Impact of Rising Food Prices on Food Consumption and Nutrition of China's Rural Poor

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***Abstract**: Using unique rural household panel data in 2005–2010, this study estimates nutrient elasticity for rural households by income group and evaluates the impacts of rising food prices on food consumption and nutrition of the rural poor. The results show that the shocks of income and rising food prices have adverse impacts on the nutrition of rural households, especially for low-income groups, purely poor farming groups, and minorities who are not capable of self-adjustment and are more vulnerable to rising food prices. Interestingly, we found that the rural poor could consciously adjust food consumption structure to adapt to rising food prices. In this regard, future research would help to provide effective policy implications for preventing shocks to the rural poor.*

***Keywords**: Rural household; Rural poverty; Food consumption; Nutrition*

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1 Introduction

Domestic food prices soared to a high in April 2008 and again in September 2011, which caused widespread concern for the food security and nutrition of the rural poor in China. Research on the food consumption of China's rural poor shows that farmers' income is the most important factor affecting grain and food consumption in poor rural areas, especially in areas of food shortage (Zhu and Zhong, 2005). It is speculated that the food consumption of poor rural households with higher proportions of food expenditure to total expenditure might be affected more by rising food prices, given that the gap between agricultural income and food expenditure is widening for even the lowest income group of rural households (**Fig. 1**). However, from the perspective of nutrition, is the impact of rising food prices on the food consumption of the poor equal to the impact on nutrition? Can the poor mitigate the impact of rising food prices on food nutrition by substituting their past food consumption items? Do different rural households suffer the same shocks from rising food prices? Few studies have focused on food and nutrition issues of China's rural poor in the context of rising food prices. This study attempts to fill the gap by analyzing the food consumption and nutrient intake of rural households in China using a nutrition elasticity tool and unique rural household panel data against the background of rising food prices.

The rest of the paper is organized as follows. Section 2 reviews the related literature. Section 3 presents econometric models, corresponding variables, and the dataset. Empirical results are presented and discussed in Section 4. Section 5 concludes.

2 Literature review

Income affects residents' nutrition in two ways: food intake quantity and nutritional content of food. Many empirical studies have verified that a positive correlation exists between income and nutritional intake (Ward and Sanders, 1980; Bunch and Hall, 1983; Bhargava, 1991), that is, income has a positive impact on nutritional intake. However, the extent of such influence is still a controversial issue among scholars. The effect of income on the nutritional content of food means that some groups might improve their nutritional content after their income increases (e.g., by purchasing better quality food), which leads to an increase of unit nutritional costs while keeping nutritional intake quantity significantly unchanged. In order to undertake quantitative analysis, tools of nutrition elasticity, such as the impacts of income, prices, and other factors on nutritional intake, are applied widely by researchers around the world.

Based on a synthesis of research on nutrition elasticity in the past 30 years, there is considerable variability in the estimators of nutrition elasticity, ranging between zero and one. In the early 1980s, the nutrition elasticity of income estimated by scholars was 0.7–0.9 (Murty and Radhakrishna, 1981; Strauss, 1982; Pitt, 1983). Ward and Sanders (1980) estimated nutrition elasticity of 0.33–0.74 using survey data in northeast Brazil, which proved elastic income of nutritional intake. In view of such research results, Wolfe and Behrman (1983) analyzed the data of 1,167 households in Nicaragua and found that the nutrition elasticity of income was only 0.1. Based on this research, Behrman and Wolfe (1984) extended samples to the whole country and included more samples of much poorer households. They considered previous nutrition elasticity data to be overrated. Furthermore, later research is in line with this conclusion (Alderman, 1986; Behrman and Deolalikar, 1988, 1989; Bouis and Haddad, 1992).

Chinese researchers (Zhang and Cai, 2002) have estimated rural residents' nutrition elasticity using the data of poor rural households in China. They found that although food demand was elastic with a value of about 0.74, nutrition demand was relatively inelastic with a value of about 0.14. Zhang and Cai (2002) believed that the reason for this difference was possibly the use of different estimation methods, namely, a direct and an indirect estimating method. Direct estimation is used to calculate nutrition demand elasticity directly using an equation of nutrition and demand. Indirect estimation is used to obtain the nutrition demand elasticity indirectly by estimating a food demand equation. In other words, the demand elasticity of different kinds of food should be calculated first, and then, food demand elasticity can be transformed into nutrition demand elasticity with reference to a table of standard food composition. In addition, the indirect estimating method assumes there is no substitution between food varieties. As a result, the estimate of nutrition elasticity tends to be higher, leading to a larger error. Generally speaking, the indirect estimation method is adopted when the data of food consumption are for the whole family, namely, there is uncertain allocation of food between family members.

Since the data of this study are at the household level, the indirect estimation method is used to estimate the nutrition elasticity. In addition, this study uses two ways to improve the accuracy of the estimation results. On one hand, in order to reduce errors from indirect estimation, family members are reshaped into "reference individuals" [1] according to age, gender, and other factors. After calculating per capita food consumption in each family, the demand elasticity for food can be estimated more accurately. On the other hand, this study uses unique large samples, which covers areas of east, west, south, north, and central China. Thus, our method has the advantage of sound representative features. Moreover, the panel data covering 2005–2010, can eliminate the influence of unobservable effects, which makes estimate of nutrition elasticity more accurate.

