Structural Change in the Impact of Income on Food Consumption in China, 1989–1993*

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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, descriptive evidence indicates that the adoption of new family planning technologies and declines in fertility are happening at increasingly lower income levels. These changes have been rapid, and the rate of change appears to have accelerated.[1] Since the 1960s fertility declines appear to have become uncoupled from the economic changes that are experienced at the individual level. With respect to nutrition, 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 ever 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 describing 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 modeling and providing cohesive hypotheses about the changes. J. Huang and H. Bouis, for example, used aggregate time-series and cross-sectional data to develop the hypothesis that the transformations in

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the Asian economies are linked with rapid urbanization.[3] Similarly, a cross-nutritional ecological analysis of gross national product (GNP) and the structure of the diet seems to point to a powerful effect of urbanization.[4] However, these are not relationships that have been rigorously tested, nor have researchers controlled for the wide range of observed and unobserved factors that affect consumption decisions.

In this article we start by presenting evidence that points to a shift in the relationship between income and diet at the macro level, and we discuss the broad trends in Asia and elsewhere. Following this, we present a longitudinal study of 3,800 households in China for data collected in 1989, 1991, and 1993. In this case study we show that in China the increase in income over time coincided with a shift in the demand for a range of inferior and normal food groups. Income elasticities for more luxury foods increased significantly from 1989 to 1993, while less-superior goods became more inferior over this 4-year span. These results suggest that researchers using standard income elasticities will fail to predict accurately 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 other case studies allow us to 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 its socioeconomic development in less than one generation. China's per capita income grew at a remarkable 8.2% annual rate between 1978 and 1996.[5] During this period there was a significant reduction in the number of absolute poor in China, in conjunction with a rapid increase in income inequality. A rapid improvement of food supply and consumption accompanied these economic changes. China has attained a high measure of food security and has experienced marked changes in dietary structure.[6]

Change has not always been steady in China, and evidence of increased 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, particularly among higher-income groups, the incidences of high-fat diets and obesity have increased rapidly.[7] There has been a marked shift not only in obesity but also in other diet-related chronic diseases such as cardiovascular disease, diabetes, and certain types of cancers. These are rapidly becoming major health problems in the higher-income population.[8]

In this article we first present the overall picture with a cross-country analysis of changes in the dietary structure, and we explore the income-fat and diet-obesity relationships. Then we present data from China that demonstrate the trend in the dietary structure. This is followed by a more rigorous examination and testing of the income-food

consumption relationship. The behavioral changes that we uncover in the income-food relationship have important implications for the formulation of future nutrition policies in China. We explore some of these implications in the concluding section.

Data

This study uses longitudinal data from the China Health and Nutrition Survey (CHNS). The CHNS was designed as a time-cohort survey. It started in 1989 and covers eight Chinese provinces. 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 sample design for the CHNS is complex, but it can be described as a multistage cluster design.[9] A total of 5,787 adults, 20–45 years old and surveyed from 3,126 households, were included in the 1989 CHNS for the dietary survey. Among these subjects, 5,625 individuals who had multiple-day dietary records 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 dietary data came from two sources—the household survey instrument and the individual dietary surveys. Detailed weighed inventory change of household food data were combined with three consecutive days of repeated 24-hour recalls. Detailed descriptions of the dietary survey are presented elsewhere.[10] The 1991 Food Composition Table for China is used to calculate macronutrients for each food item.[11]

The income variable used in this study represents per capita household income, including all cash and noncash income components.[12] To reduce the potential for biases due to measurement error in the income variable, a two-stage 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 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 3 survey years. Income and price variables were deflated by the consumer price index (CPI) to 1980 yuan.[13]

From the CHNS food prices that had been collected from each sample community, we examined three sources of food prices: state store prices, free market prices, and authority price records published by the State Statistical Bureau (SSB), which provide the provincial average. Free market prices were found to be the most meaningful prices in terms of affecting consumption decisions. We use these prices in this analysis.[14]

In our introductory cross-national macroeconomic analysis of changes in the income-diet relationships over time, we use national food

consumption data from the Food and Agriculture Organization (FAO) food balance sheets for 1962–90.[15] We combined data on food availability, expressed in the percentage of daily energy from macronutrients, with the official estimates of GNP.[16] The 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. This part of the analysis uses data from 99 countries for the 1962 regressions and data from 134 countries for the 1990 regressions. After this overview of the changes over time in the aggregate relationships between diet and income, we present evidence on the aggregate relationship between the incidence of obesity and fat consumption. Following World Health Organization (WHO) recommendations, we define the incidence of obesity as a Body Mass Index (BMI) of 25.0 or higher.[17]

The Nutrition Transition in the Developing World

The estimated regression lines displayed in figure 1 show that the aggregate income-fat relationship underwent a dramatic change from 1962 to 1990.[18] Most significant, by 1990 even the poor nations had access to a relatively high-fat diet. Whereas in 1962, a diet that derived 20% of energy (kilocalories) from fat was associated with a GNP of $1,475, the same diet in 1990 was associated with a GNP of only $750 (both in 1992 dollars). This dramatic change arose from a major increase in the consumption of vegetable fats by poor and rich nations alike. The proportion of energy from vegetable fats accounted for up to 13% of total energy in 1990, compared to 10% in 1962. The availability of animal fats continued to be linked to income, though less strongly than before. Vegetable fats in 1990 accounted for a greater proportion of dietary energy than did 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 consumed an additional 4%–5% of energy from fat by 1990. Although meat consumption declined in high-income countries (by 6%–9%), there was little overall reduction in fat intake. The results shown in figure 1 indicate that there has been a substantial shift in the relationship between GNP and the composition of diets over time. However, there was little information in the 1962 GNP-nutritional composition analysis that would have predicted the form of the relationships in 1990.

