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MEAT CONSUMPTION PRACTICE IN CHINA: AN EMPIRICAL ANALYSIS BASED ON ELASTIC THEORY

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ABSTRACT

Meat consumption elasticity coefficient can reflect the processing traces of living standard. This paper analyzes these coefficients of urban and rural residents in China with the AIDS (Almost Ideal Demand System Model). Meat consumption structure of residents has begun to show signs of adjustment following their respective trajectories, which has been discussing in academic but lacks theoretical proof for decade years. Based on elastic theory, we have provided favorable evidence for this fact, and we found: (1) Elasticity coefficients show both urban and rural residents have been all sensitive to price, especially the city dwellers. The Urban residents is more sensitive to poultry than others. Rural residents have long been more interested in pork, though the mutton has been the trustiest. (2) Income and meat price are two main causes affect meat consumption, but there is no significant positive correlation between meat consumption and disposable income in Urban, different from Rural. With the income increasing, the kinds and quality of meat in basket of different residents are changing. (3) Furthermore, meat consumptions between urban and rural residents are not synchronized, and even sometimes the trends show the opposite directions because of income, habits, etc.

Keyword: Meat consumption, Elasticity, AIDS
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INTRODUCTION

Meat is vital to life for its irreplaceable energy, amino acids, proteins and so on. Pork, beef, mutton as well as poultry from chickens, ducks and geese are the main meat of human beings. Food reflects people's living conditions and standard (Eshetie, 2018). Meat is the main source of protein and fat from animals. The quality of different meat varies greatly in fiber and taste. However, meat not only brings nutrition, but also various diseases (Daniel *et al.*, 2011), such as cardiovascular and cerebrovascular diseases, so the threat alters when contains of meat basket changes. Moreover, meat production produce a lot of pollution, affecting the welfare of residents and the sustainable development of human beings (Rückert-John, 2017). So, the change in food consumption structure has always been widely concerned by scholars.

According to the Life Cycle Theory, the Permanent Income Hypothesis and Keynes's Consumption Theory, the Marginal Propensity to Consumption (MPC) of meat changes with the income. Low-income groups have a strong desire for meat in the process of income growth, and there is high income elasticity and price elasticity in demand of poultry meat, beef and mutton in rural (Yang *et al.*, 2018). However, when the income reaches to a certain level, preferences will change (Yin and Zang, 2009; Burggraf *et al.*, 2015), and the demand for meat will diversify, and their attention will gradually shift from quantity to quality, safety, and health (Yan and Hu, 2018). Therefore, the increase of income will inevitably transform residents' meat consumption. Some studies have found that the rate of consumption upgrade in low-income starting groups is slower than that in high-starting groups, and the meat consumption upgrade of urban residents is ahead of rural residents (Yan and Hu, 2018). With the economic development and the residents' income going up, the urban and rural residents' food consumption is decreasing, but the demand for animal production is enhancing now (Wang and Li, 2007). In addition, the differences of income gap, consumption structure and living habits are also important reasons for the differences in the optimization of meat consumption structure between urban and rural (Zang and Sun, 2003; Wang, 2015). Narrowing the income gap between urban and rural is the only way to achieve integration in China, which will inevitably lead to the food consumption upgrading, increase the demand for meat and optimize the meat consumption (Cong, 2013).

Research on consumers' meat choices is also a focus of academic interest. The quality of beef and mutton in nutritional value than pork and chicken, so the consumption of beef and mutton is bound to increase. However, the beef cattle and mutton sheep industries lag behind, which restricts the supply of beef and mutton. At the same time, cooking technology and product safety risks have seriously restricted the demand (Cheng *et al.*, 2015; Mao *et al.*, 2016). But the growing trend of pork in

the meat consumption in China is hard to change in a short time. The pork industry should be green, brand, and quality. There is much room for income growth of rural residents, optimization of market and consumption mode, so the household meat consumption remains promising (Yang*, et al.*, 2018). The total meat consumption in urban will continue to grow, but the structure transform has become the main direction, and more attention should be paid to quality, safety, nutrition and health (Yang*, et al.*, 2018).

