full use of their comparative advantages in non-agricultural economic activities, the chances are higher for their income to increase (Shi et al., 2010). In addition, income mobility is affected by government's macroeconomic policies (Ding and Wang 2008). Goldthorpe (2013) argues that educational policies are the most important tools to enhance income mobility.

Undoubtedly, there has been research providing insights into income mobility of rural residents in China. But the existing literature has ignored the impact of public investments, particularly public bus expansion into villages, on rural households' income mobility. Additionally, scholars have currently been committed to investigating overall changes of income mobility, thus paying little attention to the income mobility of different classes.

Impact of public bus expansion into villages on Farmers' Income Mobility

The differences in endowments among rural households can be attributed to variations in the marginal effects of road infrastructure. This causal mechanism may have implications for income distribution. Specifically, rural households in the medium and high income groups often work outside of their villages and require transportation to commute between their homes and workplaces. Some of these households may even be employed in the public bus industry or industries that have emerged as a result of public bus development. Consequently, households in these income groups tend to rely more heavily on public transportation and benefit more from its availability. Conversely, rural households in the low and relatively low income groups face constraints, such as limited human capital, which may result in low utilization efficiency of public buses. This may explain why public transportation has a limited impact on improving the income levels of these households. Based on these observations, we propose Hypothesis 1:

H1: The negative impact of public bus expansion into villages is mainly exerted on the income mobility of low-income families.

The expansion of public bus services into rural villages can have a positive impact on non-agricultural employment. Firstly, it can improve access to opportunities beyond the village. The expansion of public bus services to villages can reduce transportation costs, enabling rural households to access opportunities outside of their immediate vicinity at a lower cost (Dillon, Manohar, and Xiaobo 2011). This increased access can encourage the agricultural labour force to work in urban areas. Secondly, public bus expansion can create favourable conditions for the development of rural enterprises in various aspects. For example, it can reduce transport costs, shorten the distance

between the place of production and the market, and improve the timeliness of information transmission, all of which can facilitate the establishment of enterprises in rural areas. Additionally, public bus expansion can optimize the distribution of economic activities and promote the formation of economic clusters within specific regions. Thirdly, public bus expansion can contribute to the integration and sharing of inter-regional resources and labour forces, lowering the threshold for enterprises to enter different markets (Gibson and Olivia 2010). Public bus expansion can strengthen the effective labour force and labour capital return rate. However, the impact of road infrastructure on non-agricultural employment of low-income households and households with relatively low-income levels is relatively limited. These households may lack effective labour forces and have weak human capital, making it difficult for them to seize job opportunities created by the development of transport. Only households with incomes above the medium level may be able to afford the increasing costs of labour mobility and bear potential mobility risks. On the other hand, road infrastructure can create opportunities for households with high human capital or abundant effective labour forces to increase their household income. Therefore, we propose Hypothesis 2:

H2: Public bus expansion into villages might impair the non-agricultural employment level of the low-income group, compared with families of other income groups

Road infrastructure has emerged as a significant factor influencing the structural adjustment of agricultural production in recent times (Jacoby 2000). Thunnen's agricultural location theory suggests that plantation structural adjustment is primarily determined by the geographical distance between the place of origin and the end-users. The expansion of public buses into villages has the potential to significantly reduce both economic and temporal distances between the origin and end-users, thereby diminishing the significance of geographical location in agricultural production. Shamdasani's (2021) analysis shows that remote households are increasingly diversifying their crop selection, with non-cereal crops such as pulses becoming popular choices. According to the 'Compilation of Materials Concerning Costs and Benefits of National Agricultural Products', the returns per return per mu (a Chinese unit of area, equal to 1/15 of a hectare or 1/6 of an acre) area from fruit and vegetable plantations are higher than those from grain crops. This finding implies that rural households can increase their land productivity by shifting towards more profitable crops such as fruits and vegetables. However, economic crops often require greater financial and technical support, which may not be easily accessible to impoverished households, limiting their ability to adjust their agricultural structure. In contrast, wealthy households have better access to such resources, and the expansion of public buses into villages could further increase land concentration among the wealthy. Consequently, the structural adjustment of agricultural production towards large-scale planting may be more pronounced among the affluent. This leads to the formulation of the third hypothesis of this study:

H3: Expansion of public buses into villages reduce the possibility of restructuring agricultural production of the low-income rural families, compared with other income groups.

