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Meat Consumption, Dietary Structure and Nutrition Transition in China

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Meat Consumption, Dietary Structure and Nutrition Transition in China

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Meat Consumption, Dietary Structure and Nutrition Transition in China

Abstract:

Nutrition transition is driven by quantity increase and structural change in food consumption. Particularly, meat consumption plays an important role. This study proposes a simple but innovative method to empirically decompose the total income effect on nutrition improvement into direct income effect and structural change effect, mediated by meat consumption share. With the use of the China Health and Nutrition Survey (CHNS) data, we find that a 1% increment in income will boost per capita calorie consumption by 0.02% within a family. The calories elasticity with respect to income is very small. However, 16 to 21% of the increase is due to dietary structural change, while the rest part is attributed to the conditional income effect. In addition, the dietary structural change effect is more prominent in the rural region, which implies a rural-urban gap in the diet.

Key Words: Meat consumption, Nutrition transition, Dietary structural change, Seemingly unrelated regression model, Income effect, China

JEL: Q10

1. Introduction

Increasing specific nutrients intake and calorie consumption, in coincidence with rapid economic growth and fierce social change, occurs in developing and emerging economies. (Guo et al., 2000; Du et al., 2002; Popkin et al., 2002; Jensen & Miller, 2010; Tian and Yu, 2015). Early studies (Popkin, 1999; Subramanian & Deaton, 1996) focus on the relationship between income and energy intake, under a static framework, especially for the income elasticity of calorie intake. Lifestyle change that induces a reduction in physical activity levels, people's preference towards processed food and sugar-sweetened beverages, and food patterns change like the popularity of having food away from home also contributes to the prevalence of obesity and obesity-related non-communicable disease in emerging and developing countries. (Popkin et al., 2012). A general finding is that nutrition consumption first increases drastically, and then slows down until reaching a saturate point with income growth (Zhou and Yu 2015; Tian and Yu, 2015; Shimokawa, 2010). Consequently, the income elasticity of nutrition would keep declining, and this is confirmed by a meta-analysis of Zhou and Yu (2015) and Min et al. (2020).

Income does not only increase the food quantity but also food quality (Yu and Abler 2009). Food quality is measured by dietary structure. Some recent researchers start to shed light on dietary structural change in the nutrition transition. Jensen and Miller (2010) use the share of calories from staple food as an index to measure the level of undernutrition, as it first maintains at a high level and then decreases drastically when income reaches a certain level. Min et al. (2020) find that the effect of dietary knowledge is heterogeneous for food and calorie loss with household features and income.

Tian and Yu (2015) used semi-parametric methods and demonstrated that dietary structure changes over income in China. A typical phenomenon is that traditional diets dominated by fiber and staples are being replaced by meat consumption in recent decades (Yu & Abler, 2009 & 2014; Tian & Yu,2013; Zhou et al., 2015). This is confirmed by a large volume of literature on food demand analysis in China. Chen et al. (2016) and Zhou et al. (2017) conducted meta-analyses for the demand elasticities in China. As income still grows, meat consumption is expected to increase in a mid-term. Zhou et al. (2017) projected that meat consumption will increase by about 50% from 2015 to 2030.

In addition to income, many other factors have been taken into account in the literature of nutrition analysis, such as household structure, gender, and other socioeconomic variables (Tian and Yu, 2015). For instance, intrahousehold calorie allocation responds asymmetrically to expected declines and increases in household food availability in China

(Shimokawa, 2010). However, the linkage between dietary structural change and nutrition improvement has not been thoroughly examined quantitatively. Low level of overall economic development other than low income could be the main cause of insufficient calorie consumption in development countries (Dawson, 2007). Meat itself as a food category has some unique attributes such as the high environmental and ecological burdens, compared with cereals, fruits, and vegetables (Shimokawa, 2015; Yu, 2015). Democracy levels of countries could also correlate with meat consumption as a democratic government has incentives to reach food security and ensure sufficient meat supply (Hasiner and Yu, 2016). Other than nutrient intake, cooking style, and food patterns in China have changed drastically as the snacking and fried food are limited in traditional Chinese daily meals (Wang et al., 2008).

In order to fill in the research gap, this paper will propose a simple but innovative framework to decompose the total income effect on nutrition improvement into direct income effect and structural effect. Specifically, the dietary structure is measured by meat consumption.

