

Structural changes in the demand for food in Asia: empirical evidence from Taiwan

Jikun Huang^{a,*}, Howarth Bouis^b

^a Center for Chinese Agricultural Policy, CAAS, 30 Baishiqiao Road, Beijing 100081, PR China

^b International Food Policy Research Institute, 2033 K Street, NW, Washinton, DC 20006, USA

Received 10 December 1998; received in revised form 14 May 2000; accepted 1 July 2000

Abstract

Many Asian countries are expected to undergo structural transformations in their economies and rapid urbanization over the next 25 years. The changes in tastes and lifestyles engendered by urban living are likely to have significant influences on food demand. Changes in marketing systems and occupational changes, closely linked with increasing GNP per capita, also may influence the demand for food. In this paper, estimates presented for Taiwan demonstrate that structural changes in food demand (as distinguished from changes due to income and price effects) have been significant factors driving the rapid changes in dietary patterns seen in East Asia over the past three decades. Because most previous demand studies have ignored the possible influence of structural shifts which are highly correlated with increases in per capita income over time, the effects of income on food demand have been overestimated. © 2001 Elsevier Science B.V. All rights reserved.

Keywords: Food demand; Consumption pattern; Asia; Taiwan

1. Introduction

Direct per capita consumption of cereal as food has declined over the past three decades in the rapidly growing economies of Japan, Korea, and Taiwan, while meat, fish, and dairy consumption has increased dramatically. Typically, economists have explained such changes in Asian food consumption patterns primarily as resulting from increases in disposable income and changes in food prices (Ito et al., 1989; Capps et al., 1994).

There is no doubt that household income and food prices strongly influence food consumption patterns. This fact is perhaps as well substantiated empiri-

cally as any relationship in the economics literature. Nevertheless, in projecting food demand patterns over the long run, particularly in Asian economies already undergoing rapid structural transformation and urbanization, changes in tastes and lifestyles also may be important influences on food demand.

Unfortunately, methodologies for measuring the effects of such changes in tastes and lifestyles have not been as well developed as those for measuring income and price effects. Moreover, because these changes in tastes and lifestyles are strongly correlated with increasing gross national product (GNP) per capita, it is difficult to separate the two effects empirically in time-series estimations.

A case in point is consumption of rice in Japan which has declined from 131 to 74 kg per capita between 1962 and 1992 (FAO, 1994). There is no denying the negative correlation between rice

* Corresponding author. Tel.: +86-10-62178580;

fax: +86-10-62178579.

E-mail address: jikhuang@public.bta.net.cn (J. Huang).

consumption and the rapid increase in Japanese disposable income that occurred during this period. The question raised here is whether this correlation also implies causality, so that projected future increases in income are a good indicator of future shifts in demand. That is, as Japanese incomes continue to increase, will Japanese rice consumption continue to decline to 60 kg, and then to 50 kg per capita, and so on before leveling off? At what point will per capita consumption of rice stabilize?

Beside income and price changes, urbanization, market development, changing lifestyle and occupations are often found to contribute to food consumption pattern changes (Bouis, 1991; Huang and David, 1993; Huang and Rozelle, 1998; Sahn and Alderman, 1998). While changes in food demand patterns that cannot be attributed to increases in household incomes and changes in food prices may first be noticed in urban areas as structural transformation proceeds to a more advanced level, these same changes in food demand patterns eventually may occur in rural areas as well. At some point, market availability and lifestyles in urban and rural areas become virtually indistinguishable. Because structural shifts in food demand patterns have been ignored for the most part in previous Asian food demand studies (Bouis, 1991 and Huang and David, 1993, are exceptions), the primary objective of this paper is simply to establish their importance empirically using data from Taiwan.

After providing a mathematical framework for a hypothesized shift in food preference patterns as societies urbanize and agriculture commercializes, household survey data for Taiwan for 2 years, 1981 and 1991 are analyzed. These data permit comparison of food consumption patterns in farm and non-farm households after differences in family income are controlled as well as comparison of food consumption in rural areas, towns, and cities. The empirical results indicate substantial structural shifts in demand in addition to the expected price and income effects. Conclusions are drawn in the final section of the paper.

2. A general framework and model of national food demand based on occupation

There are a number of reasons to think that there may be structural shifts (as distinguished from income

and price effects) in food demand patterns as populations move from rural to urban areas.

1. There may be a wider choice of foods available in urban markets. Some evidence of this for China is provided in Huang and Rozelle (1998).
2. Urban residents are more likely to be exposed to the rich variety of dietary patterns of foreign cultures.
3. Urban lifestyles may place a premium on foods that require less time to prepare, for example, if employment opportunities for women improve and the opportunity cost of their time increases (Sahn and Alderman, 1998).
4. Urban occupations tend to be more sedentary than rural ones. Persons engaged in more sedentary occupations require fewer calories to maintain a given body weight.
5. Urban residents typically do not grow their own food. Thus, their consumption choices are not constrained by the potentially high-cost alternative of selling one food at farmgate prices (say, rice) to buy another food (say, bread) at retail prices (a choice faced by semisubsistence producers).¹

In this section, a framework is developed for understanding the effects on national aggregate demand for food staples brought about by the shifts described in (4) and (5) above. Then the effects of lifestyle changes described in (1), (2), and (3) are incorporated into this framework in the context of demand for nonstaple foods.

