MASTER THESIS HEALTH ECONOMICS, POLICY AND LAW

The effect of food prices and community environment on changes in Body Mass Index in China 1991-2009

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Abstract

Introduction: The worldwide prevalence of overweight and obesity has more than doubled since 1980, also in developing countries like China, due to rapid social and economic development. Changes have occurred in dietary patterns, physical activity patterns and the disease patterns among the Chinese population. This study explores what accounted for the rise in body mass index (BMI) in China over time between 1991 and 2009.

Methods: This study uses longitudinal data from the China Health and Nutrition Survey (CHNS). Food prices and information about the community have been collected for each community from the CHNS. 3361 adults aged 18-65 were included in this study. Ordinary least squares (OLS) regressions are performed to estimate the effects of various food prices and community environment variables on BMI for 1991 and 2009 separately. In addition OLS regressions are performed with overweight and underweight as outcome. The last part of the analysis uses the traditional Blinder-Oaxaca decomposition technique in order to understand whether changes in the mean of the determinants or changes in the effect of the determinants have driven the increase in average BMI and the technique is also used to approximate the contribution of each determinant to the increase in BMI for the years 1991 and 2009.

Results: Results from the OLS regressions show that different food prices play a significant role. In 1991, an increase in the price of sugar resulted in a decrease in BMI and an increase in the price of green vegetables resulted in an increase in BMI. While in 2009, an increase in the price of rapeseed oil gives a decrease in BMI. In addition, age has a significant increasing effect on the BMI and a high share of the community engaged in agriculture has a significant decreasing effect on the BMI. The decompositions make clear that the constant plays an important role in explaining the gap in mean outcome between 1991 and 2009. For BMI and overweight changes in the effects of the determinants accounted for a large part of the gap in mean outcomes and for underweight changes in the means of the determinants were more important in explaining the gap in mean underweight.

Conclusion: The results make clear that the constant reduced the total contribution of the variables used in the decomposition and that the changes in the effect of the determinants accounted most for the gap in mean BMI between 1991 and 2009. This means it were not the changes in the means of the determinants that drove the rise in average BMI between 1991 and 2009. To effectively prevent overweight and obesity changes in community environment and pricing policies are needed to tackle the rise in overweight and obesity, but first more research is necessary about the effect of more food item prices on the BMI and the effect of more community environment variables on BMI.

Introduction

Worldwide obesity has more than doubled since 1980 and overweight and obesity are the fifth leading risk for global deaths (World Health Organization (WHO), 2012). Overweight and obesity are a growing concern because of its association with chronic diseases like diabetes type II, cardiovascular diseases and some cancers (e.g. endometrial, breast and colon) (WHO, 2012). At least 2.8 million adults die each year because of being overweight or obese and people with severe obesity die 8 to 10 years sooner than people with normal weight, with every 15 extra kilograms increasing the risk of early death by approximately 30% (OECD, 2012).

Overall causes of overweight and obesity are an energy imbalance between consumed and expended calories, due to an increased intake of energy-dense food and a decrease in physical activity (WHO, 2012). This imbalance is often the result of environmental and societal changes associated with development and lack of supportive policies in sectors such as health, agriculture, transport, urban planning, environment, food processing, distribution, marketing and education (WHO, 2012).

The increase in overweight and obesity is not only found in Western countries, but also in developing countries like China due to environmental and social changes causing increasing overweight and obesity rates following the rest of the World. China is a large country where the total population in mainland China consisted of almost 1.35 billion persons at the end of 2011 (National Bureau of Statistics of China, 2012) and its economy has grown rapidly in recent decades with annual GDP growth rates of 9 to 10% in the course of 1980-2005 (Shankar, 2010). This is accompanied by an increased health risk of the population and associated healthcare and indirect costs. Therefore, it is relevant to investigate why the distribution of the BMI has changed over time in China. Have the economic and social developments of the last couple of decades contributed to the increase of the obesity epidemic in China in the same pace as in Western countries? By focusing on the economic and societal changes we can investigate what contributed most to the rise in BMI in China. By better understanding the underlying mechanisms of the rise in BMI in China, more targeted and more appropriate policy measures can be used in order to be able to reduce the overweight and obesity rates and thus the health risks and healthcare costs.

Background

China was once considered as a country with one of the leanest populations, but now catching up with Western countries (Wu, 2006). As a result of rapid social and economic development, changes have occurred in dietary patterns, physical activity patterns and the disease patterns among the Chinese population (Ministry of Health, Ministry of Science and Technology & the National Bureau of Statistics, 2004).

According to the World Health Organization (WHO) 'overweight' and 'obesity' are defined as 'abnormal or excessive fat accumulation that may impair health' (WHO, 2012). It is measured by the Body Mass Index (BMI), also termed Quetelet's Index (QI), and defined as weight in kilograms divided by height in meters squared (kg/m^2). The BMI is universally used in medicine and the WHO considers a BMI between 18.5 and 24.9 as a healthy/normal weight for adults. A BMI between 25 and <30, and a BMI > 30 are considered as overweight and obese respectively. Although, the mentioned cutoff points between the categories are occasionally redefined and can vary from country to country. The proportion of Asian people with a high risk of cardiovascular disease and diabetes type II is substantial at BMIs lower than the existing WHO cut-off point of overweight (≥ 25 kg/m^2) (Expert Consultation WHO, 2004). Where the cut-off point for observed risk varies from 22 kg/m^2 to 25 kg/m^2 in different Asian populations and for high risk from 26 kg/m^2 to 31 kg/m^2 (Expert Consultation WHO, 2004). The Asian population generally has a higher (abdominal) body fat percentage than non-Asian population of the same age, sex and BMI (Wu, 2006). Because of the higher health risk at lower BMIs in Chinese people the Working Group on Obesity in China has recommended that a BMI of 18.5 to 23.9 should be considered as optimal, a BMI of 24.0 to 27.9 as overweight and a BMI of ≥ 28.0 as obese (Table 1). These recommendations were based on a meta-analysis of the relation between BMI and risk factors for cardiovascular diseases which indicated that Chinese people have higher risks for obesity related diseases even with a lower BMI (Zhou, 2002).

Table 1. Cut-off points overweight and obesity according to the WHO standards and the Chinese standard

	Overweight (kg/m^2)	Obesity (kg/m^2)	Overweight and obesity (kg/m^2)
WHO standard	25≤BMI<30	BMI≥30	BMI≥25
Chinese standard	24≤BMI<28	BMI≥28	BMI≥24

In China overweight and obesity rates vary from area to area. In 2003 the overall obesity rates according to the WHO (standard) was 5% in China as a whole but are larger than 20%

in some cities (WHO, 2003). In 2006 the prevalence of overweight and obesity[1] in China was 33.4% of the Chinese adults being overweight and 8.0 % being obese (Shankar, 2010). Furthermore, it is predicted that a large rise of the obesity rate will occur in the future and in 2025 the prevalence of overweight and obesity in China is expected to be the same as current overweight and obesity rates of Mexico, Egypt, Africa and the United States (Popkin et al. 2006). The prevalence of overweight and obesity in the United States were 67.7% in 2008 (Centers for disease control and prevention (CDC), 2010). Not only an increase in overweight and obesity in adults was found but also an increase in the prevalence of both overweight[2] and obesity[3] was found in children and adolescents from 2.1% in 1981-1985 to 20.7% in 2006-2010 (Yu et al. 2012).

Major increases in the total healthcare costs and indirect costs (mortality, disability and sickness/ absenteeism) are a result of the fast increase in overweight and obesity in China. It is estimated that the total costs of overweight/obesity (-related chronic diseases) were 4.06% of China's gross national product (GNP) in 2000 and it will rise to 9.23% of GNP by 2025 (Popkin et al., 2006).

Theoretical framework

The explanation for the high prevalence of obesity in China include changes in the traditional diet, reduced levels of physical activity and an increase of sedentary lifestyles (Wu, 2006). Next to these changes, China's rapid economic growth since late 1970's is characterized by rapid industrialization, massive flow of internal migrants, growing urbanization and an ageing population (WHO, 2008).

To explain the change in BMI over time in China my theoretical model is partly based on the framework of Costa-Font, Fabbri & Gil (2009). Weight is a function of individual calorie intake and expenditures of calories, according to the function:

$$W\ (FI, PA)$$

where FI is intake of calories and PA is the calories used in physical activity, so that $W_{FI} \geq 0$ and $W_{PA} \leq 0$.

The cause of obesity must be that calories from food intake exceed the calories expended. At a given point in time, the BMI of an individual provide a snapshot that reflects the accumulated difference between an individual's intake of calories and expenditure of calories that he/she experienced in his/her life. Therefore the current BMI of an individual should be

[1] According to the Chinese Standard. According to the WHO criteria 25.0 % of the population is overweight and 4.5% is obese (Shankar, 2010).
[2] The prevalence of overweight increased from 1.8% in 1981-1985 to 13.1% in 2006-2010.
[3] The prevalence of obesity increased from 0.4% in 1981-1985 to 7.5% in 2006-2010.

properly modeled within a framework where we can investigate what accounted for the rise in BMI in China over time. In the emerging framework the individual's BMI is determined by:

$$BMI_i = x'\beta + \varepsilon_i \quad (1)$$

where x' is a vector containing the predictors and a constant and ε_i is a measure of unobservables.

