Urbanization, Nutrition Transition, and Obesity: Evidence from China

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Abstract

This paper explores the effects of urbanization on nutrition transition and obesity. Taking adult individuals from the China Health and Nutrition Survey (CHNS), from the year 1989 to 2009, this study confirms the hypothesis that rising urbanization has positive effects on the obesity level. Also, the results reveal a nutrition transition towards a dietary pattern of more fat and protein intake in China. Particularly, evidence from the gender difference indicates that the effect of urbanization, along with the factors as education and income, on obesity is more pronounced for females than males.

1. Introduction

Over the past three decades, China has experienced an unprecedented urbanization growth. Figure 1 shows the proportion of the population living in urban areas increased from only 20% in 1981, to 52% in 2012[1]. Also, it is forecasted to reach 61% in 2020 and 65% in 2025[2]. This paper examines the effect of urbanization on nutrition transition and obesity in China.

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[1] Source: World Bank. *World Development Indicators*. 2013.
[2] Source: Population Division of the Department of Economic and Social Affairs of the United Nations Secretariat, *World Urbanization Prospects: The 2011 Revision*, November, 2012.

There are significant differences between urban and rural dietary patterns. Urban residency is linked with large changes in diet and body composition and also with high levels of obesity in lower and middle-income countries including China. (Popkin, 1999). The concept of the "nutrition transition" focuses on shifts in the structure of diet. Popkin (1993) provides a framework that accommodates the dynamic nature of diet and the relationship of diet and economic, social, demographic, and health factors. A substantial shift in eating preferences is induced mainly by shifts in income, prices and food availability, also by the modern food industry and the mass media. Also, the shift in the occupations structure from agriculture towards manufacturing and service sectors implies a reduction in energy expenditure. Furthermore, the shift towards a diet higher in fat and meat and lower in carbohydrates and fiber, along with the shift towards less physical activity, brings about negative nutritional and health effects. A rapid increase in obesity is one of the consequences of nutrition transition in lower-income countries (Popkin, 2001a).

China is unique among countries in nutrition transition because of the extraordinary pace at which these changes are occurring and also because of its size in population. The classic Chinese diet based on rice and vegetables is being replaced by increasing amounts of animal products and a Western-type diet profile (Weng and Caballero, 2007). Take the fast food restaurants as an example, the restaurant counts of "Yum! Brands" in China (including Pizza Hut and KFC), grew from 2497 to 4260 during the 5 year from 2008 to 2012 with annual growth rate of 15%, compared with 4% worldwide in the same period of time[3]. Paeratakul *et al.* (1998) finds that diet is becoming an increasingly important determinant of body weight in Chinese adults. In addition, economic and technological development has dramatically lowered the energy demands of work and daily living, thus increasing the risk of a positive energy balance and excess weight gain in China's population (Weng and Caballero, 2007).

Some of previous empirical studies find increasing prevalence of overweight and obesity in China (Wang *et al.*, 2007; Wildman *et al.*, 2008). Obesity has been linked to several diseases including high cholesterol, diabetes, hypertension, and asthma (Kopelman, 2000; Koplan and Diez, 1999; Peeters *et al.*, 2003; Wellman and Friedberg, 2002). In addition, obesity-related morbidity has been estimated to account for a significant share of total medical expenditures in China. The total medical cost attributable to overweight and obesity was estimated at about 2.74 billion dollars

[3] http://www.yum.com/investors/restcounts.asp

accounting for 3.7% of national total medical costs in 2003 (Zhao *et al*., 2008). Therefore, the obesity level in the population of China with rising urbanization is worth addressing.

This paper aims to explore the effects of urbanization on nutrition transition and obesity level in China. Using an urbanization index which incorporates a comprehensive representation of urbanization growth across China, this analysis evaluates the impact of urbanization on body weight and body fat over time, as well as on changes in diet structure. Also, this study examines whether variation in food prices could affect the obesity level through inducing the changes in diet pattern. In addition, the regression analysis examines the effects of individual factors, such as age, income, education, and physical activity levels, on nutrition transition and obesity. Moreover, this paper would examine the role of gender and regional differences in explaining the impact of urbanization on obesity level in population.

The paper proceeds as follows. Section 2 presents description of data. Section 3 introduces the econometric methodology. Section 4 discusses empirical results, and Section 5 concludes.

2. Data and Descriptive Statistics

The data for this analysis come from the China Health and Nutrition Survey (CHNS). It is an on-going panel of individuals from 216 communities in 9 provinces, namely, Liaoning, Heilongjiang, Shandong, Jiangsu, Henan, Hubei, Hunan, Guizhou, and Guangxi. In this analysis, 8 panel waves from the year 1989 to 2009 are utilized. For each wave, the sample is limited to adult individuals with age between 18 and 75 at the time of interview. For female individuals, this analysis excludes the waves when they were pregnant to eliminate those irrelevant weight shocks. Therefore, the sample in this paper includes 14,748 individuals and 31,612 individual-year observations in total. Notably, it is an unbalanced panel, because the number of time periods is not the same for all individuals.

In this paper, obesity is measured by two proxy variables: BMI and TSF. BMI is defined as weight in kilograms divided by the square of height in meters: BMI = weight (kg)/height-squared (m^2). An individual is classified as overweight with a BMI ≥ 25, and obese if the BMI ≥ 30 (National Institute of Health, 1998). TSF is a measure of anthropometry for body fat, specifically, a vertical skinfold measured at the posterior midpoint between the acromion and the olecranon of the upper arm. Another set of response variables of interest are nutrients which are the proxies for diet structure that documents nutrition transition. I use energy, fat, carbohydrate, and protein from CHNS to examine the nutrition transition in the scenario of the rising urbanization in China.

