Impacts of Income Changes and Model Specification on Food Demand in Urban China

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Abstract

Functional form specification is a crucial task in demand analysis. Four food demand systems for 12 aggregated food items in urban China are estimated and compared using province level data for the period 1992-1999. The results show the expenditure elasticities especially for grain are different based on the functional form selection. According to the measures of forecasting accuracy, we conclude the following: for *ex post* simulation, the simpler the models, the better the performances, whereas for *ex ante* forecasting, the more complicated the model, the better the predictions. We further conclude that the LES and QES outperform the LA/AIDS and AIDS. Therefore, model selection should depend on the study purpose. In addition, as urban Chinese household income increases, they will consume more aquatic products, poultry and milk than other foods. This potential trend will certainly benefit the fishery and livestock industries as well as feed grain producers in China or other countries such as Taiwan. However, high own-price elasticities of these three food groups suggest that the profitability of suppliers and traders is very sensitive to price changes.

Key words: Food demand systems, urban China, forecasting, Taiwan

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1. Introduction

Income is one of the most significant determinants in demand analysis, and people allocate their income on expenditures and savings to satisfy their needs. Findings from previous studies of consumer expenditures confirm the Engel's Law, in that the poorer a family is, the greater proportion of total expenditure spent on food. Hence, it is of interests to researchers to understand how income changes affect budget allocations, as well as food consumption, especially for people in developing countries with a high density of population and potential poverty problems.

This study is motivated by the previous findings in estimating food demand in China using the linear approximate almost ideal demand system (LA/AIDS). Several previous studies show very high expenditure elasticities for grain in China (Chen, 1996; Han and Wahl, 1998; Chern, 1997, 2000). A high expenditure elasticity of grain often translates to a high income elasticity for grain, which many forecasters would find unacceptable in predicting the long-term demand for grain in China (World Bank, 1997). This study attempts to investigate the predicting performance of the models showing high expenditure elasticities for grain in China.

Functional form specification is an important aspect of any empirical demand analysis. There is no single "one-size-fits-all" functional form that is ideal for all applications (Pollak and Wales, 1992). The selection of functional forms will affect the analysis of specific data, the validity of forecasting, and policy implications. For example, if the income elasticities of grain demand estimated from two models were 1.20 and 0.80, respectively, the implications of income effects for future grain demand would be quite different. Therefore, it is important to choose a suitable model for a demand analysis.

China is an excellent case to study. Billions of people and market-oriented economic reforms since 1978 make China one of the major agricultural markets in the world. In addition, its rapidly growing economy not only has increased people's income level, but also has dramatically changed the food consumption patterns in urban China. For example, per capita annual disposable income of urban households jumped from 480 Yuan in 1980 to 1,510 Yuan in 1990, and reached 5,850 Yuan in 1999, representing a phenomenal tenfold increase in income within only two decades. In addition, during the last ten years, annual per capita grain consumption dropped from 130 kg in 1990 to 85 kg in 1999 whereas consumption of aquatic products and fresh milk increased by 75 percent in the same period, from 7.7 kg and 4.6 kg to 12.2 kg and 7.9 kg, respectively. To accurately forecast demand and understand the effects of income and price changes on food consumption in China, precise and reliable estimates of food demand are important and indeed necessary.

Several studies have already estimated food demand systems in urban China (Lewis and Andrews, 1989; Wang and Chern, 1992; Chern and Wang, 1994; Wu, *et al.*, 1995; Shi, *et al.*, 1995; Chern, 1997, 2000). Particularly, Chern (1997) compared the methodologies, estimation results, and assessments of the studies of urban household demand for food. Since food control policy, especially grain rationing, was still in effect during the sample periods covered by these studies, several studies, including Chern (1997), addressed and incorporated food rationing in their empirical analyses. However, there exist several problems with respect to model specification and forecasting accuracy.

First, it is still uncertain which model specification is most preferable in analyzing the food demand system for urban China. Even though the almost ideal demand system (AIDS) and particularly its linear approximate version (LA/AIDS)[1], and the linear expenditure system (LES)[2] are the most popular specifications for analyzing Chinese food consumption behavior, the results show notable differences between the LA/AIDS and the LES (Chern, 1997). Chern and Wang (1994) compared the LES with the quadratic expenditure system (QES)[3] and found the estimated elasticities to be similar despite the nested test rejecting the LES. Chern (2000) further compared the performance of the AIDS and LA/AIDS. However, to our knowledge, neither a comparison between the AIDS and QES nor a comparison of four models has been done. Since the shortcomings of the LA/AIDS have been extensively investigated (Buse, 1994; Hahn, 1994; Moschini, 1995), there have been more attempts to estimate the original AIDS. It would be interesting to know how different the performance would be among these four models. Second, none of these previous papers dealt with forecasting accuracy. The predictive accuracy is another important measurement to appraise the performance of models (Park, 1969). Therefore, from the estimated demand models, we can compare and investigate the predicted changes in food consumption with the actual changes observed within and beyond the sample period in the Chinese market.

The remainder of the paper is organized as follows. In section 2, we present model specifications. In section 3, the database is described and the descriptive statistics of selected variables of interest are presented. In section 4, we present the empirical

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[1] The AIDS was developed by Deaton and Muellbauer (1980) and they proposed to use the Stone index in the LA/AIDS.

[2] The LES was developed by Richard Stone (see Pollak and Wales, 1978).

[3] The QES was developed by Pollak and Wales (1978).

results and appraise the simulation accuracy of the selected empirical models. In section 5, we draw implications from the empirical results for the agricultural trade between Taiwan and China. In section 6, a brief summary, limitations, and conclusions are provided.

2. The Demand Systems

Following the neoclassical utility maximization framework, two classes of demand system are compared and estimated in this study. One is the class of the nested QES/LES system and the other is the non-nested AIDS and LA/AIDS model.

The λ-QES demand equations in share form are given by

$$(1) \qquad w_i = \frac{p_i h^i(\mu, \mathrm{P})}{\mu} = \frac{p_i b_i}{\mu} + a_i\left(1 - \sum \frac{p_k b_k}{\mu}\right) + (c_i - a_i)\lambda \prod \left(\frac{p_k}{\mu}\right)^{-c_k} \left(1 - \sum \frac{p_k b_k}{\mu}\right)^2$$

where $\sum a_i = \sum c_i = 1$. W_i denotes the budget share of food *i*, which is between 0 and 1. P_i is the price of food *i*, $h^i (\mu, P)$ is the Marshallian quantity demand function for food *i*, and μ is the total expenditure. Parameters to be estimated in the QES are ***a_i's, b_i's, c_i's***, and λ. If $\lambda=0$ or $a_i = c_i$ for all *i*, then the λ-QES is reduced to the LES.

On the other hand, the AIDS demand equations in share form are given by

$$(2) \qquad w_i = \frac{p_i h^i(\mu, \mathrm{P})}{\mu} = \alpha_i + \sum_k \gamma_{ik} \log p_k + \beta_i \log\left(\frac{\mu}{\mathrm{P}^*}\right)$$

where $\sum \alpha_i = 1$, $\sum \beta_i = \sum_i \gamma_{ij} = \sum_j \gamma_{ij} = 0$, and $\gamma_{ij} = \gamma_{ji}$ to satisfy the regularity conditions. The price index (P^*) in the original AIDS is given by

$$(3) \qquad \log \mathrm{P}^* = \alpha_0 + \sum \alpha_k \log p_k + \frac{1}{2} \sum \sum \gamma_{ij} \log p_i \log p_j \ .$$

If this price index is replaced by the Stone index, $\log \mathrm{P}^* = \sum w_k \log p_k$, the original AIDS becomes the LA/AIDS, which reduces the AIDS to a linear model. Therefore, the parameters to be estimated in the AIDS are α_i**'s,** β_i**'s,** and γ_{ij}**'s**.

3. The Data

This study utilizes Chinese urban household consumption data at the province level for 1992-1999, collected and released by the National Bureau of Statistics (NBS), People's Republic of China. From the dataset, 12 food categories– grain, vegetable oil, sugar, pork, poultry, other meats, aquatic products, eggs, milk and dairy products, vegetables, fruits, and wine– are aggregated from 132 food items. Other meats include beef, mutton, and other meat products. Even though there are 30 provinces in China, in the statistical yearbook, Tibet is missing for 1993-1995 and 1997-1998 and Chongqing is added after 1997, so we decide to exclude them. There are 232 observations employed in this study.

