Güneysu Atasoy, F. (2019). Analysis of household food consumption pattern: an application for China. Gümüşhane Üniversitesi Sosyal Bilimler Enstitüsü Elektronik Dergisi, 10(3), 473-483

Analysis of Household Food Consumption Pattern: An Application for China

Hanehalkı Gıda Tüketim Modelinin Analizi: Çin Örneği

Filiz Güneysu Atasoy[1]

Abstract

This study analyzes consumption pattern of three aggregated food categories for households in China. Grain, meat products and aquatic products are chosen to understand consumption pattern in Jiangsu and Guangdong provinces in China. The Linear Expenditure (LES) and Indirect Translog Demand Systems (ITDS) implemented to estimate income elasticities, own price elasticities, and cross price elasticities of these food categories. In addition to that an economic variable is used in the system to explain impact on household consumption pattern, so ITDS with and without economic variable are also examined. Analysis results show that fish have the highest income elasticities among others, while grain has the lowest income elasticity. According to high own price elasticities of fish and meat products traders and policy makers should be more circumspect to maintain profitability.

Keywords: *Consumption Patterns, Elasticities, Linear Expenditure System, Indirect Translog Demand System, SAS.*

Öz

Bu çalışma 3 farklı gıda kategorisindeki tüketim modelini analiz etmektedir. Tahıl, et ve deniz ürünleri, Çin'in Jiangsu ve Guangdong şehirlerindeki hane halkının tüketim modelini analiz etmek için seçilmiştir. Gelir esnekliği, ürünün kendi fiyat esnekliği ve çapraz fiyat esneklikleri Doğrusal Harcama (LES) ve Dolaylı Translog Talep Sistemleri (ITDS) aracılığıyla tahmin edilmiştir. Ayrıca, çalışmada hane halkının tüketim modellerini belirlemek için analize bir de ekonomik değişken eklenmiştir. Böylece, ITDS modeli ekonomik değişken eklenerek ve eklenmeden de analiz edilmiştir. Analiz sonuçlarına göre, gelir esnekliği en yüksek deniz ürünlerinde iken, en düşük tahıllarda bulunmuştur. Ürünlerin kendi talebinin fiyat esneklikleri baz alındığında balık ve et ürünleri yüksek esnekliklere sahiptir. Bu nedenle gerek tüccarlar gerekse politika yapıcılar, söz konusu ürünlerin gelecekte karlılığı sürdürülebilirliğine dair daha dikkatli olmalıdırlar.

Anahtar Kelimeler: *Tüketim modeli, Esneklikler, Doğrusal Harcama Sistemleri, Dolaylı Translog Talep Modeli, SAS.*

Araştırma Makalesi [Research Paper]

JEL: *D11, D12, D04, Q21*

Submitted: 20 / 12 / 2018
Accepted: 09 / 08 / 2019

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Introduction

There are many reasons behind on changing food consumption or food consumption pattern in China. One of the reasons is development in economic and social area, food consumption has been increasing. Also, increase in educational attainments and average income per capita lead to raise household consumption level in every country. Another reason of changing in life style is people have to work long hours. It can be a trigger to escalation of food away from home's (FAFH) consumption. Like the other countries in the world, China has the same changes on household expenditure due to its fastest developed process and population. In addition to this, estimation of long-term demand is becoming very crucial due to global food situation and climate changes. Long term food demand depends on income and price elasticities of food commodities and how these food price and quantities interacted as consumption pattern changes. In the economic literature, there are many researches evaluating the food consumption changes using elasticities. In the US, the consumption of FAFH is almost 4% share of household expenditure (Lee and Brown, 1986). Consumption decision of FAFH is related to race, ethnic origin, household size and age of household' occupations (Nayga and Capps, 1992).

China's expeditious economic growth has captivated crucial interests from economists; therefore, many studies examined food and especially agricultural goods demand. However, study results do not support each other. For instance, one of the recent study results show that own price elasticity of demand for dairy products is 0.24 for Urban China (Zheng and Henneberry, 2011) On the contrarily Zheng and Henneberry, (2011) Liu and Zhong (2009), represent a high own price demand elasticity for dairy product which is 1.12. Different econometric and economic analysis methods may impact the results. Thus, using more than one method can give more robust results comparison to only one method application.