Meat consumption in the developed countries provides precious references for China. The United States, Japan and other developed countries have also experienced a sustained growth stage, and there are a number of consumers turn to the higher quality of poultry, but red meat (including beef, mutton, and pork) is still dominated, accounting above 50% of the total consumption (Daniel*, et al.*, 2011). Since the AHA (American Heart Association) first recommended reducing dietary cholesterol, saturated fat, and total fat in the late 1950s to prevent cardiovascular disease, the intake of fat and meat (mainly from red meat) has been a public concern (Willett and Skerrett, 2017). According to the WCRF (World Cancer Research Foundation) and AICR (American Cancer Institute Report), the evidence linking red and processed meat to colorectal cancer is considered "compelling" and "limited or suggestive" for other cancer sites (WCRF and AICR, 2007). So, humans cannot consume meat without restriction. According to the recommendation of the DGE (the German Society for Nutrition), the daily average per capita meat is 64 grams, while the WCRF is 71 grams (WCRF and AICR, 2007; Rückert-John, 2017). Furthermore, the empirical research on meat consumption frequency of Dutch consumers shows that when the income reaches to a certain level, many people will turn into meat reducers, and the meat consumption frequency will decrease, at the same time, the flextime employees with mild, moderate and severe degree will take the lead (Dagevos and Voordouw, 2013). Therefore, the transformation of meat structure may be an inevitable trend for the residents of China in the future.

The existing researches have provided a solid theoretical and practical basis for our study. However, they focused on a certain aspect of the city or the countryside, from the perspective of nutrition, disease, or others, but paid little attrition to the combination of meat consumption and living standards, all of which results in not fully reflecting the current situation of the urban or rural residents in China. So, we invite the AIDS model to calculate and analysis the urban and rural elasticity coefficient, to find out the structural evolution of household meat consumption in China over the past 20 years, which is based on the Revealed Preference Theory, that is, the change of meat consumption status can show the gap in preference and change trajectory of urban and rural residents, as well as the gap in living standards between them to a certain extent through flexibility (Richter, 1966).

MATERIALS AND METHODS

Data and Material: To analyze the meat consumption of Chinese urban and rural residents, we introduce the data from China Statistical Yearbook and Chinese Animal Husbandry and Veterinary Yearbook. These data also have been widely used in the analysis, such as Duan (2018) using food consumption quantity data from the China Statistical Yearbook to analysis the Chinese residents' food consumption, and Ren *et al.* (2018) using the statistical yearbook data to analysis the time-space evolution law of urban residents' consumption structure and its application in demand model. The price data in the Chinese Animal Husbandry and Veterinary Yearbook is surveyed from 500 counties, which is very close to the actual consumption situation of Chinese residents. These data are released on the China Animal Husbandry Early Warning Information Network and China Animal Husbandry Information Network every week by the China Ministry Agriculture and Village. Chinese scholars have made a lot of academic analyses using these data, as Tian *et al.* (2016) and Mao *et al.* (2018) respectively analyzed the residents' meat consumption and the relationship between the meat prices. All the results are very close to the reality of China, which adds our confidence to build econometric models of urban residents and rural residents respectively for empirical analysis.

Since the consumption statistics in China's Statistical Yearbook are annual data, but the price data is weekly and monthly statistics, we should reduce the frequency of price series in accordance with statistical rules firstly. At the same time, we setting 2000 as the base period, the urban and rural price index is used to adjust the price data to the actual value. Besides, in order to avoid autocorrelation of the time series data, we should preprocess them before the model. Therefore, according to the time series analysis method, the index data used in the model are processed by first-order difference to eliminate the influence of autocorrelation of linear sequence and the synchronous correlation between data (Li and Fang, 2008; Hu *et al.*, 2014). In fact, in the process of the model, we also find that some index data do exist linear correlation. It is necessary to carry out differential processing. And then, all data are independent and stable. The ADF (Augmented Dickey-Fuller test) results of the series used in this study are shown in **Table 1**.