Per capita food consumption patterns in urban China for the period 1992-1999 are summarized in Table 1. As mentioned previously, grain consumption dropped dramatically during the sample period whereas vegetable oil, poultry, aquatic products, and milk climbed and reached a peak in 1999. Meanwhile, pork consumption fluctuated slightly with a downward trend. However, wine and sugar consumption remained almost the same within these eight years. The consumption trend for the sample period indicated that the Chinese urban inhabitants reduced their staple foods, but consumed more protein foods and vegetable oils.

Prices (unit values) for the selected food items are presented in Table 2. Surprisingly, all the prices reached a climax around 1996 and 1997. However, milk reached its peak price in 1998 with 5.0 Yuan/kg. In addition, the prices before 1994 stayed at a lower level. Note that the Chinese government terminated food rationing in 1993. After 1994, the prices fluctuated more for all the selected foods. After 1998, they stabilized. For example, the price for aquatic products was 8.9 Yuan/kg in 1993, jumped to 11.2 Yuan/kg in 1994, and reached its peak at 14.4 Yuan/kg in 1996; after three years, the price dropped slowly back to its 1994 level.

Income and expenditure patterns are different from those of price and consumption (Table 3). Living expenditure and disposable income have been increasing rapidly. However, the food expenditure, as well as the expenditure for 12 selected food items, increased dramatically in the early 1990s, reached its peak at 1,943 Yuan in 1997, and then dropped slightly to 1,932 Yuan in 1999. This trend shows that the food expenditure in urban China follows Engel's Law, that is, the expenditure in food increases while income increases but at a decreasing rate. All of this makes an investigation of how income and prices affect food demand in China very intriguing.

4. Estimation and Simulation Results

Four complete demand systems, the LA/AIDS, AIDS, LES, and QES are estimated using the full information maximum likelihood (FIML) estimator with 12 aggregated food items for five periods, [1] 1992-1996, [2] 1993-1996, [3] 1994-1996, [4] 1995-1996, and [5] 1992-1999. Excluding Tibet and Chongqing, as mentioned in Section 3, sample sizes for the five periods are 145, 116, 87, 58, and 232, respectively[4]. In addition, the budget share functional forms are employed to reduce the heterscadasticity problem. Using SAS software with theoretical restrictions of homogeneity and symmetry

[4] We present the parameter estimates only for period 1993-1996 to compare the model performance by forecasting accuracy with *ex post* simulation and *ex ante* forecasting.

imposed, the estimated parameters for the four models and for the period of 1993-1996 are presented in Appendix A.

The estimates of food demand elasticities in China are summarized in Tables 4 and 5. As one can see in Table 4, the expenditure elasticities are very different among the selected models and range from -0.19 to 3.25. The negative expenditure elasticity corresponds to poultry demand from the LA/AIDS whereas the highest expenditure elasticity corresponds to aquatic products from the QES. In addition, the LA/AIDS provides different patterns of expenditure elasticities from the other three models. For example, the elasticity for poultry from the LA/AIDS is -0.19, indicating poultry as an inferior good, whereas those from the AIDS, LES, and QES are 1.93, 1.94, and 2.77, respectively, showing a highly elastic demand. Pork and aquatic products are similar to poultry. On the other hand, the LA/AIDS shows an expenditure elastic demand for vegetables, fruits, and vegetable oils whereas the other three models indicate their demand as being expenditure inelastic. As for grain and wine, the expenditure elasticities in the LA/AIDS and AIDS are elastic whereas those in the LES and QES are not.

Grain is one of the most important food items with its particularly important relevance to China's self-sufficiency policy in food. The estimated expenditure elasticities show dramatic differences between the two classes of models. Specifically, the estimated expenditure elasticities are 1.30 and 1.04 from the LA/AIDS and AIDS verses 0.20 and 0.32 from the LES and QES. These elasticities have extremely different implications for future food grain demand and agricultural trade. Which functional specifications should be used to explain food demand in urban China? We need other criteria to determine this.

There are other patterns of differences among the expenditure elasticities of the four models. For example, the LA/AIDS and AIDS provide higher expenditure elasciticies than the LES and QES for grains, vegetable oil, and wine. However, it is the opposite for pork, poultry, and aquatic products. As for sugar, other meats, eggs, milk, and fruits, the LA/AIDS and LES have similar elasticity patterns compared with the AIDS and QES. This shows the similarity for model complexity. Even though Deaton and Muellbauer (1980) suggested using the LA/AIDS instead of the original nonlinear AIDS model due to difficulty in parameter estimation, our results show a big difference in expenditure elasticities between the two models. The difficult question, as we mentioned earlier, is which set of expenditure elasticities should be used to predict future food demand in China.

In Table 5, the uncompensated own-price elasticities not only show more similarity among the four models but also have the correct signs and distribute from -2.50 (for other meats from the QES) to -0.05 (for grain from the AIDS). Almost all the protein food, such as pork, poultry, other meats, aquatic products, eggs, and milk, show a high price elastic demand except for poultry and aquatic products from the LA/AIDS and AIDS. On the other hand, the other foods indicate price inelastic demand except for fruits from the LA/AIDS with a unitary own-price elascitity. Therefore, if we want to increase the total expenditure on the selected foods, the price policies for protein food and non-protein food should be the opposite. As to the differences among the four models, the results indicate that the own-price elasticities from the LA/AIDS and AIDS are closer to each other whereas those from the LES and QES are similar for almost all food items.

Hence, the empirical results obtained in this study suggest that price elasticities are less variant among model specifications as compared with expenditure elasticities.

Graphs 1-12 show the actual and simulated quantity demanded for urban China by food items. Observations for period 1993-1996 are utilized to perform an *ex post* simulation within the sample period for four models followed by an *ex ante* forecasting (or may be alternatively termed as *ex post* forecasting) for the following three years, 1997-1999. The actual food consumption patterns have been discussed in the previous section. This exercise allows us to focus on the performance of predicting ability among the selected models. Basically, the four models have a similar predicting pattern. More precisely, the LA/AIDS and AIDS, as well as the LES and QES, are closer to each other than the other models. For example, for fruits, both the LA/AIDS and AIDS over-predict their consumption whereas the LES and QES show under-predictions. As for grain, eggs, and vegetables, all four models are over-estimated; however, poultry, aquatic products, and milk are under-estimated. For grain, aquatic products, and milk, especially, none of the models perform well enough to predict closely to the actual consumption levels. These simulation and predicting results indicate that if we used these elasticities to predict the future demand for grain, aquatic products, and milk, it would cause a huge problem stemming from prediction errors in assessing food market and potential agricultural trade in China. In order to assess further the predicting performance of various models, we need more precise statistical measurements on predictive accuracy.

The predictive accuracy of the four models is appraised by several alternative measures suggested by Pindyck and Rubinfeld (1998). A comparison of the Root Mean

Square (RMS) error and the RMS percent error of four models for *ex post* simulations[5] (1993-1996) are shown in Tables 6-7. The ranking of models are ordered from the best to the worst. For example, for grain, the ranking is ACDB, which means the LA/AIDS outperforms the LES, the QES, and then the AIDS. This is surprising because the LA/AIDS yields a huge expenditure elasticity of 1.30 for grain.

Not surprisingly, the RMS and the RMS percent errors conclude the same ranking for individual food. However, if we sum up the RMS errors by the weights from budget share[6], which provides an overall measure of model performance, the conclusions drawn from the RMS and the RMS percent errors are different. We conclude from the RMS error that the simple model is better whereas we conclude from the RMS percent error that the LES and QES are better than the LA/AIDS and AIDS. Moreover, both measures allow us to conclude that the LES is the best and the AIDS is the worst with respect to the forecasting accuracy. If we compare the performances for each food items, we find that, overall, the LES outperforms the QES (11 out of 12 food items) and the AIDS is preferable to the LA/AIDS (7 out of 12). To treat the LA/AIDS and AIDS as Group A and the LES and QES as Group B, the performance of Group B is better than that of Group A for 6 out of 12. Only the RMS error for aquatic products from Group A is better than that from Group B. Therefore, from simulation prospective, the simpler the model, the better.

