Working Paper 99-02
Department of Economics
University of North Carolina, Chapel Hill
http://www.unc.edu/depts/econ

Structural Change in the Impact of Income on Food Consumption in China, 1989-93[*]

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June 21, 1999

Introduction

Economic change in the lower income and transitional economies of the world appears to coincide with increasing rapid social change. In the fertility area, for example, there is ample descriptive evidence that the adoption of new family planning technologies and declines in fertility are happening at increasingly lower income levels. These changes have been taking place more rapidly, and the rate of change appears to have accelerated.[1] The fertility transition from the 1960's onwards has exhibited rapid change that appears to be increasingly uncoupled from the economic changes experienced at the individual level. In the nutrition area, there is similar ecologic evidence that lower income countries are changing their diets; these changes and the associated changes in body composition seem to be happening at a faster pace than before.[2] The overriding questions are: Are these changes related to changes in income, prices, and all the associated population composition shifts that have been occurring. Or are there changes in the structure of behavior that appear to be happening separately from the measurable determinants of the economic changes? That is, has the structure of the decision-making process been changing, and if so can we document this?

To date, most nutrition and demographic studies in developing countries have focused on documenting the rate of change in factors such as dietary composition, obesity, modern family planning acceptance rates, and fertility. Few studies have been able to address at the micro level the determinants of these temporal changes in behaviors, let alone attempt to model and provide any

coherent hypotheses about the changes. Huang and Bouis,[3] for example, used aggregate time series and cross-sectional data to develop the hypothesis that the transformations in the Asian economies are linked with rapid urbanization; in turn, there appears to be a structural relationship linked with urbanization and consumption. Similarly an ecological analysis of GNP and the structure of the diet seems to point to a similar powerful effect of urbanization.[2] However these are not relationships that have been rigorously tested, nor have they controlled for the wide range of observed and unobserved characteristics that affect consumption decisions.

In this paper we start by presenting evidence that points to a shift in the relationship between income and diet at the macro level and discuss the broad trends in Asia and elsewhere. Following this, we present a detailed longitudinal study of 3,800 households in China for data collected in 1989, 1991, and 1993. In this case study we show that the increase in income in China over time coincides with a shift in the demand for a range of inferior and normal food groups. We document shifts in the income elasticities for a range of goods that are related to flour and flour products, inferior grains, rice, meat and meat products, eggs, and edible vegetable oils. Income elasticities for more luxury foods increased significantly from 1989 to 1993, while less superior goods became more inferior over this four year span. Based on these results, it would appear to be very difficult to use cross-sectional and longitudinal income and price elasticities to predict changes in consumption over time in developing countries. What is needed is an

understanding of how preferences develop and change during the course of modernization. Until we are able to develop similar case studies that allow us to be able generalize from China, it will be impossible to derive accurate predictions about nutritional change in developing countries.

China represents one of the world's most rapidly developing economies. With its 1.2 billion people, China has achieved major advances in her socioeconomic development within the space of less than a generation. The annual gross domestic product (GDP) increment stood at 12.1 percent from 1992 to 1996.[4] The World Bank has noted that the Chinese per capita income grew at a remarkable 8.2 per cent annual rate between 1978 and 1996.[5] During this period there has been a significant reduction in the number of absolute poor in China, in conjunction with a rapid increase in income inequality. Accompanying these economic changes has been a rapid improvement of food supply and consumption. China has attained a high measure of food security and has seen marked changes in dietary structure.[6,7]

Change has not always been steady in China, and evidence of a worsening of poverty among some subpopulation groups exists. For example, among the rural poor in some areas there has been an increase in chronic energy deficiency, while in others the incidences of high-fat diets, as well as obesity, have rapidly increased, particular among higher income groups.[8,9] There has been a marked shift not only in obesity but also in other diet-related chronic diseases, such as cardiovascular

heart disease, diabetes, and certain types of cancers. These are rapidly becoming major health problems in this population.[10-12]

In this paper we first present the overall picture with a cross-country analysis of changes in the structure of diet and occupational structures and explore the income-fat relationships. Then we present data from China that demonstrates the trend in the structure of diet, activity and obesity. This is followed by a more rigorous examination and testing of the income-food consumption relationship. We conclude by discussing the implications of the behavioral changes in consumer's responses that we uncovered for the formulation of nutrition policies in China.

Data

This study uses longitudinal data from the China Health and Nutrition Survey (CHNS). The CHNS was designed as a time-cohort survey, initiated in 1989 from eight provinces in China. It followed a large sample of communities, households, and individuals biannually from 1989 to 1993. The basic sampling unit of the CHNS was the household. The sampling design used in the CHNS is complex, but it can be described as a multistage cluster design.[13] Briefly, in each of the eight provinces, cities and counties were stratified by income tertiles using per capita income figures from the State Statistical Bureau of China (SSB). A weighted sampling scheme was used to select randomly 32 urban cities, 30 suburban villages, 32 county capitals and 96 villages. From these final sampling units, twenty households were drawn from each urban neighborhood and rural village.

