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An analysis of structure change of food demand in China

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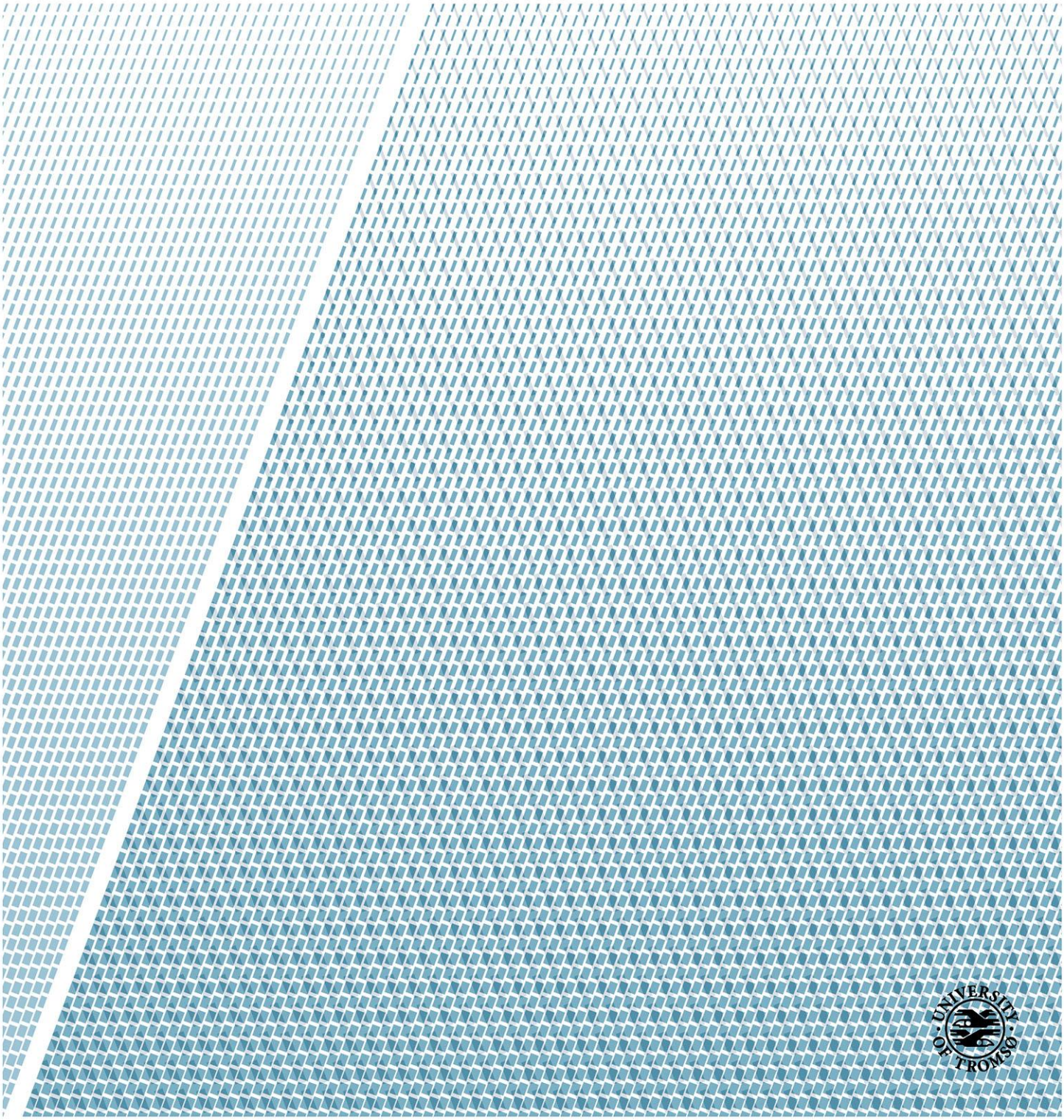

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Abstract

The estimation of consumer demand is playing an important role in applied econometrics. Chinese food demand has fundamentally changed as the result of growing income and urbanization ever since the economic reform in 1978. Although food demand of the western countries has been widely studied in the literature, the study of demand in the developing countries like China has been much ignored. In this study, we aim at analyzing structure changes of food demands in China. We intend to estimate Chinese household consumer demand for five food categories at a regional level by applying the Rotterdam model, Almost Ideal Demand System (AIDS), and the CBS model and we use a 17-year period household survey dataset. Price elasticities and expenditure elasticities are estimated for all five main food categories in five regions in China. The trend effects on food consumptions are also modeled and presented. Apart from the temporal food consumption structure changes, which are mostly studied in empirical researches, we have also researched on spatial structure changes, which is rather new in this field.

Our estimate results have provided evidences for structural change in Chinese food consumption patterns. Household food consumption pattern is shifting from 'mainly grain together with little fiber and protein' in less developed regions to 'less grain together with much fiber and protein' in more developed regions. Our results are supported by most of the empirical researches. However due to data limitations currently, we would expect there still exist improvements in our future study. And more precise results will be obtained if food categories are divided into more specific food types.

Key words: Chinese food demand, demand system, AIDS model, Rotterdam model, CBS model

Contents

1 Introduction

1.1 Research Background

The consumer demand estimation has been considered as one of the most important economics topics for a substantial period of time; meanwhile it is also playing an important role in applied econometrics. The consumer demand theory makes its own development with the help of econometric approaches. In this study, we are aiming at analyzing structure changes of food demands in China. We intend to estimate Chinese household demand for various categories of food by applying appropriate econometric models, which are the Rotterdam model, Almost Ideal Demand System (AIDS), and the CBS model.

Ever since the economic reform, China's economy has maintained a rapid growth rate at 7-8% annually. As the result of growing income and urbanization, Chinese food demand has increased tremendously. With increased income, people tend to consume less cereals and starches but more rich protein foods. According to food production figures from FAO (Food & Agriculture Organization of the United Nations), as a prototype of a populous developing country, China has undergone especially dramatic changes in food consumptions during the last two decades. For example the consumption of vegetable oils has increased 680%, meat 349% and sugar 305% (Kearney, 2010). These significant changes in Chinese food demand make us wonder if there exist structural changes in food demand.

One of the most important factors that cause structure changes of food demand is changes in food policies. Chinese market, especially food market has experienced two different policies after the economic reform. During the first period – late 1970s to early 1980s –markets were unevenly developed because of the rules and regulations in the pre-reform period that limited the exchange of goods and services in the rural economy (Walker, 1984). Until the early 1990s, most of the interregional movement of grain, oil, sugar, cotton, tobacco, and a number of other specialized agricultural products were still controlled by national plans (Sicular,

1991). However, even after some of the prohibitive regulations had been abolished, markets that were highly related to rural food consumption were still incomplete (Sicular, 1988). This is because of the remoteness of the rural areas and residents there were still primarily self-sufficient. Huang and Rozelle (1998) reported that typically even the richest households in a rural area adjacent to a coastal city could only get fresh meat when the local market was open periodically every 10 days. High transaction costs, lack of infrastructure, and underdeveloped institutions were the factors that limited the scope for market transactions.

From mid-1990s until now, it has become the prosperous period of economic growth in China. During this period of time, the development of food market has gradually become even in the rural and urban areas. Urbanization has lowered the cost of market transactions and lots of infrastructures begin to appear in both urban and rural areas. At the same time, Chinese food market has changed significantly from a centrally-planned economy to a market-based, consumer-oriented economy. Market liberalization has shown significant influences on flexibility of food market, household income level, and rural-urban income disparity (Liu, 2003).

In addition to policy changes, structure changes of food demand in China are also caused by changes in consumer preferences, education levels, and market supply. Since China is a big nation, various food consumption patterns can be clearly noticed in different regions. It is therefore useful to investigate food demand structure in different regions. According to the geographical standard, China can be divided into the north part and the south part, concerning the location of the Yellow River. In most parts of northern China, staple food is often made of wheat, while in southern China, more rice-made staple food, more sugar and fish is consumed. These consumer preferences are mostly based on geographical conditions such as the difference between mountainous and coastal areas.

Moreover, China has been playing an important role in global market ever since its accession into World Trade Organization (WTO) in December 2001. Hence food demand structure changes in China will have dramatic impacts on the global food markets. Our investigation on

demand structure changes will be able to show a guiding way on policy making and food providing.

1.2 Research Objective

We will estimate Chinese food demand in different regions, using the Chinese household survey dataset between 1995-2011 obtained from National Bureau of Statistics of China (NBS). Five categories of food are included in the study. They are grain, vegetables and fruits, meat, poultry and related products, eggs, and aquatic products. By comparing the different demand structures among the households of each region in China, we will see to the following questions: if there exist structural changes in food demand; if the answer is yes, what are the factors that affect food demand and to what extend can food demand be influenced, etc. More specific results can be obtained when we estimate food demand structures at a regional level.

1.3 Research Methodology

We will first test three different models for analyzing consumer demands, which are the Almost Ideal Demand System (AIDS) model, the Rotterdam model and the Dutch Central Bureau of Statistics (CBS) model. Seemingly Unrelated Regression (SUR) method will be used in conducting these three models. For the final results of each region, we will select the model that performs best.

1.4 thesis structure

The structure of this thesis is as follows. Chapter 1 is introduction. In chapter 2, we present the theoretical framework and the model forms, which are the basis of this thesis. In chapter 3 we introduce the data and our estimation procedures and apply them to our methodology; we analyze our results obtained from our model in chapter 4. Chapter 5 brings the paper to

summary and conclusions.

2 Literature review

In this chapter, we will first provide a review of relevant literatures of Chinese food demand analysis. Then we take a glance at the literatures of demand theories and their empirical applications with the aim of making our present study more understandable and plausible. Consumer demand and consumer behavior have long been a widely discussed topic in many countries. Researchers have introduced various types of demand models for analyzing consumer demand problems in all aspects of people's lives. In agricultural economics area, there are three types of consumer demand models which have taken up a dominant position recently, which are: the Rotterdam model, the Almost Ideal Demand System (AIDS), and the CBS model.

2.1 Chinese food demand analysis

In most empirical researches, Chinese food demand is analyzed from an urban-rural respect. Specifically, they analyze food demand of Chinese urban households or rural households during a given period or in a given year.

The longest period was covered by Fan, Cramer and Wailes (1994). They used a dynamic AIDS model to analyze food demand for Chinese rural households and they applied a household survey dataset of eight categories of food consumptions for the period from 1957-1990. Their conclusion was that the Chinese rural households' food demand was greatly affected by the rural reforms happening in 1979. The rural reforms influenced consumption behaviors by affecting the commodity prices and household income levels. And in another research of them (1995), a two-stage LES-AIDS model was applied in order to estimate household demand in China for five commodity groups, which were food, clothing, fuel, housing, and other commodities. Pooled time-series and cross-section data for rural China for the period 1982 to 1990 was used in this study. They found out that most commodity groups showed out the quality of normal goods and their demands were price inelastic, while housing

and "other commodities" were luxury goods. In addition, they reached the conclusion that it could be highly possible that China would play an important role in the international agriculture market by importing increased amount of wheat and exporting rice.

Many researches investigate Chinese food demand from the angle of income change. An increased income will cause the changes in food consumption patterns. Chern and Wang (1994) used survey data for the period from 1985 to 1990 of 28 major cities and provinces in China, and they found out more than 50 percent of the budget of Chinese urban households was spent on food consumptions. When income increased, 42 percent of the increased income was spent on food and people tended to consume more pork, poultry and fish, and less grain, oil and beef. They also discovered that it was possible for the producers of meat products, eggs, and fish to increase total revenue if they reduced the prices of these food items.

Such results were also proved by Halbrendt, Tuan and Gempesaw (1994), who estimated the consumer behavior on food in rural China by using Guangdong household consumption expenditure survey data on 9 commodities in 1990. It was noticed that most food items had inelastic own-price elasticities, which was obviously caused by the fact that a large part of the household budget was spent on foods. In addition, meat consumption increased together with households' rising income. They also found out that the direct consumption of grain would probably be replaced by indirect grain consumption such as meat, poultry and relative products. In order to give a solution of this problem, they suggested that Chinese government should encourage foreign direct investment in the processed food and animal feed industries to promote rapid growth in meat production capacity.

Zhuang and Abbott (2005) concentrated more in grain demand and income changes. They estimated the consumption demand and elasticities of wheat, rice, corn, pork, and poultry using a 24-year time series dataset of China. Their results suggested that for the period from 1978 to 2001, as income increased, households were more willing to consume more fine grains and less coarse grains. By estimating trade elasticities, they made the conclusion that China had market power in the trade for all of the five commodities.

By defining structural change as a change in the underlying parameters of food demand, Dong and Fuller (2007) applied the Rotterdam model and the Almost Ideal Demand System using the Chinese survey household data on 7 food groups for the period from 1981 to 2004. They found out that during that period, the structural changes of food demand in Chinese urban households existed mostly in meat, vegetables, fruits and fish; while the most often consumed food – grain – did not show strong evidence of structural change. In addition, their results also indicated that consumer preferences were changing in response to food price changes and the consumer demands on food were becoming less price elastic. With increased incomes, consumers were gradually changing their behaviors on preparing and shopping food. It was thus reasonable that consumers took more considerations on food attributes than only the food prices.

When income has reached stagnation, food consumption will also stagnate. Researches on such a situation can be noticed from Gao, Wailes, and Cramer (1996), who analyzed economic and demographic effects on China's rural household demand by using micro data from Jiangsu province of China in 1990. They found out that income stagnation had caused the stagnation of the demand for grain and other food. Moreover, they concluded that Chinese rural households continued to take the demand for better food and shelter as a vital concern. They also concluded that rural households would be mainly spending their increasing incomes on animal products, which in the future would most likely cause the rising prices of grains.

Other factors such as changes in demographics, market developing process, urbanization level, and education level can also be causes of changes in food consumption pattern. Yen, Fang and Su (2004) estimated a translog demand system, using the survey dataset in 2000 to investigate the effects of prices, income and demographic characteristics on the household food demand in urban China. Thirteen types of food were included in the study. They claimed that all foods are normal commodities and consumption of all foods would grow together with China's development for the reason that income was a substantial driving force for food demand. In addition, their results suggested that changing demographics would have a significant

influence on China's future food demand, and in the next decade China would be expected to depend much on importing corn and soy meal.