2.1. Demand for food staples

As semisubsistence producers move into production of commercial crops and into nonagricultural occupations, decisions governing household-level supply of and demand for food become less closely linked.

¹ Thus, one can expect that semisubsistence rice farmers will eat above-average amounts of rice, and corn farmers will eat above-average amounts of corn, and so on whereas it is impossible to make a priori judgments about the staple food preferences of urban residents relative to national norms. Often there are urban-rural differences in the *retail* prices of foods that also will account for a part of the difference in the levels of consumption of specific foods between urban and rural areas. However, the effects of such price differentials (perhaps due to transportation costs) on food demand already are taken into account in the existing food demand literature, using economic models that do not include structural shifts in demand.

Observed reactions to changes in market prices and income may change substantially because of *how* income is earned, even though underlying preference functions may remain unaltered.

To sketch this mathematically, assume that price and income elasticities of demand are to be estimated using time series data for aggregate national per capita consumption of a particular food staple for a country where semisubsistence production of that food staple is common. For simplicity, assume two production technologies for this staple, a large-scale commercial technology and a small-scale semisubsistence technology.²

All households are classified into one of four types with θ denoting the share of total population, where θ_{subsis} is the small-scale semisubsistence producers of the staple food, θ_{commer} the large-scale commercial producers of the staple food (both small- and large-scale producers of the staple food may produce other agricultural products as well), θ_{othrur} the other households in rural areas that are not engaged in production of the staple food,³ and θ_{urban} the urban residents.

Letting Q denote aggregate national per capita consumption, and q denote per capita consumption of the pertinent occupation group in any particular year

$$Q = \theta_{\text{subsis}} q_{\text{subsis}} + \theta_{\text{commer}} q_{\text{commer}} + \theta_{\text{othrur}} q_{\text{othrur}} + \theta_{\text{urban}} q_{\text{urban}} \quad (1)$$

Certainly, in general, q_{subsis} , q_{commer} , q_{othrur} , and q_{urban} will not be equal, both because income levels will differ among these groups and because rural retail food prices may be lower than urban retail food prices. Standard time-series estimation recognizes such differences. Aggregate national prices and incomes are weighted averages for various population groups. Often an implicit assumption, however, is

that the demand functions across household groups are similar, that is,

$$q_{\text{subsis}} = f_1(y, p, z) \quad (2a)$$

$$q_{\text{commer}} = f_2(y, p, z) \quad (2b)$$

$$q_{\text{othrur}} = f_3(y, p, z) \quad (2c)$$

$$q_{\text{urban}} = f_4(y, p, z) \quad (2d)$$

where y is per capita income, p the retail price of the staple food and z a vector of other relevant variables.

However, household economics theory suggests that *how* income is earned influences the entire vector of group-specific demand parameters (although not necessarily the food preference functions themselves), implying that f_1 , f_2 , f_3 , and f_4 may be quite dissimilar. For example, for specific urban occupations, y might reasonably be treated as exogenous in Eq. (2d) but certainly y is endogenous in Eq. (2a). One implication is that a semisubsistence farm household's consumption of a specific food staple may be dramatically reduced, for example, by a decision to migrate to an urban area, apart from differences in retail prices between urban and rural areas and earning power. At least two reasons could account for such a reduction.

First, semisubsistence producers of a food staple avoid retailing and other marketing costs when they consume out of own production. Apart from greater risks associated with growing nonfood crops such a cost saving may be an important additional incentive for semisubsistence farmers to continue growing staples, and to resist commercialization and specialization. In effect, a decision to migrate to an urban area or even to reduce staple production below household 'requirements' is at the same time a decision to pay a substantially higher price for that staple at the margin, thus, affecting consumption.

Second, assume that two persons with the same demand preferences and levels of income and facing the same prices differ only in the activity levels necessary for earning that income. Energy requirements will be greater for the person engaged in the more active occupation.

Under a reasonable set of assumptions, more active persons will spend more for food than less active persons; more important, diets of those who are more active will be proportionately more staple-based, since staples are relatively inexpensive sources of

² Individual farm sizes and the share of total production marketed by individual farms, of course, will range between these two extremes.

³ Landless agricultural laborers are included in this group, although, to the extent that they receive in-kind wages in the form of the staple food, they may behave like semisubsistence producers. In many countries, members of producer households will also earn income as agricultural laborers. Such categorizations are simplifications and are intended to make a point without loss of generality.

calories (Bouis, 1996). If rural occupations require a greater energy expenditure than urban occupations, one would expect that rural populations would consume more calories and more food staples, controlling for prices and income (some empirical evidence of this is provided in Ravallion, 1990; Bouis, 1991). Again, how income is earned affects demand.⁴

It is possible that controlling income and any observed differences in retail prices across geographical regions

$$q_{\text{subsis}} > q_{\text{commer}} > q_{\text{othrur}} > q_{\text{urban}} \quad (3)$$