III. Data, variables and model

Data sources

Data adopted for this study are derived from the dataset of the China Health and Nutrition Survey (CHNS). The CHNS is a social health survey project jointly launched by the University of North Carolina and the Chinese Center for Disease Control and Prevention. This survey carries out a multi-stage layered stochastic sampling of demographic, economic, educational and infrastructure data at the community and household. Meanwhile, it seeks a long-term tracking of households. On the whole, the CHNS dataset features a long-time span, and has established a large-sample panel data, which can ensure a high data quality. Its

Table 1. Descriptive statistics of variables.

Variables	Definitions	Mean	Standard Deviation
Income mobility	Transition value of the rural household's income order from the *t-1* period to the *t* period	0.000	1.181
bus	Whether a village has the public bus station	0.786	0.410
Age	Current actual age (year) of the rural household	53.607	12.617
Edu	Actual educational level (year) of the rural household	0.227	1.748
Labor forces	Changes of the percentage (%) of labor forces in household population	0.137	20.002
Dependency ratio	Changes of the percentage (%) of labor forces below the age of 16 among family members	−0.026	0.123
Household size	Changes of the household population scale	0.236	1.980
Cultivated land	Changes of per capitaarable area (mu/person) of rural household	−0.044	1.129
House	Changes of per capitafloor space (m^2/person) of rural household	1.407	22.672
Zone	Whether there is a nearby (within two hours) development zone (1=yes; 0=no)	0.362	0.481
Railway	Whether the village has a train station (1=yes; 0=no)	0.271	0.444
Electric	Whether the community has electricity supply (1=yes; 0=no)	0.994	0.077
Medical Insurance	Whether the agricultural household has purchased the cooperative medical insurance (1=yes; 0=no)	0.633	0.482
Irrigation	Changes of the percentage (%) of irrigable areas in the total sown area	2.027	8.027
Medical	Changes of the ratio of the number of doctors to the total population	0.004	0.030
Employment	Changes of the percentage (%) of per capitanon-agricultural employment income	3.170	34.977
Non-grain crop income	Changes of the percentage (%) of non-grain crop income in the total agricultural income	3.650	32.419

questionnaire on rural households' income and agricultural infrastructure is also relatively exhaustive, which can give more references to our study.

Variables

The explained variable is $Mobility_{it}$, which is defined as the extent to which a rural household leaps from one income group to another. We divide rural households into five groups by the income level. The value of $Mobility_{it}$ under other conditions can be given by the parity of reasoning. For instance, if the household previously fell into the low-income group but is currently in the below-medium-income group, the value of $Mobility_{it}$ will be set to be 1. If this rural household's current income falls in the medium-income group, the value of $Mobility_{it}$ will be set to be 2. On the contrary, if the rural household previously belonged to the high-income group but is currently in the above-medium-income group, then the value of $Mobility_{it}$ will be −1. But if this rural household is currently in the medium-income group, then the value of $Mobility_{it}$ will be −2.

The core explaining variable for this study is whether a village has the public bus stop. If the village where the rural household resides has the public bus stop, $bus_{jt}$is set to be 1; otherwise, $bus_{jt}$is set to be 0.

Among literature concerning income mobility, demographic structural characteristics are believed to be the most influential factors. Therefore, this study adopts the household labour force percentage, dependency ratio of juveniles, and household scale to indicate the household demographic structural characteristics. The household owner is the main decision-maker in a household. Hence, this study mainly takes into account the impact of the household owner's age and educational background. Besides, the control variables of this study include the per capitaarable area, per capitahousing area, development zone, railway infrastructure, electric facilities, medical insurance, irrigation facilities, and medical facilities. Of special note is that all price indexes of the CHNS database are based on the price of the survey year. Hence, we conduct deflation of these price indexes using the Consumer Price Index (1991 = 100). Table 1 presents the descriptive statistics of different variables.

