Effects of the poverty alleviation relocation program on diet quality among low-income households

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Abstract

Purpose – This paper aims to examine impacts of the poverty alleviation relocation (PAR) program on diet quality of low-income households in China. We explore the impact mechanism of relocation on diet quality and the heterogeneous effects of different relocation modes.

Design/methodology/approach – A fixed effects model is constructed using panel data of 1126 low-income households collected over three years in eight provinces of China. The PAR program provides a natural experiment which dramatically changes the living conditions surrounding farmers. We are able to identify the causal effects of relocation on diet quality free from selection bias.

Findings – The empirical results show that the PAR program improves diet quality of low-income households and that better market access and increasing incomes induced by relocation play an important role in this improvement. Improved market access significantly reduces the over-consumption of staple foods, whereas higher income significantly reduces the intake divergences of non-staple foods. The impacts of different relocation modes on diet quality are highly heterogeneous.

Practical implications – Our findings indicate that the PAR program benefits diet quality of low-income households through greater market access and increases in total household income. Market improvements and food subsidies are conducive to improving the diet quality of the low income.

Originality/value – Despite widespread evidences of healthy diets being associated with household environments and income, selection bias remains. This paper utilizes an exogenous program to explore the causal impacts of market access and family income on diet quality and to separate their different effects.

Keywords Market access, Income constraint, Diet quality, Poverty alleviation relocation, China

Paper type Research paper

1. Introduction

While economies have developed rapidly across the globe, more than 821 million people and 149 million children still suffer from malnutrition internationally (UN, 2019). A low-income diet due to malnutrition has numerous health implications. In 2017, 11 million deaths and 255 million disability-adjusted life-years (DALYs) were attributable to dietary risk factors (GBD, 2019). In poverty-stricken areas, inadequate diets are a common problem. Inadequate diets and undernutrition uniformly affect asset accumulation and labor productivity in most states (Dutta, 2015; You *et al.*, 2018), significantly limiting countries' development (Jha *et al.*, 2009). Moreover, more than half of the UN's sustainable development goals are related to food security and nutrition. Thus, it is important to research means to address unbalanced diets in low-income areas.

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The low-income population in rural China suffers from extremely deficient food market access and income constraints. Areas in which structural constraints limit food access are called "food deserts" (Kato and McKinney, 2015; Alviola *et al.*, 2013; Thomsen *et al.*, 2016). Low-income households located in food deserts consume fewer healthy foods, which contributes to poor quality diets, greater health disparities the development of diet-related diseases, malnutrition and delayed childhood development (Abel and Faust, 2020; Larson *et al.*, 2009; Hilmers *et al.*, 2012). Income constraints constitute another problem in rural areas with low-income populations. A lack of income limits the consumption of healthy foods. Thus, poor quality diets may be attributed to severe conditions that surround low-income households and income constraints.

Research on effects of market access and income conditions on diet quality is often limited by selection bias. Several works have examined the diet quality of different populations over the past few years. Some show that improvements in diet quality correlate with increases in income (Huang *et al.*, 2017; Tsiboe *et al.*, 2018) while others draw connections between living conditions and food consumption (Fitzpatrick *et al.*, 2019; Stifel and Minten, 2017), and some literatures explored the effect of programs about nutrition subsidy on nutrition, such as the Women, Infants and Children (WIC) program (Wu *et al.*, 2017) and the Supplemental Nutrition Assistance Program (SNAP) in the United States (Fitzpatrick *et al.*, 2016). However, because diet quality is often endogenous to household characteristics and as households endogenously determine where to reside, it is difficult to disentangle the causal relationships between locations, income levels and diets. Few works have also separated the effects of market environments and income on diet and estimated the magnitudes of such effects.

Therefore, this study utilizes a unique policy experiment, the Poverty Alleviation Relocation (PAR) program, to circumvent selection bias and explore the causal impacts of market access and income conditions on the diet quality of low-income households in rural China. Over the past 40 years, China has made significant progress toward poverty reduction (Liu *et al.*, 2019). The PAR program is a massive relocation program as a part of China's poverty-eradication policy. The program was designed to relocate 10 million households living in remote rural areas into villages or towns with their new residence places assigned in a nearly random fashion through a lottery. The random nature of the allocation treatment allows for a unique empirical analysis free of selection bias issues. A survey was carried out and panel data of 1126 households from eight major relocation provinces, namely Gansu, Guangxi, Guizhou, Hubei, Hunan, Shaanxi, Sichuan and Yunnan, were collected over the years of 2016, 2017 and 2019.

Several studies have evaluated the effects of the PAR program on poverty reduction and livelihood. Some research find that relocation reduces poverty incidence (Liu *et al.*, 2019; Wang *et al.*, 2018) and improves livelihood conditions (Liu *et al.*, 2018; Guo and Li, 2019). A few studies find that the PAR program changes livelihood strategies and habits of low-income households (Zou *et al.*, 2019; Wilmsen and Wang, 2015). However, none of these studies evaluated impacts of the relocation program on diet quality. The objectives of this research are to determine whether the PAR program benefits low-income populations' diet quality through the channels of greater market access and higher income levels. We also examine the heterogeneous effects of different relocation modes on diet.

This study attempts to address research gaps and contribute to the literature in three ways. First, this study enriches the empirical literature on the relationships between market access, income constraints and the diet quality of low-income households in rural areas by providing new evidences from the PAR program. Our work is novel that we are able to explore the causal impacts of market access and income levels on food consumption and diets. Second, a fixed effects model is employed to control for unobserved household-specific and time-invariant factors using unique research panel data. Third, as poverty alleviation relocation is one of China's "five groups of targeted poverty alleviation projects", we assess the broader implications of China's relocation of 10 million households in terms of diet quality. The presented insights into the program's effectiveness have important implications for poverty alleviation internationally.

This paper is organized as follows. Section 2 provides the analytical framework and estimation model used. Section 3 introduces data sources and descriptive statistics. Empirical results are presented in Section 4, and Section 5 concludes the paper and provides policy implications.

2. Analytical framework and estimation model

2.1 Theoretical analysis of diet decision-making process

Based on consumer utility theory, we set up the following maximization problem describing the decision-making process of food consumption for low-income households. The objective is to maximize diet utility, which is derived from food consumption and other household characteristics, with income and market constraints shown in Eqns (2) and (3).

$$\text{Max } U(x_i, \varepsilon) \tag{1}$$

$$\text{s.t.}\, I = \sum_{i=1}^{n} (P_i + C_i) x_i \tag{2}$$

$$C_i = C(M, \delta) \tag{3}$$

The diet utility U is a function of x_i and ε, where x_i denotes the consumption of food category i, $i = 1, \ldots, n$, and ε representing other exogenous household characteristics such as personal preferences, the proportion of women in a family and so on. We assume that the utility function is not monotonically increasing in food consumption, which conforms to the property that when $x_i \leq \tilde{x}_i$, $U_{x_i} \geq 0$, and when $x_i \geq \tilde{x}_i$, $U_{x_i} \leq 0$, where $\tilde{x}_i$ is the ideal intake level of food item i. In Eqn (2), I is total family income, P_i is the price of food i, and C_i represents the access cost to food i, including transportation costs, labor costs and so on. Eqn (3) shows that the access cost to food i is a function of the food market environment, M, such as the distance to food market and other influencing factors, δ.