Chern and Liu's (2001) stated that 12[2] aggregated food items for 4 food demand system in urban China. In their study it is explained that an increment of Chinese household income level raises consumption, mostly in aquatic products, milk and poultry products rather than other foods. It may be beneficial for fishery and livestock industries. Katchova and Chern (2004) focused on household expenditure pattern for three food groups which are consumed generally by all households, such as grain foods, and meat (meat products), and food away from home[3] for urban and rural household in specific provinces. Authors used price and expenditure elasticities, and determined food consumption characteristics by implementing the Almost Ideal Demand System (AIDS). They also tested for homogeneity and symmetry. Their study results indicated that the effects of the cross-price elasticity of meat and food away from home on quantity demand.

Liu, and Savenije (2008) examined the potential impact of edible material utilization on water requirements. For analysis, they used 3 level food categories which are the basic, the subsistence and the cultural levels. These categories comprised of total six food item categories which are cereal, sugar, oil crop, vegetables, alcoholic beverages and animal products. The study results showed that water requirements for food have been increased in recent decades.

Zheng, and Henneberry (2009) examined urban household in Jiangsu province in China using by AIDS and generalized Almost Ideal Demand System model (GAIDS). Their analysis showed that changing demographic profile of the province has a significant effect on food demand. One of the recent studies analyzed the dynamic food demand in urban China, using of dynamic demand system and a linear AIDS on aggregate data set from 1995 to 2010 (De et al., 2014). The authors stated that static models may misspecified of demand function and credibility of the elasticity's estimation. Their study results indicate many essential food products, such as wheats, fish and meat products, and also vegetables are price inelastic in China's urban areas.

All in all, the aim of this study is to examine consumption pattern of three aggregated food categories for households in China. For this purpose, the data set is retrieved from National Brue of Statistics in 2015. The study specifically chooses Jiangsu and Guangdong provinces for prediction of the China's households consumption pattern. The reason is that Jiangsu is one of the China's major provinces, in terms of its gross domestic product (GDP). According to national GDP results, accounting for more than 9% of China's national GDP in Jiangsu province. In addition to this, Jiangsu's urban per capita disposable income was ranked seventh among thirty-one provinces in the nation in 2004 (NBS, 2005). Therefore, the study examines the Jiangsu's and Guangdong's households' food consumption pattern. They may represent national demand of China and the factors that potentially affect it.

Linear Expenditure Demand System, Indirect Translog Demand System with and without economic variable is used for examination. The models provide information for estimation of income and price elasticities of demand that can be used of food and agricultural markets in China. Income, own-price, and cross-price elasticities are estimated for three commonly used food categories. This study differs from previous studies because it examined three different models' Linear Expenditure Demand System, Indirect Translog Demand System with and without economic variable, which provide more

[2] These 12 foods are, wine, edible oils, grain, sugar, pork, poultry, other meats, aquatic products, eggs, milk and milk products, vegetables and fruits.

[3] The demand changing of the food away from home is examined at Guneysu Atasoy (2018) using Multinomial Probit and conditional Logit model. For the analysis of these models and SAS coded, see the aforementioned study.

robust results for estimation comparison to applied only one model. Also, it uses more recent data set to analyze and estimate future food demand. In addition to this, SAS codes are reported for the analysis of Linear Expenditure System and Indirect Translog Demand System with and without economic variable in the appendix section. It can be beneficial for the analyses and application of similar studies for future researches.