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 with a reduction in physical activity). To measure the prevalence of overweight individuals, we employ data from 20 countries on the fraction of each population having a BMI

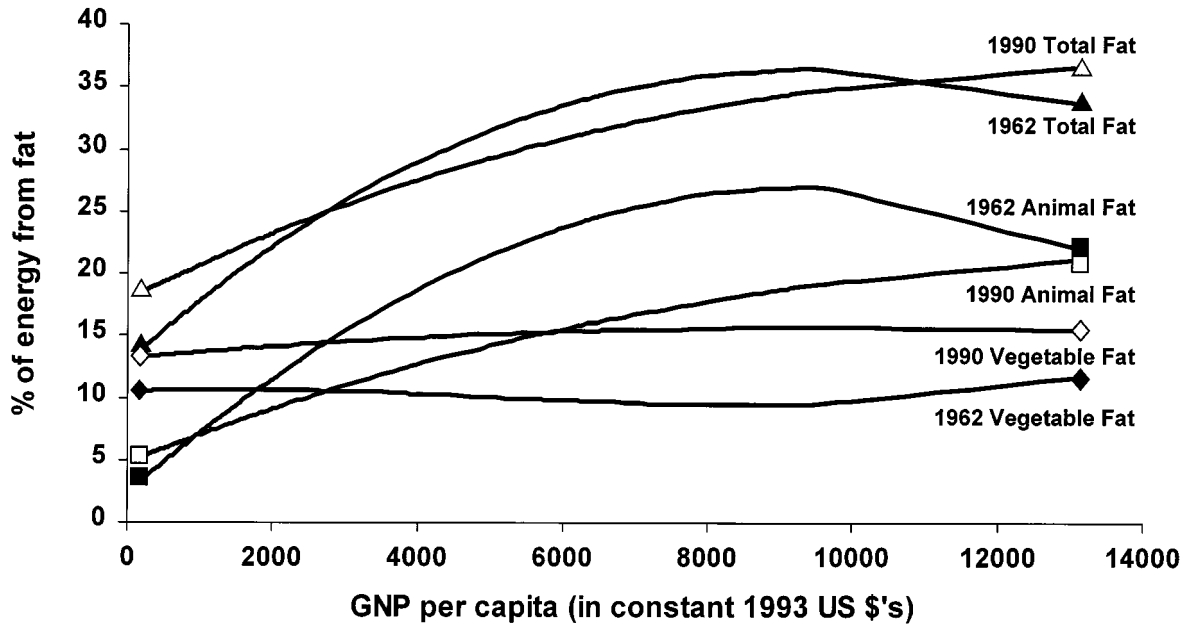

FIG. 1.—Relationship between the percentage of energy from fat and GNP per capita, 1962 and 1990. Sources: The food energy data are from Food and Agricultural Organization, FAOSTAT, Food Balance Sheets, 1961–94, Diskette (Rome: Food and Agriculture Organization, 1997). The GNP data are from the World Bank, *World Data, 1995,* CD-ROM (Washington, D.C.: World Bank, 1995).

of 25.0 or higher. The timing of these BMI measurements varies across countries from 1976 to 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 percentage of obese individuals to the average proportion of dietary energy from fat. The regression coefficient of 2.6 ($P < .001$; adjusted $R^2 = 0.79$) indicates a large significant positive association between dietary fat consumption and the proportion of individuals who were overweight. These results speak directly to the potential of increased dietary fat consumption leading to increases in the level of obesity in lower- and middle-income countries.

There has been a marked increase in obesity in Asia and other regions of the lower-income world. In fact, the rate of increase in overweight individuals in some Asian countries matches that found in the United States.[19] Other studies on China that used the CHNS data have uncovered similar shifts in diet and physical activity and have examined how the shifts in diet and activity relate to changes in the incidence of obesity.[20]

Dietary change has been very rapid in China. During the past decade, China has attained overall adequacy in diet. The composition has concomitantly undergone remarkable change. In table 1, we present patterns of dietary intake by income level for adults 20–45 years old from 1989 to 1993. While the traditional Chinese diet is considered to be low fat, we found only a small proportion of the population following this traditional low-fat diet. An ever increasing proportion of the population consumed more than 30% of energy from fat. This high-fat diet was significantly more common among urban and higher-income populations than in rural and lower-income areas, and a decrease in the proportion of adults consuming a low-fat diet was common to all income groups.

These dietary changes are part of a broader longer-term shift in China's dietary structure.[21] Both per capita total cereal consumption and per capita vegetable consumption increased between 1978 and 1984 but remained constant thereafter. In contrast, consumption of meat, edible oils, sugar, eggs and fish, and (to a lesser extent) fruit increased at least through the mid-1990s. The dietary structure shifted to one in which the proportion of energy from both vegetable and animal fat increased each year. A. Piazza provides detailed consumption information from earlier periods when overcoming food scarcity was the sole nutritional concern of the Chinese.[22]

Using various longitudinal models, a number of studies have shown that a change in diet and physical activity affect the shift in BMI.[23] These large changes in consumption patterns and in body mass suggest important structural shifts in consumption decisions in China. We address this issue by rigorously examining the determinants of dietary intake in China, and we focus particularly on the key foods and total fat intake that reflect the shift in dietary intake.