The urbanization index, which is a key independent variable in this analysis, is a measure of urbanicity from CHNS. This index is a multi-component scale to measure urban features on a continuum in China. Jones-Smith and Popkin (2010) identify 12 components to define and distinguish urbanicity that could be incorporated in the CHNS data. A maximum total of 10 points are allotted to each of the 12 components, which include: population density, economic activity, traditional markets, modern markets, transportation infrastructure, sanitation, communications, housing, education, diversity, health infrastructure, and social services.

This paper considers the price effects on nutrition transition and obesity level as urbanization proceeds. Ng *et al.* (2008) finds that price policy effects on edible oil can influence dietary composition (particularly of the poor) in China. Also, the growth in weight has been related to how individuals respond to changes in food price (Goldman *et al.*, 2009; Lakdawalla and Philipson, 2002; Lu and Goldman, 2010; Powell, 2009). Following Lu and Goldman (2010), this paper includes a set of controlling variables of relative food prices at the community level, namely, the price of staple food (rice, wheat, and noodle), pork, and vegetables divided by price of staple (cooking) oil respectively. Because cooking oil is the most caloric of all foods, the fraction of oil used in food preparation helps determine the sum of calories a meal contains. For the price effects, oil and other foods are considered complementary to each other. The hypothesis is that consumption of foods corresponds to how expensive the foods are, and when the relative price of cooking oil decreases, people will use more of it when preparing meals, and vice versa. Therefore, more oil consumption can result in a higher level of calorie intake, thereby leads to increasing obesity (Lu and Goldman, 2010). Among all edible oils with price information available, soybean, rapeseed, and peanut oil are identified as staple oils as they account for more than 80% of the edible oil consumption in certain regions of China (Fang and Beghin, 2002; Lu and Goldman, 2010). Accordingly, each sample province is assigned with the price of its major staple oil, depending on the region it belongs to. Specifically, it is soybean oil for Liaoning, Heilongjiang, Shandong; rapeseed oil for Jiangsu, Henan, Hubei, Hunan, Guizhou; peanut oil for Guangxi. Free market prices are used by default, and are substituted with either state store market prices (1989, 1991, 1993, and 1997) or large store retail prices (2000, 2004, 2006 and 2009) wherever free market prices are missing (Lu and Goldman, 2010).

Besides the covariates of community level food prices, this paper includes control variables of individual characteristics such as age, income levels, educational attainment, and physical activity levels.

Previous literature documents the association between education and obesity (Anderson *et al*., 2011; Webbink *et al*., 2010). Two levels of educational attainment are constructed for this study, namely, 0 for lower and 1 for higher education. Lower education includes: no education, elementary school (primary school), lower middle school in CHNS. Higher education includes: upper middle school (high school) or equivalent (including technological and vocational school education), bachelor's degree (university or college degree) and beyond in CHNS. The rational in this classification of educational attainment is based on the national policy of "Nine-year Compulsory Education"[4]. Since the promulgation of the "Compulsory Education Law of the People's Republic of China" in 1986, the nine-year compulsory education has been implemented by government. In China, the nine-year schooling in primary and lower middle schools pertains to compulsory education, typically six years at primary school and three years at lower middle school. After the stage of "Nine-year Compulsory Education", individuals' educational attainments become more diversified. In addition, this paper uses three levels of educational attainment. Specifically, "bachelor's degree and beyond" is picked out to be a third level, which is examined for more specific effect of higher educational attainment on obesity level.

There are two categories of income variables in CHNS: individual income and household income. This analysis uses household income divided by household size to calculate household income per person. This calculation, following Lu and Goldman (2010), is based on two considerations: (1) there are significantly fewer missing data in household income than in individual income; (2) food preparation and consumption often do not vary within the household level in China, and per capita household income can better represent the level of disposable income for food than individual income.

Physical activities available in CHNS are categorized into two levels: light and heavy. "Light" includes light activities such as sedentary office work, and jobs with some standing and sitting, such as counter salesperson, and lab technician. "Light" also includes some moderate activities

4 http://www.china.org.cn/english/education/184879.htm

such as driver and electrician. “Heavy” includes occupations with heavy physical activities such as farmer, athlete, dancer, steel worker, and lumber worker.

The descriptive statistics of the variables are summarized in Table 1 for full sample and Table 2 for gender subsamples. There are about equal numbers of males and females in the sample. Average BMI is around 22.58, while females have a slightly higher level but fairly close to males. While the difference between men and women is more distinctive in terms of TSF. Females have an average TSF 15.99 mm, 36% higher than that of males. In addition, in Figure 2 and Figure 3, I plot the time trend for BMI and TSF in full sample. The figures reveal different dynamic characteristics. For BMI, it follows a steady trend over time, from 21.45 in 1989 to 23.33 in 2009, increasing 9%. The increase in TSF is more significant, from 12.55 in 1989 to 16.21 in 2009, increasing 29%, but follows an unstable trend with 1993 the lowest and 2006 the highest. The mean of urbanization index over time is depicted in Figure 4. It shows a steady and remarkable growth in the past two decades, increasing 53%, from 43.76 in 1989 to 67.12 in 2009. Along with the urbanization process, overweight and obesity have become more prevalent in the population by the definition of BMI cutoffs: the fraction of overweight ($25 \leq BMI < 30$) individuals has increased from 8% in 1989 to 26% in 2009, and the fraction of obese ($BMI \geq 30$) individuals has increased from 0.44% in 1989 to 3.77% in 2009, as shown in Figure 5 and Figure 6.

