URBANIZATION, NUTRITION TRANSITION, AND OBESITY: EVIDENCE FROM CHINA

by

Song Zhou

A thesis submitted to the Faculty of the University of Delaware in partial fulfillment of the requirements for the degree of Master of Science in Agricultural and Resource Economics

Spring 2013

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Song Zhou

Approved: ____
Titus O. Awokuse, Ph.D.
Professor in charge of thesis on behalf of the Advisory Committee

Approved: ____
Titus O. Awokuse, Ph.D.
Chair of the Department of Applied Economics and Statistics

Approved: ____
Mark W. Rieger, Ph.D.
Dean of the College of Agriculture and Natural Resources

Approved: ____
James G. Richards, Ph.D.
Vice Provost for Graduate and Professional Education

ACKNOWLEDGMENTS

I would never have been able to finish this thesis without the support of many people. First and foremost I would like to express my utmost gratitude to my advisor Professor Titus Awokuse, for his support and encouragement through my graduate study. His illuminating guidance and incredible patience, has made immeasurable contribution in every stage of the writing of this thesis. Moreover, he has always been supportive, encouraging and inspiring in every step of my academic progress while at the University of Delaware. I sincerely appreciate Professor Thomas Ilvento and Professor John Bernard for their extensive knowledge and insightful advice on my thesis work. With the guidance of my thesis committee members, this challenging thesis work has proved to be an enjoyable and wonderfully rewarding learning experience.

I greatly benefited from research assistance from Yue Tan, who has always been helpful on my thesis. Also, I would like to extend my appreciation to Professor Siyan Wang for her advice on econometric methods in this thesis.

I owe my sincere gratitude to Professor James Butkiewicz and Professor Jeffrey Miller, for their insightful advice and generous help in my study on Economics and in my pursuit of academic career.

Also, I would like to extend my appreciation to Erma Wolpert and Margaret Brumit for helping out with all the administrative needs during my graduate study.

I would like to thank my fellow students in the Department of Applied Economics and Statistics, and in the Department of Economics. They have made my life very enjoyable in the University of Delaware in these two years. Especially, my sincere gratitude goes to Ruizhi Xie and Weibiao Li.

Finally, I would like to take this opportunity to express my deepest gratitude to my parents for their endless support, encouragement and caring through all these years. Without their support, I would not have been able to make this accomplishment.

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ABSTRACT

This thesis explores the effects of urbanization on nutrition transition and obesity. Taking adult individuals from a longitudinal dataset, the China Health and Nutrition Survey (CHNS), from the year 1989 to 2009, this study uses the fixed effects model to examine the effects of urbanization on nutrition transition and obesity, controlling for community-level food prices and individual characteristics. The findings confirm the hypothesis that rising urbanization has positive effects on the obesity level in the adult population in China. Also, the results reveal a nutrition transition towards a dietary pattern of more fat and protein intake, which is consistent with previous studies.

The regression analysis uses Body Mass Index (BMI) as measurement for body weight and Triceps Skin Fold (TSF) for body fat. The empirical results show that urbanization has positive effect on BMI, but the effect is not statistically significant for TSF. Evidence from the analysis on gender difference indicates that the effect of urbanization on obesity is more pronounced for females than for males. For regional difference, Heilongjiang and Hubei, among other provinces, appear to have consistent results for urbanization’s positive effect on obesity levels. This study also indicates price effects of food on the obesity level, and confirms the previous empirical

evidence that obesity corresponds to food price changes. Individual characteristics act as significant predictors for obesity level. The effect of education on obesity yields mixed results. And physical activity has negative effect on BMI. Income has negative effect on obesity level in females.

Chapter 1

INTRODUCTION

1.1 Motivation

Over the past three decades, China has experienced an unprecedented urbanization growth, which is much faster than that experienced for over a hundred years in the West. As shown in Figure 1, the proportion of the population living in urban areas increased from only 20% in 1981, to 51% in 2011(World Bank, 2012)[1], and is forecasted to reach 61% in 2020 and 65% in 2025 (United Nations, 2012)[2]. Popkin (1999) shows that 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.

The concept of the "nutrition transition" focuses on shifts in the structure of diet. The same underlying socioeconomic and demographic changes, urbanization in particular, associated with these dietary changes are also linked with shifts in physical activity and body composition patterns (Popkin, 1999). Compared with rural

[1] Source: World Bank. *World Development Indicators*. 2012.
[2] Source: Population Division of the Department of Economic and Social Affairs of the United Nations Secretariat, *World Population Prospects: The 2010 Revision and World Urbanization Prospects: The 2011 Revision*, November 12, 2012.

diets, urban diets exhibit trends toward consumption of more milled and polished grains, food higher in fat, more animal products, more sugar, more food prepared away from the home, and more processed foods (Popkin and Bisgrove, 1988; Popkin *et al.* 1993). The developing world is facing dramatic changes in food availability, dietary patterns, and life style. These changes constitute “nutrition transition” and bring about health consequences, particularly obesity. And those changes in diet and activity patterns are fueling the obesity epidemic (Popkin, 2001b).

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. Take the fast food restaurants as an example, the restaurant counts of “Yum! Brands” in China (including Pizza Hut and KFC), grew from 2558 to 4493 during the 5 year from 2007 to 2011 with annual growth rate of 12%, compared with 3% worldwide in the same period of time[3]. At the same time, 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 (Weng and Caballero, 2007).

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

Wang *et al*. (2007) show that the prevalence of overweight and obesity increased in all gender and age groups and in all geographic areas in China in the period between 1992 and 2002. The prevalence of overweight and obesity increased from 14.6 to 21.8%. Also, Wildman *et al.* (2008) evaluate trends in BMI and the prevalence of overweight and obesity between 1991 and 1999-2000 among Chinese adults. The results show that the prevalence of overweight and obesity increased in all age groups in rural and urban areas.

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 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.