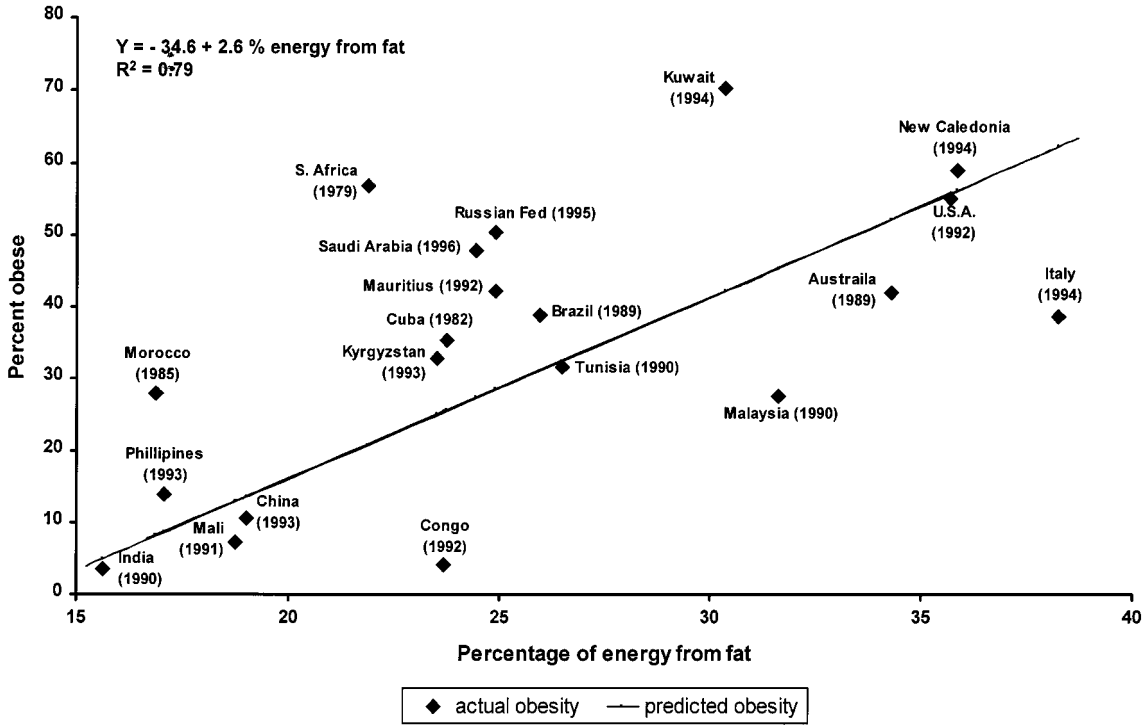

FIG. 2.—The relationship between the percentage of the population that is obese and the proportion of energy intake from fat (BMI and dietary survey year in parentheses). Sources: Regression run with GNP data from the World Bank, *World Data, 1995*, CD-ROM (Washington, D.C.: World Bank, 1995); obesity data are from B. M. Popkin and C. Doak, ''The Obesity Epidemic Is a Worldwide Phenomenon,'' *Nutrition Reviews* 56 (1998): 106–14.

TABLE 1

PERCENTAGES OF STUDY POPULATION IN HIGH AND LOW ENERGY CONSUMED FROM FAT DIETARY INTAKE CATEGORIES FOR ADULTS 20–45 YEARS OLD, BY TERTILE OF HOUSEHOLD INCOME, CHNS 1989, 1991, AND 1993

	HOUSEHOLD INCOME								
	Low			Middle			High		
DISTRIBUTION OF SAMPLE BY PERCENT ENERGY FROM FAT	1989	1991	1993	1989	1991	1993	1989	1991	1993
% consuming <10%:									
Urban	14.3[a]	10.0[b]	1.5[a]	8.6	2.7	.4	7.1	.4	.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
% 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,*]	1.28[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 ($P < .05$).
[b] The proportion differs significantly among three income groups within same year ($P < .05$).
* The proportion differs significantly from corresponding value in other 2 years ($P < .05$).
** The proportion differs significantly from corresponding value among the 3 years ($P < .05$).

Determinants of Diet in China

It holds for any specific food group that some proportion of the population does not consume it; for those who do consume it, the distribution of consumption level is quite skewed. Under these conditions, researchers recommend using a two-part model to analyze consumption behaviors.[24] The first part examines the decision to consume or not consume a given food group, and the second part examines only positive consumptions within the food group. We follow these recommendations by log-transforming income, consumptions, and food prices to reduce skewness.

We use two-stage estimation methods to control for measurement error and endogeneity of household income in the demand function analyses. The instruments for identifying the income effects include community information, family background variables, and household business and asset measures. We also use individual-level, random-effect estimators to obtain increased accuracy. This strategy considerably enhances the reliability of the estimated parameters.[25] We use bootstrap procedures to obtain standard errors. These methods allow us to control for within-household unobservables that influence the food and nutrient demands through time.

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, and educational level; and a vector of time-invariant variables such as sex, place of residence, and region. There were no significant loss-to-follow-up self-selectivity effects apparent in these data. Elsewhere the sample is described in depth.[26] Appendix A presents means for the dependent variables in this analysis, and appendix B contains selected regression estimates for wheat flour, pork, and edible oil consumptions.[27]

Overall Patterns of Food Consumption

Table 2 presents information on the consumption of six food groups and three macronutrients by Chinese adults in 1989 and 1993. These six food groups were among the top 10 food sources of dietary fat, representing approximately 70%–75% of total fat intake. The average per capita consumption of oils more than doubled from 1989 to 1993, 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 an increase of almost 12 grams in the average daily amount of oil consumed.