The rest of this paper is organized as follows: Section 2 and 3 describe the theoretical framework and the empirical model. Section 4 introduces the data source and descriptive statistics. Section 5 discusses the empirical results, followed by Section 6 of the conclusion.

2. Theoretical Framework

We assume nutrition consumption C (e.g. Calories) is a function of income (X) and dietary structure (S). Following Jensen & Miller (2010) and Tian & Yu (2015), the dietary structure can be measured by the calories share of meat products (S_c), or the expenditure on meat expenditure in total food expenditureS_e.

$$C = F(X, S) \tag{1}$$

However, if we assume income is exogenous, food structure can be driven by income growth, as is observed in the literature. That is, S is also a function of X. That is,

$$C = F[X, S(X)] \tag{2}$$

The relationship between income, food structural change, and nutrition transition can be demonstrated in Figure 1. That is, income has two channels to impact nutrition consumption: expansion of food consumption and change of food structure. Taking total differentiation for (2) with respect to X, we have

$$\frac{dlnC}{dlnX} = \frac{\partial lnC}{\partial lnX}|_{Constant\ S} + \frac{\partial lnC}{\partial S}\frac{\partial S}{\partial lnX} \tag{3}$$

where $\frac{dlnC}{dlnX}$ is the unconditional income elasticity of calorie consumption, measuring the total income effect. That is equation (3) decomposes the total income effect into two terms : $\frac{\partial lnC}{\partial lnX}$ and $\frac{\partial lnC}{\partial S}\frac{\partial lnS}{\partial lnX}$.

$\frac{\partial lnC}{\partial lnX}$ is the direct income effect after controlling for the dietary structure. From an economic perspective, this term measures the direct income effect, mainly driven by the food quantity expansion with the assumption of fixed food structural change. While the second term $\frac{\partial lnC}{\partial S}\frac{\partial lnS}{\partial lnX}$ measures the effect of dietary change on total calorie consumption.

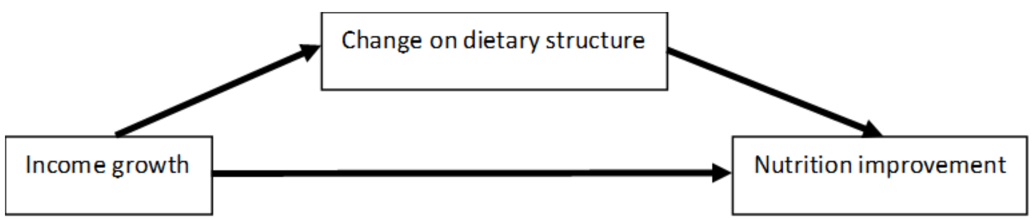
If we use the calories share of meat or expenditure share of meat as the measure of dietary structure, we have a hypothesis that $\frac{\partial lnC}{\partial S} > 0$ and $\frac{\partial S}{\partial lnX} > 0$, as income increases meat consumption generally in developing and emerging economies. Hence, we have

$$\frac{dlnC}{dlnX} > \frac{\partial lnC}{\partial lnX}|_{\text{Constant S}}.$$

It implies that the direct (conditional) income effect on nutrition consumption is often lower than the total effect. It is our common wisdom that dietary quality increase also could enhance nutrition consumption. However, to what extent the dietary structural change affect nutrition improvement is an empirical problem. This will be studied in the next section.

The channel for the impact of income growth on nutrition improvement is summarized below in Figure 1.

Figure 1: Theoretical framework



3. Empirical Model

Following the intuition of the above theoretical framework, we assume equation (1) is a set of two linear functions, and have the following specifications:

$$lnC_i = \alpha_0 + \alpha_1 * lnX_i + \alpha_2 * S_i + z_i\alpha_3 + e_i \quad (4)$$

$$S_i = \theta_0 + \theta_1 * lnX_i + z_i\theta_2 + \varepsilon_i \quad (5)$$

Where α_r (r=0,1,2,3) and θ_t(t=0,1) are parameters to be estimated. $z_i$is a vector of control variables. e_i and ε_i are error terms following normal distribution N(0, σ_e^2) and N(0, σ_ε^2) respectively.

However, the current literature often has the following conventional model without considering dietary structural change,

$$lnC_i = \tilde{\alpha}_0 + \tilde{\alpha}_1 * lnX_i + z_i\tilde{\alpha}_2 + \tilde{e}_i \quad (6)$$

Where similarly, $\tilde{\alpha}_0$, $\tilde{\alpha}_1$, $\tilde{\alpha}_3$ are parameters to be estimated, while $\tilde{e}_i$ is the error term.