The observed growth in obesity and urbanization leads to inspiration to investigate the association between these two trends more thoroughly. According to previous studies, the increasing prevalence of overweight and obesity along with the urbanization course could be owing to several potential reasons as dietary and activity pattern shifts. For example, during rapid urbanization, a growing proportion of population engage in more sedentary jobs when they transfer from rural to urban living, from agricultural sector to non-agricultural sectors, thereby shift towards lower physical activity level, which indicates a risk of increasing obesity level (Monda *et al.*, 2007). Second, urban life offers more availability of fast food and restaurants, which could contribute to the obesity level (Chou *et al.*, 2004). Moreover, increasing urbanization in China is linked to economic growth and increases in income level as people move from agricultural sector to industrial and service sectors. Popkin *et al.* (1993) shows that higher income levels, particularly in urban areas, are associated with consumption of a diet higher in fat and with problems of obesity. Beside the income effect, the price effect on dietary patterns could also contribute to the obesity level (Lu and Goldman, 2010). Therefore, this paper will focus on the effects of urbanization on the diet structure and obesity level, controlling for relative food prices and individual characteristics such as income levels, physical activity levels and so on. I turn to a research design for this idea in Section 3.

3. Econometric Methods

The empirical analysis aims to estimate the effects of urbanization on nutrition transition and obesity. The hypothesis is that, rising urbanization has positive effects on the obesity level. Also, the urbanization would induce significant nutrition transition with respect to dietary patterns. The regression analysis controls for the unobserved individual heterogeneity through all of the survey years. Prior to that, a Hausman test (Hausman, 1978) will be employed to examine the choice of model specification between fixed effects model and random effects model. Also, diagnostic tests for heteroscedasticity and serial correlation will be conducted in the regression model. In the regression, obesity or nutrients intake is a function of community level urbanization indexes, community level relative food prices, and individual level characteristics, such as age, income level, educational attainment, physical activity level, and year fixed effects. (Cameron and Trivedi, 2005; Wooldridge, 2001)

Here two measurements of "OBESITY" are used for comparison: BMI as a measurement of body weight and TSF of body fat. Both BMI_{ijt} and TSF_{ijt} are continuous variables, for each individual *i* and community *j* at time *t*. Another group of response variables are nutrients, namely "*NUTRITION*", such as "$ENERGY_{ijt}$", "FAT_{ijt}", "$CARBOHYDRATE_{ijt}$", and "$PROTEIN_{ijt}$", for each individual *i* and community *j* at time *t*. The key independent variable "$URBAN_{jt}$", i.e. the urbanization index, is a measurement of the levels in urbanization for community *j* at time *t*. There are two groups of control variables in this regression analysis. The variables of "$PRICE_{jt}$" are community level relative food prices in community *j* at time *t*. Departing from the model specification of Lu and Goldman (2010), which uses 3 different settings of relative prices, this paper uses staple food, pork, and vegetable prices deflated by edible oil price respectively as a uniform relative price setting. Another group of control variables are individual characteristics "X_{ijt}", for each individual *i* and community *j* at time *t*, such as age, income level, educational attainment, and physical activity level. An age-squared term is included here as a regressor to captures the nonlinear age effects if there is any. Also, I introduce an interaction term of education attainment and income level as an explanatory variable. In the regression, τ_t is the time fixed effect. μ_i is the individual fixed effect, and ε_{ijt} is the error term. The models are specified as follows:

$$OBESITY_{ijt} = \beta_1 URBAN_{jt} + \beta_2 PRICE_{jt} + \beta_k X_{ijt} + \tau_t + \mu_i + \varepsilon_{ijt} \qquad (1)$$

$$NUTRITION_{ijt} = \beta_1 URBAN_{jt} + \beta_2 PRICE_{jt} + \beta_k X_{ijt} + \tau_t + \mu_i + \varepsilon_{ijt} \qquad (2)$$

The first regression can be used to capture the relationship between urbanization and obesity level. Among the coefficients, β_1 is the coefficient of urbanization variable. According to our hypothesis, β_1 is expected to be positive. β_2 is expected to be positive, for the reason that the lower relative price of cooking oil means energy-dense food sources are cheaper thereby prompt consumption, which leads to higher obesity level. For the coefficients of individual characteristics β_k, I do not have expectation on these signs. The second regression is designed to examine the relationship between urbanization and change in diet structure, which captures the nutrition transition (Popkin, 1999). In this regression, I do not have expectation on the signs of the coefficients.

More specifically, the models are specified as follows:

$$\ln(OBESITY_{ijt}) = \beta_0 + \beta_1\ln(URBAN_{jt}) + \beta_2\ln(FOOD_{jt}/OIL_{jt}) + \beta_3\ln(PORK_{jt}/OIL_{jt}) + \beta_4\ln(VEGETABLES_{jt}/OIL_{jt}) + \beta_5 AGE_{ijt} + \beta_6 AGE^2_{ijt} + \beta_7 EDU_{ijt} + \beta_8\ln(INCOME_{ijt}) + \beta_9[EDU_{ijt} * ln(INCOME_{ijt})] + \beta_{10} PACT_{ijt} + \tau_t + \mu_i + \varepsilon_{ijt}$$

$$\ln(NUTRITION_{ijt}) = \beta_0 + \beta_1\ln(URBAN_{jt}) + \beta_2\ln(FOOD_{jt}/OIL_{jt}) + \beta_3\ln(PORK_{jt}/OIL_{jt}) + \beta_4\ln(VEGETABLES_{jt}/OIL_{jt}) + \beta_5 AGE_{ijt} + \beta_6 AGE^2_{ijt} + \beta_7 EDU_{ijt} + \beta_8\ln(INCOME_{ijt}) + \beta_9[EDU_{ijt} * ln(INCOME_{ijt})] + \beta_{10} PACT_{ijt} + \tau_t + \mu_i + \varepsilon_{ijt}$$

All the regressions are in log-log models, partly because it is easier to interpret the coefficients as elasticities (price elasticity, income elasticity, and elasticity of urbanization effect). The regression will be run on the full sample of adult individuals. In addition, the analysis will be extended to gender differences, regressing on female and male subsamples respectively. Moreover, this study will examine regional differences at provincial level, regressing on provincial subsamples. The next section presents the empirical results.

