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NUTRITION IN CHINA: MALNUTRITION, NUTRITION INEQUALITY AND NUTRITION POVERTY

This paper describes and analyzes the nutrition status of China on the base of the China Health and Nutrition Survey data. The author discusses the decreasing nutrition level and rising nutrition inequality and nutrition poverty in China, estimates the correlation between nutrition and income, discloses the significant influence of expenditure uncertainty on the nutrition level, and advances to perfecting the social security system to reduce residents' uncertainty expectation and improve food consumption.

Keywords: nutrition, inequality, poverty, income, expenditure uncertainty.

Ван Хуей

ПРОБЛЕМИ ХАРЧУВАННЯ В КИТАЇ: НЕДОЇДАННЯ, НЕРІВНІСТЬ СПОЖИВАННЯ І ХАРЧОВА БІДНІСТЬ

У стаття описано й проаналізовано проблеми харчування в Китаї з урахуванням даних опитування з охорони здоров'я і харчування. Відзначено тенденцію зниження кількості та якості харчування, зростання нерівності в споживанні продуктів і харчової бідності, оцінено кореляцію між харчуванням і доходом, розкрито вплив невизначеності доходів на якість харчування. Запропоновано заходи щодо вдосконалення системи соціального забезпечення для зниження невизначеності доходів населення та покращення якості харчування.

Ключові слова: харчування, нерівність, бідність, доходи, невизначеність доходів.

Рис. 1. Табл. 7. Форм. 7. Літ. 15.

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ПРОБЛЕМЫ ПИТАНИЯ В КИТАЕ: НЕДОЕДАНИЕ, НЕРАВЕНСТВО ПОТРЕБЛЕНИЯ И ПИЩЕВАЯ БЕДНОСТЬ

В статье описаны и проанализированы проблемы питания в Китае с учетом данных опроса по здравоохранению и питанию. Отмечена тенденция снижения количества и качества питания, роста неравенства в потреблении продуктов и пищевой бедности, оценена корреляция между питанием и доходами, раскрыто влияние неопределенности доходов на качество питания. Предложены меры по совершенствованию системы социального обеспечения для снижения неопределенности доходов населения и улучшения качества питания.

Ключевые слова: питание, неравенство, нищета, доходы, неопределенность доходов.

1. Introduction.

China experienced a growth miracle over the last 30 years. But the rapid growth of Chinese economy didn't bring a significant improvement of the overall nutrition level. Taking calorie as the substitute variable of nutrition, the average calorie intake levels were decreasing accompanied by the per capita income growth (Du et al., 2002; Meng et al., 2004; Ma and Zhang, 2011). Not only in China, other developing countries also had similar situations. In spite of having the period of rapid economic growth from 1980 to 2005, the per capita calorie intakes of the Indians indicated a declining trend by the research of Deaton and Dreze (2008). Deaton and Dreze excluded the food price affect on the decreasing per capita calorie intake. They

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thought that it was the decline of general labor intensity which resulted in the decrease of per capita calorie intake. There are also other interpretations on the negative correlation between calorie intake and income. One of the most popular interpretations is that the calorie-income elasticity may be negative. People in developed countries may pay much more attention to the components of diet and control the intakes of calorie for health. But in developing countries there was a big income gap as compared with developed countries. Many studies show the positive income elasticity of nutrition demand in developing countries (Pitt, 1983; Strauss, 1984; Alderman, 1987; Bouis and Haddad, 1992).

The existing studies mainly discuss what factors result in the decrease of average nutrition intake. There are few studies on the demographic structure of nutrition. That is, as income level rising, whether does the nutrition intake get much more unequal, whether the rate of malnutrition increases or does the poverty rate of nutrition get worse. This paper studies the above problems based on the China Health and Nutrition Survey (CHNS) data. The remainder of this paper is organized as follows. Section 2 is the data description, Section 3 presents the calculation method of inequality and nutrition poverty. Section 4 is the statistical results. The further analysis of the relationship between income and nutrition and between medical insurance and nutrition are shown in Section 5. And we place the research conclusions in Section 6.