Huang and Rozelle (1998) tested the hypothesis that in China the rural demand for food, especially for meat products, might be restricted by the incomplete development of markets. By using the 1993 survey dataset for rural households in 6 counties of Heibei province, they concluded that rural consumption patterns were affected both by increased income and structural changes in food structure. And they also suggested that the Chinese government should engage in fostering emerging rural consumption markets, given the fact that in most rural regions of China the consumption markets were not very complete.

Zhang and Wang (2003) estimated demand elasticities of 17 food items by using Chinese urban household survey data of the year 1998. Their results suggested that firstly, the Chinese urban consumers demand for non-staple food products was most likely to increase significantly in response to increased incomes. This indicated that food consumption pattern in urban China was probably shifting from staple grain commodities to non-staple and high-value food products as income increased. Secondly, food demand of the Chinese urban consumers was sensitive to price change. Thirdly, besides prices, there were many other factors, such as regional factors, urbanization level and education level of each individual in each household, that also affected the food demand of urban Chinese households,. Fourthly, the growing demand for non-staple and high-value food products would be continuously influenced by income growth, changes in food consumption pattern, urbanization and improvement of market efficiency.

2.2 The Rotterdam model

Constructed by Theil (1965) and Barten (1966) and named after Theil's residence, the Rotterdam model has been playing a significant role in analyzing consumer demand. As a turning point of demand models, it was developed primarily to test the restrictions of demand

theory. However it has gradually become quite popular among applied work.

There are normally two important types of restrictions in demand systems: homogeneity and symmetry. Barten (1967) was the first one to test these two restrictions. He first applied a non-restricted Rotterdam model to commodities of four composite groups with Nederland data and found out that the model matched properly with the data. In an attempt to estimate a demand system under various constraints with respect to the coefficients of the system, in 1969 he used Dutch time series data of 16 groups of goods during the period 1923 - 1939 and 1950 – 1962. The result showed that the empirical validity of those constraints was uncertain even though it is reasonable to think that using constraints is able to reach more precise estimates of the coefficients by strikingly reducing the values of their estimated standard errors. With uncertain reasons, both tests of homogeneity and symmetry were rejected in this study. However, Barten created a new era of introducing different restrictions to Rotterdam model.

In the early years (before 1990s), Rotterdam was not very widely used as today. Early applications were Parks (1969) and Deaton (1974).Both of them used time series data. However they applied Rotterdam model in different ways. Parks used time series data on series for the value of output devoted to final consumption for eight economy sectors in Sweden with the purpose of comparing the theoretical properties and empirical usefulness of three different demand models -- Rotterdam model, the indirect addilog demand model and the linear expenditure system with and without linear trend. He reached the conclusion that among all three models the Rotterdam model showed out the best performance while the linear expenditure model without trend together with the indirect addilog model were generally inferior. Deaton (1974) applied various consumer demand models to 9 groups of commodities in UK using a 70-year dataset (1900-1970) and he at the same time tested the two theoretical restrictions. It was shown that homogeneity was declined and symmetry was accepted. Moreover, the Rotterdam model with symmetric restriction performed better than the direct addilog model, the linear expenditure system and zero substitution matrix system; while the linear expenditure system performed better than the additive version of the

Rotterdam model and zero substitution matrix system.

The applications of the Rotterdam model have become rather prosperous ever since 1990. Kinnucan et al. (1997) applied the Rotterdam model to U.S. meat demand using quarterly data for the period 1976-1993 with the aim of finding out whether generic advertising and health information had detectable effects on U.S. meat demand. Four categories of meat were analyzed, which were beef, pork, poultry (chicken and turkey) and fish. They were specified as four equations to be estimated in the Rotterdam model. Their findings suggested that a structure change in meat consumptions in the U.S. and consumer preference influenced the steady increase in per capita poultry consumption at the expense of beef consumption. The basic reason of this finding was that health information was significant in each of the estimated equations.

Schmitz and Wahl (1998) applied the Rotterdam model in estimating the degree of substitutability among different types of wheat imports in Japan, by using annual data of eight different types of wheat imports data for the period from 1970-1994. Maximum likelihood estimation was used in the estimation procedure. After imposing homogeneity and symmetry restrictions to the model, they found out that the theory and data were in conflict, which indicated that the restrictions were not acceptable. Their results suggested that Canadian and U.S. durum wheat were highly income elastic and that the income elasticity varied significantly across time periods. Moreover, Canadian and U.S. durum wheat and white wheat imports from Australia and the United States were specific substitutes; while hard red spring wheat from Canada and the United States were specific complements.

Xiao, Kinnucan and Kaiser (1999) applied the Rotterdam model in order to examine whether there existed detectable effects from advertising of non-alcohol beverages on aggregate demand. A dataset of five types of non-alcohol beverages -- milk, juice, soft drinks, coffee and tea -- of the period from 1970-1994 were analyzed in this study. The results suggested that both advertising and structural change affected the demand for non-alcohol beverages in the United States; however, advertising was playing a less important role than the structural

change. Market shares other than market size of non-alcohol beverages were affected more by advertising.

The Rotterdam model also performs well in estimating price elasticities and income elasticities. Mann (1980) applied the Rotterdam model together with personal consumption expenditure data from the United States for the period 1949-1977, aiming at studying the interaction of consumer expenditures. Twelve categories of expenditure data were analyzed and a matrix of own-price elasticities, cross-price elasticities and income elasticities were estimated.

2.3 The Almost Ideal Demand System (AIDS)

The Almost Ideal Demand System (AIDS) model was developed by Deaton and Muellbauer (1980). It permits exact aggregation over consumers, satisfies the axioms of choice exactly and has a semi-log function form known to be consistent with consumer budget behaviors. In empirical researches, the AIDS model has been intensively used in estimating consumer demand elasticities or demand structures.

The AIDS model was first introduced by Deaton and Muellbauer (1980) with the purpose of estimating demand on eight nondurable groups of consumer expenditure for the postwar period (1954-1974) in Britain. These eight groups of goods included food, clothing, housing services, fuel, drink and tobacco, transport and communication services, other goods, and other services. They reached the conclusion that the AIDS model was capable of explaining a high proportion of the variance of the commodity budget shares.

Early application of AIDS model on food demand analysis was Ray (1982), who applied the household AIDS model to Indian budget survey data for the period from April 1952 to June 1969 with the purpose of estimating a complete demand system of Indian households. Non-linear FIML procedure was used on both time series data and pooled cross section data.

Four groups of commodities were estimated in this study. The result was that the homogeneity and symmetry restrictions were sensitive to both rural/urban sectors and the nature of the data. Moreover, different elasticities were obtained on time series data and cross section data. And the sensibility of the estimated coefficients together with calculated elasticities to the inclusion of family size were both generally greater in time series data over cross section data.

When estimating elasticities, autocorrelation might be a problem when applying the AIDS model. Blanciforti and Green (1983) applied dynamic AIDS system to annual United States time series data for the period from 1948-1978 in order to estimate the consumer demand system for 11-aggregate groups of commodities. In addition, the study aimed at testing if there existed habits or persistence in consumers' consumption behavior patterns and the results showed that consuming habits were really present. The study also found out that autocorrelation had shown a large effect on elasticities estimated by the AIDS model. It suggested that the AIDS model incorporating habits and autocorrelation appeared to be a more viable demand system in consumer behavior estimation process.

Similar problem with autocorrelation was also found by Green and Alston (1990) when they examined the AIDS model and linear approximate almost ideal demand system (LA/AIDS). By using the U.S. food consumption data for meats, fruits and vegetables, cereal and bakery products and miscellaneous foods, they compared the uncompensated price elasticities for AIDS and LA/AIDS. It was noticed that all approaches reported to calculate elasticities for LA/AIDS were theoretically incorrect. Thus they presented three alternative formulas to compute uncompensated elasticities for LA/AIDS, and these elasticities obtained were essentially identical to the elasticities obtained for the AIDS model. Meanwhile, correcting for autocorrelation by using the new-developed approach essentially reduced the real income effect to zero. Therefore the theoretically correct formula was recommended when computing elasticities for LA/AIDS and the AIDS price elasticity formula should only be used for the AIDS model.

Researchers are also interested in comparing the performances of various types of demand

systems when analyzing the same type of food demand. Meanwhile many different versions of demand systems have been introduced. Brester and Wohlgenant (1991) introduced absolute price version of the Rotterdam model and LA/AIDS model to the United Stated annual data for non-fed beef, fed beef, pork, poultry, ground beef and table cut beef for the period from 1962-1989. The purpose was to estimate the interrelated meat demands in the U.S. A non-nested test of the alternative specifications was developed and used. The results showed that the choice of data generally affected the price elasticities of hamburger beef and table cuts beef. And because the ground beef data were constructed with the unrealistic assumption that fixed proportions of beef carcasses were processed into ground beef, it was necessary to extend the ground beef data such as allowing the proportions to be influenced by economic factors, so that the weights were able to be attached to each category of beef animal time variant.

Alston, Chalfant and Piggott (1993) applied two alternative models of the Rotterdam form and four alternative variations of the first-differenced LA/AIDS to the United States quarterly per capita consumption and retail prices of beef, chicken, pork, and fish in the United States, for the period from1967-1988. The aim was to test the flexibility and compatibility of the two models with the demand theory. The Rotterdam model was accepted in the test while LA/AIDS model was rejected. However, it could be dogmatic to make the conclusion that LA/AIDS model was inferior to the Rotterdam model. Different datasets might lead to quite different or totally opposite conclusions. Therefore, they suggested that it was only acceptable to apply the test procedure to compare models for specific datasets.

2.4 The CBS model

A third type of consumer demand system is called the CBS model, which was first introduced by W. J. Keller and J. Van Driel in 1982 at the Dutch Central Bureau of Statistics (CBS). It is a hybrid model system of the AIDS and the Rotterdam model.

The CBS model has not been so widely applied as the Rotterdam model and the AIDS model, thus there are only a limited range of literatures we are going to take a brief review of. In most of the literatures, the performance of the CBS model is compared with the Rotterdam model and the AIDS model at the same time.

Kaabia, Angulo and Gil (2001) introduced a health information index into a cointegrated CBS model using Spanish Quarterly Household National Expenditure Survey data of beef, pork, poultry and fish for the period from 1985-1997. Their purpose was to examine if there exists an influence on meat and fish demands in Spain caused by the increasing information about the relationship between diet and health. The elasticities of health information and meat and fish demands were estimated. Their empirical results showed that the increasing impact of the health information on different types of meat is significant. There was a negative impact on red meats -- beef and pork, and a positive impact on white meats -- poultry and fish.

When applying the similar CBS model, it is also possible to compare the results obtained from using different types of datasets. Van Driel, Nadall and Zeelenberg (1997) estimated food demands in USA and the Netherlands for the period from 1929-1988 by applying the CBS model to both budget-survey data and time-series data. They then compared their results with the results of Tobin, who analyzed food demand in USA during the pre-war period and used budget-survey data for 1941 and time series data for 1913-1941. Both income elasticity and own-price elasticity were calculated in this study. Their results showed that the income elasticity obtained from cross-section / budget-survey data was generally larger than that from time-series data.

In addition, trend effects can also be examined. Taha and Hahn (2012) estimated South Africa's meat import demand system during the period 1997-2010. The CBS model applied in their study also included a trend and trend-squared term with the aim of testing the technology impact on consumer demand for meat products. The changes in consumer demand caused import demand for poultry and pork to rise, and import demand for beef, sheep / goat, and offal to decline during 1997-2010 in South Africa. The cross-price elasticities they obtained

from the CBS model show that poultry were statistically significant substitute for most of the red meats, namely pork, sheep / goat, and offal, excluding beef, and pork was a statistically insignificant complementary to beef. The trend and trend-squared term were highly significant. These results suggested preference change or other factors affected consumer demand.

Van Imhoff (1984) argued that these three demand systems might have similar performance. He compared the different performance of the Rotterdam model, the AIDS model and the CBS model by using time series data from the Dutch Central Bureau of Statistics (CBS) for the period from 1951-1977. Five groups of commodities were included. Price elasticities were estimated by using time series data and income elasticities were estimated by using both time series and cross section data. In addition, all three models were tested with and without an intercept term. The results showed that the elasticities estimated from the three models were quite alike. Durables were falling into luxury goods while stimulants and services ended up into normal goods.

It is also possible that the demand systems perform differently with one superior than the others. Lee, Brown, and Seale (1994) tested the performances of the Rotterdam model, the AIDS model, together with the two demand systems the CBS model and the NBR model, which have the features of both Rotterdam model and AIDS model. A dataset of Taiwanese household consumption on seven categories of goods for the period from 1970-1989 was used in this study. A general demand system was also introduced which satisfies all the restrictions and includes all of the characteristics of the four demand systems. The restrictions in the general model were further tested. The estimated results showed that almost the same size and trend of both expenditure elasticities and price elasticities were obtained from the four models. However, higher-order comparisons with the general model led to selecting the AIDS over the other systems. Thus the AIDS model performed the best among the four models in analyzing the consumer demand behavior in Taiwan. And they suggested that the general model which they developed could be a suitable demand system since it combined the features of all four models.

3 Materials and methodology

In this chapter, we first discuss the theoretical framework of three different demand systems, and then estimate the Chinese urban demand for the main food categories using the different demand systems. The final discussion of estimated result will be based on the model which gives the best results.

3.1 Theoretical framework

The Rotterdam model and almost ideal demand system (AIDS) are the two types of demand systems that have been highly developed and most widely used in estimating consumer behaviors. The CBS model is a hybrid model system that can be seen as a combination of the Engel curve and Slutsky matrix (Keller and Van Driel, 1985).

3.1.1 The Rotterdam model

The basic Rotterdam model can be written as:

(3.1) $R_i dlnq_i = \sum_{j=1}^{n} \theta_{ij} dlnP_j + u_i dln\frac{Y}{P}$ i=1, 2, ..., n

Here

n denotes the number of commodities in the market.

q_i denotes the quantity demand for each commodity.

P_i denotes the price of each commodity.

Y denotes consumers' total budget for these n commodities.

R_i denotes the budget share of commodity i.