4. Results

Results of Model Specification Tests and Diagnostic Tests

The Hausman Test result rejects the null that RE estimator is consistent and more efficient than FE estimator (The Chi-square statistic is 584.46 with p-value 0.0000). Then I turn to FE regression and take diagnostic tests for heteroscedasticity and serial correlation. Modified Wald test for groupwise heteroscedasticity in fixed effects model yields result of heteroscedasticity (The Chi-square statistic is 2.4e+35 with p-value 0.0000). For serial correlation, Wooldridge test rejects the null hypothesis of no first-order autocorrelation (F statistic is 102.797 with p-value 0.0000). Upon the problems of heteroscedasticity and serial correlation, clustering on the panel variable produces a variance-covariance estimator that is robust to cross-sectional heteroscedasticity and within-panel serial correlation that is asymptotically equivalent to that proposed by Arellano (1987). Although the test above applies the fixed effects estimator, the robust and cluster robust variance-covariance estimators are also available for the random effects estimator (Arellano, 2003; Wooldridge, 2009). Therefore, I estimate the coefficients with clustered robust standard errors. Upon the suspicion of time-invariant exogenous variables in the model, notably, education, income and physical activity, the Hausman-Taylor instrumental variable estimation (Hausman and Taylor, 1981) shows that there are no time-invariant exogenous variables in the model.

Urbanization and Obesity

Table 3 presents the effects of urbanization on BMI and TSF in the full sample. In the table, there are four regressions. The first two on the left are the results for BMI, and the other two are for TSF.

First of all, the key regressor, urbanization, turns out to be positively associated with obesity levels for the measurement of BMI. This confirms the hypothesis that the obesity level increases as urbanization proceeds. The regression result is not significant for TSF. Urbanization index captures the comprehensive process of urbanization for a community. Here in the regression analysis, the results suggest that the urbanization in China has been significantly contributed to the overweight and obesity level in adult population. This means that the urbanization comes along with negative health outcomes as increasing body weight level, which deserve policy considerations.

The control variables of relative food prices reveal significant effects on body weight and body fat. As the price of staple food relative to cooking oil increases, which means that cooking oil becomes cheaper relative to staple food, TSF increases. But the results are not statistically significant for BMI. In addition, the price of pork relative to oil is positively associated with BMI. This regressor can capture to what extent individuals would substitute animal protein with cooking oil when price variations are noticeable (Lu and Goldman, 2010). However, the price of vegetables relative to oil has negative correlation with BMI, which is contradictory to the testing hypothesis. One potential explanation could be price endogeneity that healthier, light-weighted individuals have more preference for vegetables, driving both price and consumption up (Lu and Goldman, 2010). Nonetheless, this hypothesis can not be tested here. Those findings on price effects are generally consistent with previous study (Lu and Goldman, 2010).

The factors of individual characteristics, such as age, education, income, and physical activity, have significant effects on obesity level. Age and age-squared are significant predictors for BMI and TSF, which indicates non-linear and quadratic age effects. Specifically, BMI increases with age at a decreasing rate. TSF decreases with age at a decreasing rate. The coefficient of education variable is positive and statistically significant for BMI but significantly negative for TSF. As educational attainment goes from lower to higher, BMI increases, while TSF decreases. The coefficient of the interaction term of education and income is negative and statistically significant for BMI, which indicates that the effect of additional income increment on body weight is less for an individual with higher education than for an individual with lower education. The coefficient of the physical activity variable is negative and statistically significant for BMI but not significant for TSF. A light physical activity level is associated with more body weight as compared to heavy activity. These results are intuitively understandable and consistent with previous findings by Van de Poel *et al.* (2009) that higher income and lower engagement in physical activity contributes to the urban concentration of overweight in China, and education advantage has an offsetting effect.

Individual fixed effects such as gender, which is time invariant, can not be estimated with FE model. Therefore, one approach to overcome that limitation is to run FE model regressions using subsamples of gender groups. Table 4 and Table 5 present the results of regression analysis on males and females subsamples respectively using fixed effects model. Urbanization has positive effects on body weight and body fat of female group at the significance level of 1%, while the results are not statistically significant for male group. This finding indicates that the problem of overweight and obesity is more pronounced for females in the scenario of urbanization. Notably, the difference between the gender groups also lies in education and income. Educational attainment is a positive predictor for female's BMI, especially for the level of high school educational attainment. However, education has no significant effect on male's BMI. Income level has positive effect on BMI of females, but no significant effect for males. The coefficient of the interaction term of education and income is negative and statistically significant for BMI in female group, which reveals that the effect of additional income increment on body weight is less for a female individual with higher education than the one with lower education. Income level has positive effect on TSF of females, but no significant effect for males. Educational attainment has negative effect on TSF at high school level and beyond for males, but at level of bachelor's degree and beyond for females. Those gender differences of education and income effect might be owing to transitions of women's social-economic status during the past decades, which, of course, requires further research effort to clarify the causal relationship.