The CHNS sample consisted of 3,800 households to cover about 16,000 individuals. A total of 5,787 adults, aged 20--45 years from 3,126 households, were included in the 1989 CHNS for the dietary survey. Among these subjects, 5,625 individuals had multiple-day dietary records. They were revisited in subsequent surveys. A total of 16,049 dietary measurements for prime aged adults were available for this longitudinal analysis. There were no systematic loss-to-follow-up issues as the response rates were inordinately high. The CHNS91 was able to resurvey 95.3 percent of the households from the CHNS89; only 177 households were not resurveyed. In CHNS93, an additional 171 households were lost. The individual response rate has been equally high with 94% of the CHNS89 individuals surveyed in CHNS91 and close to 90% for all 3 time periods.

The dietary data came from two sources -- the household survey instrument and the individual dietary surveys. Detailed household food consumption data were collected from changes in household food inventories for three consecutive days, in combination with three days of individual dietary data based on repeated 24-hour recalls. Detailed descriptions of the dietary survey are presented elsewhere.[9,14] This study focuses on six major food groups as major sources of fat and energy in the Chinese diet. They are rice, wheat flour, coarse grains, pork, eggs, and edible oils. The 1991 Food Composition Table for China is used to calculate macronutrients for each food item.[15]

The income variable used in this study represents total household income. It included all cash and noncash income components. We did not adjust for food

subsidies, as these comprised only a trivial part of real income in 1989 and were virtually non-existent during the 1990s. To reduce the potential for biases due to measurement error in the income variable, a two step procedure similar to two stage least squares was used. First the natural logarithm of measured per capita income was regressed on a set of community and household characteristics. The predicted log incomes and the squares of these predicted log incomes from this first stage regression were then used as the income measures in the analyses of the food groups and nutrient intakes. Separate income regressions were carried out for each of the three survey years. All the standard errors presented here account for the two-stage estimation approach with bootstrap methods.

The CHNS collected food prices from each sample community. We examined three sources for food prices: state store prices, free market prices, and authority price records published by SSB, which provide the provincial average. The state store prices were no longer used after the 1991-92 price reform in China. We also examined provincial and country price data collected by the State Statistics Bureau. These were found to be less related to consumption decisions and are not presented here. Free market prices were found to be the most meaningful prices, in terms of affecting consumption decisions, and they are the prices used in this analysis.[16]

Income and price variables were deflated by the consumer price index - CPI[17-19] for the particular time period when the surveys were carried out, and for the particular regions where the samples were located. The Chinese CPI, which is

reported only for urban and rural samples with the index of 1980 was used as the baseline to deflate the nominal values for the urban and rural consumers, respectively.

In our introductory cross-national macroeconomic analysis of changes in the income diet relationships over time we use national food consumption data from FAO food balance sheets for the period 1962-1990; these data are now available in the FAOSTAT database.[20] We combined data on food availability, expressed in percentage of daily energy from macro-nutrients, with the official estimates of gross national product (GNP) as established by the World Bank.[21] GNP per capita was expressed in 1993 dollars to allow for an easier comparison of the results. Regressions focused on 1962 and 1990, and we used all countries for which we had data from both sources. There were 99 countries in 1962 and 134 in 1990. These results were not changed substantially when we looked only at those countries with full sets of data for both 1962 and 1990. Obesity measures come from the standard population-based measure of overweight and obesity status:[22] 25.0 to 29.99 for overweight, and 30.0 and above for obesity.

The Nutrition Transition in the Developing World

The estimated regression lines[23] displayed in Figure 1 show that the aggregate income-fat relationship had undergone a dramatic change from 1962 to 1990. Most significantly, by 1990 even the poor nations now had access to a relatively high-fat diet. Whereas in 1962, a diet deriving 20% of energy from fat was associated with a GNP of $1475, the same diet in 1990 was associated with a GNP of only $750 (both in 1992 dollars). This dramatic difference was largely accounted for by a major increase in the consumption of vegetable fats by poor and rich nations alike. The proportion of energy from vegetable fats is now much higher, accounting for up to 13% of total energy, compared to 10% in 1962. The relationship between GNP and the proportion of energy from animal fats indicates that richer nations consumed less fat over time, while the poorest nations consumed both more animal products and more fats in 1990 than in 1962. The availability of animal fats continued to be linked to income, though less strongly than before. Vegetable fats now accounted for a greater proportion of dietary energy than animal fats for countries in the lowest 75% of the per capita income distribution. The absolute level of vegetable fat consumption increased, but there remained at most a weak association of GNP and vegetable fat intake in these aggregate data.