That $q_{\text{commer}} > q_{\text{othrur}}$ assumes that the price effect due to the ability to ‘buy’ own production at favorable prices is stronger than the energy expenditure effect. Commercial producers presumably are using mechanized technologies or hiring in labor. Their activity levels may not be substantially different from those of urban residents. Such an assumption is not crucial to the arguments being made. Over time as aggregate per capita income increases in developing countries and as their economies undergo structural transformation, θ_{subsis} and θ_{othrur} will decline (they are negatively correlated with income) and q_{commer} and θ_{urban} will increase (they are positively correlated with income). At some later stage of development, especially as rural population densities decline, θ_{commer} may also decline. One would expect then to observe a negative correlation between Q and Y over time as structural transformation takes place. This correlation is independent of the influence of income per se on demand, and it measures the effect of changes in the way that income is earned. This in turn leads to an upwardly biased (in absolute value) estimate of the income elasticity.⁵ Although, for some time, this biased estimate may provide accurate predictions of aggregate demand as structural transformation proceeds, at some point

⁴ Other plausible but empirically less tractable reasons can be given for arguing that producers of a food will eat more of that food. Aside from the intrinsic satisfaction of eating what they have grown themselves, farmers know the quality of their own produce and are familiar with ways to prepare it. Even though alternative foods may become available, habits change slowly.

⁵ Aggregate domestic production may increase or decrease depending on the profitability of commercial production of the staple relative to other commercial crops. Related to this, staple food prices could increase, decrease, or remain constant depending on government trade and buffer stock policies.

this transformation process runs its course, and food consumption patterns will diverge from those predicted using time-series income elasticity estimates.

2.2. Demand for nonstaple foods

The result just discussed for Eq. (3) provides a plausible explanation for declining rice consumption throughout Asia, in addition to possible income and price influences. Incorporating effects (1), (2), and (3), outlined in the introduction simply reinforces this result, implying increased consumption of wheat, meat, fish, and fruits.

Typically, baked wheat products are more readily available in urban markets than in rural areas. They provide some variety in staple food consumption and are less labor-intensive to prepare for meals.

In addition, a greater variety of meat, fish, dairy products, and fruits will be available in urban markets than in rural areas, encouraging habitual consumption of these foods. Adults who have recently migrated from rural to urban areas may resist significant changes in accustomed dietary patterns but their children may be less resistant. Because adult energy requirements may be lower in urban areas (due to less strenuous occupations), hunger in urban areas may be more easily satiated (for a given total expenditure on food). Therefore, a higher percentage of calories may be derived from higher-cost nonstaple foods.

This section has provided several arguments for expecting structural shifts in food demand patterns in Asia. The next section will attempt to measure their importance empirically, using a data set from Taiwan.

3. Taiwan household expenditure surveys

3.1. An overview of changing food consumption patterns in Taiwan

Average diets may change rapidly in countries experiencing rapid economic growth and structural transformation. In the 30 years between 1959–1961 and 1989–1991, per capita rice consumption in Taiwan declined by one-half (Table 1). Consumption of meat (including pork, chicken, and beef) quadrupled. Fruit consumption increased five times and fish consumption doubled. Thus, substitution of calories obtained

Table 1
Per capita annual food consumption, Taiwan, 1940–1992^a

Period	Rice (kilograms/ capita/year)	Wheat (kilograms/ capita/year)	Sweet potato (kilograms/capita/year)	Meat (kilograms/ capita/year)	Fish (kilograms/ capita/year)	Fruit (kilograms/ capita/year)
1949–1951	133	7	66	13	12	16
1959–1961	137	22	62	16	23	20
1969–1971	136	25	24	25	33	43
1979–1981	105	24	4	40	38	72
1989–1991	68	29	2	62	45	108

^a Source: Taiwan Council for Agricultural Planning and Development, various years.

Table 2
Indexes of real income, expenditure, and real food price levels for food groups, 1971, 1981, and 1991^a

Year	Per capita		Real food price				
	Income	Expenditure	Rice	Wheat	Meat	Fish	Fruit
1971	41	58	n.a. ^b	n.a.	n.a.	n.a.	n.a.
1981	100	100	100	100	100	100	100
1991	213	192	99	79	77	149	134

^a Sources: Taiwan Department of Agriculture and Forestry, 1981, 1991; Taiwan Department of Budget Accounting and Statistics, 1991, various years.

^b n.a.: means not available.

from nonstaple food sources for staple food sources has been substantial.

Table 2 shows indexes of real per capita income and food price levels for these food groups for 1971, 1981, and 1991 (1981 = 100), using the consumer price index as a deflator. Incomes have increased substantially; prices of wheat and meat have fallen by one-fifth while fish and fruit prices have risen by one-third to one-half. To what extent do increases in income and declining food prices explain the dramatic transformation of Taiwanese diets shown in Table 1 as compared with changing tastes and lifestyles? Conventional wisdom, of course, holds that rising incomes and declining food prices explain most of the change.

An ideal data set for measuring structural shifts in food demand patterns would record foods consumed, prices, income by source, and standard demographic information for a large number of families before and after these families migrated from rural to urban areas. Such a longitudinal data set would record this information across two or more generations. To the best of the authors' knowledge such complete data are unavailable.