Similarly, there were major changes in the consumption of pork and eggs. The daily average consumption of pork increased about 14 grams, and the proportion of individuals consuming pork increased 8 percentage points from 1989 to 1993. Among those consuming eggs, average daily consumption increased by 42%; the proportion of individuals consuming

TABLE 2

PATTERNS OF MAJOR FOOD-GROUPS CONSUMPTION AND MACRONUTRIENT INTAKE AMONG ADULTS 20–45 YEARS OLD IN CHINA, 1989 AND 1993

	1989 (5,625)[a]			1993 (5,031)[a]		
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)	2,655			2,636		
Protein	81.0			78.1		
Fat	54.7			74.3		
% energy from fat	18.5			25.5		

NOTE.—g/capita/day refers to the average consumption of the good or nutrient per day across all individuals; g/user/day refers to the average consumption of the good in grams per day across those who had positive consumption of the good.

[a] Sample size.

any eggs rose by 31%. In contrast, the consumption of staple foods decreased substantially. The decrease in the average amount of grains consumed (rice, flour, and coarse grains) was about 57 grams 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 from about 19% of calories from fat in 1989 to 26% in 1993. This intake of energy and protein is above the FAO/WHO's recommended daily allowances for those living in less developed countries.[28]

Multivariate Longitudinal Analysis

The most important estimates relate to the differences in income elasticities for foods and nutrients across income levels and over time. Since we estimated nonlinear income effects, it is most convenient to characterize the variations in elasticities through graphs. In our graphs we present estimates of the income elasticities for 1989, 1991, and 1993, along with 95% confidence bands for selected foods and macronutrients.[29] We also examined the changes from 1989 to 1993 in the income elasticities and confidence bands. Figures 3–7 present some of the more important results related to the variations in income effects.[30]

The income elasticities for wheat flour and wheat-flour products are quite informative. 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 change in elasticity between 1989 and 1993 as a function of income. The dashed lines indicate pointwise 95% confidence bands about the graphed regression lines.[31]

Figure 3 shows that the probability of consuming any wheat flour is weakly positively related to income in 1989.[32] The estimated elasticity is statistically significant only 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 4 years, higher-income individuals became increasingly less likely to consume any wheat-flour products.

Figure 4 presents nearly identical information about the amount of wheat flour consumed, given positive consumption. By 1993, the income elasticity was significant and negative for all incomes below the ninetieth percentile. The fall in the income elasticity across time was significant for most income levels. Wheat-flour products had clearly become inferior goods over just a 4-year span.

The demand functions for other grain products also shifted in somewhat similar ways.[33] For the other major staple food, rice, there was a

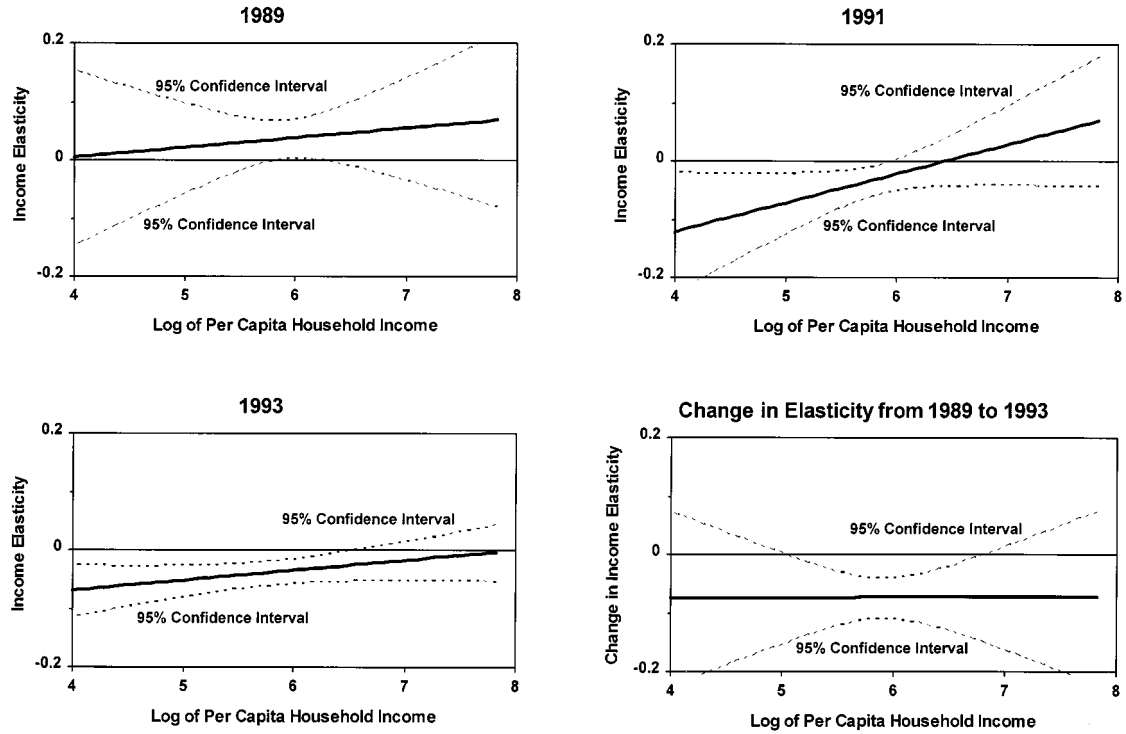

FIG. 3.—Income elasticities for the probability of consuming wheat flour among adults 20–45 years old in China, 1989–93

