Household Food Demand Analysis in Rural China:

Implications for Food Imports

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Introduction

Prior to1978, production and distribution of China's agricultural products were controlled by rigid central planning in the People's Republic of China. This commune system limited the exchange of goods and services in the rural economy (Fan, Wailes and Cramer, 1995). Trade among regions was discouraged and market exchanges among households within local economies were restrained (Walker, 1984).

In 1978, China initiated fundamental economic reforms in the agricultural sector which significantly increased agricultural production and rural household consumption (Gao, Wailes, and Cramer, 1996a). Extensive changes in rural policy began at the end of 1978 and market-oriented reforms influenced rapid growth in all key sectors of agriculture (Yifu Lin, 1992). During the first phase of the reform from 1978-1984, the standard of living for the average Chinese rural family increased significantly so that in 1990, it was more than double that of 1978 (Gao, Wailes, and Cramer, 1996). The structure of China's food expenditure has been changed due to its rapid income growth. With an increase of real per-capita income at 7.1% per year, rural households increased their consumption of rice, wheat, pork, fish, poultry, fruit, and eggs, while consumption of coarse grains decreased (Gao, Wailes, and Cramer, 1996). During the period from 1979-1990, consumption of rice and vegetables slightly changed, while wheat consumption increased more than 20 kilograms per person and meat consumption rose rapidly, almost doubling. Consumption of fine grains started decreasing in the 1990s because these grains had become an inferior good for China's rural households (Huang and Rozelle, 1998). One of the

major changes in the consumption pattern of rural households was the increase in housing expenditures (Fan, Cramer and Wailes, 1995).

Since market reforms in 1978, China has transitioned from a rigid central planning to a socialist market economy (White, Howell, and Shang, 1996). These reforms had substantial effects on rural household food demand and consumption behavior in China. China's population has more than 40% rural residents; therefore, changes in the consumption pattern of China's rural population can have a significant impact on both domestic and international food and agricultural trade. As China grows, Chinese population differentiate their diets away from rice and wheat flour, to one that consists of more livestock products (Gould, 2002).

As China's population grows, it is to be expected that its import demand for food would rise, while its land/labor ratio would decline (Ahmadi-Esfahani, 1998). Today, China is an upper middle-income country and the second largest economy with an average GDP growth of nearly 10% a year and a population of 1.3 billion (The World Bank, 2017). China's rapid income growth indicates that its demand for food is rising faster than its production capability (Gale, Hansen, and Jewison, 2014). This information has significant implications for China's agricultural and food sector and for international trade in agricultural products. China represents an important global trader of agricultural commodities and is increasingly playing an important and influential role in global agricultural markets. This role become more visible since China joined the World Trade Organization (WTO) in 2001 and when barriers to agricultural imports were lowered. According to the United States Department of Agriculture (USDA) report, the United States accounted for over 24% of the value of China's agricultural imports during 2012-2013, while U.S. agricultural sales to China doubled from 2008 to 2012 (Gale, Hansen, and

Jewison, 2014). The USDA forecasts continued growth in Chinese agricultural imports through 2023.

As income in China continuously grows, consumption patterns change, it is to be expected that China would increase either meat imports or feed grain imports to increase animal production (Fan, Wailes and Cramer, 1995). China would turn to international meat markets to satisfy its food needs, instead of importing grain as feed (Huang et al., 1999). If China imported a quantity of meat equal to 10% of its 2000 meat demand, grain net imports in 2020 could be reduced to 6 MMT from the baseline of 30 MMT (Huang, Rozelle and Rosegrant, 1999). If China selects to buy meat on global markets, that would reduce projected feed grain imports. China is the world's largest producer and largest consumer of cereal grains, thus, the supply and demand of grain in China will impact the world food trade significantly.

The main objective of this study is to quantitatively evaluate Chinese rural household food demand elasticities and discuss the potential of food import in China. Expenditure, consumption, and consumer price indices used in this study were obtained from the Chinese National Bureau of Statistics (NBS). A pooled time-series and cross-section data, which included China's rural households from thirty provinces (autonomous regions or municipalities), during the period 2007-2016, were used in this analysis. A complete demand system of Chinese rural households was estimated using the Almost Ideal Demand System (AIDS) model.