The analysis on regional differences yields mixed results, as shown in Table 6. Among other provinces, urbanization has positive effect on body weight and body fat in Heilongjiang and Hubei. In addition, the urbanization is a positive predictor for BMI in Jiangsu, and TSF in Shandong and Henan. Also, the urbanization is a negative predictor for BMI in Shandong, and TSF in Hunan and Guangxi. We can see the effects of urbanization on obesity level vary substantially across different regions within China.

Urbanization and Nutrition Transition

Table 7 presents the results of regression analysis on urbanization and nutrition transition. Urbanization has positive effect on fat and protein intake. This finding reveals the diet structure change towards a pattern with higher protein and fat in Chinese population. For price effects, the regression on nutrition yield mixed results. In particular, the relative price of staple food to cooking oil is a positive predictor for fat intake, and a negative predictor for carbohydrate intake. Specifically, as cooking oil becomes cheaper, people consume more of it while substituting staple food (mainly rice and wheat). Among individual characteristics, income has positive effect on energy, fat and protein intake. Physical activity has positive effect on energy, carbohydrate and protein intake. Also, there are quadratic age effects. Energy, carbohydrate, and protein increase with age at decreasing rate. Those findings are consistent with previous studies (Du *et al.*, 2002; Jones-Smith and Popkin, 2010; Popkin, 1994; Popkin, 1999; Popkin, 2001a; Popkin *et al.*, 1993; Popkin *et al*., 2001). These dietary changes might be attributed to more consumption of cooking oil, meat, egg, and dairy products as the urbanization proceeds and income increases.

5. Conclusion

This paper provides new evidence on the effect of the rising urbanization on nutrition transition and obesity level in China, introducing relative food prices as control variables and adding recent panels of longitudinal data for longer dynamics. Also, this paper extends to the analysis of gender and regional differences, which reveals more specific demographic patterns of obesity level in the scenario of urbanization. The empirical findings confirm the hypothesis that urbanization induces a nutrition transition towards more fat and protein intake, and higher obesity level in Chinese population.

Results in the regression analysis show urbanization has a positive effect on the obesity level. Specifically, urbanization index is a significant predictor for rising obesity level in terms of BMI in adult population in China. This finding is consistent with previous study on urbanization and obesity (Popkin, 1999). Also, the obesity level responds to the relative food prices, namely, the prices of staple food, pork, and vegetables with respect to cooking oil. As price of cooking oil get relatively cheaper, individuals consume more. Therefore, the dietary pattern with higher calories intake leads to a higher obesity level. This paper yields empirical evidence that confirms the previous finding (Lu and Goldman, 2010). Notably, the empirical evidence reveals significant gender differences. Urbanization is a positive predictor on obesity level for female population but not for males, in terms of both BMI and TSF. Also, education and income effects are more significant for women's obesity level. Moreover, empirical evidence from this paper reveals the regional differences of urbanization effects on obesity among nine provinces in the sample. Beside on obesity, this paper yields some further empirical evidence on nutrition transition in China. Urbanization induces a nutrition transition towards a dietary pattern with higher fat and protein intake.

As we can see from the findings of this paper, urbanization comes at a price, considering the health outcomes, as obesity levels rise. For China, there should be something to be done in the policy agenda concerning the overweight and obesity issues in the urbanization scenario. Also, it is the case for other countries that are undergoing a rapid urbanization progress to take more policy considerations on dynamics of obesity levels. Specifically, it is possible to induce healthier dietary patterns by initiating pricing policies and marketing efforts, thereby to control the growth of obesity level. In addition, systematic effort might be taken to reduce sedentary physical status and improve overall physical activity patterns, since more people will take the occupations in relatively sedentary jobs as urbanization proceeds. Moreover, the policy addressing the overweight and obesity should emphasize more on female population. Of course, those issues require additional research effort.

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TABLES

Table 1: Descriptive Statistics of Variables

Variables	Observations	Mean	Standard Dev.	Min	Max
BMI	60,413	22.581	3.155	13.061	34.991
TSF (mm)	60,413	13.983	7.467	3.000	40.000
Energy (kcal)	57,186	2,351.606	672.228	652.968	4,985.771
Fat (g)	57,186	70.132	35.567	6.016	218.956
Carbohydrate (g)	57,186	355.538	126.896	90.103	830.901
Protein (g)	57,186	69.309	22.331	18.071	154.997
Urban	60,413	56.775	20.083	14.240	106.582
Oil (Yuan/500gms)	54,485	4.051	1.623	0.300	12.000
Food (Yuan/500gms)	39,823	1.417	0.672	0.390	13.250
Pork (Yuan/500gms)	55,951	7.740	2.992	0.500	30.000
Vegetables (Yuan/500gms)	50,876	0.703	0.640	0.033	7.667
Age (year)	60,413	43.734	14.411	18.000	75.000
Gender	60,413	0.522	0.499	0	1
Income (RMB Yuan)	57,703	5,536.910	5,464.627	0.884	35,964.030
Education	60,413	0.219	0.413	0	1
Physical Activity	58,030	0.437	0.496	0	1

Source: CHNS

Table 2: Descriptive Statistics by Gender Groups

	Male		Female	
Variables	Observations	Mean	Observations	Mean
BMI	28867	22.459	31546	22.693
TSF (mm)	28867	11.786	31546	15.993
Urban	28867	56.629	31546	56.910
Oil (Yuan/500gms)	26046	4.058	28439	4.046
Food (Yuan/500gms)	19125	1.414	20698	1.419
Pork (Yuan/500gms)	26737	7.738	29214	7.742
Vegetables (Yuan/500gms)	24334	0.699	26542	0.707
Age (year)	28867	43.672	31546	43.790
Gender	28867	0	31546	1
Income (RMB Yuan)	27457	5602.724	30246	5477.166
Education	28867	0.259	31546	0.182
Physical Activity	27725	0.455	30305	0.421