2. Data Description.

The data comes from the China Health and Nutrition Survey database. The surveys began in 1989 and have been carried out 8 times in 1989, 1991, 1993, 1997, 2000, 2004, 2006, and 2009, respectively. We use the calorie as the substitute variable of nutrition. The database gives the 3 days average kcal-based calorie intake level. We take the people who are over one year old as the research samples. As Deaton and Dreze has pointed out that the labor intensity is the main factor of the per capita calorie intake level reduction, we standardize the calorie intake level to eliminate the impact of labor intensity and reflect the real nutritional status of China's residents. The method is indicated as below. Based on the Chinese Recommended Nutrient Intake (RNI) table of calorie for genders and labor intensities with different ages edited by Chinese Nutrition Society, the value of resident's calorie intake in CHNS database is divided by the corresponding RNI of calorie to get the standardized calorie intake level. If the standardized value equals to 1, it means the present sample has moderate calorie intake. And what means insufficient (or excess) calorie intake if it is less (or more) than 1. The labor intensities include light physical activity, moderate physical activity and heavy physical activity. The light physical activities include jobs in a sitting position such as office workers or in a standing position such as salesperson, laboratory, teacher etc. We also take the no working ability and unemployment as light physical activity. Moderate physical activities include the jobs such as student, driver, electrician, metal worker etc. Heavy physical activities include the jobs such as farmer, dancer, steel worker, athlete, loader, logger, miner, stonecutter etc. Table 1 indicates the results of standardization. From 1989 to 2009, the average standardized level has dropped 19.8% from 1.16 to 0.93. This also suggests that the decrease of labor intensity isn't the main factor which induced the decline of China residents' calorie intake.

Table 1. Standardized per capita calorie intake level of China's residents

	1989	1991	1993	1997	2000	2004	2006	2009
Samples	6580	12294	11863	11423	12370	10983	10528	10927
Average level	1.1552	1.0436	1.0077	0.9441	0.9489	0.9480	0.9167	0.9262

3. Nutrition Inequality and Nutrition Poverty: The Method.

Table 1 only shows the downtrend of the average calorie intake. It doesn't show the demographic structure of nutrition which are presented by the nutrition inequality and poverty. That is, whether nutrition inequality gets worse and the rate of malnutrition becomes greater. The nutrition inequality and poverty can be calculated using FGT indices. The FGT indices were advanced by Foster, Greer and Thorbecke to measure poverty in 1984. The FGT indices have some desirable properties such as additive decomposability. The FGT poverty measures can be defined as:

$$P_{\alpha} = \int_0^z \left| \frac{z-x}{z} \right|^{\alpha} f(x) dx, \tag{1}$$

where x is the stochastic variable presenting standardized nutrition level, $f(x)$ is its density (roughly the proportion of the population consuming x), z denotes the poverty line which equals 1 here, and α is the sensitivity parameter which is nonnegative. The higher are the values of α , the greater the sensitivities of the poverty measure to inequality are. That is, if α is high, those with lower values (far below z) are given more weight in the measure.

We describe the estimation of poverty measures P_{α} for $\alpha = 0, 1, \text{ and } 2$. If $\alpha = 0$, P_0 is the headcount ratio which means the fraction of the population that lives below the poverty line. If $\alpha = 1$, P_1 is the average poverty gap which means the necessary amount for people in poverty up to the poverty line rightly. And if $\alpha = 2$, P_2 is the squared poverty gap which means the weighted necessary amount for people under the poverty line. The weight is P_1 . We use H , PG , and SPG to denote P_0 , P_1 , and P_2 respectively.