Compare equation (6) with equations (4) and (5), we could easily obtain,

$$\tilde{\alpha}_1 = \frac{dlnC}{dlnX}$$

$$= \frac{\partial lnC}{\partial lnX}|_{S\ is\ controlled} + \frac{\partial lnC}{\partial S}\frac{\partial S}{\partial lnX}$$

$$= \alpha_1 + \alpha_2 * \theta_1 \quad (7)$$

Equation (7) empirically decompose the total income effect into a conditional income effect and a structural change effect, consistent with the Equation (3) in the theoretical framework section.

Compared with the conventional model, our model can easily decompose the confounding mixed total income effect ($\tilde{\alpha}_1$) into two part: the direct (conditional) income effect or the intensive margin of calorie consumption (α_1) and the dietary structural change effect or the extensive margin of calorie consumption ($\alpha_2 * \theta_1$). The structural change effect ($\alpha_2 * \theta_1$) can be also regarded as an indirect effect of income. This is consistent with the Equation (3) of the theoretical framework section.

Here comes to the proxy variables for dietary structure. Following Jensen & Miller (2010) and Tian & Yu (2015), we propose two measures for dietary structure: the calories share of meat products ($calsmeat_i$), and the ratio of expenditure on meat to total food expenditure ($esmeat_i$).

4. Data source and descriptive statistics

We use China Health and Nutrition Survey (CHNS) dataset for this study. CHNS is a widely recognized long-lasting survey specifically shedding light on nutrition and health issues for Chinese people. It is supported by three institutes: Carolina Population Center of the University of North Carolina at Chapel Hill, the Chinese Center for Disease Control and Prevention, and the National Institute of Nutrition and Food Safety. The current project covers more than 7000 households.

The survey starts initially in 1989, but the early surveys cover limited information on the prices of food. As a result, we only make use of data in 2004, 2006, and 2009, since the price information is reported in those three rounds.

The calculation of expenditure share of meat consumption which is an indicator of food structure requires the prices of individual food items. which are reported in the community survey. Then we estimate total food expenditure as well as expenditures for specific food categories. In this way, we finally calculate the expenditure share of meat consumption.

As we have the information each food category consumed by the samples, the calculation of calorie share of meat consumption can be easily realized by multiplying the food consumption quantity by calories contents for each food category. The calories contents can be easily obtained from China Food Composition Table 2002 and 2004 (which are released by Chinese Center for Disease Control and Prevention).

The definition of the variables of our interests is reported in Table 1.

Table 1: Summary of descriptions of variables

Category	Variable name	Unit	Description
Dependent Variable	lncalint	kcal	The natural logarithm of calorie intake
Mediator Variables	esmeat	%	Share of food expenditure spend on meat
	calsmeat	%	Share of calorie absorbed from meat
Independent Variable	lnincome	CNY	The natural logarithm of income, inflated to the 2004 price level
	facility	counts	Number of nearby food facilities
	hhage	year	Age of household head
	hhagesqr	year^2	Squared term of household head's age
	hhedu	year	Years of household head's education
	hhmale	dummy	The gender of household head, if male, it equals 1, or else 0
	share_child	%	Share of kids younger than or equal to 5 years old
	share_old	%	Share of family members older than 60
	share_madult	%	Share of male members aged between 19 and 60

As Table 1 shows, we follow the common social-economical factors to construct the covariates. We compute food consumption data for each category and each specific food item by calculating the inventory change plus the food away from home. Afterward, we estimate the calorie consumption per capita per day for each member of each family. But it is noticeable that the accuracy of calorie consumption per capita we calculated here may suffer from food waste and the differences in the household size of the survey and real food consumption size of households (Yu and Abler, 2016).

