Supermarket environments and nutrition outcomes in rural China

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Introduction

With growing incomes and accelerating urbanisation in developing countries, food consumption and nutrition have undergone profound changes, such as more demand for food quality and highly nutritious foods, as well as more diverse food products (REN et al. 2018). Chinese consumers are switching from traditional Chinese foods, which are largely characterised by grains and vegetables, to high-fat and high-sugar foods. As a result of this change in food consumption, like in many developing societies, the prevalence of overweight and obesity has become a serious threat to individual health and a major public health challenge in China. In the transitional economy of China especially, it has been reported that nearly 40% of adults in China aged 18–65 are estimated to be overweight (REN et al. 2019). At the same time, there is a large difference in the nutritional status between rural and urban areas in China. In rural compared to urban China, incomes are lower, while infrastructure and access to services, markets, and value chains are limited.

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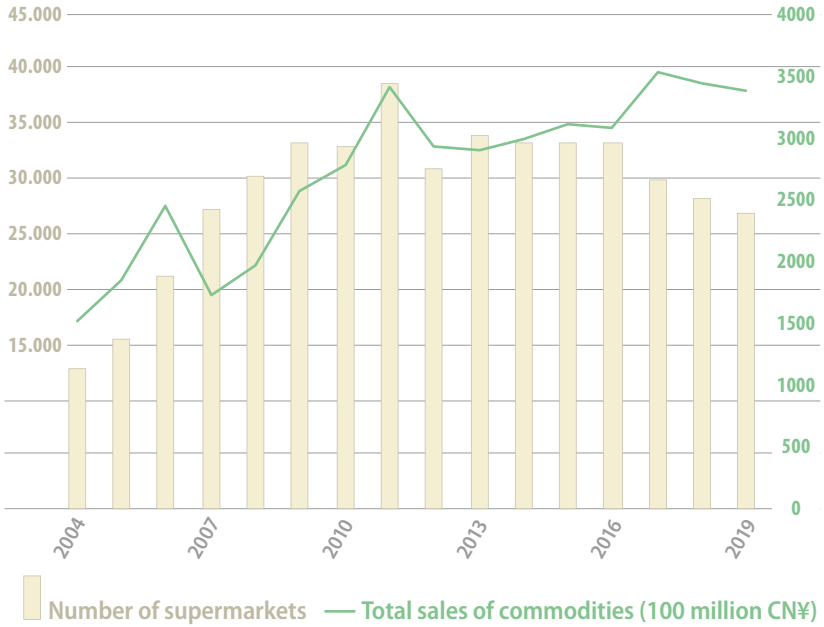
In addition to socio-demographics and socioeconomic factors, studies have increasingly revealed that a changing food environment plays a significant role in nutrition transition. Within various aspects of food environments, the establishment of supermarkets as one of the most important changes in food retailing contributes remarkably to the process of nutrition transition. In developing countries especially, a 'supermarket revolution' started in the early 1990s and continues to the present, which has driven the spread of modern supermarkets considerably. This trend is observable worldwide, and China is no exception. The number of supermarkets in China in 2016 reached 33,372, which is two times more than in 2004 (12,877), and the total sales of commodities in supermarkets accounted for roughly 3,067.2 (100 million CN¥) in 2016, up from 1527.4 (100 million CN¥) in 2004.

Despite the increasing number of supermarkets worldwide, the effects that supermarkets have on nutrition outcomes is still unclear. Results from the existing literature confirm that the food retail environment consistently affects people's food choices and health, but with mixed results. Some argue that, as supermarkets usually offer more convenience foods than traditional free markets and shops, such modernisation of the retail sector could possibly contribute to negative nutrition outcomes, such as overweight and obesity (DEMMLER et al. 2018). However, other studies reveal no significant effect of shopping in supermarkets on the nutrition outcomes of Body Mass Indexes (BMIs) and overweight in Indonesia (Umberger et al. 2015), or even a negative effect on the prevalence of obesity and overweight (MORLAND et al. 2006). To the best of our knowledge, there is no specific study addressing

Figure 1: Supermarket development in China, 2004–2019



this issue in China; therefore, we attempt to close this research gap by investigating the effects of supermarket environments on nutrition outcomes.

Available studies on the nutrition effects of supermarkets exclusively focus on the issues of overnutrition but less attention is paid to malnutrition. Supermarkets provide plenty of processed foods with high calories, which are known as the main contributors to overweight and obesity (LAW et al. 2019). However, in some developing countries or for some low-income households, supermarkets play a significant role in ensuring food security. In the transitional economy of China, there are still approximately 150.8 million people malnourished, though overnutrition such as overweight and obesity has become a major public health issue. The nutrition effect of supermarkets might, therefore, be varying. We seek to understand the heterogeneous effects of the supermarket environment on being underweight, overweight, or obese using a multinomial logit regression for panel data.