As a result of these diet adjustments, the lowest income countries now had access to an additional 4-5% of energy from fat. Although meat consumption

declined in high-income countries (by 6-9%), there was little overall reduction in fat intake, as animal fats were replaced by a greater proportion of vegetable oils and products. Elsewhere we have shown that this relationship varies significantly and depends greatly on the proportion of urban residents in a country.[2] The Figure 1 results indicate that there has been a substantial shift in the relationship between GNP and the composition of diets over time. There was little information in the 1962 GNP-nutritional composition analysis, however, that would have predicted the form of the relationships in 1990.

--Figure 1 about here--

We also use cross-national data on the prevalence of overweight individuals and dietary fat intake to point to one of the most immediate effects of this dietary change (linked in combination with a reduction with physical activity). Data were available for 20 countries in which the prevalence of BMI >25 kg/m^2 is known at some point in time between 1976 and 1997. Figure 2 presents the scatter plot relating the incidence of obesity to the fat composition of the diet across countries. An ordinary least squares regression that weighted each country with its population was used to relate the BMI to the proportion of dietary energy from fat. The regression coefficient of 2.6 ($p < .001$; Adj R-squared = 0.79) shows the relationship between higher proportions of dietary energy from fat and the prevalence of overweight individuals in a country within the sample available to us. There is a large significant positive association between dietary fat consumption and the proportion of individuals who were overweight. What is important to note

in Figure 2 is the rapid shift from the low overweight low dietary fat populations such as India, China, and the Philippines to the moderate overweight and dietary fat countries such as Brazil, Cuba, Saudi Arabia, and Tunisia. Clearly some countries such as Russia and Kuwait are outliers in that they have much higher levels of overweight than would be expected for their percentage of energy from fat. Others such as Malaysia and the Congo have much lower levels of overweight than would be expected from their fat intake. Nevertheless, there is a marked increase in overweight levels in countries with higher fat intakes. These results speak directly to the potential role of reducing the intake of dietary fat as a means of preventing increases in the level of obesity in lower and middle income countries.

--Figure 2 about here--

There has been a marked increase in overweight status in Asia and other regions of the lower income world. In fact, the rate of increase in overweight in some Asian countries matches that found in the US (Popkin and Doak, 1998). In other studies on China with the CHNS data we traced out such shifts in diet and physical activity and examined changes in diet and activity as they relate to changes in body mass index and overweight status. These changes are significant.[24,25] The CHNS data allows us to trace the dramatic changes in diet and physical activity among Chinese adults.

Dietary change has been very rapid in China. During the last decade, this country has attained overall adequacy in diet and has seen a marked change in its

structure. The rates of change in dietary patterns continue to be very rapid. In Table 1 we present patterns of dietary intake for adults aged 20-45 from the 1989-93 period by income level. While the traditional Chinese diet was believed to be a low-fat one, we now find only a small proportion of the population following this traditional low-fat pattern. An ever-increasing proportion of the population consumes more than 30% of energy from fat. This high-fat diet was significantly more common in urban and higher-income populations than in rural and lower-income ones. At the same time, there were decreases in the proportion of adults consuming a low-fat diet among all income groups.

--Table 1 about here--

These dietary changes fit into a broader longer term shift in the structure of diet in China.[7] Per capita total cereal consumption and per capita vegetable consumption both increased between 1978 and 1984, but then remained constant. In contrast, consumption of meat, edible oils, sugar, eggs and fish, and (to a lesser extent) fruit increased throughout this early period. The net effect was a marked shift in the structure of the diet to one in which the proportion of energy, from fat from both vegetable and animal sources, increased each year. Piazza[26] provides detailed information on consumption data from earlier periods when overcoming food scarcity was the sole nutritional concern of the Chinese.

Associated with this change in diet has been a marked change in physical activity patterns, as defined by the proportion of adults with the lowest and highest levels of physical activity. In particular, urban residents in all income groups were

more likely in 1991 or 1993 to have adopted a more sedentary activity pattern than in 1989 (Table 2). In contrast, this pattern was not seen in the rural areas. In fact, low-income rural residents showed a significant change from low and moderate activity patterns toward a high physical activity pattern. When coupled with the dietary intake changes, it is clear that one would expect an increase in obesity in the urban sample and possibly an increase in undernutrition among the low-income rural residents.