Model

The response variable, income liquidity, is a group of classified discrete variables. It can reflect changes in income status, with larger positive values indicating greater upward mobility and larger negative values indicating greater downward mobility. As the data exhibits an inherent ordering structure, they can be classified as ordered data, so ordered Probit or ordered Logit models are more feasible for estimation. Considering that the superior covariate balance of the Logit model compared to the Probit model, this study employs an ordered Logit model to estimate the probability equation of improving farmers' income liquidity through transportation infrastructure upgrade. The specific functional form is presented mathematically below:

$$y_i^* = x_i\beta + \varepsilon_i \quad (1)$$

Where, y_i^* denotes the actually observed income liquidity, with the value falling in [−4, 4]; x_i is a potential factor that may influence farmers' income liquidity; ε_i is a random disturbance term. Selection of $y_i$follows the rule below:

$$y_i = \begin{cases} 0, if\ y_i^* \le r_0 \\ 1, if\ r_0 < y_i^* \le r_1 \\ 2, if\ r_1 < y_i^* \le r_2 \\ \text{L L L} \\ J, if\ \ r_{J-1} \le y_i^* \end{cases} \quad (2)$$

Where, $r_0 < r_1 < r_2 < \cdots < r_{J-1}$ is a parameter to be estimated; $r_0 < r_1 < r_2 < \cdots < r_{J-1}$ denotes the discrete variable of income liquidity, whose value falls in [−4, 4]. The measurement model can be written as below:

$$mobility_{it} = \alpha + \beta^* bus_{jt} + \theta^* \Delta X_{it} + \varphi^* X_{it} + \mu_j + \nu_t + p^* t + \varepsilon_{it} \quad (3)$$

Where, the subscript i and t indicate the i individual and the t period, respectively; the explained variable, $Mobility_{it}$, is the rural household income mobility, which can reflect the variation and variation range of the rural household income level within the research period. The variable bus_{jt} is set in light of the regional and time difference of public bus expansion into villages to denote whether public bus services are expanded to j village of the research year. ΔX_{it} is used to reflect the control variable after the first-order difference, such as the labour force percentage and per capitaarable area. X_{it}stands for the control variable without the difference, such as the household gender. η_j denotes the community fixed effect; ν_t denotes the time fixed effect; $p * t$ denotes the fixed effect of the interaction item between the province and the time; ε_{it} denotes the stochastic error item.

The objective of this research is to examine how the extension of public bus services to rural communities on the mobility of income among individuals with varying levels of income. Considering this, this study adds the interaction item between the base period low-income group (D_{i1991}) and the public bus expansion into villages (bus_{jt}) to Eq. (3). It should be noted that the year 1991 is adopted as the base period of the income variable, which can not only effectively avoid the endogeneity of the rural household income mobility, but also help to compare rural households of the same income group at different periods or compare rural households of different income groups at the same period. The cross-group comparison covers five dummy variables, namely the low-income group, below-medium income group, medium income group, above-medium income group and high-income group, which are indicated by *D1, D2, D3, D4* and *D5*, respectively. Among them, the medium-income group (of the year 1991) is pinpointed as the control group. The interaction item between the rural household's affluence and public bus expansion into villages is used to further analyse the income mobility difference among individuals of the same income group after expansion. Combining the above analysis, we design the measurement model as below:

$$Mobility_{it} = \alpha_0 + \beta_1{}^* bus_{jt} + \beta_2{}^* D_{i1991} + \beta_3{}^* bus_{jt}{}^* D_{i1991} + \beta_4{}^* \Delta X_{it} + \beta_5{}^* X_{it} + \eta_j + \nu_t + p^* t + \varepsilon_{it} \quad (4)$$

The meaning of the variable is the same as that in the previous equation.

IV. Results and discussion

Primary results

Table 2 reports the impact of public bus expansion into villages on the rural income mobility. As shown in Table 2, Column (1) includes regression results of the core explaining variable, control variable, community fixed effect and time fixed effect. Column (2) controls the interaction item between the province fixed effect and the year fixed effect to identify whether the variation adopted by the coefficient of public bus expansion is originated from different villages within the same province in the same year (Wang and Wan 2015), which help to more accurately identify the causality between public bus expansion into villages and rural household income mobility. Column (3) seeks clustering of the standard error at the rural level for the convenience of eliminating the impact and heteroscedasticity of the serial correlation between regression

Table 2. Benchmark regression results.