Table 1 The ADF test results of the series.

Series	Test type (C,T,K)	t-Statistic	Prob.*	Series	Test type (C,T,K)	t-Statistic	Prob.*
ω_b^U	C,0,0	-5.1959	0.0009***	ω_b^R	0,0,0	-4.5916	0.0001***
ω_p^U	C,0,2	-5.9482	0.0004***	ω_p^R	0,0,0	-3.3124	0.0026***
ω_m^U	C,0,0	-5.0016	0.0013***	ω_m^R	0,0,1	-6.4756	0.0000***
ω_p^U	0,0,1	-5.6227	0.0000***	ω_p^R	C,0,1	-6.8763	0.0001***
$ln\ p_b^U$	C,0,1	-3.3466	0.0310**	$ln\ p_b^R$	C,0,1	-3.3998	0.0281**
$ln\ p_p^U$	0,0,0	-4.5101	0.0002***	$ln\ p_p^R$	0,0,0	-4.7296	0.0001***
$ln\ p_m^U$	0,0,0	-2.2149	0.0298**	$ln\ p_m^R$	0,0,0	-2.2650	0.0268**
$ln\ p_p^U$	0,0,1	-5.1581	0.0001***	$ln\ p_p^R$	0,0,1	-5.4284	0.0000***
$\ln(x/p)^U$	0,0,1	-5.0620	0.0001***	$\ln(x/p)^R$	0,0,0	-3.7212	0.0010***

Note: C is the Constant, T is the Linear Trend，and K is the Lag Length. ***, ** and * indicate significance at 1%, 5 % and 10 % respectively. The meaning of the series' name is described in the next chapter when explain the model.

The results show that all series are stationary. The beef and mutton price series in urban and rural areas are stable at 5% level, and all other series are stable at 1% level. Therefore, there is no autocorrelation in all the sequences, so the data is suitable for analysis with the AIDS model.

Methods: The criteria for the model selection used in the study is the relative explanatory ability of practical problems, the consistency with economic theories and the realizability of computational estimates (Wang *et al.*, 1996). AIDS model, namely Almost Ideal Demand System, is an econometrics model developed by Deaton and Muellbauer by expanding the price variable part of Engel's coefficient theory to minimize expenditure at a given level of utility (Deaton and Muellbauer, 1980). The AIDS model is currently widely used in dietary composition research (Blanciforti and Green, 1983). At the same time, this mature model has been extended by many scholars in order to carry out empirical research. Sun and Su (2013) extended the model by introducing income transition factors, and Hu, *et al.* (2014) introduced the urban-rural income gap into the model based on relaxing the constraints of the model. These exploration and analysis led to research conclusions that were more consistent with China's reality. In this research, we invite this model for empirical analysis based on theoretical and practical considerations (Green and Alston, 1990), and considers the popularity of the analysis (Ray, 1980; Fulponi, 1989; Chen and Veeman, 1991; Wu *et al.*, 1995; Wang, *et al.*, 1996; Holt and Goodwin, 1997).

The AIDS demand function used in this study is as follows:

$$\omega_i = \alpha_i + \sum_{j=1} \gamma_i\ ln\ p_j + \beta_i ln\ \frac{x}{p} \quad (1)$$

Where: i and j are two items. ω_i is the proportion of the consumption expenditure of item i, p_j is the price of item j, x is the total consumption expenditure per capita, and p is the price index. γ_i is the effect of price change of item j to ω_i. The formula for calculating the p price index is as follows:

$$ln\ = \alpha_0 + \sum_{i-1} \alpha_i ln\ p_i + \frac{1}{2}\sum_i \sum_j b_i\ ln\ p_i ln\ p_j \quad (2)$$