Literature Review

Numerous previous studies have examined the food consumption in China at provincial, regional, and national level, including: Chow (1984), Van der Gaag (1984), Yang, (1985), Li, Yang and He (1985), Carter and Zhong (1988), Lewis and Andrews (1989), Halbrendt and

Gempesaw (1990), Peterson, Lan and Ito (1991), Huang and David (1993), Fan, Cramer and Wales (1994), Samuel (1994), Wu, Li and Samuel (1995), Fan, Wailes and Cramer (1995), Han, Cramer and Wahl (1997), Gao, Wailes and Cramer (1996a), etc.

To evaluate consumption patterns in rural households, the early studies of household demand in China utilized the Engel function and Linear Expenditure Systems (LES) (Chow, 1984; Van der Gaag, 1984; Li, Yang and He, 1985). Van der Gaag (1984) calculated income elasticities for food, housing, and clothing, and projected consumption based on the Engel Curve using data from 1981-1982. The results indicated that an increase in per capita income would affect the consumption patterns. Yang (1985) used the national income to derive personal income per capita, which in his opinion, determines an individual's consumption. Carter and Zhong (1988) estimated the consumption function for rural and urban households and specified per capita consumption levels. However, their models disregarded income-in-kind payments, the impact of government rationing policy and the impact of government subsidies.

Lewis and Andrews (1989) used the pooled time-series and cross-sectional data from China's urban and rural household surveys for the period from 1982-1985. They assessed the household expenditures and income elasticities by applying a Linear Expenditure System (LES) to rural household demand and the extended LES to urban household demand. The results of their study indicated that the demand for food and non-commodities such as water, rent, power, transportation, telecommunications, posts, school fees, and child care is inelastic with respect to income and expenditure.

Halbrendt and Gempesaw (1990) obtained data on China's total wheat consumption from China's State Statistical Bureau and the USDA for the period 1960-1987. They utilized Ordinary

Least Square (OLS) to calculate price elasticities and estimate consumption equations. The results showed that price elasticities varied from -0.2 to -0.055. Peterson, Lan and Ito (1991) used OLS model to estimate rice consumption in China from 1960 to 1986. They concluded that the reforms had a significant impact on a rise in per capita rice consumption.

In the 1990s, researchers started analyzing household demand and consumption in China by applying the AIDS model. Huang and David (1993) used an LA/AIDS model to estimate the effect of urbanization on the demand for rice, wheat and coarse grains in several Asian countries including China. They found that effect of urbanization was not significant in China.

To estimate various food demand parameters for Chinese rural households, Fan, Cramer and Wailes (1994) utilized a dynamic AIDS model. They used rural household survey data released by the China State Statistical Bureau from 1982 to 1990. The results of this study indicated that all major food commodities such as: rice, wheat, coarse grains, vegetables, meat, tobacco and alcohol had positive expenditure elasticities. Necessities include rice, wheat, and coarse grains, while meat, vegetables, alcohol and tobacco represent luxuries. Furthermore, the results indicated a decrease in expenditure elasticities for rice, coarse grains and an increase for wheat, meat, vegetables and alcohol. This study concluded that, to avoid food shortages, China should continue to increase its food production by a greater rate in the future. Samuel (1994) estimated the effect of demographic factors and household income on consumption of processed food. The results indicated that income and age of household members would have an impact on food consumption.

Wu, Li and Samuel (1995) used an LA/AIDS model to estimate consumption patterns of urban households in thirty-three Chinese cities. They found that China had high-income elasticities for

fruit, vegetables and pork, which implies that with income growth, demand for these products will shift significantly.

Fan, Wailes and Cramer (1995) pooled provincial and time-series data from 1982 to 1990 and applied a two-stage LES-AIDS model to estimate a complete demand system of Chinese rural households. In the first stage, total expenditure was allocated over a broad group of commodities including food, clothing, fuel, housing, and other. In the second stage, group expenditures were allocated over individual commodities, which in this case were specific food commodities such as grain, meat, vegetables, etc. Results from this study showed that expenditure elasticities were lower for grains and higher for meat, tobacco, and alcohol. This study indicated that there was a gap between food demand and supply and hence, concluded that China would face pressure to import food.