> Different from previous studies, this study contributes to the literature from the following three main aspects:

First, heterogeneous nutrition effects of supermarkets are investigated using a multinomial logit model for underweight, overweight, and obesity. Second, three aspects of supermarket environments are analysed, including supermarket accessibility, availability, and food variety in the supermarket. Third, we analyse the heterogeneity of the results by gender. Finally, we shed light on the mechanisms through which supermarket environments impact nutrition outcomes in rural China, considering indicators measuring nutritional intakes and dietary quality. Our focus is on rural China rather than all of China due to the large differences in nutritional status between residents in urban and rural China, which is

linked to disparities in income and infrastructure. Residents in rural areas are more likely to experience various nutrition outcomes during the process of the supermarket revolution.

Estimation method

To investigate how supermarkets' accessibility, availability, and food variety could affect individuals' nutritional outcomes, we estimated a Multinomial Logistic regression for panel data. The dependent variable of nutrition outcome consisted of four categories: normal weight (reference), underweight, overweight, and obese. The main independent variables of concern included supermarket accessibility, supermarket availability, and food variety in the supermarket, which were introduced separately into the estimation. We also controlled for individual socio-demographic variables, behavioural characteristics, household fixed effects, and community and province fixed effects.

Since our data has a panel structure, we applied a pseudo-fixed-effects (Mundlak) estimator as an additional comparison to Random Effect estimates. The main advantage of the Mundlak (MK) estimator is that it can control for biases that may arise from individual heterogeneity and omitted time-varying variables by including covariate mean values as additional explanatory variables in the estimation. In this way, the individual heterogeneity can be addressed with the MK estimator if the joint significance test of the mean value of all time-varying covariates are statistically significant.

Beyond individual heterogeneity, other omitted variables that simultaneously affect both individuals' nutrition outcomes and the supermarket environment still exist, which casts doubt on the potential endogeneity problem of the supermarket environment. For instance, some omitted county characteristics or eating habits that can hardly be controlled for in empirical estimations could both affect individuals' nutrition outcomes and the supermarket environment. In addition, individuals' nutrition demands could also stimulate retailers' decisions on supermarket allocation and food variety in the supermarket. To cope with the potential endogeneity due to other unobservables and the reverse causality between individual nutrition outcomes and the supermarket environment, a Control Function approach was applied.

Sample and data

The data used in this study was from the **China Health and Nutrition Survey (CHNS)**, which, in its current form, covers the period of 1989 to 2011. The CHNS applies a multistage and random cluster process to draw a sample of roughly 4,400 households with a total of approximately 26,000 individuals. For the analysis of this article, we applied three restrictions to the CHNS dataset. First, as the CHNS survey includes information on the supermarket environment from 2004 onwards only, our analysis used data for the waves from 2004 to 2011 only. Second, we restricted the sample to adults living in rural areas, and considered those adults aged 18 and above at the time of the survey. Third, given specific BMI measurements for children, pregnant women, and adults suffering from chronic diseases, these individuals were excluded as not to confound BMI effects. In addition, we also excluded those individuals who migrate from the household or are not living in the household, as their food consumption can hardly be affected by the food

Table 1: Descriptive statistics of nutrition outcomes for rural residents

Variables	Definition	Mean	S.D.
BMI	**Body Mass Index (kg/m^2)**	**23.245**	**3.563**
Normal weight	1 if BMI ≥ 18,5 and BMI < 24; 0 otherwise (reference)	0.569	0.495
Underweight	2 if BMI ≤ 18,5; 0 otherwise	0.057	0.233
Overweight	3 if BMI ≥ 24 and BMI < 28; 0 otherwise	0.285	0.452
Obesity	4 if BMI ≥ 28; 0 otherwise	0.088	0.284

environment in the regions where their households are located. Finally, 8,686 individuals amounting to 18,504 observations were kept for the main outcome variables.

The main dependent variable of this study was nutrition outcome from food consumption. The CHNS includes measures of height and weight, which were used to calculate BMI. Nutrition outcomes were defined via four categories according to adults' BMI: underweight (BMI < 18.5), normal weight (18.5 ≤ BMI < 24), overweight (24 ≤ BMI < 28), and obese (BMI > 28). As shown in **Table 1**, the average BMI is 23.25. Approximately 5.7% of rural residents are underweight, and 28.5% and 8.8% of rural residents are overweight or obese, respectively. **Figure 2** shows the trend of BMI from 2004 to 2011, which indicates an increasing tendency, and it tends to increase slowly between 2006 and 2009 but presents a steep rise between 2009 and 2011. A similar pattern can also be found for overweight and obesity, as shown in **Figure 2**. The total prevalence of overweight and obesity increased from 33% in 2004 to 43% in 2011, representing an increase of approximately 10%. **Figure 2** also suggests that gender differences in BMI and being overweight tend to disappear over time, and females were more likely to have higher BMIs and be obese in 2011. We also observe a decreasing trend of individuals being underweight across the surveyed years; after 2009 there was an especially enormous decline.