The theoretical restrictions on price and expenditure parameters for equation (3.1) are:

(3.2) $\sum_{i=1}^{n} \theta_{ij} = 0 \quad \sum_{i}^{n} \mu_i = 1, \quad j = 1, 2, \dots, n$ (Adding up)

(3.3) $\sum_{j=1}^{n} E_{ij}^{*} = 0 \quad i = 1, 2, \dots, n$ (Homogeneity)

(3.4) $\theta_{ij} = \theta_{ji} \quad i \neq j$ (Symmetry)

The elasticities of the Rotterdam model are as follows:

(3.5) Income elasticity: $A_i = \frac{u_i}{R_i}$

(3.6) Compensated / Hicksian cross price elasticity: $E_{ij}^* = \frac{\theta_{ij}}{R_i} \quad (i \neq j)$

(3.7) Compensated / Hicksian own price elasticity: $E_{ii}^* = \frac{\theta_{ii}}{R_i}$

Moreover, we obtain Marshallian price elasticities by using Slutsky equation:

(3.8) $E_{ij}^* = E_{ij} + R_j A_i$

Then we get:

Uncompensated / Marshallian cross price elasticity: $E_{ij} = \frac{\theta_{ij} - u_i R_j}{R_i}$

Uncompensated / Marshallian own price elasticity: $E_{ii} = \frac{\theta_{ii}}{R_i} - u_i$

3.1.2 The Almost Ideal Demand System (AIDS)

The common presumption of all the demand systems is that the demand for each commodity is weakly separable from all the other goods purchased by the consumers, which also applies to the AIDS model. The original AIDS model by Deaton and Muellbauer (1980) can be written as

(3.9) $R_i = \alpha_i + \sum_{j=1}^{n} \gamma_{ij} \, lnp_j + \beta_i \ln(y/P)$ i=1, 2, ..., n

Where $lnP = \alpha_0 + \sum_{j=1}^{n} \alpha_j \, lnp_j + \frac{1}{2} \sum_{j=1}^{n} \sum_{i=1}^{n} \gamma_{ij} lnp_i lnp_j$ and $R_i = p_i q_i / \sum_i p_i \, q_i$. Here p_i is the price of good i; q_i is the consumption quantity of good i; $\sum_i p_i \, q_i$ is the total expenditure spent on n goods and R_i is the budget share of good i.

We are able to notice that the AIDS model (3.9) is a non-linear estimation since there exists $\beta_i \alpha_j$. One possible way of solving this problem is to use the Stone price index $lnP^* = \sum_i R_i lnp_i$ to approximate the translog price index P, if prices are closely collinear (Deaton and Muellbauer, 1980). However, Moschini argued that the (arbitrary) choice of units of

measurement for prices would affect Stone price index and further affect the approximation properties (Moschini, 1995). A more efficient solution is to use geometrically weighted average of prices $lnP^* = \sum_i R_i^0 \, lnp_i$ where R_i^0 represents the mean of the budget share of good i.

The theoretical restrictions on price and expenditure parameters for equation (3.9) are:

(3.10) $\sum_{i=1}^{n} \beta_i = 0, \ \sum_{i=1}^{n} \gamma_{ij} = 0, \ j = 1, 2, \dots, n$ (Adding up)

(3.11) $\sum_{j=1}^{n} \gamma_{ij} = 0 \, , i = 1, 2, \dots, n$ (Homogeneity)

(3.12) $\gamma_{ij} = \gamma_{ji}, \ \ i \neq j$ (Symmetry)

In order to obtain the linear form of AIDS model, we introduce the Stone price index. By using the logarithmic differential of Stone price index $\sum_i R_i^0 \, dlnp_i$, we get the differential form of (3.9):

(3.13) $dR_i = \sum_{j=1}^{n} \gamma_{ij} \, dlnp_j + \beta_i \mathrm{dln}(y/P^*)$

where $\mathrm{d}lnP^* = \sum_i R_i^0 \, dlnp_i$ i=1, 2, ..., n

Equation (3.13) is the linear form of AIDS model.

The own price elasticity, cross price elasticity and income elasticity of the linear form of AIDS model are calculated as follows:

(3.14) Own price elasticity: $E_{ii} = \frac{\gamma_{ii} - \beta_i R_i}{R_i} - 1$

(3.15) Cross price elasticity: $E_{ij} = \frac{\gamma_{ij} - \beta_i R_j}{R_i}$

(3.16) Expenditure elasticity: $\mathrm{A}_i = \frac{\beta_i}{R_i} + 1$

By using Slutsky equation (3.8) we are able to obtain Hicksian price elasticities of the AIDS model:

(3.14) Compensated / Hicksian own price elasticity: $E_{ii}^* = \frac{\gamma_{ij}}{R_i} + R_i - 1$

(3.15) Compensated / Hicksian cross price elasticity: $E_{ij}^* = \frac{\gamma_{ii}}{R_i} + R_j \quad (i \neq j)$

3.1.3 The CBS model

CBS model was proposed by W. J. Keller and J. Van Driel in 1985 in the name of acknowledging the support of the Netherlands Central Bureau of Statistics. In their research, they used the Dutch data on 108 commodities for the period from 1953-1981. By using the same assumptions of Rotterdam model and applying different 'parameterization' to the differentials of budget shares, Keller and Van Driel managed to find out a new demand system – CBS model – for analyzing consumer demands. 'Parameterization' has the meaning of making assumptions with the concern of the constancy of certain parameters (Keller, Van Driel, 1985). Before being parameterized, the Rotterdam model can be written as:

(3.1) $R_i dlnq_i = \sum_{j=1}^{n} \theta_{ij} dlnP_j + u_i dln\frac{Y}{P}$ i=1, 2, ..., n

while the differential of the budget share is expressed as

(3.16) $dR_i = R_i dlnP_i + R_i dlnq_i - R_i dlnY$

Bu putting (3.16) into (3.1) we obtain:

(3.17) $dR_i = \sum_{j=1}^{n} \theta_{ij} dlnP_j + u_i dln\frac{Y}{P} + R_i dlnP_i - R_i dlnY$

After being parameterized, equation (3.17) becomes:

(3.18) $dR_i = \beta_i dln\frac{Y}{P} + \sum_{i=1}^{j} \gamma_{ij} dlnP_j$

where

(3.19) $\beta_i = u_i - R_i$

(3.20) $\gamma_{ij} = \theta_{ij} - R_i R_j + R_i \Delta_{ij}$

Here Δ_{ij} is the Kronecker Delta.

As shown in equation (3.18), by assuming β_i and γ_{ij} as constant, we are able to propose a new version of the Rotterdam model (3.18). The constancy of β_i implies Engel curves of PIGLOG type (Keller, Van Driel, 1985):

(3.21) $R_i = \alpha_i + \beta_i lnY$

It was proved by Deaton and Muellbauer (1980) that the PIGLOG type of Engel curves guarantee consistent aggregation over individuals. It is obvious for us to find out that equation (3.18) -- the absolute price version where price changes are measured in absolute terms -- is

similar to the Almost Ideal System (AIDS) model. Therefore equation (3.18) is called 'the absolute price version' of AIDS model (Keller and Van Driel, 1984). However, one of the defects of the AIDS model is that it might not be very easy to impose the concavity restriction on the matrix γ_{ij} in view of its relation to θ_{ij} as is shown in equation (3.20). Thus a new type of parameterization is introduced to solve this problem (Keller and Van Driel, 1985). In the new parameterization it is necessary to use the differential of budget share which is shown as

(3.22) $dR_i = R_i dlnP_i + R_i dlnq_i - R_i dlnY$

together with

(3.20) $\gamma_{ij} = \theta_{ij} - R_i R_j + R_i \Delta_{ij}$

And we are able to get

(3.23) $R_i dln\left(\frac{q_i}{Q}\right) = \beta_i dln\left(\frac{Y}{P}\right) + \sum_{j=1}^{n} \theta_{ij} dlnP_j \qquad i = 1, 2, \dots, n$

where $dln\left(\frac{Y}{P}\right) = dlnQ$ is a quantity index.

Equation (2.41) shows the CBS model. Not only has CBS model integrated the preferred Engel Curve with Slutsky matrix, but it also manages to make it easier to impose the concavity and other restrictions (Keller and Van Driel, 1985).

The theoretical restrictions on price and expenditure parameters which the CBS model should satisfy are:

(3.24) $\sum_{i=1}^{n} \beta_i = 0$ (adding up)

(3.25) $\sum_{i=1}^{n} \theta_{ij} = 0 \qquad j = 1, 2, \dots, n$ (adding up)

(3.26) $\sum_{j=1}^{n} \theta_{ij} = 0 \qquad i = 1, 2, \dots, n$ (homogeneity)

(3.27) $\theta_{ij} = \theta_{ji} \qquad i \neq j$

The elasticities of the CBS model are calculated as follows:

(3.28) Income elasticity: $A_i = 1 + \frac{\beta_i}{R_i}$

(3.29) Marshallian / uncompensated cross price elasticity: $E_{ij} = \frac{\theta_{ij} - (\beta_i + R_i) R_j}{R_i}$

(3.30) Hicksian / Compensated cross price elasticity: $E_{ij}^{*} = \frac{\theta_{ij}}{R_i} \quad (i \neq j)$

(3.31) Hicksian / Compensated own price elasticity: $E_{ii}^{*} = \frac{\theta_{ii}}{R_i}$

Table 1 Demand elasticities of the three demand systems

Model	Income elasticity A_i	Marshallian / uncompensated price elasticity		Hicksian / compensated price elasticity	
		own E_{ii}	cross E_{ij}	own E_{ii}^{*}	cross E_{ij}^{*}
Rotterdam	$\frac{u_i}{R_i}$	$\frac{\theta_{ii}}{R_i} - u_i$	$\frac{\theta_{ij} - u_i R_j}{R_i}$	$\frac{\theta_{ii}}{R_i}$	$\frac{\theta_{ij}}{R_i}$
AIDS	$\frac{\beta_i}{R_i} + 1$	$\frac{\gamma_{ii} - \beta_i R_i}{R_i} - 1$	$\frac{\gamma_{ij} - \beta_i R_j}{R_i}$	$\frac{\gamma_{ij}}{R_i} + R_i - 1$	$\frac{\gamma_{ii}}{R_i} + R_j$
CBS	$1 + \frac{\beta_i}{R_i}$	$\frac{\theta_{ii}}{R_i} - (\beta_i + R_i)$	$\frac{\theta_{ij} - (\beta_i + R_i)}{R_i}$	$\frac{\theta_{ii}}{R_i}$	$\frac{\theta_{ij}}{R_i}$

Dummy variables can often be added in the demand systems. For example, sometimes it is important to use monthly data to analyze monthly or seasonal demands since seasonal effects might be expected in the demand systems. Therefore seasonal dummy variables D_k can be added in the estimation procedure. The different demand systems with seasonal dummy variables are shown in the following table.

Table 2 Three demand systems with seasonal dummy variables

Rotterdam model	$R_i dlnq_i = \alpha_i + \sum_{j=1}^{n} \theta_{ij} dlnP_j + + \sum_{k=2}^{4} D_k + u_i dln\frac{Y}{P}$
AIDS model	$R_i = \alpha_i + \sum_{j=1}^{n} \gamma_{ij}\, lnp_j + \sum_{k=2}^{4} D_k + \beta_i \ln\left(\frac{y}{P}\right)$
CBS model	$R_i dln\left(\frac{q_i}{Q}\right) = \alpha_i + \sum_{j=1}^{n} \theta_{ij} dlnP_j + \sum_{k=2}^{4} D_k + \beta_i dln\left(\frac{Y}{P}\right)$

$(i = 1, 2, \dots, n)$

Meanwhile, other dummy variables can also be added in the model. For example if we are eager to know about the economic crisis effect on the consumer demands for commodities, it is possible that we add economic crisis dummy variables, say, EC. Taking the AIDS model as an example, then the AIDS model with both seasonal and economic crisis dummy variables

can have the following equation form:

$$R_i = \alpha_i + \sum_{k=2}^{4} D_{ik} + EC_i + \sum_{j=1}^{n} \gamma_{ij}\, lnp_j + \beta_i \ln\left(\frac{y}{P}\right) \qquad i = 1, 2, \ldots, n$$

3.1.4 A comparison of the three demand systems

As we discussed in the section of literature review, the three demand systems have similar characters in several aspects. All of them are second-order locally flexible functional forms, and they require the same level of data and same number of parameters (ERDİL, 2003).

In a study of Barnett and Seck (2008), the performances of Rotterdam model and AIDS were tested. Their conclusion was that the both demand systems performed well when the substitution among goods was low; while AIDS had a better performance than the Rotterdam model when the substitution among goods was very high.

Although different results might be obtained by the two models in some empirical applications, it still cannot stop the fact that the Rotterdam model and AIDS are quite good alternates in empirical studies. The possible reason can be that both models are linear, have the same requirements for datasets and have quite similar structural appearances.

Meanwhile the AIDS model has its own advantages. Firstly, the cost function can be seen as a local second order approximation to the underlying cost function. Secondly, the budget share equations contain sufficient parameters to be regarded as a local first-order approximation to any demand system unlike the Rotterdam model. Thirdly, the AIDS model appears to be a suitable method in testing the general restrictions of consumer demand theory because these general restrictions are unchanged for all the values of total expenditure and prices and can be expressed in terms of the parameters of the budget share equations (ERDİL, 2003).

The CBS is more or less superior to the AIDS model and the Rotterdam model. By using the CBS model, the Engel curve model can be interpreted to a direct representation of the price

effects through the matrix of estimated price coefficients. Estimates that satisfy all the restrictions from consumer demand theory can be obtained by imposing restrictions on the matrix. Meanwhile, the estimates also provide flexible and 'aggregable' Engel curves. Particularly, the advantage of the CBS model is that it is possible to impose concavity restriction directly on the matrix of Slutsky coefficients (ERDİL, 2003).

Each of the three types of demand systems has its own advantages and drawbacks. There is no basis provided by economic theory in choosing ex ante among the three models and only a limited basis is provided for ex post differences such as when one model violates the law of demand or another strong prior belief (Taljaard, Schalkwyk and Alemu, 2006).Therefore it is not easy to give an order on the superiorities of the three demand systems, and it is reasonable to conclude that they seem to have alternative functions when it comes to empirical studies.

