Diet quality and income in Rural and Urban China: evidence from the Health and Nutrition Survey

Capacci S.[1], Mazzocchi M.[2] and Liu Y.[3]

[1] Department of Statistics, University of Bologna, Bologna, Italy
[2] Department of Statistics, University of Bologna, Bologna, Italy
[3] Department of Agricultural and Food Economics, University of Reading, UK

Abstract - **The specific objective of this paper is the investigation of the link between an improvement in Chinese households' wealth and the quality of their diet and the role played by this relationship on the overall nutrition transition process. Better economic conditions mean a worsening of the diet in terms of higher energy intakes from fats, only partially compensated by higher fruit and vegetable intakes. China nutrition transition is going on and the rapid economic growth may lead to adverse health consequences if the negative effects of this transition will not be contrasted.**

Keywords – **Nutrition, diet quality, China**

I. INTRODUCTION

China is right in the middle of the so called nutritional transition [1], which is pushing the country far from the early receding famine stage to a kind of westernization of food patterns. According to Popkin's analysis, since the Eighties the country has started to recover from a situation of inadequate nutrition, which reached the most dramatic momentum with the Great Leap Forward between 1957 and 1962 with the liberalization of food production, while China was experiencing a 10% GDP growth rate.

It is because of this rapid growth and the development of a free food market that a slow but continuing transformation of Chinese households' diets has been generated. The traditional Chinese food habits have been considered quite healthful – when sufficient intakes are achieved - by many scholars for years. However, since the Eighties, a diet which was low in fats and rich in cereals and vegetables has been progressively substituted by animal origin foods, with a larger fat content [2].

Hence, China seems like the perfect example of the global convergence towards a westernized diet, rich in saturated fats, sugars, refined foods and poor in fibres. The change in diet composition is accompanied by relevant transformations in general health conditions of the population. As a matter of fact, the nutrition transition process is also marked by the transition towards the most common nutrition diseases: famine is associated with malnutrition and nutrition deficiency disease, while the westernization process leads to an increasing prevalence of diet-related non-communicable diseases such as obesity, diabetes, cardiovascular diseases and cancer.

This paper contributes to the literature on the nutrition transition in China by confirming with 2000 data the westernalization trend observed in the Nineties and the increase in the relative weight of energy from fats already observed in most of previous studies. The specific objective of this paper is an investigation of the link between an improvement in Chinese household wealth and the quality of their diet and the role played by this relationship on the overall nutrition transition process.

The original contribution of this analysis is especially in the application at the household level of an indicator of compliance with WHO recommendations for an healthy diet [3] as developed at the macro-level for 149 countries in [4]. This indicator proves to be a useful synthetic indicator to compare diet composition at the micro-level and provides a good predictor of the health outcomes of changing dietary patterns.

II. DATA.

The analysis is based on data from the China Health Nutrition Survey (CHNS) which is the outcome of a multi-year and ongoing project conducted by the Carolina Population Center (University of North Carolina), the National Institute of Nutrition and Food Safety, and the Chinese Center for Disease Control and Prevention[1]. The aim of the project is to collect biomedical and socioeconomic information on Chinese households for policy analysis purposes. The size of the database (both in terms of observations and in terms of observed variables) allows to gather a large set of health, demographic, socioeconomic and nutrition information.

1. http://www.cpc.unc.edu/projects/china

The dataset include a household survey, a nutrition survey, an individual energy and physical examination record and a community survey.

Our paper, aiming to investigate nutrition transition in China, exploits one of the most interesting opportunity offered by the CHNS database. Thanks to the detailed dietary data, collected both for individuals and for the households as a whole, an analysis of the variety of factors affecting food choice becomes possible. Moreover the CHNS data has been merged with data from the 2002 Chinese Food Composition Survey in order to compute the nutrient content of each consumed food [5]. This allowed us to focus on nutrient intakes and to refer the analysis of nutritional status of Chinese households to universal guidelines (like the WHO recommendations) expressed in terms of nutrient goals.