The poverty indices P_{α} can be estimated with Lorenz curves. The general quadratic (GQ) Lorenz curve (Villasenor and Arnold, 1989) and the Beta Lorenz curve (Kakwani, 1980) are the two most popular models. The GQ model fits the data much better than the Beta model in drawing the Lorenz curve in our studies. So we choose the GQ model to estimate the Lorenz curve and the equation is defined as:

$$L(1-L) = a(P^2 - L) + bL(P-1) + c(P-L), \tag{2}$$

where P is the cumulative proportion of population, L is the cumulative proportion of stochastic variable x . Through estimating the parameters a , b , and c , we can calculate the poverty indices based on the following equations (Datt, 1998):

$$H = -\frac{1}{2m} \left\{ n + r \left(b + \frac{2z}{\mu} \right) \left[\left(b + \frac{2z}{\mu} \right)^2 - m \right]^{-1/2} \right\}, \tag{3}$$

$$PG = H - \frac{\mu}{z} L(H), \tag{4}$$

$$SPG = 2PG - H - \left(\frac{\mu}{2} \right)^2 \left[aH + bL(H) - \frac{r}{16} \ln \left(\frac{1-H/s_1}{1-H/s_2} \right) \right] \tag{5}$$

A widely used measure of inequality, namely the Gini index, is easily calculated using the estimated parameters a , b and c of the Lorenz curve. The relevant formulas are:

$$Gini = \frac{e}{2} - \frac{n(b+2)}{4m} - \frac{r^2}{8m\sqrt{m}} \ln \left\{ \left[\frac{2m+n+2\sqrt{m}(a+c-1)}{n-2e\sqrt{m}} \right] \right\} \text{ if } m > 0$$

$$Gini = \frac{e}{2} - \frac{n(b+2)}{4m} + \frac{r^2}{8m\sqrt{-m}} \left(\sin^{-1} \frac{2m+n}{r} - \sin^{-1} \frac{n}{r} \right) \text{ if } m < 0,$$
(6)

Here $e = -(a+b+c+1)$, $m = b^2 - 4a$, $n = 2be - 4c$, $r = \sqrt{n^2 - 4me^2}$, $s_1 = \frac{r-n}{2m}$, $s_2 = \frac{r+n}{2m}$ and μ is the average value of the x , Gini is the coefficient which represents the inequality degree of x .

4. The Estimated Results.

This paper uses an interactive software, POVICAL available as a freeware at the website: <http://iresearch.worldbank.org/PovcalNet/index.htm?0,5> worked out by Shaohua Chen and Martin Ravallion, to estimate the calorie intake FGT indices of China. The Gini coefficients which mean the nutrition inequality show the rising trend. And the rise of poverty indices, H, PG, and SPG, indicate the deprivation of the nutrition poverty phenomenon. They all suggest that the demographic structure of nutrition has been getting worse with the development of Chinese economy (Table 2).

Table 2. FGT indices and Gini coefficients (%)

Year	H	PG	SPG	Gini
1989	36.99	6.73	1.85	17.74
1991	49.04	8.70	2.33	15.20
1993	55.32	10.79	3.15	16.12
1997	63.79	13.70	4.40	15.94
2000	64.14	14.88	4.98	17.93
2004	63.96	15.28	5.29	18.51
2006	67.12	16.95	5.97	18.35
2009	67.45	16.72	5.91	18.93

The tri-relationships between average calorie intake level, nutrition inequality and nutrition poverty can be analyzed by poverty elasticity. The poverty elasticity refers to the percentage change in poverty in response to 1% change of the variable. Kakwani (1990) derived the point estimates of the elasticity of poverty measures with respect to mean value of the stochastic variable (here is mean nutrition intake level) and the Gini index. We define them η_G and η_I respectively. The estimation formulas (Datt, 1998) are presented in Table 3.

Table 3. Elasticity of poverty measures with respect to the mean value and the Gini index

Elasticity of	with respect to	
	Mean value	Gini index
H	$-z/(\mu HL''(H))$	$(1-z/\mu)/(HL''(H))$
PG	$1-H/PG$	$1+(\mu/z-1)H/PG$
SPG	$2(1-PG/SPG)$	$2[1+(\mu/z-1)PG/SPG]$

The η_G is always negative. It means that the increase of average nutrition intake could reduce the nutrition poverty definitely. The η_I refers to the influence of the Gini coefficient. It may be 0, negative, or positive. It means that the increase of Gini coefficient could be to the benefit (disadvantage) of the poverty reduction as it is negative (positive). And if $\eta_I = 0$, the improvement of the overall nutritional status can reduce the poverty monotonically. Using η_G and η_I can define the poverty reduction index (ϕ) as

$$\phi = 1 + \frac{\eta_I}{\eta_G} \tag{7}$$

If $\phi > 0$, the improvement of average nutrition intake level will reduce the nutrition poverty, and if $\phi < 0$, the improvement of average nutrition intake level will increase the nutrition poverty contrarily (Lin, 2003). The results are shown in Table 4.