There has been a growing body of empirical evidence focusing on the causes and effects of obesity, and on nutrition transition in developing countries. However, only a few have addressed the impact of urbanization on nutrition transition and obesity levels (Popkin, 1999; Van de Poel *et al*., 2009). Previous studies have investigated the comparison between urban and rural diets, the difference of which could lead to diet structure change within the urbanization process. Some have shown that urban residency is linked to transitions of diet structure and also with increasing levels of obesity in lower and middle-income countries (Popkin 1993, 1994, 1998, 1999, 2001b). Those studies use very few panels of survey individuals for urbanization and its effects on diet and physical activity patterns. However, that short period of time can not sufficiently reveal the dynamics of nutrition transition and obesity in the scenario of urbanization. Thus, panels with more time periods need to be included in the analysis to evaluate the relationship between urbanization, nutrition transition, and obesity.

1.2 Objectives

This thesis aims to explore the effects of urbanization on nutrition transition and obesity level in China. This analysis uses an urbanization index which incorporates a comprehensive representation of urbanization growth across China, to evaluate 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 by inducing the changes in diet pattern. Previous studies find some empirical evidence that when the prices of staple cooking oil become cheaper relative to other food, people will consume more of it. And because cooking oil is the most energy-dense of all foods, such a food substitution can lead to a higher level of calorie intake (Lu and Goldman, 2010). In addition, the regression analysis controls for individual characteristics, such as age, income, education, and physical activity levels, to examine the effects of these individual factors on nutrition transition and obesity. Moreover, this thesis would examine the role of gender and regional differences in explaining the impact of urbanization on nutrition transition and obesity.

1.3 Contribution

This study expands the previous literature in three aspects. First, this study analyzes more recent data than previous studies and includes more dynamics by using more panels of the longitudinal survey data. Following Popkin (1999), which is basically a static analysis on urbanization, nutrition transition, and obesity, I further explore the changes in dynamics. Compared with Popkin (1999), which used 3 waves of data, including 1989, 1991, and 1993, this study uses 8 panel data waves from 1989 to 2009.

Second, variation in food prices can have effects on obesity by influencing individuals' diet patterns (Lu and Goldman, 2010). This study incorporates food prices, as a group of control variables along with other control variables of individual characteristics, such as age, gender, educational attainment, income levels, and physical activity levels. Following the empirical method of Lu and Goldman (2010), I employ the fixed effects model using a larger time span for exploring dynamic changes in nutrients intake and obesity level in the scenario of urbanization in China. I use BMI for body weight and TSF for body fat as proxies for obesity as comparison. I set the urbanization index at community-level as the key regressor along with other covariates, as community-level relative prices of cooking oil, and individual-level characteristics. Departing from Lu and Goldman (2010), who use 3 different settings of relative prices, I use staple food, pork, and vegetable prices deflated by edible oil prices as a uniform model specification. Also, I introduce an interaction term of education attainment and income level as an explanatory variable.

Third, the analysis will extend to gender and regional differences, which could provide additional insight on the linkage between urbanization and obesity level in China. This could reveal more specific demographic patterns in nutrition and obesity in the scenario of urbanization.

The remainder of the thesis proceeds as follows. The next section covers literature review. Section 3 presents descriptions of data. Section 4 introduces the econometric methodology. The empirical results are discussed in Section 5, and Section 6 concludes the study.

Chapter 2

LITERATURE REVIEW

2.1 Empirics of Urbanization and Health Outcomes in China

Previous studies have investigated the linkages between urbanization and health outcomes, such as physical activity, overweight, hypertension and so on (Liu *et al*., 2003; Monda *et al.*, 2007; Van de Poel *et al*., 2009; Jones-Smith and Popkin, 2010; Van de Poel *et al*., 2011).

Liu *et al*. (2003) examine the impact of urbanization on rural health care and insurance. The empirical analysis uses a logistic model with data from China Health and Nutrition Survey, from 1989 to 1993. The results indicate that urbanization leads to a significant and equitable increase in insurance coverage, which in turn plays a critical role in access to health care. Urbanization can help make substantial changes in rural health care and insurance status.

Monda *et al.* (2007) examine the effect of rapid urbanization on adult occupational physical activity in China. Longitudinal data was taken from individuals aged 18 to 55 from the years 1991 to 1997 of the China Health and Nutrition Survey.

Logistic multi-level regression analyses indicates that men have 68% greater odds, and women have 51% greater odds, of light versus heavy occupational activity given the mean change in urbanization over the 6-year period. Further, simulations show that light occupational activity increases linearly with increasing urbanization. After controlling for individual-level predictors, community-level urbanization explains 54% and 40% of the variance in occupational activity for men and women, respectively. The empirical results show a reduction in the intensity of occupational activity with urbanization which indicates a risk of dramatic increase in the numbers of overweight and obese individuals.

Van de Poel *et al.* (2009) construct an index of urbanicity from longitudinal data on community characteristics from the China Health and Nutrition Survey. They compute a rank-based measure of inequality in disease risk factors by degree of urbanicity. Prevalence rates of overweight and hypertension almost doubled between 1991 and 2004. Decomposition analysis reveals that one-half of the urbanicity-related inequality in overweight is directly owing to community level characteristics. Meanwhile for hypertension the contribution of such characteristics increased from 20% in 1991 to 62% in 2004. At the individual level, lower engagement in physical activity and farming explains more than half of the urban concentration of overweight and a rising share (28%) of the greater prevalence of hypertension in more urbanized areas. Higher income explains around one-tenth of the urban concentration of both overweight and hypertension. While the education advantage of urban populations has a similar sized offsetting effect.

Jones-Smith and Popkin (2010) utilize established scaling procedures from the psychometric literature to construct and evaluate a multi-component scale to measure urban features on a continuum in China. The fixed effects regression of change in a community's level of urbanicity and change in an individual's percentage of total energy from fat, indicate that increasing community urbanicity is associated with increasing energy from fat. In addition, the results from the analogous logistic regression, indicates that there is no significant difference between urban and rural places on the odds of overweight and obesity.

Van de Poel *et al.* (2011) estimate the net health impact of China's unprecedented urbanization. The study uses community and individual level longitudinal data from the China Health and Nutrition Survey. An index of urbanicity is constructed from a broad set of community characteristics; and urbanization is defined in terms of movements across the distribution of this index. The empirical analysis employs difference-in-difference estimators to identify the treatment effect of urbanization on the self-assessed health of individuals. The results show that urbanization raises the probability of reporting poor health and that a greater degree of urbanization has a larger effect.