Table 2: Descriptive statistics

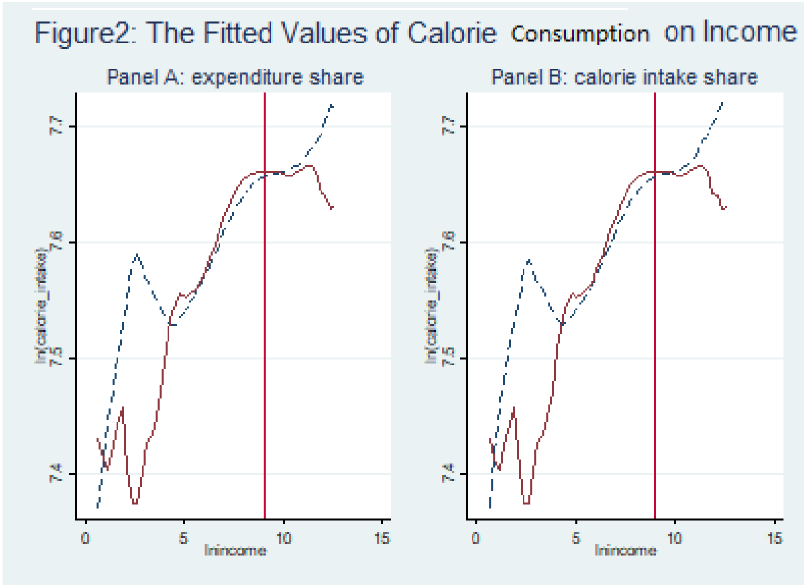
Category/mean	Variable	Whole sample	Rural sample	Urban sample
Dependent variable	lncalint	7.639	7.649	7.618
Mediator variables	esmeat	0.236	0.213	0.282
	calsmeat	0.107	0.093	0.137
Independent variable	lnincome	8.497	8.326	8.853
Covariates	facility	47.895	42.888	58.268
	hhage	54.222	53.548	55.619
	hhagesqr	3112.48	3036.211	3270.475
	hhedu	7.515	7.066	8.444
	hhmale	0.836	0.871	0.763
	share_child	0.028	0.031	0.022
	share_old	0.199	0.175	0.25
	share_madult	0.311	0.317	0.298
Number of observations		11678	7876	3802

Notice: the sample mean of lncalint is 7.639, while e^7.639=2077.67. The sample mean of household daily calorie intake per capita is about 2000 to 2100 kcal.

Table 2 above shows the descriptive statistics of all the variables. After dropping the observations with missing values or outliers, we have 11678 observations staying in the sample. Meat belongs to a high-quality food category and accounts for 24% of total food expenditure, but only 11% of the whole calorie consumption. More than 80% of household heads are males, and the average age of the household head is 54 years old. Meanwhile, around two-thirds of participation families come from rural regions.

We particularly exploit the expenditure share and calorie share for meat products as the indicators of dietary structural change. Yu and Tian (2013) describe that the dietary change in China is represented by the fast preference transformation from the grain intense food to the meat intense food. An increase in meat consumption is a general trend in nutrition transition observed in developing and transition countries.

Besides the variables listed above, we add the county level dummies in regression to control for unobserved regional disparity and the food price differences.



Notice: The dashed line shows the fitted local polynomial smooth values, while the solid line shows the local polynomial smooth of the sample. The vertical line represents the mean income of the sample, 8385.063 CNY per capita per year.

Figure 2 straightforwardly shows the relationship between income and household per capita calorie consumption. As we can observe, calorie consumption and income are positively correlated except for very low and very high-income people. Very poor people may tend to be engaged in labor-intensive work so that they need to consume more calories to support their activities. Similarly, we find that very rich people tend to consume slightly less energy. We argue that rich people can easily obtain enough energy, so they pay more attention to the dietary quality and diversity of food.