A next best alternative (not involving observations for the same households over time) would be two national cross-sectional household surveys taken several years apart. Cross-sectional survey data are available for Taiwan for 1981 and 1991, consisting of 11,886 observations in 1981 and 12,734 observations in 1991. These surveys contain household-level information on (1) age and gender of family members, (2) total expenditures on specific food and nonfood items, (3) income earned and occupations of various household members, and (4) geographic location among other variables.

A major shortcoming of the data set for this analysis was absence of data on food quantities or prices. Prices for specific food items were obtained from published sources (Taiwan Department of Agriculture and Forestry, 1981, 1991), which provided county- and region-specific variation in prices. As outlined later in the paper, the dependent variables in the regression estimations are budget shares for various foods so that food quantity data are not required for these estimations. Prices for rice, wheat flour, chicken, eggs, and fruit are available at the county level. Prices for other foods are available at the regional level for Taipei, Taichung, Tainan, and Kaohsiung. Weighted

average prices for major meat products (pork, beef, mutton, and chicken), six major fish products (sea bream, marlin and sailfish, tuna, cuttlefish, striped prawn, and shrimps), and three major fruits (banana, pineapple, and citrus) were used as the prices of meat, fish, and fruit, respectively, in the regression analysis. County and provincial-level food budget shares for these disaggregate and individual foods for 1981 were used as weights in computing both the 1981 and 1991 prices for the aggregate food groups.⁶ Tables 3 and 4 give per capita food consumption levels for 1981 and 1991, respectively, disaggregated by villages, towns, and cities (that is, moving from the least to the most urbanized settings) and income quintile. In constructing these tables, all households were placed in one of five income quintiles based on real income with 1981 used as the base.

In comparing food consumption between villages, towns, and cities within identical income groups (say income quintile 3) for a specific year, note that rice consumption is lower in more urbanized areas and occupations while wheat, meat, fish, and fruit consumption is somewhat higher. These differences presumably are due to structural differences in tastes and lifestyles between geographic locations and occupations.⁷

When food consumption is compared across income quintiles for a given year and geographic location or occupation, income elasticities appear to be high for all foods except rice (although still positive for rice). Note that rice consumption declines substantially between 1981 and 1991 for income quintile 3, even though the rice price changed little. This suggests a considerable structural shift in demand.

Meat prices declined between 1981 and 1991 while fish and fruit prices increased. Thus, the increased meat consumption for income quintile 3 and declining fish and fruit consumption are to be expected. Price

⁶ Household-level food quantity data are required for construction of Tables 3, 4, 6 and 7. These were obtained by dividing average household expenditures for a specific food (from the household surveys) by national per capita availability (from published food balance sheets) to obtain an average national-level price for each food. The household-level expenditure data for individual foods were divided by national prices to obtain a household-level estimate of quantity consumed.

⁷ Urban-rural *retail* price differentials may explain some of the difference in consumption levels between urban and rural areas. However, rural consumption is lower for several foods for which the rural price can be expected to be lower than the urban price.

Table 3
Annual per capita food consumption^a, by region and expenditure group, Taiwan, 1981^b

Region/ income ^c	Rice (kgs/ capita/year)	Wheat (kgs/ capita/year)	Meat (kgs/ capita/year)	Fish (kgs/ capita/year)	Fruit (kgs/ capita/year)
City	86.9	28.6	46.8	42.9	105.5
1	83.3	16.9	29.2	25.9	55.2
2	86.5	24.3	41.6	37.8	89.0
3	87.7	31.7	51.1	46.4	115.2
4	88.9	37.4	59.0	55.1	144.9
5	90.6	47.4	71.5	68.4	182.4
Town	100.6	21.9	39.6	34.0	75.9
1	96.9	15.5	28.8	23.0	46.7
2	101.5	21.9	40.0	34.2	76.1
3	103.6	28.2	48.0	43.7	97.4
4	104.0	32.6	57.6	50.3	127.0
5	105.9	34.0	65.3	61.9	162.6
Village	114.4	17.9	32.0	28.3	52.7
1	107.3	12.8	26.2	23.3	36.3
2	121.9	21.1	35.5	31.5	63.0
3	126.0	32.9	43.9	40.9	92.2
4	132.8	34.0	57.6	47.7	112.7
5	142.8	42.1	78.1	50.1	162.2
Average	99.4	23.4	40.1	35.8	80.5
1	100.0	14.3	27.4	23.7	42.6
2	100.5	22.7	39.4	35.0	78.2
3	97.5	30.9	49.2	44.9	107.1
4	97.7	35.9	58.6	53.1	137.0
5	97.7	44.5	70.9	65.7	177.1

^a To compute food consumption levels of various groups, an implicit aggregate price for each commodity is estimated, based on food expenditure and food balance data. This price is used to deflate the food expenditure to derive food consumption by income group and region.

^b Source: Taiwan Household Expenditure Surveys 1981.

^c The ranges of per capita expenditure in Taiwanese dollars (NT \$ in real 1981 prices) for five groups of households are: (1): <30,000; (2): 30,000–45,000; (3): 45,000–60,000; (4): 60,000–90,000; and (5): >90,000.

effects and the hypothesized positive structural shifts when income is controlled reinforce one another for meat. Price effects outweigh the hypothesized positive structural shifts for fish and fruit. Having provided an intuitive overview of possible structural influences that have caused food consumption patterns to change in Taiwan between 1981 and 1991, these influences are measured econometrically in the following section.