1. Data and Methodology

The data set includes household level observation on food consumption in 2015 in the Jiangsu and Guangdong Provinces of China. It is derived from National Bureau of Statistics (NBS) which is conducted a national household annual survey. The survey is administered directly by NBS and the main contents of the survey include: income and expenditure of the household, and surveys of employment, social security participation, housing, family operation, production investment, and also influence factors of income distribution. The integrated household survey is conducted by selecting sampled houses randomly, deciding surveyed households, with all households in the province as the population, with stratified sampling, multi-stage sampling, probability sampling in proportion to population scale. 16,000 communities of 1,650 counties in the total country are selected, more than 2 million households in them are surveyed comprehensively, and then on this basis, randomly select about 160,000 households for keeping diaries. Communities and households surveyed rotate regularly and for 2015 data was released in 2016 (National Bureau of Statistics of China, 2016).

First grain is chosen because in the literature several previous studies indicated high income elasticities (Chern, 2000), so the forecast may evaluate as inadmissible prediction in the long run grain demand in China. Grain consists of rice, wheat and others. As other food categories aquatic products and animal products are chosen because as Chinese household income increase, they potentially consume more aquatic products and animal products. This may be beneficial for fishery and livestock industries' future in China or other Asian countries which fishery products are highly consumed. Animal products consist of pork, beef and other meats which is called meat, while fish product comprises all aquatic products. Household disposable income is preferred as an economic variable in this study. Households disposable income and expenditure data come from China statistical Yearbook conducted by the China National Bureau of Statistics which is available online (CNBS) and implemented since early 1980s (Wang et al., 1995).

All in all, grain, meats and fish, which are consist of rice, wheat, other grains, pork, beef, other meats and all kind of aquatic products, are chosen to represent household consumption pattern. It means that 3 aggregated food categories are chosen which includes 7 different types of goods. For better explanation of the data set more detail information is represented in the Table-1 which is shown below.

Table 1. Selected Food prices and quantities per household, and Living Expenditure

	Jiangsu		Guangdong	
	Per household food consumed in (kg)	Price Unit value, selected food (yuan/kg)	Per household food consumed in (kg)	Price Unit value, selected food (yuan/kg)
Grain	122,0	4,7	128,3	5,6
Meat Products	26,1	22,3	36,5	23,8
Pork	19,6	19,40	29,7	20,5
Beef	1,7	26,8	1,8	27,9
Other meat	4,8	21,5	5,0	23,2
Aquatic Products	17,4	16.5	22,0	17,7
Disposable income (yuan)	37173,3		34757,2	
Selected Food's Expenditure of household (yuan)	1750,4		1924,8	
Total food expenditure (Yuan)	5740,6		6875,4	
Living Expenditure	20545,6		20875,5	

* Other meat includes edible offal, mutton and fat. Disposable income includes all kind of income after the tax deducted. Grain consist of mainly wheat, rice and others. Living expenditures includes, food, clothing, residence, transportation, education, miscellaneous expenditures, and also includes healthcare and other medical services' expenses. Source: Author own calculation.

Linear Expenditure System and Indirect Translog Demand System with and without economic variable are used to estimation of Chinese household consumption pattern. All empirical results are shown in the third section of the study.

For estimation and analyses of the demand system, the neoclassical utility maximization is used. One class of demand system are measured and estimated which is the class of nested QES/LES system[4]. The λ- QES (Quadratic Expenditure System) demand equation in share form are given by

$$w_i = \frac{p_i b_i}{M} + a_i\left(1 - \sum \frac{p_k b_k}{M}\right) + (c_i - a_i)\lambda \prod \left(\frac{p_k}{M}\right)^{-c_k} \left(1 - \sum \frac{p_k b_k}{M}\right)^2 \quad (1)$$

$$\sum a_i = \sum c_i = 1.$$

where, w_i is the budget share of the food i, for brevity in the study it is stated as budget share but it's actually refers to total expenditure share in the selected 3 food categorize. p_i is the price of food i, M is the total expenditure. λ and a_i, b_i, c_i are the parameter which are the estimated by QES. If λ=0 or a_i=c_i for all I, then λ-QES is reduced to the LES (Linear expenditure system). The advantage of the LES is that it is simple and it provides an intuitive economic interpretation, despite its strong separability assumption (Deaton, and Muellbauer, 1980). The separability assumption is not overly restrictive for such commodities as food, housing, or clothing (Timmer and Alderman, 1979). In a Linear Expenditure System, a demand curve can be estimated by following equation;

$$q_i = \gamma_i + \beta_i \frac{M - \sum_j p_j \gamma_j}{p_i} \quad (2)$$

Where γ_i is a minimum consumption level of good i; β_i is marginal budget share for good i. $M - \sum_j p_j \gamma_j$ the other parts of budget, after making subsistence expenditure is to purchase additional amount of goods until the budget is consumed, it is called supernumerary income. M symbolizes total expenditures.