	Explained variable:Income Mobility			
	(1)	(2)	(3)	(4)
Bus	−0.0293	−0.0408	−0.0408	−0.0408
	(0.0598)	(0.0637)	(0.0659)	(1.2714)
D1	0.2227***	0.2250***	0.2250***	0.2250***
	(0.0420)	(0.0421)	(0.0182)	(0.0421)
D2	0.1135***	0.1146***	0.1146***	0.1146***
	(0.0403)	(0.0404)	(0.0186)	(0.0404)
D3	−0.1138***	−0.1145***	−0.1145***	−0.1145***
	(0.0399)	(0.0399)	(0.0195)	(0.0399)
D4	−0.2183***	−0.2195***	−0.2195***	−0.2195***
	(0.0430)	(0.0431)	(0.0193)	(0.0431)
Control variables	Yes	Yes	Yes	Yes
atanhrho_12				0.1857
				(0.2473）
Constant	Yes	Yes	Yes	Yes
Villages FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Province-Year FE	No	Yes	Yes	Yes
Cluster (Villages）	No	No	Yes	Yes
Observations	7672	7672	7672	7672
pseudo R^2	0.0136	0.0168	0.0168	0.0168

Standard errors in parentheses; *** $p<0.01$, ** $p<0.05$, * $p<0.1$.

samples[2] According to regression results, no significant impact of public bus expansion into villages on rural household income mobility is noticed.

Nevertheless, due to the potential endogeneity of public bus expansion into villages, regression results might be biased. In this study, endogeneity is likely to be resulted from missing variables and reciprocal causation. First of all, the missing explaining variables are discussed. Some factors which cannot be observed or can be observed but cannot be measured by the CHNS database (such as natural conditions, climate, culture, and customs) can affect both public bus expansion into villages and rural residents' income level. Missing of these factors can result in biased regression results. Second, reciprocal causation is also potentially responsible for the endogeneity, which has actually been proved as the most important cause of endogeneity. Public bus expansion into villages can directly affect rural residents' income level, and the latter can in turn affect the former as well. For example, i. in villages with a relatively high per capitaincome level, their public bus services are also relatively complete. Since earlier, road construction mostly relied on villagers' fund-raising, rural household income level and public bus expansion into villages are directly linked. ii. Improvement of public transport probably benefits from relocation. Relocation of impoverished residents or relocation of the whole family is generally realized through income improvement, so the rural household income and the accessibility of public transport are directly related.

In this study, the instrumental variable estimation approach is employed to cope with endogeneity caused by public bus expansion into villages. Following research findings of Redding and Turner (2015), road density [3] and posts of the Ming Dynasty are chosen as instrumental variables of public bus expansion into villages. The aforesaid instrumental variables can indicate the historical level or construction conditions of the regional infrastructure, so they have a close bearing on post-stage road infrastructure construction. Meanwhile, these instrumental variables are free from the impact of the post-stage rural household income, and can satisfy requirements of the relevant and exogeneity of instrumental variables.

In the panel data fixed effect model, instrumental variables not changing with time are less effective. To address this, we construct an interaction variable for infrastructure by creating an interaction item between the history variable and the time

[2]The disturbing items of the ordinary standard error hypothesis are independent identically distributed, but its value is relatively small, due to comprehensive effects of serial correlation and heteroscedasticity.
[3]Road density of the Ming dynasty is indicated by the road length on the unit area of different places.

dummy variable (Ding, Fan, and Lin 2018). Following the spirit of previous research, the time dummy variable is set based on the tax distribution system reform, with the variable set to 1 for 1994 and after, and 0 for before 1994.

This study uses the conditional mixed process (CMP) for regression of the instrumental variable. The specific regression results are presented in Column (4) of Table 2. Regression results show that the parameter estimation results of atanhrho_12 are not significantly different from 0. This suggests that endogeneity is not a problem facing public bus expansion into villages. Therefore, regression results of the aforesaid probit model are valid and reliable.

The aforesaid regression results only indicate the average effect of public bus expansion into villages on rural residents, but it cannot reflect the impact of public bus expansion into villages on different groups. Because of this concern, we follow the approach of the National Bureau of Statistics and divides rural households into five groups to investigate the impact of public bus expansion into villages on the income mobility of different groups. Table 3 gives an account of the impact of public bus expansion into villages on the income mobility of different income groups. Results display that the estimation coefficient of the interaction item between public bus expansion into villages and the low-income group, and the estimation coefficient of the interaction item between public bus expansion into villages and the medium and below-medium income group are significantly negative. This means that the negative impact of public bus expansion into villages on the income mobility is mainly found among low-income households. The estimation coefficient of the interaction item between public bus expansion into villages and the high-income group is significantly positive, which indicates that the expansion can positively improve the income mobility of high-income families. Public bus expansion into villages has failed to materialize the pro-poor growth of rural income mobility, and this can lead to further deterioration of the income pattern. Hypothesis 1 has been proven.