The positive poverty reduction indices ϕ and negative mean value elasticity η_G suggest that the decline of overall average nutrition intake be the most important reason of worsening the nutrition poverty status in China. The Gini index elasticity of H became negative after 1997 which imply the decline in the proportion of nutrition poverty population with the improvement of Gini indices. But the Gini index elasticity of PG and SPG are always positive which mean the gaps between the actual nutrition intake and the poverty line z for the malnutrition have positive relationship with nutrition inequality. So the Gini index elasticity η_I indicate that the nutrition poverty is stimulated by nutrition inequality. That is, the rising Gini indices make the nutrition poverty more further away from the poverty line. Taking into account the absolute value of η_G is greater than the absolute value of η_I , improving the overall nutrition level is the primary means to reduce nutrition poverty.

Table 4. Decomposition of nutrition elasticity and poverty reduction index

Year	Elasticity of	with respect to		Poverty reduction index (ϕ)
		Mean value (η_G)	Gini index (η_I)	
1989	H	-3.692	0.573	0.845
	PG	-4.499	1.853	0.588
	SPG	-5.265	3.127	0.406
1991	H	-3.490	0.152	0.956
	PG	-4.638	1.246	0.731
	SPG	-5.475	2.326	0.575
1993	H	-2.957	0.023	0.992
	PG	-4.125	1.040	0.748
	SPG	-4.851	2.053	0.577
1997	H	-2.442	-0.136	1.056
	PG	-3.657	0.740	0.798
	SPG	-4.226	1.652	0.609
2000	H	-2.117	-0.108	1.051
	PG	-3.311	0.780	0.764
	SPG	-3.978	1.695	0.574
2004	H	-2.076	-0.108	1.052
	PG	-3.186	0.783	0.754
	SPG	-3.778	1.700	0.550
2006	H	-1.783	-0.148	1.083
	PG	-2.961	0.670	0.774
	SPG	-3.678	1.527	0.585
2009	H	-1.848	-0.136	1.074
	PG	-3.034	0.702	0.769
	SPG	-3.661	1.582	0.568

5. Further Analysis.

5.1. Nutrition and Income. In many related references, income is thought to be the most important variable influencing people nutrition. This paper divides the samples into quintile by income. The respective average nutrition intake is listed in Table 5. China has been experiencing the reform of market economy system since 1992. So the nutrition intake differences between different income groups were very little before 1992. Even in 1989, the average nutrition intakes of the 1st and 2nd quintile are greater than the rest populations who have much higher income levels. The reason is that Chinese people got goods through the rationing in the planned economy period with the shortage of necessities. And the prices for necessities such as education, housing, and medical treatment were controlled by government. There were no uncertainties of income and expenditure, even the average income level was much lower than that of today. And in addition, the lower the income is, the higher the degree of food self-sufficiency is in shortage economy. Self-sufficiency became a kind of advantage for food consumption in shortage economy. But the nutrition intake levels of the 1st, 2nd, and 3rd quintiles indicated continuing downward trend, the 4th and 5th quintiles then performed steadily. The differences between income groups became greater and greater. Even in the period of short planned economy, peoples still could achieve the Pareto improvement of food consumption through exchange. The income may be not the primary factor which influences the nutrition intake of China's residents. We think that the expenditure uncertainty brought by the reform of market economy system impelled the lower income groups to scant themselves in foods consumption. They put much more proportions of income on the precautionary savings to deal with uncertainties. If China's government wants to change the deterioration trend of nutrition, it should perfect the social security system to reduce the residents' uncertainty expectations.