3.2 Materials and data structure

The national economic census is held each year in China and regarded as the most direct and authentic way of handling the economic situation of Chinese households. There are 9 main categories of food consumptions that are taken into consideration in the economic census every year. They are grain, vegetable and fruits, edible oil, pork, beef and mutton, poultry, eggs, aquatic products, sugar, and liquor. In this thesis, we plan to examine the structure change of 5 food categories – grain, vegetable and fruits, meat, poultry and related products, eggs, and aquatic products. 3 food categories – edible oil, sugar, and liquor -- are not estimated in this thesis for the reason that these categories of food have relatively much less consumption than the other 5 food categories. Take the consumption of these 3 food categories in year 1995 as an example, the consumption of edible oil accounts for only 0.4% of the whole 9 categories of food consumption, while sugar accounts for 2% and liquor 6%. Moreover, it is not very reasonable to take into consideration of these 3 food categories in this thesis either, because edible oil is normally categorized into condiment, and sugar is seen as ingredient, while liquor is usually at the drink category. We have also combined two food

categories which are beef and mutton, and poultry into one aggregated category called meat, poultry and related products. The reason is that the structure change we are planning to test should be of parallel food categories; however beef, mutton, and poultry all fall into the category of meat. Thus it is reasonable to put the three same types of food into one category.

Data used in this study are per capita consumption and expenditure of urban household on five main food categories, which include grain, vegetables and fruits, meat, poultry and other meat products, eggs, and aquatic products.

We collected the data from the statistical database of National Bureau of Statistics of China (NBS) for the period from 1995 until 2011. The database covers urban household annual data of 26 provinces and 4 municipalities in China (Tibet, Hong Kong, Taiwan and Macau excluded because of data limitations), together with the national average data.

According to the administrative division of China, the 26 provinces and 4 municipalities are categorized into four regional groups, which are north, east, south, and west, respectively (table 1). In addition, it is necessary that we pick out the 4 municipalities and place them in a single group. The reason is that the municipalities have been playing an important role in China's total developments, especially in economy aspects. Therefore it is extremely attracting for us to figure out the food demand patterns and structural changes of these 4 municipalities, together with all the other 26 provinces.

Table 3 The 26 provinces and 4 municipalities to be analyzed (categorized by the administrative division of China)

Region	**Province type**	
	Coastal province	**Inland province**
North	Liaoning	Hebei, Shanxi, Inner Mongolia, Jilin, Heilongjiang

East	Jiangsu, Zhejiang, Fujian, Shandong	Anhui, Jiangxi
South	Guangdong, Hainan (island)	Henan, Hubei, Hunan, Guangxi
west	N/A	Sichuan, Guizhou, Yunnan, Shanxi, Gansu, Qinghai, Ningxia, Xinjiang
Direct controlled Municipalities	Tianjin, Shanghai	Beijing (capital), Chongqing

3.3 A nationwide overview of food consumptions in China

Before we analyze Chinese regional food consumption demand, it is important for us to take a glance at the food demand from a nationwide point of view. Two figures are obtained by using Chinese national average food consumption on 5 food categories during the period 1995-2011. Figure 1 represents the nationwide annual per capita food expenditures, and figure 2 represents the nationwide annual per capita food consumptions (quantities).

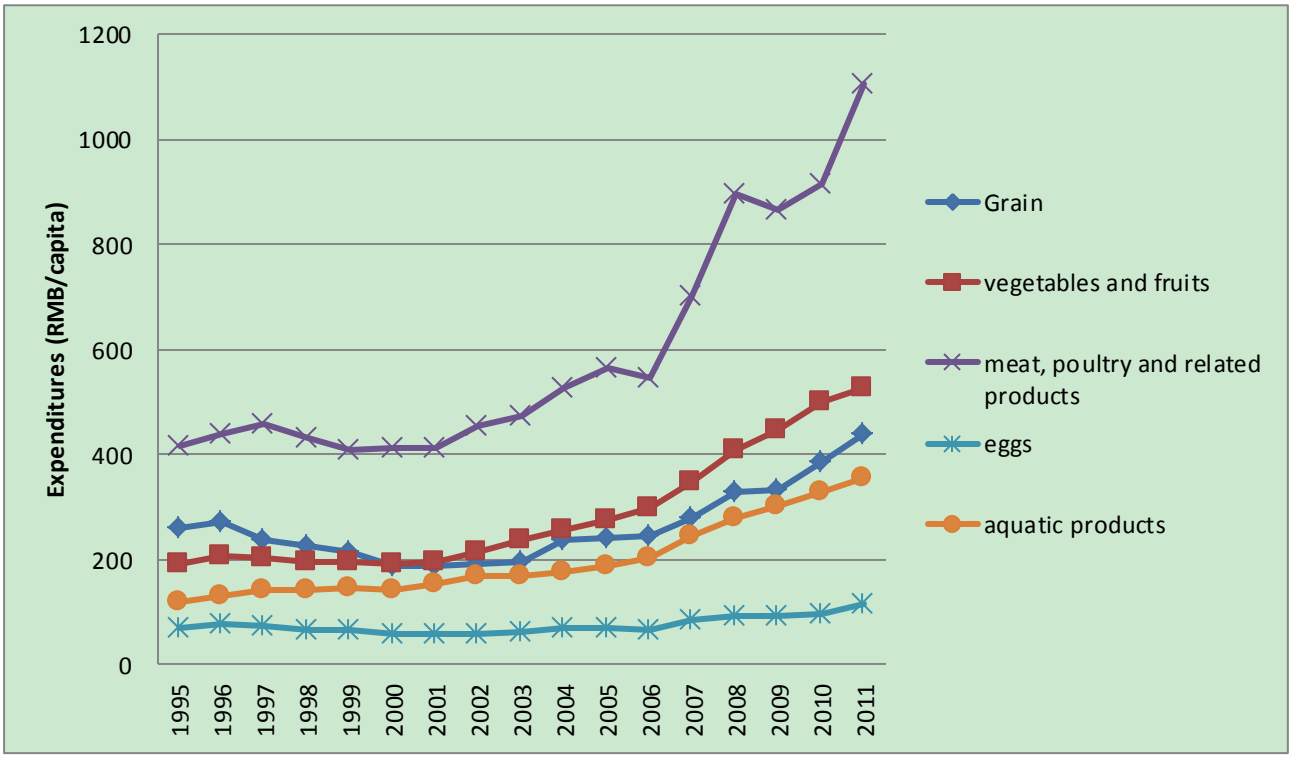

Figure 1 Annual per capita food expenditures in China

(National average data, 1995-2011)

As shown in figure 1, the expenditure on 'meat, poultry and related products' grew from 416.27 RMB per capita in 1995 to 1105.93 RMB per capita in 2011, which inevitably takes up the largest proportion of total food expenditure per capita. The second highest expenditure on food in 1995 was grain, which had the amount of 260.53. However its second position was taken by vegetables and fruits in 2000 and in 2011 the expenditure per capita on grain was 437.58 RMB, which took up the third largest position and right after the category 'vegetables and fruits' which had 527.32 RMB of expenditure per capita. Expenditure per capita on food category aquatic products started from 120.64 RMB in 1995 and it had a rather steady growing trend all the way till 2011 when the expenditure per capita then became 353.99 RMB. The food category 'eggs' had a rather low level of expenditure in 1995, compared to all the other 4 food categories. And it was still staying at the last position in 2011. Among all food categories, the expenditures of three categories – ''meat, poultry and related products', 'vegetables and fruits', and 'aquatic products' have shown a clearly upward trend during the whole estimate period.

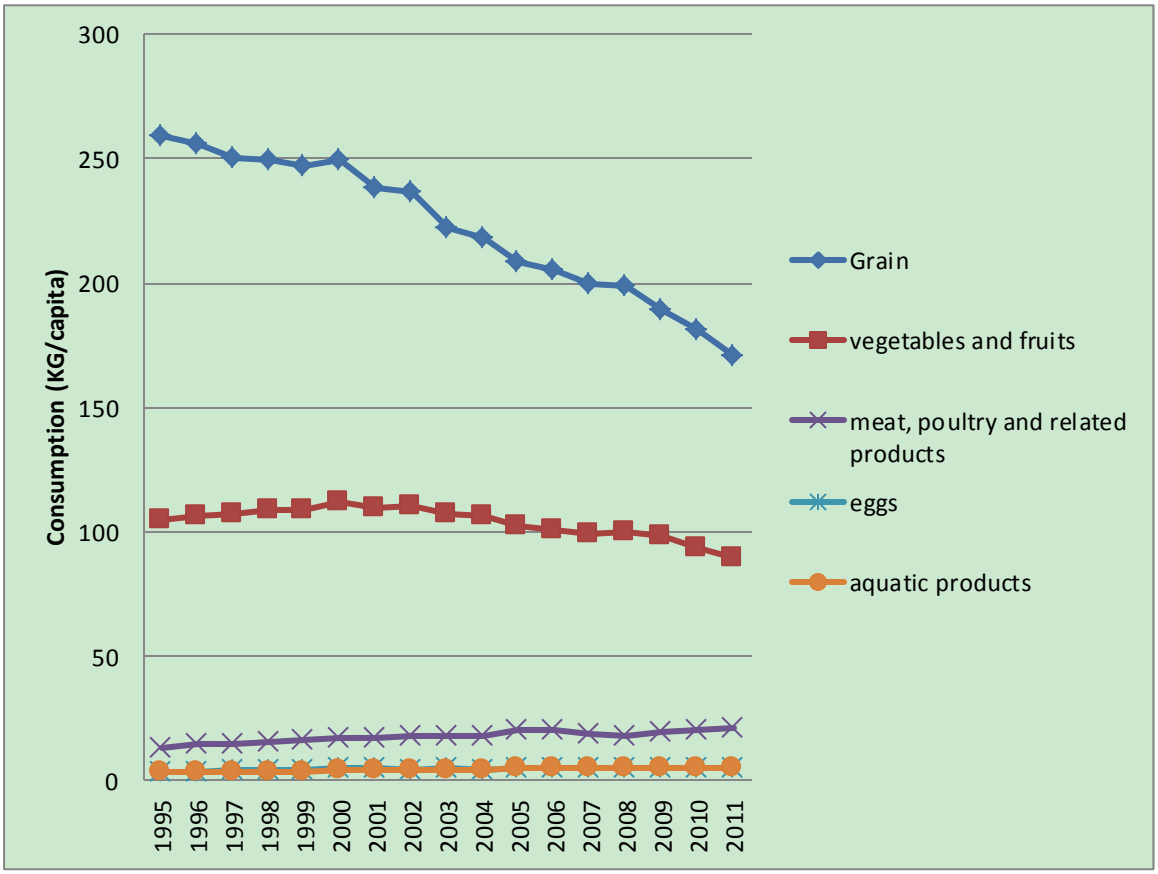

Figure 2 Annual per capita food consumptions in China

(National average data, 1995-2011)

According to Figure 2, from a nationwide point of view, annual per capita grain consumption has shown a very steep downward trend, from 258.92kg in 1995 to 170.74kg in 2011, with a decrease of more than 34 percent. The annual per capita consumptions of meat, aquatic products and eggs have shown a mild upward trend. The amount of aquatic products consumption is almost the same as that of eggs since the two consumption lines in Figure 2 have overlapped each other. Annual per capita consumption of category 'vegetables and fruits' has shown an interesting trend. It falls from 104.62kg in 1995 to 89.36 in 2011. However this is not unreasonable. Category 'vegetables and fruits' consists of two food types – vegetables and fruits. The decreased consumption of the sum of the two food types is very probably caused by a decreased consumption of vegetables together with an increased consumption of fruits.

Table 4 is Chinese dietary guidelines and food guide pagoda (2007). It lists out the standard annual per capita food consumptions recommended by the Chinese Nutrition Society. Comparing the annual food consumptions in Figure 2 to Table 4, we can easily find out that annual consumption of 'meat, poultry and related products' has almost reached the standard level in the 21 century. This situation indicates that food consumption structure of Chinese residents is heading for a meat-based food consumption pattern direction. However this situation does not mean that it is very good for health. Annual consumptions of aquatic products, vegetables and eggs are far less than the recommended amount while consumption of meat and poultry has a prominent position, which can be contrary to the diversification principle of food consumption.

Table 4 Chinese dietary guidelines and food guide pagoda

level	food category	standard per capita consumption	
		daily (g)	annual (kg)
fifth floor	salt	<6	<2.19
fifth floor	oil	25-30	9.125-10.95
fourth floor	soybeans and related products	30-50	10.95-18.25
fourth floor	dairy	300	109.5
third floor	eggs	25-50	9.125-18.25
third floor	meat, poultry and related products	50-75	18.25-27.375
third floor	aquatic products	50-100	18.25-36.5
second floor	fruits	200-400	73-146
second floor	vegetables	300-500	109.5-182.5
first floor	grains	250-400	91.25-146

(Source: the Chinese Nutrition Society http://www.cnsoc.org/en/)

Table 5 (See Appendix A) lists out the budget share of each food category and Figure 3 gives

a more straightforward expression of how the food budget allocation changes, i.e. the budget share trend, during the analyzing period.

From Figure 3 we are able to see clearly from 1995 to 2011, the food budget of average Chinese household on meat, poultry and related products is taking the largest part in the whole food consumption; the second most consumed food category was grain for the period from 1995 to 2000 while after year 2000, vegetables and fruits have gradually become the second most consumed food category. The budget share of egg consumption has always been the lowest during the whole period and it has been lowered from 0.06 in 1995 to 0.03 in 2011. Aquatic products has been consumed quite steady from 1995 to 2011, thus this food category is always taking the second least consumed position.