The Translog demand system is created by Christensen at all (1975). The Translog consumer demand system comes from by implication Roy's Identity to quadratic, logarithmic specification of an indirect utility function written in terms of expenditure-normalized price (Holt and Goodwin, 2009). The indirect demand curve of Indirect Translog Demand System can estimate using by following equation;

$$w_i^I = \frac{p_i q_i}{M} = \frac{\alpha_i + \sum_j \beta_{ij} \ln\frac{p_j}{M}}{\sum_k \alpha_k + \sum_j \beta_{ij} \ln\frac{p_j}{M} + \sum_i \beta_{ji} \ln\frac{p_i}{M}{}_i} \quad (3)$$

Where, w_i represents the budget share of commodity of I. It gets value between 0 and 1. P_i, is the price of i, and p_j is the price of the commodity j. The parameters in the Indirect Translog Demand System need to impose the following restrictions;

$$\sum_k \alpha_k = 1, \sum_j \beta_{ij} = 0, \sum_i \beta_{ji} = 0, \sum_i \sum_j \beta_{ij} = 0 \quad (4)$$

Then, demographic scaling method is implemented to integrate demographic variables into the demand systems. In the Indirect Translog Demand System, the elasticities are estimated by the following formulas;

- Own Price;

$$\varepsilon_{ii} = -1 + \frac{\partial w_i}{\partial p_i}\frac{p_i}{w_i} = -1 + \frac{1}{D}\left(\frac{\beta_{ii}}{w_i} - \sum_j \beta_{ij}\right) \quad (5)$$

- Cross Price;

$$\varepsilon_{ij} = \frac{\partial w_i}{\partial p_j}\frac{p_j}{w_i} = \frac{1}{D}\left(\frac{\beta_{ij}}{w_i} - \sum_{i \neq j} \beta_{ij}\right) \quad (6)$$

- Expenditure;

[4] Some studies use non-nested AIDS and LA/AIDS models in the economy litreature (Jiang, and Davis, 2007; Guneysu Atasoy, 2019).

$$\varepsilon_{iM} = 1 + \frac{\partial w_i}{\partial M}\frac{M}{w_i} = 1 + \frac{1}{D}\left(-\frac{\sum_j \beta_{ij}}{w_i} + \sum_i \sum_j \beta_{ij}\right) \quad (7)$$

2. Empirical Results

All equation system is estimated with Seemingly Unrelated Regression (SUR) in the study. Table-2 presents estimation of parameters from Linear Expenditure System (LES) and Indirect Translog Demand System (ITDS) with economic and also without economic variables. Parameter estimates capture own price and cross price impacts within the demand system.

Table 2. Parameter Estimates from Linear Expenditure System (LES) and Indirect Translog Demand System (ITDS)

	LES	**Indirect Trnslog Demand Model (without economic)**	**Indirect Translog Demand (with economic)**
Parameter	**Estimates (standard Error)**	**Estimates (standard Error)**	**Estimates (standard Error)**
a1	0.257* (0.012)	0.386* (0.397)	0.382*** (0.041)
a2	0.488** (0.016)	0.3895 (0.037)	0.393*** (0.038)
a3	0.253** (0.011)	0.224** (0.024)	0.224*** (0.024)
b1	27.401*** (10.609)		
b2	-8.376*** (3.418)		
b3	3.692*** (4.233)		
b11		-0.015** (0.024)	-0.013*** (0.024)
b12		0.049** (0.016)	-0.048** (0.016)
b13		-0.011** (0.018)	-0.117*** (0.012)
b22		0.066*** (0.016)	0.069*** (0.026)
b23		-0.136** (0.027)	0.131*** (0.027)
b33		0.169*** (0.011)	0.168*** (0.016)

Commodities: 1; grain, 2; meats, 3; fish. ***, **, * presents that significant at 0.01, 0.05 and 0.10 level in respectively.