--Table 2 about here--

The net effect has been a significant change in adult body composition. In a series of studies we have shown using various longitudinal models that changes in diet and physical activity each affect the shift in body mass index and overweight status.[24,25] These large changes in consumption patterns and body mass in China suggest the possibility of important structural shifts in consumption decisions. We address this issue by examining rigorously the determinants of dietary intake in China. In particular, we focus on the key foods and the key food constituent, total fat intake, that seem to be most important for their reflection of the shift in dietary intake.

Determinants of Diet in China

The analysis of food-group consumption requires special statistical considerations. For a specific food group, a certain proportion of population does not consume, and among those who do consume, the distribution of consumption

level is quite skewed. Under these conditions, a two-stage model is recommended to address the consumption behavior.[27] Specifically, the first stage examines the decision to consume or not consume a given food group, and the second stage is conditional on consuming within the food group to study the quantity of food consumed.

We use two stage estimation methods to control for measurement error and endogeneity of household income in the demand function analyses. We also use individual level random effect estimators to obtain more accurate estimators. This considerably enhances the reliability of the estimated parameters.[16,28] We use bootstrap procedures to obtain standard errors. These methods allow us to control for any within-household unobservables influencing the food and nutrient demands; these unobservables are allowed to persist through time for any household.

The full set of explanatory variables in these two models included per capita household income, a set of food prices, sociodemographic characteristics with time-varying variables, such as age, household size, educational level, and a vector of time-invariant variables, such as sex, place of residence and region. To adjust for skewness, income and food prices were log-transformed. Elsewhere the sample is described in depth.[16] There were no significant loss-to-follow-up self-selectivity effects apparent in these data. Appendices A, B, and C contain complete sets of regression results for the estimates reported in this study. Appendix D presents a full set of descriptive statistics as well as information on the exclusion restrictions

used to identify the impacts of income on food consumptions after controlling for possible endogeneity and measurement errors.

Overall Patterns of Food Consumption

Table 3 presents the consumption pattern and trend of six food groups and three macronutrients among the Chinese adults in 1989, and their follow-up measurements in 1993. These food groups were in the form of top ten food sources of dietary fat, representing approximately 70-75% of total fat intakes. The average per capita consumption of oils more than doubled over this period, with increases in both the proportion of people consuming oils and the amount of oils consumed. The main edible oils consumed in China were: soybean, peanut, sunflower-seed, and vegetable-seed oils. Between 1989 and 1993 there was almost a 12 g increase in the average daily amount of oil consumed among the consumers.

Similarly, the consumption of pork and eggs underwent large changes. The daily average consumption of pork increased about 14 g, and the proportion of people consuming pork increased 8 percentage points during the period of 1989-93. The consumption of eggs went up by 42% for the average amount and by 31% for the proportion of population consuming. In contrast, the consumption of staple foods decreased substantially. The difference in the average amount of grains consumed (rice, flour, and coarse grains) was about 57 g per day between 1989 and 1993. The rising consumption of high-fat foods is reflected in an increasing proportion of energy from fat, which rose by 28%, from about 19 percent of

calories from fat in 1989 to 26 percent in 1993. This intake of energy and protein is above the FAO/WHO recommended daily allowances for this population.[29]

--Table 3 about here--

Multivariate Longitudinal Analysis

Appendices A-C contain estimates of the impacts of incomes, prices, and demographic characteristics on food consumptions from random effect probit procedures for whether the individuals consumed any if the foods and from random effects linear regression models for the positive quantities of the foods that were consumed. The most important and interesting estimates relate to the differences in income elasticities for foods and nutrients across income levels and across time. Since we estimated nonlinear income effects, it is most convenient to characterize succinctly the variations in elasticities through graphs. In these graphs we present estimates of the income elasticities for 1989, 1991, and 1993 along with 95 per cent confidence bands for these income elasticities for selected foods and macro nutrients.[30] We also examine the changes from 1989 to 1993 in the income elasticities and confidence bands about these temporal changes in elasticities. Figures 3-8 present some of the more important results about the variations in income effects uncovered in this analysis.

The income elasticities for wheat flour and wheat flour products are quite informative, and in Figures 3 and 4 we present estimates of income elasticities for this food group. The first three panels in Figure 3 display the income elasticities for the probability of consuming any wheat flour products in 1989, 1991 and 1993 as a

function of the income level. The lower right hand panel displays the changes in elasticities between 1989 and 1993 as a function of income. The dashed lines indicate pointwise 95% confidence bands about the graphed regression lines.[31]

From Figure 3 we see that the probability of consuming any wheat flour is weakly positively related to income in 1989.[32] The estimated elasticity is only statistically significant about the mean income level. By 1991 wheat flour had become a statistically significant inferior good for individuals in the lower half of the income range, and by 1993 wheat flour had become an inferior good over nearly the entire range of incomes. The lower right panel in Figure 3 indicates that the elasticity of the probability of consuming any wheat flour fell at all income levels and that this fall was statistically significant over the central portion of the income distribution. During these four years, higher income individuals became increasingly less likely to consume any wheat flour products.