3 Model, Variables, and Data

3.1 Model specification

According to the classic consumption theory model, demand for goods tends to be considered as a function of income and prices, that is, under the constraint of income and prices, the best solution is to obtain a maximum benefit by selecting an optimal commodity combination. In practice, the food consumption of rural residents is not only affected by income and prices, but is also influenced by other factors, such as family and regional features and consumption habits. Based on the theory of consumption and demand, and by carefully considering the sampling features and economic levels of residents, this study follows Sahn's (1988) model of food demand and establishes the following econometric model to estimate the influence of residents' income, prices, and other factors on food demand for 10 main food categories, namely grain, vegetables,

[1] This originates from the concept *Reference Persons* that has been studied more carefully with respect to anthropometric measurements, physical capacity, food consumption, and energy expenditure, that is, healthy young men and women living in temperate zones under satisfactory nutritional conditions (FAO, 1950).

beans and their products (hereafter, beans), edible oils and fats (hereafter, oils and fats), sugar, fruit, meat, fish, eggs, and dairy).

$$\begin{aligned} LnQ_{iht} = {} & \alpha + \beta_1 LnEXP_{ht} + \beta_2 (LnEXP_{ht})^2 + \gamma_i LnP_{iht} + \sum_j \gamma_j LnP_{jht} \\ & + \lambda_i LnP_{iht} LnEXP_{ht} + \sum_j \lambda_j LnP_{jht} LnEXP_{ht} + \sum_n \phi_n Z_{nht} \\ & + \sum_m \theta_m Z_{mht} LnEXP_{ht} + \mu_{it} \end{aligned} \tag{1}$$

Here, for the h^{th} farmer (h=1, 2, 3, …… , n):

LnQ_{iht} refers to food *i* consumed by the h^{th} farmer in period *t*, in logarithm form;

$LnEXP_{ht}$ refers to food expenditure paid by the h^{th} farmer in period *t*, in logarithm form;

LnP_i and LnP_j refer to the food price of food *i* and *j*, respectively, ($i \neq j$) in logarithm form;

Z_n are regional and family control variables;

Z_m is a subset of Z_n;

and α, β_1, β_2, γ_i, γ_j, λ_i, λ_j, ϕ_n, θ_m are parameters to be estimated.

In order to reduce the estimation error and facilitate the elasticity calculation of food demand, logarithmic forms of consumption quantity, income, and food price are used in the model. It should be noted that in addition to income, price, and all other control variables, income square, the cross term of income and price, and the cross terms of income and other control variables are added in the model. Income square is added to capture the inverse relationship between income and food expenditure, which has been proved previously in other research (Lyu et al., 2012). For the cross items, it can be understood easily that for general food, increasing income or decreasing food prices would lead to an increase of food consumption. However, does this hold in the situation of simultaneous increases of income and prices? It is difficult to determine the final direction of their influence on food consumption. An empirical analysis is needed to identify the final effects and cross terms that are added in the model.

The model could be used to simulate the food consumption behavior of China's rural residents. In this study, the model is adopted to calculate the effects of income, price, and the cross terms for different income groups and category farmers under the context of rising food prices. Then, a direct estimation on food consumption equations can be implemented without the need to set constraints for parameters.

3.2 Variable descriptions

The focus of this study is to analyze how agricultural prices are influenced by the three main intake nutrients of the rural poor, that is, energy (mainly, carbohydrates), proteins, and fats (hereafter, nutrients). Therefore, per capita daily intake nutrients are taken as the dependent variables in model. It is well known that when the factors affecting nutritional intake change, it is impossible that the three major nutrient groups remain unchanged, even if other nutrients are influenced. Therefore, it is reasonable to select the three main nutrient groups as the measure the dietary nutrition.

Furthermore, independent variables, in addition to the variables of income and food prices, mainly consider farmer type (living purely off farming or not living purely off farming), family size, number of children, education, minority dummy, regional dummy, and other factors. Combined with previous research results, **Table 1** summarizes the expected influential directions of each factor on food consumption.

3.3 Data source

This research uses panel data of farmers in 2005–2010, which covers five provinces, that is, Gansu, Heilongjiang, Hubei, Jiangsu, and Sichuan. Each sampling province includes five to seven villages. After data cleaning, we obtained a final number of 1,032 valid rural household samples. The survey includes the following two information parts. The first provides the farmer's family and member features, such as members' gender, age, occupation, non-farm income, length of time living at home, health condition, education, migrant work, family revenue, operating income, agricultural income, life consumption expenditure, food consumption expenditure, management of cultivated land area, and situation of agricultural product sales. The second part provides information on farmers' main food consumed, recording each household's consumption quantity and variety, including grain, vegetables, fruit, beans, oils and fats, pork, beef, mutton, eggs, and fish.

As for the food consumption price, this study chooses an agricultural product selling price as an alternative since relatively reliable data on food consumer prices at the rural household level are not available. Specifically, the selling price could be obtained by dividing agricultural product selling income by the corresponding selling quantity. Considering the high correlation between the selling price of agricultural products and food prices in the market, the selling price could reflect a large part of the price for consumers of purchasing food in the market. However, it could also bring about a new problem. Because most families sell only one or a few agricultural products in the market, the selling price obtained by the abovementioned method may generate a large number of missing values, which leads to a large deviation in the estimation models.

In order to solve the problem of missing values, this study adopts the following two methods to improve the results. The first is to substitute the missing value with the median price of the village or province because the selling prices of agricultural products have strong regional features, namely, the selling prices in a single region are very close in the same period. The second method is to monitor the selling prices of provincial agricultural products, which could provide completely the missing values of the selling prices even after processing by the first method.