2.2 Nutrition Transition and Obesity

In the previous literature, some take the perspective of nutrition transition on addressing the obesity issues. (Popkin, 1993, 1994, 1996, 1998, 1999, 2001a, 2001b, 2004). The concept of nutrition transition is used to capture the dynamic nature of diet, particularly large shifts in its overall structure. Many of the same factors that explain shifts in diet also explain those in physical activity and body composition. The changes in diet and physical activity are reflected in nutritional outcomes such as stature and body composition. Moreover, these changes are paralleled by changes in life style and health status, as well as by major demographic and socioeconomic changes (Popkin, 1998).

Popkin (1993) provides a framework that accommodates the dynamic nature of diet and the relationship of diet and economic, social, demographic, and health factors. Dietary changes are reflected in nutritional outcomes, such as changes in average stature and body composition. Popkin (1993) puts forward some propositions as an approach to understand the nutrition transition. Notably, major shifts in population growth, age structure, and spatial distribution are closely associated with nutritional trends and dietary change. Urbanization process, which related to spatial distribution, is closely associated with nutritional trends and dietary change.

Also, for the majority of developing world, evidence of increasing obesity along with nutrition transition is found significant (Popkin, 1994, 1998, 1999, 2001b; Popkin and Doak, 1998; Popkin and Gordon-Larsen. 2004). Diets of the developing world are shifting rapidly, particularly with respect to fat (edible oil for example), caloric sweeteners, and animal source foods. Obesity shifts in adults are occurring globally, while changes in the developing world are faster than in higher-income countries (Gordon-Larsen. 2004).

Popkin *et al.* (1993) explore China's recent history with respect to nutrition and identify patterns of under and over-nutrition. The finding shows that higher income levels, particularly in urban areas, are associated with consumption of a diet higher in fat and with problems of obesity.

Popkin (1994) finds evidence of changes and trends in dietary intake, physical activity, and body composition patterns in low-income countries. These changes vary significantly over time, along with problems of under- and over-nutrition often coexist, reflecting the trend in which an increasing proportion of people consume the types of diets associated with a number of chronic diseases. China, as a case study, has undergone very rapid dietary changes. Using data from China Health and Nutrition Survey, the study finds a high-fat diet is significantly more common in urban and higher income populations than in rural and lower income ones.

Popkin (1996) presents an overview of nutrition transition and experiences in China and Russia with monitoring of economic and health changes. Dietary changes are evident in changes in average stature and body composition and parallel major changes in health status. Nutritional trends and dietary change are associated with population growth, age structure, and spatial distribution. Urban population has a distinctly different diet from rural population. Urban diets include superior grains, more milled and polished grains, higher fat content, more animal products, more sugar, and more prepared and processed food. Urban and rural diets are farther apart in low-income countries. Diet and activity are affected by income, patterns of work, and socioeconomic changes.

Popkin (2001a) illustrates an increase from 22.8% to 66.6% in the proportion of adults consuming a higher-fat diet in 1989 to 1993, rapid shifts in the structure of diet as income changes, and important price relationships in China. These reflect a substantial shift in eating preferences, induced mainly by shifts in income, prices and food availability, also by the modern food industry and the mass media. Moreover, the remarkable shift in the occupations structure in lower-income countries from agricultural labor towards employment in manufacturing and service sectors implies a reduction in energy expenditure. One consequence of the nutrition transition has been a decline in under-nutrition accompanied by a rapid increase in obesity. Also there are significant differences between urban and rural dietary patterns, particularly regarding the consumption of food prepared away from home. Furthermore, the shift towards a diet higher in fat and meat and lower in carbohydrates and fiber, together with the shift towards less physical activity, brings about negative nutritional and health effects.

Du *et al.* (2002) explore the long-term shifts in the nutrition transition and the full implications of these changes in the Chinese diet. Using data from China Health and Nutrition Survey from 1989 to 1997, China National Nutrition Survey from 1982 to 1992, the annual household consumption surveys of the State Statistical Bureau, and the Annual Death Report of China, the study finds that the total energy intake of residents has decreased, as has energy expenditure, large changes in the composition of energy have occurred. The overall proportion of energy from fat increased quickly, reaching an overall average of 27.3% and 32.8% for urban residents in 1997. Large shifts towards increased inactivity at work and leisure occurred. These changes are linked with rapid increases of overweight, obesity and diet-related non-communicable diseases as well as total mortality for urban residents.

Paeratakul *et al.*, (1998) examine the relationship between diet, particularly dietary fat intake, and BMI, taking the Chinese adults aged 20 to 45 as a study sample from China Health and Nutrition Survey. Multiple regression analysis is employed to examine the cross-sectional relationship between diet and BMI at baseline (1989) survey, controlling for other biological and socio-economic factors. The results indicate that diet is becoming an increasingly important determinant of body weight in that population.

Ng *et al.* (2008) investigate the price policy effects on edible oil in China. With four waves of data collected in 1991, 1993, 1997 and 2000 from the China Health and Nutrition Survey, this analysis uses a longitudinal random effects probit model and a longitudinal random effects generalized least squares model. The findings reveal that price policy effects on edible oil can influence dietary composition (particularly of the poor) in China.

Lu and Goldman (2010) study the effects of relative food prices on obesity in China. The study employs pooled OLS regressions, random effects model, and fixed effects model. Using the longitudinal data from China Health and Nutrition Survey, from 1991 to 2006, they find that the decreases in the price of energy-dense foods have consistently led to elevated body fat, but the price effect does not always hold for body weight. The results suggest that changes in food consumption patterns induced by varying food prices can increase the percentage of body fat to risky levels even without substantial weight gain.

The nutrition transition in developing countries is associated with a major shift from the consumption of staple crops and whole grains to processed foods. Asfaw (2011) examines the contribution of processed foods consumption to the prevalence of overweight and obesity in Guatemala. The results show that all other things remaining constant, a 10% point increase in the share of partially processed foods from the total household food expenditure increases the BMI by 3.95%. Moreover, the impact of highly processed foods is much stronger.

2.3 Obesity and Some Related Factors

There are another strand of literature focus on specific factors related to obesity, such as population density (Zhao and Kaestner, 2010), food prices (Goldman *et al.,* 2009; Lakdawalla and Philipson, 2002), education (Anderson *et al.*, 2011; Webbink *et al.,* 2010), fast food (Powell, 2009; Chou *et al.*, 2004).