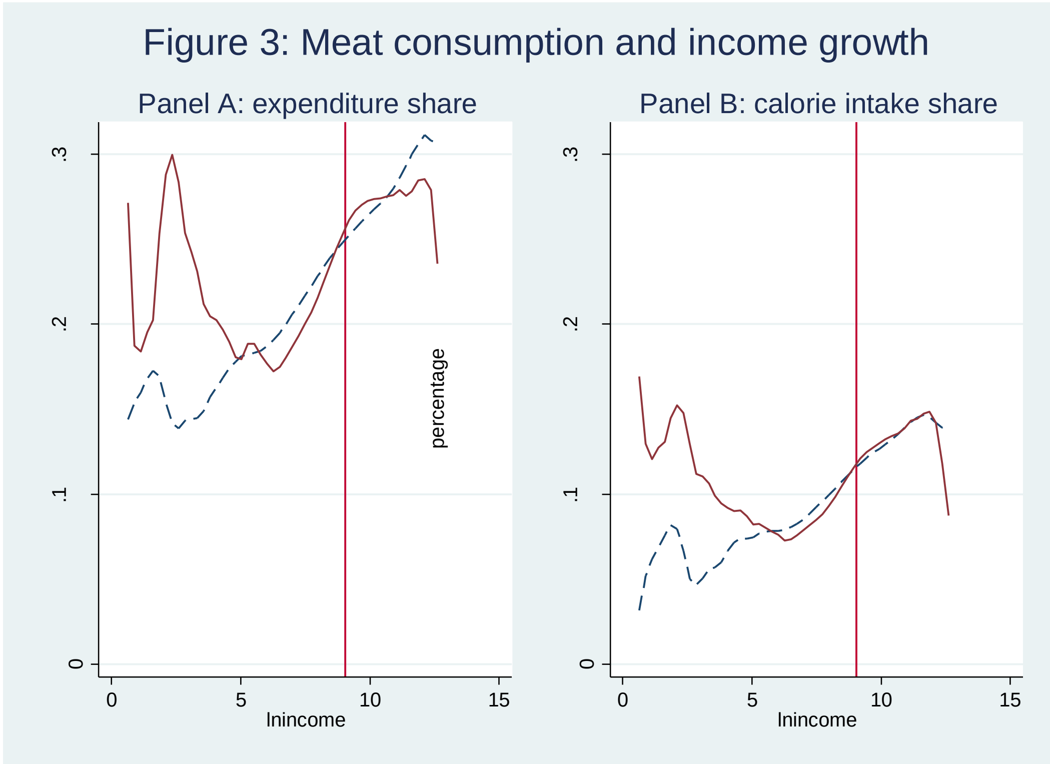


Figure 3: Meat consumption and income growth

Notice: The dashed line shows the fitted local polynomial smooth values, while the solid line shows the local polynomial smooth of the sample. The vertical line represents the mean income of the sample, 8385.063 CNY per capita per year.

Figure 3 shows the relationship between food structure change and income growth without controlling for other factors. Generally speaking, the upward shape of the fitted curve implies that Chinese consumers tend to spend more expenditure on meat when they can afford to, and the percentage of calories obtained from meat also increases with income growth.

5. Empirical Results

- Conditional income effect and dietary structural change

As error terms in equation (4) and (5) might be correlated, the seemingly unrelated regression (SUR) with bootstrapped standard errors could serve the purpose better and obtain a more efficient estimator (Preacher and Hayes, 2008).

Table 3: Empirical results

Variables	Estimation Method	SUR with Bootstrapped SE	
	lncalint	Expenditure share	Calorie share
Mediation Variables	esmeat	0.197***	
		(0.024)	
	calsmeat		0.282***
			(0.051)
Independent Variable	lnincome	0.016***	0.017***
		(0.004)	(0.004)
Control Variables	facility	-0.000***	-0.000***
		(0.000)	(0.000)
	hhage	0.011***	0.011***
		(0.002)	(0.002)
	hhagesqr	-0.000***	-0.000***
		(0.000)	(0.000)
	hhedu	-0.003**	-0.002*
		(0.001)	(0.001)
	hhmale	0.042***	0.042***
		(0.011)	(0.012)
	share_child	-0.404***	-0.404***
		(0.045)	(0.045)
	share_old	-0.039	-0.040*
		(0.025)	(0.024)
	share_madult	0.047	0.048
		(0.029)	(0.030)
	constant	7.032***	7.038***
		(0.070)	(0.070)
	County Fixed Effect	Yes	Yes
	Mediation Variables	Expenditure share	Calorie share
Independent Variable	lnincome	0.021***	0.011***
		(0.002)	(0.001)
	constant	0.078***	0.033**
		(0.028)	(0.016)
	Control Variables	Yes	Yes
	County fixed effect	Yes	Yes
	N	11678	11678

Note: Standard Errors are reported in brackets. and ***, **, * denote significant at 1%, 5% and 10% respectively. All the other results estimated share the same group of control variables, so we do not list them one by one in other tables.

In Table 3, the first column reports the results using the expenditure share of meat consumption ($esmeat_i$) as an indicator for dietary structural change; while the second column reports the results using the calories share of meat ($calsmeat_i$). For both measures of food structure, all the coefficients of interests, including the parameters of $lincome_i$, $esmeat_i$ and $calsmeat_i$, are positive and statistically significant. It is consistent with our expectations.