3.4 Different food consumption of residents

There is a big difference in the structure of food consumption, which is linked to food variety, among rural residents (**Table 2**). For example, there is a small difference in the food consumption of grain but a big difference in that of relatively luxurious products, such as fish and fruit. First, the distribution of grain, which provides the most energy for rural residents, is a flat reverse "U-shape," which means that (a) there is a small difference of grain consumption among rural residents and (b) as income increases, to improve nutritional intake, farmers substitute grain with more expensive food. Second, the consumption of oils and fats increases with income growth. Universally, the fat intake of rural Chinese residents is high; even rural residents in the lowest income bracket have reached the average level of local dietary recommendations. Third, there is a bigger difference between low-income residents and high-income residents in the consumption of vegetables, meat, fish, and eggs. Only a small proportion of high-income residents have reached the recommended dietary standard, but low-income residents have a serious shortage in the intake of this food category. Fourth, the correlation of milk consumption and income is not obvious. Average per capita milk consumption of the third income level of residents is 5.8 kg annually, while the per capita dairy consumption of highest-income residents is 4.87 kg annually although, generally speaking, rural residents in China have a low intake of milk. According to this analysis, income is indeed one of the important factors that affect the food consumption of China's rural poor. In the case of rising food prices, poor rural residents could select cheaper food to substitute for expensive food. However, if there is a narrow range of substitution for such food as meat, eggs, and milk, they would receive bigger shocks due to insufficient food intake.

3.5 Income distribution and structure of nutritional content

Is there an inevitable link between income differences and nutritional intake channels of rural residents in China? We attempt to find an answer in the statistical data of income distribution and energy sources (**Table 3**). First, grains, which provide 57.15–71.09% of energy, are still the main energy source of rural residents; second, the lower income is, the higher are the energy provided by food. This is consistent with the expected result, because when income is low, to meet energy requirements, residents subjected to income constraints are required to obtain the cheapest energy. With increasingly higher income, residents can begin to eat more and better food to meet the requirements for energy and other nutrients. For example, although vegetable consumption expenditure accounted for a large proportion of family consumption expenditure, the proportion of energy provided by vegetables is not high. This means that the cost of eating vegetables as the main energy source of is still relatively high, so that low-income groups obtained extremely low energy, only 1.74%, from vegetable consumption. Third, oils and fats are the second highest energy source of rural residents in China in the range of 13.47–16.37%; the higher the income, the bigger the share of this food group. Overall, differences in the proportion of expenditure between each income level are small. Fourth, meat (including pork, beef, mutton, poultry, and their products) is the third largest energy source of rural residents in China; it provides 6.02–9.36% of total energy, and the proportion increases as income increases. Meat is a source of high quality protein, and the higher income is, the more residents choose this high quality food to substitute energy intake. Fifth, for most rural residents, the energy provided by fruit, eggs, fish, and milk are less than 1%. As the analysis results show, there is a direct relationship between residents' income and their selection of nutritional content.

3.6 Changes in main food prices during 2005–2010

Sample data show that the volatility trends of most of the main food prices during 2005–2010 are increasing significantly (**Table 4**). Except sugar and fruit, the overall trend of price changes of other food is highly consistent with the statistical data released by the National Statistical Bureau, which may be caused by differences between statistical varieties or speculation time. During 2005–2006, the prices of sugar and oils and fats increased, but the prices of other foods were generally declining. It is noteworthy that during 2005–2010, the prices of grain were the most stable of all food prices, showing a rising trend with an average growth of 7% per year, while the largest price fluctuations and rises were for oils and fats, meat, and fish. Oil and fat prices increased sharply in 2008, after the growth rate reached a high of 61.5%, falling sharply in 2009 by 40%, and rising again in 2010. Meat prices doubled a few times in this timeframe, increasing by 44.39% in 2007 and again by 107.26% in 2010. Fish prices fluctuated, surging to an average 4.99 yuan per kg in 2007, dropping to 3.06 yuan per kg in 2008, and surging to 4.30 yuan per kg in 2011. From the viewpoint of annual data, egg prices were relatively stable, after falling 20% in 2007, returning to 2006 prices in 2008, and, after falling slightly, rising again in 2009. The supply of and demand for eggs of is relatively elastic; prices change are often due to seasonal differences. Milk prices have risen since 2005, which is related directly to increased demand for milk arising from income increases of Chinese residents.

Through our analysis, we find serious nutritional shortcomings of low-income groups in the consumption of vegetables, beans, fruit, fish, meat, milk, and eggs. However, there were large rises and high volatility in the prices of these foods, and we fear that such price fluctuations led low-income groups to reduce sharply their food intake, which would have affected their nutrition significantly. However, whether we can obtain this conclusion needs further analysis through the use of the nutrition elasticity tool.

4 Empirical result and discussion

4.1 Model test

The fixed effects model and random effects model should be determined by whether individual effects are random for panel data. This study separately determined which model should be used for food demand equations (1)–(10) using the Hausman Test. The test results are shown in **Table 5**.

The results showed that the random effects model is suitable for equations (2), (6), and (7), and the fixed effects mode is suitable for the other equations. Moreover, heteroscedasticity of stochastic disturbance terms in the equations should be tested in the case of inefficient estimators. Heteroscedasticity tests are implemented for equations (1)–(10), and the results strongly reject the null hypothesis for no heteroscedasticity.

4.2 Estimation results of food demand elasticity

4.2.1 Income elasticity of food demand

According to the estimation results of income elasticity of food demand (**Table 6**), the sign directions of income elasticity are generally in accordance with expectations. Income elasticity of all foods is positive, except for grain and beans, which means that consumption of these foods will rise with an increase of income, that is, these foods are normal goods. The negative income elasticity of grain, which remains consistent with our practical expectations, shows that grain is no longer a normal good but an inferior good when income increases above a certain threshold. This can be confirmed by official annual statistics: per capita grain consumption of each income group in rural China shows a downward trend after the first increase because almost all rural residents in China have achieved adequate subsistence. As incomes increase, people pay more attention to dietary structural adjustment, that is, reducing grain consumption while increasing intake of other nutritious foods, such as meat, eggs, and milk.