Han, Cramer and Wahl (1997) estimated China' rural household demand with special emphasis on changes in demand for food commodities across different income groups by using a two-stage LES-LA/AIDS model. Data used in this study came from China's National Rural Household sample survey in 1993. The results demonstrated that own-price elasticity for food is more elastic than that for clothing, housing, durable goods, and other items. Within the food group, wheat and coarse grains are still important staple foods for the average rural household with an expenditure elasticity of almost unity. They also found that meat is the most price elastic among non-staple foods. Gao et al. (1996b) utilized a differential Rotterdam mixed-demand system to estimate China's urban household food demand and consumer behavior.

From the summary of the literature review, it is noticeable that earlier studies have made a significant contribution to having better insights on China's food consumption patterns.

However, researchers have noted that the findings of earlier studies are to some extent "outdated", thus variables such as income and price elasticities derived using old data are not adequate for understanding China's current food consumption (Zhou et al., 2012). This study aims to fill this gap in the literature review and calculate parameters including price and income elasticities using the most recent data on food consumption in China for the period from 2007 to 2016.

Data and Methods

This study utilizes pooled time-series and cross-section data for rural China, for the period from 2007 to 2016. Thirty provinces (autonomous regions or municipalities) were included in the analysis and Tibet was excluded due to missing data. Data on expenditure, food consumption, and the provincial consumer price indices for each commodity (grain, oil, meat, egg, aquatic, and vegetable) are obtained from the Chinese National Bureau of Statistics (NBS), and total contains 300 observations.

AIDS Model

A complete demand system of Chinese rural households is estimated using the Almost Ideal Demand System (AIDS) model, developed by Deaton and Muellbauer. The share equation for AIDS model is as follows:

$$W_i = \alpha_i + \sum_j \gamma_{ij} \ln p_j + \beta_i \ln \frac{E}{P} \quad (1)$$

where W_i is the budget share of good i and p_j is the price of commodity j. E is the total expenditure, and P is the price index. The γ_{ij} and β_i are parameters to be estimated.

$$\ln P = \alpha_0 + \sum_i \alpha_i \ln p_i + \frac{1}{2} \sum_i \sum_j \gamma_{ij} \ln p_i \ln p_j \quad (2)$$

The restrictions are as follows:

$$\sum_i \alpha_i = 1 \quad (3)$$

$$\sum_i \beta_i = 0 \quad (4)$$

$$\sum_i \gamma_{ij} = 0 \text{ (adding up)} \quad (5)$$

$$\sum_i \gamma_{ij} = 0 \text{ (homogeneity)} \quad (6)$$

$$\gamma_{ij} = \gamma_{ji} \text{ (symmetry)} \quad (7)$$

The uncompensated price elasticity of commodity *i* with respect to commodity *j*'s price is as follows:

$$\varepsilon_{ij} = -\sigma_{ij} + \frac{\gamma_{ij}}{w_i} - \frac{\beta_i \alpha_j}{w_i} - \frac{\beta_i}{w_i} \sum_j \gamma_{ij} \ln p_j \quad (8)$$

Where $\sigma_{ij} = 1$ if $i = j$, and $\sigma_{ij} = 0$ otherwise. The expenditure elasticity is:

$$\eta_{ij} = \frac{\beta_i}{w_i} + 1 \quad (9)$$

The compensated price elasticity can be calculated as:

$$\varepsilon_{ij} *= \varepsilon_{ij} + \eta_i w_j \quad (10)$$

Results

Six commodities are included in estimation of the China's rural household food demand system. These commodities are: grain, oil, meat, eggs, aquatic products, and vegetables. A descriptive summary of these commodities' consumer price indices and consumption is listed in the Appendix Table 1. Since the demand system in this study includes a group of demand equations, the Seemingly Unrelated Regression (SUR) approach is used to conduct the estimation in SAS 9.4. Even though parameters estimated in the LA/AIDS model do not have direct economic interpretation, these parameters are the bases for calculating elasticities. All estimated parameter values and their statistical significance are listed in Appendix Table 2. The Lagrangian Multiplier test is used to test for heteroscedasticity, and the Breusch-Godfrey test is used to test for autocorrelation. Both tests are rejected at 5% significance level, indicating the absence of heteroscedasticity and autocorrelation.