The Lagrange equation and the indirect utility function are derived respectively as follows,

$$L(x_i, \lambda, P, I, M) = U(x_i, \varepsilon) + \lambda \left\{ I - \sum_{i=1}^{n} [P_i + C(M, \delta)] x_i \right\} \text{with } \lambda > 0 \tag{4}$$

$$V(P, I, M) = U^* \left(x_1^*, x_2^*, \ldots, x_n^* \right) = U^* \left(x_1^*(P, I, M), x_2^*(P, I, M), \ldots, x_n^*(P, I, M) \right) \tag{5}$$

The indirect utility function V is determined by food prices, income and market environments. According to the envelope theorem, we obtain the following three differential equations

$$\frac{\partial V}{\partial I} = \frac{\partial L(x^*, \lambda^*)}{\partial I} = \lambda^* \tag{6}$$

$$\frac{\partial V}{\partial P_i} = \frac{\partial L(x^*, \lambda^*)}{\partial P_i} = -\lambda^* x_i^* \tag{7}$$

$$\frac{\partial V}{\partial M} = \frac{\partial L(x^*, \lambda^*)}{\partial M} = -\lambda^* x_i^* \cdot \frac{\partial C(M, \delta)}{\partial M} \tag{8}$$

The optimal decisions in terms of food consumption, x_i^*, are derived as

$$x_i^* = -\frac{\partial V/\partial C(M,\delta)}{\partial V/\partial I} \tag{9}$$

According to Eqn (9), the optimal food consumption is affected by market environments, family income and other factors. We thus can disentangle the effects of market access and income on food consumption based on this equation. As $\lambda^* > 0$ and thus $\partial V/\partial I > 0$. When total income increases, the constraints are relaxed and diet utility increases. As Kato and McKinney (2015) proposed, economic constraints may create an initial barrier to market and product access. In addition, because $\lambda^* > 0$ and $x_i^* > 0$, we have $-\lambda^* x_i^* < 0$ and therefore $\partial V/\partial C(M,\delta) < 0$, implying that diet utility decreases as access cost to food increases. As an increase in food market access reduces cost to obtain food, better market access contributes to diet utility.

Based on the theoretical analysis, we demonstrate that when food category i is over-consumed, better food access and increasing income reduce the intake, whereas when food category i is under-consumed, improved food access and higher income increase its intake level, both leading to a diet of higher quality.

2.2 Analysis of relocation effects

From the above theoretical analysis, we suggest that food consumption decisions are affected by market conditions and income. In this section, we explain how the PAR program may directly or indirectly affect the market access and income of low-income populations.

The PAR program may directly reduce barriers of relocated low-income households to get access to food, reflected as decreasing distance to food market and greater access to a broader variety of food. On one hand, there are more supermarkets located in towns and cities than remote villages. As relocated households moved from remote areas to more developed villages, towns or cities, they get closer to food markets. Since targeted households in the PAR program are not required to purchase the houses that they were relocated to, they do not pay for the improvements in living environments and their economic constraints are basically not affected by relocation. In addition, since there are more varied food options available at supermarkets, these households are able to gain access to more kinds of food after relocation, especially to more types of non-staple foods which farmers cannot grow by themselves. Considering that the poor areas with lower food access generally have higher food prices while larger cities have lower food prices (Andreyeva *et al.*, 2008; Handbury and Weinstein, 2015; Fan *et al.*, 2018) due to more competitive markets and more convenient purchasing channels (Hilmers *et al.*, 2012), the relocated households are likely to enjoy lower food prices. Furthermore, the relocated households may spend less on transportation due to closer proximity to food markets, reducing food costs further. All of these changes to consumption environments can be attributed to relocation.

The PAR program may improve household income through providing more non-agricultural employment opportunities and promoting industrial development. In terms of non-agricultural employment, Ahmed and Hossain (1990) proved that better infrastructure improves farmers' access to the employment market, increases the likelihood of earning an income and enhances family income by 33% and business incomes by 17%. Households relocated to larger villages, towns or cities are equipped with better infrastructure, affording them better employment opportunities. In terms of industrial development, low-income farmers get access to better and cheaper inputs for agricultural production since they are positioned closer to inputs and sales markets after relocation. In general, household income can be improved by relocation.

As illustrated in Figure 1, the PAR program is supposed to affect the market access and income levels of low-income households, which may improve diet quality. Because the relocation treatment is random in the PAR program, these effects should not be influenced by household characteristics and thus can be identified through the special quasi-experimental tool.

2.3 Modeling the impacts of PAR program on diet quality

Under the PAR program, each household is under either of two states: relocated and not relocated. According to the national relocation plan [1], in 2016 when the relocation program was launched, 25.4% of households were planned to relocate. In 2017, around 34.7% of the targeted households were arranged to relocate. In 2019, about 98.8% of the targeted households were planned to relocate, with the remaining population to be relocated in 2020. The time to be relocated is randomly assigned for each low-income household.

To estimate the impacts of PAR program on diet quality, we employ the dynamic panel fixed effects model and conduct the analysis in three steps. In the first phase, we estimate the overall effects of relocation on diet quality, which covers individual effects of market access and income. Second, we explore the impact mechanism of relocation on diet quality by constructing mediation models for market access and income respectively. Distance to market and household income per capita are empirically tested as influence channels through which the PAR program affects diet quality. Third, we investigate the heterogeneous effects of different types of relocation on diet quality for low-income households.

The model used to evaluate the overall impacts of relocation on diet quality is constructed as follows:

$$Y_{it} = \mu_i + \sum_{t=2}^{3} \delta_t + \beta^{FE}\mathrm{Treat}_{it} + \sum_{j=1}^{15} \gamma_j Z_{itj} + \varepsilon_{it} \tag{10}$$

where Y_{it} is the diet quality for household i in survey round t, which is measured using the diet quality divergence (DQD) index; μ_i denotes household fixed effects; δ_t are survey round dummies; Treat_{it} is a dummy variable with $\mathrm{Treat}_{it} = 1$ if household i receives the relocation treatment in year t and 0 otherwise. The coefficient of interest is β^{FE}, which represents the average treatment effects of relocation on diet quality. We add time-varying household characteristics Z_{itj} as control variables in the model, including household size, average age of family members, asset ownership, proportion of females, farm size, production diversity and so on. Standard errors are clustered at the household level and at time t.