Table-3 shows the correlation between household income and food consumption. Household disposable income has negative relationship to the consumption share of grain whereas, the disposable income has positively related to the consumption on fish and meats. It means that fish and meat consumption increase when households' disposable income increase.

Table-4 reports the income elasticities, own price elasticities and cross price elasticities estimated by LES, ITDS with economic and ITDS without economic variable. The elasticities result present similar directions. Own price elasticities for all three types of goods come negative. Grain own price elasticity is 0,65 for LES model while ITDS with economic variable is 0,72. Grain is less sensitive to own price changes among three food categories. Fish products have the highest own price elasticities for all models which is 1,16. It means that demand is more sensitive for fish and meat products rather than for grain. If the LES results compares with ITDS with economic variables, the second model is more sensitive to own price elasticities for all three aggregated food categories.

For cross price elasticities ITDS with economic variable represents highest cross price elasticities among three models. As expected, fish and meat are substitute products. Therefore, an increase in the meat price would increase fish demand.

In addition to this all income elasticities are positive as estimated by three models and shown in the Table-4. In the LES grain is a normal good but others are luxury good. Grain income elasticity is 0.69. This estimation is higher than some previous studies such as Wan (1996). The author measured the elasticity is 0.4 using by an Engel function on rural household data. However, David (2008) results support current study results. Also, grain, meat and fish income elasticities are more sensitive to the households' income changes in ITDS with economic variables rather than 2 others models.

Table 3. Correlation between households' Income and Food Consumption

	Grain	**Meat**	**Fish**	**HDI**	**THF/HTLE**
Grain	1.00	0.50***	0.25***		
Meats		1.00	0.48***		
Fish			1.00		
HDI	-0.16***	0.03	0.23***	1.00	
THF/HTLE	0.29***	0.27***	0.20***	-0.43***	1.00

*HDI is Household disposable income. THF is Total food expenditure of selected food and HTLE is Household total living expenditure. THF/HTLE means the proportion of the selected food expenditure in the total living expenditure

Table 4. Estimated Income and Price Elasticities for Chinese Households

Model	**Commodities**	**Price Elasticities**			**Income Elasticities**
		Grain	Meat	Fish	
LES	Grain	-0.6507	0.0043	0.0229	0.6881
	Meat		-1.0298	0.0956	1.0539
	Fish			-1.0741	1.1025
ITDS without economic variable	Grain	-0.6884	0.0061	0.0243	0.6984
	Meat		-1.1122	0.1950	1.1232
	Fish			-1.1255	1.1312
ITDS with economic variable	Grain	-0.7189	0.0107	0.0357	0.7389
	Meat		-1.1227	0.1948	1.1627
	Fish			-1.1609	1.1717

ITDS: Indirect Translog Demand Systems.

Conclusion

In economy literature a model specification is a kind of art, therefore it is pretty challenging to find most convenient model to evaluate food consumption patterns. For instance, Linear Expenditure system (LES), Quantile Expenditure system (QES), Translog Demand System, Almost Ideal Demand System, The Rotterdam Model some of the models which is highly applicable for analysis demand system and consumption pattern the literature (Ipek, 2014). According to Deaton and Muellbauer, (1980) the advantage of the LES is that it is simple and it provides an intuitive economic interpretation, despite its strong separability assumption. Therefore, in the current study uses LES and also ITDS.