Another set of comparison is important as well, according to predicting/ forecasting purpose. Comparisons of the Root Mean Square (RMS) error and the RMS percent error of four models for *ex ante* forecasting period (1997-1999) are presented in

[5] In this study, we use five measures to compare the simulation results. The results from Theil's inequality, mean simulation error, and mean percent error are presented in the appendix C.
[6] This is adapted from Blanciforti *et al.* (1986).

Tables 8-9. The predicting performances are extremely different from *ex post* simulation. Overall, the LA/AIDS is the least preferable model among the four. In addition, the more complicated the model, the better the performance; that is, the QES outperforms the AIDS, the LES and then the LA/AIDS, from the RMS error. However, from the RMS percent error, we still conclude Group B is better than Group A, and the LES is the most preferable. The comparison of each food items show that the LES is the most preferable for 6 out of 12 food items and the QES is the best for 5 out of 12. Hence, the LES and QES are rather competitive. From Table 9, we find Group B outperforms Group A for 8 out of 12 food items and none of the Group A outperforms Group B. Therefore, we can conclude, according to the *ex ante* forecasting accuracy, that the more complicated the model, the better the performance and that the LES and QES are better than the LA/AIDS and AIDS.

5. Implications for Agricultural Trade

In this section, we try to draw implications for agricultural trade between Taiwan and China. Taiwan, compared with other countries, has several advantages due to its similar culture with China and its geographic circumstances. Agriculture is very important across the Taiwan Straits. A precious investigation of future food demand will benefit both Taiwan and China.

Comparisons of the food intake and food supply in Taiwan identify the agricultural surplus in Taiwan. The 1996 food balance sheet, obtained from the Council of Agriculture (COA), subtracted from food intakes in 1996 (Pan and Huang, 1997), allows us to understand the types of food available for export from Taiwan to China. Fruits have the most surplus with over 100 grams per capita per day followed by fats and oils with over 50 grams, aquatic products with 30 grams, and poultry with 20 grams. In the previous discussion, Chinese urban inhabitants increased their consumption of vegetable oil, poultry, aquatic products, milk and milk products, and fruits for 1992-1999. Therefore, it may be profitable to export Taiwan's surplus agricultural products to China to supply the climbing need for these food groups.

From previous discussion, the LES and QES perform better than the LA/AIDS and AIDS models, according to the comparisons of *ex post* simulation and *ex ante* forecasting. From the expenditure and own-price elasticities of the selected food groups, we find an interesting phenomenon: high expenditure elasticity is accompanied with high own-price elasticity. For example, the aquatic product from the QES has high expenditure elasticity (3.25) and high own-price elasticity (-1.61) whereas vegetable oil from the LES has low expenditure elasticity (0.30) and low own-price elasticity (-0.24). This association between expenditure and own-price elasticities suggests that the profitability of suppliers and traders is very sensitive to price changes.

6. Concluding Remarks

In summary, model specification is an art, and it is still difficult to find the most appropriate model to describe major food consumption patterns in urban China. However, the estimated expenditure elasticities imply that as urban Chinese household income increases, the Chinese urban inhabitants will consume more aquatic products, poultry, and milk. This potential trend will undoubtedly benefit the fishery and livestock industries as well as feed grain producers in China and other countries such as Taiwan. According to the high own-price elasticities of these three food groups, traders need to be cautious when instituting a price policy in order to maintain profitability. These elasticities need to be used cautiously to investigate the potential impact of the long-term trend of income and prices on China's domestic agriculture as well as international trade.

In terms of forecasting/predicting accuracy, the LES and QES are more preferable than the LA/AIDS and AIDS, regardless of whether it is considered from *ex post* simulation or from *ex ante* prediction. In addition, the LES appears to be the best, with the least predicting errors. This result implies that the expenditure system stemmed from a direct utility can predict more accurately within and also beyond the sample period.

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Table 1
Per Capita Food Consumption Patterns in Urban China for the Period (1992-1999)
Units: kilogram

Year	1992	1993	1994	1995	1996	1997	1998	1999
Grain	111.50	97.78	101.67	97.00	94.68	88.59	86.72	84.91
Vegetable Oil	6.65	7.14	7.52	7.11	7.14	7.20	7.55	7.78
Sugar	1.85	1.77	1.91	1.68	1.71	1.63	1.76	1.81
Pork	17.70	17.40	17.12	17.24	17.07	15.34	15.88	16.91
Poultry	5.08	5.20	5.67	5.79	5.37	6.51	6.28	6.69
Other Meats	2.42	2.51	2.29	1.84	2.14	2.10	2.13	2.29
Aquatic Products	8.19	8.02	8.55	9.19	9.19	11.06	11.63	12.20
Eggs	9.45	9.36	10.17	10.37	10.14	11.73	10.76	11.53
Milk & Products	6.32	6.12	6.71	5.23	5.56	5.92	7.25	9.19
Vegetables	127.20	122.77	123.00	118.55	120.47	115.24	115.75	116.94
Fruits	47.78	44.55	45.53	45.41	46.59	52.55	55.34	54.78
Wine	8.68	8.66	9.06	8.90	8.83	8.79	8.90	8.80

Table 2
Price (Unit Value) for Selected Food in Urban China for the Period (1992-1999)
Units: Yuan/kilogram

Year	1992	1993	1994	1995	1996	1997	1998	1999
Grain	0.94	1.33	1.99	2.69	2.87	2.69	2.62	2.54
Vegetable Oil	4.42	5.25	8.27	9.51	8.82	8.98	9.30	8.92
Sugar	2.48	3.06	3.92	5.71	5.15	5.13	4.70	3.94
Pork	5.85	6.91	9.79	12.46	12.56	14.37	12.79	10.73
Poultry	7.61	9.63	12.04	14.18	15.82	14.65	14.13	13.84
Other Meats	8.74	10.54	13.34	17.96	18.94	20.01	19.90	18.14
Aquatic Products	7.24	8.90	11.20	13.13	14.35	12.75	12.25	11.80
Eggs	4.27	5.03	5.70	6.71	7.76	6.27	6.23	5.68
Milk & Products	2.00	2.35	2.70	3.99	4.60	4.97	5.02	4.89
Vegetables	0.78	0.96	1.24	1.60	1.72	1.77	1.70	1.66
Fruits	1.29	1.55	1.96	2.47	2.53	2.42	2.18	2.37
Wine	3.30	3.73	4.48	5.30	5.76	5.99	5.69	5.84

Table 3
Per Capita Expenditure and Disposable Income in Urban China for the Period (1992-1999)
Units: Yuan

Year	1992	1993	1994	1995	1996	1997	1998	1999
Expenditure for 12 food in study	603.54	721.55	992.26	1227.76	1294.66	1296.48	1253.79	1237.95
Food expenditure	883.65	1058.20	1422.49	1766.02	1904.71	1942.59	1926.89	1932.10
Living expenditure	1671.73	2110.81	2851.34	3537.57	3919.47	4185.64	4331.61	4615.91
Disposable income	2026.59	2577.44	3496.24	4282.95	4838.90	5160.32	5425.05	5854.02

Table 4
Comparison of Expenditure Elasticities of Four Models for the Period (1993-1996)

	Budget	Model			
Food Group	Share	LA/AIDS	AIDS	LES	QES
Grain	0.214	1.302	1.041	0.199	0.322
Vegetable Oil	0.058	1.209	0.908	0.294	0.321
Sugar	0.008	0.573	1.418	0.757	1.365
Pork	0.168	0.492	1.161	1.421	1.561
Poultry	0.062	-0.188	1.926	1.943	2.774
Other Meats	0.031	1.031	0.602	2.485	0.999
Aquatic Products	0.086	0.190	1.890	2.178	3.245
Eggs	0.060	1.539	0.988	1.076	0.158
Milk & Products	0.019	1.308	0.688	1.454	0.923
Vegetables	0.160	1.170	0.401	0.552	0.375
Fruits	0.092	1.327	0.185	0.994	0.539
Wine	0.042	2.373	1.523	0.932	0.509

Table 5
Comparison of Own-Price Elasticities of Four Models for the Period (1993-1996)