Using equation (7), with the estimated coefficients in the first and the second column in hand, the estimated unconditional income elasticity of calorie consumption is 0.017+0.282*0.011=0.020 with meat expenditure share as the measure for the dietary structure which is 0.016+0.197*0.021= 0.020. The unconditional income elasticities are very close even we have different food structure measures.

Consistent with the literature, almost all control variables are statistically significant, such as household head gender, household head age, and household head education, local food facilities, etc. It evidences that the model fits the data very well.

- Staple food ratio as the mediator

An alternative measure for changes in food structure induced by nutrition transition in the developing and emerging economy is the expenditure and calorie share of staple food. As we listed in Table 4, the results are highly significant and not surprising: when the household becomes rich, the family members tend to consume more food and have higher calorie intake. Meanwhile, they tend to decrease the expenditure and calorie ratio devoted to staple food.

Table 4: Empirical results with staple food ratio as a mediator

Variables		SUR with Bootstrapped SE	
Main regression	lncalint	expenditure share	calorie share
Mediation variables	esstaple	0.203***	
	calsstaple		0.135***
Independent variable	lnincome	0.024***	0.022***
	Control Variables	Yes	Yes
	County fixed effect	Yes	Yes
	lnincome	esstaple	calsstaple
Independent variable		-0.020***	-0.017***
Control variables	Yes	Yes	Yes
County fixed effect	Yes	Yes	Yes
	N	11678	11678

Note: Standard Errors are reported in brackets. and ***, **, * denote significant at 1%, 5% and 10% respectively.

- Robustness check

To implement a robustness check, we conduct subsample estimations separately for each year. Since the demand elasticity for meat may change over time (Chavas, 1983). The results are reported in Table 5.

Table 5: SUR results for each year

lncalint	Expenditure share			Calorie share		
Year	2004	2006	2009	2004	2006	2009
esmeat	0.149***	0.261***	0.183***			
	(0.038)	(0.044)	(0.047)			
calsmeat				0.175*	0.460***	0.296***
				(0.089)	(0.088)	(0.093)
lnincome	0.022***	0.020***	0.026***	0.024***	0.021***	0.026***
	(0.007)	(0.006)	(0.007)	(0.007)	(0.006)	(0.007)
facility	-0.000	-0.000*	-0.001***	-0.000	-0.000*	-0.001***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
hhage	0.009**	0.012***	0.013**	0.009**	0.011***	0.013**
	(0.004)	(0.004)	(0.005)	(0.004)	(0.004)	(0.005)
hhagesqr	-0.000**	-0.000***	-0.000***	-0.000**	-0.000***	-0.000***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
hhedu	-0.001	-0.007***	0.000	-0.001	-0.007***	0.001
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
hhmale	0.030	0.081***	0.019	0.030	0.080***	0.019
	(0.020)	(0.018)	(0.021)	(0.020)	(0.016)	(0.021)
share_child	-0.428***	-0.322***	-0.414***	-0.429***	-0.332***	-0.407***
	(0.078)	(0.074)	(0.082)	(0.078)	(0.074)	(0.082)
share_old	-0.105**	-0.105***	0.043	-0.108***	-0.103***	0.042
	(0.041)	(0.038)	(0.042)	(0.041)	(0.039)	(0.044)
share_madult	0.037	-0.010	0.101*	0.035	-0.004	0.099
	(0.052)	(0.038)	(0.061)	(0.050)	(0.038)	(0.061)
constant	7.134***	6.943***	6.800***	7.139***	6.941***	6.801***
	(0.123)	(0.117)	(0.147)	(0.122)	(0.123)	(0.148)
County Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes
Year	2004	2006	2009	2004	2006	2009
lnincome	0.028***	0.019***	0.013***	0.013***	0.008***	0.007***
	(0.003)	(0.003)	(0.003)	(0.002)	(0.002)	(0.002)
_cons	0.028	0.070	0.143***	-0.006	0.043*	0.087***
	(0.052)	(0.043)	(0.049)	(0.026)	(0.026)	(0.028)
Control Variables	Yes	Yes	Yes	Yes	Yes	Yes
County fixed effect	Yes	Yes	Yes	Yes	Yes	Yes
N	3754	3896	4028	3754	3896	4028

Note: Standard Errors are reported in brackets. and ***, **, * denote significant at 1%, 5% and 10% respectively.

While the conditional income elasticity stays between 0.020 and 0.026, slightly larger than the counterpart elasticity in the primary results, the importance of the structural change effect varies as well. The signs of coefficients in the year-specific regression are consistent with the primary setting.