It is well known that weight gain is caused by caloric imbalance, where consumption of calories exceeds calories expended. Nevertheless, it is not clear why the prevalence of overweight and obesity has increased so dramatically over the last decades. In the literature theoretical frameworks are found to explain important economic reasons for the long-run growth in weight and obesity (Philipson & Posner, 1999; Lakdawalla & Philipson; 2002, Chou et al., 2004). Philipson & Posner (1999) used a framework to explain important economic reasons for the long-run growth in weight and obesity. Sedentary technological change has lowered the real price for food and also the physical expenditure of calories per hour worked in market and household production (Philipson & Posner, 1999). This has contributed to the rise in weight and obesity in two ways: by lowering the cost of calorie consumption and by raising the cost of physical expenditure of these calories. Lakdawalla & Philipson (2002) showed that technological change has induced the growth in weight by making home- and market production more sedentary and by lowering food prices through agricultural innovation. They found that these technology-based reductions in food prices and job strenuousness have a significant impact on weight across time based on data of the USA where the BMI is negatively correlated to the strenuousness of jobs. In addition, they found that about 40% of the recent growth in weight seems to be caused by supply side factors such as agricultural innovation that has lowered prices, and 60% may be due to demand factors such as a decline in physical activity from technological changes in home- and market production (Lakdawalla & Philipson, 2002).

Previous evidence

Different factors can influence weight and thus the BMI. Large shifts have occurred in diet patterns and physical activity patterns where diets are high in saturated fats, sugar and refined foods but low in fiber and where levels of physical activity have declined (Popkin & Gordon-Larsen, 2004). This has resulted in changes in average stature, body composition and morbidity. The diets of people living in urban areas are different from the diets of people living in rural areas (Popkin & Larsen, 2004). In 2012, the Chinese government estimated that the proportion of the urban population reached 51.27% in 2011, an increase of 1.32 percentage points compared to 2010 (National Bureau of Statistics of China, 2012). Because urban residency is linked to a higher increase of the BMI (Wang et al., 2007; Popkin et al., 1995; Popkin, 1999; James, 2008) an increase in the proportion of the urban population in China is also a factor that causes growing rates of overweight and obesity. This is partly due to the introduction of mechanical aids at work. In addition, the use of household aids and living in urban areas leads to a much more confined life than living in rural areas (James, 2008). Also due to China's continuing modernization, a decrease in work strenuousness and a decrease in physical activity in both rural and urban areas and in addition the lack of consideration towards constructing environments that promote physical activity makes a high energy expenditure extremely difficult (Wu, 2006).

Besides, technological change has caused a decline in food prices and the amount of physical exertion needed at work has fallen (Philipson & Posner, 2003). The transformation of the working conditions includes the introduction of mechanical aids at work and an increase in computer technology. Bell et al. (2002) examined the association between vehicle ownership and obesity and found that the odds of being obese were 80% higher for men and women in households who owned a motorized vehicle compared with those who did not own a vehicle (Bell et al., 2002). According to James (2008) caloric intake may need to fall by 400-800 kcal/day for each Chinese adult as their working and living conditions change.

Additionally, changes in food prices have shown to have an impact on overweight and obesity rates. The study of Ng et al. (2008) showed that declining edible oil prices have resulted in an increase in the consumption of edible oils and in fats as a percentage of dietary composition. Guo et al. (2000) have shown that high fat foods became much more responsive to income levels and that the quantity of fat in diets increased significantly with increases in income in China between 1989 and 1993. Lu & Goldman (2010) showed that changes in food consumption are induced by varying food prices which can increase percentage of body fat even without substantial weight gain. Furthermore, Chou et al. (2004) found a large positive effect associated with the per capita number of restaurants and they found downward trends in food prices accounted for the part of the upward trend in weight outcomes. In addition, statistical significant associations were found between food prices and weight outcomes in a literature review performed in the USA (Powell & Chaloupka, 2009). The effects were generally small in magnitude and larger for low socioeconomic status populations.

Recent studies have been focusing on the relation between changed dietary patterns, changed physical activity patterns and other health-related behaviors like smoking and drinking in China and the increase of BMI or chronic diseases. (Ng et al., 2012; Popkin et al., 1995; Du et al., 2002; Shankar, 2010). Other studies were not focused on China and investigated the effect of pricing policies and economic causes of obesity (Drewnowski & Darmon, 2005; Finkelstein et al, 2005; Cutler et al., 2003). According to Drewnowski & Darmon (2005) food technology and agricultural developments have made added sugars and vegetable oils accessible globally at remarkably low costs. Some studies were more focused on the effect of relative food prices and consumption or demand for food (Andreyeva et al., 2010) or were more focused on the effect between changes in food prices on the changes in body mass index/ obesity over a longer period of time (Lu & Goldman, 2010; Ng et al., 2008; Chou et al., 2004). To my knowledge none of these studies have focused on both the economic determinants and the societal determinants that are associated with the rise in weight/BMI.

This study will focus on determinants that have been cited by others as key factors associated with the rise of the obesity epidemic. Therefore, I will investigate the relation between various food prices and a number of community environment variables and their effect on changes in BMI in China between 1991 and 2009. Most of the determinants that will be used are more difficult to influence by the individuals themselves and these determinants suffer less from endogeneity problems compared to variables related to dietary patterns and other health related behavior like smoking, drinking and exercise patterns. The aim of the study is to investigate what accounted for the rise in BMI in China over time (1991-2009). What is the relative importance of the differences in the determinants in generating differences in BMI? The outcome of this study gives information about the most important changes contributing to the increase in mean BMI over time. Why do these differences in BMI exist and why have these changes occurred over time? It is valuable to know whether the rise in BMI reflects a differential distribution of variables or whether something else is going on that causes the effect of a variable to manifest differently. The decomposition allows us to see whether the rise in BMI is due to changes in the mean of the determinants or due to changes in the effects of the determinants. Without better understanding of the underlying mechanisms of the rise in BMI it is difficult to identify possible effective measures that might prevent the rise in overweight and obesity rates.

Methods

Study Population

This study uses longitudinal 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 local and national governments and to see how the economic and social transformation of the Chinese communities is affecting the health status of its population.[4] The CHNS collects longitudinal data on anthropometric measurements based on physical examinations, household data (including information about income and ownership of consumer durables), and detailed community-level data of food markets, health facilities, and commodity prices.

Data Collection

The CHNS started in 1989, involving 4400 households in nine provinces that varied substantially in geography, economic development, public resources, and health indicators. And thereafter 7 additional panels were collected in 1991, 1993, 1997, 2000, 2004, 2006 and 2009. A multistage, random cluster process was used to draw the samples surveyed in the nine provinces; Guangxi, Guizhou, Heilongjiang, Henan, Hubei, Hunan, Jiangsu, Liaoning, and Shandong. Counties in the nine provinces were stratified by income, and a weighted sampling scheme was used to randomly select four counties in each of the above mentioned province. Villages and townships within the counties and urban and suburban neighborhoods within the cities were selected randomly.

Sample selection

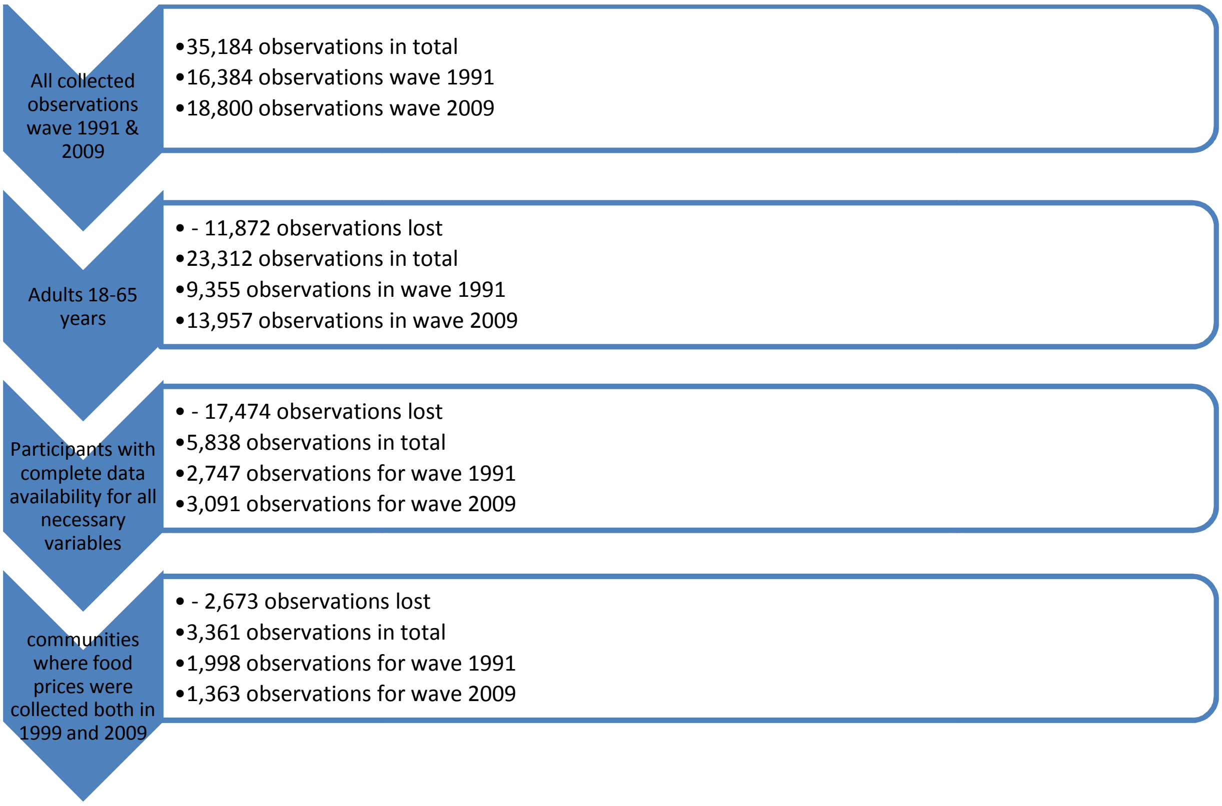
The analysis is limited to adults who were surveyed at least once and who were older than 18 years and younger than 65 years during the wave they were interviewed. People older than 65 are excluded in this study because elderly people have a different fat distribution which results in an increase in fat mass and a decrease in muscle mass (Baumgartner et al., 1995). Therefore changes in the BMI in the elderly can be attributed to changes in body composition and not to the determinants used in this study.