Figure 4 presents nearly identical information about the consumption of wheat flour given that there was some positive consumption by household members. By 1993 wheat flour had become an inferior good over almost the entire range of incomes. The income elasticity is significantly negative for all incomes below the 90^{th} percentile in 1993. The fall in the income elasticity across time is significant for most income levels. Wheat flour products have clearly become quite inferior goods over just a four year time span.

--Figures 3 and 4 about here--

The demand functions for other grain products have also shifted in somewhat similar ways.[33] Rice, the other major staple food, had a stable income elasticity for the likelihood of consuming rice. There was only a small and insignificant shift over time in the income elasticity for the probability of consuming any rice. But there was a significant reduction from 1989 to 1993 in the income elasticity for the amount of rice consumed by those who consume it, and this reduction was much greater among the lower income groups. The income elasticity for rice fell at the 10^{th} percentile of income from 0.20 to 0.04, while at the mean income level the elasticity shifted from 0.05 to 0.00. These downwards shifts in the income elasticities for rice were significant over most of the income range. Coarse grains were an inferior good in terms of both the likelihood of consuming them and the quantity consumed among those who ate them in both 1989 and 1993. But the income elasticities for the likelihood of consuming any coarse grain and grain products shifted from about -0.07 in 1989 to -0.02 to 0.00 in 1993 for a positive and statistically significant change. There was only a nearly imperceptible downward shift in the income elasticity for the quantity of coarse grains consumed by consumers of coarse grains between 1989-93. Coarse grains remained inferior goods from 1989 to 1993.

To simplify the presentation for pork and edible oil, we present only the summary changes in income elasticities in Figures 5 and 6. There was a positive income elasticity for the probability of consuming any pork in 1989. This income elasticity increased significantly over the 1989-93 period with the increase being

somewhat larger among lower income groups (Figure 5, left panel). The income elasticity for the quantity of pork consumed (conditional on positive consumption) has become more positive among all income groups, but higher income groups experienced the greatest increases in elasticities (Figure 5, right panel). These shifts are statistically significant for all per capita incomes above the first quartile. For edible oil, the income elasticity for the probability of consuming this product is quite small, and there has not been a significant change over time (Figure 6, left panel). This is most likely due to the fact that nearly all households consume some oil. The income elasticity for the amount of oil consumed (given positive consumption), surprisingly, was negative in 1989, but it was insignificantly different from zero over almost the entire income range. This income elasticity rose significantly by 1993, and it was positive at all income values and significantly different from zero for all but the top few percent of the income distribution.

--Figures 5 and 6 about here–

In most development situations, nutrition change is associated with a shift toward more processed and more expensive foods and toward reductions in energy intake.[2] Typically this is matched by reductions in physical activity as the occupation mixture shifts toward reduced energy expenditure.[34] There is evidence of this inverse relationship between energy intake and income in 1989 and 1991, as income elasticities were negative for all income groups (Figure 7, top panels). By 1993, however, the income elasticity for total energy was positive among higher income groups. Income elasticities for total energy increased between 1989 and

1993 at all income levels. These increases in elasticities were significant about the center of the income distribution, but the levels of the income elasticities for total energy intakes were always substantively quite small (less than 0.05 in absolute value).

The estimated income elasticity for fat calories was small (less than 0.10) and insignificantly different from zero in 1989. By 1993 this elasticity had become significantly positive over almost the entire range of income. The increase in the income elasticity for fat was about 0.08 at all income levels, and the increase was significant about the center of the income distribution (Figure 8, left panel). Fat intakes rose more than total energy intakes from 1989 to 1993. The income elasticity for protein intake was negative at all income levels prior to 1993. The income elasticity for protein, however, increased at all income levels from 1989 to 1993 (Figure 8, right panel), and it did become positive at higher incomes by 1993. These changes in the income elasticity for protein, however, are not statistically significant, and never did the absolute value of the income elasticity for protein exceed 0.04.

--Figures 8 and 9 about here--

In summary, there were remarkable shifts in how Chinese diets varied with income over just these four years. In 1989, wheat flour products were normal goods over most of the range of incomes, but by 1993 they became inferior goods. By 1993 the quantity of rice consumed appeared unrelated to variations in income, while coarse grain products remained quite inferior goods. These relatively low fat,

high fiber foods became much less important in Chinese diets from 1989 to 1993, and they were increasingly less important at higher income levels. During the same time span higher fat foods became much more responsive to income levels. Pork, edible oils, and eggs had significant increases in their income elasticities. Overall there were only modest increases in total energy intake associated with higher income, but the quantity of fat in the diets increased significantly and now appears to increase much more rapidly with increases in incomes. These changes portend an important deterioration in the healthiness of the Chinese diets that could burgeon as the Chinese economy continues its expansion.