Surprisingly, the income elasticity of beans is negative, which is not in line with expectations. A possible reason is the missing consumption record on bean products. The survey shows that nowadays, bean consumption in rural China relies increasingly on bean products, such as bean curd and its derivatives, rather than on direct consumption of beans, which might lead to underestimation of total consumption and negative income elasticity of beans. A comparison of income elasticity of different foods shows that the income elasticities of grains, oils and fats, and vegetables are lower than those of fruits, meat, eggs, and milk. In fact, such foods as grains, oils and fats, and vegetables are necessary for the subsistence of rural residents suffering from the impacts of the lowest income.

Compared with the non-poor in rural areas, most of the food consumption of the rural poor is more sensitive to income changes. For consumption of such products as vegetables, oils and fats, sugar, meat, fish, and eggs, the income elasticity of the rural poor is larger than that of mid- and high-income residents, and is lower only than the income elasticity of the non-poor for the consumptions of grain and milk. This result confirms that the rural poor in China are more prone to be affected by income shock. The abovementioned statistical analysis shows that total food intake of the poor is lower than that of the non-poor, and is even much more deficient in fish, which means that income policy might be an effective policy to improve the food consumption of the rural poor against the background of a larger income impact on their food consumption.

A comparison of income elasticity of food consumption between purely farming and non-purely farming rural households shows that in the same income level, sensitivity to income of different foods differs. For vegetables, beans, oils and fats, sugar, and other foods, the income elasticity of the purely farming group is larger than that of the non-purely farming group. However, the income elasticity of the non-purely farming group in the consumption of fruit, meat, fish, milk, and so on, is significantly higher than that of the purely farming group, which means that the non-purely farmers in the low-income group are more sensitive to the consumption of these foods.

4.2.2 Price elasticity of food consumption

Price elasticity is calculated from the estimator results, including own-price elasticity and cross-price elasticity. **Table 7** presents the price elasticity of each income group. The signs of all foods' own-price elasticity are negative, which means that a rise in the food price reduces food demand. Absolute values of own-price elasticity show that the price elasticity of grain, vegetables, oils and fats, meat, and eggs, is smaller, that is, it is relatively inelastic. On the other hand, the own-price elasticity of beans, fruit, fish, and milk is larger, that is, it is relatively elastic. These results indicate that for residents in rural China, the former food groups are consumed as necessities for subsistence, and they are less affected by price, whereas the latter food groups are relatively luxurious foods, and are influenced significantly by price.

Comparisons of own-price elasticity among each income group show that in the consumption of subsistence food, the price elasticity of the rural poor is higher than that of the non-poor. Although none of the elasticity values of these foods is large, it is observed that the poor are significantly more sensitive to the price changes of these foods than the non-poor are. In addition, there is no significant difference in the price elasticities of fish and milk between the poor and the non-poor.

Cross-price elasticity proves there are some substitutive and complementary relationships between different foods. First, the cross-price elasticities of grain for other foods are all negative, that is, a rise in the grain price will reduce the consumption of other foods. Second, the cross-price elasticities of meat for fish, eggs, and milk are all positive, which indicates that there are substitutive relationships between meat and these foods. In fact, these foods are the main source of animal protein. Once the prices of meat rise, meat consumption is reduced accordingly, and animal protein intake from other foods rises simultaneously. Therefore, it could be inferred that the impact of meat prices on protein intake is comparatively small. This is similar to other cases.

4.3 Estimation of the elasticity of nutrition

To obtain the elasticity of nutrition, this study adopts an indirect estimation method, that is, the value of nutrition elasticity is generated from the estimator results of food demand equations. According to the results, we can predict the change of consumption propensity when income or price changes. To understand the impact of these changes further on the nutrition of rural residents, especially the poor in China, we estimate the nutrition elasticity of demand for residents of different income groups based on the estimators of demand elasticity.

Owing to the additivity of each food, nutrition elasticity can be derived from the weighted sum of each food demand equation, which is written as follows:

$$E_I = \left(\frac{\sum_i n_i q_i M_i}{\sum_i n_i q_i}\right)$$

$$E_{ni} = E_{ii}\alpha_i + E_{ij}\alpha_j$$

where, $i = 1, 2, 3 \ldots\ldots 10$ and $i \neq j$;

E_I refers to the expenditure (or income) elasticity of nutrients, which include energy, proteins, and fats;

M_i refers to the expenditure (or income) elasticity of each food *i*;

n_i is the amount of nutrient *n* in per unit food *i*;

q_i refers to the quantity of food *i* consumed;

E_{ni} is the price elasticity of nutrient *n* for food *i*;

α_i refers to the expenditure share of food *i* in total living expenses;

E_{ii} is the own-price elasticity of food *i*;

E_{ij} refers to the cross-price elasticity of food *i* for food *j*.

4.3.1 Estimation results of income elasticity of nutrition

Table 8 provides the estimators of income elasticity of nutrition. To compare and analyze the income elasticity of nutrition of different income groups and farmer types, this study calculates the income elasticity of nutrition for the low-, mid-, and high-income groups, and makes a distinction between purely and non-purely farming rural households for each income group.

The main results are as follows. First, most signs of income elasticity of nutrition are positive, which indicates that there is positive relationship between income and nutrition. Rising income could be helpful to improve the nutrition intake of rural citizens.