The numbers of observations vary by year due to added households or participants to replace households/participants/communities who were no longer participating in the study. To show the large possible effects of changes in BMI the widest possible period of time is chosen. Because the first wave (1989) was lacking information about several variables the next wave is chosen. Therefore, data from the second wave (1991) and the last wave (2009) are used for data analysis. In order to balance the data at community-level, only communities

[4] See for more information about the China Health and Nutrition Survey: http://www.cpc.unc.edu/projects/china

where food prices were collected both in 1991 and 2009 are used. Figure 1 provides an overview of the determination of the analytical sample size and the number of observations that did not meet the inclusion criteria.

Figure 1. Determination of the analytical sample size



Dependent variables

In the analysis three different outcome variables are used; the body mass index (BMI), underweight and overweight. The BMI can be calculated by weight in kilograms divided by height in meters squared (kg/m^2) and this was obtained from the Nutrition & Physical Examination data. Adults received detailed physical examinations that included weight and height. The BMI is a good predictor of weight-related morbidity at the level of the population and by using the BMI as outcome we can investigate which determinants were affecting the rise in BMI in China. In addition to BMI, overweight and underweight were used as outcome to investigate if the various determinants differ between the two groups. Overweight is defined by a BMI above 24.0 and underweight by a BMI below 18.5 according to the Chinese Standard.

Independent variables

Several studies investigated causes in dietary shifts in China (Guo et al., 2000; James, 2008; Ng, et al., 2012; Popkin & Larsen, 2004; Wang et al., 2007; Wu, 2006). Different factors have been mentioned to affect changes in diet and obesity like food prices, income, labor intensity, use of transportation and place of residency. Therefore, various variables that are most likely to be exogenous and that are mentioned by other researchers as important influences in caloric imbalance are used: food prices and various community environment variables. By using food price variables and community environment variables changes in the averages between 1991 and 2009 and the effect of it on the BMI can be measured.

Food prices have been collected for each of the communities from the CHNS. Community prices for a representative basket of goods were from three sources: state stores, free markets and large stores. In the analysis free market prices were used as standard. When no free market prices were available state store prices were used for wave 1991 and large store retail price were used in wave 2009.

Several food items which are often used by the Chinese population were included, including rice, rapeseed oil, white sugar, green vegetables (rape) and lean pork. All food items were priced at one kilogram and were corrected for inflation using the inflation index of 2009 to get the real prices of food items. The real prices of the food items were skewed to the right and therefore log real food prices were used.

Next to food prices the availability of public transport (bus stop and train station), place of residence (urban/rural), share of the community engaged in agriculture and the real community mean per capita household income were used as predictors of changes in BMI. These data have been collected during both waves with a community survey. The distance to public transportation was also measured, but unfortunately it contained too many missing data and therefore not included in the analysis.

Besides the key variables of food prices and community variables I included several individual covariates such as age, age squared, gender and household size.

Analysis techniques

All analyses were performed in Stata 12.0. The first part of the analysis estimates the effects of the determinants on BMI using ordinary least squares (OLS) for 1991 and 2009 separately. Thereafter OLS regressions were performed with overweight and underweight as outcome variables.

The second part of the analysis uses the traditional Blinder-Oaxaca decomposition (1973) technique in order to explain if changes in the means of the determinants (x’s) or changes in the effects of the determinants (β's) contributed to the rise in BMI and to approximate the contribution of each determinant to the increase in BMI for the years 1991 and 2009.

Within the framework of Equation (1) a standard decomposition to deal with the over time comparison of mean BMI in China is proposed by Oaxaca (1973) and Blinder (1973) as follows:

$$BMI^{2009} - BMI^{1991} = \sum_{j=1}^{K} (\overline{X}_{2009}^{-(j)'} - \overline{X}_{1991}^{-(j)'})\, \beta_{1991}^{(j)} + \sum_{j=1}^{K} \overline{X}_{2009}^{-(j)'} \left(\beta_{2009}^{(j)} - \beta_{1991}^{(j)} \right) \quad (2)$$

+ residual

where BMI^{1991} is mean BMI in 1991 and where BMI^{2009} is the mean BMI in 2009, $\beta_{1991}^{(j)}$/ $\beta_{2009}^{(j)}$ is a column vector of estimated coefficients for the set of regressors comprising the *j*th among *K* variables, and $\overline{X}_{1991}^{-(j)'}/\overline{X}_{2009}^{-(j)'}$ is a row vector of regressors' mean for the set of regressors comprising the the *j*th among *K* variables.

The Oaxaca decomposition is widely used to study mean outcome differences between groups. The technique is often used to analyze wage gaps by sex or race but in general it can be employed to study group differences in any outcome variable (Jann, 2008). The Oaxaca decomposition explains the gap in the means of an outcome variable between two groups and therefore allows us to decompose the gap in mean BMI between 1991 and 2009. So the gap between the mean outcomes BMI^{2009} and BMI^{1991} is equal to

$$BMI^{2009} - BMI^{1991} = \alpha^{2009} + x'_k\beta^{2009} + \varepsilon^{2009} - \alpha^{1991} + x'_k\beta^{1991} + \varepsilon_i^{1991} \quad (3)$$

where x'_k are the variables used in this analysis.

In the x'_k vector I include determinants that are likely to be exogenous factors of physical expenditure and caloric intake; relative food prices, availability of public transport, share of the community engaged in agriculture, mean community per capita household income, urbanization and a set of individual demographics are included to control for age, gender and household size.

With the decomposition we can investigate how much of the overall gap is attributable to differences in the means of the determinants rather than differences in the effects of the determinants. Also the gap specific to any one of the determinants (x's) can be investigated with the Oaxaca decomposition.

The gap between the two means in BMI can be expressed in two ways:

$$BMI^{2009} - BMI^{1991} = \Delta x'\beta^{1991} + \Delta\beta x'^{2009} \quad (4)$$

$$BMI^{2009} - BMI^{1991} = \Delta x'\beta^{2009} + \Delta\beta x'^{1991} \quad (5)$$

where in the first decomposition (4) the differences in de x's are weighted by the coefficients of the 1991 group and the differences in the coefficients are weighted by the x's of the 2009 group. And the other way around for the second decomposition (5) where the differences in the x's are weighted by the coefficients of the 2009 group and the differences in the coefficients are weighted by the x's of the 1991 group. Because both decompositions are equally valid, the first decomposition (4) will be used to describe the results in order to keep the results clear. The results of equation 5 can be found in the Appendix. When results differ between the two equations differences will be discussed.

Data analysis

For the whole sample summary statistics are shown in Table 2. The sample consisted of almost equally numbers of males and females. Mean BMI has increased with 1.81 between 1991 and 2009. The percentage people who were overweight have been doubled and the percentage of people who were underweight is reduced by half. The prices of rice, vegetables and lean pork increased and the price of rapeseed oil and sugar decreased between 1991 and 2009. Public transport became more available in 2009. Remarkably, the percentage of people living in urban residency decreased in 2009 compared to 1991 while China is urbanizing. This could be due to the fact that we only included communities where food prices have been collected both in 1991 and 2009. Another explanation for the decrease in urban residency is that we only looked at the dichotomous variable urban/rural which is similar over time. In reality urbanization has increased, but is not captured according to the dichotomous definition of the CHNS. A way to capture the increase of urbanization is proposed by Van de Poel et al. (2012) where an “index of urbanicity” is generated depending on population size, land use in the community, transportation facilities, educational facilities, economic activity and public services (Van de Poel et al., 2012). Urbanization is then defined in terms of movement of a community up the distribution of this urbanicity index (Van de Poel et al., 2012) and therefore it better allows to capture a more urbanized environment. Yet in this analysis we have chosen to use the administrative dichotomously defined urban/rural classification available in the CHNS.