Table 6: Rural-urban Gap

lncalint	Expenditure share		Calorie share	
Regions	Rural	Urban	Rural	Urban
esmeat	0.223***	0.145***		
	(0.030)	(0.040)		
calsmeat			0.362***	0.162**
			(0.067)	(0.077)
lnincome	0.014***	0.021***	0.015***	0.022***
	(0.005)	(0.006)	(0.005)	(0.006)
facility	- 0.000***	-0.000	- 0.000***	-0.000
	(0.000)	(0.000)	(0.000)	(0.000)
hhage	0.016***	0.004	0.016***	0.003
	(0.003)	(0.003)	(0.003)	(0.003)
hhagesqr	- 0.000***	-0.000**	- 0.000***	-0.000**
	(0.000)	(0.000)	(0.000)	(0.000)
hhedu	-0.002	-0.004**	-0.001	-0.004**
	(0.002)	(0.002)	(0.002)	(0.002)
hhmale	0.046***	0.036**	0.046***	0.035**
	(0.016)	(0.017)	(0.017)	(0.016)
share_child	- 0.469***	-0.206**	- 0.469***	-0.201**
	(0.052)	(0.080)	(0.049)	(0.087)
share_old	-0.039	-0.029	-0.040	-0.030
	(0.033)	(0.033)	(0.033)	(0.033)
share_madult	0.021	0.091**	0.023	0.090**
	(0.039)	(0.045)	(0.040)	(0.044)
constant	6.914***	7.455***	6.915***	7.476***
	(0.089)	(0.096)	(0.087)	(0.099)
County Fixed Effect	Yes	Yes	Yes	Yes
Regions	Rural	Urban	Rural	Urban
lnincome	0.023***	0.018***	0.012***	0.010***
	(0.002)	(0.003)	(0.001)	(0.002)
_cons	0.057*	0.231***	0.033*	0.074***
	(0.033)	(0.051)	(0.017)	(0.027)
Control Variables	Yes	Yes	Yes	Yes
County fixed effect	Yes	Yes	Yes	Yes
N	7876	3802	7876	3802

Note: Standard Errors are reported in brackets. and ***, **, * denote significant at 1%, 5% and 10% respectively.

Some researchers may concern the rural-urban gap on the dietary change dynamics in China (e.g. Shimokawa 2010; Tian and Yu 2015). Our results in Table 6 show that rural consumers have a higher marginal effect of food structure on calorie consumption, but the condition income elasticities are very close: both are very small. It implies that different nutrition transition processes between rural and urban in China rests on food structure. Particularly, rural households demand more for dietary quality and food diversity.

- Decomposition

Table 7: The decomposition of nutrition improvement

	Expenditure share			Calorie share		
Sample	Whole sample	Rural Region	Urban Region	Whole sample	Rural Region	Urban Region
Indirect effect	0.004***	0.005***	0.003***	0.003***	0.004***	0.002*
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Direct effect	0.016***	0.014***	0.021***	0.017***	0.015***	0.022***
	(0.004)	(0.005)	(0.007)	(0.004)	(0.005)	(0.006)
Total effect	0.020***	0.019***	0.023***	0.020***	0.019***	0.023***
	(0.004)	(0.005)	(0.006)	(0.004)	(0.005)	(0.006)
Indirect ratio	0.210***	0.266***	0.112	0.155***	0.216**	0.069
	(0.058)	(0.099)	(0.299)	(0.047)	(0.091)	(0.058)
Direct ratio	0.790***	0.734***	0.888***	0.845***	0.784***	0.931***
	(0.058)	(0.099)	(0.299)	(0.047)	(0.091)	(0.058)
N	11678	7876	3802	11678	7876	3802

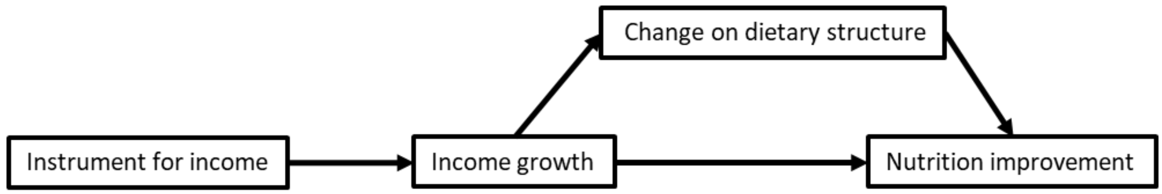
Note: Standard Errors are reported in brackets. and ***, **, * denote significant at 1%, 5% and 10% respectively.