Second, comparisons of income elasticity of nutrition of different income groups indicate that the income elasticity of nutrition of the rural poor is higher than that of the rural non-poor in China. Such a distinction is much more significant for energy and protein. The income elasticity of energy of the rural poor is 0.038, which is four times as high as that of the high-income group. In addition, the income elasticity of protein of the rural poor is 0.053, compared with 0.003 for the high-income group. Although the income elasticity of fats is higher than that of the other two nutrient groups, the distinctions between each income group are relatively smaller. These results imply that in the same circumstances, policies targeting raised income could help to improve the nutrition level of the poor effectively, although similar policies would not work for the non-poor.

Third, comparisons show that income elasticity of nutrition for the purely farming groups is higher than that for the non-purely farming groups. The nutritional position of the poor purely farming groups is more vulnerable to income shocks. This implies that under the same conditions, the adjustment abilities of the non-purely farming groups' food structures are more flexible; therefore, the impact of income changes on their nutrition is relatively smaller.

Fourth, the absolute values of income elasticity of nutrition are lower than those of the income elasticity of food demand. The income elasticities of nutrition range from

0.001 to 0.212, while the income elasticities of food demand are from 0.2 to 1.8. Such results signify that rural residents suffer less in food nutrition from income shocks that may sharply reduce the quantity of their food consumption because they could adjust their food structure to reduce such negative impacts.

4.3.2 Estimation results of price elasticity of nutrition

The estimation of the price elasticities of the three nutrient groups in rural China are presented in **Table 9**, which describes the impacts of rising food price on these nutrient groups.

First, generally speaking, the price elasticity of nutrition is lower than the price elasticity of food, which means that the impact of changes in food prices on nutrition is lower than that on food demand. The absolute values of the price elasticity of energy range from 0.001 to 0.48, while the absolute values of the price elasticity of proteins range between 0.001 and 0.397. This indicates that rural residents could adjust the structure of their food consumption to reduce the impact of rising food prices on their nutrition levels. Obviously, the nutrition of the rural population in China is relatively inelastic.

Second, there are significant differences in the price elasticities of the three nutrient groups. The results show that under the same conditions, the absolute values of the price elasticity of proteins and fats are larger than those of energy food. This indicates that against the background of rising agricultural product prices, rural residents' demand for protein and energy is more sensitive to changes in food prices than demand for energy in China. The reason is that after satisfying the basic demand for energy, rural residents' price elasticities for consumption of meat, fish, eggs, and milk increases. Meat, fish, eggs, and milk all contain higher proteins and fats. The results show that the intake changes of proteins and fats induced by their rising prices are relatively larger. Contrary to expectations, the intakes of proteins and fats in each income group increase with a rising milk price. The main reason lies in greater flexibility of milk consumption. Therefore, once the price increases, residents choose a more efficient substitute to reduce the consumption of milk substantially and to consume more meats and eggs as alternatives.

Beans and grain are the main sources of plant protein for rural residents. The results indicate that the price elasticity of protein for these two food groups is relatively inelastic. In addition, although oils and fats are the main sources of the nutrient group fats, the impact of rising prices of oils and fats on the fat intake of rural residents is very small. The main reason is that the residents' elasticities of demand for oils and fats are smaller.

Third, the relationship between grain prices and the food nutrition of rural residents in each income group is negative. Judging by energy intake, grain prices exert the greatest impact on low-income rural residents in China. With an increase of 1% of the grain price, the energy intake reduces by 0.11% for the low-income group, but by 0.03% for mid- and high-income residents. For proteins, a rising grain price exerts a smaller impact on the intake of protein for rural residents in China. The price elasticity of protein is less than 0.1. A rising grain price exerts more impact on the intake of fats than it does on the other two nutrient groups for rural residents in China. Meanwhile, the impact of rising grain prices on the intake of fats for low-income residents is lower than that for mid- and high-income residents. It can be seen from the abovementioned results that stable grain prices have played an important role in ensuring the food and nutritional security of residents in rural China.

Fourth, rising prices of some foods have hardly affected the nutrition of each income group. The prices of vegetables, beans, oils and fats, sugar, and fruit have had little impact on the nutrition of each income group. From the perspective of elasticity, the absolute values of the price elasticities of energy food, proteins, and fats for these foods are all less than 0.1. The reasons are two-fold. (1) There is lower price elasticity of demand for these foods, such as vegetables, oils, and fats. (2) Consumption of and nutrients contained in these foods are smaller. For example, although the price elasticity of fruit demand is relatively larger, fruit is consumed less and contains few nutrients, which leads to a smaller nutritional change induced by a rising price.

Fifth, against expectations, the price elasticity of nutrition for meat is positive, that is, nutrition would improve with a rise in meat prices. As shown above, rising meat prices would reduce meat consumption of rural residents. Such results indicate that if meat prices rise, rural residents would choose other foods that are more cost-effective to substitute for meat. For example, they would consume more grain for more energy or more eggs for more protein.

Sixth, against the background of rising prices of agricultural products, the nutrition of the rural poor is affected significantly by rising prices of fish and eggs. For rural poor residents, such price rises would lead to an intake reduction of energy, protein, and fats. For example, the price elasticity of energy for fish is −0.501, that is, the intake of energy would be reduced by 0.5% with a 1% increase of aquatic product prices. The price elasticity of energy for eggs is −0.244, that is, the intake of energy would be reduced by 0.244% with a 1% increase of egg prices. The price elasticities of proteins for fish and eggs are −0.308 and −0.481, respectively, that is, the rural poor would reduce their intake of proteins by 0.308% and 0.481% with a 1% rise of egg or fish prices, respectively. Moreover, the fat intake of rural residents is sensitive to the changing prices of fish and eggs, and the price elasticities are −0.161 and −0.228, respectively.