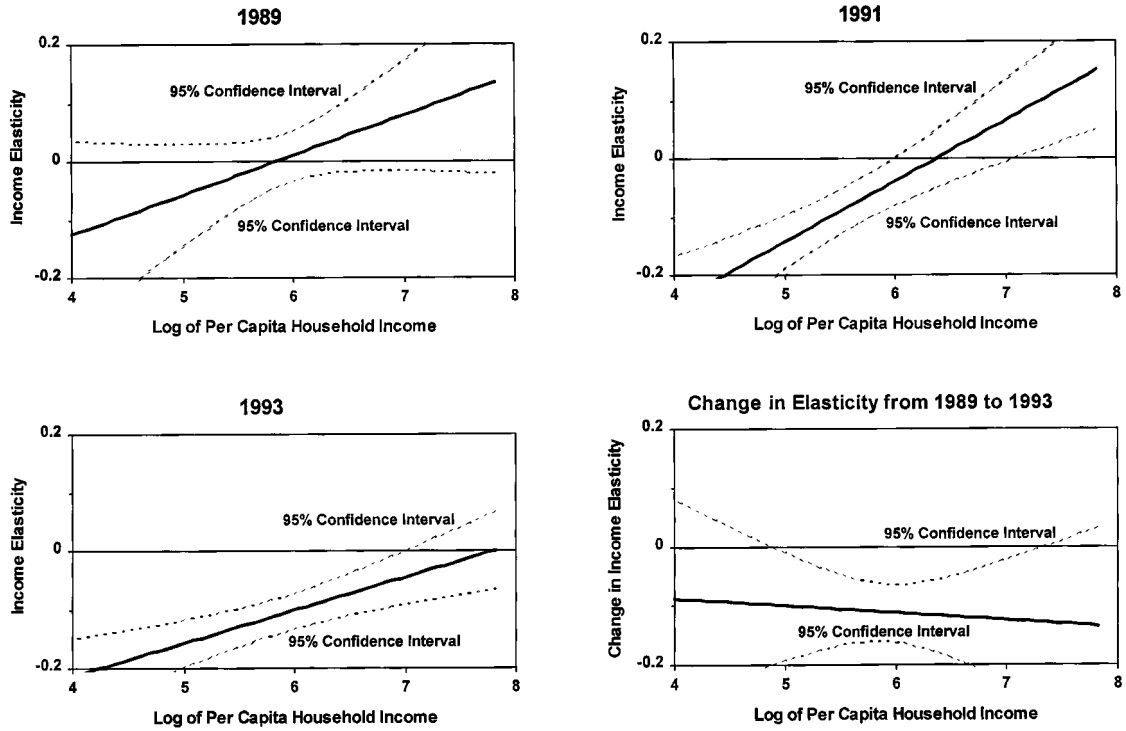

FIG. 4.—Income elasticities for the amount of wheat products consumed among adults 20–45 years old who consumed any wheat products in China, 1989–93.

stable income elasticity for the incidence of any positive consumption. But there was a significant reduction from 1989 to 1993 in the income elasticity for the quantity of rice consumed, and this reduction was much greater among the lower-income groups. The income elasticity for rice fell at the tenth 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 downward 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 in both 1989 and 1993, with only a slight downward shift in the income elasticity for the quantity consumed between 1989 and 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 (fig. 5, left panel). The income elasticity for the quantity of pork consumed (conditional on positive consumption) became more positive among all income groups, but higher-income groups experienced the greatest increases in elasticities (fig. 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 (fig. 6, left panel). The income elasticity for the amount of oil consumed (given positive consumption), to our surprise, 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 percentages of the income distribution.

The income elasticities for total energy intake (kilocalories) and total protein consumption also increased over these 4 years.[34] Income elasticities for both consumptions were small and negative in 1989. They increased slightly by 1993 and became positive at higher-income levels. The magnitudes of these 1993 income elasticities, however, were less than 0.02 in absolute value at all income levels.

As a convenient and relevant summary measure, consider the income elasticities for the total amount of fat consumed in the diet as depicted in figure 7. The estimated income elasticity for fat intake was not significantly different from zero in 1989. By 1993 this elasticity had increased and 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 (fig. 7, lower right panel).

In summary, there were remarkable shifts in how Chinese diets varied with income over just these 4 years. The income effects for low-fat,