Table 3. Impact of public bus expansion into villages on income mobility of different income groups.

	Explained variable:Income Mobility			
	(1)	(2)	(3)	(4)
Bus	0.0478	0.0028	−0.0079	−0.0079
	(0.0656)	(0.0859)	(0.0885)	(0.0667)
*Bus*D1*	−0.1665*	−0.1973**	−0.1881*	−0.1881***
	(0.0907)	(0.0970)	(0.0973)	(0.0708)
*Bus*D2*	−0.0922	−0.1117	−0.1186	−0.1186*
	(0.0878)	(0.0918)	(0.0920)	(0.0612)
*Bus*D4*	0.1049	0.0806	0.0776	0.0776
	(0.0949)	(0.0984)	(0.0985)	(0.0657)
*Bus*D5*	0.0991	0.1348	0.1538	0.1538*
	(0.1027)	(0.1096)	(0.1103)	(0.0810)
D1	0.3413***	0.3738***	0.3694***	0.3694***
	(0.0800)	(0.0860)	(0.0862)	(0.0573)
D2	0.1882**	0.1989**	0.2048**	0.2048***
	(0.0763)	(0.0805)	(0.0807)	(0.0525)
D4	−0.1860**	−0.1774**	−0.1756**	−0.1756***
	(0.0851)	(0.0881)	(0.0882)	(0.0539)
D5	−0.2545***	−0.3343***	−0.3518***	−0.3518***
	(0.0938)	(0.1011)	(0.1016)	(0.0697)
Other controls	Yes	Yes	Yes	Yes
Constant	Yes	Yes	Yes	Yes
Villages FE	No	Yes	Yes	Yes
Year FE	No	Yes	Yes	Yes
Province-Year FE	No	No	Yes	Yes
Cluster (Villages）	No	No	No	Yes
Observations	7672	7672	7672	7672
pseudo R^2	0.0121	0.0142	0.0174	0.0174

Standard errors in parentheses; *** $p<0.01$, ** $p<0.05$, * $p<0.1$.

Robustness test

The empirical results presented above provide insights into the impact of public bus expansion into villages on the income mobility of different groups. However, these results are subject to several issues that remain unresolved, such as the potential impact of the measurement of core variables and different regression models. To address these concerns, a series of robustness tests is conducted based on Column (4) of Table 3. Firstly, the lag phase 1 of the independent variable is considered, as the full impact of public bus expansion into villages may involve a time lag. This study provides a quantitative analysis of the lag phase 1 of public bus expansion into villages on rural household income mobility. [Refer to Column (1) of Table 4.] Secondly, changes are made to the dependent variable, whereby households with higher current period income levels than the last period are classified as upwardly mobile (assigned a value of 1), those with stable income are assigned a value of 0, and those with a lower current period income level than the last period are classified as downwardly mobile (assigned a value of −1). [Refer to Column (2) of Table 4.] Thirdly, the definition of the low-income group is revised to follow the Eurostat approach, whereby relative poverty is defined as the wealth status that is just 60% of the median per capita net income. [Refer to Column (3) of Table 4.] Fourthly, a different regression approach is employed, with the ordinal logit model being used for the robustness test as it outperforms the probit model in accounting for concomitant variables. [Refer to Column (4) of Table 4.] Finally, the potential impact of high-speed rail on income mobility is controlled for.

Table 4. Robustness test.