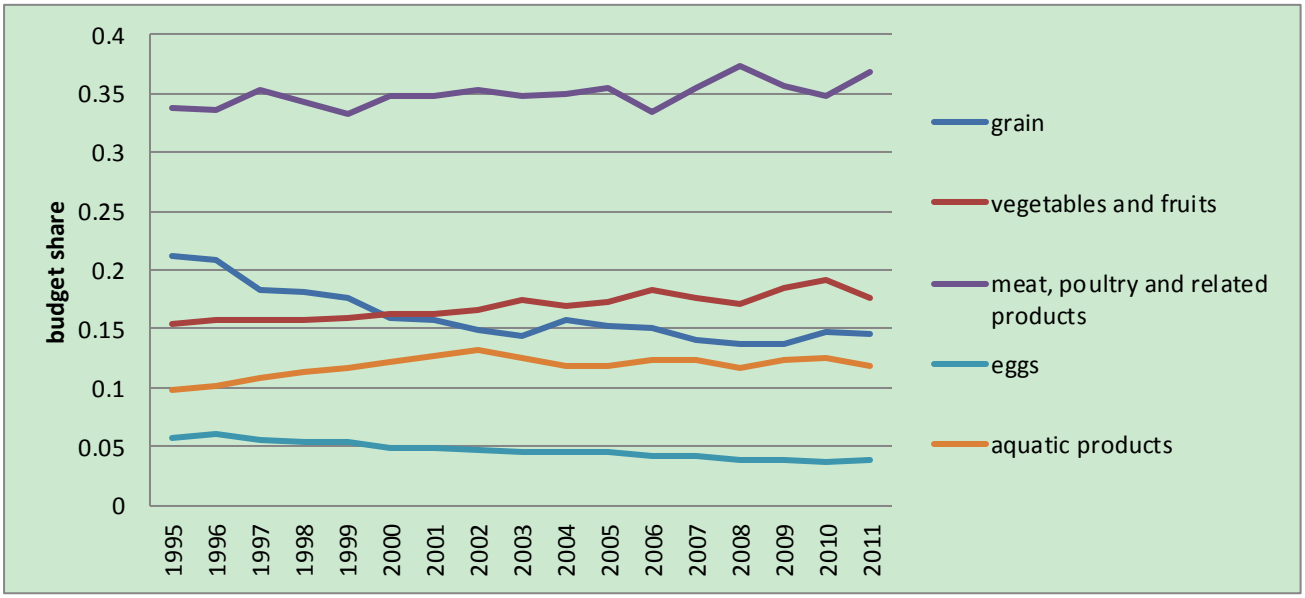

Figure 3 Trend of budget share of each food category in China National average expenditure (1995-2011)

4 Estimations of Chinese household food demand

In this chapter, we will present the estimates of Chinese regional household food demand which can be a good explanation of food consumption patterns of Chinese households and food demand structural change. We will first test the three demand systems without restrictions, and then we impose the restrictions, which are homogeneity and symmetry. We are then able to pick out the proper demand system that performs best for each region. Income elasticities and price elasticities of various food categories will also be calculated.

4.1 Model selection

In this paper, we estimate the Rotterdam model, AIDS, and CBS model by using Seemingly Unrelated Regressions (SUR). Since one equation should be deleted when estimating the demand system in order to avoid the singularity in the variance-covariance matrix of the residuals across equations, we need to estimate each model twice: the first time we would drop the equation of "vegetables and fruits", and the second time we would drop the equation of "meat, poultry and related products".

We estimate the demand system with yearly dummy variables using year 1995 as the base year, and we are separating the period from year 1996 to year 2011 into two periods, first from year 1996 to year 2000, second from year 2001 to year 2011. We have two reasons in estimating the periods before and after year 2001. The first reason is that China became a member of WTO in year 2001, which is an important milestone for Chinese agriculture and food market. The second is that the well-known Asian financial crisis lasted from year 1997 to the end of 1998 with its aftermath lasting after year 2000. The whole economy environment was largely influenced by the long-lasting financial crisis. Even though this crisis mainly took place in Southeast Asia, we are still concerned of the impacts of the financial crisis on

Chinese economy during that period of time. We might expect a decreasing trend of aquatic products consumption during the financial crisis period since China imports part of the aquatic products from the Southeast Asian countries. After we have tested the homogeneity and symmetry restrictions for each model, we apply the restrictions on these different models according to the test results. Then we pick out one most properly estimated model for each region and estimate the price and income elasticities, together with the yearly effects on different categories of food consumptions.

4.2 Own-price and cross-price elasticities

The estimated own price elasticities and cross price elasticities for all 5 food categories are presented in the tables in Appendix A, each region separately. We would discuss demand elasticities for each region before we compare the differences in the elasticities between the regions. As we can see from the tables, own price elasticities for all food categories in all regions are negative and significant, which indicates that for each category of food, when the price goes up, household demand will go down; this complies with the law of demand. The magnitudes of smaller than 1 indicate all food are own-price inelastic in each region. Table 6 presents the food categories that have the most and the least sensitive demand in each region. In two regions where household per capita incomes are highest among all regions – 'East' and 'DCM', 'Vegetables and fruits' has the most sensitive consumer demand. 'Aquatic products' has the most sensitive demand in 'West'. However 'Aquatic products' has the least sensitive demand in region 'East' and 'Meat, poultry and related products' takes up 3 seats as the least sensitive demand food category in all 5 regions. Among all the food categories that have the most sensitive demand to price change, 'Aquatic products' in region 'West' has the highest own price elasticity (absolute value) and is relatively more elastic than other 4 food categories. 'Meat, poultry and related products' in region 'South' has the lowest own price elasticity (absolute value) among all the food categories that are least sensitive to price change, and demand for this food category is thus relatively less elastic than other 4 food categories.

Table 6 The most and least sensitive food demand in each region

Food demand	North	East	South	West	DCM
Most sensitive to price change	Eggs	Vegetables and fruits	Eggs	Aquatic products	Vegetables and fruits
Own price elasticity	-0.68	-0.60	-0.81	-0.90	-0.77
Least Sensitive to price change	Grain	Aquatic products	Meat, poultry and related products	Meat, poultry and related products	Meat, poultry and related products
Own price elasticity	-0.32	-0.16	-0.11	-0.31	-0.46

Grain

The uncompensated own price elasticities of grain of all regions are in the interval of -0.47 and -0.27, which means when price of grain increases by 1%, the household demand will decrease by from at least 0.27% to at most 0.47% concerning different regions. This result is close to that of Fan and Chern (1997) where they estimated Chinese food demand by using provincial panel data for the period 1985-1990 of 28 provinces. The own price elasticity of grains in their research is -0.26. The region in our study where grain has the own price elasticity of -0.27 is 'East'. According to our estimation, for region 'East' grain is complement for vegetables and fruits and aquatic products but substitute for meats and eggs. Compared with the result of Fan and Chern (1997) again, the only difference in their research is that grain is complement for meats. Even though grain is substitute for vegetables in their research, it is however complement for fruits, and the cross price elasticity of grain with respect to the price of fruits is -0.14 which has a larger absolute value than 0.01, which is the cross price elasticity of grain with respect to the price of vegetables. The only difference between our and their results might be because their food category 'meats' comprises 'pork, beef, poultry and fish', while in our study 'pork, beef, poultry' and 'fish' are two separate categories. And since in our study the cross price elasticity of grain with respect to the price of 'aquatic products'

(-0.25) is larger in absolute value than the cross price elasticity of grain with respect to the price of 'meat, poultry and related products' (0.09), it is very likely that grain becomes complement for meats if we combine those two categories together.

Vegetables and fruits

Own price elasticity of vegetables and fruits has the highest value of -0.80 (in absolute value) in region 'West' and the smallest value of -0.43 (in absolute value) in region 'South'. This result is close to most of the research results in the field where own price elasticity of vegetables has an interval of -0.83 (Gao et al., 1996) to -0.50 (Zheng and Henneberry, 2009). An interesting result is that for region 'West' where category 'vegetables and fruits' has the most elastic consumer demand, it behaves as a luxury good; while in region 'South', this category is consumed as a necessary good. This is still consistent with the results of Gao et al. (1996) and Zheng et al. (2009). In the research of Gao et al. (1996) food category vegetables has an expenditure elasticity of 1.26, indicating it is a luxury good. And Zheng et al. (2009) reported an expenditure elasticity of 0.81 for vegetables, indicating it is a necessity. Both Gao et al. (1996) and Zheng et al. (2009) used household data of Jiangsu province. The only difference is that the former used data from 1990 and the latter used data from 2004. The changing of food category vegetables from a luxury good to a necessary good in 14 years might be the consequence of an increased average income and a higher living standard. This can also be used to explain the difference between the expenditure elasticities of different regions in our study. The average income level in region 'West' is much lower than that in region 'South', therefore 'vegetables and fruits' is luxury good in region 'West' and necessary good in region 'South'.

'Vegetables and fruits' is substitute for 'meat, poultry and related products' in all regions, which is consistent with the result of Fan and Chern (1997). 'Vegetables and fruits' is also substitute for 'aquatic products' in our study; while in the research of Fan and Chern (1997) 'aquatic products' was estimated together with other kinds of meat. In the research of Dong and Fuller (2010), 'vegetables' is also substitute for 'fish'. However in other people's researches 'vegetables' and 'fish' are complements (Gao et al.,1996; Zhang and Wang, 2003;

Yen et al., 2004). This might be due to the reason that the datasets in both our study and the study of Dong and Fuller (2010) are panel data and other researchers used only cross section data. Gao et al (1996) used household data of Jiangsu province in 1990. Zhang and Wang (2003) used household data of 226 cities in 1998, and Yen et al (2004) used household data of 30 cities in 2000.

Meat, poultry and related products

Own price elasticities of 'Meat, poultry and related products' in our study range from -0.46 to -0.11, which are quite low. Yen et al. (2004) reported a similar result where own price elasticity of 'pork' was -0.21. In our study 'Meat, poultry and related products' is substitute for 'grain' and 'aquatic products' in all regions. This result is consistent with that of Hovhannisyan and Gould (2012) where they used 9-year provincial panel data of 31 provinces. However they reported that 'Meats' is complement for 'vegetables and fruits', which is just opposite to our result. A possible explanation might be because they only used 'Beef' to represent the whole meat category and they also divided 'Vegetables and fruits' into two separate categories – 'vegetables' and 'fruits'. Their cross price elasticity of beef with respect to the price of vegetables is quite low, with a number of -0.006, and the cross price elasticity in our study is also not very high, ranging from 0.17 to 0.20. This means it is very likely that we obtain the same result if other types of meat are also taken into consideration and vegetables and fruits are combined together as one food category in the research of Hovhannisyan and Gould.

Eggs

The highest own price elasticity of category 'Eggs' in our study is in region 'South' with a number of -0.81 (in absolute value) while in most of the empirical studies, where panel datasets are used, the own price elasticities of eggs are around -0.83 to 0.85. Thus our result is quite close to empirical results. 'Eggs' is substitute for 'Grain' and 'Vegetables and fruits' in region 'East' and 'West' where cross price elasticities are significant. This is consistent with the result of Fan and Chern (1997) where they used 6-year provincial panel data of 28 provinces and they reported an own price elasticity of 'eggs' of -0.83. However in our study

‘Eggs’ is substitute for ‘Meat, poultry and related products’ which is consistent with most of the empirical studies, while in Fan and Chern (1997) ‘Eggs’ and ‘Meats’ are complements. This might again be explained by the fact that ‘Fish’ is categorized as ‘Meats’ in their study. Because in our study ‘Eggs’ and ‘Aquatic products’ are complements in region ‘North’ and the provinces in this region are contained in the 28 provinces in Fan and Chern’s study, it is likely that we get the same results if they separate category ‘Fish’ from ‘Meats’.

Aquatic products

‘Aquatic products’, with own price elasticities ranging from -0.16 to -0.9 (in absolute value) and 3 of 5 cross price elasticities being around 0.45 to 0.75, is substitute for ‘Vegetables and fruits’ in all regions, and this result is consistent with the results of most empirical researches (Gao et al, 1996; Zhang and Wang, 2003; Yen et al, 2004; Zheng and Henneberry, 2009&2012; Dong and Fuller, 2010; Hovhannisyan and Gould, 2012). In most of these researches the category ‘Vegetables and fruits’ is separated into two categories, which are ‘vegetables’ and ‘fruits’. Even though some of these results show that ‘Aquatic products’ is substitute for ‘Vegetables’ and complement for ‘Fruits’, the cross price elasticities of demand for aquatic products with respect to the price of ‘fruits’ is always larger than that of ‘vegetables’ (in absolute value). Therefore if these two categories are merged into one big category as what we do in this study, it is highly possible that ‘Aquatic products’ becomes substitute for this merged category ‘Vegetables and fruits’.

4.3 Expenditure elasticities

The estimated expenditure elasticities of each food category for all 5 regions are presented in the following Table 7. The positive signs of the expenditure elasticities of the studied food categories indicate that all the food categories are normal goods in all regions.

For ‘vegetables and fruits’, expenditure elasticities in regions ‘West’ and ‘DCM’ are almost unitary elasticities, while expenditure elasticities in other 3 regions are less than 1.

Expenditure elasticities of 'grain' and 'eggs' in all regions are less than 1, and the smallest value is 0.22 which is the elasticity of 'grain' in region 'DCM'. Almost all of the expenditure elasticities of 'meat, poultry and related products' and 'aquatic products' in most regions are significantly larger than 1. 'Aquatic products' in region 'DCM' has the highest value of 2.06.

These results indicate that when an increasing tendency is noticed in household food expenditures, no matter which region people live in, they all tend to spend proportionately more on firstly 'aquatic products' and secondly 'meat, poultry and related products'.

Table 7 Estimated expenditure elasticities

Region	Food category	grain	vegetables and fruits	meat, poultry and related products	eggs	aquatic products
North	A_i	0.56	0.50	1.40	0.86	1.41
	P-value	0.00000	0.00000	0.00000	0.00000	0.00000
East	A_i	0.25	0.90	1.14	0.44	1.94
	P-value	0.00011	0.00000	0.00000	0.00143	0.00000
South	A_i	0.42	0.77	1.33	0.24	1.24
	P-value	0.00000	0.00000	0.00000	0.14269	0.00000
West	A_i	0.57	1.05	1.20	0.82	1.21
	P-value	0.00000	0.00000	0.00000	0.00000	0.00000
DCM	A_i	0.22	1.07	0.90	0.55	2.06
	P-value	0.04559	0.00000	0.00000	0.00000	0.00000

Grain

Food category 'Grain' has a relatively lower expenditure elasticity compared to other food categories. This result is consistent with most of the researches in the field, and it is supported by the fact that is the most widely consumed staple food in China is starch food. It is thus the

most affordable food category in all regions.

This result also indicates that households tend to spend proportionately least on 'Grain' when their incomes increase, no matter which region they live in.