To investigate the impact mechanism of the PAR program on diet, the following mediation models are set up:

$$M_{it} = \mu_i + \sum_{t=2}^{3} \delta_t + \beta_1^{a}\mathrm{Treat}_{it} + \sum_{j=1}^{15} \gamma_j Z_{itj} + \varepsilon_{it} \tag{11}$$

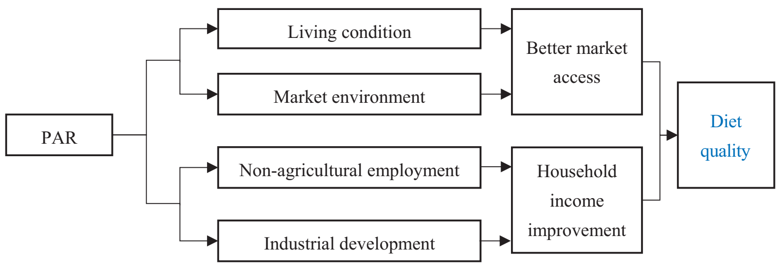

Figure 1. Theoretical framework of relocation effects on diet quality

$$Y_{it} = \mu_i + \sum_{t=2}^{3} \delta_t + \beta^d \text{Treat}_{it} + \beta_2^b M_{it} + \sum_{j=1}^{15} \gamma_j Z_{itj} + \varepsilon_{it} \tag{12}$$

where M_{it} represent mediators which are market access and household income in this paper. The other variables are defined the same as Eqn (10). The coefficient β_1^a denotes the impacts of relocation on mediators. According to Wen *et al.* (2004), the overall effects of relocation on quality diet are computed as $\beta^d + \beta_1^a \times \beta_2^b$. With other variables controlled, the coefficient β^d represents the direct effect of relocation on diet quality, and $\beta_1^a \times \beta_2^b$ denotes the average indirect treatment effects of market access or income on diet quality caused by relocation. If β_1^a and β_2^b are both significant, significant mediation effects exist. If one coefficient is insignificant, we conduct the Sobel test with $z = \widehat{ab}/S_{ab}$, where $\widehat{a}$ and $\widehat{b}$ are estimators of β_1^a and β_2^b respectively, and $S_{ab} = \sqrt{a^2 S_b^2 + b^2 S_a^2}$. If $|z|$ is greater than 0.9, the corresponding mediation effect is significant at the 5% level.

3. Data and descriptive statistics

3.1 Data sources

Our survey started in 2016 before the PAR program was launched and when impoverished households did not know that the project would later affect them. As the local government determined who was to be relocated and when and where to relocate, targeted households cannot choose the relocation time or resettlement destination. According to the principle of voluntary resettlement characterized by free, prior, and informed consent (Lo and Wang 2018), the PAR project is not a typical "voluntary resettlement" program. On one hand, due to the relocation assignment, the local government publicizes the benefits of relocation to poor households and strongly encourages them to move. Almost all of the targeted poor households living in deep and remote mountainous areas are softly forced to move. On the other hand, once new houses are built, targeted households will be pushed to move. Their old houses will be pulled down and land will be reclaimed within a year. Thus, the relocation time and resettlement destination are exogenous. Selection bias does not exist in this estimation.

We launched a large-scale survey of low-income households enrolled in the PAR project from 16 counties of Gansu, Guangxi, Guizhou, Hubei, Hunan, Shaanxi, Sichuan and Yunnan in 2016, 2017 and 2019. Approximately 150 households have been investigated for each province. Our panel data consist of 1126 household samples from 106 resettlement sites and 251 villages (village groups) which have been consecutively tracked for the three rounds of survey. The survey data contain information on relocation types, household characteristics, living conditions, income status, consumption habits, employment status and social integration patterns.

The PAR program was planned to relocate 10 million low-income residents across the country within five years starting from 2016. Table 1 shows that in our data sample no households were relocated in 2016. Around 29.4% of the 1126 households were relocated in 2017 and 83% households moved in 2019. In total, 35% of the households moved to small towns or industrial park, recorded as "relocated to towns", and 65% of the households moved to villages or newly constructed villages, recorded as "relocated to villages".

3.2 Variable selection and descriptive statistics

We use the diet quality divergence (DQD) index as a proxy for diet quality. Following Zhou *et al.* (2020), we calculate DQD as the absolute divergence value (percent) between real food consumption and recommended intake levels specified in the Chinese Food Pagoda (CFP) 2016. The CFP 2016 is illustrated in Chinese dietary guidelines 2016, which provides the daily recommended intakes of eight food categories for adults with age from 18 to 64 years old. The DQD is an appropriate measure for diet quality since reducing diet divergences improves diet

Province	Sample size	2017 Relocated to villages	2017 Relocated to towns	2017 Not relocated	2019 Relocated to villages	2019 Relocated to towns	2019 Not relocated
Yunnan	151	56	0	95	135	0	16
Sichuan	159	83	0	76	154	4	1
Guangxi	109	0	1	108	0	106	3
Hubei	128	49	0	79	117	4	7
Hunan	150	5	0	145	48	69	33
Gansu	175	8	10	157	63	21	91
Guizhou	118	3	59	56	4	106	8
Shanxi	136	50	7	79	85	14	37
Total	*1126*	*254*	*77*	*795*	*606*	*324*	*196*

Table 1. Relocation distribution of data samples

quality and environmental sustainability (Lei and Shimokawa, 2017). In addition, DQD derived from the CFP 2016 is especially suitable for Chinese people. The food consumption and dietary habits in China are different from those in western countries, where healthy eating index (HEI), diet quality index (DQI), Mediterranean diet scale (MDS) and their derivatives are commonly used to measure diet quality (Zhou *et al.*, 2020).

Table 2 compares the daily intakes for eight food categories recommended by the CFP 2016 and the daily intake per capita of our household samples in the baseline year. The daily per capita intake of staple food (cereal and potatoes) is 509.2 g for household samples on average, greater than the recommended intake, which suggests over-consumption of staple food for the low-income households. The daily fruit intake is 6.4 g per capita, far less than the recommended intake, which is 200–350 g daily. The recommended daily intake range of vegetables is 300–500 g, slightly larger than the actual intake level of 268.7 g/d for sampled households. Eggs' recommended daily intake is 40–50 g, which is greater than the average intake of low-income households (23.4 g/d). The aquatic products like fish and crabs are recommended to consume 40–75 g per day, while the low-income households live in deep mountains seldomly eat aquatic products and they only take 1.6 g per capita per day, far less than the recommended level. The actual daily intake of meat and poultry is 53.4 g, which falls within the recommended range from 40 g to 75 g. The consumption of legumes and nuts is 21.5 g, a little below its recommended range from 25 g to 35 g. The recommended intake of milk and milk products exceeds 300 g per day, while the average daily intake of low-income households is only 2 g per capita. In summary, the intakes of staple food exceed the recommended level, whereas the intakes of non-staple food like fruits, vegetables, aquatic products, legumes and nuts, milk and milk products for low-income households are far less than the recommended intakes.