Source: CHNS

Table 3: Effects of Urbanization on Obesity in Full Sample

	ln(BMI)		ln(TSF)	
ln(Urban)	0.010***	0.010***	0.031	0.030
	(0.004)	(0.004)	(0.025)	(0.025)
ln(Food/Oil)	-0.001	-0.001	0.087***	0.088***
	(0.002)	(0.002)	(0.012)	(0.012)
ln(Pork/Oil)	0.003*	0.003*	-0.004	-0.004
	(0.002)	(0.002)	(0.011)	(0.011)
ln(Veg/Oil)	-0.002**	-0.002*	0.001	0.001
	(0.001)	(0.001)	(0.008)	(0.008)
Age	0.076***	0.076***	-0.694***	-0.694***
	(0.008)	(0.008)	(0.055)	(0.055)
Age^2	-0.000***	-0.000***	-0.000***	-0.000***
	(0.000)	(0.000)	(0.000)	(0.000)
ln(Income)	0.001	0.001	0.009**	0.009**
	(0.001)	(0.001)	(0.004)	(0.004)
Education1	0.027**	-	-0.038*	-
	(0.013)	-	(0.021)	-
Edu1*[ln(Income)]	-0.003**	-	-	-
	(0.001)	-	-	-
Education01	-	0.029**	-	-0.036*
	-	(0.013)	-	(0.021)
Education02	-	-0.000	-	-0.078**
	-	(0.037)	-	(0.038)
Edu01*[ln(Income)]	-	-0.003**	-	-
	-	(0.001)	-	-
Edu02*[ln(Income)]	-	-0.000	-	-
	-	(0.004)	-	-
Physical Activity	-0.006***	-0.006***	0.001	0.001
	(0.001)	(0.001)	(0.010)	(0.010)
Year FE	included	included	included	included
Constant	0.606**	0.613**	25.274***	25.290***
	(0.255)	(0.255)	(1.771)	(1.771)
Observations	31612	31612	31612	31612
Individuals	14748	14748	14748	14748

Education1 (Edu1): 0/1 education dummy for 1;
Education01: 0/1/2 education dummy for 1;
Education02: 0/1/2 education dummy for 2;
Robust standard errors in parenthesis;
*** p<0.01, ** p<0.05, * p<0.1

Table 4: Effects of Urbanization on Obesity for Males

	ln(BMI)		ln(TSF)	
ln(Urban)	0.005	0.005	-0.048	-0.049
	(0.006)	(0.006)	(0.040)	(0.040)
ln(Food/Oil)	-0.003	-0.003	0.106***	0.107***
	(0.003)	(0.003)	(0.020)	(0.020)
ln(Pork/Oil)	0.003	0.003	0.003	0.002
	(0.002)	(0.002)	(0.017)	(0.017)
ln(Veg/Oil)	-0.003*	-0.003*	-0.003	-0.003
	(0.002)	(0.002)	(0.012)	(0.012)
Age	0.080***	0.080***	-0.818***	-0.818***
	(0.011)	(0.011)	(0.090)	(0.090)
Age^2	-0.000***	-0.000***	-0.000***	-0.000***
	(0.000)	(0.000)	(0.000)	(0.000)
ln(Income)	-0.000	-0.000	0.005	0.005
	(0.001)	(0.001)	(0.007)	(0.007)
Education1	-0.004	-	-0.058**	-
	(0.017)	-	(0.032)	-
Edu1*[ln(Income)]	0.001	-	-	-
	(0.002)	-	-	-
Education01	-	0.001	-	-0.056*
	-	(0.018)	-	(0.032)
Education02	-	-0.031	-	-0.094*
	-	(0.045)	-	(0.051)
Edu01*[ln(Income)]	-	0.000	-	-
	-	(0.002)	-	-
Edu02*[ln(Income)]	-	0.004	-	-
		(0.005)	-	-
Physical Activity	-0.006***	-0.006***	0.015	0.015
	(0.002)	(0.002)	(0.016)	(0.016)
Year FE	included	included	included	included
Constant	0.506	0.502	29.428***	29.445***
	(0.356)	(0.356)	(2.916)	(2.916)
Observations	15106	15106	15106	15106
Individuals	7115	7115	7115	7115

Education1 (Edu1): 0/1 education dummy for 1
Education01: 0/1/2 education dummy for 1
Education02: 0/1/2 education dummy for 2
Robust standard errors in parenthesis
*** p<0.01, ** p<0.05, * p<0.1