For the sake of economic significance, the model must meet the following conditions (Deaton and Muellbauer, 1980) :

$$\sum_i \alpha_i = 1; \sum_i \beta_i = 0; \quad (3)$$

$$\sum_j \gamma_i\ = 1;\ \gamma_i\ = \gamma_j\ ;\ \sum_i \gamma_i\ = 0; \quad (4)$$

In order to reduce the difficulty of calculating price index p, stone proposed a simpler calculation method of price index in 1953 (Stone and Rowe, 1966), but this method also has a good estimation ability, and many scholars have used it to estimate price index (Blanciforti and Green, 1983). Stone's price index is commonly used instead of p, which is:

$$ln\ = \sum_i \omega_i ln\ _i \quad (5)$$

Where: p_i is price of the meat item, and p is a price index.

Given the above specifications, Marshallian (uncompensated) and Hicksian (compensated) price elasticities were computed from the estimated parameters of the AIDS model by the exact formulas developed by Green and Alston (Green and Alston, 1990). The economic implication of the Marshallian elasticity is that: The change in the demand for a good caused by a change in the price without changing the nominal income of the consumer. The Hicksian price elasticity refers to the reaction of demand to changes in price while keeping utility constant, which can be calculated by using Marshall price elasticity through Slutsky equation (Varian, 2014). Expenditure elasticity refers to the rate of change of commodity consumption caused by the rate of change of total consumption expenditure when prices remain unchanged, that is, when the total expenditure changes, how will the consumer demand for the goods change(Pawlowski and Breuer, 2012).

Marshallian price elasticities:

$$\delta_{ij} = \frac{d\ q_i}{d\ p_j} = \frac{d\ \omega_i}{d\ p_j} - \phi_i ,$$
$$= \frac{\gamma_{ij} - \beta_i \frac{d}{d\ p_j}}{\omega_i} - \phi_i ,$$
$$= \frac{\gamma_{ij} - \beta_i(\alpha_j + \sum_k \gamma_{kj} \ln p_k)}{\omega_i} - \phi_i ,$$
$$= \frac{\gamma_{ij} - \beta_i(\alpha_j + p_j)}{\omega_i} - \phi_i \quad (6)$$

Where: $p_j = \sum_k \gamma_{kj} \ln p_k$, ϕ is the *Korola* sign, $\phi_{ij} = 0, i \neq j; \phi_{ij} = 1, i = j$

Expenditure elasticities:

$$\varepsilon_i = 1 + \frac{\beta_i}{\omega_i} \quad (7)$$

Hicksian price elasticities:

$$\eta_{ij} = \left(\frac{\gamma_{ij} - \beta_i(\alpha_j + \sum_k \gamma_{kj} \ln p_k)}{\omega_i} - \phi_{ij}\right) + \omega_j\left(1 + \frac{\beta_i}{\omega_i}\right) = \delta_{ij} + \omega_j \varepsilon_i \quad (8)$$

RESULTS AND DISCUSSION

Parameter estimation is important in model analysis. Appropriate parameter estimation methods should be selected according to data characteristics and model characteristics. In previous researches on the composition and elasticity of food consumption, the OLS (Ordinary Least Squares) method, and the FGLS (Feasible Generalized Least Squares) method based on SUR (Sur Regression) model proposed by Zellner are used to estimate the parameters of time series data, panel data and cross-sectional data (Zellner, 1963; Liu *et al.*, 2009; Hu, *et al.*, 2014). When Hu, *et al.* (2014) studied the impact of income gap on consumption of urban and rural residents in China, he compared the difference between the results estimated by OLS regression and FGLS regression based on the mixed model. It was found there is no significant difference between the two methods. Moreover, according to the mathematical formula, when $E_{(i}u_i'u_j = \sigma_i^2 I$, $E_{(i}u_j' = 0$, $i \neq j$, the estimated results of the two methods were the same (Hsiao, 2014). Therefore, the parameter estimation method should be selected according to the feasibility of calculation and the practical analysis, too. So, we introduce OLS method to estimate the parameters in the AIDS models. The regression results are shown in **Table 2**.