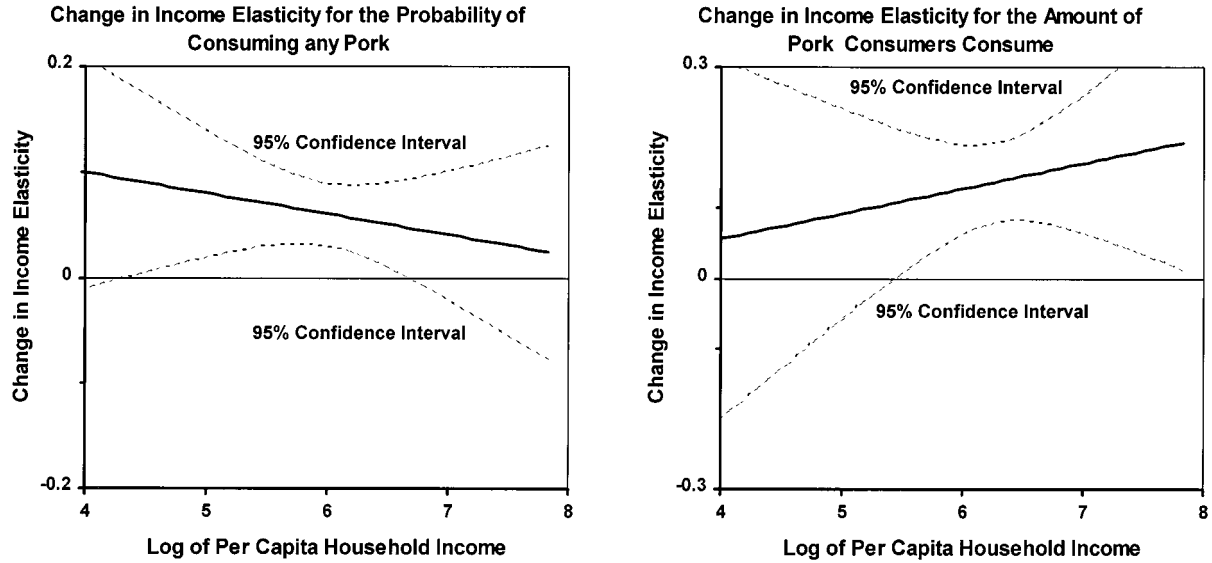

FIG. 5.—Changes in income elasticities for pork consumption among adults 20–45 years old in China, 1989–93

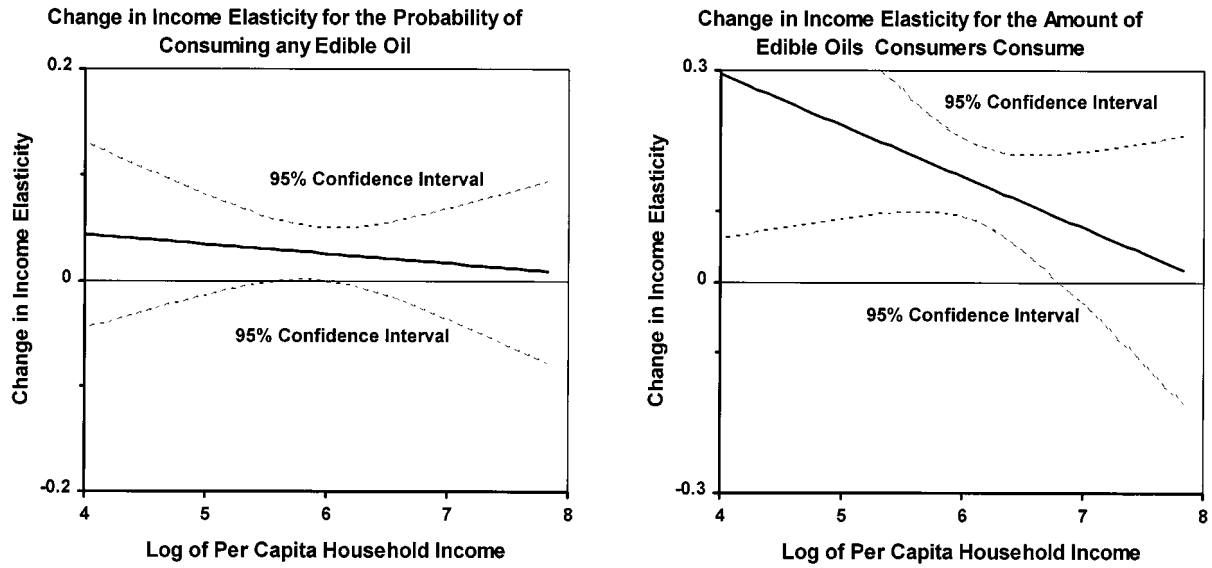

FIG. 6.—Changes in income elasticities for edible oils consumption among adults 20–45 years old in China, 1989–93