Also household size seems to be larger in 2009 compared to 1991. Of all adults that entered the study (23.312 observations); adults who lived in rural areas had a larger household size compared to adults living in urban areas for both 1991 and 2009. Mean household size for rural and urban residents were 4.6 and 5.0 respectively for 1991 and 5.3 and 4.2 for 2009. Because more rural residents were included in 2009 compared to 1991, this could be a possible explanation for the bigger household size in 2009 compared to 1991.

Table. 2 Demographics

	1991	2009
Variable list	Mean (SD)	Mean (SD)
BMI (kg/height^2)	21.54 (2.65)	23.35 (3.19)
Overweight (%)	0.16	0.39
Underweight (%)	0.078	0.039
Log real price of rice per kg	0.97 (0.31)	1.23 (0.29)
Log real price of rapeseed oil per kg	2.52 (0.18)	2.43 (0.26)
Log real price of sugar per kg	2.11 (0.15)	1.65 (0.24)
Log real price of vegetables per kg	0.070 (0.57)	1.07 (0.49)
Log real price of lean pork per kg	2.90 (0.38)	3.17 (0.16)
Bus stop availability (%)	0.50	0.69
Train station availability (%)	0.22	0.26
Urban residency (%)	0.17	0.16
Share in agriculture (%):		
0-25	0.34	0.35
26-50	0.17	0.28
51-75	0.13	0.072
76-100	0.37	0.30
Log mean community household income per capita	7.84 (0.46)	9.21 (0.47)
Age	38.32 (12.21)	46.65 (11.74)
Male (%)	0.49	0.50
Household size (%)		
0-5	0.74	0.67
6-10	0.26	0.32
11-15	0.0040	0.0095
No. of observations	1998	1363

Results

OLS regressions

Table 3 shows the effects of several food prices, community environment variables and a set of individual covariates on BMI for 1991 and 2009 separately. For 1991 an increase in the ln(price) of sugar has a significant negative effect on the BMI and an increase in ln(price) of vegetables (rape) has a significant positive effect on the BMI compared to 2009 where an increase in the ln(price) of rapeseed oil has a significant negative effect on the BMI. When food prices increase, less consumption of the food is expected and therefore a decrease in BMI is expected. With vegetables however, an increase in BMI is found. An explanation could be that people consume fewer vegetables when the price of vegetable increases and they substitute it for more carbohydrates or fats. Remarkable is that in 2009 the price of rapeseed oil played an important role compared to prices of sugar and vegetables in 1991. A possible explanation for this is the governmental control over the price of edible oil which was eliminated by 1992 (Ng et al., 2008). From 1953 several rationing systems and subsidy systems exists to address shortage of edible oil. It could be that in 2009 edible oil was better available and therefore people could consume more of it when compared to 1991. Besides price changes for one food might impact the demand for other foods and resultant nutritional intakes (Ng. et al. 2008) which impacts changes in BMI. An explanation for the significant contribution of sugar in 1991 and not for 2009 could be that the impact of sugar is smaller for 2009 because there is a lot more fattening food available in 2009 compared to 1991. A possible explanation for the significant contribution of vegetables (rape) in 1991 and not for 2009 might be because the availability and diversity of vegetables has grown because of import. Because only green vegetables (rape) were taken into account in the analysis it is possible that the impact of an increase in price of rape is really small for 2009 because much more other vegetables were available. While compared to 1991 where there was less choice and import and therefore the impact of an increase in ln(price) of rape could have a significant contribution to the BMI.

In Appendix 1 the magnitudes of the effects of food prices on the BMI are shown in three different ways for a better interpretation of the magnitude of the effect on BMI. First, the effect of the food prices are shown when the price increases from the 10% lowest price (p10) to the 10% highest price (p90). Second, the effect of food prices are shown when price increases from the 25% lowest price (p25) to the 25% highest price (p75). And finally, the effects are shown for a 10% price increase in mean price. For 1991 the increase in price of sugar and vegetables gives the largest effect on BMI when the prices increase from p10 to p90 and from p25 to p75. When the mean price of the food items increases with 10% then the effect of sugar is the largest (-0.153). In 2009 the increase in price of rapeseed oil has the largest effect on the BMI. When comparing the effect of the food prices with the effects of the community environment, it makes clear that for some food prices the effects are relatively large, for example a 10% price increase of sugar in 1991 and a 10% increase in 2009. Besides, when we compare the price range of the food items between 1991 and 2009, it makes clear that the price ranges have become smaller in 2009. This seems plausible because of increased trade, more competition and less government control in 2009.

Table 3. Effects on Body Mass Index

	Outcome BMI	
Variables	OLS 1991	OLS 2009
Log real price of rice per kg	-0.00186 (0.219)	-0.203 (0.280)
Log real price of rapeseed oil per kg	-0.154 (0.431)	-2.161** (0.367)
Log real price of sugar per kg	-1.610** (0.517)	0.620 (0.472)
Log real price of vegetables per kg	0.268* (0.115)	0.0346 (0.184)
Log real price of lean pork per kg	0.0972 (0.163)	0.846 (0.673)
Bus stop (no/yes)	0.136 (0.153)	0.113 (0.209)
Train station (no/yes)	-0.402* (0.168)	-0.363 (0.229)
Urban residency (rural/urban)	0.476 (0.263)	-0.227 (0.302)
Share community in agriculture		
26-50 %	-0.244 (0.209)	-0.335 (0.274)
51-75 %	-1.206** (0.209)	-0.685 (0.379)
76-100 %	-0.585** (0.199)	-0.482* (0.237)
Log mean community household income per capita	0.282 (0.202)	0.402 (0.220)
Age	0.186** (0.0296)	0.329** (0.0484)
Age squared	-0.00188** (0.000383)	-0.00329** (0.000551)
Gender (female/male)	-0.463* (0.111)	0.298 (0.169)
Household size		
6-10	0.260 (0.136)	0.115 (0.199)
11-15	-0.0792 (0.602)	1.556* (0.724)
Constant	19.227** (2.161)	13.810** (3.156)
R-squared	0.126	0.0787
Number of observations	1998	1363

Robust standard errors in brackets
** p<0.01, * p<0.05

In 1991 the availability of a train station had a significant negative effect on the BMI which results in a decrease in BMI. However an increase in BMI is expected because the availability of public transport makes a more sedentary lifestyle possible. A possible explanation for a decrease in BMI is that train stations are built in high density communities. And residents from communities with higher density, greater connectivity and more land use mix walk/cycle more for utilitarian purposes than low-density, poorly connected and single land use communities (Saelens et al. 2003).

In 1991 and 2009 a high share of the community engaged in agriculture significant lowered the BMI because work in agriculture is accompanied with more strenuousness compared to sedentary jobs. A reason why lower effects are found in 2009 for a high share engaged in agriculture could be that jobs nowadays are more mechanical driven and service-oriented.

Age increased the BMI in both years significantly, which is plausible because ageing is associated with changes in body composition with an increase in body fat and a decrease in muscle mass (Baumgartner et al. 1995). Especially the redistribution of body fat is accompanied by less subcutaneous fat storage and more abdominal fat storage in the body. This explains the increase in BMI with increased age in both years (see Appendix 2).

In 2009 a household that consisted of 11-15 persons had a significant higher BMI compared to household sizes with a size of 1-5 persons, where the magnitude is also very large. In contrast to 1991 a big household size did not seem to influence the BMI much. An explanation why a big household size in 2009 influenced the BMI and why it did not influence the BMI in 1991 is unclear.

Finally, when we look at gender, being a male in 1991 was associated with a significant lower BMI compared to a female, but compared to 2009, males in 2009 have a higher BMI when compared to females and it was not significant anymore ($p=0.078$).

Table 4 shows the effects on overweight and underweight by food prices, the set of community environment variables and covariates for 1991 and 2009 respectively. For overweight as outcome the same variables as in the previous regression of 1991 and 2009 with BMI as outcome were significant. Additionally, living in an urban area increased the probability in being overweight significantly for 1991. This is in line with findings by other authors indicating that urban residency is linked to a higher increase in BMI (Wang et al., 2007; Popkin et al., 1995; Popkin, 1999; James, 2008).