2.3.1 Population Density

Zhao and Kaestner (2010) examine the effect of changes in population density on obesity of residents in metropolitan areas in the U.S. between 1970 and

2000. The empirical analysis addresses the possible endogeneity of population density by using a two-step instrumental variables approach. The empirical evidence indicates a negative relationship between population density and obesity. Specifically, the estimates imply that if the average metropolitan area had not experienced the decline in the proportion of population living in dense areas over the last 30 years, the rate of obesity would have been reduced by approximately 13%. Notably, the urban sprawl in the study of Zhao and Kaestner (2010) contrasts with the scenario of urbanization in my thesis. Urban sprawl in the U.S. from 1970 to 2000 can be regarded as a post industrialized and post urbanization era. While in China in the past decades, urbanization is a typical transition among developing world towards a more industrialized and more urbanized country. Due to the different stages of economic growth and urbanization development, the comparison of the results of Zhao and Kaestner (2010) and this thesis should be cautious.

2.3.2 Food Price

The growth in weight has been related to how individuals respond to changes in food price. Goldman *et al.* (2009) study the short-run and long-run body weight consequences of changing food prices. The study employs a fixed effects model, using health data from the Health and Retirement Study (HRS), a biennial survey of the population over age 50 and food price data. The results show very modest short-term effects of price per calorie on body weight, while the long-term effect is much bigger, but it takes a long time for the effect to reach the full scale. The results suggest that policies raising the price of calories will have little effect on weight in the short term, but might curb the rate of weight growth and achieve weight reduction over a very long period of time.

Lakdawalla and Philipson (2002) present a dynamic theory of body weight. Also, they conduct an empirical analysis with linear regression model, using data from National Health Interview Survey. They argue that technological change has induced weight growth by lowering food prices through agricultural innovation.

2.3.3 Education

Previous literature also documents the association between education and obesity. Anderson *et al.* (2011) investigate the impact of attending school on body weight and obesity. Using a regression-discontinuity design, the study compares weight outcomes of similar age children with one versus two years of school exposure due to regulations on school starting age. The results show that school exposure is related to unobserved determinants of child weight. If this endogeneity is not taken into account, it appears that an additional year of school exposure results in a greater

BMI and a higher probability of being overweight or obese. When actual exposure is instrumented with predicted school exposure in a regression-discontinuity framework, the significant positive effects disappear.

Webbink *et al.* (2010) analyze the causal effect of education on the probability of being overweight by using longitudinal data of Australian identical twins. In the empirical model, the family fixed effect is removed by differencing within pairs of twins. The estimation results confirm the negative association between education and the probability of being overweight. The estimated effect of education on overweight status increases with age.

2.3.4 Fast Food

Recent empirical studies suggest that the growth of fast-food and restaurants is contributing to the growth in obesity. Powell (2009) examines the relationship between adolescent BMI and fast food prices, as well as fast food restaurant availability. The study draws on four waves of the 1997 National Longitudinal Survey of Youth and external data. The empirical model of adolescent BMI regresses on fast food price and the availability of fast food restaurants, controlling for individual and household characteristics and year dummy variables. The findings indicate that the price of fast food, not the availability of fast food restaurants has a statistically significant effect on adolescent BMI. Also there is evidence that the weight of adolescents in low to middle-socioeconomic status families is most sensitive to fast food prices.

Chou *et al.* (2004), employing the 1984 -1999 Behavioral Risk Factor Surveillance System, find that the large positive effects associated with the per capita number of restaurants. They also find the importance of increasing trends in body weight in explaining the stability of obesity between 1960 and 1978 and the increase since 1978. The result implies fast food and full service restaurants are culprits in undesirable weight outcomes.

Related to my thesis, the urbanization usually proceeds along with increasing availability of fast food and full service restaurants, which could contribute to the obesity level.

Chapter 3

DATA

3.1 Data Source

This thesis uses data from the China Health and Nutrition Survey (CHNS), which was designed to examine the effects of the health, nutrition, and family planning policies and programs implemented by national and local governments and to see how the social and economic transformation of Chinese society is affecting the health and nutritional status of its population. It is an on-going panel from over 200 communities in 9 provinces.[4] The survey takes place over a 3-day period using a multistage, random cluster process to draw a sample of about 4400 households with a total of 26,000 individuals. CHNS collects longitudinal data on demographics, anthropometric measurements, health indicators, and community-level commodity prices. It began in 1989 and followed the participants subsequently in 1991, 1993, 1997, 2000, 2004, 2006, and 2009.

4 The nine participating provinces include Liaoning, Heilongjiang, Shandong, Jiangsu, Henan, Hubei, Hunan, Guizhou, and Guangxi. Heilongjiang was not surveyed in 1991 and 1993, and Liaoning was not surveyed in 1997.

3.2 Obesity and Nutrition

The key variable is obesity, which is defined as the condition of having an abnormally high proportion of body fat (National Institutes of Health, 1998, p174). BMI is traditionally used as a proxy for obesity, mainly because it is convenient to obtain and easy to interpret. It is defined as weight in kilograms divided by the square of height in meters: BMI = weight(kg)/height-squared(m^2). An individual with a BMI $\geq$ 25 is classified as overweight and is further considered obese if the BMI $\geq$ 30 (National Institute of Health, 1998). TSF is a measure for body fat. It is a measure of anthropometry of the upper arm, specifically, a vertical skinfold measured at the posterior midpoint between the acromion and the olecranon. It directly measures subcutaneous body fat, and is widely used to measure body composition in clinical studies.

Another set of response variables of interest are nutrients which are the proxies for diet structure that represents nutrition transition. I use energy, fat, carbohydrate, and protein from CHNS to investigate the nutrition transition along with the rising urbanization in China.

3.3 Urbanization

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**: total population of the community divided by community area, from official records.
- **Economic activity**: typical daily wage for ordinary male worker and percent of the population engaged in non-agricultural work.
- **Traditional markets**: distance to the market in three categories: within the boundaries of the community, within the city, but not in this community, or not within the city/village/town); number of days of operation for eight different types of market (including food and fuel markets).
- **Modern markets**: number of supermarkets, cafes, internet cafes, indoor restaurants, outdoor fixed and mobile eateries, bakeries, ice cream parlors, fast food restaurants, fruit and vegetable stands, bars within the community boundaries.