In regions 'East' and 'DCM' the household demand for food category 'Grain' is driven less by income change than in other regions, while 'West' is the region where household demand for 'Grain' is most driven by income change. The reason is that per capita household incomes in the former two regions have relatively higher ranks than that in the latter region, thus the share of grain consumption in the former two regions is much lower than that in the latter region.

Vegetables and fruits

Most of the expenditure elasticities of 'Vegetables and fruits' are around 1, indicating the household demand for this food category reacts more sensitive to income change than category 'Grain'. Notice also category 'Vegetables and fruits' has higher expenditure elasticity than 'Eggs' in most of the regions. Most of the researches in the field estimate the consumption demand for 'Vegetables' and 'Fruits' separately, but still the expenditure elasticities of these two categories of food are around 1. Thus our result is in consistent with empirical researches.

It is reasonable that category 'Vegetables and fruits' has expenditure elasticities higher than 1 in region 'DCM'. The cities in this region have relatively higher per capita household income compared to other regions, indicating the Engel coefficient has a quite low value. Firstly, we should bear in mind that this category includes both 'vegetables' and 'fruits', thus the elasticity shows out the effects caused by both food types. Residences with high incomes tend to consume more types of fruits than those with low incomes because fruits are normally more expensive than vegetables. And we should notice that demanding for a higher quality of life and healthier food is positively related to people's income, which means that the more people earn the larger amount of healthy food they intend to consume. This simple fact thus

can be used in explaining why category 'vegetables and fruits' has higher expenditure elasticity than 'eggs'. It has been propagated for a long time that the more vegetables and fruits people eat, the healthier they will become. As a result, more households tend to consume not only more amount of 'vegetable and fruits' but also vegetables and fruits with better qualities such as organic vegetables, imported fruits instead of the normal types consumed in other regions of China.

The expenditure elasticities of 'Vegetables and fruits' in region 'West' and 'DCM' are very close to each other (1.05 and 1.07) which is unexpected. However region 'West' is where households have the lowest per capita income and Engel coefficient in this region is much higher than other regions thus even normal types of vegetables and fruits can be consumed as luxury goods.

Meat, poultry and related products

Expenditure elasticities of 'Meat, poultry and related products' are much larger than 1 in most regions, except in region 'DCM', where per capita household income is the highest in China. Thus this food category is consumed as luxury good in 4 regions but not in 'DCM'. In region 'South', 'Meat, poultry and related products' has the lowest own price elasticity (-0.11) (in absolute value) among all regions but a rather high expenditure elasticity (1.33), indicating household demand for this food category in region 'South' is more driven by household income change than commodity price change. In region 'DCM' there exists an absolutely opposite situation where own price elasticity is the highest (-0.46) (in absolute value) and expenditure elasticity is the lowest (0.90) of all regions.

This can be caused by several reasons. Firstly the difference between household per capita incomes of the two regions causes the consumption behavior difference. Secondly, average price of 'Meat, poultry and related products' per kilo in region 'South' (34.66) is higher than that in region 'DCM' (31.47), indicating same amount of price change will have lower effect on the commodity with higher price. Therefore it is reasonable that the household demand for 'Meat, poultry and related products' in region 'South' is less sensitive than that in region

'DCM' to price change but more to income change.

Eggs

Expenditure elasticities of category 'Eggs' are less than 1 in all regions, indicating 'Eggs' is consumed as a necessary good. The expenditure elasticities range from 0.44 to 0.86. Region 'South' is excluded because the expenditure elasticity is not significant. Our result is in consistent with most of the researches in the field (Gao et al, 1996; Yen et al, 2004; Gould and Villarreal, 2006; Liao and Chern, 2007; Dong and Fuller, 2010; Zheng and Henneberry, 2009, 2012). It is not hard to understand that 'Eggs' is consumed as a necessary good while 'Meat, poultry and related products' is luxury good. Compared to meat, egg contains enough protein body needs meanwhile it has a much lower price than meat. For the two regions that have relatively higher household per capita income – 'East' and 'DCM', expenditure elasticities for 'Eggs' are lower than those in lower household per capita income regions – 'North' and 'West'. This is because when income per capita of different regions increase by the same amount, the change in household demand for normal goods will have a lower impact in the region that has a relatively higher income per capita than the one having a lower income per capita.

Aquatic products

In all regions the expenditure elasticities of 'aquatic products' are much larger than 1, indicating this category is consumed as luxury good. In most of the empirical researches, 'aquatic products' all have expenditure elasticities larger than 1, except in the result of Gao et al. (1996), which is 0.89. However, they estimated the distribution of expenditure elasticities by current disposable income using household data of Jiangsu province in 1990, and the expenditure elasticities of fish range from 0.5646 to 1.3263. For the 3% of households that have the least income and the 5% of households that have the second highest income, the expenditure elasticities of fish are around 0.98 to 1. For the 87% of households that have intermediate income, the expenditure elasticities of fish range from 0.56 to 0.79. For the 5% of households that have the highest income, the expenditure elasticity of fish is surprisingly high – 1.33. However the result obtained from Gao et al. has exactly supported our result. For

regions 'North', 'South' and 'West' where households have lower and intermediate incomes, expenditure elasticities of aquatic products are from 1.21 to 1.41. But as household incomes increase, such as for regions 'East' and 'DCM' where incomes are higher, expenditure elasticities of aquatic products are also becoming larger, from 1.94 to 2.06. This is due to different food kinds consumed at different income levels. Relatively more aquatic products are consumed at the high income levels, thus there is a more elastic expenditure response (Gao et al., 1996).

In region 'East' the category aquatic products has a relatively lower own price elasticity (-0.16) and a relatively higher expenditure elasticity (1.94) than other regions, indicating that the household demand for aquatic products in this region is driven more by the changing in household income than in commodity price. Therefore if per capita household income is increasing, then the demand for aquatic products is also expected to have an inclining tendency. A similar situation applies to region 'West' where household demand for aquatic products is driven more by price change than income change because of a lower expenditure elasticity (1.21) and a higher own price elasticity (-0.90) (in absolute value).

The reason for such situations might be the difference between per capita household incomes of the two regions. Per capita household income in region 'East' is much higher than that in region 'West'. However since the food market is an integrated market in the modern society, price change in one region will lead to a same level of change in other regions. When there is a same amount of change in price, the percentage change of the purchasing power of the households where they have lower incomes will be much larger than that of higher income households. Therefore the households that have lower per capita income will be more concerned of the price change of the commodities than those who have higher per capita income. Moreover, our result for region 'East' supports the finding of Zheng and Henneberry (2009) where they used household data of Jiangsu province in 2004. This is quite reasonable since Jiangsu province is included in region 'East'.

4.4 Effects of year dummy variables

Parameters of dummy variables are important signals for trend effects. The estimated parameters of year dummy variables are presented in the following Table 8.

Table 8 Estimated parameters of year dummy variables

Region	Independent variables	grain	vegetables and fruits	meat, poultry and related products	eggs	aquatic products
North	Y96TO00	-0.131	0.050	0.077	-0.004	0.050
		(-11.005)*	(2.736)*	(5.970)*	(-0.719)	(6.121)*
	Y01TO11	-0.126	0.053	0.076	-0.006	0.051
		(-10.961)*	(2.753)*	(6.038)*	(-1.116)	(6.363)*
East	Y96TO00	-0.128	0.038	0.050	-0.018	0.058
		(-8.050)*	(2.552)*	(2.170)*	(-1.672)	(2.213)*
	Y01TO11	-0.127	0.044	0.044	-0.018	0.058
		(-7.390)*	(2.713)*	(1.745)	(-1.557)	(2.048)*
South	Y96TO00	-0.031	0.057	0.044	0.015	-0.084
		(-2.992)*	(4.372)*	(1.996)*	(2.378)*	(-6.691)*
	Y01TO11	-0.023	0.062	0.039	0.011	-0.089
		(-1.948)	(4.291)*	(1.579)	(1.510)	(-6.315)*
West	Y96TO00	-0.081	0.070	0.005	-0.005	0.011
		(-5.293)*	(4.097)*	(0.265)	(-0.865)	(1.874)
	Y01TO11	-0.078	0.075	-0.001	-0.007	0.011
		(-4.700)*	(4.056)*	(-0.048)	(-1.181)	(1.729)
DCM	Y96TO00	-0.063	0.060	0.075	0.0268	-0.101
		(-5.808)*	(6.832)*	(4.005)*	(7.5277)*	(-7.389)*
	Y01TO11	-0.057	0.066	0.072	0.025898	-0.108
		(-5.164)*	(7.299)*	(3.907)*	(7.0282)*	(-7.900)*

Note: * indicates significance at 5% level.

Firstly, Most dummy variables are significant except those for food category 'Eggs', which are only significant in region 'South' for period 1996-2000 and in region 'DCM' for both two periods.

Secondly, for all regions there is a downward trend in the consumption of 'Grain', meanwhile an upward trend in the consumptions of both 'vegetables and fruits' and 'meat, poultry and related products' for both of the two periods 1996-2000 and 2001-2011, compared to the base year 1995. A declination of the demand for 'Grain' is probably the consequence of high income households' need for higher protein food products, which also leads to the inclination of the demands for meat and eggs. Meanwhile, the inclination of the demand for 'Vegetables and fruits' might be explained by Chinese households' expectation for a healthier life style. According to the old saying 'an apple a day keeps the doctor away', consuming more vegetables and fruits can be considered as a good leading path to a healthy life style.

Thirdly, category 'Eggs' has shown an upward trend in both region 'South' and 'DCM'.

Fourthly, for 'Aquatic products', only the dummy variables for region 'West' are not significant. And for regions 'North' and 'East', we have observed an upward trend for both of the two periods; while for regions 'South' and 'DCM', a downward trend has been observed, compared to the base year 1995. The declining demand of Southern Chinese households for aquatic products for the period 2001 to 2011 might have various causes. It can be the consequence of the financial crisis happened in Southeast Asia in year 1997, or rather, an aftermath.

According to FAO, there was a slowdown in the growth of aquatic products supplies, starting from 1997-1998. The main reasons are the stable or decreased landings from marine capture fisheries and a slower rate of growth in aquaculture production than that recorded for the early 1990s. The negative impact of El Niño on capture aquatic products was already evident in 1997. In 1998, landings were likely to have declined even further, and production would take

some time to recover. Supplies from aquaculture were affected by a drop in demand in the two to four years afterwards, particularly in Asian economies [1]. In addition to this environmental change, many businessmen in Philippine who relied solely on tuna fishing went bankrupt when the 1997 Asian financial crisis hit the region, thus the declined production of tuna fish in Philippine can influence the fish supply in the Chinese market, where tuna fish from Philippine takes up a large part.

Another possible cause is the Indian Ocean earthquake and tsunami that happened on December 26 in 2004. This catastrophe led to a drastic downfall of the production of aquatic products and consequently damage to the aquatic products export industry of Southeast Asia.

Seven Southeast Asian countries were affected by the tsunami, which were Indonesia, Sri Lanka, India, Thailand, Malaysia, Bangladesh and the Maldives, where aquaculture is dominating the economy. Among these countries, four largest aquatic product producers -- Indonesia, India, Malaysia, and Thailand were greatly damaged. And this situation could not recover in a short period of time. The supply of ribbonfish of these four countries accounts for more than 80% of the total import of ribbonfish in China. Thus the tsunami caused a shortage of imported ribbonfish in the Chinese market which was impossible to be filled with domestic ribbonfish. Aquaculture in the other three countries was also destroyed. For example, butterfish and croaker supplies of India and frozen shrimp supply of Thailand confronted a great loss and thus had a huge impact on China's aquatic products market.

As we have mentioned previously, one of the most important reasons of food consumption pattern change is the change of commodity prices. After China has participated in WTO, prices of domestic products have been under constantly downward pressure caused by the reduced tariffs. Consumers can be greatly attracted to imported low-price foreign commodities, especially those commodities that have the highest own-price elasticities. In this sense, consumption of eggs in 'North' and 'South', vegetables and fruits in 'East' and 'DCM', and aquatic products in 'West' should be the categories that are affected most (See Table 6 in 4.3), i.e., the consumptions of these food categories in these regions will increase most. Apart

from the results that are not significant, our estimates are almost following this explanation. It is thus quite reasonable to conclude that China's participation in WTO did have effects on Chinese food consumption changes.

4.5 Concluding Remarks

We have previously demonstrated the Chinese household demands and demand changing tendencies in 5 regions for 5 different types of food categories by analyzing the price elasticities and income elasticities together with the estimated parameters of independent variables of 3 econometrics models. Table 9 presents various qualities of the 5 food categories we have been researching on in all of the 5 regions. As we can see in Table 9, none of the 5 food categories shows up as an inferior good. In 4 regions -- North, South, East, and DCM -- 2 of the 5 food categories appear as luxury goods; while in region 'West', 3 of the 5 food categories appear as luxury goods. In all 5 regions, food categories 'Grain' and 'Eggs' are consumed as normal goods, and 'Aquatic products' as a luxury good. Category 'Vegetables and fruits' is consumed as a normal good in 3 regions except in region 'West', where households have the lowest income, and in region 'DCM', where households have the highest income. Category 'Meat, poultry and related products' is consumed as a luxury good in 4 regions except in the region where households have the highest income, where this food category is consumed as a normal good.

Table 9. The qualities of five food categories in different regions

Region	grain	vegetables and fruits	meat, poultry and related products	eggs	aquatic products
North	normal	normal	luxury	normal	luxury
East	normal	normal	luxury	normal	luxury
South	normal	normal	luxury	normal	luxury

West	normal	luxury	luxury	normal	luxury
DCM	normal	luxury	normal	normal	luxury

The parameters of dummy variables show that for both of the two periods 1996-2000 and 2001-2011 there exists a decreasing tendency in the consumption for food category 'Grain' in all 5 regions, and 'Grain' is the only food category in our research that has such a tendency. There are 2 food categories that show out an increasing consumption tendency in all of the 5 regions during both periods, which are 'Vegetables and fruits' and 'Meat, poultry and related products'. Category 'Eggs' also has an increasing consumption tendency in 'South' and 'DCM'. For category 'Aquatic products', it shows out various consumption tendencies in different regions. It has a decreasing tendency in 'South' and 'DCM' and an increasing tendency in the other 3 regions.