Table 7 reports the decomposition of unconditional income effect into a direct (conditional) income effect and structural change effect. We already calculated that the unconditional income elasticity of calorie consumption is 0.016. It means that a 1% improvement in income will increase per capita calorie consumption by 0.02%. This shows that the marginal effect income on calorie consumption is a trivial number, as most of the Chinese residences are released from hunger. However, given such a small income elasticity, the contribution rates of dietary structural change (indirect effect of income) are estimated at around 20%, the rest 80% is still attributed to the food quantity expansion driven by direct income growth.

Meanwhile, the rural-urban gap should not be ignored. Early study shows that high income correlates with obesity and high in fat food patterns especially in urban China. (Popkin et al., 1993). In our case, more than 20% of the total income effect can be attributed to a dietary structural change in rural China, while only 7% to 11% can be attributed to a dietary structural change in urban China. One possible explanation is that consumers in rural China still have more room to improve their dietary quality and food diversity, while the food demand for urban consumers is much closer to a saturation point.

To deal with the endogeneity issue of income, we further use a mediation analysis with a single instrument approach proposed by Pinto et al. (2019) and elaborated by Dippel, Ferrara & Heblich (2019). The advantage of this approach compared with traditional two-step least squares (2SLS) is that the former allows the disentangling of the direct effect (or conditional effect) from the indirect effect while the latter does not. Figure 4 shows the intuition of the Pinto et al. (2019) method explicitly.

Figure 4: Extended framework



As for the choice of instrumental variable, we follow Nie and Sousa-Poza (2014) and use the number of durable assets of the household as the instrumental variable for household income. In detail, the number of durable assets is the summation of numbers of air conditioning, camera, fan, personal computer, refrigerator, sewing machine, telephone, TV, VCR, and wash machine owned by the household.

Based on the single instrument mediation analysis, we report the result in Table 8. Notice that the result is hard to be explained since the indirect effect becomes even negative when we add durable assets as an instrument variable. In this case, after controlling for the endogeneity, the income growth leads to both the negative effect for meat consumption via dietary structure and the positive meat consumption growth effect assuming the dietary structure unchanged.

Table 8: The decomposition in the extended framework

	Meat expenditure share	Meat calorie share	Staple expenditure share	Staple calorie share
Indirect effect	-0.004	-0.004	-0.004	-0.004
	0.018	0.019	0.019	0.019
Direct effect	0.020	0.020	0.021	0.021
	0.005	0.005	0.005	0.005
Total effect	0.016	0.016	0.016	0.016
	0.016	0.016	0.016	0.016
Indirect ratio	-24.872%	-25.315%	-25.944%	-25.838%
Direct ratio	124.872%	125.315%	125.944%	125.838%

N	11678	11678	11678	11678

6. Conclusion

Nutrition transition has been widely studied in the literature. Food structure is known to play important roles in nutrition improvements, but its effect has not been quantitatively examined. To fill in the research gap in the literature, this study proposes a simple but innovative method to empirically decompose the total income effect on nutrition improvement into direct (conditional) income effect and dietary structural change effect. With the use of the China Health and Nutrition Survey (CHNS) data, we find that unconditional income elasticity of calorie consumption is 0.02: a 1% increment in income will boost per capita calorie consumption by 0.02% within a family. It is evident that Chinese consumers have been released from the hunger stage so that the total marginal effect of income on calorie consumption is very small.

By decomposition, we find that about 16% to 21% of the calorie consumption uprising is driven by the dietary structural change, while the remaining part is attributed to the direct income effect. This implies that dietary structural change plays an important role in nutrition improvement.

The importance of dietary structure is found to be different between rural and urban areas. Specifically, the dietary structural change effect is more prominent in the rural region, which implies a rural-urban gap in the diet. 22% to 27% of the total income effect can be attributed to a dietary structural change in rural China, while only 7% to 11% in urban China. More meat consumption is expected in rural China. One policy implication is that global demand for meat is expected to be driven by the high demand for animal source products as households' increasing demand in rural China. It is wise to make predictions and bridge the gap in advance to avoid unnecessary market frictions and deal with the food security issue. Given China's enormous population, this is not only a local food security issue, but a challenge for global meat producers and the environment as the high carbon emission of meat compared with other categories of food.

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