Discussion

China is undergoing a marked transition in its diet, activity and nutritional status patterns. This research on the changing relationship between income and the structure of diet and total nutrient intake points out a number of important issues. First, as the longer term trends have shown, the proportion of the diet that is coming from what were previously viewed as superior grain and grain products--rice and wheat--is being reduced. Second, more pork and oil are being consumed. The largest increases in pork consumption are taking place among higher income adults, and the larger increases in the edible oils are happening among lower income adults. The net effect of all these changes in diet has been to increase the income elasticity for total energy intake across all income groups with slightly larger increases among higher income groups.

While these changes in the patterns of overall energy consumption were taking place, there was a pronounced increase in the income elasticity for the proportion of calories from fat from 1989 to 1993. This upward shift takes place over nearly the entire income range, resulting in a positive income elasticity for fat at all income levels in 1993. There is also a slight structural shift in the income elasticity for protein such that we find greater protein income elasticities for all income groups between 1989 and 1993, but this change is small when compared to the change in the elasticities for most other nutrients.

There results fit very closely with the larger trends toward increased obesity. The reduction in activity related to both technological change (not studied here) and to the shift toward lower activity occupations in the service and manufacturing sector is an important component of this change in obesity. There has been a shift toward a larger proportion of lower activity patterns among adults, and this is linked with the increased obesity.[25] Nevertheless the dietary changes are also significant. Moreover the structural shifts that indicate increased income elasticities for total energy and for energy from fat are indicative of a worsening of the pattern of diet that is linked with obesity. This represents one of the negative dimensions of the transition taking place in China.

There are several important issues. One is that in China it appears increasingly likely that lower income people can afford more fat (from edible oils) and that the upward shift in fat consumption is important for explaining part of the nutrition transition. This result fits clearly with the result presented above in Figure

1 and also with regression analyses presented in the previous CHNS study.[2] All show that lower income countries in the 1990s consume much greater amounts of energy from fat than they were in the 1960s, holding income levels constant. This increase in fat intake comes from edible oils. But the structural shift in the decision-making related to edible oil intake can not be easily explained.

A second is that the reduction in protein from the reduced intake of the key grain products is more than offset by the increase in consumption of other protein-rich food products such that total protein intake has not suffered. Elsewhere we have shown that dietary diversity has increased.[2] It is this increased fat and protein intake coupled with the increased diversity that is important for improving nutritional status and reducing many of the classic aspects of dietary deficit that dominated the preschool populations (and other age groups depending on the country) of the developing world into this last decade.

Third, it is clear that the nutrition transition in China is not decelerating but actually increasing. What is not clear is why. The shifts in the nature of work and leisure are straightforward, but the changes in diet and the reasons for the structural shifts in diet are what cannot be explained. Is it the rapid spread of mass media. In Asia between 1984 and 1989, the ownership of television sets increased from 62 million to 211 million.[35] In the CHNS sample, for example, TV ownership nearly doubled, from 43% to 82%, for households in the lowest income tertile between 1989 and 1993; and TV ownership went from 56% to 94% among the middle income tertile during this same period of time. While television

programming inside China is highly controlled, most individuals are now exposed to Western advertising and Western TV shows. Perhaps this marked shift in television viewing is part of the explanation for the dietary change.

As the WHO, in a recent volume prepared by a distinguished panel of scholars from the nutrition and cancer area, and other major studies have shown, the types of diets starting to be consumed by the Chinese and others throughout the developing world are relatively high in fat and processed food. These diets are low in fiber, vegetables, and carbohydrates, and such diets are linked with increases in noncommunicable diseases such as coronary heart disease and cancer.[10,11,36] The cancer volume, in particular, was the first to look at the trends in diet and consider what they might mean for cancer incidence and mortality in the world.

This study points out that a great deal must be done not only to understand what is causing this dietary shift but to begin to consider policy options. The dietary patterns, at least for Chinese adults from the late 1980s to the mid 1990s, have changed in complex ways. Low fat, high fiber foods like coarse grains have become more inferior goods, and the oils, fats, and meats have become more superior goods. Simple income changes alone cannot explain such structural shifts in the consumption of the food groups. If one were to rely upon estimates of demand functions from early in the transition to project dietary changes in the near future, say using 1989 data to estimate relationships in China to describe changes

in diets by 1993, then one would understate seriously the extent of dietary change associated with real income growth during this short time span.