- **Transportation infrastructure:** most common type of road, distance to bus stop, and distance to train stop. (Distance is categorized as: within community, ≤ 1 km from community, and ≥ 1 km from community).
- **Sanitation**: proportion of households with treated water and prevalence of households without excreta present outside the home.
- **Communications**: availability (within community boundaries) of a cinema, newspaper, postal service, telephone service; and percent of households with a computer, percent of households with a television, and percent of households with a cell phone.
- **Housing**: average number of days a week that electricity is available to the community, percent of community with indoor tap water, percent of community with flush toilets, and percent of community that cooks with gas.
- **Education**: average education level among adults above 21 years old.
- **Diversity**: variation in community education level and variation in community income level.
- **Health infrastructure**: number and type of health facilities in or nearby (12 km) the community and number of pharmacies in community.

- **Social services**: provision of pre-school for children under 3 years old, availability of (offered in community) commercial medical insurance, free medical insurance, and/or insurance for women and children.

3.4 Food Prices

Another set of independent variables are relative food prices at the community level, including the price of staple food (rice, wheat, and noodle), pork, and vegetables relative to 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 oil when preparing meals, and vice versa. Therefore, higher oil intake leads to more obesity.

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). 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.

3.5 Individual Characteristics

Besides the covariates of community level food prices, I include 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. 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. The rational in this division of educational attainment is based on the national policy of "Nine-year

Compulsory Education”[5]. 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 governments at various levels. 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. Still, I try three levels of educational attainment here. Specifically, I pick the “bachelor’s degree and beyond” 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. In this analysis, I use 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.

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

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, like counter salesperson, and lab technician. “Light” also includes some moderate activities such as driver and electrician. “Heavy” includes heavy physical activities, covering occupations such as farmer, athlete, dancer, steel worker, and lumber worker.

3.6 Statistical Summary

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 women, I exclude the waves when they were pregnant to avoid irrelevant weight shocks. Thus there are 31,612 individual-year observations and 14,748 individuals in total. Also, it is an unbalanced panel, because the number of time periods is not the same for all individuals.

The descriptive statistics of the variables are listed 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. In contrast, 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 urbanization index has an average of 56.78. I plot the mean of urbanization index over time 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≤BMI<30) individuals has increased from 8% in 1989 to 26% in 2009, and the fraction of obese (BMI≥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, people tend to 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. Second, urban life offers more availability of fast food and restaurants, which could contribute to the obesity level. Moreover, increasing urbanization in China is linked to economic growth and increases in income level as people move from lower productivity and income in agricultural sector to higher productivity and income in industrial and service sectors. This income growth will induce the diet structure changes in population, in which people can afford more energy-dense food. And this evolution represents the nutrition transition course in China. Beside the income effect, the price effect on dietary patterns could also contribute to the obesity level (Lu and Goldman, 2010). Therefore, I 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 the next chapter.

Chapter 4

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 regard to dietary patterns.

4.1 Background

Previous studies that focus on obesity and contributing factors mainly use the fixed effects model. In these studies, obesity is a function of contributing factors of interest, controlling for regional level characteristics, individual level characteristics, regional or individual fixed effects, and year fixed effects.

Gruber and Frakes (2006) estimate the impact of cigarette taxes on BMI. In that paper, BMI is the function of cigarette tax, unemployment rate, individual specific covariates, and fixed effects for the state and year. The results reveal a negative effect of cigarette taxes on body weight, implying that reduced smoking leads to lower body weights.

Zhao and Kaestner (2010) set a model specification that BMI is a function of area fixed effects, year fixed effects, individual characteristics, and population density, to obtain estimates of the association between the proportions of metropolitan living and the weight of residents. The empirical evidence indicates a negative relationship between population density and obesity.

Lu and Goldman (2010) use OLS, random effects model and fixed effects model to explore a causal relationship between food prices and obesity. In the regression, obesity, using BMI and TSF for measurement of body weight and body fat respectively, is a function of community level relative cooking oil prices, and individual level characteristics, such as age, gender, educational attainment, type of residence, physical activity levels and year fixed effects. Also that paper extends to gender differences for the price effects on obesity. The empirical results show that oil consumption can correspond to relative cooking oil prices and increase individuals' body fat at a faster rate than it affects body weight.

Popkin (1999) investigates the relationship between diet structure and urbanization. The tested hypothesis is that 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. The paper uses OLS regression in which energy intake is the dependent variable and the independent variables are GNP per capita, the proportion of the population residing in the urban areas, and an interaction term between GNP per capita and the proportion of urban residents. The regression model predicts that rapid urbanization, usually associated with greater incomes and economic growth, can have independent effects on diet structure. Rising urbanization of lower income countries is accelerating the shift towards increasing consumption of sweeteners and fats. In the case of China, results show that urban residence is linked with shifts in the structure of diets towards higher fat foods. In addition, when urbanization is interacted with a time-varying physical activity measure, its coefficient is significant as a determinant of obesity in fixed effects model.

4.2 Panel Data Regression[6,7]

This thesis uses a panel dataset from CHNS. Population models for panel data contain time-invariant unobserved effects, i.e. unobserved individual heterogeneity that maybe correlated with regressors. Thus, the exogeneity assumption that is critical for the OLS regression is violated; thereby the OLS method will provide inconsistent estimates of the parameters. Also, such unobserved heterogeneity leads to

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[6] Wooldridge J.M. (2001). "*Econometric Analysis of Cross Section and Panel Data*" The MIT Press.

[7] Cameron, A. C., and P. K. Trivedi. 2005. "*Microeconometrics: Methods and Applications*" Cambridge University Press.

omitted variable bias. These problems due to existence of unobserved individual heterogeneity in panel data induce departure form OLS estimation. Thus, panel regressions should be set in a model specification that coherently incorporates individual specific effects.