	Budget	Model			
Food Group	Share	LA/AIDS	AIDS	LES	QES
Grain	0.214	-0.383	-0.049	-0.182	-0.102
Vegetable Oil	0.058	-0.211	-0.198	-0.242	-0.159
Sugar	0.008	-0.448	-0.451	-0.605	-0.467
Pork	0.168	-1.948	-1.581	-1.065	-1.057
Poultry	0.062	-0.952	-0.599	-1.369	-1.340
Other Meats	0.031	-1.274	-1.263	-1.829	-2.504
Aquatic Products	0.086	-0.530	-0.507	-1.446	-1.614
Eggs	0.060	-1.347	-1.275	-0.839	-1.207
Milk & Products	0.019	-1.588	-1.612	-1.116	-1.141
Vegetables	0.160	-0.782	-0.671	-0.469	-0.509
Fruits	0.092	-1.012	-0.647	-0.784	-0.895
Wine	0.042	-0.554	-0.615	-0.736	-0.700

Table 6

Comparison of Root Mean Square (RMS) Errors of Four Models for the Period (1993-1996)

Food Group	Budget Share	Model				Ranking of Models
		LA/AIDS(A)	AIDS(B)	LES(C)	QES(D)	
Grain	0.214	2.452	8.392	3.250	5.307	ACDB
Vegetable Oil	0.058	0.373	0.183	0.316	0.235	BDCA
Sugar	0.008	0.198	0.181	0.065	0.147	CDBA
Pork	0.168	1.354	0.930	0.844	0.987	CBDA
Poultry	0.062	0.855	0.816	0.315	1.047	CBAD
Other Meats	0.031	0.765	0.845	0.219	0.615	CDAB
Aquatic Products	0.086	0.833	0.761	1.098	1.650	BACD
Eggs	0.060	1.465	1.374	0.296	1.524	CBAD
Milk & Products	0.019	1.284	1.530	0.785	1.197	CDAB
Vegetables	0.160	4.563	4.851	1.202	4.332	CDAB
Fruits	0.092	5.454	5.240	0.913	3.709	CDBA
Wine	0.042	1.608	2.086	0.273	0.342	CDAB
Total	1.000	2.336	3.565	1.298	2.705	CADB

Table 7

Comparison of Root Mean Square (RMS) Percent Errors of Four Models for the Period (1993-1996)

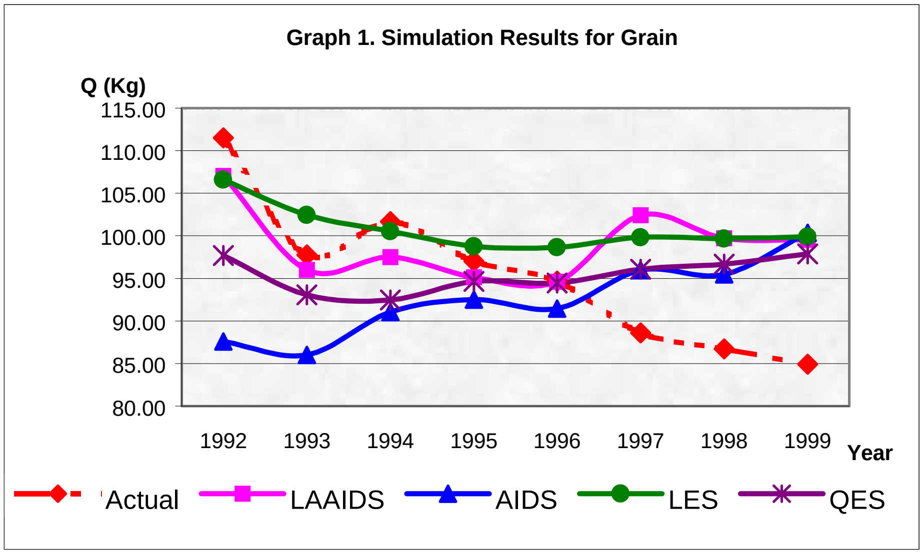
Food Group	Budget Share	Model				Ranking of Models
		LA/AIDS(A)	AIDS(B)	LES(C)	QES(D)	
Grain	0.214	2.44%	8.47%	3.36%	5.27%	ACDB
Vegetable Oil	0.058	5.20%	2.57%	4.37%	3.19%	BDCA
Sugar	0.008	10.99%	10.20%	3.74%	8.00%	CDBA
Pork	0.168	7.87%	5.40%	4.88%	5.71%	CBDA
Poultry	0.062	15.23%	14.94%	5.79%	18.69%	CBAD
Other Meats	0.031	35.26%	38.63%	10.42%	29.49%	CDAB
Aquatic Products	0.086	9.26%	8.49%	12.51%	18.53%	BACD
Eggs	0.060	14.53%	13.77%	2.93%	14.90%	CBAD
Milk & Products	0.019	21.06%	25.14%	13.40%	20.26%	CDAB
Vegetables	0.160	3.75%	4.02%	1.00%	3.59%	CDAB
Fruits	0.092	11.93%	11.44%	2.01%	8.12%	CDBA
Wine	0.042	18.50%	23.95%	3.14%	3.87%	CDAB
Total	1.000	8.81%	9.81%	4.49%	8.76%	CDAB

Table 8
Comparison of Root Mean Square (RMS) Errors of Four Models for the *ex ante* Forecasting Period (1997-1999)

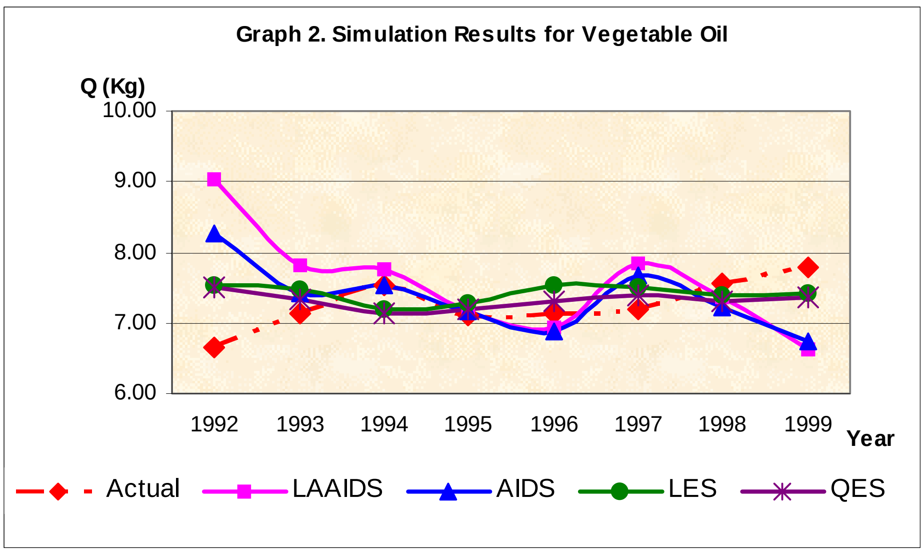
Food Group	Budget Share	Model				Ranking of Models
		LA/AIDS[(A)]	AIDS[(B)]	LES[(C)]	QES[(D)]	
Grain	0.194	13.834	11.084	13.145	10.386	DBCA
Vegetable Oil	0.058	0.776	0.684	0.290	0.300	CDBA
Sugar	0.006	0.314	0.249	0.218	0.121	DCBA
Pork	0.159	2.512	2.050	1.884	2.060	CBDA
Poultry	0.068	1.139	0.936	0.671	1.165	CBAD
Other Meats	0.032	0.165	0.133	0.207	0.107	DBAC
Aquatic Products	0.096	2.987	2.330	1.954	2.188	CDBA
Eggs	0.054	2.513	2.477	0.868	1.842	CDBA
Milk & Products	0.030	3.044	3.153	2.685	2.590	DCAB
Vegetables	0.160	8.226	5.973	3.086	4.665	CDBA
Fruits	0.100	3.204	1.393	5.047	3.871	BADC
Wine	0.043	0.719	0.646	0.206	0.198	DCBA
Total	1.000	5.400	4.165	4.245	3.976	DBCA

Table 9
Comparison of Root Mean Square (RMS) Percent Errors of Four Models for the *ex ante* Forecasting Period (1997-1999)