Category	Food group	Recommended intake (g/d)	Average intake of baseline samples (g/d)
1	Cereal and Potatoes	(250, 400)	509.2
2	Fruits	(200, 350)	6.4
3	Vegetables	(300, 500)	268.7
4	Eggs	(40, 50)	23.4
5	Aquatic products	(40, 75)	1.6
6	Meat and poultry	(40, 75)	53.4
7	Legumes and Nuts	(25, 35)	21.5
8	Milk and Milk Products	300+	2.0

Table 2. The range of daily recommend intakes in Chinese food pagoda 2016 and the daily intake per capita of baseline samples

In our survey, we ask each household the quantities of each food category they have eaten in the past two weeks. As the recommended intake is known, the DQD can be calculated as follows

$$X_{itk} = \frac{1}{14n}\sum_{d=1}^{14} x_{itkd} \tag{14}$$

$$\text{DQD}_{itk} = \frac{(|X_{itk} - R_k|)}{R_k} \times 100\% \tag{15}$$

$$\text{DQD}_{it} = \sum_{k=1}^{8} \text{DQD}_{itk} \tag{16}$$

where X_{itk} is the daily per capita intake of food category k for household i in survey round t. x_{itkd} is the total consumption of food category k for household i on day d in the past two weeks and n is the number of household members eating at home. DQD_{itk} is the diet quality divergence index of food category k for household i in survey round t, computed as the absolute divergence value (percent) between the average daily consumption X_{itk} and corresponding recommendation R_k in CFP 2016. Since R_k are daily recommended intake intervals, when $X_{itk} < \min(R_k),\ R_k = \min(R_k),\ X_{itk} > \max(R_k),$ and $\min(R_k) < X_{itk} < \max(R_k)$, $\text{DQD}_{itk} = 0$. The total DQD for each household in survey round t is obtained by summing up all divergences for eight food categories, as shown in Eqn (16). The range of DQD is $[0, +\infty)$, and a smaller DQD index indicates better diet quality and vice versa. When DQD approaches 0, it means the respondent's diet is fully consistent with the intake standards of CFP 2016 (Zhou *et al.*, 2020).

The core explanatory variables considered are the relocation treatment and relocation modes. Whether relocation has occurred is tested in August 2016, July 2017 and in May 2019, when three rounds of survey were conducted. Different relocation modes may have different effects on diet quality. Households relocated to villages mainly rely on agricultural production while households relocated to towns may have more off-farm employment opportunities. The mode of village resettlement includes relocation to the nearest administrative village and to new villages. Town resettlement involves households relocated to county towns, small towns or industrial parks.

Market distance and income are two mediating variables to be tested. Market distance measures relocated households' food accessibility and market environments. The market in this paper is defined as a free market or supermarket for residents where they usually buy fresh foods and other products. It is generally an open-air or enclosed free market before relocation where people can rent a place to sell products and the final price is decided by consumers and vendors (Huang and Tian, 2019). After relocation, market normally refers to the supermarket near the resettlement sites where people can buy fresh foods. The shorter the market distance, the more convenient to get access to fresh food. We use total household net income per capita to measure economic constraints on relocated household. Household net income is composed of wage, operating net income, property and transfer income, which is deflated by the annual CPI index and then divided by household size.

Other control variables include the number of household members eating at home over the past two weeks, farm size, production diversity, average age of household members, transportation convenience, dependency ratio and so on. Household members eating at home over the last two weeks refer to those who lived and ate at home for the last two weeks. Farm size is the land area in which food or cash crops are planted throughout the year. Production diversity may influence the dietary pattern and food diversity (Sibhatu *et al.*, 2015; Huang and Tian, 2019). Following Sibhatu *et al.* (2015), we calculate production diversity as the total number of crop and livestock species. Transportation convenience is measured as the distance to the closest asphalt road. Dependency ratio is the proportion of children less than 16 years old and of elders over the age of 60 in a household. Healthy people are self-rated healthy household members who are without disabilities, chronic diseases and mental illness. Table 3 displays the explanations and descriptive statistics for all variables.

3.3 Dynamic statistics of DQD

Figure 2 illustrates the dynamics of DQD index for eight food categories over the period 2016–2019. The total DQD index increases by 2.1 from 2016 to 2017, indicating that overall

Variable	Explanation	Mean	Std
Dependent variables			
Total DQD	Diet quality divergence index: sum divergences over eight food categories to measure overall diet quality (%)	623.784	284.911
DQD of food category			
Cereal and Potatoes	Diet quality divergence index of cereal and potatoes (%)	42.229	103.686
Fruits	Diet quality divergence index of fruits (%)	93.949	20.724
Vegetables	Diet quality divergence index of vegetables (%)	39.391	38.092
Eggs	Diet quality divergence index of eggs (%)	85.364	102.304
Aquatic Products	Diet quality divergence index of aquatic products (%)	95.27	19.201
Meat and Poultry	Diet quality divergence index of meat and poultry (%)	61.881	130.822
Legumes and Nuts	Diet quality divergence index of legumes and nuts (%)	108.914	132.549
Milk and Milk Products	Diet quality divergence index of milk and milk products (%)	97.482	11.957
Independent variables			
Relocation	Whether relocated. Relocated = 1; Not relocated = 0	0.377	0.485
Distance to market	Distance to a market (km)	9.937	10.564
Total income	Net household income per capita (Yuan)	4222.147	6301.192
Control variables			
Household size	Number of household members living and eating at home over the last two weeks	2.87	1.424
Average age	The average age of household members	42.885	12.834
Asset ownership	Number of durable consumer goods owned by a household	9.766	3.74
Healthy people proportion	Proportion of self-reported healthy people in a household	0.617	0.317
Dependency ratio	Proportion of household members under the age of 16 and over the age of 60	0.402	0.284
Woman proportion	Proportion of female household members	0.449	0.181
Education proportion	Proportion of people with over 9 years of education in a household	0.245	0.257
Farm size	Farming land area (mu)	6.625	10.565
Production diversity	The number of crop and livestock species produced on a farm	4.126	2.557
Road distance	Distance to the nearest road (km)	1.248	2.494
Labor proportion	Proportion of healthy working-age adults (16–60 years of age) in a household	0.422	0.298
House construction	Home construction status: 0 "no house" 1 "thatched house" 2 "wood house" 3 "civil structure" 4 "brick and wood house" 5 "brick and concrete house"	3.826	1.093
Social capital	Money a household can borrow from social networks (yuan)	5676.335	23886.32
Distance to village committee	The distance to village committee (km)	13.113	10.698
Off-farm worker proportion	Proportion of non-agricultural employment in a household	0.254	0.257
Year	Year dummy variables, 2016 = 0; 2017 = 1; 2019 = 2	1	0.817