Table 5: Effects of Urbanization on Obesity for Females

	ln(BMI)		ln(TSF)	
ln(Urban)	0.015***	0.015***	0.101***	0.102***
	(0.006)	(0.006)	(0.030)	(0.030)
ln(Food/Oil)	0.000	0.000	0.070***	0.070***
	(0.003)	(0.003)	(0.015)	(0.015)
ln(Pork/Oil)	0.003	0.003	-0.011	-0.011
	(0.002)	(0.002)	(0.014)	(0.014)
ln(Veg/Oil)	-0.001	-0.001	0.005	0.005
	(0.002)	(0.002)	(0.009)	(0.009)
Age	0.071***	0.071***	-0.593***	-0.598***
	(0.011)	(0.011)	(0.064)	(0.065)
Age^2	-0.000***	-0.000***	-0.000***	-0.000***
	(0.000)	(0.000)	(0.000)	(0.000)
ln(Income)	0.002**	0.002**	0.013**	0.013**
	(0.001)	(0.001)	(0.005)	(0.006)
Education1	0.073***	-	-	-
	(0.020)	-	-	-
Edu1*[ln(Income)]	-0.008***	-	-	-
	(0.002)	-	-	-
Education01	-	0.068***	-0.021	0.044
	-	(0.020)	(0.025)	(0.123)
Education02	-	0.061	-0.091*	-0.789**
	-	(0.061)	(0.055)	(0.378)
Edu01*[ln(Income)]	-	-0.008***	-	-0.007
	-	(0.002)	-	(0.014)
Edu02*[ln(Income)]	-	-0.009	-	0.075*
	-	(0.007)	-	(0.041)
Physical Activity	-0.007***	-0.007***	-0.018	-0.018
	(0.002)	(0.002)	(0.012)	(0.012)
Year FE	included	included	included	included
Constant	0.745**	0.748**	21.864***	22.031***
	(0.362)	(0.362)	(2.089)	(2.090)
Observations	16506	16506	16506	16506
Individuals	7633	7633	7633	7633

Education1 (Edu1): 0/1 education dummy for 1
Education01: 0/1/2 education dummy for 1
Education02: 0/1/2 education dummy for 2
Robust standard errors in parenthesis
*** p<0.01, ** p<0.05, * p<0.1

Table 6: Effects of Urbanization on Obesity by Provinces

	Dependent Variable	
ln(Urban)	ln(BMI)	ln(TSF)
21 Liaoning	-0.006	0.094
	(0.019)	(0.116)
23 Heilongjiang	0.029***	0.147**
	(0.010)	(0.063)
32 Jiangsu	0.025**	-0.028
	(0.012)	(0.059)
37 Shandong	-0.038***	0.271***
	(0.013)	(0.081)
41 Henan	0.031	0.604***
	(0.020)	(0.134)
42 Hubei	0.020*	0.149*
	(0.012)	(0.079)
43 Hunan	-0.005	-0.593***
	(0.022)	(0.131)
45 Guangxi	0.008	-0.489***
	(0.011)	(0.062)
52 Guizhou	-0.003	-0.028
	(0.012)	(0.079)

Robust standard errors in parenthesis
*** p<0.01, ** p<0.05, * p<0.1

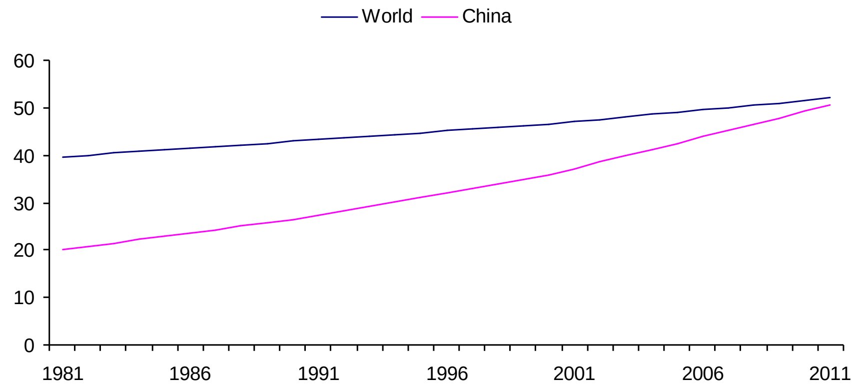
Table 7: Effects of Urbanization on Nutrition

	ln(Energy)	ln(Fat)	ln(Carbohydrate)	ln(Protein)
ln(Urban)	0.015	0.134***	-0.014	0.034*
	(0.015)	(0.031)	(0.017)	(0.019)
ln(Food/Oil)	-0.005	0.065***	-0.057***	0.014
	(0.007)	(0.014)	(0.008)	(0.009)
ln(Pork/Oil)	0.014**	-0.002	0.026***	0.014*
	(0.007)	(0.013)	(0.007)	(0.008)
ln(Veg/Oil)	0.005	-0.008	0.017***	0.012**
	(0.005)	(0.009)	(0.005)	(0.006)
Age	0.121***	0.125**	0.184***	0.224***
	(0.032)	(0.058)	(0.035)	(0.037)
Age^2	-0.000***	0.000*	-0.000**	-0.000***
	(0.000)	(0.000)	(0.000)	(0.000)
Education	-0.061	0.051	-0.085	-0.034
	(0.056)	(0.101)	(0.062)	(0.064)
ln(Income)	0.014***	0.039***	0.002	0.022***
	(0.003)	(0.006)	(0.003)	(0.004)
Edu*[ln(Income)]	0.007	-0.007	0.011	0.003
	(0.006)	(0.011)	(0.007)	(0.007)
Physical Activity	0.039***	-0.006	0.060***	0.024***
	(0.006)	(0.012)	(0.007)	(0.007)
Year FE	included	included	included	included
Constant	3.811***	-0.462	0.010	-3.177***
	(1.025)	(1.878)	(1.127)	(1.184)
Observations	30409	30409	30409	30409
Individuals	14449	14449	14449	14449