	Explained variable:Income Mobility					
	(1)	(2)	(3)	(4)	(5)	(6)
Bus_lag	0.0335					
	(0.0679)					
*Bus_lag*D1*	−0.1985***					
	(0.0623)					
*Bus_lag*D2*	−0.0765					
	(0.0529)					
*Bus_lag*D4*	0.0538					
	(0.0566)					
*Bus_lag*D5*	0.1558**					
	(0.0703)					
Bus		−0.0133	−0.0062	−0.0060	−0.0071	−0.0089
		(0.0702)	(0.0639)	(0.1198)	(0.0670)	(0.0712)
*Bus*poor*			−0.1343**			
			(0.0643)			
*Bus*D1*		−0.2049***		−0.3253**	−0.1880***	−0.1868***
		(0.0754)		(0.1290)	(0.0708)	(0.0720)
*Bus*D2*		−0.1070		−0.2137*	−0.1185*	−0.1246**
		(0.0739)		(0.1177)	(0.0612)	(0.0620)
*Bus*D4*		0.0952		0.1020	0.0775	0.0874
		(0.0822)		(0.1299)	(0.0658)	(0.0740)
*Bus*D5*		0.1553*		0.2467*	0.1536*	0.1598*
		(0.0816)		(0.1475)	(0.0813)	(0.0876)
poor			0.3307***			
			(0.0534)			
D1	0.3693***	0.4010***		0.6443***	0.3693***	0.4034***
	(0.0476)	(0.0621)		(0.1048)	(0.0573)	(0.0555)
D2	0.1716***	0.1931***		0.3571***	0.2048***	0.2227***
	(0.0450)	(0.0633)		(0.1003)	(0.0525)	(0.0539)
D4	−0.1547***	−0.1773***		−0.2760**	−0.1755***	−0.1823***
	(0.0447)	(0.0685)		(0.1083)	(0.0539)	(0.0615)
D5	−0.3467***	−0.3329***		−0.5758***	−0.3517***	−0.3771***
	(0.0565)	(0.0675)		(0.1274)	(0.0699)	(0.0758)
Other controls	Yes	Yes	Yes	Yes	Yes	Yes
Constant	Yes	Yes	Yes	Yes	Yes	Yes
Villages FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Province-Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Cluster (Villages）	Yes	Yes	Yes	Yes	Yes	Yes
Observations	7672	7672	7672	7672	7672	7672
pseudo R^2	0.0174	0.0233	0.0143	0.0170	0.0174	0.0197

Standard errors in parentheses; *** $p<0.01$, ** $p<0.05$, * $p<0.1$.

The impact of public bus expansion into rural villages on income mobility among different groups has been empirically verified in the preceding analysis. However, several issues remain unresolved, such as whether the regression results are sensitive to variations in core variable measurements and different modelling approaches. In light of these concerns, a series of robustness tests are conducted based on Column (4) of Table 3. First, the lag phase 1 of the independent variable is analysed. As the impact of public bus expansion into villages takes time to fully manifest, its effect on rural household income mobility does not occur at a specific moment. Consequently, this paper provides a quantitative analysis of the lag phase 1 of public bus expansion into villages. [Refer to Column (1) of Table 4.] Second, the dependent variable is altered. Specifically, if the current period income level of the rural household is higher than that of the previous period, the household income is defined as transitioning upward, and the value of income mobility is set to 1. If the current and previous period income levels are the same, the household income is defined as relatively stable, and the value of income mobility is set to 0. If the current period income level is lower than that of the previous period, the household income is defined as transitioning downward, and the value of income mobility is set to −1. [Refer to Column (2) of Table 4.] Third, the low-income group is defined differently. Following the approach of the Eurostat, relative poverty is defined as the wealth status equivalent to just 60% of the median per capitanet income. [Refer to Column (3) of Table 4.] Fourth, a different regression approach is employed. Since the logit model is superior to the probit model in terms of concomitant variable equilibrium, the ordinal logit model is used for robustness testing. [Refer to Column (4) of Table 4.] Fifth, the impact of high-speed rail on income mobility is controlled for.Being fast and efficient, high-speed railway has been the top choice of people's transportation. Therefore, this section controls the impact of high-speed railway on rural household income. Sixth, the effects of the average age and average years of education of household labour force on rural household income mobility. [See Column (6) in Table 4 for regression results.]

Table 4 reports the regression results of the robustness test. Regression results show that the coefficient estimation results are basically consistent with expectations.

Placebo test

We carry out the following two placebo tests to prevent the benchmark from being affected by artificial settings or missing variables. First, hypothesize the time of public bus expansion into villages. This study resorts to the approach developed by Abadie, Diamond, and Hainmueller (2010) to advance the time of public bus expansion into villages by two survey years. Second, hypothesize the treatment group. This study follows the research thinking of Cai et al. (2016) to hypothesize areas without public bus services as the treatment group while the remaining areas as the control group. Of special note is that, in order to make effects of the placebo test more obvious, this study deletes samples with public bus services all the time. The final regression results are presented in Table 5 below:

Table 5 presents placebo test results. Regression results reveal that the interaction item between the dummy variable of public bus expansion into villages and the dummy variable of the low-income group has failed to pass the significance test. In other words, placebo tests can effectively substantiate regression results stated above.