Table 3. Variable explanations and summary statistics

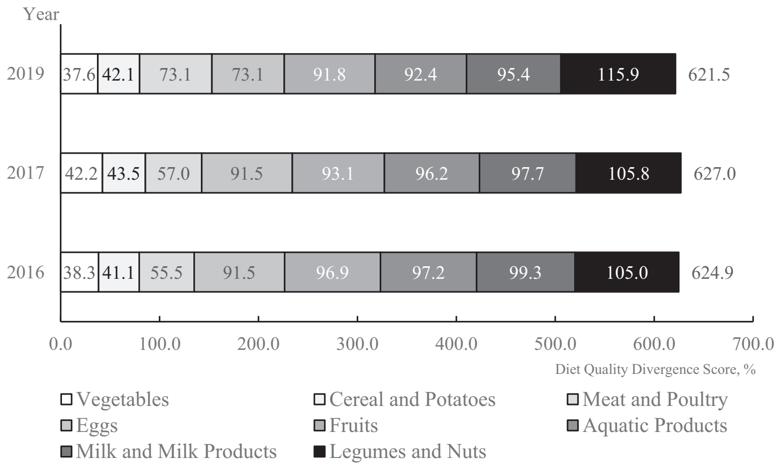

Figure 2.
Dynamics of diet quality divergence index and its structure in 2016, 2017 and 2019

diet quality get worse. From 2017 to 2019, the DQD index decreases by 5.5, implying overall diet quality improves for low-income households. In terms of the structure of the DQD, the largest part of the DQD comes from legumes and nuts. Its QDQ increases gradually from 2016 to 2019, consistent with the results found by Zhou *et al.* (2020). The second largest part of the divergence derives from milk and milk products, which is followed by aquatic products, fruits and eggs. The divergences of these food categories all shrink from 2016 to 2019, which indicates improvements in consumption of these foods. The DQD of meat and poultry increases from 2016 to 2019. The QDQ of cereal and potatoes and vegetables increases first and then decreases, which represents that the intakes of these two food categories decreases first and then improves.

4. Empirical results

4.1 The overall impacts of the PAR program on diet quality

We apply the Hausman test to differentiate between fixed effects model and random effects model. With a p-value less than 0.001, the test shows that fixed effects model is preferred. The column (1) in Table 4 displays the regression results of Eqn (10). The relocation causes a decrease of 52.6 points in total DQD at the 5% significance level, implying significant improvements in overall diet quality. This finding suggests that the PAR project greatly improves diet quality of low-income households. Results also show that the more household members eating at home, the better overall diet quality becomes. As proportion of children and elders increases, the dietary divergences increase, which means that raising more people leads to worse diet quality. House construction has positive impacts on DQD, implying that more expenditure on constructing house may crowd out food expenditure, resulting in worse diet quality. As expected, longer distance to village committee leads to a higher DQD index, confirming that access to information and transportation convenience both play an important role in improving diet quality.

We also investigate the overall impacts of relocation on the structure of DQD. As shown in column (2) to column (9) in Table 4, relocation treatment effects are different across the eight food categories. Compared to households who have not been relocated, relocated households have a significant lower DQD of cereal and potatoes, aquatic products and legumes and nuts, which suggests that relocation improves the intakes for these foods. The effects of the PAR project are insignificant for consumption of other food categories.

Table 4. Regression results of the fixed effects model for low-income households

	(1) DQD	(2) DQD of cereal and potatoes	(3) DQD of fruits	(4) DQD of vegetables	(5) DQD of eggs	(6) DQD of aquatic products	(7) DQD of meat and poultry	(8) DQD of legumes and nuts	(9) DQD of milk and milk products
Relocation	-52.585^{**} (26.066)	-21.356^{**} (9.996)	−1.542 (1.435)	−2.314 (2.814)	3.063 (8.818)	-2.354^{*} (1.333)	−9.739 (12.522)	-18.616^{*} (9.613)	0.614 (0.714)
Household size	-29.368^{***} (6.227)	-6.978^{***} (1.431)	0.966^{**} (0.416)	2.903^{***} (0.894)	-5.070^{**} (2.311)	-0.978^{**} (0.389)	-8.173^{***} (2.121)	-12.694^{***} (4.101)	0.062 (0.187)
Average age	−0.743 (1.073)	−0.375 (0.368)	0.043 (0.084)	−0.117 (0.199)	0.012 (0.342)	−0.033 (0.100)	−0.248 (0.483)	−0.023 (0.680)	−0.007 (0.044)
Asset ownership	0.574 (1.716)	0.077 (0.475)	-0.338^{**} (0.140)	0.027 (0.320)	−1.202 (0.811)	-0.365^{**} (0.143)	0.502 (0.740)	2.329^{**} (1.009)	-0.440^{***} (0.087)
Healthy people proportion	5.820 (22.618)	1.231 (6.732)	2.116 (2.357)	1.894 (5.106)	−12.474 (9.828)	−0.651 (2.254)	9.845 (11.391)	3.465 (14.876)	1.065 (1.508)
Dependency ratio	75.865^{*} (38.887)	−9.764 (12.872)	3.352 (3.117)	10.226 (7.231)	11.679 (17.095)	6.591 (4.077)	34.483^{*} (19.126)	18.666 (23.889)	1.701 (2.214)
Woman proportion	15.004 (49.145)	−16.037 (15.828)	−0.857 (4.474)	3.780 (8.704)	26.333 (17.815)	2.123 (4.002)	15.837 (28.885)	−12.613 (26.924)	−4.521 (3.338)
Education proportion	53.281 (32.619)	−0.544 (10.586)	2.789 (2.774)	−2.797 (4.587)	30.867^{**} (13.898)	0.320 (2.336)	27.832^{**} (13.743)	−3.705 (17.143)	−0.930 (1.386)
Farm size	0.353 (1.349)	0.010 (0.577)	0.002 (0.115)	−0.105 (0.144)	−0.089 (0.353)	0.075 (0.048)	−0.401 (0.676)	0.855^{*} (0.447)	0.027 (0.030)
Production diversity	−0.320 (3.401)	−0.479 (1.269)	−0.309 (0.236)	−0.469 (0.465)	−0.881 (1.126)	−0.025 (0.245)	1.988 (1.490)	−0.036 (1.723)	−0.244 (0.180)
Road distance	0.025 (1.670)	0.126 (0.497)	−0.174 (0.167)	−0.384 (0.300)	0.980 (1.056)	0.123 (0.129)	0.698 (0.581)	−1.173 (1.148)	-0.199^{*} (0.108)
Labor proportion	17.617 (32.477)	−7.216 (11.775)	−0.035 (2.828)	8.079 (5.418)	10.792 (14.128)	0.472 (2.330)	−8.836 (14.280)	14.179 (16.510)	2.085 (1.631)
Social capital	−0.000 (0.000)	0.000 (0.000)	−0.000 (0.000)	0.000 (0.000)	−0.000 (0.000)	−0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)
House construction	16.071^{**} (6.386)	1.240 (1.635)	0.123 (0.517)	3.283^{***} (1.037)	−1.886 (2.931)	0.194 (0.620)	0.304 (2.754)	13.463^{***} (3.702)	-0.829^{***} (0.231)
Distance to village committee	1.140^{*} (0.681)	−0.042 (0.136)	0.018 (0.049)	0.090 (0.080)	−0.096 (0.194)	0.007 (0.049)	0.364^{*} (0.191)	0.769 (0.566)	−0.013 (0.020)
Off-farm worker proportion	3.909 (27.371)	−4.095 (6.973)	−2.585 (2.170)	6.829^{*} (4.081)	−19.359 (13.263)	1.512 (1.958)	−1.318 (10.384)	19.481 (17.486)	0.003 (1.250)
Year = 2017	8.142 (13.991)	8.951^{*} (4.603)	-2.912^{***} (0.951)	1.573 (1.950)	5.022 (4.667)	0.766 (0.846)	5.174 (6.433)	−7.703 (7.178)	−0.626 (0.445)
Year = 2019	8.797 (35.572)	15.775 (14.981)	-3.311^{**} (1.394)	−3.815 (2.893)	-14.302^{**} (6.542)	−1.934 (1.309)	23.916 (17.769)	−5.689 (11.385)	-2.425^{***} (0.851)
Constant term	637.157^{***} (60.601)	91.575^{***} (20.358)	93.987^{***} (4.763)	20.956^{*} (11.378)	105.836^{***} (21.106)	99.563^{***} (6.015)	43.359 (28.381)	79.098^{**} (38.489)	105.602^{***} (3.084)
N	3,378	3,378	3,378	3,378	3,378	3,378	3,378	3,378	3,378
R-square	0.0198	0.0201	0.0118	0.0101	0.0113	0.0113	0.0098	0.0164	0.0209
p-value	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.007	0.000
F	2.700	3.571	5.494	2.784	3.327	3.473	2.601	2.012	4.588