5 Conclusion

The study calculated the income and price elasticities of nutrient groups, based on the estimators of rural residents’ food demand models for each income group. The results prove that shocks of income and rising food prices have adverse impacts on the nutrient intake of rural households, especially poor low-income groups, the purely farming groups, and minorities who possess lower capacity to self-adjust and are more vulnerable to rising food prices.

The nutrition of poor rural households in China is relatively inelastic. When food prices rise in general, poor rural residents are able to adjust their food consumption structure consciously. Through turning to food alternatives, they can reduce the degree of affected nutrient intake. Therefore, there is limited impact of food prices on the nutrition of the rural poor.

Grain prices affect the nutrient levels of each income group, especially poor residents. Rising grain prices have a negative impact on the nutrition of every income group. From the perspective of energy, the low-income group suffers most from grain price shocks with a price elasticity of 0.108%. Thus, stabilization of grain prices plays an important role in ensuring the food and nutritional security of rural households.

The nutritional intake of the rural poor is affected more via price increases of fish and eggs. Such rising prices could significantly reduce the rural poor's intake of energy, proteins, and fats. Therefore, stabilizing the prices of fish and eggs would be helpful to ensure the nutritional security of the rural poor.

Rising meat prices would not cause a great impact on the nutritional status of the rural poor. While it would lead to reduced meat consumption, the rural poor could improve nutrition by choosing a more cost-effective alternative food. For example, they could supplement their calorific intake by consuming more food or by adding more proteins, such as eating more eggs. Of course, nutrients here are considered only via the intake of energy, proteins, and fats. If we were to consider the quality of nutrients and micronutrients, we may not reach such a conclusion.

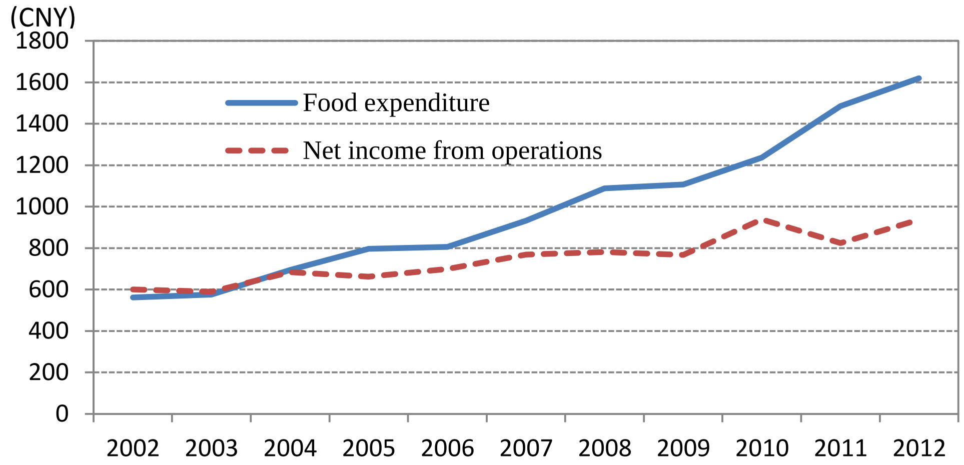

Fig.1 Per capita Annual Food Expenditure and Operation Income of Poorest Quintile Rural Households

Note: Net income from household operations concludes operation income by family unit from such sector as agriculture, industry, construction, food and service. However, for the rural poor families their operation income is mainly sourced from agricultural business.

Data source: NBS (National Bureau of Statistics of China).

Table 1 Expected Direction of Each Influential Factor on Food Consumption

Influence factors	Expected direction
Income (or expenditure)	+
Food prices	?
Self price	-
Other food prices	+/-
Other influencing factors	?
Family size	-
Number of children	-
Education level	+
Ethnic minorities	-
Farmers attributes (purely farming groups/non-purely farming groups)	+/-
Province (dummy)	+/-

Table 2 Rural Residents' Food Consumption among Income Decile Groups

Unit：kg

Income level	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**Recommended Dietary Level**
Grain	217.5	232.0	229.3	240.8	238.6	233.4	233.3	231.9	233.4	237.3	135
Vegetable	74.89	91.04	107.59	116.06	131.65	141.61	169.01	175.72	210.25	239.31	140
Beans	3.13	4.12	4.86	5.19	6.20	6.52	6.54	7.73	8.07	12.11	13
Oils and fats	11.09	12.71	13.53	14.32	15.67	15.76	17.18	18.05	17.64	19.42	12
Sugar	1.44	1.76	2.09	2.09	2.53	2.81	3.23	2.90	3.05	3.39	-
Fruit	8.81	10.62	12.24	17.20	19.08	19.23	20.39	23.53	23.41	26.97	60
Meat	16.18	18.87	20.32	23.70	26.69	27.1	29.29	30.85	29.48	36.32	29
Fish	3.14	4.48	5.22	5.10	6.65	7.52	9.78	11.01	12.31	13.90	18
Eggs	3.10	4.19	4.91	5.44	6.49	6.66	7.39	8.27	9.27	11.73	16
Milk	1.70	3.49	5.81	3.15	3.15	3.25	2.88	3.14	4.30	4.87	45
Other food	8.27	8.43	9.70	8.32	8.22	8.44	10.59	11.18	12.05	15.62	-

Data source: Surveyed data.