All in all, this study analyzes the consumption pattern in two provinces, Jiangsu and Guangdong in China by using LES, ITDS with economic variable and without economic variable. These models estimate price and expenditure elasticities for grain, meats and fish products. Fish and meats are chosen to explain the relationship of possible income changes, as well as, grain is chosen because it is still a base food product for many countries. Also, in the literature several previous studies indicated high income elasticities (Chern, 2000), so the forecast might be an inadmissible prediction in terms of long run grain demand in China. More importantly, Chinese household income increase, they potentially consume more aquatic products and meat products. This may be beneficial for fishery and livestock industries' future in China or other Asian countries where fishery products are highly consumed.

According to analysis results, the household disposable income is negatively related to the consumption share on food. Also, the income is negatively related to the consumption of grain, while it is positively related by fish and meats consumption. As an economic variable, household disposable income was chosen and it has no statistically significant impact in the model. Moreover, grain is a normal good by three models whereas; meats and fish are luxury goods in the ITDS model for Chinese households. Finally, among these three food categories, grain has the lowest income elasticities while fish has the highest income elasticities for LES, ITDS with and without economic variable. It means that in the model fish looks a more luxury good rather than grain and meat products. According to high own price, elasticities of fishery and meat products traders and policy makers should be more circumspect to maintain profitability. In addition, elasticities need to be evaluated carefully in the long term for China's domestic agriculture as well as international trade by policy makers or traders.

Acknowledgement

I would like to thank Prof. Dr Diane Hite for guidance for analysis of the models.