Table 4. Effects on overweight and underweight

	Outcome overweight		Outcome underweight	
Variables	OLS 1991	OLS 2009	OLS 1991	OLS 2009
Log real price of rice per kg	-0.205 (0.032)	-0.0449 (0.0479)	-0.0280 (0.0220)	0.00495 (0.0194)
Log real price of rapeseed oil per kg	-0.00879 (0.0581)	-0.275** (0.0596)	-0.0167 (0.0440)	-0.0121 (0.0210)
Log real price of sugar per kg	-0.250** (0.0754	0.0723 (0.0745)	-0.0424 (0.0432)	0.000671 (0.0272)
Log real price of vegetables per kg	0.0352* (0.0156)	0.0118 (0.0300)	-0.00651 (0.0115)	0.0321* (0.0129)
Log real price of lean pork per kg	0.0163 (0.0222)	0.174 (0.105)	-0.00113 (0.0196)	-0.0975* (0.0408)
Bus stop (no/yes)	0.0206 (0.0211)	0.0158 (0.0333)	-0.0166 (0.0159)	-0.0252 (0.0143)
Train station (no/yes)	-0.0456* 0.0225	-0.0344 (0.0362)	0.0382* 0.0193	0.0327* (0.0160)
Urban residency (rural/urban)	0.0747* (0.0377)	-0.0272 (0.0483)	-0.0213 0.0212	0.0121 (0.0152)
Share community in agriculture				
26-50 %	-0.00813 (0.0308)	-0.0441 (0.0438)	0.0116 (0.0208)	0.0347* (0.0146)
51-75 %	-0.1425** (0.0265)	-0.141* (0.0584)	0.00752 (0.0268)	0.0166 (0.0253)
76-100 %	-0.0808** (0.0280)	-0.0771* (0.0373)	-0.0224 0.0236	0.0227 (0.0144)
Log mean community household income per capita	0.00219 (0.0294)	0.0361 (0.0329)	-0.0236 (0.0206)	-0.0154 (0.0154)
Age	0.0187** (0.00383)	0.0260** (0.00747)	-0.0148** (0.00353)	-0.00968* (0.00389)
Age squared	-0.000173** (0.0000492)	-0.000244** (0.0000849)	0.000183** (0.0000466)	0.0000995* (0.0000424)
Gender (female/male)	-0.0640** (0.0154)	0.0353 (0.0262)	-0.00611 (0.0121)	-0.00908 (0.0105)
Household size				
6-10	0.00569 (0.0182)	0.000163 (0.0300)	-0.0106 (0.0145)	0.00873 (0.0127)
11-15	-0.128** (0.0359)	0.0619 (0.136)	0.0632 (0.118)	-0.0299** (0.0106)
Constant	0.287 (0.312)	-0.519 (0.492)	0.712** (0.191)	0.690** (0.242)
R-squared	0.1073	0.0418	0.0200	0.0286
Number of observations	1998	1363	1998	1363

Robust standard errors in brackets
** p<0.01, * p<0.05

For 2009 a big household does not seem to play an important role for the probability of being overweight. When we look at the magnitude of the effect of the food prices on the probability of overweight (Appendix 1) then we can see that an increase in price of rice and sugar has the largest effects on the probability of overweight for 1991 when the price goes from p10 to p90 and from p25 to p75. In 2009 price increase of sugar and rapeseed oil gave the largest effects. When mean price increases with 10% then the largest effect on the probability in overweight can be found for sugar for both 1991 and 2009.

For underweight as outcome the availability of a train station and age seems to matter for both years. The availability of a train station seems to increase the probability of underweight which is in line with what we found for BMI and overweight as outcome. The largest effects for 1991 are found for rice and sugar (Appendix 1). When the price of rice and sugar increases from p10 to p90 the probability of underweight decreases with 1.6% and 1.4% respectively. For 2009 the largest effect can be found for vegetables and lean pork where a price increase of vegetables gives an increase in the probability of underweight and an increase of the price in lean pork gives a decrease in the probability of underweight.

At the same time all variables with underweight as outcome have a small impact on the probability in being underweight when compared to the impact of the variables on BMI and overweight. Presumably other factors play a more important role in the probability in being underweight. When comparing the sign of the effects of the food prices between overweight and underweight in Table 4 most food price variables have a similar effect for overweight and underweight. For example log real price of rapeseed oil lowers the probability in overweight but at the same time lowers the probability in underweight. I would have expected an opposite effect, for example when a price increase increases the probability in overweight it would have decreased the probability in underweight. This is not the case, it could be that for example rapeseed oil lowers the probability in overweight and that people will have a more normal/healthy weight, but at the same time the BMI won't be that low that people will become underweight.

Additional fixed effect regressions were performed (a standard OLS with dummies for every community) to examine the sensitivity of the results. The results of this test confirmed that the OLS regression results were reliable.

Oaxaca decompositions

Table 5 shows the decomposition results for BMI, overweight and overweight. The decompositions weigh the x's by the characteristics of 1991 and the β's by the characteristics of 2009.

The gap in average BMI between 1991 and 2009 is 1.812 but when the constant is not taken into account the gap in average BMI is 7.231. Of this latter gap 24.3% (1.760) was explained by the 1991 group having lower levels of food price related and community related characteristics at the mean than the 2009 group. While 75.7% was attributable to other potential effects of differences in unobserved variables meaning that changes in the coefficients contributed to the gap in average BMI. Table 5 also shows the large contribution of the constant for each of the decompositions. The constant of the decomposition of BMI shows that the trend in average BMI is negative and is not related to one of the variables.

For overweight as outcome variable the changes in the effects of the determinants also accounted for the greatest part of the gap in mean overweight. When underweight is the outcome the x's accounted for the greatest part in the gap of mean underweight, meaning that changes in the mean of the determinants accounted for the major part of the difference between the gap in underweight between 1991 and 2009. The contributions of the effects of the determinants play a smaller part in explaining the differences in underweight and a larger part in explaining the gap in mean BMI and overweight.

Table 5. Decomposition results

	BMI	Overweight	Underweight
Mean prediction high	23.348 (2009)	0.392 (2009)	0.078 (1991)
Mean prediction low	21.535 (1991)	0.156 (1991)	0.039 (2009)
Difference 1991-2009	1.812	0.236	0.039
Constant	-5.417	-0.806	0,021
Overall difference 1991-2009	7.231	1.042	0.018
% due to x's	24.3%	19.1%	138.9%
% due to β's	75.7%	80.9%	-38.9%

Table 6 shows how far gaps in individual predictors contribute to the overall gap of BMI. The results presented for the x's are calculated using the 1991's coefficients as weights. When using the 2009's coefficients as weights (equation 5), there are no major differences in the overall contributions of the x's and the β's (Appendix 3).

Table 6. BMI decomposition results for variables

Variables	Equation 4		Overall effect
	x's	β's	
Log real price of rice per kg	0	-0.247	-0.247
Log real price of rapeseed oil per kg	0.013	-4.885	-4.872
Log real price of sugar per kg	0.723	3.699	4.422
Log real price of vegetables per kg	0.268	-0.249	0.019
Log real price of lean pork per kg	0.026	2.373	2.399
Bus stop (no/yes)	0.026	-0.016	0.010
Train station (no/yes)	-0.019	0.011	-0.008
Residency (rural/urban)	-0.005	-0.111	-0.116
Share of community in agriculture	0.086	0.042	0.128
Log mean community household income per capita	0.386	1.10	1.486
Age	0.242	3.407	3.649
Gender	-0.003	0.377	0.374
Householdsize	0.017	-0.03	-0.013
Total contribution	**1.760**	**5.471**	**7.231**
Constant			-5.417

As shown earlier in Table 5 changes in the effects of the determinants explained most of the difference in the gap of mean BMI between 1991 and 2009. Several variables contributed to the overall gap in mean BMI, but the largest effects are for the log real price of rapeseed oil (favor the 1991 group), log real price of sugar and pork and age (disfavor the 1991 group).

In Table 7 decomposition results for BMI are shown for grouped variables. Those results are derived from Table 6 but all food prices were grouped together, as well as the community variables specific for the community: bus stop, train station, residency, share of the community in agriculture and log mean community household income. The last group is grouped based on individual demographic information; age, gender and household size. Variables were grouped in order to get insight whether food prices, community environment or individual demographics accounted most in explaining the gap in mean BMI.

Table 7. BMI decomposition results for grouped variables

Variables	**Equation 4**		**Overall effect**
	x's	β's	
Food prices	1.03	0.691	1.721
Community variables	0.474	1.026	1.500
Individual demographics	0.256	3.754	4.010
Total contribution	**1.76**	**5.471**	**7.231**
Constant			-5.417

In Table 6 was shown that the contribution of the β's for almost all the individual food prices were larger than the contribution of the x's. But in Table 7 we can see that the overall contribution of the x's is larger for food prices when they are grouped. This indicates that changes in mean price of the food items grouped contributed slightly more to the overall effect of the food prices on BMI. In contrast to the community variables and the demographics; where changes in the effects of the determinants accounted for differences in average BMI between 1991 and 2009. When we look at the overall effect, the effect of the constant and the effect of individual demographics are the largest.

In equation 5 all large contributions were due to changes of the β's. For food prices grouped changes in the effects of food prices on BMI contributed to an increase in BMI. This could imply that supply and demand could have changed in the mean time causing an increase in the BMI. For the community variables this could have several implications. Work strenuousness could have decreased because of technological change by using more mechanical aids and computer technology. For bus stops and train stations this could mean that more people were able to take a bus or a train in 2009 compared to 1991, and therefore caused changes in the effects of those determinants on BMI. When we look at individual demographics like age and gender, the contribution of the effects of these determinants are positive and the contribution is large when we look at the total contribution. It could be that being a specific gender in 2009 has more advantages, for example, women that took care of the household in 1991 and now are more participating in employment. For age it is more difficult to find an explanation why the coefficients are more important. The average age did increase from 1991 to 2009, but why the effects of age changed is difficult to explain, it could be biologically determined. The contribution of the constant to the overall effect is large but negative, thus when holding all other variable at zero the BMI in 2009 was smaller compared to 1991 (-5.417). This negative effect is not captured by the variables used in the decomposition.