Elasticities

The estimates of own-price elasticities, cross price elasticities, and expenditure elasticities of the six food commodities are listed in the Appendix Table 3 (uncompensated price elasticities and expenditure elasticities) and Table 4 (compensated price elasticities and expenditure elasticities). Most of the coefficients are significant at the 5% level.

The own-price elasticity measures the reaction of quantity demanded for a good with respect to its own price change. As shown in Tables 3 and 4, own-price elasticity of each food commodity is negative with an absolute value between 0 and 1, indicating that the estimated elasticity is inelastic.

The cross-price elasticities measure the responsiveness of the quantity of a good demanded with respect to the price change of another good. A positive cross-price elasticity indicates the two

goods are substitutes, and a negative cross-price elasticity implies the two goods are complements. Most of the cross-price elasticities in this study indicate positive signs, which is consistent with previous studies of Fan, Wailes and Cramer (1995), implying that major food items are substitutes. Grain is a complement to oil, eggs, and vegetables, as showed by the negative cross-price elasticities.

The expenditure elasticity for each food commodity indicates that all the commodities are normal goods and most of them are necessities. Aquatic products have the highest expenditure elasticities, which may be due to high prices of these products in some of the inland provinces in China.

Conclusion and Discussion

Numerous studies estimated and forecasted the overall Chinese demand of food, however, few studies focused specifically on the Chinese rural household food demand. Studies conducted by Fan, Wailes, and Cramer (1995) and Han, Cramer, and Wahl (1997) discussed the Chinese rural household demand. However, they used data prior to the year 2000.

This research used an AIDS model to estimate Chinese rural household food commodities' price elasticities by using pooled data during the 2007 to 2016 period. The demand of all food commodities (grain, oil, meat, eggs, aquatic products, and vegetables) is inelastic and the expenditure elasticities indicate that most of the goods are necessities. The cross-price elasticity between grain and meat indicates they are substitutes. Although the Engel's coefficients have shown that the Chinese expenditure on food in both urban and rural areas are declining, the food consumption preference is shifting from grain and vegetables to more animal protein. The meat own-price elasticity in this study indicates that a 1% decrease of meat price would increase the Chinese rural household meat consumption by 14.9%. Moreover, the expenditure elasticity of

meat implies that a 1% increase in consumer's income would result in a 77.3% increase in the rural household meat consumption. According to the China's NBS data, the per capita rural household income had increased from 4,140.36 yuan to 12,363.4 yuan, which almost tripled in ten years from 2006 to 2016. Furthermore, Chinese rural residents were reported as approximately 590 million and accounted for 42.65% of the total population, according to the Chinese NBS. Given the rapidly increasing income and the large population, the Chinese rural residents could potentially increase the meat consumption. As Brown (1995) discussed in his book, China would face the pressure of importing either meat or feed grain due to the limitation of arable land and resources. Currently, not only the income is rapidly growing but eating habits of both urban and rural residents in China are changing, and this could result in a significant increase in demand for meat in the future. The international meat markets are good resources to satisfy the increasing meat demand in China, especially the US exports, which have a price advantage compared to its meat exporting competitors such as Brazil and Australia.