Note(s): Standard errors are shown in parentheses. $^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$

4.2 Analysis of the impact mechanism of the PAR program on diet quality

This section presents an empirical test of whether the PAR program affects the diet quality through channels of market access and income. Table 5 displays the test results for mediation effects of distance to market on diet quality. As shown in column (1), distance to market significantly decreases by 6.06 km on average at the 1% significance level after relocation. Compared to households that have not been relocated, the relocated households are closer to markets and enjoy better market access. We then examine the impacts of distance to market on the total DQD and its structure based on Eqn (12). Results displayed in column (2) to (10) demonstrate that the marginal effects of distance to market on total DQD and the DQD for each food category are insignificant controlling for other variables. The direct effects of relocation on total DQD and the DQD of cereal and potatoes are significant at the 5% level and the direct relocation effects on DOD of aquatic products and legumes and nuts are significant at the 10% level. Sobel tests are conducted to investigate whether the average indirect treatment effects of market access on diet quality is significant. Tested results reveal that the mediation effect of distance to market on DQD of cereal and potatoes is significant at the 5% level, indicating that relocation leads to greater market access, which further leads the relocated households to consume less staple foods and thus improves their diet quality.

Our findings echo those of Goudet *et al.* (2011) that inappropriate environment and food conditions lead to insufficient dietary intake and poor household food security. The findings are also in agreement with the results of Hirvonen *et al.* (2017) that areas with relatively good market access contribute to improvements in dietary diversity and the conclusions in Huang and Tian (2019) that food accessibility contributes to improvements in diet quality with decreases in the consumption of staple foods.

The test results for mediation effects of income on diet quality are displayed in Table 6. Relocation has positive effects on total income at the 1% significance level. Compared to households that have not been relocated, the relocated households' total income per capita had increased by 22.7%. The marginal impacts of income on intake divergences are insignificant except for the effects on the DQD of fruits. The coefficients of total income and its squared term on the DQD of fruits are both significant at the 5% level, implying that as income increases, intake divergences of fruits rise first and then decline. The mediation effects of income are significant on the intakes of fruits. Sobel statistic tests show that mediation effects of income also exist on the DQD of vegetables, legumes and nuts, milk and milk products, although the influence directions are different. As income increases with relocation, divergences of vegetables increase first and then decrease, whereas divergences of legumes and nuts decrease initially and then increase, and divergences of milk and milk products keep decreasing. Compared to the effects of market access on diet quality which are pronounced on consumption of staple foods, the mediation effects of income on diet quality focus on non-staple foods.

These findings are consistent with the results derived by several previous studies. For example, Chege *et al.* (2015) found that development of supermarket leads to higher income for farm households and is beneficial to nutrient intakes. Income growth effects on diet quality are generally nonlinear (Tian and Yu, 2015). Higher household income leads to more balanced dietary habits (Rehm *et al.*, 2016) and increases the consumption of macronutrients like protein and consumption of micronutrients such as calcium and iron (Xie *et al.*, 2003).

4.3 Analysis of different relocation modes on diet quality

Regarding different modes of relocation, the living and production conditions of relocated household vary considerably. Households relocated to villages generally have larger farm size than those related to towns. Households relocated to towns enjoy greater market access and more off-farm employment opportunities than those relocated to villages. Table 7

Table 5. Mediation effects of market access on diet quality of low-income households

	(1) Distance to market	(2) Total DQD	(3) DQD of cereal and potatoes	(4) DQD of fruits	(5) DQD of vegetables	(6) DQD of eggs	(7) DQD of aquatic products	(8) DQD of meat and poultry	(9) DQD of legumes and nuts	(10) DQD of milk and milk products
Relocation	-6.060^{***} (0.680)	-44.560^{**} (19.979)	-15.491^{**} (6.234)	−1.525 (1.456)	−2.069 (2.883)	2.209 (8.866)	-2.239^{*} (1.357)	−6.764 (8.850)	-18.500^{*} (10.086)	0.617 (0.734)
Distance to market		1.324 (1.719)	0.968 (0.765)	0.003 (0.046)	0.040 (0.075)	−0.141 (0.198)	0.019 (0.046)	0.491 (0.881)	0.019 (0.313)	0.000 (0.016)
Year = 2017	−0.014 (0.412)	9.003 (8.552)	8.965^{*} (4.597)	-2.912^{***} (0.951)	1.574 (1.952)	5.020 (4.666)	0.766 (0.846)	5.181 (6.436)	−7.703 (7.177)	−0.626 (0.445)
Year = 2019	3.195^{***} (0.826)	−3.190 (17.449)	12.682 (12.608)	-3.320^{**} (1.406)	−3.944 (2.925)	-13.852^{**} (6.525)	−1.995 (1.302)	22.348 (15.299)	−5.750 (11.607)	-2.426^{***} (0.863)
Control variables	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Constant term	6.671^{**} (2.700)	164.088^{***} (45.911)	466.547^{***} (39.436)	85.117^{***} (23.479)	93.968^{***} (4.754)	20.686^{*} (11.383)	106.776^{***} (21.106)	99.436^{***} (5.996)	40.083 (31.651)	78.971^{**} (38.308)
Sobel test	–	0.767	1.253^{**}	0.065	0.532	0.710	0.413	0.556	0.061	0.000
N	3,378	3,378	3,378	3,378	3,378	3,378	3,378	3,378	3,378	3,378
p-value	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.010	0.000
F	24.380	2.580	3.682	5.231	2.660	3.215	3.330	2.628	1.915	4.406