Table 5. Average nutrition intake levels by income quintiles

Year	1st quintile	2nd quintile	3rd quintile	4th quintile	5th quintile
1989	1.2311	1.155	1.1415	1.1072	1.1411
1991	1.0349	1.044	1.0319	1.0525	1.0547
1993	1.004	1.0129	1.0107	1.0079	1.0031
1997	0.9099	0.9333	0.9587	0.9671	0.9616
2000	0.913	0.9118	0.9662	0.9559	0.9974
2004	0.8727	0.9102	0.9494	0.9767	1.0113
2006	0.8775	0.8759	0.932	0.964	0.9841
2009	0.8612	0.8692	0.9294	0.9701	0.9811

We can also use the nonparametric regression for a technological test. The nonparametric regression is a kind of regression analysis in which a research doesn't take a predetermined form but is constructed according to information derived from the data. The nonparametric regression can reflect the true relationship between variables better than traditional linear and nonlinear regressions. This paper considers estimating the unknown regression function using Nadaraya-Watson kernel regression. We set the 15% of the range of explanatory variable as bandwidth. Here, the *per_income* presents the resident's annual income level which is the explanatory variable; the *calorie* presents the resident's standardized nutrition intake level which is the explained variable. Figure 1 shows the estimated regression function using Gaussian kernel.

For the overwhelming majority samples, the resident's income doesn't indicate a significant positive relationship with its nutrition intake in the every year nonparametric regression result. But the volatilities of the lower-income groups are much greater than of higher-income groups. Because there is a strong elasticity of substitution between various priced foods, peoples have to deal with the uncertain expenditure by economizing food expenditure. But lower-income groups have more difficulties in keeping their balance on food consumption and others. Government should enhance public welfare payments to reduce uncertainty and meet the nutritional needs of residents, especially lower-income ones. Figure 1 also indicates that the volatilities converge to 1 gradually with the rising of income. It suggests that the higher the income is, the more attention people pay to diet qualities instead of quantities to meet health needs.