To investigate the effect of supermarket environments on nutrition outcomes, we used three dimensions: supermarket availability (whether there is an accessible supermarket in the neighbourhood or not), supermarket accessibility (distance to the nearest supermarket), and food variety in the supermarket. We aggregated the total types of fresh fruits and vegetables available to proxy food variety in the supermarket. The descriptive statistics of supermarket availability, accessibility, and food variety

Figure 2: The trend of nutrition outcomes across the survey years, 2004–2011

are shown in **Table 1**. Approximately 45.8% of individuals considered in our sample live in regions with supermarkets. The average distance to reach a supermarket is roughly 7.16 km. The food variety in the supermarket shows, on average, that more than 44 kinds of vegetables and fruits are provided in the nearest supermarket in each community.

Regarding the mechanism through which a supermarket environment may influence nutrition outcomes, indicators to measure nutritional intakes and dietary quality were constructed. Specifically, to measure the nutritional intakes, information provided by the CHNS on food consumption for three consecutive days was paired with information on the nutritional contents of these food items that was provided by the 2002 Chinese Food Nutrition Table. Total calories (kcal) consumed at the individual level was calculated to measure the nutritional intakes. The **Chinese Healthy Eating Index (CHEI)** was used to check how supermarket environments affect dietary quality in rural China.

Conclusion and discussion

Worldwide, the supermarket revolution has played a more and more significant role in nutritional transition and public health outcomes. According to our panel estimations' results, we find that there are no significant effects of supermarket availability and accessibility on nutrition outcomes. However, our results support that food variety has a significant and negative effect on the risk of being malnourished (underweight) and overnourished (overweight and obese), suggesting that nutrition-related health issues could be reduced by increasing food variety in supermarkets in rural China. To further investigate the mechanisms through which food variety influences nutrition outcomes, the total calorie intake was estimated to examine how food variety affects nutritional intakes. Furthermore, the Chinese Healthy Eating Index, as a measurement for food quality, was evaluated to detect the impact of food variety on dietary quality. Our findings suggest that food variety in the supermarket has a significant and negative impact on total calorie intake, but a positive impact on food quality measured with the CHEI. Policies targeted at efficiently improving nutrition outcomes in rural China might, therefore, be more effective if their focus is on food variety in the supermarket instead of emphasising supermarket accessibility and availability. To promote food variety in the supermarket, a combination of measures that promote changes in the supply and demand of food products is suggested. In particular, laws and policies that promote the sale of more healthy foods—such as fruits and vegetables—and limit access to unhealthy foods are crucial for addressing overweight and promoting dietary quality (DEMMLER et al. 2018). On the supply side, supermarkets need to have financing and tax incentives to provide more healthy food offerings. Possible measures for achieving healthier food offerings in supermarkets include, for example, property tax exemptions and financing programs that provide loans not only to supermarkets, but also to grocery stores, farmers markets, and other food stores to cover the costs associated with offering healthier foods. This could include costs such as refurbishing storage facilities and refrigeration equipment for fresh products, as well as subsidies for healthier foods. Moreover, transportation infrastructure for supplying supermarkets with healthy food products could also be improved. On the demand side, local governments might deter unhealthy food choices through taxing unhealthy food and beverages, such as sugar-sweetened beverages, and promote healthy food choices through increasing awareness by focusing on nutrition education and guidelines and their marketing.

On the consumer side, better knowledge of basic nutrition principles as well as a better expertise in reading labels have significant effects on consumers' food choices and nutrition related issues. Dietary education programs can be an attractive practice to prevent overweightness and obesity, given that food availability is tending to increase in rural China, especially when the government aims to increase the poor's food purchasing power by providing financial assistance, such as the Food Stamp Program in the US.

The limitations of this study are related to the data. The CHNS only includes information regarding the number of accessible supermarkets in the community rather than information on actual purchases made in the supermarket,

which might have more meaningful policy implications. To better understand the role of supermarkets in studying nutrition-related issues, future studies might include field surveys to capture the percentage of household food purchased in supermarkets and consider applying Random Control Trials (RCT) to investigate the impact of supermarket environments on adult health from the perspective of behavioural economics.

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