A general panel data regression model assumes the existence of unobserved individual heterogeneity and it is written as

$$y_{it} = \alpha + X_{it}\beta + u_{it} \qquad t = 1,\ldots,T$$

Here α is the intercept, X_{it} is a vector of explanatory variables, the error term u_{it} contains the unobserved heterogeneity, which is presumed to be constant over time but varies across cross-sectional units. Different assumptions about the error term u_{it} will generate different forms of the panel regression model. There are two commonly specified models: the fixed effects (FE) model and random effects (RE) model.

In an Unobserved Effects Model (UEM) for randomly drawn cross section observation i:

$$y_{it} = \alpha + X_{it}\beta + c_i + u_{it} \qquad t = 1,\ldots,T$$

X_{it} are observed explanatory variables. c_i is individual effect. u_{it} is idiosyncratic errors that change across t and i. In fixed effects (FE) model, c_i is a parameter to be estimated and has arbitrary correlation with X_{it}. While in random effects (RE) model, c_i is a random variable and has no correlation with X_{it}.

The basic framework of fixed effects model is presented as follows:

$$y_{it} = \alpha + X_{it}\beta + c_i + u_{\text{it}} \qquad t = 1,\ldots,T$$

Here α is the intercept, c_i is the unobserved heterogeneity and u_{it} is the error term. Under the assumption of strict exogeneity of the explanatory variables conditional on c_i, i.e. $E\,(u_{it} \mid X_i\,,\,c_i) = 0$, the idea for estimating β is to transform the equations to eliminate the unobserved effect c_i. Specifically, this fixed effects transformation is the time demeaning of the original equation, which has removed the individual specific effect $c_{i.}$ Time-constant variables are not allowed in fixed effects analysis unless they interact with time-varying variables. Based on fixed effects transformation, the unobserved heterogeneity term is eliminated by subtracting the group means:

$$y_{it} - \overline{y_i} = \beta^{'}(X_{it} - \overline{X_i}) + u_{it} - \overline{u_i} \qquad t = 1,...,T$$

In addition, heteroskedasticity and serial correlation would cause estimation problems in panel data regression. Heteroskedasticity could be inspected via Modified Wald test with the null hypothesis of no groupwise heteroskedasticity. With regard to serial correlation, the Wooldridge test is applied to check whether there is autocorrelation within the residuals. The null hypothesis states that there is no serial correlation. If heteroskedasticity and serial correlation exist, the robust standard error could be applied to address these problems.

As to random effects model, it is analyzed by generalized least squares (GLS) when the variance structure is known and by feasible generalized least squares (FGLS) when the variance is unknown. The random effects model allows for time-invariant explanatory variables:

$$y_{it} = \alpha + X_{it}\beta + v_{it} \qquad t = 1,\ldots,T$$

$$v_{it} = c_i + u_{it}$$

Here α is the intercept, v_{it} is defined as a composite error term, c_i is the unobserved heterogeneity which follows the random effects assumption that it is uncorrelated with the explanatory variables. Under this assumption, the composite error term is serially correlated across time:

$$Corr(v_{it}, v_{is}) = \sigma_a^2 / (\sigma_a^2 + \sigma_\mu^2) \qquad t \neq s$$

Because pooled OLS standard errors usually ignore this positive serial correlation, they will be inefficient. In addition, pooled OLS estimation assumes no unobserved individual heterogeneity which makes it less efficient when estimating panel data. Breusch and Pagan (1980) developed a Breusch-Pagan Lagrangian Multiplier test for choice between a random effects model and an OLS model.

Rejection of the null hypothesis that there is no significant difference across units implies the appropriateness of a random effects model instead of a pooled OLS model.

The Hausman's (1978) specification test is used to determine which of the two alternative model specifications (FE *versus* RE) is more appropriate. The null hypothesis of the test is no correlation between unobserved effects and the explanatory variables. Under the null hypothesis, both FE and RE model yield consistent estimates, but the estimates from RE model are more efficient. Rejecting the null hypothesis is in favor of FE model against RE model.

In this study, I control for the unobserved individual heterogeneity through all of the survey years. Prior to that, a Hausman test will be employed to examine the choice of model specification between fixed effects model and random effects model. Also, diagnostic tests for heteroskedasticity and serial correlation will be conducted in the regression model.

4.3 Model Specification

In this thesis, I use the panel data regression to test whether the urbanization effects on nutrition transition and obesity. 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.

I use two measurements of "OBESITY" 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, specifically, the prices of staple food, pork, and vegetables, deflated by the price of cooking oil in community j at time t. Another group of control variables are individual characteristics "X_{ijt}", such as age, income level, educational attainment, and physical activity level. 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 of this food source, 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 represents 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.

Chapter 5

RESULTS

The thesis explores the effects of urbanization on the nutrition transition and obesity level for the adult population in China. Specifically, I use BMI and TSF as proxies for obesity, and use nutrients intake such as energy, fat, protein and carbohydrate to capture the changes in dietary patterns in nutrition transition. I employ panel data regression to examine the effects of urbanization on dietary structure and obesity level, controlling for the community level relative food prices and individual level characteristics including age, income, education, and physical activity levels.

5.1 Results of Model Specification Tests and Diagnostic Tests

In this analysis, I conduct a Hausman test to see whether we can reject the null hypothesis that RE estimator is consistent and more efficient than FE estimator. The test result rejects the null, thereby shows to be in favor of FE model against RE model (The Chi-square statistic is 584.46 with p-value 0.0000). Then I turn to FE regression and take diagnostic tests for heteroskedasticity and serial correlation.

Modified Wald test for groupwise heteroskedasticity in fixed effects model yields result of heteroskedasticity (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 heteroskedasticity and serial correlation, clustering on the panel variable produces a variance-covariance estimator that is robust to cross-sectional heteroskedasticity 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. Compared to the conventional standard errors, these clustered robust standard errors do not change point estimates of the coefficients, but would produce larger standard errors and therefore decrease the likelihood for a coefficient to be statistically significant. Nevertheless it is necessary for correcting heteroscedasticity and serial correlation problems.

As to the suspicion of time-invariant exogenous variables in the model, notably, education, income and physical activity, I conduct a Hausman-Taylor instrumental variable estimation (Hausman and Taylor, 1981). The result shows that there are no time-invariant exogeneous variables in the model.

5.2 Urbanization and Obesity

5.2.1 Full Sample Results

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, is shown 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. 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. These findings are generally consistent with previous study (Lu and Goldman, 2010), which indicates that obesity corresponds to food price changes.