5 Summary and conclusions

We intend to research on four things in this study.

Firstly, we want to investigate household food consumption structures in five regions of China in order to find out if there are different consumption patterns between regions due to the different economic development and conventions of food consumptions. This is done by comparing price elasticities, expenditure elasticities and the qualities of food categories in different regions.

Secondly, we want to compare our findings with what are reported by the previous literature to see if there is some structural change in food consumption as a result of overall booming of the China economy.

Thirdly, we want to find out if the Chinese household behaved differently before and after China's participation in the WTO, which is an important milestone for Chinese agriculture and food market. This is done by adding a yearly dummy variable into the demand system.

Fourthly, we want to investigate the substitution/complement between food categories. Particularly attention will be focused on degree of substitution between differ types of protein. Asche (2014) mentioned that the empirical literature generally supports the view that there seems to no or very little substitution between seafood and other types of meat in Europe and North America. We would like to see if it will be different in developing countries like China.

Lastly, we use provincial panel data for the period of 1996 to 2010 from NBS. However, the previous studies use either cross sectional data or panel data of only several provinces for several years, and they only pay attention to one type of demand specification. We think both dataset choosing and model selection of our study are better / more comprehensive than those of previous studies.

Our estimate results of price and expenditure elasticities show that all food are own-price inelastic and household demands for all food categories in all regions are consistent with the law of demand. Expenditure elasticities of two high-protein containing food categories – 'aquatic products' and 'meat, poultry and related products' are much larger than 1 in all regions. Category 'vegetables and fruits' has almost unitary expenditure elasticities, and 'grain' and 'eggs' have expenditure elasticities that are less than 1 in all regions. This means when an increasing tendency is noticed in household food expenditures, no matter which region people live in, they all tend to spend proportionately more on firstly 'aquatic products' and secondly 'meat, poultry and related products'.

By comparing the expenditure elasticities of the same food categories among different regions, we find that regions 'East' and 'DCM' have relatively lower expenditure elasticities than other 3 regions in 'grain' but higher elasticities in 'aquatic products'. Meanwhile, region 'West' has the highest expenditure elasticities in 'grain' and 'vegetables and fruits' but the lowest elasticity in 'aquatic products'. This indicates household demand for 'grain' in 'East' and 'DCM' and household demand for 'aquatic products' in 'West' are less sensitive to income changes. For 'aquatic products' in 'East' and 'DCM' and 'vegetables and fruits' in 'West', the household demands are more sensitive to income changes.

This might have multiple reasons. Firstly, 'East' and 'DCM' are China's most developed regions and household per capita income in these two regions are the highest among all regions, while 'West' is least developed in China and household per capita income is the lowest. Among all food categories, price is the highest for aquatic products and lowest for grain.

Households that have the highest income are more affordable to pay for expensive goods than those who have the lowest income. Likewise, households in region 'West' consume more grain, vegetables and fruits instead of aquatic products, especially when both grain and vegetables and fruits are substitutes for aquatic products. This consumption pattern makes

household demands for grain and vegetables and fruits in region 'West' react more sensitively to income changes and thus the expenditure elasticity of grain in region 'West' is much higher than that in other regions, especially in East and DCM that have the highest per capita incomes.. In an extreme situation, grain can be consumed as an inferior good in high-income regions (Fan and Chern, 1997).

Secondly, aquatic products are consumed as luxury goods in all regions. We find the relatively higher expenditure elasticities in regions 'DCM' and 'East', compared to those in regions 'South' and 'West'. This suggests that the higher household per capita income a region has, the larger expenditure elasticity aquatic products have in that region. This is due to different food kinds consumed at different income levels. A similar finding has also been observed by Gao et al., (1996). Their explanation is that a more elastic expenditure is the response of the fact that relatively more aquatic products are consumed at the high income levels. This can also be one of the reasons for the positive relationship between expenditure elasticity of aquatic products and income levels in our study. In addition, more types of aquatic products with higher qualities are consumed in high income regions.

Table 10 lists the top ten provinces in aquatic product consumption. In these areas both per capita aquatic products consumption and household per capita income are the highest in China. Aquatic products are the traditional protein sources in coastal areas.

Most Chinese consumers tend to pay much attention to the prices of aquatic products. Freshwater aquatic products for example carps, shrimps and prawns are very popular in household consumptions because of their relatively affordable prices. Domestic seafood such as croaker, octopus and cutlass fish are highly welcome in coastal provinces. A great amount of imported seafood for example cod, squid, flounder and mackerel together with processed clams / shrimp / prawn and tilapia have also become more popular among the busy city dwellers. High-value seafood such as lobster, giant clam, salmon and crab are widely supplied in luxury hotels and restaurants. Take year 2010 as an example, salmon import from Norway has increased more than 80% compared to the previous year. With the help of the prosperous

economy in China, middle class are growing in large cities and coastal areas. The growing middle class are thus gradually tending to consume more nutritious food.

Table 10 Top ten provinces in aquatic product consumption

Province	Household aquatic products consumption per capita (Yuan)	Region	Province type
Fujian	954	East	Coastal
Shanghai	728	DCM	Coastal
Zhejiang	623	East	Coastal
Hainan	619	South	Coastal
Guangdong	594	South	Coastal
Jiangsu	382	East	Coastal
Tianjin	395	DCM	Coastal
Liaoning	350	North	Coastal
Shandong	312	East	Coastal
Beijing	246	DCM	Inland (capital)

(Source: NBS database)

The household per capita income of each region can be put in the following order from low to high: West, South, North, East, and DCM. A clear food consumption pattern difference can be noticed from our estimate results. Grain' and 'aquatic products' are two categories that behave exactly opposite to each other. The cheapest food category 'Grain' is consumed as necessary good in all regions, and the expenditure elasticity of 'grain' has a decreasing trend when household per capita income increases. The most expensive and most-protein containing food category 'aquatic products' is consumed as luxury good in all regions and the expenditure elasticity of this category is increasing when household per capita income gets higher. For 'meat, poultry and related products' and 'eggs' that contain less protein than aquatic products,

their expenditure elasticities have a more bell-shaped trend following the increasing household incomes. For 'vegetables and fruits', expenditure elasticity has a valley-shaped trend when household incomes increase, i.e. expenditure elasticities in the least developed region 'West' and the most developed region 'DCM' are very close to each other. This is because in region 'West', the data of 'vegetables and fruits' is consisted mostly of vegetables, while in region 'DCM', fruits take up a large part of the data. This fact can be the reason of the larger-than-one own price elasticities of 'vegetables and fruits' in both the most developed region and the least developed region. However, we are not quite sure about the reason why they have similar elasticities. Further research is needed in order to find out if this is only a coincidence.

We have also investigated the effects of dummy variables. Our estimate results show that for all regions there is a downward trend in the household demand for 'Grain' and an upward trend in the demand for both 'vegetables and fruits' and 'meat, poultry and related products' in the whole period. The household demand for 'Aquatic products' has an upward trend for 'North' and 'East' and a downward trend for 'South' and 'DCM'. Reasons can be the consequence or an aftermath of the economic crisis in Southeast Asia in year 1998, or the damaged fish export industry caused by the Indian Ocean earthquake and tsunami in year 2004.

Our estimate results have thus provided evidences for structural change in Chinese food consumption patterns. Household food consumption pattern is shifting from 'mainly grain together with little fiber and protein' in less developed regions to 'less grain together with much fiber and protein' in more developed regions. For coastal regions household consumptions of aquatic products seem to have a downward trend however this might be temporary.

Our estimate results are supported by most of the empirical researches. Apart from the temporal food consumption structure changes which are mostly studied in empirical researches, we have also researched on spatial structure changes, which is rather new in this

field. However due to data limitations currently, we would expect there still exist improvements in our future study. And we will be able to obtain more precise results if food categories are divided into more specific food types.

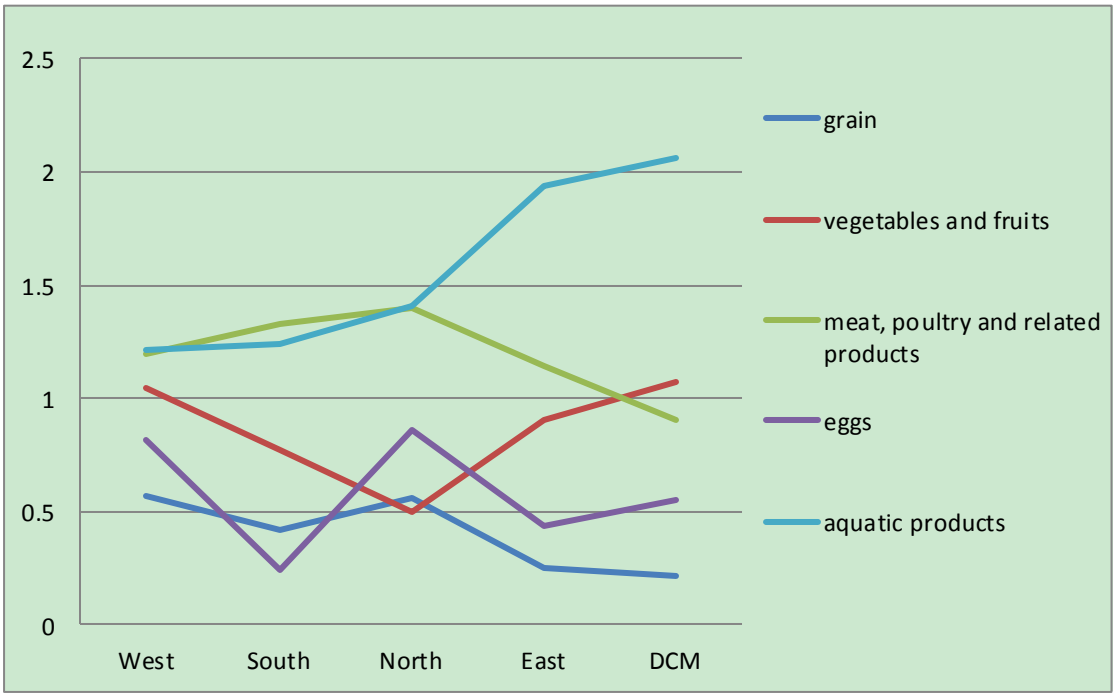

Figure 4 Trend of estimated expenditure elasticities
(sorted by regions with different income levels)

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Appendix A

Table 5 Budget share of each food category

National average expenditure (1995-2011)

Item / Year	grain	vegetables and fruits	meat, poultry and related products	eggs	aquatic products
1995	0.212	0.154	0.338	0.057	0.098
1996	0.208	0.158	0.336	0.060	0.101
1997	0.183	0.157	0.353	0.056	0.108
1998	0.181	0.157	0.343	0.053	0.113
1999	0.176	0.159	0.333	0.053	0.117
2000	0.159	0.162	0.347	0.048	0.121
2001	0.158	0.163	0.347	0.048	0.127
2002	0.148	0.165	0.353	0.046	0.132
2003	0.143	0.174	0.348	0.045	0.125
2004	0.158	0.170	0.349	0.045	0.118
2005	0.152	0.173	0.355	0.045	0.119
2006	0.151	0.183	0.335	0.041	0.124
2007	0.140	0.176	0.355	0.042	0.123
2008	0.137	0.171	0.374	0.038	0.117
2009	0.137	0.184	0.357	0.038	0.124
2010	0.147	0.191	0.348	0.037	0.125
2011	0.146	0.176	0.368	0.039	0.118

North

Test results with theoretical restrictions

Independent variables	grain	vegetables and fruits	meat, poultry and related products	eggs	aquatic products
dlnp1	-0.081262	0.037573	0.034910	0.0067651	-0.012464
	(-7.3004)*	(3.238)*	(2.8817)*	(1.3186)	(-1.6213)
dlnp2	0.017525	-0.11919	0.062859	0.014122	0.013403
	(1.8441)	(-12.22)*	(6.0774)*	(3.2239)*	(2.0420)*
dlnp3	0.047348	0.031430	-0.15765	0.036603	0.025487
	(6.0390)*	(3.369)*	(-18.475)*	(10.129)*	(4.7068)*
dlnp4	0.0053967	0.0017274	0.023364	-0.048125	0.013104
	(0.68646)	(0.2277)	(2.7306)*	(-13.281)*	(2.4134)*
dlnp5	0.010992	-0.0022940	0.036519	-0.0093644	-0.039530
	(1.5338)	(-0.3331)	(4.6823)*	(-2.8351)*	(-7.9871)*
dlnQ	-0.11101	-0.11058	0.14584	-0.010097	0.035990
	(-6.3963)*	(-4.703)*	(7.7206)*	(-1.2621)	(3.0025)*
y96to00	-0.13125	0.050315	0.077487	-0.0039523	0.050416
	(-11.005)*	(2.736)*	(5.9698)*	(-0.71900)	(6.1208)*
y01to11	-0.12637	0.053501	0.075768	-0.0059316	0.050667
	(-10.961)*	(2.753)*	(6.0381)*	(-1.1162)	(6.3629)*
Intercept	0.12123	-0.050481	-0.070764	0.0048663	-0.048361
	(11.04)*	(-2.806)*	(-5.921)*	(0.9614)	(-6.376)*
R-square	0.9216	0.7684	0.9191	0.8481	0.7397
Durbin-Watson	2.2076	2.5309	2.2011	2.3236	2.3341

Note: * indicates significance at 5% level.