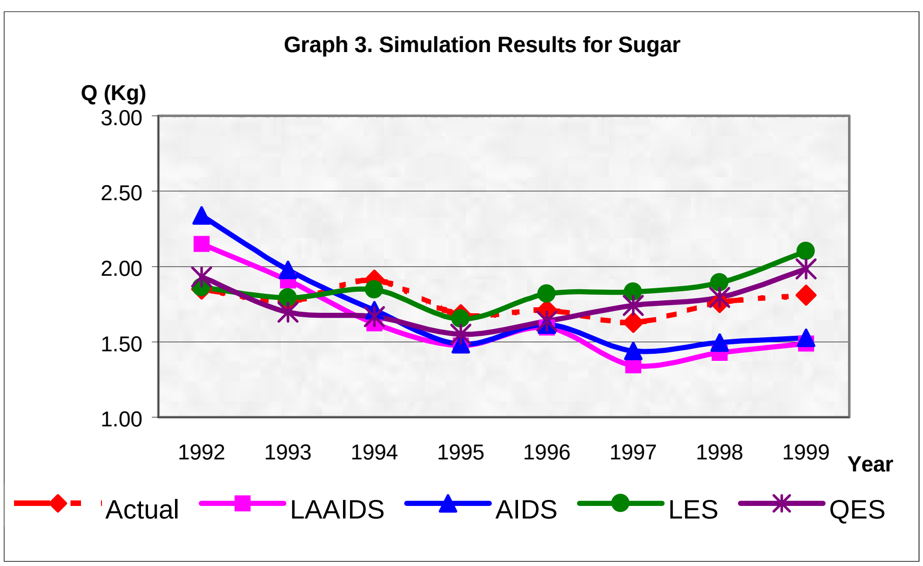
Food Group	Budget Share	Model				Ranking of Models
		LA/AIDS[(A)]	AIDS[(B)]	LES[(C)]	QES[(D)]	
Grain	0.194	15.97%	12.92%	15.22%	12.07%	DBCA
Vegetable Oil	0.058	10.18%	8.93%	3.86%	3.92%	CDBA
Sugar	0.006	18.06%	14.21%	12.48%	6.90%	DCBA
Pork	0.159	15.43%	12.46%	11.21%	12.28%	CDBA
Poultry	0.068	17.47%	14.18%	10.23%	17.91%	CBAD
Other Meats	0.032	7.53%	6.29%	9.62%	4.98%	DBAC
Aquatic Products	0.096	25.49%	19.90%	16.63%	18.73%	CDBA
Eggs	0.054	22.42%	22.16%	7.77%	16.39%	CDBA
Milk & Products	0.030	35.08%	36.11%	31.41%	29.98%	DCAB
Vegetables	0.160	7.13%	5.18%	2.67%	4.03%	CDBA
Fruits	0.100	5.95%	2.60%	9.26%	7.08%	BADC
Wine	0.043	8.17%	7.34%	2.34%	2.25%	DCBA
Total	1.000	14.48%	11.85%	10.44%	10.97%	CDBA