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 (high school) 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. This result is intuitively understandable and consistent with previous findings, such as Van de Poel *et al.* (2009) that lower engagement in physical activity contributes to the urban concentration of overweight in China.

5.2.2 Gender Differences

For gender differences in RE and OLS regressions, the results in Table 3 show that more females are gaining body weight and body fat than males except in RE model for BMI. Due to the limitation of FE model, 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 presents the results of regression analysis on gender subsamples in fixed effects model. Urbanization has positive effects on body weight and body fat of female group at the significance level 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 than males. Notably, the difference between the gender groups mainly lies in education and income. Educational attainment is a positive predictor for female's BMI, especially for high school educational attainment level. 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.

5.2.3 Regional Differences

The analysis on regional differences yields mixed results, as shown in Table 5. 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 the country.

5.3 Urbanization and Nutrition Transition

Table 6-1 and Table 6-2 present 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 of higher protein and fat in dietary structure of Chinese population. The result is consistent the finding from Jones-Smith and Popkin (2010) that increasing community urbanicity is associated with increasing energy from fat. 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. Notably, the findings are consistent with previous study such as Popkin (1994), Popkin (1999), Popkin (2001a), Popkin *et al*. (1993), and Popkin *et al*. (2001), Du *et al.* (2002), Jones-Smith and Popkin (2010).

Chapter 6

CONCLUSION

This thesis focuses on the impact of the rising urbanization on the nutrition transition and obesity level. Taking adult individuals from a longitudinal dataset, the China Health and Nutrition Survey (CHNS), from the year 1989 to 2009, this study uses the fixed effects (FE) model to examine the effects of urbanization on nutrition transition and obesity, controlling for community level food prices and individual characteristics. The empirical results confirm the hypothesis that urbanization induces the nutrition transition and higher obesity level in population. This study contributes to the existing literature by introducing relative food prices as control variables and adding recent panels of longitudinal data for longer time span on the nutrition transition and obesity dynamics in the urbanization scenario. Also, this thesis extends to the analysis of gender and regional differences.

Following the study of urbanization, nutrition transition and obesity level in Popkin (1999), which is basically a static analysis and uses energy intake as a response variable, I use more data panels to explore the dynamic changes in obesity level associated with urbanization. Following the empirical method of Lu and Goldman (2010) on relative food prices and obesity, I employ the fixed effects model using data with a larger time span for exploring dynamic changes in obesity level with urbanization progress in China. I use Body Mass Index (BMI) as measurement for body weight and Triceps Skin Fold (TSF) for body fat as comparison. I set the urbanization index at the community-level as the key independent variable along with two groups of covariates, community-level relative food prices, and individual level characteristics. Different from Lu and Goldman (2010), which use 3 different settings of relative prices, I use staple food, pork, and vegetable prices deflated by edible oil prices as a uniform specification for regression with BMI and TSF outcomes respectively.

Results in the regression analysis show urbanization has a positive effect on the obesity level. Specifically, urbanization index is a significant predictor for obesity level in adult population in China. This finding confirms the hypothesis of this thesis and is consistent with previous study on urbanization and obesity (Popkin, 1999).

In addition, the obesity level responds to the relative food prices, namely, the prices of staple food, pork, and vegetables to cooking oil. As price of cooking oil get relatively cheaper, individuals consume more. Therefore, the change in the diet pattern leads to a higher level of calorie intake, and more body fat when excess calories are stored in the body. Also, empirical evidence yields more significant results for BMI than TSF from factors in individual education, income and physical activity. For BMI, the obesity level of females is more sensitive to education and income levels compared with males. Moreover, my thesis explores the regional differences of urbanization effects on obesity among nine selected provinces in CHNS. The provinces of Heilongjiang and Hubei show the significant positive effects of urbanization on obesity with both BMI and TSF as outcome of interest.

Also, this study yields some further empirical evidence on nutrition transition as urbanization proceeds. Urbanization progress has positive effect on fat and protein intake. These can be attributed to more consumption of cooking oil, meat, egg, and diary products as the urbanization proceeds.

As we can see from the findings of this thesis, urbanization comes at a price, from the perspective of 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 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. In addition, systematic effort is needed to reduce sedentary physical status and improve overall physical activity patterns, as more people take the occupations in relatively sedentary jobs along with the urbanization process. Moreover, the policy addressing the overweight and obesity should emphasize more on female population.

For future studies, progress may lies on the identification of more specific factors affecting the obesity levels in the scenario of urbanization. Furthermore, the mechanism of urbanization, nutrition transition and obesity could be more clarified based on the findings of those contributing factors. Still, there can be more findings regarding to regional and community-level specifics on obesity and nutrition if more data are available.

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

	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

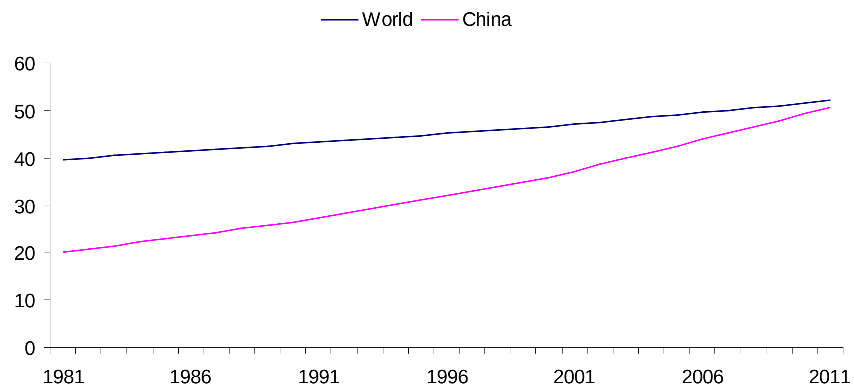
	ln(Energy)	ln(Fat)	ln(Carbohydrate)	ln(Protein)
ln(Urban)	0.015	0.134***	-0.014	0.034*
	(0.015)	(0.031)	(0.017)	(0.019)
ln(Food/Oil)	-0.005	0.065***	-0.057***	0.014
	(0.007)	(0.014)	(0.008)	(0.009)
ln(Pork/Oil)	0.014**	-0.002	0.026***	0.014*
	(0.007)	(0.013)	(0.007)	(0.008)
ln(Veg/Oil)	0.005	-0.008	0.017***	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