The coefficients of the two separate models are shown in **Table 2**. The R-squared statistics indicate the fitting degree of the model is above 60%, an acceptable level. The Adjusted R-squared statistics also meet the statistical requirements. Durbin-Watson stat is around 2, statistically significant. The Prob(F-statistic) shows that all statistics are significant at the 1% level, but ω_m^U, ω_p^R and ω_b^R at 5%. On the whole, the models work well in explaining meat consumption behavior. Most of the coefficients reported statistically significant at the 1%, 5%, or 10% level. In particular, the coefficients γ_b and γ_m are significant for Rural meat items, such as poultry and pork, but they are statistically insignificant for Urban meat items. Other insignificant coefficients in Urban and Rural are due to the substitutions among meats. However, these insignificant coefficients don't affect our results (Hsiao, 2014).

Given the differences existing in urban and rural, we ran two regression processes using the rural and urban time series separately. The expenditure elasticities, Marshallian price elasticities, and Hicksian price elasticities are shown in **Tables 3** and **Table 4**.

Table 2 The regression results of the Models.

Variable	Coefficient of Urban			Coefficient of Rural				
	ω_b^U	ω_m^U	ω_p^U	ω_p^U	ω_b^R	ω_m^R	ω_p^R	ω_p^R
α	0.007***	0.003**	-0.010*	0.001	0.006**	0.007**	-0.012***	-0.001
β	-0.213***	-0.157	-0.255**	0.625***	-0.104*	-0.223***	0.324**	0.003
γ_b	-0.010	-0.040	0.253	-0.202	-0.173**	-0.125	0.096	0.202**
γ_p	0.060	0.031	-0.656**	0.565**	0.086	-0.024	-0.375*	0.312**
γ_m	0.035	0.085	-0.218	0.098	0.156**	0.124	-0.159	-0.122
γ_p	-0.160***	-0.112**	0.594***	-0.321***	-0.085*	-0.105**	0.351***	-0.161***
R^2	0.9117	0.6322	0.8603	0.8811	0.644	0.726	0.769	0.638
$\overline{R^2}$	0.8716	0.4650	0.7968	0.8271	0.482	0.601	0.664	0.474
D.W.	2.2162	1.9254	2.8793	2.4414	2.419	1.950	2.450	1.740
Prob(F-statistic)	0.0000***	0.0308**	0.0002***	0.0001***	0.026**	0.007***	0.003***	0.028**

Note: ***, ** and * indicate significance at 1 percent, 5 percent and 10 percent respectively.

Tables 3 Gross elasticities and expenditure elasticities.

Meat	Period	Marshallian price elasticities		Hicksian price elasticities		Expenditure elasticities	
		Urban	Rural	Urban	Rural	Urban	Rural
Beef	2001	-2.848	-5.504	-2.966	-5.569	-1.251	-1.697
	2010	-2.379	-4.115	-2.463	-4.163	-0.653	-0.846
	2017	-2.049	-3.371	-2.092	-3.400	-0.248	-0.391
Mutton	2001	-0.906	1.040	-0.993	0.865	-1.227	-3.639
	2010	-0.897	0.264	-0.988	0.115	-1.391	-2.028
	2017	-0.886	0.214	-0.950	0.065	-0.676	-2.014
Pork	2001	-0.083	-0.499	0.304	0.590	0.603	1.423
	2011	-0.015	-0.477	0.352	0.562	0.590	1.453
	2017	0.110	-0.434	0.409	0.554	0.540	1.488
Poultry	2001	12.338	1.098	12.967	1.250	4.243	1.023
	2010	7.891	0.941	8.499	1.104	3.792	1.021
	2017	7.977	0.661	8.809	0.852	4.437	1.018