Robust standard errors in parenthesis
*** p<0.01, ** p<0.05, * p<0.1

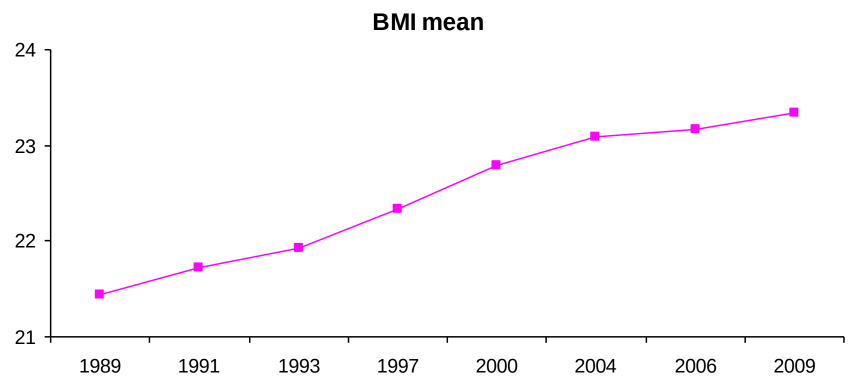
FIGURES

Figure 1: Percentage of Urban Population to Total Population



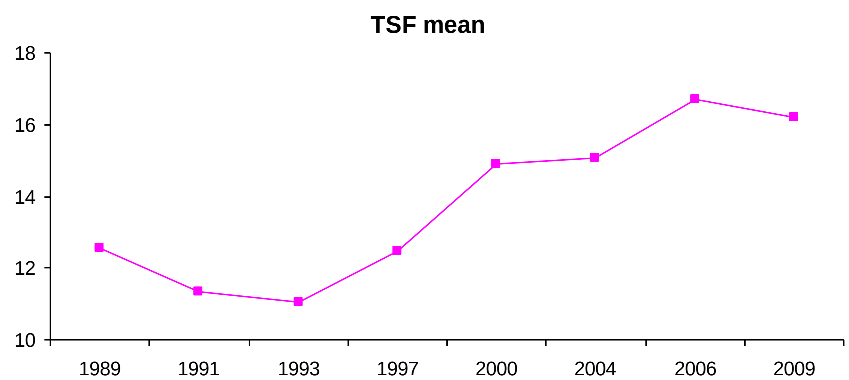
Source: World Bank

Figure 2: Trend of BMI Average Level



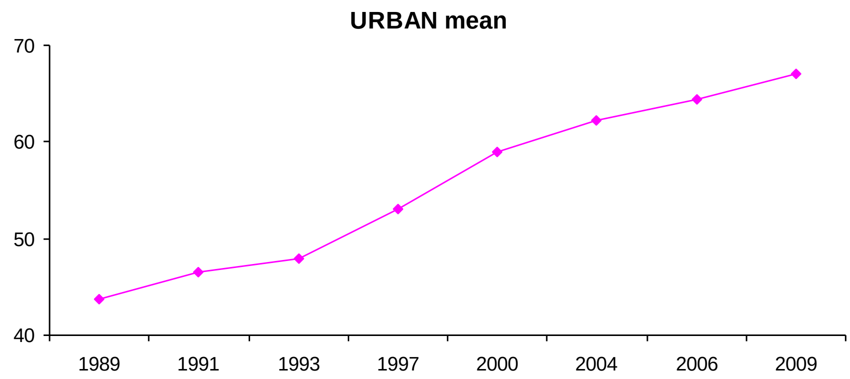
Source: CHNS

Figure 3: Trend of TSF Average Level



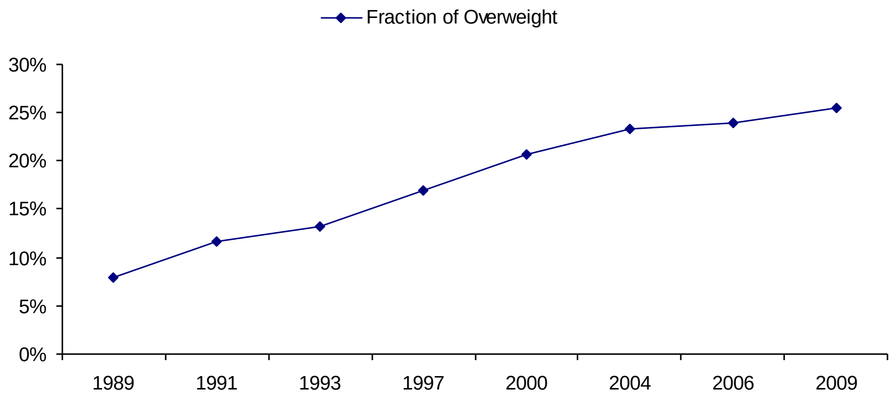
Source: CHNS

Figure 4: Trend of Urbanization Index Average Level



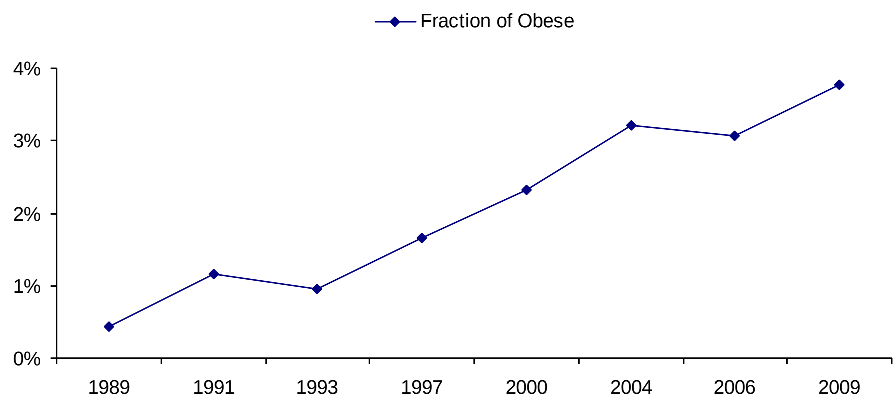
Source: CHNS

Figure 5: Fraction of Overweight (25≤BMI<30) People in Population



Source: CHNS

Figure 6: Fraction of Obese (30<BMI) People in Population



Source: CHNS