3.2. Model specification

An almost ideal demand system (AIDS) is used as the basic modeling framework (Deaton and Muellbauer, 1980). The effects of nonincome and nonprice factors (structural shifts, Z) on food consumption can be introduced into the AIDS equations by allowing

a subset of parameters to depend on these structural variables as

$$w_i = a_i + \sum a_{is}z_s + \left(b_i + \sum_s b_{is}z_s \right) \log \left(\frac{X}{P} \right) + \sum r_{ij} \log p_j \tag{4}$$

for $i, j = 1, \dots, n$, where w_i is the budget share of the i th commodity, $Z = (z_1, \dots, z_m)$, X is total consumption expenditure, p is commodity price, P is a price index defined by

$$\log P = a_0 + \sum_k \left(a_k + \sum a_{ks}z_s \right) \log p_k + \frac{1}{2} \sum_k \sum_j r_{kj} \log p_k \log p_j \tag{5}$$

Table 4
Annual per capita food consumption^a, by region and expenditure group, Taiwan, 1991^b

Region/ income ^c	Rice (kgs/ capita/year)	Wheat (kgs/ capita/year)	Meat (kgs/ capita/year)	Fish (kgs/ capita/year)	Fruit (kgs/ capita/year)
City	61.1	35.4	70.0	45.5	122.3
1	57.4	9.8	33.6	21.1	36.5
2	64.3	18.9	48.4	29.3	61.8
3	61.6	23.8	59.0	37.1	87.3
4	61.7	31.7	68.8	44.6	112.2
5	59.8	46.4	79.2	52.3	156.5
Town	68.3	27.7	60.3	37.5	98.3
1	64.3	10.7	39.2	22.3	38.0
2	69.3	16.4	49.4	29.2	66.5
3	69.1	21.8	55.4	34.2	81.4
4	68.3	28.7	63.1	39.2	102.8
5	66.9	41.8	70.2	45.0	136.2
Village	79.0	18.4	56.2	35.6	92.5
1	69.0	9.1	39.1	22.6	46.0
2	73.0	13.4	47.5	29.2	64.5
3	78.1	16.6	55.6	35.0	83.9
4	83.4	21.2	63.1	40.0	109.5
5	88.8	31.7	68.0	46.4	156.9
Average	67.6	28.9	63.5	40.4	107.2
1	66.3	9.7	38.7	22.4	42.4
2	70.0	15.5	48.4	29.2	64.8
3	69.4	21.0	56.5	35.3	83.9
4	67.7	28.9	65.7	41.8	108.3
5	64.6	43.6	75.5	49.6	150.5

^a To compute food consumption levels of various groups, an implicit aggregate price for each commodity is estimated, based on food expenditure and food balance data. This price is used to deflate the food expenditure to derive food consumption by income group and region.

^b Source: Taiwan Household Expenditure Surveys 1981.

^c The ranges of per capita expenditure in Taiwanese dollars (NT \$ in real 1981 prices) for five groups of households are: (1): <30,000; (2): 30,000–45,000; (3): 45,000–60,000; (4): 60,000–90,000; and (5): >90,000.

and a_0 , a_i , a_{is} , b_i , b_{is} and r_{ij} are parameters to be estimated. To specify a stochastic structure for Eqs. (4) and (5), using h to index household-level information, the error term, ε_{ih} , may be added to Eq. (4).

The demand model presented above is a nonlinear system. Assuming that ε_{ih} follows a multivariate normal distribution, this nonlinear system of equations can be estimated by the full information, maximum likelihood method (FIML) (Amemiya, 1997) with the imposition of the homogeneity and symmetry restrictions. The commodities included in the system are rice, wheat, meat, fish, fruit, other foods, and all nonfoods, which are aggregated.

In applying the model to the data for Taiwan, Z is a vector with nine elements: four dummies (town, city, occupation, and $d_{91} \times$ village, the last representing 'urbanization' and other structural changes over the

period 1981–1991 *within* rural areas; $d_{91} = 1$ for 1991 survey data and $d_{91} = 0$ for 1981 survey data), and five demographic variables (family size and age composition). Since the dependent variables are in budget shares and the error-covariance matrix is singular, one of the shares is dropped during estimation.

The expenditure (e_{iy}), uncompensated price (e_{ij}), and compensated price (ce_{ij}) elasticities are derived as follows:

$$e_{iy} = 1 + \frac{(b_i + \sum_s b_{is} z_s)}{w_i} \quad (6)$$

$$e_{ij} = -\delta_{ij} + \frac{r_{ij}}{w_i} - \left(b_i + \sum_s b_{is} z_s \right) \times \frac{[a_i + \sum_s a_{is} z_s + \sum_k r_{kj} \log p_k]}{w_i} \quad (7)$$

$$ce_{ij} = e_{ij} + w_j e_{iy} \tag{8}$$

where δ_{ij} is the Kronecker delta.

In Eqs. (6)–(8), to the extent that coefficients associated with the z_i variables are statistically significant, expenditure and price elasticities of demand vary as the level of urbanization, occupation, family structure, and the other factors change.