Note(s): Standard errors are shown in parentheses
$^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$

Table 6. Mediation effects of income on diet quality of low-income households

	(1) Total income (log)	(2) Total DQD	(3) DQD of cereal and potatoes	(4) DQD of fruits	(5) DQD of vegetables	(6) DQD of eggs	(7) DQD of aquatic products	(8) DQD of meat and poultry	(9) DQD of legumes and nuts	(10) DQD of milk and milk products
Relocation	0.227*** (0.080)	−16.396 (28.147)	−9.411 (9.433)	−2.549 (1.943)	0.050 (3.390)	8.198 (12.125)	1.056 (1.783)	−2.360 (12.547)	−12.385 (13.125)	−0.132 (0.921)
Total income (log)		11.687 (39.777)	13.340 (16.004)	5.842** (2.700)	7.865 (5.653)	−1.419 (13.040)	−0.203 (2.462)	7.525 (18.638)	−17.831 (16.654)	−1.420 (1.162)
Total income (log)^2		−0.743 (3.111)	−1.114 (1.276)	−0.445** (0.195)	−0.559 (0.378)	0.001 (0.869)	−0.028 (0.179)	−0.383 (1.488)	1.525 (1.210)	0.074 (0.082)
Year = 2017	0.135*** (0.046)	7.172 (13.323)	9.179** (4.463)	−2.370** (0.954)	2.450 (1.991)	5.270 (4.798)	1.412* (0.853)	2.228 (6.203)	−8.641 (6.688)	−0.532 (0.419)
Year = 2019	0.182*** (0.067)	9.959 (35.256)	18.302 (14.958)	−2.433* (1.342)	−2.597 (2.969)	−12.748* (6.945)	−0.757 (1.294)	21.358 (17.701)	−7.712 (10.177)	−2.253*** (0.823)
Control variables	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Constant term	5.472*** (0.297)	676.786*** (161.806)	58.145 (62.982)	70.123*** (11.261)	−9.405 (24.592)	119.392** (54.079)	108.827*** (10.541)	43.419 (75.216)	172.219** (78.555)	109.009*** (5.475)
Sobel test 1	–	0.292	0.800	–	1.249**	0.109	0.082	0.400	1.002**	1.122**
Sobel Test 2	–	0.238	0.834	–	1.311**	0.001	0.156	0.256	1.152**	0.860
N	3,221	3,221	3,221	3,221	3,221	3,221	3,221	3,221	3,221	3,221
p-value	0.000	0.001	0.000	0.000	0.001	0.000	0.000	0.001	0.134	0.000
F	40.327	2.283	3.275	5.314	2.343	3.063	3.770	2.370	1.366	3.924

Note(s): Sobel test 1 is for total income in logarithm and Sobel test 2 is for the quadratic term of total income in logarithm. Standard errors are shown in parentheses
$^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$

Table 7. The effects of different relocation modes on diet quality for low-income households

	(1) Total DQD	(3) DQD of cereal and potatoes	(4) DQD of fruits	(5) DQD of vegetables	(6) DQD of eggs	(7) DQD of aquatic products	(8) DQD of meat and poultry	(9) DQD of legumes and nuts	(10) DQD of milk and milk products
Relocating to villages	-62.472^{**} (27.707)	-24.871^{**} (10.180)	0.591 (1.450)	1.608 (3.164)	7.905 (11.092)	−0.759 (1.599)	-27.429^{**} (12.500)	−17.392 (11.227)	−0.326 (0.897)
Relocating to towns	−39.444 (28.157)	−16.684 (10.486)	-4.378^{**} (1.964)	-7.526^{**} (3.208)	−3.373 (7.836)	-4.474^{**} (1.740)	13.774 (14.111)	-20.242^{*} (11.548)	1.864^{**} (0.855)
Year = 2017	8.814 (14.019)	9.190^{**} (4.600)	-3.057^{***} (0.947)	1.307 (1.949)	4.693 (4.663)	0.658 (0.835)	6.375 (6.491)	−7.786 (7.243)	−0.563 (0.448)
Year = 2019	8.664 (35.575)	15.727 (14.984)	-3.282^{**} (1.393)	−3.762 (2.895)	-14.236^{**} (6.525)	−1.913 (1.311)	23.677 (17.769)	−5.672 (11.374)	-2.438^{***} (0.852)
Control variables	Y	Y	Y	Y	Y	Y	Y	Y	Y
Constant term	630.763^{***} (61.302)	89.302^{***} (20.340)	95.366^{***} (4.802)	23.492^{**} (11.432)	108.968^{***} (21.344)	100.594^{***} (6.102)	31.918 (28.599)	79.890^{**} (38.750)	104.994^{***} (3.095)
N	3,221	3,221	3,221	3,221	3,221	3,221	3,221	3,221	3,221
p-value	0.001	0.000	0.000	0.001	0.000	0.000	0.001	0.134	0.000
F	2.283	3.275	5.314	2.343	3.063	3.770	2.370	1.366	3.924

Note(s): Standard errors are shown in parentheses. $^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$

displays the heterogeneous effects of different relocation modes on diet quality. As shown in column (1), households relocated to villages show significant reductions in total DQD by 62.5 points after relocation, indicating improvements in overall diet quality. However, changes in the total DQD for households relocated to towns are insignificant. In terms of the QDQ structure, relocating to villages significantly reduces the divergences of cereal and potatoes as well as meat and poultry. Relocating to towns significantly reduces the divergences of fruits, vegetables, aquatic, and legumes and nuts, which are non-staple food categories that the low-income households under-consumed before relocation. Relocating to towns increases the divergences of milk and milk products slightly by 1.86. This may due to the fact that some households quitted raising livestock after resettled in towns and thus the consumption of self-provided milk decreases. Another possible explanation is that consumption of milk and milk products is crowd out by consumption of other non-staple food categories which increase remarkably, such as legumes and nuts.

The above results indicate that the effects of relocation modes on diet quality for low-income households are heterogeneous. These findings have not been investigated before. The most related results are that spatial constraints do not significantly affect individuals' abilities to access the market (Kato and McKinney, 2015), less remote households are characterized by healthier diets (Stifel and Minten, 2017) and there are possible influences of farm production on diet diversity (Jones *et al.*, 2014).

4.4 Robustness test

Although the low-income households cannot choose whether, when and where to move, in the actual process of policy implementation, the relocated households can decide the specific time to move into the new house within two months after the house being built. There is a certain decision-making space for the check-in time. In order to eliminate the potential selection bias, we apply the propensity score matching and difference in difference (PSM-DID) using the survey data of 2016 and 2019 for robustness tests. The PSM method has been used in numerous studies such as Verwimp and Muñoz-Mora (2018) and Ma and Abdulai (2019). We calculate the propensity matching score based on characteristics of low-income households at baseline and use the kernel matching method to pair each relocated household with the control group. After matching, we compare the differences in dietary quality between the treated and control groups before and after relocation, and then conduct significant tests for the observed differences.