Our analysis is conducted on 2000 CHNS data. The dataset is made up of 4074 households living in 9 provinces differing in geographical, economic and health conditions: Liaoning, Heilongjiang, Jiangsu, Shandong, Henan, Hubei, Hunan, Guanxi, Guinzhou. Household and individual food consumption data has been collected during 3 consecutive days. The quality of the food data collection has been checked by comparing individual and family diaries. An average individual daily consumption has been computed from the household data and has been transformed in term of energy intake, and protein, carbohydrates and fat contents.

A. The Recommendation compliance index (RCI).

As in [4], an indicator of distance from the WHO recommendations is built on a subset of aggregate nutrient goals. The indicator synthesises nutrient intake proportions with actual food intakes, such as fruit and vegetables, as this provides a useful benchmarking tool to compare dietary behaviours across households.

Let us define with l_i and u_i the lower and upper limit, respectively of the WHO recommendations for each of a set of n intake goals, i=1,…n. The basic indicator for a specific recommendation is defined by:

$$y_{ik} = \frac{1_{x_{ik}<l_i}(l_i - x_{ik}) + 1_{x_{ik}>u_i}(x_{ik} - u_i)}{\max\left[l_i, x_{MAX} - u_i\right]} \quad (1)$$

Where

- x_{ik} is the actual nutrient (food) intake corresponding to recommendation i and country k, with $x_{ik} \geq 0$, as it expresses quantities or percentages
- x_{MAX} is the maximum value for nutrient (food) intake, where applicable
- l_i is the lower limit (where applicable) of the WHO recommendation for each of a set of n dietary recommendations, i=1,…n
- u_i is the upper limit (where applicable) of the WHO recommendation
- $1_{x_{ik} \notin [l_i, u_i]}$ is an indicator function which is equal to 1 when the actual data falls outside the limits set by the WHO recommendation

The numerator in (1) measures the distance from the recommended bracket, while the denominator allows to standardise the basic indicator between 0 and 1. The following step is the aggregation of the basic indicators into a composite one, as follows:

$$I_k = 1 - \frac{\sum_{i=1}^{n} y_{ik} w_i}{\overline{y}_{MAX}} \quad (2)$$

where w_i is the weight given to the i-th recommendation. The RCI has been shown to be robust to changes in the weighting system and in the current study we place an equal weight to each recommendation. The RCI in (2) is equal to 1 when all nutrition targets are met (the "perfect diet"). Since the x_{ik} are not independent one to each other (for example, the percentage of calories from fats, carbohydrates and proteins is constrained to sum to 100%), the summation $\sum_{i=1}^{n} y_{ik} w_i$ is always smaller than 1.

Hence, it is necessary to solve a simple linear programming problem to standardise the composite indicator to lie between 0 (the diet furthest away from WHO recommendations) and 1 (perfect diet):

$$\overline{y}_{MAX} = \max_{y_i} \left\{ \mathbf{y}' \mathbf{w} \right\} \text{ subject to } \mathbf{A}\mathbf{x} \leq \mathbf{b} \quad (3)$$

where $\mathbf{y} = \left\{ y_i \right\}_{i:1,..n}$ and $\mathbf{x} = \left\{ x_i \right\}_{i:1,..n}$ are the n×1 vectors of values for a generic set of basic indicators and for the original variables, respectively; $\mathbf{w} = \left\{ w_i \right\}_{i:1,..n}$ is the (fixed) vector of weights and the

constraint $\mathbf{Ax} \leq \mathbf{b}$ reflects the relationships across the basic variables. Both the indicator in (2) and $\overline{y}_{MAX}$ are conditional to the predetermined set of weights. The WHO recommendations considered here are summarized in Table 1.

Table 1. Basic indicators for WHO nutrient goals [3]

Simple indicator	Variable	WHO recommendation	
		Lower limit (li)	Upper limit (ui)
y_1	x_1: % of calorie int. from fats	15%	30%
y2	x2: % of calorie int. from proteins	10%	15%
y3	x3: % of calorie int. from carbohydrates	55%	75%
y4	x4: fruit and vegetables int.	400g	None

Data on average energy and fruit and vegetable intakes are summarized in Table 2, together with the individual distances from the WHO recommendation and the aggregated RCI index assuming equal weight for each recommendation.