Table 3 shows that the expenditure elasticity of pork and chicken have been positive for all residents, while beef and mutton have gradually changed from negative to zero. This means that pork and poultry have been the normal products for a long time, while beef and mutton have gradually become the daily goods. Therefore, when the income rise, meat consumption will increase in varying degrees. (1) Expenditure elasticity of beef, mutton and pork in rural areas is higher than that in urban areas. Under the same growth rate of disposable income, meat consumption of rural residents grows faster. There is still 564 million rural population, so the room for meat consumption in rural is still broad (Burggraf*, et al.*, 2015; Yang*, et al.*, 2018). (2) The different price elasticities indicate the meat consumption of urban residents has changed significantly. The elasticity gap between beef, mutton and pork is getting smaller. The status of beef and mutton in the consumption of residents is rising, and the diversified trend of meat consumption is obvious. (3) Although the per capita consumption has exceeded the recommended amount of the World Cancer Organization, it is far from the average level of developed countries, so there is no space for meat consumption to decline in urban (Shono *et al.*, 2000; WCRF and AICR, 2007; Daniel*, et al.*, 2011; Rückert-John, 2017). All of above are not enough to change the growing trend of meat consumption (Wang *et al.*, 2005).

Table 4 Marshallian price elasticities and Hicksian price elasticities

		Beef			Mutton			Pork			Poultry		
		2001	2010	2017	2001	2010	2017	2001	2010	2017	2001	2010	2017
Marshallian price elasticities													
Beef	Urban	-2.85	-2.38	-2.05	—	—	—	—	—	—	—	—	—
	Rural	-5.50	-4.12	-3.37	—	—	—	—	—	—	—	—	—
Mutton	Urban	0.42	0.43	0.30	-0.91	-0.90	-0.89	—	—	—	—	—	—
	Rural	3.00	1.93	1.90	1.04	0.26	0.21	—	—	—	—	—	—
Pork	Urban	2.49	1.80	1.35	-3.20	-3.45	-2.43	-0.08	0.04	0.11	—	—	—
	Rural	2.54	1.84	1.46	-2.52	-1.55	-1.48	-0.50	-0.46	-0.43	—	—	—
Poultry	Urban	0.44	0.35	0.38	0.75	0.47	0.31	-3.26	-2.84	-3.55	12.34	7.89	7.98
	Rural	0.74	0.70	0.61	0.18	0.70	0.20	-2.53	-2.34	-2.00	1.10	0.94	0.66
Hicksian price elasticities													
Beef	Urban	-2.97	-2.46	-2.09	—	—	—	—	—	—	—	—	—
	Rural	-5.57	-4.16	-3.40	—	—	—	—	—	—	—	—	—
Mutton	Urban	0.33	0.39	0.27	-0.99	-0.99	-0.95	—	—	—	—	—	—
	Rural	2.83	1.78	1.75	0.86	0.11	0.06	—	—	—	—	—	—
Pork	Urban	2.54	1.87	1.44	-3.15	-3.41	-2.38	0.30	0.36	0.41	—	—	—
	Rural	2.60	1.92	1.57	-2.45	-1.44	-1.37	0.59	0.57	0.55	—	—	—
Poultry	Urban	0.20	0.20	0.34	0.66	0.37	0.25	-3.14	-2.72	-3.45	12.97	8.50	8.81
	Rural	0.89	0.87	0.80	0.00	0.06	0.05	-2.31	-2.10	-1.72	1.25	1.10	0.85

The differences in elasticity reflect the different trend and resistance faced by different meat consumption growth in urban and rural areas. **Table 4** shows: (1) Since 2001, the elasticity of all kinds of meat has declined gradually, but the elasticity of beef and poultry meat has been higher than pork and mutton, which indicates that