Impact factors of public bus expansion into villages on income mobility

Table 6 presents Impact of Public Bus Expansion into villages on non-agricultural employment and agricultural production structure, where Column (1) shows regression results of non-agricultural employment, while Column (2) shows regression results of agricultural production structure. Regression results suggest that the estimation coefficient of the interaction item between public bus expansion into villages and low-income group is significantly negative statistically in the non-agricultural employment equation. This means that public bus expansion into villages cannot significantly improve non-agricultural employment of low-income households.Hypothesis 2 has been proven. Additionally, the estimation coefficient of

Table 5. Inspection results of placebo test.

	Explained variable:Income Mobility	
	(1)	(2)
Bus	0.0901	−0.2584
	(0.2419)	(0.3262)
*Bus*D1*	−0.3498	0.2723
	(0.2199)	(0.3856)
*Bus*D2*	−0.1903	0.3775
	(0.2120)	(0.3669)
*Bus*D4*	−0.0170	0.3336
	(0.2473)	(0.4570)
*Bus*D5*	−0.1096	0.5446
	(0.3038)	(0.5723)
D1	0.5010***	0.3025**
	(0.1780)	(0.1253)
D2	0.2858	0.1278
	(0.1741)	(0.1222)
D4	−0.1002	−0.2382*
	(0.2068)	(0.1376)
D5	−0.0898	−0.3877**
	(0.2745)	(0.1624)
Controls variables	Yes	Yes
Constant	Yes	Yes
Villages FE	Yes	Yes
Year FE	Yes	Yes
Province-Year FE	Yes	Yes
Cluster (Villages)	Yes	Yes
Observations	3408	3408
pseudo R^2	0.0243	0.0249

Standard errors in parentheses; *** $p<0.01$, ** $p<0.05$, * $p<0.1$.

Table 6. Impact of public bus expansion into villages on non-agricultural employment and agricultural production structure.

	non-agricultural employments	agricultural production structural
	(1)	(2)
Bus	3.2034	5.7460
	(3.8768)	(3.5966)
*Bus*D1*	−9.5173**	−3.0863
	(4.6670)	(4.1101)
*Bus*D2*	−1.7947	−1.6061
	(3.6650)	(3.1035)
*Bus*D4*	3.4154	2.6516
	(4.7568)	(4.3679)
*Bus*D5*	−15.5787***	10.2536***
	(4.0237)	(3.4794)
D1	12.7098***	11.9002***
	(3.9152)	(3.5003)
D2	−0.6613	0.0660
	(3.1594)	(2.7822)
D4	−3.1167	−1.3321
	(4.2451)	(4.0128)
D5	16.8629***	12.5401***
	(3.5384)	(3.1901)
Controls variables	Y	Y
Constant	33.3495***	−11.4363
	(7.9788)	(7.6081)
Villages FE	Y	Y
Year FE	Y	Y
Province-Year FE	Y	Y
Cluster (Villages)	Y	Y
Observations	7672	7672
pseudo R^2	0.3664	0.4100

Standard errors in parentheses; *** $p<0.01$, ** $p<0.05$, * $p<0.1$.

the interaction item between public bus expansion into villages and low-income group has failed to pass the significance test. This suggests that the role of public bus expansion into villages in adjusting the agricultural production structure is not significantly varied among different income groups. Hypothesis 3 has been proven.

We examine causes of the insignificant difference of the agricultural production structure. First, opportunities are relatively stable for non-agricultural employment. Statistics show that, from 2015 to 2020, the non-agricultural employment income stabilizes at around 40%. But the demographic structure of non-agricultural employment has changed. Fang and Herrendorf (2021) found that unskilled employment is on the decline. This suggests that non-agricultural employment remains generally the same. After public bus expansion into villages, the involution effect happens among farmers. The group with a relatively high human capital pushes the group with a relatively low human capital out of the non-agricultural employment sectors. Second, after public bus expansion into villages, citizens' derivative demands are on the increase, but these demands are mainly for agricultural products with a high investment value and a high added value, such as vegetables and fruits. The low-income group, because of mobility restrictions, can hardly adjust the agricultural production structure. After public bus expansion into villages, polarization within farmers are further strengthened, and low-income rural households are restricted to growing grain crops.