Table 2. Average energy intakes from fat, proteins and carbohydrates and average RCI in the sample.

	Mean (Standard Deviation)
% of energy int. from fat	30.28 (12.11)
% of energy int. from proteins	12.45 (3.52)
% of energy int. from carbohydrates	57.28 (12.71)
Fruit and vegetables (grams)	397 (443)
y1 (fats)	0.08 (0.11)
y2 (proteins)	0.08 (0.13)
y3 (carbohydrates)	0.01 (0.02)
y4 (fruit & vegetables)	0.25 (0.27)
Recommendation Compliance Index (RCI)	0.87 (0.12)

Table 2 confirms that the Chinese diet is – on average – an healthy diet. Average energy intakes are very closed to the recommended ranges and the individual distance indicators show that departure from the recommendation is very small and only noticeable for fruit and vegetables. If one compares these data with [6], the percentages of energy intakes from carbohydrates and fats are consistent with the trend observed between 1989 and 1997. Figure 1 below shows the distribution of the RCI across the sampled households. A large proportion of households meets the WHO requirements for the four selected goals or are very close to the targets.

It is interesting to look at the variation of these variables between rural and urban areas (Table 3) and according to the level of education (Table 4), gender (Table 5) and income class (Table 6) of the household head.

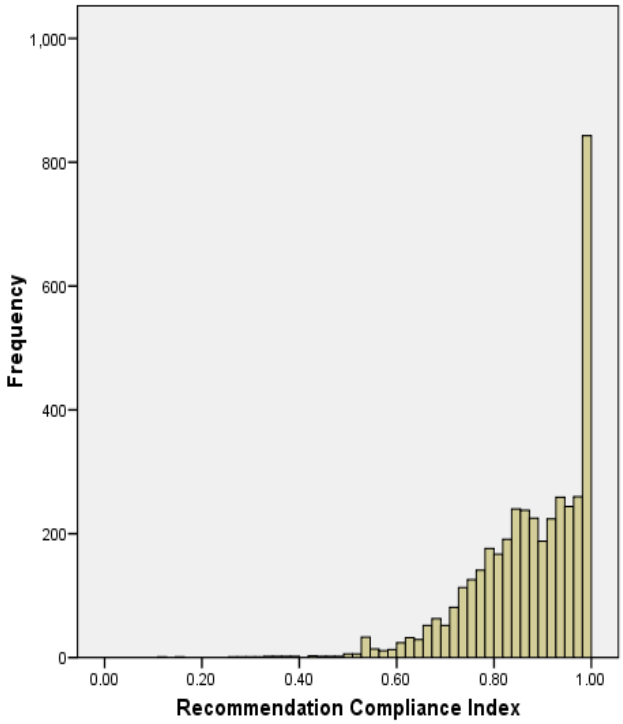

Fig 1. Distribution of the RCI across the sample (Mean=0.8771; Std.Dev.=0.11556; N=4,074)

Table 3. Diet quality indicators and income in rural and urban areas (Mean and Std. Dev.)

	Urban Areas	Rural Areas
% of energy int. from fat	35.27 (11.37)	27.70 (11.66)
% of energy int. from proteins	13.48 (3.82)	11.91 (3.22)
% of energy int. from carbohydrates	51.25 (11.80)	60.39 (12.03)
Fruit and vegetables (grams)	433.62 (492.87)	377.63 (413.92)
y1 (fats)	0.11 (0.12)	0.06 (0.10)
y2 (proteins)	0.01 (0.03)	0.01 (0.02)
y3 (carbohydrates)	0.12 (0.15)	0.06 (0.11)
y4 (fruit & vegetables)	0.20 (0.24)	0.28 (0.28)
Recommendation Compliance Index (RCI)	0.86 (0.12)	0.88 (0.11)
Per Capita Income	4663.37 (3203.94)	2871.35 (2368.91)

Table 4. Diet quality indicators and income: gender differences (Mean and Std. Dev.)