Appendix

Table 1. Summary Statistics for Data Used to Estimate the LA/AIDS Model

Variable	Mean	Standard Deviation	Minimum	Maximum
Price index of grain	105.894	4.328	99.000	120.776
Price index of oil	105.203	13.656	73.992	147.487
Price index of meat	109.641	12.425	86.702	142.015
Price index of eggs	105.338	8.536	85.300	128.895
Price index of aquatic products	106.237	5.157	95.262	124.997
Price index of vegetables	108.899	7.032	92.200	137.487
Quantity of grain (kg)	172.885	28.288	99.370	254.95
Quantity of oil (kg)	7.834	2.667	2.280	16.039
Quantity of meat(kg)	17.709	7.122	5.010	36.204
Quantity of eggs (kg)	6.013	3.198	0.550	15.484
Quantity of aquatic products (kg)	6.353	5.594	0.280	22.194
Quantity of vegetables (kg)	80.688	35.319	0.300	168.250

Table 2. Parameter estimates of food items

Commodity	γ_{i1}	γ_{i2}	γ_{i3}	γ_{i4}	γ_{i5}	γ_{i6}	β_i	α_i
Grain	0.572***						-0.305***	1.466***
	(0.099)						(0.027)	(0.277)
Oil	0.021	0.016**					-0.027***	0.452***
	(0.017)	(0.009)					(0.004)	(0.075)
Meat	-0.097***	-0.002	0.057***				-0.014	0.133
	(0.033)	(0.012)	(0.021)				(0.009)	(0.126)
Eggs	-0.010	0.034***	0.005	-0.032**			-0.021***	0.477***
	(0.026)	(0.008)	(0.013)	(0.015)			(0.006)	(0.090)
Aquatic	-0.133***	-0.013	-0.025	0.060***	0.120***		-0.012**	-0.183
	(0.035)	(0.012)	(0.017)	(0.015)	(0.029)		(-0.007)	(0.136)
Vegetables	-0.188**	-0.047***	0.064***	-0.082***	0.049***	0.089	0.378***	-1.344***
	(0.064)	(0.011)	(0.021)	(0.016)	(0.018)	(0.059)	(0.024)	(0.196)

Note: Numbers in parentheses are standard errors. ***Significant at the 1% level. ** Significant at the 5% level. *Significant at the 10% level.

Table 3. Uncompensated price elasticities and expenditure elasticities

	Grain	Oil	Meat	Egg	Aquatic	Vegetables
Grain	-0.112**					
	(0.042)					
Oil	-0.721**	-0.137***				
	(0.245)	(0.046)				
Meat	0.350**	0.534*	-0.149***			
	(0.152)	(0.297)	(0.048)			
Eggs	-0.714***	0.023	0.377	-0.130***		
	(0.253)	(0.314)	(0.229)	(0.062)		
Aquatic	0.122	0.114	0.254*	0.513***	-0.428***	
	(0.262)	(0.307)	(0.157)	(0.079)	(0.107)	
Vegetables	-0.582**	-1.340***	0.923***	-0.638***	0.146 ***	-0.612***
	(0.286)	(0.317)	(0.141)	(0.077)	(0.024)	(0.213)
Expenditure Elasticities	0.475***	0.402***	0.773***	0.431	1.168	0.228***
	(0.047)	(0.091)	(0.149)	(0.435)	(2.477)	(0.080)

Note: Numbers in parentheses are standard errors. ***Significant at the 1% level. ** Significant at the 5% level. *Significant at the 10% level.

Table 4. Compensated price elasticities and expenditure elasticity

	Grain	Oil	Meat	Egg	Aquatic	Vegetables
Grain	-0.148***					
	(0.041)					
Oil	-0.742**	-0.155***				
	(0.245)	(0.036)				
Meat	0.379**	0.559*	-0.196***			
	(0.152)	(0.296)	(0.044)			
Eggs	-0.721***	0.029	0.388*	-0.132***		
	(-0.253)	(0.313)	(0.228)	(0.016)		
Aquatic	0.123	0.116	0.251*	0.513***	-0.428**	
	(0.232)	(0.307)	(0.156)	(0.079)	(0.107)	
Vegetables	-0.442**	-1.222***	1.150***	-0.651***	0.137***	-0.612***
	(0.192)	(0.320)	(0.168)	(0.080)	(0.028)	(0.120)
Expenditure Elasticity	0.486***	0.492***	0.821***	0.629	1.641	0.322***
	(0.054)	(0.137)	(0.249)	(0.62)	(0.438)	(0.013)

Note: Numbers in parentheses are standard errors. ***Significant at the 1% level. ** Significant at the 5% level. *Significant at the 10% level.

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