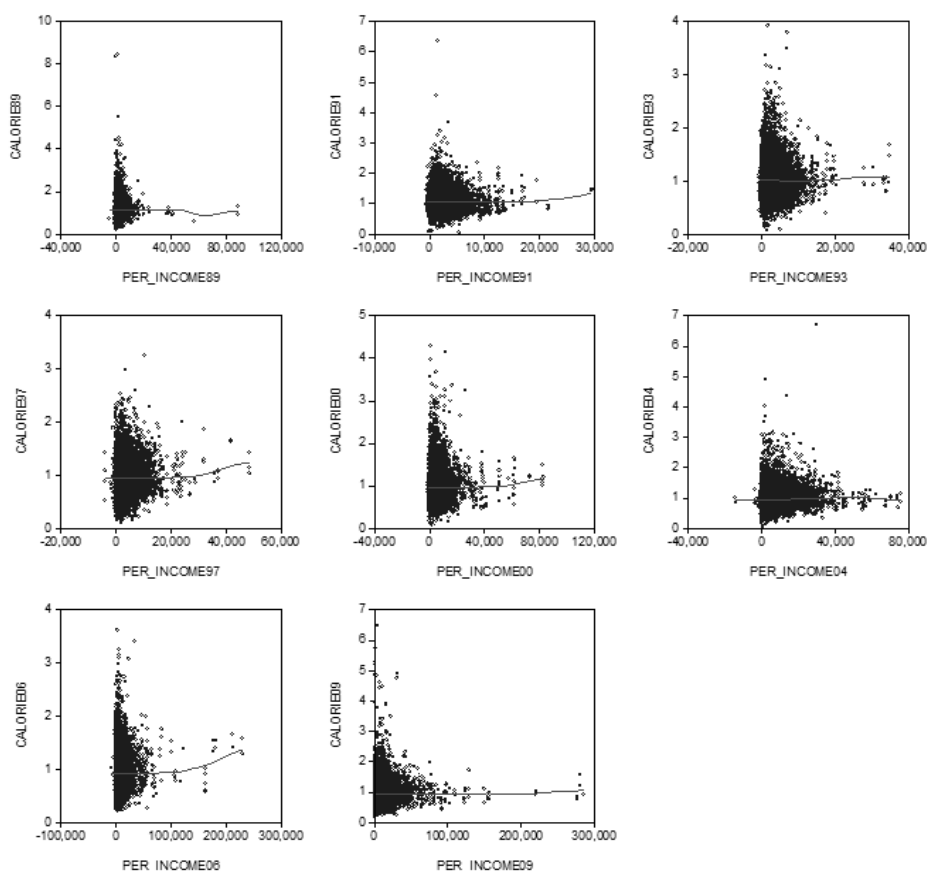


Figure 1. Estimated nonparametric regression function

5.2. Nutrition and Medical Insurance. There is a medical insurance survey in CHNS database. This paper uses the medical insurance survey as the substitute variable for expenditure uncertainty. The CHNS has seven-year survey on medical insurance except 1989. First, we divide the samples into insured and uninsured and calcu-

late the average nutrition level of every income group respectively (Table 6). Before 1993, the differences between insured and uninsured were very little. The influences of expenditure uncertainty brought by the reform of market-oriented economic system are so obvious that the insured have much higher nutrition intake level than the uninsured either for the total or for the sub-groups since 1997. For the 1st income group, the nutrition levels of insured are lower than that of the uninsured, especially in 2004 and 2009. We think that the lowest income group has the least abilities to deal with uncertainties. Some expenditure uncertainties except medical treatment may have much more influence on food consumption. Second, we use the formulas from Section 3 to estimate the nutrition inequality and poverty for insured and uninsured respectively (Table 7). Although the poverty FGT indices have been rising since 1991, the insured still have lower poverty than the uninsured. So how to get rid of the expenditure uncertainty is an effective mean to improve the overall nutrition intake level and reduce the nutrition poverty.

Table 6. Average nutrition intake level of insured and uninsured for different income groups

Year	Total		1st		2nd		3rd		4th		5th	
	Insured	Uninsured	Insured	Uninsured	Insured	Uninsured	Insured	Uninsured	Insured	Uninsured	Insured	Uninsured
1991	1.0553	1.0393	1.0093	1.0445	1.0465	1.0454	1.0416	1.0243	1.059	1.0397	1.0632	1.0409
1993	1.0149	1.0069	0.9898	1.0032	1.0042	1.0202	1.0081	1.0028	1.0026	1.013	1.0163	0.9886
1997	0.9922	0.9305	0.9907	0.9076	0.9936	0.9243	0.9784	0.9313	0.9827	0.9587	1.0062	0.9417
2000	0.9978	0.935	0.9473	0.9058	0.9119	0.8909	0.9786	0.9551	0.9855	0.9547	1.0374	0.9688
2004	1.0072	0.9256	0.8649	0.8662	0.9389	0.9213	0.9749	0.9392	1.0052	0.9625	1.0636	0.9763
2006	0.9681	0.867	0.9512	0.8299	0.9161	0.8604	0.9595	0.8815	0.9624	0.8946	1.017	0.8888
2009	0.9279	0.9103	0.8692	0.8776	0.9044	0.8572	0.9289	0.9177	0.9438	0.915	0.9898	0.9392

Table 7. FGT indices and Gini coefficients of insured and uninsured (%)

year	H		PG		SPG		Gini	
	insured	uninsured	insured	uninsured	insured	uninsured	insured	uninsured
1991	45.55	50.42	7.78	9.07	2.02	2.44	14.37	15.53
1993	53.40	55.69	10.03	10.99	2.89	3.22	15.51	16.32
1997	56.21	65.99	10.77	14.52	3.08	4.76	14.97	16.10
2000	56.09	66.17	11.34	15.84	3.51	5.38	16.34	18.23
2004	55.58	67.09	12.26	16.44	4.01	5.76	18.13	18.46
2006	59.03	73.82	13.98	19.65	4.74	7.10	18.70	18.00
2009	67.34	68.45	16.67	17.16	5.88	6.13	18.99	18.32