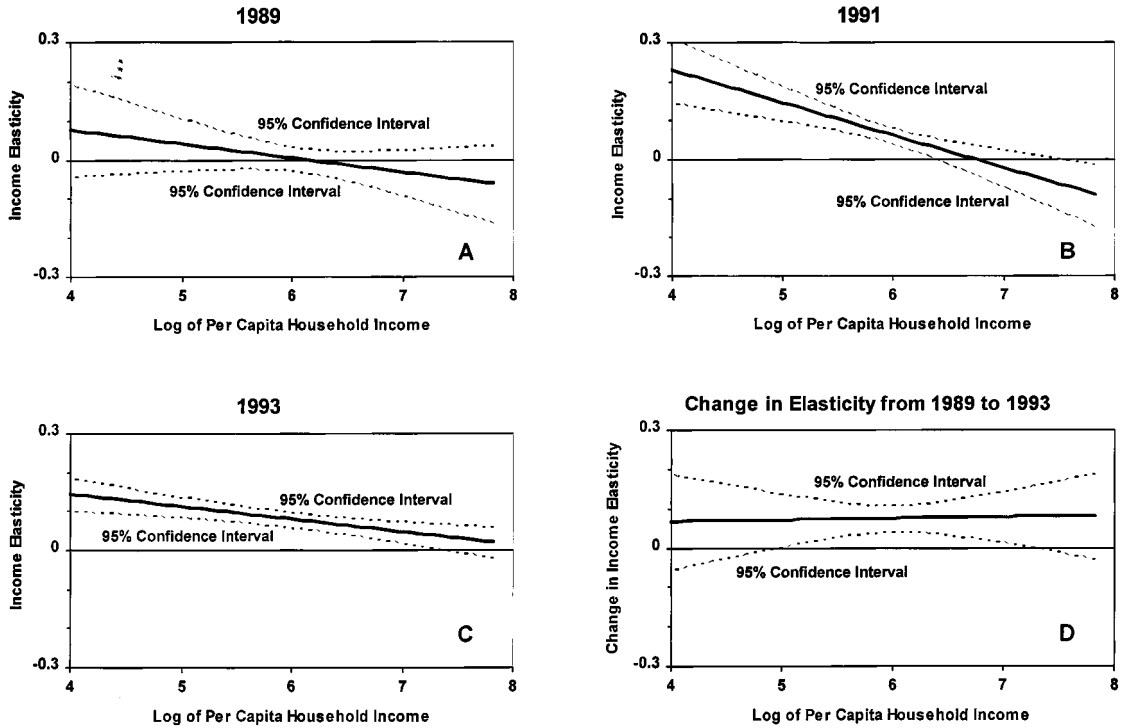

FIG. 7.—Income elasticities for dietary fat intake among adults 20–45 years old in China, 1989–93

high-fiber foods such as wheat-flour products, rice, and coarse grains fell from 1989 to 1993. These foods became much less important in Chinese diets, especially at higher-income levels. During the same time span higher-fat foods became much more responsive to income levels. The income elasticities of pork, edible oils, and eggs showed significant increases. The quantity of fat in the diets increased significantly and appears to have increased much more rapidly with increases in incomes. Overall, 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 and nutritional status patterns. This research on the changing relationship among income, the dietary structure, 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. Concomitantly, from 1989 to 1993 there was a pronounced increase in the income elasticity for calories from fat. This upward shift took place over nearly the entire income range, resulting in a positive income elasticity for fat at all income levels in 1993. The increased income elasticities for total energy and for energy from fat suggest a worsening of the composition of the diet, in ways that are linked to obesity and obesity-related diseases, as incomes continue to rise. This represents one of the negative dimensions of the transition taking place in China.[35]

These results fit closely with the trend toward increased obesity in China. Over the last decade the proportion of adults who are overweight has increased rapidly. For instance, in national surveys of over 80,000 persons between 1982 and 1992 the rate of overweight adults went from 9.7% to 14.9% of the urban adult population.[36] For the country as a whole, the increased number of overweight adults would be about 50 million based on these same national data. It is important to remember that there is a large literature for Europe and the United States that indicates that increased obesity has a significant effect on all-cause and coronary heart disease-related mortality of adults between ages 30 and 65.[37] Presumably these relationships will carry over to developing countries like China.

There are two important issues. First, lower-income people can afford more fat (from edible oils), and this upward shift in fat consumption in part explains the nutrition transition in China. This result clearly fits

the result presented in figure 1 and also regression analyses presented in a previous CHNS study.[38] But the structural shift in the decision making related to edible oils and other fatty foods cannot be easily explained.

Second, it is clear that the nutrition transition in China is not decelerating but is 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 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.[39] In the CHNS sample, for example, from 1989 to 1993 TV ownership nearly doubled, from 43% to 82%, for households in the lowest third of the income distribution and went from 56% to 94% among the middle third of the income distribution. While TV programming inside China is highly controlled, most individuals are now exposed to Western advertising and Western TV shows. Perhaps this marked shift in TV viewing is part of the explanation for the dietary changes. While still speculative, this factor should be explored to help understand the rapid dietary changes.

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, it revised the Chinese dietary guidelines to create the 1997 version. The updated guidelines focus both on the need to eliminate undernutrition and on what is termed ''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 explicitly attempt to increase considerably both the production and consumption of fish, seafood, poultry, and soybeans. The guidelines provide a clear policy basis for developing and implementing food and nutrition policies that help shift the composition of diets, but they also point out many difficulties the Chinese face, since large pockets of undernutrition exist. The difficult work of actually implementing the policy changes in terms of price and related policies still remains to be done. Nevertheless, the government efforts represent a pathbreaking attempt to address problems of undernutrition and overnutrition concurrently.

The size and strength of relationships such as that between income and dietary fat, particularly as they relate to income and price increases over time, are of particular importance for these governmental efforts. The changes in income elasticities that 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. At the same time it is important to realize that these changes in income elasticities could represent a major threat to China's and world food supplies if they foretell a major shift toward an increased demand for grain-intensive livestock and poultry for China.[40]

Significant research needs to be done to understand what is causing this dietary shift and to suggest appropriate 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. 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.

Appendix A

TABLE A1

SUMMARY STATISTICS FOR DEPENDENT VARIABLES

Dependent Variables	*N*	Mean	SD	Definition
logrice	13,465[a]	5.72	.74	Natural logarithm of the grams of rice consumed
logflour	11,031[a]	5.08	1.00	Natural logarithm of the grams of wheat flour consumed
loggrain	3,742[a]	4.70	1.00	Natural logarithm of the grams of coarse grains consumed
logmeat	10,213[a]	4.21	.78	Natural logarithm of the grams of pork consumed
logegg	5,146[a]	3.42	.79	Natural logarithm of the grams of eggs consumed
logoil	12,689	3.27	.72	Natural logarithm of the grams of edible oils consumed
logcal	16,049	7.87	.27	Natural logarithm of daily energy intake
logpro	16,049	4.34	.31	Natural logarithm of daily protein intake
logfat	16,049	4.05	.61	Natural logarithm of daily fat intake
logpcfat	16,049	2.99	.56	Natural logarithm of % of calories from fat
loginc	16,049	5.86	1.26	Natural logarithm of (deflated, 1980 yuan) per capita income, ln [max (1, household per capita income + 1)]

NOTE.—There were 16,049 observations across all 3 years (5,625 in 1989; 5,393 in 1991; 5,031 in 1993).