income changes have more impact on beef and mutton than pork, whether in urban or rural areas. (2) The self-price elasticity of beef, mutton and pork gradually tends to 0, or maintains near 0, and consumption in urban and rural areas of China is more diversified. Beef (urban in 2001 is - 5.5, rural in 2017 is - 2.05, rural in 2017 is - 3.37), mutton (urban in 2001 is 0.42, rural in 2001 is 3.0; urban in 2017 is - 0.89, rural in 2007 is 0.21), and pork (urban in 2001 is 2.49, rural in 2001 is 2.6; urban in 2017 is 0.41, rural is 0.51) are generally welcomed, which has gradually been changing the pork's dominant position. Beef and mutton are becoming more and more popular. The self-price elasticity of poultry meat in urban areas has been declining in recent 20 years, but it is still relatively high. This may be due to the frequent occurrence of poultry epidemics (Zheng *et al.*, 2018), and the sensitivity of rural residents to the epidemic is weaker. (3) Generally speaking, rural residents have more traditional living habits. The consumption elasticity of pork in rural is higher than urban, which is also the reason of higher budget share in pork than other meat in rural.

Our results are consistent with previous studies. The elasticity of poultry, beef and mutton is higher than pork (Ma *et al.*, 2006). Unlike previous studies, we found that the elasticity of poultry has been declining recent years, but the elasticity of cities and towns is still high, and the elasticity gap is large. This is because we used time-series data, instead of cross-sectional survey data or panel data used by previous studies to analysis, and the conclusion of our study shows a long-term trend, not only the situation at a certain point. The frequent occurrence of avian epidemics, especially zoonosis, has occurred frequently in the last 20 years. Urban residents have higher requirements on food quality, safety, and health than rural residents (Duan, 2018). From this point of view, our conclusions are credibility, which is in line with the actual situation of China. The higher expenditure elasticity of beef, mutton and poultry indicates the increasing consumption in the future, which is consistent with previous studies (Liu*, et al.*, 2009; Cheng*, et al.*, 2015). This may be the behavior of consumer diversification brought about by the growth of disposable income.

First of all, as far as the price elasticity, pork has maintained low price elasticity from 2001 to 2017 (the price elasticity in rural areas was 0.59 in 2001 and 0.3 in urban areas; the price elasticity in rural areas was 0.55 in 2017 and 0.41 in urban areas), which indicates that pork has always been a necessity for urban and rural residents. Secondly, in the past 20 years, the price elasticity of pork of rural residents is slightly higher than urban residents, which shows that compared with urban consumers, Chinese rural consumers still tend to eat pork as the main meat. Thirdly, as the time goes on, the price elasticity of pork of rural residents decreases slightly, indicating that with the development of China's economy, rural residents prefer pork.

The price elasticity of poultry itself declined from 12.97 to 8.8 from 2001 to 2017, maintaining a high price elasticity. It shows that the elasticity of poultry has declined in recent years, and the trust degree of urban residents in poultry has gradually increased. However, the sensitivity of poultry consumption is much higher than others. The price elasticity in rural areas dropped from 1.25 to 0.85. Poultry is widely consumed and almost as a necessity to the rural residents. The elasticity gap between urban and rural is very large. Urban residents pay more attention to health than rural residents. Previous studies have also noted that the outbreak of the epidemic will increase the sensitivity of residents to poultry consumption, and the elasticity coefficient will increase (Liu*, et al.*, 2009).

The own price elasticity of mutton varies greatly. In 2001, the elasticity of mutton (-0.99 in urban areas and 0.86 in rural areas) was higher than pork and lower than beef. The preference of urban and rural residents for mutton was higher than beef and lower than pork. But after 2010, the price elasticity of rural residents has changed greatly, lower than pork. It has become the most reliable meat. While the elasticity of urban residents has always maintained at the original level. Urban residents are more affected by price than rural residents.

The own price elasticity of beef has declined, but it still remains high (-2.09 from -2.97 in urban areas and -3.4 from -5.57 in rural areas), indicating that demand for beef is price-sensitive. This is particularly true for beef consumption at home, but Eat Out or FAFH (Far Away from Home) may be determined by other different factors, which are not the scope of our study. The beef sensitivity of rural residents is higher than that of urban residents. In Chinese history, there were servitude cattle, but no special cattle for beef. Traditionally, cattle were thought to be used for work rather than for meat, so beef was not considered as a necessity. Farmers have a deep affection for cattle. Only in recent years, with the rise of disposable income and the development of beef cattle industry, Chinese residents began to increase beef consumption gradually (Dong *et al.*, 2014). However, due to the undersupply, beef is considered "semi-luxury" because of its high price (Dong*, et al.*, 2014; Liu and Yang, 2015). Also, rural people are not familiar with the cooking methods of beef, which also hinders the consumption of rural beef.