China’s economy continues to grow rapidly and its shift in diet, activity and body composition appears to continuing to be rapidly changing. In 1993, the Chinese government organized the National Commission for Food Reform and Development. The State Council issued the first document that addressed future food production and marketing in terms of its significance for nutritional well-being. In effect, they revised the Chinese dietary guidelines to create the current (1997) version. Updated guidelines focus on the food and production to eliminate undernutrition and also on what they term "diseases of affluence" or dietary excess and obesity. Public education and other activities during the past few years have focused on retaining the current levels of fruit and vegetable intake and decreasing the proportion of high-fat sources of protein relative to low-fat ones. These guidelines attempt explicitly to increase considerably both the production and consumption of fish, seafood, poultry, and soybeans. The guidelines provided a clear policy basis for developing and implementing food and nutrition policy to shift the composition of the diet, but they also point out many difficulties the Chinese face since large pockets of undernutrition exist.

What is unique about this proclamation and the ongoing government effort in China is the Ministry of Agriculture's recognition of the need to achieve a more balanced diet for the Chinese people. The difficult work of actually implementing the policy changes in terms of price and related policies remains to be done.

Nevertheless, this government effort represents a path-breaking effort to address problems of under and over-nutrition concurrently. The size and strength of relationships such as income and dietary fat, particularly as they relate to income and price increases over time, are of particular importance. The changes in income elasticities we have documented in China forebode rapid increases in diet-related noncommunicable diseases. If incomes continue to grow and the elasticities continue to shift toward an increasing prominence of high fat diets, then it might be necessary to consider counteracting these changes with macroeconomic instruments such as price, credit, and tax policies.

Notes

* Funding for parts of the project design, data collection and computerization has been provided by the Chinese Academy of Preventive Medicine (CAPM), the Carolina Population Center (CPC) of the University of North Carolina at Chapel Hill (UNC-CH), and the National Institutes of Health (NIH) (P01HD28076-01 and R01-HD30880). Collaborative training and development work has been funded by the National Science Foundation (grant #37486) and the Ford Foundation. Funds for the research reported in this article were provided by NIH. This article is part of a collaborative research project between the CAPM, directed by Dr. Ge Keyou, formal director of the Institute of Nutrition and Food Hygiene with co-principal investigators Zhai Fengying and Jin Shuigao; and a group from UNC-CH and CPC, directed by Barry M. Popkin, with co-principal investigators John S. Akin, Barbara Entwisle, and Gail E. Henderson. We wish to thank Ms. Frances Dancy for her helpful assistance.

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23. The estimated regression lines in Figure 1 come from regressions of the dependent variable, either average percent of total calories from fat, average percent of calories from vegetable based fats, or average percent of calories from animal fats on cubic polynomials in real GNP (1992 dollars). Note that in 1962 about 75% of the countries used in the regression analysis for Figure 1 had per capita income less than $2500; for 1993 about 60% of countries had per capita income below this level. China in 1990 had a per capita income of $440. (All in 1992 US dollars.)

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30. The consumptions are regressed on log household per capita income and its square, so the income elasticities are the derivatives of the estimated quadratic polynomials in log household per capita income with respect to log per capita income. These elasticities are graphed against the logarithm of household per capita income to display elasticity differences across income levels.

31. The confidence bands recognize the within household correlation of unobservables both at each point in time and through time. The bands depicted are the pointwise bootstrap standard errors of the elasticities and of

the across time pointwise differences in elasticities. The unit of observation for the bootstrap replications was a household (containing up to three years of data for up to several prime aged individuals).

32. When interpreting these graphs, it is key to be aware of the distribution of household per capita incomes. Grouping incomes across all three years yields the following percentiles and means:

Including zero and negative incomes (1980 yuan):

percentile:	5	10	25	50	mean	75	90	95
real income (yuan):	44	100	226	447	556	741	1083	1369
log (income)	3.8	4.6	5.4	6.1	6.3	6.6	7.0	7.2

Excluding zero and negative incomes (1980 yuan):

percentile:	5	10	25	50	mean	75	90	95
real income (yuan):	62	116	237	456	566	749	1092	1375
log (income)	4.1	4.8	5.5	6.1	6.3	6.6	7.0	7.2

33. Detailed graphs, like those presented in Figures 3, 4, and 7, are available from the authors for all six food groups and macronutrients. We have included copies of these additional graphs as Appendix E in this version of the paper only to assist the referees in their evaluation.

34. B. M. Popkin, “Urbanization, Lifestyle Changes and the Nutrition Transition,” World Development 27 (in press November 1999):

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Table 1. Percentages of study population in high and low energy consumed from fat dietary intake categories for adults aged 20-45, by tertile of household income, CHNS 1989,1991 and 1993.