	Male Household head	Female Household head
% of energy int. from fat	29.79 (12.11)	32.72 (11.66)
% of energy int. from proteins	12.35 (3.49)	12.96 (3.65)
% of energy int. from carbohydrates	57.86 (12.67)	54.32 (12.43)
Fruit and vegetables (grams)	399.28 (439.44)	388.73 (485.22)
y1 (fats)	0.07 (0.11)	0.09 (0.11)
y2 (proteins)	0.07 (0.13)	0.10 (0.14)
y3 (carbohydrates)	0.01 (0.02)	0.01 (0.02)
y4 (fruit & vegetables)	0.25 (0.27)	0.25 (0.27)
Recommendation Compliance Index (RCI)	0.87 (0.12)	0.86 (0.12)
Per Capita Income	3394 .23 (2728.82)	3977.64 (3174.03)

The tables highlight the same pattern. As one moves from rural to urban areas, diet becomes richer in fats and proteins, although fruit and vegetable consumption also increases. This seems to be associated with the higher income level, because a similar difference is observed when looking at the differences by gender of the household head.

Table 5. Diet quality indicators and income according to Education of the household head (Mean and Std. Dev.)

	Education of household head		
	Less than 3 years of education	Primary school	Lower middle school
% of energy int. from fat	28.32 (12.00)	28.52 (12.50)	29.81(11.86)
% of energy int. from proteins	12.10 (3.35)	11.94 (3.51)	12.30 (3.16)
% of energy int. from carbohydrates	59.59 (12.72)	59.55 (13.01)	57.89(12.30)
Fruit and vegetables (gr.)	353 (221)	391 (493)	407 (500)
y1 (fats)	0.07 (0.10)	0.07 (0.11)	0.07 (0.11)
y2 (proteins)	0.07 (0.11)	0.07 (0.13)	0.07 (0.13)
y3(carbohydrate)	0.01 (0.02)	0.01 (0.02)	0.01 (0.02)
y4 (fruit & vegetables)	0.27 (0.28)	0.25 (0.27)	0.24 (0.27)
Recommendation Compliance Index (RCI)	0.87 (0.11)	0.88 (0.12)	0.88(0.11)
Per Capita Income	2684 (2323)	3028 (2509)	3303 (2634)

Table 5. Continues

	Education of household head		
	Upper middle school	Technical school	College-University
% of energy int. from fat	31.97(11.06)	34.44(11.02)	36.39(11.87)
% of energy int. from proteins	12.58 (3.49)	13.72 (3.34)	14.07(4.30)
% of energy int. from carbohydrates	55.45(11.55)	51.85(11.46)	49.53(12.10)
Fruit and vegetables (gr.)	380(400)	392 (259)	418 (271)
y1 (fats)	0.08(0.11)	0.10(0.12)	0.13(0.12)
y2 (proteins)	0.08(0.12)	0.11(0.15)	0.15(0.15)
y3 (carbohydrates)	0.01(0.02)	0.01(0.02)	0.02(0.03)
y4 (fruit & vegetables)	0.24(0.26)	0.25(0.29)	0.21(0.26)
Recommendation Compliance Index (RCI)	0.87(0.11)	0.85(0.12)	0.84(0.12)
Per Capita Income	3813(2796)	5757(3090)	6611 (3503)

Table 6. Diet quality indicators and per capita income (Mean and Std. Dev.)