Graph 1. Simulation Results for Grain

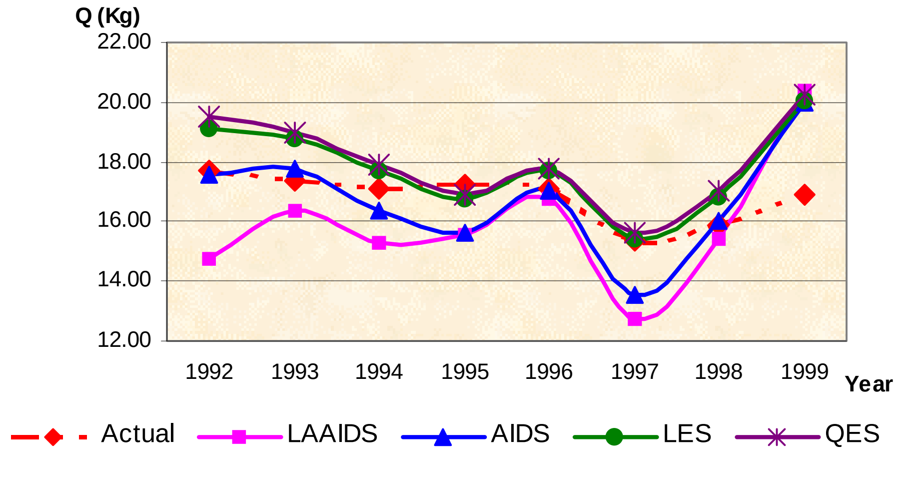


Graph 2. Simulation Results for Vegetable Oil

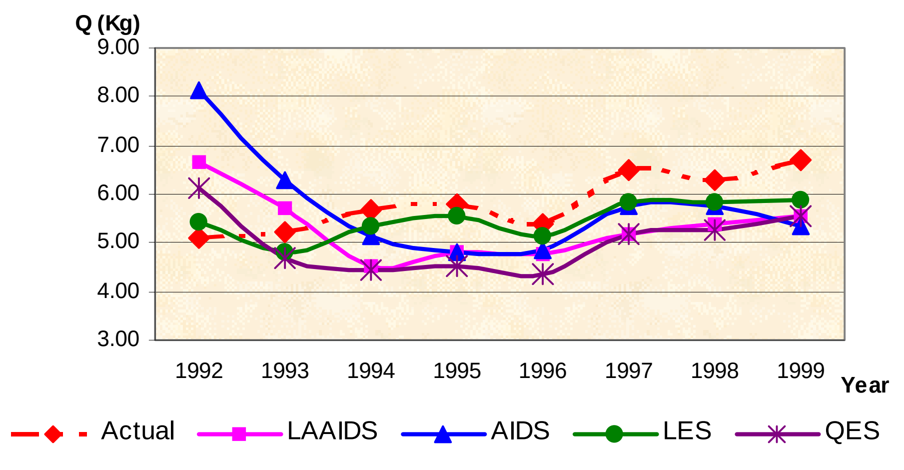


Graph 3. Simulation Results for Sugar

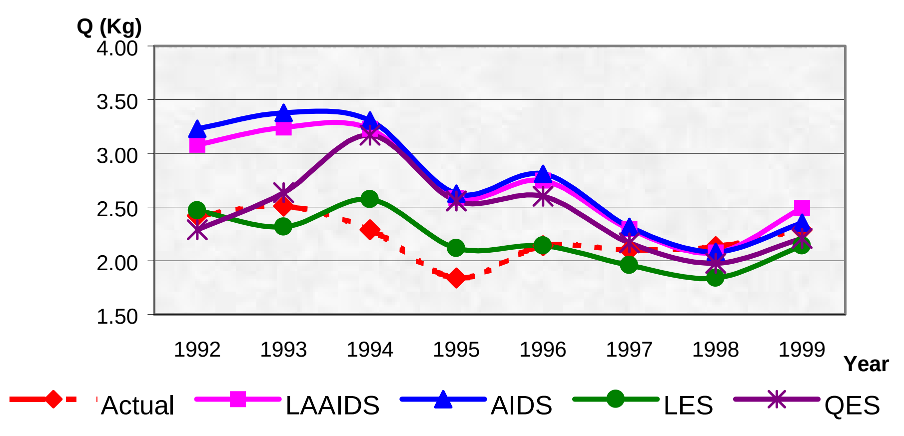
Graph 4. Simulation Results for Pork



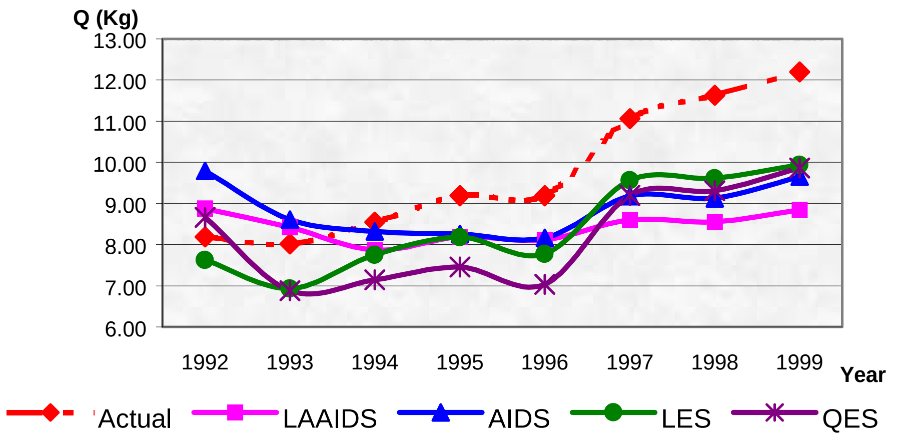
Graph 5. Simulation Results for Poultry



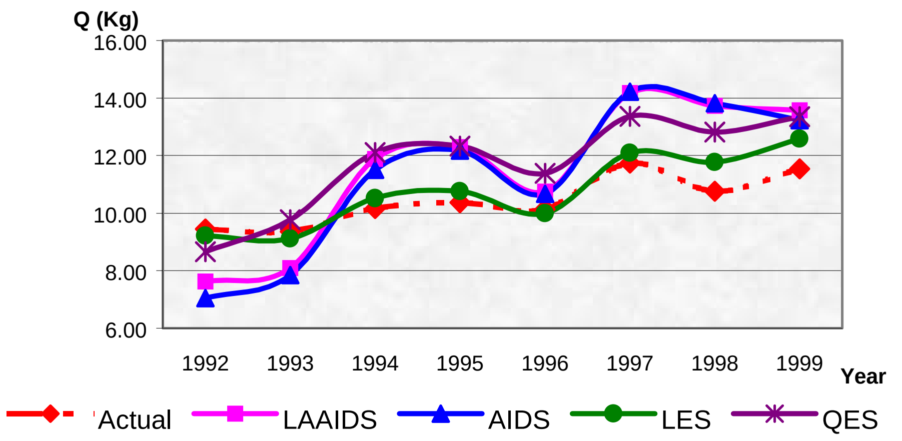
Graph 6. Simulation Results for Other Meats



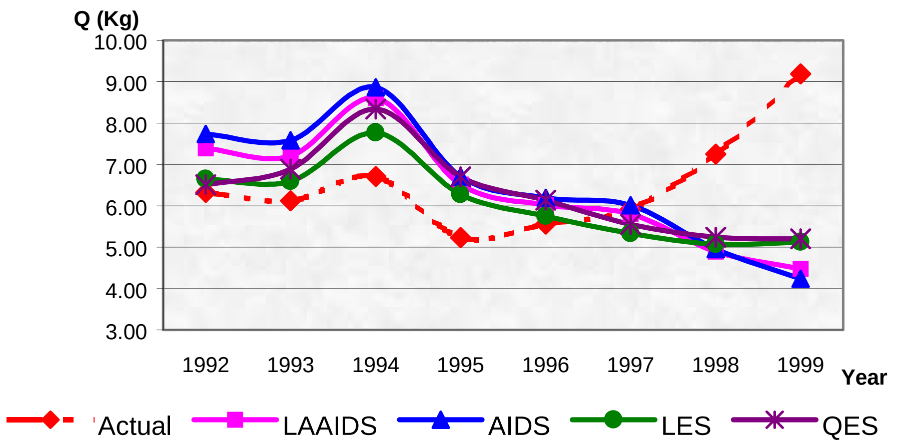
Graph 7. Simulation Results for Aquatic Products



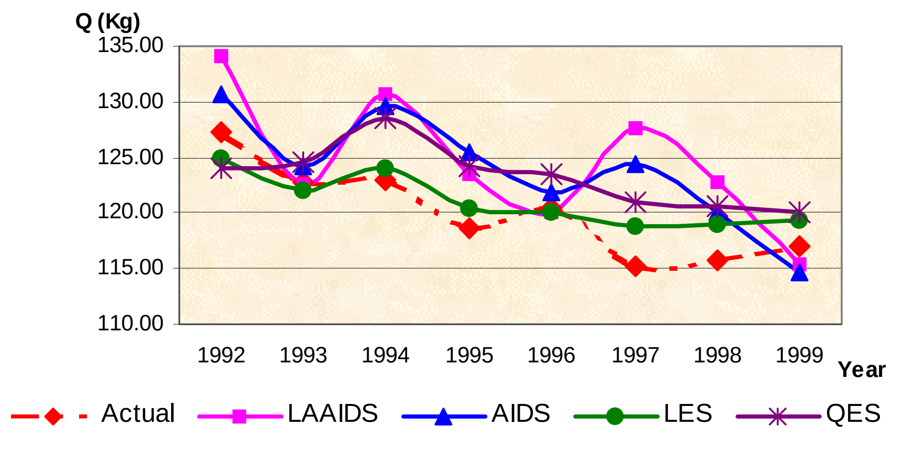
Graph 8. Simulation Results for Eggs



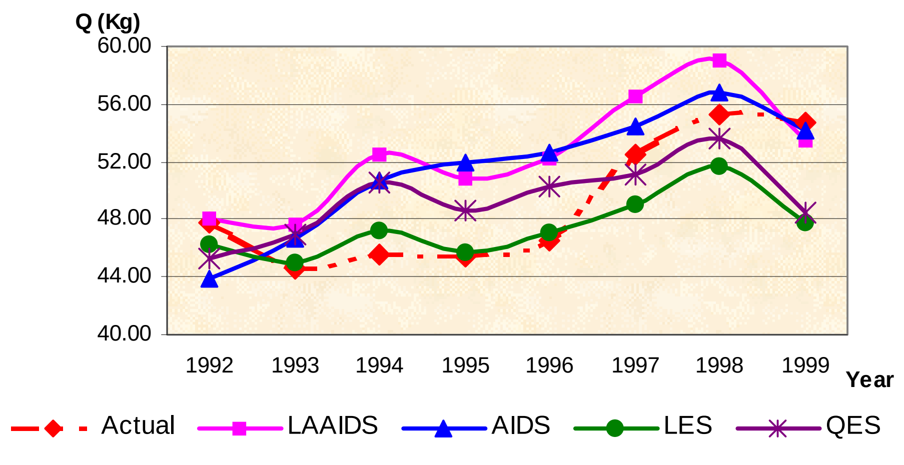
Graph 9. Simulation Results for Milk & its Products



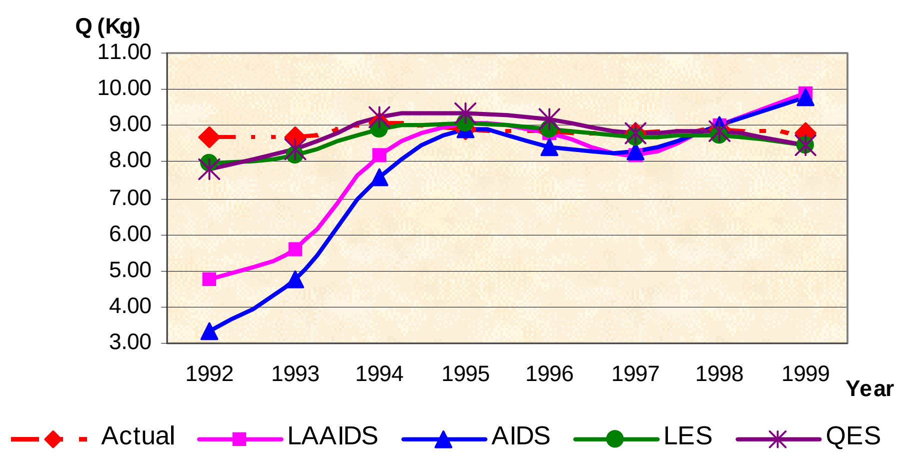
Graph 10. Simulation Results for Vegetables