Mathematically, the impact of each structural factor z_i on the commodity demand can be derived as follows. First, differentiate Eq. (4) with respect to the m th z_i , holding all other variables constant, which gives

$$\begin{aligned} dw_i = & a_{im} dz_m - \left(b_i + \sum_{s \neq m} b_{is} z_s \right) \left[\sum_j a_{js} \log p_j \right] dz_m \\ & - \left[b_{im} \sum_j a_{js} \log p_j \right] dz_m \\ & + b_{im} \left[\log X - a_0 - \sum_j \left(a_j + \sum_{s \neq m} a_{js} z_s \right) \right. \\ & \left. \times \log p_j - \sum_i \sum_j r_{ij} \log p_j \log p_j \right] dz_m. \end{aligned} \tag{9}$$

Because Eq. (9) controls for the income and price changes, dividing Eq. (9) by w_i implies the percentage change of i th commodity consumption (q_i) due to the different level of z_m . That is,

$$\frac{dw_i}{w_i} = \frac{dq_i}{q_i} = \frac{\left\{ a_{im} dz_m - \left(b_i + \sum_{s \neq m} b_{is} z_s \right) \left[\sum_j a_{js} \log p_j \right] dz_m - \left[b_{im} \sum_j a_{js} \log p_j \right] dz_m + b_{im} \left[\log X - a_0 - \sum_j \left(a_j + \sum_{s \neq m} a_{js} z_s \right) \log p_j - \sum_i \sum_j r_{ij} \log p_j \log p_j \right] dz_m \right\}}{w_i} \tag{10}$$

3.3. Econometric estimations

Nonlinear full information, maximum likelihood measure is used to estimate the Eq. (4) with the imposition of the homogeneity and symmetry restrictions using Taiwan’s household expenditure survey in 1981 and 1991 (with a total of 24,233 sample size). Many of the coefficients have relatively high t -ratios; the signs and magnitudes of most coefficients are as expected. In particular, almost all of the coefficients on variables representing structural shifts are significantly different from zero for each food. Expenditure and own-price

Table 5

Budget shares and expenditure elasticities evaluated at the sample mean, Taiwan, 1981–1991^a

Commodity	Mean	Village	Town	City
Sample mean of budget share				
Rice	4.2	6.4	4.0	3.0
Wheat	1.1	1.0	1.2	1.2
Meat	6.6	7.3	6.5	6.3
Fish	5.6	6.1	5.4	5.5
Fruit	3.8	3.5	3.8	3.9
Other food	14.0	15.1	14.2	1.3
Nonfoods	64.6	60.6	65.0	66.9
Expenditure elasticities				
Rice	0.173	0.285	0.065	0.129
Wheat	0.768	0.895	0.739	0.721
Meat	0.569	0.591	0.547	0.571
Fish	0.605	0.578	0.633	0.603
Fruit	0.807	0.919	0.794	0.752
Other food	0.795	0.828	0.775	0.788
Nonfoods	1.192	1.217	1.199	1.173
Uncompensated own price elasticity				
Rice	-0.609	-0.804	-0.614	-0.390
Wheat	-1.514	-1.578	-1.503	-1.489
Meat	-0.243	-0.317	-0.230	-0.200
Fish	-1.638	-1.599	-1.656	-1.652
Fruit	-1.412	-1.438	-1.415	-1.397
Other food	-1.259	-1.237	-1.259	-1.276
Nonfoods	-1.641	-1.701	-1.651	-1.598

^a Source: Taiwan Household Expenditure Surveys 1981, 1991.

elasticities calculated from the estimated coefficients are presented in Table 5. The net effects of structural change variables, income, and price on observed differences in consumption between geographic locations and observed changes in consumption over time are discussed later in this section.

3.3.1. Income and price elasticities

The expenditure elasticities themselves, for any given food group do not vary greatly between villages, towns, and cities. The greatest variation across geographic location occurs for rice. As expected, all

Table 6
Structural, income, and price factors contributing to differences in per capita food consumption between cities and villages, Taiwan, 1981

Commodity	Observed change	Specific structural factors								Sum of structural factors	Income, price, and other factors	Income factors	Price and other factors
		Urbanization	Occupation	Family size	Age structure								
					Total	1–7 years	18–40 years	41–50 years	Over 50 years				
Percentage change (%)													
Rice	–24.0	–22.8	–6.6	–0.4	–2.5	–1.6	–0.3	–0.3	–0.3	–32.3	8.3	7.7	0.6
Wheat	59.8	19.0	6.5	1.7	0.7	–0.6	–1.6	1.6	1.3	27.9	31.9	43.2	–11.4
Meat	46.2	4.5	1.5	0.6	–1.2	–1.0	–0.7	0.3	0.3	5.4	40.9	34.2	6.6
Fish	51.6	9.9	2.9	1.0	–1.1	–0.9	–0.8	0.5	0.2	12.7	38.9	36.2	2.7
Fruit	100.2	37.6	8.9	1.6	0.1	–0.6	–0.8	0.6	0.8	48.2	52.0	45.1	6.9
Absolute change (kg)													
Rice	–27.4	–26.0	–7.5	–0.5	–2.9	–1.8	–0.3	–0.4	–0.3	–36.8	9.4	8.8	0.6
Wheat	10.7	3.4	1.2	0.3	0.1	–0.1	–0.3	0.3	0.2	5.0	5.7	7.7	–2.1
Meat	14.8	1.5	0.5	0.2	–0.4	–0.3	–0.2	0.1	0.1	1.8	13.0	11.0	2.0
Fish	14.6	2.8	0.8	0.3	–0.3	–0.3	–0.2	0.1	0.1	3.6	11.0	10.2	0.8
Fruit	52.8	19.8	4.7	0.9	0.0	–0.3	–0.4	0.3	0.4	25.4	27.4	23.8	3.6