Table 8 and Table 9 show the decomposition results for overweight as outcome variable per individual predictor and as grouped variable respectively. Log real price of rapeseed oil (favor the 1991 group), sugar and lean pork, log mean community household income and age accounted for the major part of the overall effect. The contribution of the β's for almost all the variables are larger than the contribution of the x's. The contribution of the constant is large compared to the total contribution of the variables.

Table 8. Overweight decomposition results for variables

Variables	Equation 4		Overall effect
	x's	β's	
Log real price of rice per kg	-0.005	-0.03	-0.035
Log real price of rapeseed oil per kg	0.001	-0.649	-0.648
Log real price of sugar per kg	0.112	0.534	0.646
Log real price of vegetables per kg	0.035	-0.025	0.01
Log real price of lean pork per kg	0.004	0.498	0.502
Bus stop (no/yes)	0.004	-0.003	0.001
Train station (no/yes)	-0.002	0.003	0.001
Residency (rural/urban)	-0.001	-0.016	-0.017
Share of community in agriculture	0.013	-0.009	0.004
Log mean community household income per capita	0.003	0.312	0.315
Age	0.036	0.177	0.213
Gender	0	0.05	0.05
Household size	-0.001	0.001	0
Total contribution	**0.199**	**0.843**	**1.042**
Constant			-0.806

Table 9. Overweight decomposition for grouped variables

Variables	Equation 4		Overall effect
	x's	β's	
Food prices	0.147	0.328	0.475
Community variables	0.017	0.287	0.304
Individual demographics	0.035	0.228	0.263
Total contribution	**0.199**	**0.843**	**1.042**
Constant			-0.806

The fact that the price of rapeseed oil decreased slightly did not cause the decrease in overweight, but it was more due to changes in the effects of rapeseed oil on overweight. A possible explanation could be that people have been using other oils instead and therefore the effect of rapeseed oil had a lowering effect on overweight. For sugar the price per kilogram decreased slightly from 1991 to 2009, but the effects of the price of sugar were more important in explaining the increase in overweight. A possible explanation for this could be that in 2009 people had more choice in the variety of products where sugar is processed compared to 1991. For lean pork it was not the fact that the prices changed significantly that caused an increase in overweight but the increase was more due to the effects of the price of lean pork. A better availability of lean pork can be a possible explanation. A possible explanation for a contribution of the effects of mean community household income per capita could be that people in 1991 have been spending more on food items compared to 1991. The contribution of the constant is large and has a lowering effect on overweight, which is not captured by these variables; other variables could have begun to play a role in the mean time. Table 9 shows that food prices contributed most to the overall effect when compared to the community variables and individual demographics. This implies that the food prices had the highest contribution in explaining the overall gap in overweight between 1991 and 2009, followed by the community variables and the individual demographics. Table 9 also shows the largest contribution was due to changes in the effects of the determinants.

Table 10 and Table 11 show the decomposition results for underweight as outcome variable per individual predictor and as grouped variables respectively. In Table 5 it was already clear that changes in the mean of the determinants accounted for the major part of the gap in underweight between 1991 and 2009. This is in contrast with the decompositions of BMI and overweight, where changes in the effects of the determinants were important in explaining the gap in mean BMI and mean overweight between 1991 and 2009.

The contribution of the β’s of most of the variables is larger than the contribution of the x’s. Because of the positive and the negative signs of the contributions of the β's the total contribution of the β's has become smaller when compared to the total contribution of the x’s.

Table 10. Underweight decomposition results for variables

Variables	Equation 4		Overall effect
	x's	β's	
Log real price of rice per kg	-0.001	-0.032	-0.033
Log real price of rapeseed oil per kg	-0.001	-0.011	-0.012
Log real price of sugar per kg	0	-0.09	-0.09
Log real price of vegetables per kg	-0.032	-0.002	-0.034
Log real price of lean pork per kg	0.026	0.279	0.305
Bus stop (no/yes)	0.005	0.004	0.009
Train station (no/yes)	-0.002	0.001	-0.001
Residency (rural/urban)	0	-0.005	-0.005
Share of community in agriculture	-0.002	-0.021	-0.023
Log mean community household income per capita	0.021	-0.064	-0.043
Age	0.012	-0.062	-0.05
Gender	0	0.001	0.001
Householdsize	-0.001	-0.005	-0.006
Total contribution	**0.025**	**-0.007**	**0.018**
Constant			0.021

Table 11. Underweight decomposition for grouped variables

Variables	Equation 4		Overall effect
	x's	β's	
Food prices	-0.008	0.144	0.136
Community variables	0.022	-0.085	-0.063
Individual demographics	0.011	-0.066	-0.055
Total contribution	**0.025**	**-0.007**	**0.018**
Constant			0.021

Log real price of lean pork (favor 2009), sugar (disfavor 2009), age and log mean community household income are important determinants in explaining the overall effect on underweight between 1991 and 2009. Food prices accounted for the major part in explaining the gap in mean underweight between 1991 and 2009 (Table 11). When only looking at x’s and β’s, changes in the effects of each of the determinants were larger for the three grouped variables separately but when we look at the total contribution the effect of the β's is smaller compared to the total contribution of the x’s. In this decomposition the effect of the constant is also large and contributed more than a half of the total gap in mean underweight between 1991 and 2009.

Table 12 compares the three decomposition results of the overall effects and it makes clear that the constant explain the greater part of the gap for the decomposition results for all three decompositions. For BMI the individual demographics explain the largest part of the three grouped variables. The signs of the effects of the three grouped variables for BMI are positive which causes an increase in BMI from 1991 to 2009. For overweight and underweight the food prices explained the greater part of the overall gap compared to the community or demographic variables. When overweight is the outcome all three grouped variables contributed to the increase in mean overweight between 1991 and 2009. When underweight is the outcome food prices contribute to the decrease in underweight and the community variables and the individual demographics contribute to the increase in underweight between 1991 and 2009.

In all three decompositions the constant played an important role in explaining the gap in mean BMI, overweight and underweight. The constant is negative for BMI and overweight while the total contribution of the variables is positive resulting in a decrease in the overall difference in mean between 1991 and 2009. This means that there a other variables causing a decline in the gap of mean BMI and mean overweight, but are not captured in the variables used in this decomposition. The constant for underweight is positive and the total contribution of the variables is also positive which results in a bigger difference between 2009 and 1991.

When the focus is on the total contribution of the variables used in the decomposition then the food prices play a big role in explaining the increase in overweight and the decrease in underweight but for BMI the individual demographic information; age gender and household size were more important in explaining the increase in mean BMI over time.

Table 12. Decomposition results of BMI, overweight and underweight

Overall effect	**BMI**	**Overweight**	**Underweight**
Food prices	1.721 (23.8%)	0.475 (45.6%)	0.136 (755.6%)
Community variables	1.5 (20.7%)	0.304 (29.7%)	-0.063 (-350%)
Individual demographics	4.01 (55.5%)	0.263 (25.2%)	-0.055 (-305.6%)
Total contribution without constant	7.231	1.042	0.018
Constant	-5.417	-0.806	0.021
Difference 2009→1991	1.812	0.236	0.039

Discussion & Conclusion

The BMI has increased from 1991 to 2009, the proportion of people who were overweight increased and the proportion of people who were underweight decreased. Results from the OLS regressions suggest that age and a high share of the community engaged in agriculture both had a significant effect on the BMI. The results also suggest that different food prices played a significant role, sugar and green vegetables (rape) for 1991 and rapeseed oil for 2009. In 1991 a price increase of sugar gives a decrease in BMI and a price increase of vegetables gives an increase in the BMI. In 2009 a price increase of rapeseed oil has a lowering effect on the BMI. For 1991 the availability of a train station had a significant negative effect on the BMI which resulted in a decrease in BMI. For overweight as outcome same results were found, but place of residence (rural/urban) also had a significant effect on the probability in overweight. For underweight most of the effects were small, suggesting that other factors play a role in the probability in underweight.
In addition, all three decompositions make clear that the constant explains the greater part of the gap in mean outcome. The constant reduces the total contribution of the variables used in the decomposition for the gap in mean BMI and overweight between 1991 and 2009. The constant increased the total contribution of the variables used in underweight and resulted in a bigger decrease in people being underweight. Food prices played a large role in the total contribution of the variables in explaining the increase in overweight and the decrease in underweight but for BMI as outcome the individual demographics were more important in explaining the increase in mean BMI over time. In addition, the decomposition results for BMI and overweight also make clear that changes in the effects of the determinants accounted for the greatest part in outcomes between 1991 and 2009 in China. Unlike the decomposition results of underweight, where the contribution of the β's of most of the variables were larger than the contribution of the x's. But because of the positive and the negative contributions of the β's the total contribution of the β's became smaller when compared to the total contribution of the x's.