Table 3 Energy Source among Income Decile Groups

Unit：%

Income level	1	2	3	4	5	6	7	8	9	10
Grain	71.09	70.20	68.04	67.90	65.31	64.45	62.98	61.30	60.83	57.15
Vegetable	1.74	2.04	2.30	2.37	2.62	2.77	3.18	3.28	3.87	4.13
Beans	1.54	1.94	2.20	2.14	2.50	2.52	2.46	2.85	3.10	4.49
Oils and fats	13.47	13.90	14.66	14.55	15.19	15.23	15.77	16.47	16.05	16.37
Sugar	0.95	1.07	1.17	1.13	1.31	1.44	1.53	1.43	1.46	1.52
Fruit	0.52	0.54	0.62	0.83	0.89	0.91	0.98	1.09	1.07	1.10
Meat	6.02	6.21	6.53	6.98	7.57	8.02	8.10	8.37	7.97	9.36
Fish	0.30	0.43	0.48	0.45	0.60	0.63	0.82	0.94	1.03	1.00
Eggs	0.58	0.71	0.83	0.87	0.99	1.02	1.13	1.27	1.41	1.65
Milk	1.37	0.36	0.55	0.26	0.20	0.21	0.22	0.23	0.29	0.32
Other food	2.41	2.60	2.63	2.52	2.82	2.79	2.82	2.76	2.92	2.91

Data source: Surveyed data.

Table 4 Main Food Price in China between 2005-2010

Unit：yuan/kg

Year	Grain	Vegetable	Beans	Oils & fats	Sugar	Fruit	Meat	Fish	Eggs	Milk
2005	0.39	0.32	0.69	0.93	0.58	0.69	3.21	2.40	1.60	0.71
2006	0.37	0.22	0.66	1.08	1.34	0.28	2.95	2.26	2.47	0.77
2007	0.44	0.27	0.98	1.05	0.80	0.94	4.37	4.99	2.00	0.83
2008	0.49	0.25	0.94	1.73	1.07	2.06	5.38	3.06	2.40	0.94
2009	0.49	0.55	0.90	1.29	0.22	0.40	5.73	3.55	2.37	0.95
2010	0.52	1.04	0.90	1.29	0.94	0.58	6.33	4.30	2.53	0.95

Data source: Surveyed data.

Table 5 Model Test

Equations	Testing methods	Null hypothesis	Testing results	Result notes
Equation （1）	Hausman Test	Difference in coefficients not systematic	$chi^2(40)$=163.16 Prob>chi^2=0.0000	Rejecting null hypothesis and using fixed effects model
Equation （2）			$chi^2(40)$= 30.92 Prob>chi^2=0.8481	Accepting null hypothesis using random effects model
Equation （3）			$chi^2(40)$= 111.20 Prob>chi^2=0.0000	Rejecting null hypothesis and using fixed effects model
Equation （4）			$chi^2(40)$= 219.60 Prob>chi^2=0.0000	Rejecting null hypothesis and using fixed effects model
Equation （5）			$chi^2(40)$= 69.69 Prob>chi^2=0.0025	Rejecting null hypothesis and using fixed effects model
Equation （6）			$chi^2(40)$= 11.90 Prob>chi^2=1.0	Accepting null hypothesis using random effects model
Equation （7）			$chi^2(40)$= 46.12 Prob>chi^2=0.2689	Accepting null hypothesis using random effects model
Equation （8）			$chi^2(40)$= 180.50 Prob>chi^2=0.0000	Rejecting null hypothesis and using fixed effects model
Equation （9）			$chi^2(40)$= 89.53 Prob>chi^2=0.0000	Rejecting null hypothesis and using fixed effects model
Equation （10）			$chi^2(40)$= 238.0 Prob>chi^2=0.0000	Rejecting null hypothesis and using fixed effects model

Table 6 Income Elasticity of Food Demand

Food	Farmer Category	Income groups		
		Low*	Middle**	High***
Grain				
	Purely farming groups	-0.023	-0.042	-0.034
	Non-purely farming groups	-0.026	-0.042	-0.070
Vegetable				
	Purely farming groups	0.308	0.217	0.210
	Non-purely farming groups	0.273	0.188	0.110
Beans				
	Purely farming groups	-0.397	-0.027	-0.341
	Non-purely farming groups	0.089	-0.028	-0.215
Oils and fats				
	Purely farming groups	0.196	0.131	0.117
	Non-purely farming groups	0.152	0.102	0.057
Sugar				
	Purely farming groups	0.771	0.237	0.117
	Non-purely farming groups	0.582	0.382	0.197
Fruit				
	Purely farming groups	0.317	0.085	0.367
	Non-purely farming groups	0.473	0.257	0.422
Meat				
	Purely farming groups	0.374	0.366	0.366
	Non-purely farming groups	0.376	0.321	0.266
Fish				
	Purely farming groups	0.617	0.196	0.447
	Non-purely farming groups	0.905	0.402	0.117
Eggs				
	Purely farming groups	1.779	0.438	0.329
	Non-purely farming groups	0.795	0.449	0.154
Milk				
	Purely farming groups	0.789	1.293	1.355
	Non-purely farming groups	1.231	1.283	1.383

Note: *It is grouped by income decile. The low-income group is the poorest 10% of all sample households (Level 1), who is the poor defined in this paper;** The middle-income group is the 5th and the 6th decile (Levels 5 and Level 6); ***The high-income group the richest 10%(Level 10). The same below.
Source: Calculated from survey data.