Graph 11. Simulation Results for Fruits



Graph 12. Simulation Results for Wine



Appendix A
Regression Results

Table A1. Parameter Estimates of the LA/AIDS and AIDS by the ITSUR

Parameter	LA/AIDS	AIDS
α_0		-85.078*
	-	(33.605)
α_1	-0.039	-0.228
	(0.180)	(1.264)
α_2	-0.094	0.477
	(0.067)	(0.643)
α_3	0.025	-0.269
	(0.015)	(0.163)
α_4	0.949***	-2.087
	(0.196)	(1.618)
α_5	0.376**	-5.075**
	(0.142)	(1.902)
α_6	-0.073	0.953
	(0.074)	(0.665)
α_7	0.462*	-6.535**
	(0.214)	(2.022)
α_8	-0.159	0.084
	(0.098)	(0.867)
α_9	-0.025	0.521
	(0.037)	(0.311)
α_{10}	-0.027	8.387***
	(0.133)	(2.271)
α_{11}	-0.167	6.542**
	(0.093)	(2.058)
β_1	0.065*	0.009
	(0.029)	(0.015)
β_2	0.012	-0.005
	(0.011)	(0.007)
β_3	-0.003	0.003
	(0.002)	(0.002)
β_4	-0.085**	0.027
	(0.032)	(0.018)
β_5	-0.073**	0.057***
	(0.023)	(0.013)
β_6	0.001	-0.012
	(0.012)	(0.008)
β_7	-0.070	0.077***
	(0.039)	(0.015)
β_8	0.032	-0.001
	(0.016)	(0.010)
β_9	0.006	-0.006
	(0.006)	(0.004)
β_{10}	0.027	-0.096***
	(0.023)	(0.014)
β_{11}	0.030	-0.075***
	(0.015)	(0.009)
γ_{0101}	0.132***	0.196***
	(0.024)	(0.035)
γ_{0102}	-0.038***	-0.019
	(0.008)	(0.014)
γ_{0103}	-0.003	-0.009
	(0.002)	(0.006)
γ_{0104}	0.052*	-0.042
	(0.022)	(0.048)
γ_{0105}	-0.064***	-0.172
	(0.015)	(0.099)
γ_{0106}	-0.016	-0.006
	(0.009)	(0.025)
γ_{0107}	-0.043**	-0.157
	(0.013)	(0.138)
γ_{0108}	0.014	0.023
	(0.010)	(0.014)
γ_{0109}	-0.006	-0.002
	(0.004)	(0.012)
γ_{0110}	-0.055***	0.066
	(0.011)	(0.169)
γ_{0111}	-0.015	0.090
	(0.010)	(0.132)
γ_{0202}	0.046***	0.043***
	(0.007)	(0.012)
γ_{0203}	-0.001	0.001
	(0.001)	(0.003)
γ_{0204}	0.040***	0.047
	(0.010)	(0.031)
γ_{0205}	-0.007	0.020
	(0.008)	(0.055)
γ_{0206}	-0.013*	-0.022
	(0.005)	(0.013)
γ_{0207}	-0.011*	0.034
	(0.005)	(0.071)
γ_{0208}	0.011	0.010
	(0.006)	(0.009)
γ_{0209}	-0.010***	-0.015*
	(0.002)	(0.006)
γ_{0210}	-0.012*	-0.066
	(0.006)	(0.085)
γ_{0211}	-0.013*	-0.056
	(0.005)	(0.068)
γ_{0303}	0.004***	0.003*
	(0.001)	(0.001)
γ_{0304}	-0.004	-0.012
	(0.002)	(0.009)
γ_{0305}	-0.006***	-0.027
	(0.002)	(0.015)
γ_{0306}	0.004**	0.009*
	(0.001)	(0.004)
γ_{0307}	-0.001	-0.030
	(0.001)	(0.018)
γ_{0308}	0.006***	0.006
	(0.001)	(0.004)
γ_{0309}	-0.001**	0.001
	(0.000)	(0.002)
γ_{0310}	-0.002	0.034
	(0.002)	(0.022)
γ_{0311}	0.003*	0.031
	(0.001)	(0.016)
γ_{0404}	-0.159***	-0.182
	(0.033)	(0.119)
γ_{0405}	-0.036*	-0.168
	(0.017)	(0.142)
γ_{0406}	-0.006	0.039
	(0.010)	(0.040)
γ_{0407}	-0.023	-0.252
	(0.015)	(0.173)
γ_{0408}	0.031**	0.033
	(0.012)	(0.035)
γ_{0409}	0.018***	0.042*
	(0.005)	(0.019)
γ_{0410}	0.087***	0.364
	(0.013)	(0.213)
γ_{0411}	0.015	0.224
	(0.012)	(0.179)
γ_{0505}	0.003	-0.369
	(0.018)	(0.206)
γ_{0506}	0.080***	0.165**
	(0.008)	(0.054)
γ_{0507}	-0.018	-0.532**
	(0.011)	(0.177)
γ_{0508}	0.021*	0.028
	(0.010)	(0.074)
γ_{0509}	0.003	0.045
	(0.003)	(0.026)
γ_{0510}	-0.013	0.637**
	(0.010)	(0.216)
γ_{0511}	0.040***	0.538**
	(0.009)	(0.174)
γ_{0606}	-0.008	-0.026
	(0.007)	(0.024)
γ_{0607}	0.017**	0.135
	(0.006)	(0.076)
γ_{0608}	-0.027***	-0.025
	(0.006)	(0.016)
γ_{0609}	-0.004	-0.014
	(0.002)	(0.008)
γ_{0610}	-0.029***	-0.173*
	(0.006)	(0.087)
γ_{0611}	0.009	-0.107
	(0.005)	(0.070)
γ_{0707}	0.040*	-0.663**
	(0.020)	(0.244)
γ_{0708}	0.012	0.006
	(0.008)	(0.096)
γ_{0709}	0.003	0.062
	(0.003)	(0.034)
γ_{0710}	0.015	0.913***
	(0.011)	(0.213)
γ_{0711}	0.027***	0.721***
	(0.008)	(0.183)
γ_{0808}	-0.021	-0.017
	(0.009)	(0.012)
γ_{0809}	0.002	0.001
	(0.002)	(0.007)
γ_{0810}	-0.004	-0.013
	(0.007)	(0.116)
γ_{0811}	-0.037***	-0.047
	(0.006)	(0.091)
γ_{0909}	-0.011***	-0.017**
	(0.001)	(0.005)
γ_{0910}	0.005	-0.066
	(0.003)	(0.040)
γ_{0911}	-0.001	-0.057
	(0.002)	(0.032)
γ_{1010}	0.035**	-1.075***
	(0.011)	(0.254)
γ_{1011}	-0.018**	-0.876***
	(0.007)	(0.177)
γ_{1111}	-0.001	-0.658***
	(0.008)	(0.191)

*p<0.05, **p<0.01, ***p<0.001.

Table A2. Parameter Estimates of the LES and QES

Parameter	LES	QES
A_1	0.043	-0.149*
	(0.028)	(0.075)
A_2	0.017*	0.006
	(0.007)	(0.024)
A_3	0.006***	-0.001
	(0.001)	(0.003)
A_4	0.239***	0.304***
	(0.031)	(0.073)
A_5	0.120***	-0.052
	(0.022)	(0.071)
A_6	0.076***	0.175***
	(0.008)	(0.029)
A_7	0.187***	0.094
	(0.041)	(0.087)
A_8	0.065***	0.168***
	(0.011)	(0.038)
A_9	0.028***	0.049***
	(0.003)	(0.010)
A_{10}	0.088***	0.163***
	(0.015)	(0.037)
A_{11}	0.092***	0.178***
	(0.015)	(0.038)
B_1	83.692***	110.977***
	(10.148)	(11.955)
B_2	5.581***	6.228***
	(0.591)	(0.870)
B_3	0.700***	0.974***
	(0.116)	(0.142)
B_4	-1.486	-1.687
	(3.074)	(3.478)
B_5	-2.514	1.958
	(1.867)	(2.006)
B_6	-1.904***	-2.513***
	(0.398)	(0.432)
B_7	-5.409	-3.320
	(3.469)	(4.268)
B_8	1.569	0.362
	(0.992)	(1.134)
B_9	-0.466*	-0.485
	(0.216)	(0.253)
B_{10}	68.072***	64.265***
	(9.836)	(12.643)
B_{11}	10.450*	8.609*
	(4.446)	(4.231)
B_{12}	1.939***	2.307***
	(0.520)	(0.575)

Parameter	LES	QES
C_1	-	0.451***
		(0.135)
C_2	-	0.041
		(0.064)
C_3	-	0.030*
		(0.012)
C_4	-	0.190
		(0.194)
C_5	-	0.562***
		(0.142)
C_6	-	-0.223**
		(0.076)
C_7	-	0.603***
		(0.117)
C_8	-	-0.268**
		(0.086)
C_9	-	-0.036
		(0.031)
C_{10}	-	-0.121
		(0.080)
C_{11}	-	-0.175*
		(0.076)
λ	-	0.003*
		(0.001)

*p<0.05, **p<0.01, ***p<0.001.

Appendix B

Evaluation of Simulation Results[7]

There are several commonly used measures to test forecasting accuracy of a model. If the model has been designed for forecasting/predicting purposes, the *ex ante* RMS forecast error is an important criterion for performance comparison.