Table 7
Structural, income, and price factors contributing to changes in per capita food consumption in villages in Taiwan, between 1981 and 1991

Commodity	Observed change	Specific structural factors								Sum of structural factors	Income, price, and other factors	Income factors	
		Urbanization	Occupation	Family size	Age structure								
					Total	1–7 years	18–40 years	41–50 years	Over 50 years				
Percentage change (%)													
Rice	–30.9	–23.3	–1.8	–1.0	3.5	1.8	0.3	0.3	1.0	–22.6	–8.3	27.5	–35.8
Wheat	2.8	–23.8	1.8	3.7	–3.1	0.7	1.9	–1.6	–4.0	–21.4	24.2	86.3	–62.1
Meat	75.6	10.7	0.4	1.3	0.9	1.2	0.9	–0.3	–0.9	13.3	62.3	57.0	5.3
Fish	25.8	16.9	0.8	2.4	1.0	1.1	1.0	–0.5	–0.5	21.1	4.7	55.8	–51.1
Fruit	75.5	45.4	2.5	3.6	–1.6	0.6	0.9	–0.6	–2.6	49.9	25.6	88.6	–63.0
Absolute change (kg)													
Rice	–35.3	–26.6	–2.1	–1.2	4.0	2.1	0.4	0.4	1.1	–25.9	–9.4	31.4	–40.8
Wheat	0.5	–4.3	0.3	0.7	–0.6	0.1	0.3	–0.3	–0.7	–3.9	4.4	15.5	–11.1
Meat	24.2	3.4	0.1	0.4	0.3	0.4	0.3	–0.1	–0.3	4.2	20.0	18.2	1.8
Fish	7.3	4.8	0.2	0.7	0.3	0.3	0.3	–0.1	–0.2	6.0	1.3	15.8	–14.5
Fruit	39.8	23.9	1.3	1.9	–0.9	0.4	0.5	–0.3	–1.4	26.2	13.6	46.7	–33.1

expenditure elasticities are positive even for rice for which per capita consumption declined significantly between 1981 and 1991. With the exception of rice, all expenditure elasticities fall in a range between 0.5 and 1.0. The elasticities for meat and fish, in particular are lower than those estimated by Capps et al. (1994), using time-series data that did not take structural shifts in demand into account.

With the exception of rice and meat, own-price elasticities are above 1.0 (in absolute value). In that expenditure elasticities are relatively low, this suggests generally strong cross-price substitution effects except for meat. Real chicken prices fell substantially between 1981 and 1991 more than pork and beef prices fell, and chicken consumption increased more than consumption of pork and beef. The estimated low price response for meat in the aggregate may, to some extent, reflect shortcomings in not having household-level price data and having to use country- and provincial-level prices instead (see footnote 6). It may also be that the now wealthy consumers of Taiwan have a relatively strong desire to eat meat. They may be willing to substitute various types of meat within this aggregate group in response to changing prices.

3.3.2. *Magnitudes of structural shifts in demand*

While measured structural shifts in demand are significantly different from zero in a statistical sense, such shifts may or may not be important from a policy perspective. As seen in Table 1, the diets of Taiwanese consumers changed substantially between 1981 and 1991. How much of this change was due to price and income effects and how much was due to structural factors? Tables 6 and 7 provide information on the magnitude of shifts in demand due to various structural factors calculated from the estimated regression coefficients.

Table 6 provides a disaggregation between villages and cities of several factors determining observed differences in consumption of food in 1981: (1) urbanization, (2) occupation, (3) family size and age structure, (4) income, and (5) prices. For rice, wheat, and fruit consumption, structural factors account for a higher percentage of the differences in consumption between geographic areas than income and price influences. For meat and fish consumption, income and price factors affect differences in consumption more than structural influences.

A disaggregation of villages in 1981 and 1991 is presented in Table 7. Structural factors strongly influence consumption of rice, wheat, and fruit, and price and income effects strongly influence meat consumption. Income and price effects are individually strong for most foods but influence demand in opposite directions so that their joint influence tends to be much smaller.

4. Conclusions

Analysis of the household-level data for Taiwan for 1981 and 1991 which allows disaggregation by urban and rural areas and by occupation for a time period during which there was rapid economic development and dramatic changes in the composition of diets in Taiwan provides strong empirical support for the hypothesis that demand for food is substantially influenced not only by growth in family income and price changes as might be expected but also by differences in urban and rural lifestyles, the development of more advanced marketing systems, and occupational changes that are closely linked with increasing GNP per capita. These estimates support an hypothesis that structural changes in food demand might have been quite significant factors driving the rapid changes in dietary patterns seen in other countries in East Asia over the past three decades.