Impact of human capital and time distribution within household

According to Aggarwal (2018), infrastructure can improve the return rate of education. The group with a more advanced educational background can benefit more from infrastructure. It is necessary for this study to take the impact of rural household human capital into consideration when analysing the impact of public bus expansion into villages. Based on the interaction item between public bus expansion into villages and low-income group, the adjusting role of the human capital is investigated. The regression results are demonstrated in Column (1) of Table 7. Regression results suggest that the interaction item among public bus expansion into villages, low-income group and educational background is significantly negative. This means that, as the human capital is improving, the negative impact of public bus expansion into villages on the income mobility of the low-income group is gradually weakening. Hence, at the policy level, educational funds should be increased for rural areas. This can not only improve the human capital of the low-income group, but also increase the return rate of the public services.

Public bus expansion into villages can influence the income mobility by shortening the effective range (reducing the time taken on the way to school) and reducing the transport cost (Muralidharan and Prakash 2017). However, labour force distribution brought about by

Table 7. Impact of human capital and time distribution within household.

	(1)	(2)
Bus	−0.1083	0.0289
	(0.0714)	(0.0728)
*Bus*D1*	−0.0324	−0.2813***
	(0.0812)	(0.0758)
*Bus*D1*edu*	−0.0237***	
	(0.0077)	
*Bus*D1* dependency ratio*		0.6693***
		(0.2146)
Controls variables	Y	Y
Constant	Y	Y
Villages FE	Y	Y
Year FE	Y	Y
Province-Year FE	Y	Y
Cluster (Villages)	Y	Y
Observations	7672	7672
pseudo R^2	0.0180	0.0173

Standard errors in parentheses; *** $p<0.01$, ** $p<0.05$, * $p<0.1$.

public bus expansion into villages is subject to the influence of the household internal time distribution (mainly referring to time taken to take good care of children). This study further introduces the interaction item among public bus expansion into villages, low-income households and dependency ratio of juveniles. Regression results are shown in Column (2) of Table 7, and suggest that the interaction item of public bus expansion into villages, low-income group and dependency ratio of juveniles is significantly positive. This means that a high dependency ratio of juveniles can enhance the impact of public bus expansion into villages on the low-income group in rural areas. The household internal time distribution (such as taking care of children and supporting them to go to school) has restricted the full play of the role of labour force distribution after public bus expansion into villages.

V. Conclusions and policy implication

Income mobility is a critical index measuring common wealth. To assess the impact of public services, namely road infrastructure, on income mobility holds vital theoretical and practical significance to promote non-agricultural employment of rural households and address inequality. In this study, data from the CHNS spanning from 1991 to 2015 are chosen for a thorough research. The research finds, The low income group experiences a negative impact from public bus expansion to rural countries. The latter has caused the solidification of the low-income group. The low-income group seem to have been crowded out from non-agricultural activities by public bus expansion into villages. Besides, the low-income group are incapable of adjusting the rural structure and developing high added-value agriculture. Improvement of the human capital can significantly mitigate the impact of public bus expansion into villages on the low income group. Labor forces allocation constraints for child care have aggravated the negative impact of public bus expansion to villages on the low-income group.

The research findings stated above can provide some policy implications on how to propel common prosperity in rural areas under the condition of urban-rural integration. First, road infrastructure construction should be strengthened, and projects expanding public bus services into villages should be continuously promoted. Through the direct effect and indirect effect of public bus expansion into villages on promoting non-agricultural employment, the low-income group can realize the upward transition of their income class. Second, the low-income group's human capital level can be improved. Only by strengthening education on ability of low-income group to develop themselves can the low income group's utilization degree of public services be increased. For example, more channels to education should be set up, including school education, education targeted at development of vocational skills and periodical training of basic skills, particularly for low income households. Third, the rural public investment structure should be optimized to better get adapted to the rural economic development. As China's rural areas are heading towards common prosperity, the rural public investment structure should be adjusted in real time, and fiscal support for basic public services, including scientific and technological, cultural and health services, old-age care and medical services, should be enhanced.

Due to data constraints, CHNS has not yet published data beyond 2015, which has limited the ability of this study to analyse the impact of transportation access on rural household income mobility. Furthermore, CHNS data only includes health information up until 2002, which means that this study is unable to identify the extent to which household health status plays a role in the

association between transportation access and rural household income mobility.

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