Table 7 Own-price and Cross-price Elasticity by Income Decile Group

Food/income group		Grain	Vegetable	Bean	Oil and fat	Sugar	Fruit	Meat	Aquatic product	Egg	Milk
Grain	Low*	-0.118	0.010	-0.067	-0.039	-0.049	0.079	0.156	-0.123	-0.671	0.365
	Middle**	-0.063	0.013	-0.055	0.017	-0.041	0.060	0.152	-0.124	-0.662	0.429
	High***	-0.015	0.015	-0.044	0.066	-0.034	0.044	0.149	-0.124	-0.655	0.483
Vegetable	Low	0.130	-0.072	-0.056	-0.196	-0.038	-0.014	0.013	-0.583	0.521	0.053
	Middle	0.225	-0.046	-0.126	-0.156	-0.048	-0.054	-0.023	-0.581	0.579	0.055
	High	0.307	-0.024	-0.186	-0.121	-0.057	-0.087	-0.054	-0.580	0.629	0.056
Bean	Low	-0.463	-0.534	-0.135	1.428	0.198	0.184	2.926	-5.612	3.100	1.762
	Middle	-0.531	-0.514	-0.347	1.468	0.040	0.226	3.900	-5.607	3.632	1.935
	High	-0.590	-0.496	-0.760	1.504	-0.097	0.262	4.737	-5.602	4.088	2.084
Oils and Fats	Low	-0.148	-0.037	0.025	-0.005	-0.008	0.021	0.127	0.005	-0.328	0.393
	Middle	-0.159	-0.015	-0.003	-0.010	-0.017	0.000	0.073	0.006	-0.326	0.430
	High	-0.168	0.004	-0.028	-0.014	-0.025	-0.019	0.027	0.008	-0.325	0.461
Sugar	Low	-0.469	-0.234	-0.386	-0.303	-0.031	0.255	0.831	0.333	-0.845	0.727
	Middle	-0.333	-0.263	-0.234	-0.042	-0.049	0.209	0.560	0.335	-0.853	0.749
	High	-0.216	-0.288	-0.105	0.181	-0.064	0.169	0.328	0.336	-0.861	0.767
Fruit	Low	-0.748	-0.124	-0.022	0.074	-0.041	-0.302	0.629	0.603	-3.058	2.559
	Middle	-0.263	-0.153	0.008	-0.117	-0.013	-0.227	0.249	0.606	-3.097	2.805
	High	0.154	-0.179	0.033	-0.281	0.012	-0.162	-0.078	0.609	-3.131	3.017
Meat	Low	-0.296	-0.086	0.040	-0.125	-0.008	-0.025	-0.180	0.050	0.178	0.075
	Middle	-0.314	-0.047	0.016	-0.127	-0.005	-0.025	-0.130	0.053	0.180	0.064
	High	-0.329	-0.014	-0.005	-0.129	-0.003	-0.026	-0.087	0.055	0.181	0.056
Fish	Low	-0.573	-0.638	0.172	0.273	-0.135	0.896	0.440	-1.228	-4.664	4.890
	Middle	-0.223	-0.775	0.200	0.124	-0.147	0.590	0.396	-1.218	-4.536	5.507
	High	0.078	-0.892	0.225	-0.004	-0.158	0.327	0.359	-1.210	-4.426	6.037
Eggs	Low	-1.227	-0.256	0.123	0.021	-0.180	0.173	0.561	-0.732	-0.022	0.973
	Middle	-0.648	-0.272	-0.037	0.053	-0.046	0.182	0.476	-0.728	-0.104	1.045
	High	-0.151	-0.286	-0.174	0.080	0.070	0.190	0.403	-0.724	-0.174	1.107
Milk	Low	-0.363	-0.121	0.147	0.181	0.047	0.035	0.141	2.672	-2.351	-0.784
	Middle	-0.117	-0.064	0.067	0.005	-0.015	0.004	0.122	2.769	-2.522	-0.860
	High	0.095	-0.016	-0.001	-0.147	-0.068	-0.023	0.105	2.852	-2.669	-0.926

Source: Calculated from survey data.

Table 8 Income Elasticity of Nutrition

Farmer type	Energy	Protein	Fat
Low	0.038	0.053	0.194
Purely farming groups	0.042	0.057	0.212
Non-purely farming groups	0.033	0.044	0.159
Middle	0.021	0.049	0.170
Purely farming groups	0.039	0.058	0.184
Non-purely farming groups	0.004	0.043	0.161
High	0.010	0.003	0.137
Purely farming groups	0.021	-0.001	0.148
Non-purely farming groups	-0.010	0.011	0.112

Source: Estimated form survey data.

Table 9 Price Elasticity of Nutrients

Food income group	Energy	Protein	Fat
Grain			
Low	-0.108	-0.012	-0.139
Middle	-0.030	-0.043	-0.191
High	-0.034	-0.079	-0.223
Vegetable			
Low	-0.001	-0.041	-0.067
Middle	-0.024	-0.062	-0.066
High	0.033	-0.048	-0.032
Beans			
Low	-0.091	-0.037	0.001
Middle	-0.049	-0.059	-0.030
High	0.107	-0.044	-0.031
Oils and Fats			
Low	-0.041	0.016	-0.016
Middle	0.032	0.085	0.016
High	0.025	-0.228	-0.170
Sugar			
Low	-0.001	-0.036	-0.022
Middle	-0.032	-0.035	-0.020
High	0.013	-0.011	-0.004
Fruit			
Low	0.088	0.082	0.042
Middle	0.051	0.073	0.033
High	0.100	-0.034	-0.025
Meat			
Low	0.090	-0.276	-0.274
Middle	0.235	-0.393	-0.345
High	0.032	-0.027	-0.098
Fish			
Low	-0.501	-0.308	-0.161
Middle	-0.231	-0.506	-0.333
High	0.040	-0.050	0.011
Eggs			
Low	-0.244	-0.481	-0.228
Middle	-0.430	-0.328	-0.020
High	-0.068	-0.619	-0.195
Milk			
Low	-0.151	0.469	0.344
Middle	0.480	0.631	0.397
High	0.156	0.375	0.218

Source: Estimated form survey data.

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