Because urbanization is expected to proceed rapidly in a number of developing countries over the next several decades, projections of future global food supply and demand balances need to take such structural changes into account. Because most previous studies have tried to explain these dramatic changes in diets primarily in terms of rising incomes and changing food prices, relatively little is known about the specific reasons causing these structural shifts. Thus, it is difficult to form judgments as to the points at which in the process of economywide structural adjustment, these structural changes in food demand will begin, accelerate, then slow down, and perhaps stop.

How this lack of information will affect policy is perhaps most easily understood for rice. Almost all cross-sectional evidence on demand for rice indicates that the income elasticity is either close to zero or positive as it substitutes for less-preferred food staples with rising incomes. Yet per capita consumption

of rice has declined dramatically over time in a few countries including Japan and Taiwan. These two empirical observations could be reconciled if rice prices had risen dramatically compared with substitute foods but that has not occurred. Therefore, significant downward structural shifts in demand likely explain a substantial portion of the observed decline.

Assuming continued sustained economic growth at what level of income or structural transformation or both will per capita rice consumption begin to decline in China, India, and Indonesia (to name three countries with large populations that account for a high proportion of world rice consumption)? Once the decline begins, will rice consumption eventually fall by as much as 50%, as has happened in Japan and Taiwan, or perhaps more? Might such a decline not occur? It is interesting to note that rice consumption in Korea did not fall much between 1973 and 1992, declining from 140 to 126 kg per capita (FAO, 1994).

Two very different future scenarios are possible for demand for rice in Asia to the year 2020, one in which per capita consumption of rice declines dramatically and another in which per capita consumption falls marginally. Existing estimates of income elasticities for rice provide little insight into which scenario might occur.

An analogous dilemma presents itself in projecting demand for meat, fish, and dairy products. It would seem clear that income elasticities for these products are substantially above zero. However, existing income elasticity estimates from time-series data may be upwardly biased for countries such as Japan and Taiwan, measuring both the positive effect of income on demand for these products and structural shifts in demand, structural shifts that are positively correlated with increases in per capita gross domestic product.

Again, the crucial question for demand projections in these economically more advanced countries is at what point these structural shifts will slow down and perhaps stop, at which point the upwardly biased estimates of income elasticities for meat, fish, and dairy products will begin to overstate future demand. Interestingly, in countries such as India and Indonesia where meat consumption is presently quite low because structural transformation is in an early stage, time-series data for meat consumption will not reflect a possible impending structural shift in demand. Thus,

existing income elasticities will give underestimates of demand for meat if these structural changes in food demand do indeed materialize.

Acknowledgements

The authors gratefully acknowledge the help of Wen Chern and Hwang–Jaw Lee in making the Taiwan data available to us. We thank Julian Alston, Scott Rozelle and one anonymous referee for helpful comments. We also thank International Food Policy Research Institute and National Natural Science Foundation of China (79725001) for funding the study.

References

- Amemiya, T., 1997. The maximum likelihood estimator and the nonlinear three-stage least squares estimation in the general nonlinear simultaneous equation model. *Econometrica* 45, 955–968.
- Bouis, H.E., 1991. Rice in Asia: is it becoming a commercial good?: comment. *Am. J. Agric. Econ.* 73, 522–527.
- Bouis, H.E., 1996. A food demand system based on demand for characteristics: if there is curvature in the Slutsky matrix, what do the curves look like and why? *J. Dev. Econ.* 51, 239–266.
- Capps, O., Tsai, R., Kirby, R., Williams, G., 1994. A comparison of demands for meat products in the Pacific Rim region. *J. Agric. Res. Econ.* 19, 210–224.
- Deaton, A.S., Muellbauer, J., 1980. An almost ideal demand system. *Am. Econ. Rev.* 70, 312–326.
- FAO (Food and Agriculture Organization of the United Nations), FAO Agrost-PC, Food Balance Sheets and Population Domains, Version 3.0, 1994, Rome Computer disk.
- Huang, J., David, C., 1993. Demand for cereal grains in Asia: the effect of urbanization. *Agric. Econ.* 8, 107–124.
- Huang, J., Rozelle, S., 1998. Market development and food demand in rural China. *China Econ. Rev.* 9, 25–45.
- Ito, S., Peterson, E.W.F., Grant, W.R., 1989. Rice in Asia: is it becoming an inferior good? *Am. J. Agric. Econ.* 71, 32–42.
- Ravallion, M., 1990. Income effects on under nutrition. *Econ. Dev. Cultural Change* 38, 489–515.
- Sahn, D., Alderman, H., 1998. The effects of human capital on wages, and the determinants of labor supply in a developing country. *J. Dev. Econ.* 29, 157–183.
- Taiwan, Council for Agricultural Planning and Development. Food Balance Sheets, various years.
- Taiwan, Department of Agriculture and Forestry, Monthly Agricultural Prices and Costs, 1981.
- Taiwan, Department of Budget, Accounting and Statistics, Monthly Agricultural Prices and Costs, 1991.
- Taiwan, Department of Budget, Accounting and Statistics, Household Income and Expenditure Survey, various years.