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Appendix

SAS codes for Linear Expenditure System and Indirect Translog Demand System with and without economic variable

```
libname filiz "C:\Users\Desktop\foodconsumption";
data one; set guneysu;
expGrain=p_Grain*q_Grain;
expMeat=p_Meat*q_meat;
expFish=p_Fish*q_Fish;
TEXP=expGrain+expMeat+expFish;
w1=expGrain/TEXP;
w2=expMeat/TEXP;
w3=expfish/TEXP;
q1=q_Grain;
q2=q_Meat;
q3=q_Fish;
rename p_Grain=p1 p_Meat=p2 p_Fish=p3;
if TEXP>0;
run;
```

```
title "linear expenditure system";
proc model data=one outparms=parms;
parms r1-r3 b1-b3;
r1+r2+r3=1;
q1=r1+b1*((texp-(p2*r2+p3*r3))/p1);
q2=r2+b2*((texp-(p1*r1+p3*r3))/p2);
q3=r3+b3*((texp-(p1*r1+p2*r2))/p3);
fit q1 q2 q3/sur iter=200;
run;
options pagesize=60 linesize=80 pageno=1 nodate;
data elasticity1;if _n_=1 then set parms;set one;
e11=-((b1*(1-(p1*r1/texp)))/w1);
e12=-((b1*(p2*r2/texp))/w1);
e13=-((b1*(p3*r3/texp))/w1);
e22=-((b2*(1-(p2*r2/texp)))/w2);
e21=-((b2*(p1*r1/texp))/w2);
e23=-((b2*(p3*r3/texp))/w2);
e33=-((b3*(1-(p3*r3/texp)))/w3);
e31=-((b3*(p1*r1/texp))/w3);
e32=-((b3*(p2*r2/texp))/w3);
e1m=b1/w1;
e2m=b2/w2;
e3m=b3/w3;
proc means data=elasticity1;
var e11 e12 e13 e1m e21 e22 e23 e2m e31 e32 e33 e3m;
title "all elasticity without economic var (linear)";

proc model data=one outparms=parms;
parms a1-a3 b11-b13 b22-b23 b33;
a1+a2+a3=1;
b11+b12+b13=0;b22+b12+b23=0;b33+b13+b23=0;
D=1+(b11*log(p1)+b22*log(p2)+b33*log(p3)+b12*(log(p1)+log(p2))+b13*(log(p1)+log(p3)));
w1=((a1+b11*log(p1)+b12*log(p2)+b13*log(p3)-log(texp)*(b11+b12+b13))/D);
w2=((a2+b12*log(p1)+b22*log(p2)+b23*log(p3)-log(texp)*(b12+b22+b23))/D);
w3=((a3+b13*log(p1)+b23*log(p2)+b33*log(p3)-log(texp)*(b13+b23+b33))/D);
fit w1 w2 w3/sur iter=200;
run;
```

```
data elasticity2;if _n_=1 then set parms;set one;
D=1+(b11*log(p1)+b22*log(p2)+b33*log(p3)+b12*(log(p1)+log(p2))+b13*(log(p1)+log(p3)));
E11=-1+1/D*(b11/w1-(b12+b13));
E22=-1+1/D*(b22/w2-(b12+b23));
E33=-1+1/D*(b33/w3-(b13+b23));
E12=1/D*(b12/w1-(b12+b13));
E13=1/D*(b13/w1-(b12+b13));
E21=1/D*(b12/w2-(b12+b23));
E23=1/D*(b23/w2-(b12+b23));
E31=1/D*(b13/w3-(b13+b23));
E32=1/D*(b23/w3-(b13+b23));
E1M=1+1/D*(-(b12+b13)/w1+(b11+2*b12+2*b13+b22+2*b23+b33));
E2M=1+1/D*(-(b12+b23)/w1+(b11+2*b12+2*b13+b22+2*b23+b33));
E3M=1+1/D*(-(b13+b23)/w1+(b11+2*b12+2*b13+b22+2*b23+b33));
run;
proc means data=elasticity2;
var E11 E12 E13 E1M E21 E22 E23 E2M E31 E32 E33 E3M;
title "all elasticity without economic var (translog)";
run;

title "Translog with demographic";
proc model data=one outparms=parms;
parms a1-a3 b11-b13 b22-b23 b33;
dem=1+g1*HTLE+g2*NOCUA17;
pr1=p1*dem;pr2=p2*dem;pr3=p3*dem;
a1+a2+a3=1;
b11+b12+b13=0;b22+b12+b23=0;b33+b13+b23=0;
D=1+(b11*log(pr1)+b22*log(pr2)+b33*log(pr3)+b12*(log(pr1)+log(pr2))+b13*(log(pr1)+log(pr3)));
w1=((a1+b11*log(pr1)+b12*log(pr2)+b13*log(pr3)-log(texp)*(b11+b12+b13))/D);
w2=((a2+b12*log(pr1)+b22*log(pr2)+b23*log(pr3)-log(texp)*(b12+b22+b23))/D);
w3=((a3+b13*log(pr1)+b23*log(pr2)+b33*log(pr3)-log(texp)*(b13+b23+b33))/D);
fit w1 w2 w3/sur iter=200;
run;

data elasticity3;if _n_=1 then set parms;set one;
dem=1+g1*HTLE+g2*NOCUA17;
pr1=p1*dem;pr2=p2*dem;pr3=p3*dem;
D=1+(b11*log(pr1)+b22*log(pr2)+b33*log(pr3)+b12*(log(pr1)+log(pr2))+b13*(log(pr1)+log(pr3)));
```

```
Ea11=-1+1/D*(b11/w1-(b12+b13));
Ea22=-1+1/D*(b22/w2-(b12+b23));
Ea33=-1+1/D*(b33/w3-(b13+b23));
Ea12=1/D*(b12/w1-(b12+b13));
Ea13=1/D*(b13/w1-(b12+b13));
Ea21=1/D*(b12/w2-(b12+b23));
Ea23=1/D*(b23/w2-(b12+b23));
Ea31=1/D*(b13/w3-(b13+b23));
Ea32=1/D*(b23/w3-(b13+b23));
Ea1M=1+1/D*(-(b12+b13)/w1+(b11+2*b12+2*b13+b22+2*b23+b33));
Ea2M=1+1/D*(-(b12+b23)/w1+(b11+2*b12+2*b13+b22+2*b23+b33));
Ea3M=1+1/D*(-(b13+b23)/w1+(b11+2*b12+2*b13+b22+2*b23+b33));
run;
proc means data=elasticity3;
var Ea11 Ea12 Ea13 Ea1M Ea21 Ea22 Ea23 Ea2M Ea31 Ea32 Ea33 Ea3M;
run;
```