	Household Income								
Distribution of sample by	Low			Middle			High		
percent energy from fat	1989	1991	1993	1989	1991	1993	1989	1991	1993
Percent consuming < 10%									
Urban	14.3[a]	10.0[b]	1.5[a,*]	8.6[*]	2.7	0.4	7.1[*]	0.4	0.3
Rural	39.2[b*]	17.3[b]	14.7[b]	24.7[*]	9.1	9.1	14.8[*]	3.3	3.5
Total	36.5[b,**]	16.4[b]	12.2[b]	18.6[*]	7.1	6.5	11.1[*]	1.8	2.3
Percent consuming >30%									
Urban	19.1	25.4[b]	36.4[b,*]	19.1[**]	45.5	51.0	22.8[*]	62.0	66.6
Rural	7.6[b,*]	12.8[b]	12.9[b]	12.0[**]	19.9	24.9	15.3[**]	39.1	44.1
Total	8.8[b,**]	14.3[b]	17.3[b]	14.6[**]	27.7	32.6	18.9[*]	50.7	52.7

[a]The proportion differs significantly from middle and high-income groups within same year ($p<0.05$).

[b]The proportion differs significantly among three income groups within same year ($P<0.05$).

[*]The proportion differs significantly from corresponding value in other two years ($p<0.05$).

[**]The proportion differs significantly from corresponding value among the three years ($p<0.05$).

Table 2. Distribution of physical activity of Chinese aged 20-45, by tertile of household income and residence, CHNS 1989, 1991 and 1993.

	Household Income Per Capita Tertiles								
	Low			Middle			High		
	1989	1991	1993	1989	1991	1993	1989	1991	1993
Urban Residence									
Lowest level activity	23.7[b,**]	34.3[b]	42.6	35.5[*]	45.4	42.8	44.5[*]	58.3	55.5[a]
Middle level activity	49.6[b,*]	30.1	30.2	46.1[*]	39.7[a]	40.6	48.0[*]	34.5	32.0[a]
Highest level activity	26.7[b]	35.6[b,*]	27.2	18.4	14.9	16.6	7.5	7.2	12.5[a,*]
Rural Residence									
Lowest level activity (%)	15.3[*]	3.9[b]	4.8[b]	16.2[*]	12.3	12.6	23.7[a]	24.8	19.8
Middle level activity (%)	22.2[b,**]	5.3[b]	7.9[b]	28.9[*]	14.1	13.3	35.2[*]	24.0	26.8[*]
Highest level activity (%)	62.5[b,**]	90.8[b]	87.3[b]	54.9[*]	73.6	74.1	41.1[*]	51.2	53.4

[a]The proportion differs significantly from middle and high-income groups within same year ($p<0.05$).

[b]The proportion differs significantly among three income groups within same year ($p<0.05$).

[*]The proportion differs significantly from corresponding value in other two years ($p<0.05$).

[**]The proportion differs significantly from corresponding value among three years ($p<0.05$).

Table 3. Patterns of Major Food-Groups Consumption and Macronutrient Intake among adults aged 20-45 in China, 1989 and 1993

	1989 (5625)[1]			1993 (5031)		
Food Group/Nutrient	g/capita/day	% consuming	g/user/day	g/capita/day	% consuming	g/user/day
Rice	318.8	82.8	379.2	296.1	84.5	350.6
Wheat flour	173.6	65.8	263.9	164.1	71.3	230.0
Coarse grains	54.4	27.8	195.7	29.9	21.4	139.8
Pork	48.9	58.9	83.1	62.6	67.1	93.3
Eggs	10.8	26.5	40.7	15.3	34.6	44.1
Edible oils	15.2	63.2	24.0	31.1	87.7	35.4
Energy (kcal)	2655			2636		
Protein	81.0			78.1		
Fat	54.7			74.3		
% energy from fat	18.5			25.5		

[1] Sample size

Figure Legends

Figure 1. Relationship between the percentage of energy from fat and GNP per capita, 1962 and 1990

Figure 2. The relationship between the percentage of the population that is obese and the proportion of energy intake from fat (BMI and dietary survey year in parentheses)

◆ Actual Obesity ——— Actual Obesity

Figure 3. Income elasticities for the probability of consuming wheat flour among adults aged 20-45 in China, 1989-93

Figure 4. Income elasticities for the amount of wheat products consumed, among adults aged 20-45 who consume any wheat products in China, 1989-93

Figure 5. Changes in income elasticities pork consumption among adults aged 20-45 in China from 1989 to 1993

Figure 6. Changes in income elasticities for edible oils consumption among adults aged 20-45 in China from 1989 to 1993

Figure 7. Income elasticities for total energy intake among adults aged 20-45 in China, 1989-93

Figure 8. Changes in income elasticities for total fat and protein intake among adults aged 20-45 in China from 1989 to 1993