We analyzed meat with substitution relationships and the model results were statistically significant. Beef is a substitute for other meat products. Beef and pork have maintained a strong substitution relationship. However, in recent years, it has shown a downward trend. The substitution relationship between pork and beef has gradually weakened, and the elasticity of rural residents is greater than that of urban residents.

The substitution relationship between beef and mutton has remained stable. The substitution elasticity of them in rural areas is greater than urban, which indicates that the status of beef and mutton in both urban and rural residents remain stable. The substitution relationship between beef and poultry meat has been relatively low. The results show an upward trend among urban residents, and stabilizing around 0.9 in rural areas. In addition, there is an alternative relationship between poultry and mutton.

Generally speaking, there is a substitution relationship between the four kinds of meat in the living habits of ordinary the Han Chinese who accurate 91.5% of the whole, but the substitution intensity of meat is different among different groups and different periods due to various external reasons and personal habits, which also leads to the interrelationship between domestic meat prices (Mao*, et al.*, 2018). This study does not distinguish between eating out (such as restaurants and picnics) and cooking at home, or between ethnic taboos and income groups. Chinese residents have a habit of thrift, so the nutritional value difference to different meat has not been paid attention to in Chinese residents. It is only when eating out (hotpot, grill, etc.) that specific meat products are chosen because of different cooking tools, but this is not obvious. In many areas, hotpot restaurant, grill restaurant and hamburger restaurants have introduced various meat products (such as pork kebabs, pork chop hamburgers, beef hamburgers, roast chicken wings, etc.) in actual consumption, which are welcome by Chinese (Duan, 2018). Therefore, the complementary relationship among meats in China cannot be fully demonstrated, and the actual value of complementary relationship analysis is not great.

Conclusions: The conclusion of elasticity study shows that Chinese are still very sensitive to the price of meat. Whether in urban or rural, the rising price is still the main restriction to meat consumption. That is, the supply capacity of meat varieties impact on the consumption behavior of residents significantly. Therefore, the meat consumption of Chinese residents in the future still has broad prospects (especially in rural), if the production is continuously expanding. And with the increase of income, leisure time and pursuit of healthy nutrition, the cooking methods of beef and mutton may be gradually mastered by residents (Duan, 2018). The elasticities of beef and mutton diminish year by year, and the consumption growth space of beef and mutton may be gradually opened (Ma*, et al.*, 2006; Liu*, et al.*, 2009). The results show that income is the other cause affecting meat consumption in China. With its increase, not only will the amount of meat consumption rise, but also the composition structure will transform.

Consumption and production together determine the equilibrium price. In recent years, the rising price of beef and mutton is partly caused by the increasing demand and the insufficient supply, which further limits their consumption. Therefore, only by encouraging the development of beef cattle and mutton industry can we meet the residents' demand of nutrition. According to the consumption history of developed countries, as incomes rise, residents will expect meat with guaranteed quality and safety. In addition, with health, green, and quality gradually become the main pursuits of diet consumption of urban, the meat consumption structure of citizen is bound to adjustment. Beef cattle and mutton sheep production are gradually industrialized, while pork and poultry are developing in the direction of health and high quality. The pork and poultry industry should attach importance to safety in production, prevent and alleviate epidemic conditions (such as bird flu, swine flu, foot and mouth disease, etc.), prohibit the use of illegal additives and drugs (clenbuterol, antibiotics, etc.), and raise the overall and long-term awareness of producers. The government should pay more attention to the security of production, as well as the policy guidance to ensure a safe and healthy supply of pork and poultry. The development of a green, safe and healthy meat industry can meet the general requirements of Chinese residents (Xue and Yan, 2019).

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