The results of the balance tests are shown in Table 8. Before matching, significant differences exist between the relocated households and those having not been relocated. After matching, the two groups are similar in observed household characteristics as shown in Figure 3. We apply the DID model to examine the influence of the PAR project on diet quality utilizing the matched data. As shown in Table 9, the total DQD significantly decreases due to relocation, which are consistent with our findings using the fixed effects model. The improvement in overall diet quality for households that move to villages is greater than that of households relocated to towns, partially consistent with the results obtained using the fixed effects model, where relocating to villages has significant impacts on total and relocating to towns has insignificant impacts on total DQD. In general, our main findings are relatively robust using different evaluation methods.

5. Conclusion and discussion

This paper explores the effects of the poverty alleviation relocation program on dietary quality of impoverished households. The random nature of allocation treatment allows for a unique empirical analysis free of selection bias issues. We explore the impact mechanism of

	Control	Treated	Diff	T	$Pr(T > t)$
Distance to market	11.716	12.046	−0.330	−0.790	0.428
Total income	2797.300	2488.400	308.900	1.760	0.079*
Household size	2.901	2.952	−0.051	−0.790	0.430
Average age	42.432	43.292	−0.860	−1.500	0.134
Asset ownership	7.353	7.352	0.001	0.010	0.996
Healthy people proportion	0.553	0.510	0.043	3.010	0.003***
Dependency ratio	0.411	0.442	−0.031	−2.310	0.021**
Woman proportion	0.450	0.458	−0.008	−1.050	0.296
Education proportion	0.201	0.176	0.025	2.390	0.017**
Farm size	4.037	3.851	0.186	0.940	0.348
Production diversity	4.382	4.225	0.157	1.460	0.143
Road distance	2.055	2.286	−0.231	−1.760	0.079*
Labor proportion	0.379	0.326	0.054	4.270	0.000***
Social capital	6016.400	5456.200	560.200	1.200	0.232
House construction	1.514	1.579	−0.065	−1.130	0.257
Distance to village committee	15.230	16.741	−1.511	−3.230	0.001***
Off-farm worker proportion	0.200	0.188	0.013	1.180	0.237

Note(s): $^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$

Table 8. Baseline balance test of households that have been relocated and households that have not been relocated

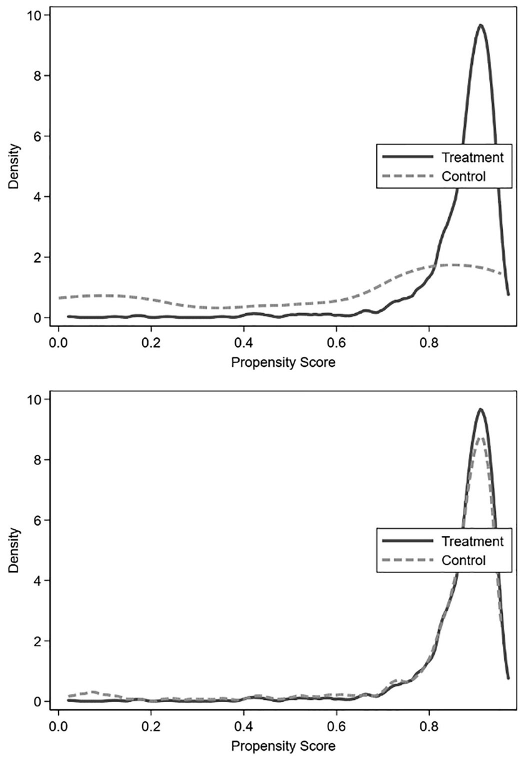

Figure 3. The nuclear density map before (left) and after (right) matching

Table 9.
Impacts of different relocation modes on DQD using the PSM-DID method

		Control	Treated	Diff (T-C)	Standard deviation	*t* value
DQD	*N*	166	919			
(Total	Before	575.624	625.352	49.728***	16.112	3.09
sample)	After	670.491	602.262	−68.229***		4.23
	DID			*−117.957****	22.786	5.18
DQD	*N*	171	587			
(Relocated	Before	575.004	614.873	39.869**	19.716	2.02
to villages)	After	679.307	594.921	−84.387***		4.28
	DID			*−124.255****	27.883	4.46
DQD	*N*	141	319			
(Relocated	Before	567.426	646.087	78.661***	21.206	3.71
to towns)	After	659.508	615.614	−43.894**		2.07
	DID			*−122.555****	29.990	4.09

Note(s): $^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$

relocation on diet quality by testing the mediation effects of market access and income. The impacts of different relocation modes, namely relocation to villages and relocation to towns on diet quality are compared. We construct fixed effects model to conduct the empirical analysis utilizing panel data of 1126 households consecutively tracked in 2016, 2017 and 2019. A diet quality divergence index is calculated based on the divergences between real food intakes for sampled households and recommendations from the Chinese food guideline. We apply the PSM-DID method to conduct robustness tests.

We find that the relocation project significantly reduces dietary divergences and improves overall dietary quality for low-income households with other factors controlled. The conclusion that relocation improves diet quality through the channels of market access and income are strongly supported by our data. Relocation brings greater market access and higher income, which further affect intake divergences of various food categories, exhibiting significant mediation effects. Improved market access reduces the over-consumption of staple foods, whereas higher income mainly reduces the intake divergences of non-staple foods, such as fruits, vegetables, legumes and nuts, milk and milk products. The impacts of relocation modes on diet quality of households are heterogeneous. Relocating to villages is helpful in reducing the divergences of staple foods and meat and poultry. Relocating to towns mainly improves the diet quality of non-staple foods, which are generally under-consumed by the low-income households.

These results indicate that the PAR program has positive effects on diet quality for low-income households. Relocation reduces divergences of food intakes and benefit the diet quality. It indicates that the PAR program is efficient and effective on dietary development interventions for those living in suboptimal environments. For low-income residents in poverty-stricken areas with less diverse food resources, poor diet quality is not only attributable to economic constraints but also to living condition and environment. Through greater access to fresh food, low-income families reduce the over-consumption of staple foods. As more off-farm employment opportunities and industrial development in the resettlement sites leading to higher income, households covered by the PAR program are able to reduce the divergences of non-staple foods. The significant effects of relocation on diet quality could lead other countries to consider similar policies and support new means of improving the nutrition and health of low-income populations.

Other issues remain worthy of discussion. First, how does the change of farm diversity after relocation affect diet quality? Whether this leads to the deterioration of living conditions over time must be explored. Second, whether the improvements in diet quality are persistent over the long term needs to be investigated. A key policy issue therefore concerns the extent to which nutrient intake can be improved and whether poverty alleviation relocation can or cannot end the cycle of poverty through nutrition.

Note

1. Data source: National relocation plan for poverty alleviation in the 13th five-years. http://www.cpad.gov.cn/art/2017/4/28/art_50_62482.html.

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