China has experienced rapid economic growth and societal changes causing an increase in overweight and obesity rates. Changes in traditional diets and reduced levels of physical activity were found by others. In this study we also confirmed that the share of the community engaged in agriculture has decreased and therefore it is likely that work strenuousness has decreased. Several authors (Wang et al., 2007; Popkin et al. 1995; Popkin, 1999; James, 2008) found that living in urban areas is also a factor that causes growing rates of overweight and obesity. We found that the BMI was higher for people living in urban areas in 1991, but

lower in 2009. We also found price decreases for certain food items and it could be that food technology and agricultural developments resulted in price decreases of several food items.
Referring back to the theoretical framework the results make clear that sedentary technological change does have an impact on the rise in BMI. When the proportion of the community engaged in agriculture is smaller the BMI is higher. Between 1991 and 2009 the share of the community engaged in agriculture declined. In 1991 50% of the communities had a share engaged in agriculture above 50% compared to only 37% in 2009.
In addition when we look at equation (1) and the results of the OLS regressions it makes clear that not all determinants played a significant role on the changes in BMI as expected. Certain food prices were more important in one year compared to another year. But for the decompositions the prices of the food items did play an important role in explaining the increase in overweight and the decrease in underweight between 1991 and 2009.

Strengths & Limitations

A strength of this study is that we only took communities into account where food prices were obtained both for 1991 and 2009. Therefore the results are more reliable. Because the CHNS collected data involving 4400 households in nine provinces that varied substantially in geography, economic development, public resources and health indicators, the results can be generalized to the general adult population in China.
Another strength is that the results are reliable because additional fixed effect regressions were performed to examine the sensitivity of the results. These results confirmed that the OLS regression results were reliable.
Most of the determinants used were less likely influenced by the individuals themselves and therefore suffer less from endogeneity problems compared to variables related to dietary patterns and other health related behaviors used by others. Besides the Oaxaca decomposition allowed us to disentangle the BMI gap in two parts; one that is attributable to changes in the means of the determinants and another one attributable to changes in the effects of the determinants. Hence, we could see whether changes in the averages of the determinants have been accompanied by changes in their impact on BMI. To my knowledge this has never been studied before.

The limitation of this study is that only BMI and the derivates of BMI (overweight and underweight) were considered as an outcome measure. Although it is considered as a good measure to measure population health other options are appropriate. More anthropometric data is available to capture the health status of the Chinese population. The Asian population generally has a higher (abdominal) body fat percentage than non-Asian population of the same age, sex and BMI (Wu, 2006) which results in a higher health risk. Therefore it would be good to take into account the percentage of body fat or the fat distribution next to for example other comorbidities.

Another limitation is that food prices were obtained by asking the community head or appropriate vendor/salesperson which was obtained at the time of the interview. The food prices may not be reliable and depend on the moment and season of the interview. Because data was not collected by ourselves it was not possible to influence this. For the analysis a selection of food items was made, reflecting food items often used by the Chinese population, although region specific consumption was not taken into account due to time constraints. Therefore, in future studies more food items can be clustered to get a broader view of their impact on BMI.

Lastly, the number of observations decreased because of missings in the data. In Figure 1 it is shown that the final sample size was just a small part of the total sample size because of missings in the data. But fortunately the number of observations is still sufficient to reflect various communities in China. In addition, we were not able to take the per capita number of fast food restaurants, Chinese restaurants and food stalls and the distance to recreational facilities. Fast food and convenience food have a high caloric density and are inexpensive. Unfortunately no data was available in the wave of 1991 and therefore we could not include this variable in the analysis. Additionally, data of the nearest gym/exercise center, park/public recreation and playground were also lacking for 1991.

Recommendations for future research

It is recommended for future research on the changes in BMI using CHNS data to include more waves than currently are available. Given the limited information about availability of recreational facilities and the availability of (fast food) restaurants and food stalls we were not able to measure these effects on the BMI or the probability in being overweight or underweight. By better reporting the information about the community environment, more insight can be provided in other possible factors influencing the BMI. In addition, more food items should be included in the analysis to better investigate the impact of changes in food prices and their impact on the BMI.

Implications for policy

The results obtained in this study have implications for policy. The results have shown that changes in the effects of the determinants accounted for the gap in mean BMI. This means that it were not the changes in the mean of the determinants that accounted for the gap in mean BMI. Furthermore, the constant played an important role in all three decompositions. Presumably, other unobserved variables have an important impact on the rise in BMI. Individual demographics of the Chinese population e.g. age are difficult to affect, but the use of different policies affecting food prices and community environment characteristics may influence the rise in BMI. For example, when the availability of bus stops or train stations did not increase significantly between 1991 and 2009, but the effect of it on the BMI did change, it could be that in 2009 more people had the resources to make use of public transport when compared to 1991. Here price policies with regard to bus fares and train fares could influence the use of public transport and therefore could affect the BMI. Also the share of the community engaged in agriculture can be influenced by examining possibilities for creating incentives to promote more physically active jobs in the community. Unfortunately we were not able to research the availability of playgrounds, gyms and other public recreation because those determinants could also have affected the BMI. Also pricing policies on food items can influence demand and supply for food. Some prices of food items do have an impact on BMI. Furthermore, by influencing the availability of several food items and by making healthier options more available in communities could affect the probability in becoming overweight or underweight. Besides, it can induce healthier food consumption patterns. To effectively prevent overweight and obesity changes in community environment and pricing policies are needed to tackle the rise in overweight and obesity. But first, more research is necessary about the effect of more food item prices on the BMI and the effect of more community environment variables on BMI.

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Appendices

Appendix 1. Regression results for food prices

BMI 1991

Variables	Coefficients 1991	Relative price increase p10→p90	Effect of price increase p10→ p90	Relative price increase p25→ p75	Effect of price increase p25→ p75
Log real price of rice per kg	-0.00186	79.4%	-0.00109	28.8%	-0.000471
Log real price of rapeseed oil per kg	-0.154	59.6%	-0.0720	23.6%	-0.0326
Log real price of sugar per kg	-1.610	39.1%	-0.532	17.7%	-0.263
Log real price of vegetables per kg	0.268	291.3%	0.366	66.6%	0.137
Log real price of lean pork per kg	0.0972	78.8%	0.0565	27.0%	0.0232

BMI 2009

Variables	Coefficients 2009	Relative price increase p10→ p90	Effect of price increase p10→ p90	Relative price increase p25→ p75	Effect of price increase p25→ p75
Log real price of rice per kg	-0.203	77.1%	-0.116	32.6%	-0.0573
Log real price of rapeseed oil per kg	-2.161	114.2%	-1.646	36.6%	-0.675
Log real price of sugar per kg	0.620	80.0%	0.365	49.9%	0.251
Log real price of vegetables per kg	0.0346	231.5%	0.0415	100.0%	0.0240
Log real price of lean pork per kg	0.846	42.6%	0.300	16.7%	0.131

Overweight 1991

Variables	Coefficients 1991	Relative price increase p10→p90	Effect of price increase p10→ p90	Relative price increase p25→ p75	Effect of price increase p25→ p75
Log real price of rice per kg	-0.205	79.4%	-0.120	28.8%	-0.0519
Log real price of rapeseed oil per kg	-0.00879	59.6%	-0.00411	23.6%	-0.00186
Log real price of sugar per kg	-0.250	39.1%	-0.0826	17.7%	-0.0408
Log real price of vegetables per kg	0.0352	291.3%	0.0480	66.6%	0.0180
Log real price of lean pork per kg	0.0163	78.8%	0.00947	27.0%	0.00389

Overweight 2009

Variables	Coefficients 2009	Relative price increase p10→p90	Effect of price increase p10→ p90	Relative price increase p25→ p75	Effect of price increase p25→ p75
Log real price of rice per kg	-0.0449	77.1%	-0.0257	32.6%	-0.0127
Log real price of rapeseed oil per kg	-0.275	114.2%	-0.210	36.6%	-0.0859
Log real price of sugar per kg	0.723	80.0%	0.425	49.9%	0.293
Log real price of vegetables per kg	0.0118	231.5%	0.0141	100.0%	0.00818
Log real price of lean pork per kg	0.174	42.6%	0.0617	16.7%	0.0269

Underweight 1991

Variables	Coefficients 1991	Relative price increase p10→p90	Effect of price increase p10→ p90	Relative price increase p25→ p75	Effect of price increase p25→ p75
Log real price of rice per kg	-0.0280	79.4%	-0.0164	28.8%	-0.00709
Log real price of rapeseed oil per kg	-0.0167	59.6%	-0.00780	23.6%	-0.00353
Log real price of sugar per kg	-0.0424	39.1%	-0.0140	17.7%	-0.00692
Log real price of vegetables per kg	-0.00651	291.3%	-0.00888	66.6%	-0.00332
Log real price of lean pork per kg	-0.00113	78.8%	-0.000657	27.0%	-0.000270