	Per Capita Income (quartiles)			
	Lower quartile	Lower middle	Upper middle	Upper quartile
% of energy int. from fat	25.42 (11.41)	29.28 (12.02)	32.02 (12.18)	34.40 (10.91)
% of energy int. from proteins	11.59 (2.79)	12.02 (3.30)	12.49 (3.29)	13.68 (4.19)
% of energy int. from carbohydrates	62.99 (11.63)	58.70 (12.46)	55.49 (12.55)	51.92 (11.51)
Fruit and vegetables (grams)	366 (362)	379 (354)	390 (316)	452 (652)
y1 (fats)	0.05 (0.09)	0.07 (0.11)	0.08 (0.12)	0.10 (0.12)
y2 (proteins)	0.05 (0.09)	0.07 (0.12)	0.09 (0.14)	0.11 (0.14)
y3 (carbohydrates)	0.01 (0.02)	0.01 (0.02)	0.01 (0.02)	0.01 (0.03)
y4 (fruit & vegetables)	0.27 (0.28)	0.26 (0.27)	0.24 (0.27)	0.22 (0.27)
Recommendation Compliance Index (RCI)	0.88 (0.11)	0.87 (0.12)	0.87 (0.12)	0.86 (0.11)
Per Capita Income	792 (375)	2097 (402)	3686 (562)	7354 (2619)

Households led by females show a higher income and a larger energy intake from fats, while fruit and vegetable consumption is higher for male household heads.

Differences are small and the RCI is slightly better for households with a male head. Gender of the

household head does not play a relevant role in determining dietary quality.

Instead, education is strongly associated with income and consequently we observe increasing fat and protein consumption for higher education level. Interestingly, the pattern is not univocal for fruit and vegetable consumption but in general the distance from the fruit and vegetable recommendation is smaller for household with a highly educated head.

Finally Table 6 confirms the above consideration by showing a clear transition towards diets richer in fats, proteins, but also fruit and vegetable as the income increases.

Table 7 looks at the percentage of individuals meeting the WHO recommendations according to some explanatory variables. Results resemble those discussed above. Although the differences are small, there is clear evidence that higher income is associated with a less healthy diet, which is also confirmed by the low but highly significant negative correlation between the RCI and income (-0.05).

Table 7. Percentage of households approaching the WHO nutrient goals

	Outside WHO recommend.	RCI 0.95 - 1	Meet WHO recommend.
Income:			
Lower quartile	64.9	23.4	11.8
Lower middle	68.2	22.7	9.1
Upper middle	68.1	22.3	9.6
Upper quartile	73.8	18.8	7.5
Rural/Urban:			
Urban	72.3	19.7	8.0
Rural	66.9	22.9	10.3
Gender:			
Male	67.7	22.3	10.0
Female	73.6	19.5	6.9
Education:			
Less than 3 yrs of ed.	70.0	19.3	10.7
Primary school	65.4	24.7	9.9
Lower middle school	66.9	23.2	9.9
Upper middle school	71.5	23.7	4.8
Technical school	71.1	16.9	12.0
College/University	75.9	14.8	9.3

III. CONCLUSION

The transition towards a diet richer in fats and proteins (because of a larger presence of animal products) observed over time in China has been associated with economic growth and westernization of the diets. These findings are confirmed by looking at the distribution of diet quality by income level and other income-related socio-demographic characteristics.

Better economic conditions mean a worsening of the diet in terms of energy intakes from fats, only partially compensated by higher fruit and vegetable intakes. China nutrition transition is continuing and the rapid economic growth may lead to adverse health consequences if the negative effects of the nutrition transition are not contrasted.

REFERENCES

1. Popkin B M (2001) The nutrition transition and obesity in the developing world. JN 131:871S-873S
2. Du S, Lu B, Fengying Z et al. (2002) A new stage of the nutrition transition in China. PHN 5:169-174
3. WHO (2003) Diet, nutrition and the prevention of chronic diseases. WHO Technical Report Series 916 Geneva
4. Mazzocchi M, Brasili C, Sandri E (2007) Trends in dietary patterns and compliance with World Health Organization recommendations: a cross-country analysis. PHN 11:535-540
5. Liu Y, Shankar B (2007) Will rising household incomes solve China's micronutrient deficiency problems? EB 15:1-14
6. Popkin B M, Kim S, Rusev E R et al. (2006) Measuring the full economic costs of diet, physical activity and obesity-related chronic diseases. OBR 7:271-293

- Author: Sara Capacci
- Institute: Department of Statistics, University of Bologna
- Street: Via delle Belle Arti 41
- City: Bologna
- Country: Italy
- Email: sara.capacci@unibo.it