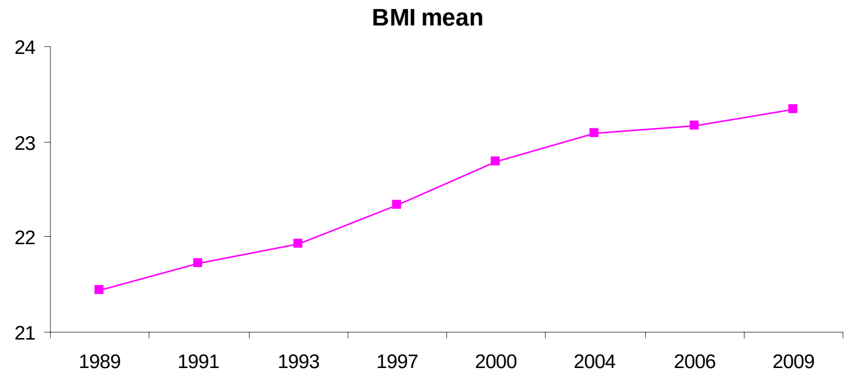
FIGURES

Figure 1: Percentage of Urban Population to Total Population



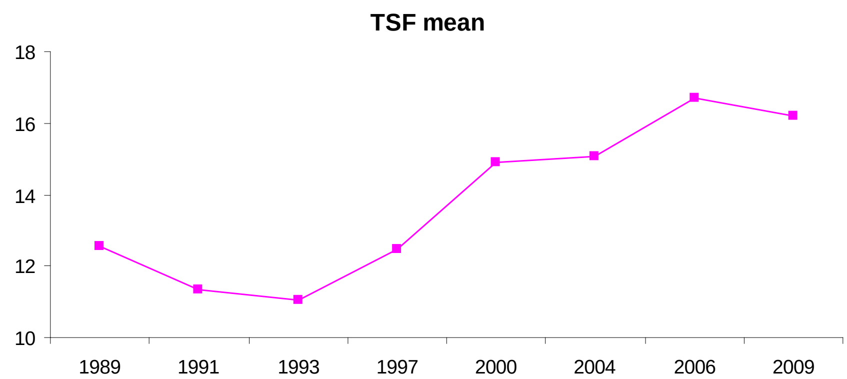
Source: World Bank

Figure 2: Trend of BMI Average Level



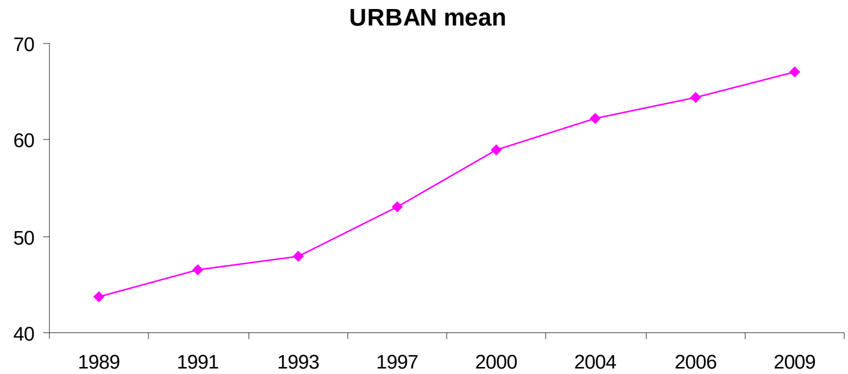
Source: CHNS

Figure 3: Trend of TSF Average Level



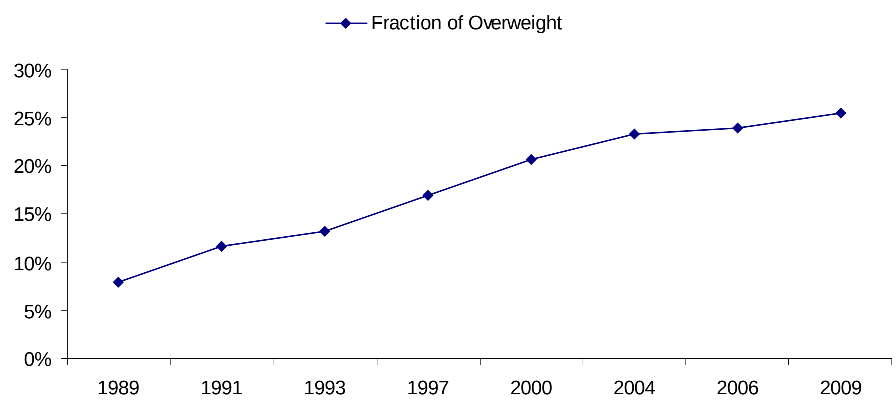
Source: CHNS

Figure 4: Trend of Urbanization Index Average Level



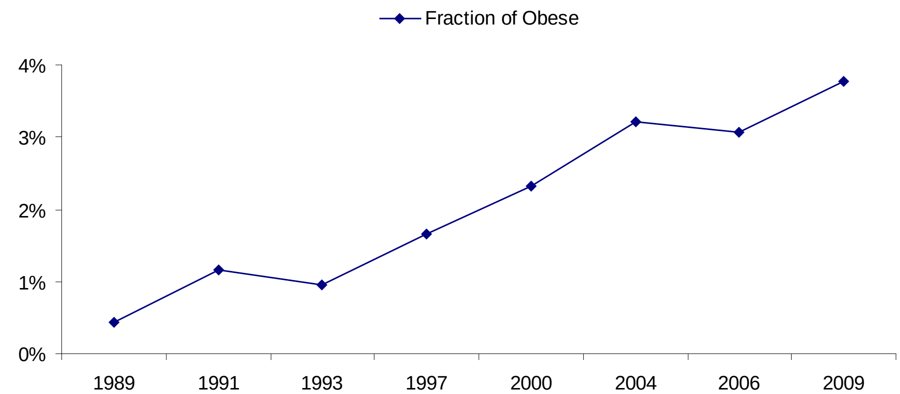
Source: CHNS

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

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