Underweight 2009

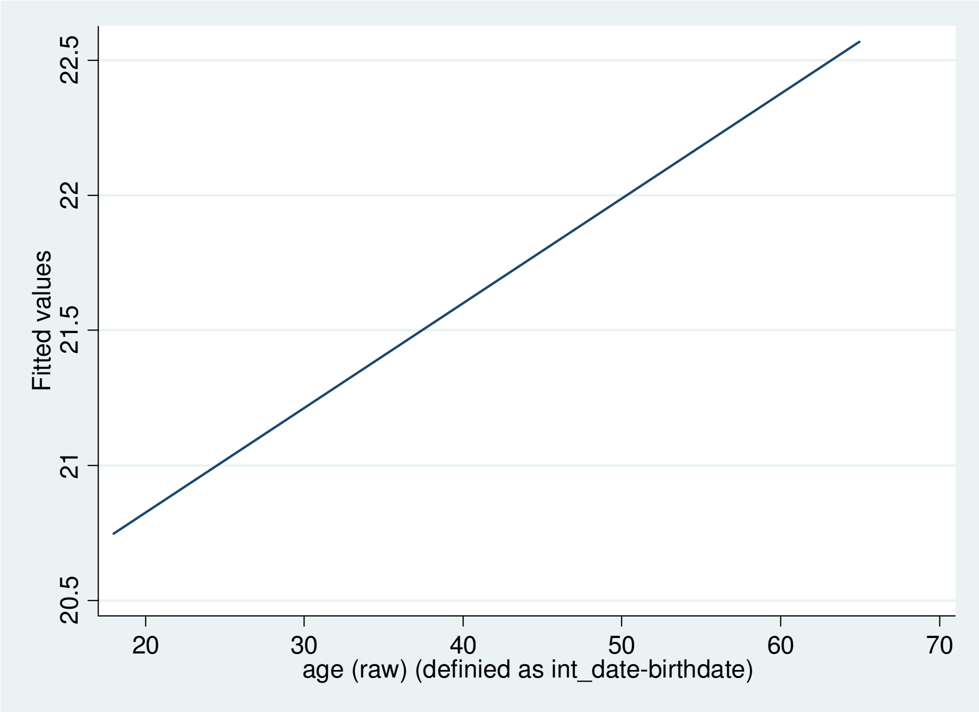
Variables	Coefficients 2009	Relative price increase p10→p90	Effect of price increase p10→ p90	Relative price increase p25→ p75	Effect of price increase p25→ p75
Log real price of rice per kg	0.00495	77.1%	0.00283	32.6%	0.00140
Log real price of rapeseed oil per kg	-0.0121	114.2%	-.,00922	36.6%	-0.00378
Log real price of sugar per kg	0.000671	80.0%	0.000395	49.9%	0.000271
Log real price of vegetables per kg	0.0321	231.5%	0.0385	100.0%	0.0223
Log real price of lean pork per kg	-0.0975	42.6%	-0.0346	16.7%	-0.0151

10% price increase in real price

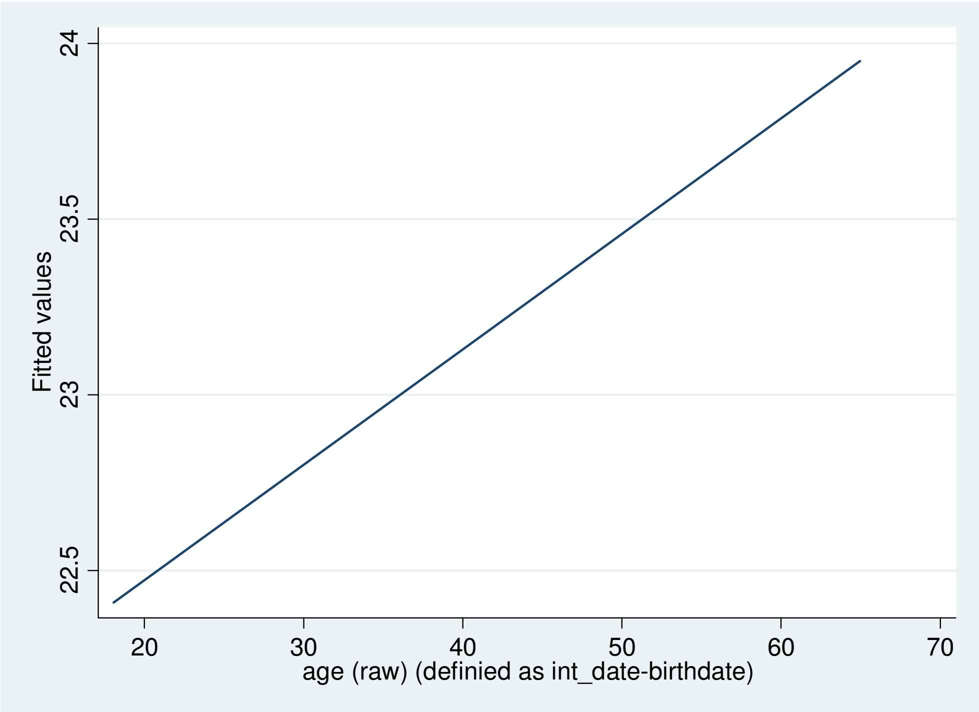
Variables	Effect BMI 1991	Effect BMI 2009	Effect Overweight 1991	Effect Overweight 2009	Effect Underweight 1991	Effect Underweight 2009
Log real price of rice per kg	-0.000177	-0.0193	-0.0195	-0.00428	-0.00267	0.000472
Log real price of rapeseed oil per kg	-0.0147	-0.206	-0.000838	-0.0262	-0.00159	-0.00115
Log real price of sugar per kg	-0.153	0.0591	-0.0238	0.0689	-0.00404	0.0000640
Log real price of vegetables per kg	0.0255	0.00330	0.00336	0.00113	-0.000620	0.00306
Log real price of lean pork per kg	0.00926	0.0806	0.00155	0.0166	-0.000108	-0.00929

Appendix 2. Relationship between age and BMI

Relationship between age and BMI, wave 1991



Relationship between age and BMI, wave 2009



Appendix 3. Decomposition results equation 5

BMI Decomposition results for variables

Variables	Equation 5		Overall effect
	x's	β's	
Log real price of rice per kg	-0.052	-0.195	-0.247
Log real price of rapeseed oil per kg	0.189	-5.061	-4.872
Log real price of sugar per kg	-0.278	4.7	4.422
Log real price of vegetables per kg	0.035	-0.016	0.019
Log real price of lean pork per kg	0.228	2.171	2.399
Bus stop (no/yes)	0.022	-0.012	0.01
Train station (no/yes)	-0.017	0.009	-0.008
Residency (rural/urban)	0.002	-0.118	-0.116
Share of community in agriculture	0.037	0.091	0.128
Log mean community household income per capita	0.549	0.937	1.486
Age	0.451	3.198	3.649
Gender	0.001	0.373	0.374
Householdsize	0.017	-0.03	-0.013
Total contribution	**1.184**	**6.047**	**7.231**
Constant			-5.417
% due to x's	16.4%		
% due to β's		83.6%	

BMI decomposition for grouped variables

Variables	Equation 5		Overall effect
	x's	β's	
Food prices	0.122	1.599	1.721
Community variables	0.593	0.907	1.5
Individual demographics	0.469	3.541	4.01
Total contribution	**1.184**	**6.047**	**7.231**
Constant			-5.417

Overweight Decomposition results for variables

Variables	Equation 5		Overall effect
	x's	β's	
Log real price of rice per kg	-0.011	-0.024	-0.035
Log real price of rapeseed oil per kg	0.024	-0.672	-0.648
Log real price of sugar per kg	-0.033	0.679	0.646
Log real price of vegetables per kg	0.012	-0.002	0.01
Log real price of lean pork per kg	0.046	0.456	0.502
Bus stop (no/yes)	0.003	-0.002	0.001
Train station (no/yes)	-0.001	0.002	0.001
Residency (rural/urban)	0	-0.017	-0.017
Share of community in agriculture	0.009	-0.005	0.004
Log mean community household income per capita	0.049	0.266	0.315
Age	0.047	0.166	0.213
Gender	0.001	0.049	0.05
Household size	0	0	0
Total contribution	**0.146**	**0.896**	**1.042**
Constant			-0.806
% due to x's	14.0%		
% due to β's		86.0%	

Overweight decomposition for grouped variables

Variables	Equation 5		Overall effect
	x's	β's	
Food prices	0.038	0.437	0.475
Community variables	0.06	0.244	0.304
Individual demographics	0.048	0.215	0.263
Total contribution	**0.146**	**0.896**	**1.042**
Constant			-0.806

Underweight Decomposition results for variables

Variables	Equation 5		Overall effect
	x's	β's	
Log real price of rice per kg	0.007	-0.04	-0.033
Log real price of rapeseed oil per kg	-0.001	-0.011	-0.012
Log real price of sugar per kg	-0.019	-0.071	-0.09
Log real price of vegetables per kg	0.007	-0.041	-0.034
Log real price of lean pork per kg	0	0.305	0.305
Bus stop (no/yes)	0.003	0.006	0.009
Train station (no/yes)	-0.002	0.001	-0.001
Residency (rural/urban)	0	-0.005	-0.005
Share of community in agriculture	-0.003	-0.02	-0.023
Log mean community household income per capita	0.032	-0.075	-0.043
Age	-0.003	-0.047	-0.05
Gender	0	0.001	0.001
Household size	-0.001	-0.005	-0.006
Total contribution	**0.02**	**-0.002**	**0.018**
Constant			0.021
% due to x's	111.1%		
% due to β's		-11.1%	

Underweight decomposition for grouped variables

Variables	Equation 5		Overall effect
	x's	β's	
Food prices	-0.006	0.142	0.136
Community variables	0.03	-0.093	-0.063
Individual demographics	-0.004	-0.051	-0.055
Total contribution	**0.02**	**-0.002**	**0.018**
Constant			0.021