[a] Only positive for natural logarithm of the grams of food consumed.

Appendix B

TABLE B1

RANDOM EFFECT PROBIT AND LINEAR REGRESSION ESTIMATES OF DEMANDS FOR SELECT FOOD GROUPS AMONG ADULTS 20–45 YEARS OLD IN CHINA, 1989–93

Determinants	Wheat Flour Probit	Pork Probit	Edible Oils Probit	Wheat Flour, if Positive	Pork, if Positive	Edible Oils, if Positive
Age (year)	.00	.04**	.03**	−.02*	.01**	.01**
Male (1, 0)	−.05	−.36**	−.29**	.30**	.07**	−.01
Education (year)	.07*	.36**	.23**	−.12**	.07**	.07**
Household size	.02	.01	.04	.02**	−.03**	.07**
Price of rice (log)	.36**	−.03	.14**	.18**	.01	−.06**
Price of wheat (log)	−.43**	.17**	−.17**	−.19**	.02	−.08**
Price of grains (log)	−.04	.05*	.01	−.05**	.09**	−.04**
Price of pork (log)	.85**	−.57**	1.28**	.08	−.39**	.56**
Price of eggs (log)	−.01	−.11**	−.1	.09**	−.13**	−.13**
Price of oils (log)	.16**	−.15**	−.24**	.34**	−.15**	−.11**
Urban (1, 0)	.52**	.14**	−.09**	.10**	.00	−.09**
North (1, 0)	.22**	−.09*	−.66**	.30**	−.06*	−.35**
South (1, 0)	−.77**	.75**	−.93**	−.85**	.30**	−.07**
Income (log)	−.55**	1.22**	1.34**	−.65**	.60**	.45**
Income^2 (log)	.05*	−.10*	−.11**	−.05	−.04	−.03*
Time89	−.84**	2.63**	2.73**	−.97**	1.08**	2.13**
Time93	−.74**	−.95**	2.53**	−.56**	.93**	.48**
Income (log) × Time89	.07	−.92**	−1.16**	.26**	−.21**	−.75**
Income^2 (log) × Time89	.01	.08	.09*	−.02	.00	.05*
Income (log) × Time93	.32**	−.46**	−.88**	.22**	−.29**	−.17**
Income^2 (log) × Time93	−.03	.05	.07*	−.02**	.02	−.01

* $P < .001$.
** $P < .05$.

Notes

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18. The regression lines in fig. 1 come from regressing the average percentage of total calories from fat, the average percentage of calories from vegetable-based fats, and the average percentage of calories from animal fats on cubic polynomials in real GNP (1992 dollars). In 1962 about 75% of the countries presented in fig. 1 had per capita income of less than $2,500; 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 U.S. dollars.)

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27. Complete descriptive statistics, information on the exclusion restrictions used to identify the impacts of income on food consumptions, regression results, and a full set of graphs detailing the relationships between nutrient consumptions and income are in X. Guo, T. Mroz, B. M. Popkin, and F. Zhai, ''Structural Change in the Impact of Income on Food Consumption in China, 1989–93,'' Working Paper no. 1999-02 (University of North Carolina at Chapel Hill, Department of Economics, 1999). This paper is also available on the world wide web at http://www.unc.edu/depts/econ.

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29. The consumptions are regressed on log household per capita income and its square. The income elasticities are the derivatives of these functions of 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.

30. See Guo, Mroz, Popkin, and Zhai.

31. The confidence bands come from bootstrap standard errors of the elasticities and of the across-time pointwise differences in elasticities. The unit of observation for the bootstrap replications is a household (containing up to 3 years of data for up to several prime-aged individuals).

32. When interpreting these graphs, it is important to be aware of the distribution of household per capita incomes. Grouping positive incomes across all 3 years yields the following percentiles and means:

REAL PER CAPITA INCOME PERCENTILE POINTS

Percentile	Real Income	Log (Income)
5	62	4.1
10	116	4.8
25	237	5.5
50	456	6.1
Mean	566	6.3
75	749	6.6
90	1,092	7.0
95	1,375	7.2

NOTE.—Excluding zero and negative incomes (1980 yuan).

33. Guo, Mroz, Popkin, and Zhai.

34. Ibid.

35. A few key summary statistics for the data used in this study appear slightly different than those reported by the State Statistical Bureau. Table 2 indicates, e.g., a 20 kilograms per year decline in total per capita grain consumption between 1989 and 1993. In contrast, the combined urban and rural sample of the household food expenditures survey of the SSB found only a 5 kilogram per capita decline. This is a difference in the grain consumption decline of approximately 40 grams per capita per day. Most likely such differences in trends reflect variations in sample composition. The CHNS data come mostly from eastern and central provinces, while the SSB data are more nationally representative. In particular, the CHNS sample has 5%–6% more urban residents and, consequently, higher incomes than the country as a whole. Additionally, the eight CHNS provinces have experienced a higher rate of increase in income than the country as a whole. While these data might give a somewhat biased description of country-wide trends in levels of food consumption, they should be able to provide accurate information on the changing relationship between income and dietary intake. The two data sources do, however, indicate the same general trend of the shift in diets away from grain consumption.

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