Estimated Hicksian own price elasticity and cross price elasticity (CBS)

Quantity demanded from	E_{ij}^{*} (price elasticities)				
	E_{i1}^{*}	E_{i2}^{*}	E_{i3}^{*}	E_{i4}^{*}	E_{i5}^{*}
	grain	vegetables and fruits	meat, poultry and related products	eggs	aquatic products
grain	-0.31995	0.069003	0.18642	0.021248	0.043277
P-value	0.00000	0.06517	0.00000	0.49242	0.12507
vegetables and fruits	0.17023	-0.53998	0.14239	0.0078258	-0.010393
P-value	0.00120	0.00000	0.00076	0.81991	0.73905
meat, poultry and related products	0.095451	0.17187	-0.43105	0.063881	0.099849
P-value	0.00396	0.00000	0.00000	0.00632	0.00000
eggs	0.095090	0.19849	0.51449	-0.67645	-0.13163
P-value	0.18731	0.00126	0.00000	0.00000	0.00458
aquatic products	-0.14099	0.15161	0.28829	0.14823	-0.44714
P-value	0.10495	0.04115	0.00000	0.01580	0.00000

East

Test results with theoretical restrictions

Independent variables	grain	vegetables and fruits	meat, poultry and related products	eggs	aquatic products
dlnp1	0.085937	-0.064682	-0.8004989	0.011667	-0.024424
	(6.7589)*	(-5.422)*	(-0.46045)	(1.3590)	(-1.1695)
dlnp2	-0.032718	0.039463	-0.029180	-0.0097325	0.032168
	(-3.6438)*	(4.685)*	(-2.2387)*	(-1.6052)	(2.1811)*
dlnp3	0.0030846	0.018599	0.078032	0.0013229	-0.10104

	(0.24332)	(1.564)	(4.2400)*	(0.15453)	(-4.8522)*
dlnp4	-0.00071570	-0.0069042	-0.0096137	0.0039582	0.013275
	(-0.89093E-01)	(-0.9161)	(-0.82438)	(0.72970)	(1.0061)
dlnp5	-0.011116	-0.00080810	-0.032511	-0.0078220	0.052258
	(-2.6614)*	(-0.2062)	(-5.3618)*	(-2.7734)*	(7.6170)*
dlnQ	0.051381	0.064058	-0.026003	-0.034626	-0.054810
	(2.5565)*	(3.397)*	(-0.89121)	(-2.5515)*	(-1.6603)
Y96TO00	-0.12764	0.037957	0.049959	-0.017905	0.057632
	(-8.0501)*	(2.552)*	(2.1704)*	(-1.6724)	(2.2129)*
Y01TO11	-0.12749	0.043916	0.043690	-0.018131	0.058018
	(-7.3904)*	(2.713)*	(1.7446)	(-1.5565)	(2.0475)*
Intercept	0.12043	-0.039040	-0.042983	0.016850	-0.055253
	(7.571)*	(-2.616)*	(-1.862)	(1.569)	(-2.115)*
R-square	0.8170	0.4727	0.5105	0.3667	0.6193
Durbin-Watson	2.3960	2.3572	2.5929	2.0245	2.0247

Note: * indicates significance at 5% level.

Estimated Hicksian own price elasticity and cross price elasticity (Rotterdam)

Quantity demanded from	E_{ij}^{*} (price elasticities)				
	E_{i1}^{*}	E_{i2}^{*}	E_{i3}^{*}	E_{i4}^{*}	E_{i5}^{*}
	grain	vegetables and fruits	meat, poultry and related products	eggs	aquatic products
grain	-0.26476	-0.25365	-0.021205	0.24261	0.045965
P-value	0.00000*	0.00000*	0.61776	0.00000*	0.14162
vegetables and fruits	0.11173	-0.60005	0.45328	-0.085473	0.013554
P-value	0.01992	0.00000*	0.00000*	0.00454*	0.71568
meat, poultry and	0.09156	0.17950	-0.31617	0.037339	0.055031

related products					
P-value	0.00010*	0.00000*	0.00000*	0.01936	0.00529*
eggs	0.57387	-0.070704	0.29985	-1.1728	-0.028404
P-value	0.00000*	0.25026	0.00083*	0.00000*	0.66699
aquatic products	-0.25055	0.49211	0.12716	0.14231	-0.16259
P-value	0.00016	0.00000	0.06943	0.00065*	0.00161*

South

Test results with theoretical restrictions

Independent variables	grain	vegetables and fruits	meat, poultry and related products	eggs	aquatic products
dlnp1	-0.082481	-0.030619	0.053139	0.0045968	0.055364
	(-9.9913)*	(-3.006)*	(3.0481)*	(0.93879)	(5.5897)*
dlnp2	-0.00087255	-0.082891	0.0052209	0.0071036	0.071439
	(-0.16554)	(-12.75)*	(0.46904)	2.2721*	11.297*
dlnp3	0.016836	0.013299	-0.051391	0.0045327	0.016723
	(3.3343)*	(2.135)*	(-4.8194)*	(1.5134)	(2.7605)*
dlnp4	0.015989	0.027517	0.023282	-0.035632	-0.031155
	(2.9928)*	(4.174)*	(2.0635)*	(-11.2448)*	(-4.8605)*
dlnp5	-0.0022897	0.021482	0.052147	0.018014	-0.089353
	(-0.27015)	(2.054)*	(2.9135)*	(3.58328)*	(-8.7869)*
dlnQ	0.075548	0.14919	0.60155	0.010610	0.16310
	(6.1913)*	(9.909)*	(23.344)*	(1.4658)	(11.140)*
Y96TO00	-0.031456	0.056707	0.044309	0.014830	-0.084391
	(-2.9921)*	(4.372)*	(1.9958)*	(2.3783)*	(-6.6905)*
Y01TO11	-0.022928	0.062322	0.039248	0.010545	-0.089187
	(-1.9479)	(4.291)*	(1.5789)	(1.5103)	(-6.3154)*
Intercept	0.023772	-0.057748	-0.038663	-0.011015	0.083653

	(2.221)*	(-4.372)*	(-1.710)	(-1.735)	(6.514)*
R-square	0.8421	0.8218	0.9311	0.7425	0.8621
Durbin-Watson	2.7247	2.2475	2.4645	1.5986	2.3513

Note: * indicates significance at 5% level.

Estimated Hicksian own price elasticity and cross price elasticity (Rotterdam)

Quantity demanded from	E_{ij}^{*} (price elasticities)				
	E_{i1}^{*}	E_{i2}^{*}	E_{i3}^{*}	E_{i4}^{*}	E_{i5}^{*}
	grain	vegetables and fruits	meat, poultry and related products	eggs	aquatic products
grain	-0.46272	-0.0048951	0.094448	0.089697	-0.012845
P-value	0.00000	0.86852	0.00086	0.00276	0.78704
vegetables and fruits	-0.15740	-0.42611	0.068366	0.14145	0.11043
P-value	0.00265	0.00000	0.03279	0.00003	0.00000
meat, poultry and related products	0.11764	0.011559	-0.11377	0.051543	0.03996
P-value	0.00230	0.63904	0.00000	0.03906	0.00357
eggs	0.10475	0.16188	0.10329	-0.81197	0.41049
P-value	0.34784	0.02308	0.13017	0.00000	0.00034
aquatic products	0.42056	0.54266	0.12703	-0.23666	-0.67874
P-value	0.00000	0.00000	0.00577	0.00000	0.00000

West

Test results with theoretical restrictions

Independent variables	grain	vegetables and fruits	meat, poultry and related products	eggs	aquatic products
dlnp1	-0.098585	0.050272	0.033059	0.019244	-0.0039902
	(-7.0300)*	(3.197)*	(1.9560)	(3.7455)*	(-0.76566)
dlnp2	0.036986	-0.18337	0.11672	0.010810	0.018861
	(5.4406)*	(-24.06)*	(14.245)*	(4.3401)*	(7.4656)*
dlnp3	0.036838	0.069749	-0.13427	0.010326	0.017352
	(4.2573)*	(7.189)*	(-12.875)*	3.2571*	5.3963*
dlnp4	0.013486	0.0067769	0.010618	-0.038864	0.079838
	(1.9766)*	(0.8859)	(1.2913)	(-15.548)*	(3.1489)*
dlnp5	0.018404	0.013976	0.019224	-0.0026861	-0.048917
	(3.7610)*	(2.547)*	(3.2597)*	(-1.4983)	(-26.901)*
dlnQ	-0.098696	0.010957	0.085990	-0.0094959	0.011245
	(-3.9266)*	(0.3888)	(2.8386)*	(-1.0312)	(1.2038)
Y96TO00	-0.080943	0.070256	0.0048815	-0.0048453	0.010650
	(-5.2930)*	(4.097)*	(0.26486)	(-0.86482)	(1.8741)
Y01TO11	-0.077660	0.075142	-0.00095372	-0.0071474	0.010619
	(-4.7001)*	(4.056)*	(-0.047892)	(-1.1807)	(1.7294)
Intercept	0.073914	-0.069700	-0.000068745	0.0056578	-0.0098037
	(4.877)*	(-4.102)*	(-0.003764)	(1.019)	(-1.741)
R-square	0.9477	0.9884	0.9611	0.9219	0.9382
Durbin-Watson	2.1952	2.4842	2.6019	2.7015	2.2497

Note: * indicates significance at 5% level.

Estimated Hicksian own price elasticity and cross price elasticity (CBS)

Quantity demanded from	E_{ij}^{*} (price elasticities)				
	E_{i1}^{*}	E_{i2}^{*}	E_{i3}^{*}	E_{i4}^{*}	E_{i5}^{*}
	grain	vegetables and fruits	meat, poultry and related products	eggs	aquatic products
grain	-0.42623	0.15991	0.15927	0.058305	0.079567
P-value	0.00038	0.00000	0.00002	0.04809	0.00017
vegetables and fruits	0.21931	-0.79995	0.30428	0.029564	0.060969
P-value	0.00139	0.00000	0.00000	0.37568	0.01086
meat, poultry and related products	0.076509	0.27012	-0.31074	0.024573	0.044490
P-value	0.05047	0.00000	0.00000	0.19661	0.00112
eggs	0.36279	0.20379	0.19467	-0.73268	-0.050640
P-value	0.00018	0.00001	0.00113	0.00000	0.13405
aquatic products	-0.073431	0.34709	0.31933	0.14692	-0.90021
P-value	0.44388	0.00000	0.25363	0.00164	0.00000

Direct controlled municipalities

Test results with theoretical restrictions

Independent variables	grain	vegetables and fruits	meat, poultry and related products	eggs	aquatic products
dlnp1	-0.077078	0.015474	0.027421	0.0027395	0.016237
	(-7.7249)*	(3.219)*	(2.8173)*	(0.91555)	(2.3448)*
dlnp2	0.0034735	-0.14339	0.069552	0.0038417	0.073126
	(0.71647)	(-42.36)*	(10.017)*	(2.4677)*	(13.913)*
dlnp3	0.027421	0.505932	-0.18857	0.022695	0.091729
	(2.8173)*	(7.149)*	(-11.037)*	(7.0817)*	(8.7413)*

dlnp4	0.0027395	0.0065973	0.022695	-0.038537	-0.00032038
	(0.91555)	(3.938)*	(7.0817)*	(-18.363)*	(-0.12060)
dlnp5	0.016237	0.042483	0.091729	-0.00032038	-0.12520
	(2.3448)*	(7.259)*	(8.7413)*	(-0.12060)	(-12.412)*
DLNQ	0.036801	0.23395	0.37414	0.031831	0.34901
	(1.9992)*	(16.78)*	(12.876)*	(5.1854)*	(16.158)*
Y96TO00	-0.062940	0.060257	0.075364	0.026799	-0.10148
	(-5.8083)*	(6.832)*	(4.0053)*	(7.5277)*	(-7.3894)*
Y01TO11	-0.057314	0.066391	0.072421	0.025898	-0.10762
	(-5.1635)*	(7.299)*	(3.9066)*	(7.0282)*	(-7.8998)*
Intercept	0.057627	-0.062294	-0.070039	-0.025366	0.10050
	(5.408)*	(-7.184)*	(-3.897)*	(-7.217)*	(7.633)*
R-square	0.8609	0.9870	0.8939	0.9186	0.9238
Durbin-Watson	2.2112	2.3892	2.5847	2.0392	2.3000

Note: * indicates significance at 5% level.

Estimated Hicksian own price elasticity and cross price elasticity (Rotterdam)

Quantity demanded from	E_{ij}^* (price elasticities)				
	E_{i1}^*	E_{i2}^*	E_{i3}^*	E_{i4}^*	E_{i5}^*
	grain	vegetables and fruits	meat, poultry and related products	eggs	aquatic products
grain	-0.46906	0.021138	0.16687	0.016671	0.098812
P-value	0.00000	0.47370	0.00484	0.35990	0.01904
vegetables and fruits	0.15794	-0.77215	0.24054	0.069099	0.090357
P-value	0.00004	0.00000	0.00000	0.00026	0.02122
meat, poultry and related products	0.066242	0.16802	-0.45554	0.054825	0.22159

P-value	0.00484	0.00000	0.00000	0.00000	0.00000
eggs	0.047102	0.066051	0.39020	-0.66258	-0.0055084
P-value	0.35990	0.01360	0.00000	0.00000	0.90401
aquatic products	0.095904	0.43191	0.54179	-0.0018923	-0.73947
P-value	0.01904	0.00000	0.00000	0.90401	0.00000

Appendix B

Expenditure elasticities from empirical researches on Chinese food demand

	Grain	Vegetables	Fruits	Meats	Eggs	Aquatic products
Gao et al (1996)	0.52	1.26	0.72	0.29-1.15	0.91	0.89
Fan and Chern (1997)	0.27	0.72	1.60	1.06	1.85	N/A
Zhang and Wang (2003)	1.18	1.11	0.96	0.83	1.04	1.05
Yen et al (2004)	0.82	0.83	0.60	0.94-1.41	0.77	1.41
Gould and Villarreal (2006)	0.75-1.16	0.95	0.85	1.18-1.20	0.92	1.40
Liao and Chern (2007)	0.54-1.36	0.74-1.13	0.80-1.07	0.77-1.34	0.85-0.98	0.83-1.34
Zheng and Henneberry (2009)	0.80	0.81	0.98	1.00-1.04	0.82	1.20
Dong and Fuller (2010)	0.78	0.48	1.05	1.23	0.81	1.63
Zheng and Henneberry (2012)	0.80	0.95	0.76	1.14-1.21	0.87	1.25

Note: Gao et al (1996) use household data (1990) of Jiangsu province. Fan and Chern (1997) use provincial panel data (1985-1990) of 28 provinces. Zhang and Wang (2003) use household data (1998) of 226 cities. Yen et

al (2004) use household data (2000) of 30 cities. Gould and Villarreal (2006) use household data (2001) of 5 provinces. Liao and Chern (2007) use provincial panel data (2002-2003) of 4 provinces. Zheng and Henneberry (2009) use household data (2004) of Jiangsu province. Dong and Fuller (2010) use urban household panel data (1981-2004). Zheng and Henneberry (2012) use household data (2004) of Jiangsu province.