6. Discussion and Conclusion.

Food consumption is a kind of basic consumption behavior which maintains the body health for daily activities and improve human capital. But we find that the overall nutritional status of Chinese residents was worsening from 1989 to 2009 with the rapid economic growth. And it is more serious for lower-income groups than for higher-income groups. The population structure of nutrition can be calculated through the estimated parameters of the Lorenz curve. The decreasing overall nutritional level is coexisting with the increasing nutrition inequality and poverty. The elastic analyses indicate that the deterioration of overall nutrition level is the main reason for increasing the nutrition poverty. And the nutrition inequality also contributes to the rise of nutrition poverty. At last, through comparing the nutrition level of different income groups, making a nonparametric regression, and taking into account medical insurance, we conclude that the expenditure uncertainty, not income uncer-

tainty, is the essential reason which leads to insufficient nutrition in China. Chinese government should reduce the residents' expenditure uncertainty through perfecting the social security system. Only in this way, the residents would cut down the precautionary savings and improve nutrition intake level. In the view of the rising uncertainties during the market-oriented process in developing countries, the residents' nutrition intake level may present an inverse U-shaped. In the beginning, the marginal utility of food consumption is the biggest. People allocate much more fractions of their incomes on food consumption. But when food consumption is satisfied gradually, the marginal utility of food consumption gets smaller and smaller and the marginal utilities of other requirements increase gradually. Rational consumers would cut down food consumption to increase the total utility level. We also divide the samples into urban and rural residents. The results are the same as above.

In this paper, calorie intake has some limitations as a nutrition intake while calorie is extremely important. And the objective of diet is very different for various income levels. Food consumption purpose of the poor is to satisfy the basic survival needs. But rich people prefer to satisfy their preferences and health. If we want to interpret what induce the decreasing calorie intake, we need to do huge statistics on the intake of all kinds of nutrients in future studies.

References:

- Alderman, H.* (1987). Cooperative Dairy Development in Karnataka, India: An Assessment. Research Report 64, IFPRI, Washington, DC.
- Bouis, H. E., Haddad, L. J.* (1992). Are Estimates of Calorie-Income Elasticities Too High? An Recalibration of the Plausible Range. *Journal of Development Economics*, 39: 333–364.
- Chinese Nutrition Society (2010). Chinese DRIS, China Light Industry Press, Peking, 5 p.
- Datt, G.* (1998). Computational Tools for Poverty Measurement and Analysis. FCND Discussion Paper, №50.
- Deaton, A., Dreze, J.* (2008). Nutrition in India: Facts and Interpretations. SSRN Working Paper, April: 1–77.
- Du, S., Lu, B. Zhai, F., Popkin, B. M.* (2002). A New Stage of the Nutrition Transition in China. *Public Health Nutrition*, 5, Vol. 1: 169–174.
- Foster, J., Greer, J., Thorbecke, E.* (1984). A Class of Decomposable Poverty Measures. *Econometrica*, 52: 761–766.
- Kakwani, N.* (1980). On a class of poverty measures. *Econometrica*, Vol. 48, №2: 437–446.
- Kakwani, N.* (1990). Testing for Significance of Poverty Differences: with Application to Cote D'Ivoire. World Bank Working Paper.
- Lin, B. Q.* (2003). Economic Growth, Income Inequity, and Poverty Reduction in the China. *Economic Research Journal*, 12: 15–25.
- Ma, S., Zhang, J.* (2011). New Rural Cooperative Medical System and Household Nutrient Structure. *Economic Research Journal*, 5: 126–137.
- Meng, X., Gong, X., Wang, Y.* (2004). Impact of Income Growth and Economic Reform on Nutrition Intake in Urban China: 1986–2000. IZA Discussion Paper №1448: 1–33.
- Pitt, M.* (1983). Food Preference and Nutrition in Rural Bangladesh. *Review of Economics and Statistics*, 65: 105–114.
- Strauss, J.* (1984). Joint Determination of Food Consumption and Product in Rural Sierra Leone: Estimates of a Household-Firm Model. *Journal of Development Economics*, 29: 157–184.
- Villasenor, J., Arnold, B. C.* (1989). Elliptical Lorenz curves. *Journal of Econometrics*, 40(2): 327–338.

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