1. Root-mean-square (RMS) simulation error

(B1) $$rms\ error = \sqrt{\frac{1}{T}\sum_{t=1}^{T}\left(Y_t^s - Y_t^a\right)^2}$$

where Y_t^s = simulated value of Y_t

Y_t^a = actual value of Y_t

T = number of periods in the simulation

2. RMS percent error

(B2) $$rms\ percent\ error = \sqrt{\frac{1}{T}\sum_{t=1}^{T}\left(\frac{Y_t^s - Y_t^a}{Y_t^a}\right)^2}$$

3. Mean simulation error

(B3) $$Mean\ simulation\ error = \frac{1}{T}\sum_{t=1}^{T}\left(Y_t^s - Y_t^a\right)$$

4. Mean percent error

(B4) $$Mean\ percent\ error = \frac{1}{T}\sum_{t=1}^{T}\frac{Y_t^s - Y_t^a}{Y_t^a}$$

5. Theil's inequality coefficient

(B5) $$U = \frac{\sqrt{\frac{1}{T}\sum_{t=1}^{T}\left(Y_t^s - Y_t^a\right)^2}}{\sqrt{\frac{1}{T}\sum_{t=1}^{T}\left(Y_t^s\right)^2} + \sqrt{\frac{1}{T}\sum_{t=1}^{T}\left(Y_t^a\right)^2}}$$, where U is between 0 and 1.

[7] This part is adapted from Pindyck and Rubinfeld, Econometric Models and Economic Forecasts, 1998.

Appendix C

Comparison of Forecasting Accuracy of Four Models

Table C1
Comparison of Theil's Inequality Coefficients of Four Models for the Period (1993-1996)

Food Group	Budget Share	Model				Ranking of Models
		LA/AIDS[(A)]	AIDS[(B)]	LES[(C)]	QES[(D)]	
Grain	0.214	0.062	0.215	0.083	0.135	ACDB
Vegetable Oil	0.058	0.011	0.005	0.010	0.007	BDCA
Sugar	0.008	0.006	0.005	0.002	0.004	CDBA
Pork	0.168	0.038	0.026	0.024	0.028	CBDA
Poultry	0.062	0.023	0.022	0.009	0.029	CBAD
Other Meats	0.031	0.020	0.022	0.006	0.016	CDAB
Aquatic Products	0.086	0.021	0.019	0.029	0.042	BACD
Eggs	0.060	0.036	0.034	0.008	0.038	CBAD
Milk & Products	0.019	0.031	0.036	0.019	0.029	CDAB
Vegetables	0.160	0.102	0.108	0.027	0.097	CDAB
Fruits	0.092	0.181	0.177	0.031	0.127	CDBA
Wine	0.042	0.056	0.074	0.010	0.012	CDAB
Total	1.000	0.062	0.094	0.034	0.071	CADB

Table C2
Comparison of Mean Simulation Errors of Four Models for the Period (1993-1996)[a]

Food Group	Budget Share	Model				Ranking of Models
		LA/AIDS[(A)]	AIDS[(B)]	LES[(C)]	QES[(D)]	
Grain	0.214	-1.976	-7.522	2.331	-4.131	ACDB
Vegetable Oil	0.058	0.195	0.015	0.145	0.018	BDCA
Sugar	0.008	-0.117	-0.071	0.010	-0.129	CBAD
Pork	0.168	-1.218	-0.506	0.529	0.701	BCDA
Poultry	0.062	-0.552	-0.240	-0.306	-1.005	BCAD
Other Meats	0.031	0.756	0.835	0.090	0.545	CDAB
Aquatic Products	0.086	-0.586	-0.398	-1.075	-1.606	BACD
Eggs	0.060	0.741	0.535	0.087	1.387	CBAD
Milk & Products	0.019	1.178	1.431	0.691	1.111	CDAB
Vegetables	0.160	3.021	4.072	0.448	4.024	CADB
Fruits	0.092	5.271	4.954	0.729	3.575	CDBA
Wine	0.042	-0.957	-1.436	-0.112	0.165	CDAB
Total	1.000	0.316	-0.613	0.640	0.134	DABC*

[a] There exist several different rankings among food groups. Surprisingly, in total, the weighted average for the model performance for the ranking shows a very different story, that the LES is the least preferable model by the mean simulation error. The over-estimate and under-estimate will off-set each other in the computation of the mean forecasting errors.

Table C3
Comparison of Mean Percent Errors of Four Models for the Period (1993-1996)[a]

Food Group	Budget Share	Model				Ranking of Models
		LA/AIDS(A)	AIDS(B)	LES(C)	QES(D)	
Grain	0.214	-1.98%	-7.63%	2.43%	-4.14%	ACDB
Vegetable Oil	0.058	2.69%	0.22%	2.09%	0.32%	BDCA
Sugar	0.008	-6.55%	-4.02%	0.66%	-7.19%	CBAD
Pork	0.168	-7.07%	-2.95%	3.07%	4.06%	BCDA
Poultry	0.062	-9.59%	-3.84%	-5.59%	-18.07%	BCAD
Other Meats	0.031	34.75%	38.24%	4.87%	25.96%	CDAB
Aquatic Products	0.086	-6.35%	-4.14%	-12.29%	-18.21%	BACD
Eggs	0.060	6.93%	4.86%	0.79%	13.64%	CBAD
Milk & Products	0.019	19.66%	23.90%	11.71%	18.83%	CDAB
Vegetables	0.160	2.49%	3.37%	0.38%	3.33%	CADB
Fruits	0.092	11.55%	10.84%	1.60%	7.84%	CDBA
Wine	0.042	-10.95%	-16.38%	-1.29%	1.83%	CDAB
Total	1.000	0.21%	0.03%	0.34%	0.39%	BACD*

[a] There exist several different rankings among food groups. Surprisingly, in total, the weighted average for the model performance for the ranking shows a very different story, that the AIDS is the most preferable model by the mean percent error. The over-estimates and under-estimates tend to cancel each other in the computation of the mean percent forecasting errors.

Table C4
Comparison of Mean Errors of Four Models for the *ex ante* Forecasting Period (1997-1999)

Food Group	Budget Share	Model				Ranking of Models
		LA/AIDS(A)	AIDS(B)	LES(C)	QES(D)	
Grain	0.194	13.819	10.510	13.054	10.139	DBCA
Vegetable Oil	0.058	-0.234	-0.300	-0.073	-0.165	CDAB
Sugar	0.006	-0.313	-0.246	0.208	0.106	DCBA
Pork	0.159	0.125	0.463	1.393	1.615	ABCD
Poultry	0.068	-1.127	-0.875	-0.654	-1.158	CBAD
Other Meats	0.032	0.114	0.078	-0.195	-0.056	DBAC
Aquatic Products	0.096	-2.963	-2.310	-1.927	-2.177	CDBA
Eggs	0.054	2.485	2.414	0.808	1.834	CDBA
Milk & Products	0.030	-2.397	-2.387	-2.278	-2.124	DCBA
Vegetables	0.160	5.908	3.726	3.041	4.538	CBDA
Fruits	0.100	2.127	0.856	-4.779	-3.167	BADC
Wine	0.043	0.196	0.213	-0.186	-0.124	DCAB
Total	1.000	3.564	2.570	2.498	2.371	CDBA

Table C5
Comparison of Mean Percent Errors of Four Models for the *ex ante* Forecasting Period (1997-1999)

Food Group	Budget Share	Model				Ranking of Models
		LA/AIDS(A)	AIDS(B)	LES(C)	QES(D)	
Grain	0.194	15.94%	12.19%	15.09%	11.74%	DBCA
Vegetable Oil	0.058	-2.81%	-3.74%	-0.86%	-2.09%	CDAB
Sugar	0.006	-18.05%	-14.10%	11.98%	6.12%	DCBA
Pork	0.159	0.15%	2.39%	8.38%	9.77%	ABCD
Poultry	0.068	-17.32%	-13.37%	-10.01%	-17.82%	CBAD
Other Meats	0.032	5.19%	3.64%	-9.04%	-2.51%	DBAC
Aquatic Products	0.096	-25.39%	-19.79%	-16.49%	-18.68%	CDBA
Eggs	0.054	22.04%	21.45%	7.20%	16.25%	CDBA
Milk & Products	0.030	-28.60%	-28.02%	-28.09%	-25.80%	DBCA
Vegetables	0.160	5.12%	3.24%	2.63%	3.92%	CBDA
Fruits & Melons	0.100	3.96%	1.60%	-8.79%	-5.81%	BADC
Wine	0.043	2.22%	2.42%	-2.11%	-1.41%	DCAB
Total	1.000	1.05%	0.86%	0.75%	0.77%	CDBA