Food demand projections using full demand systems

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Disaggregated food demand projections for developing countries, although essential for improved development planning and effective policy making, are rare. Moreover food demand projection models are usually based on aggregated, national-level data. In this article, under conditions of weak separability and multistage budgeting decisions, a structural model capable of generating regional-level food demand projections for a disaggregated set of commodities is developed and estimated using data from an Indonesian expenditure survey. Regional food demand projections in Indonesia obtained under a scenario assuming constant real prices are then combined into national-level estimates.

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The adequacy of food supplies remains a serious problem in many developing countries. Inadequate food supplies usually cause nutritional problems and may result in political and social instability. Food shortages can be eliminated either by increasing food imports or through expansion of domestic food production. Whatever the case, knowledge of future food demand needs of a country is essential for both improved development planning and policy decision making.

Food demand projections are often obtained by multiplying estimates of population size with estimates of per capita consumption of food commodities.[1] Estimates of per capita consumption for food commodities are usually obtained either as future values of base-year levels using current real income growth rates and income elasticities,[2] or as functions of own-prices and total per capita expenditure.[3] In either case the effects of changes in prices of substitute and complement commodities are assumed to be zero or to cancel each other out.

To the extent that food demand is in reality determined by other factors besides population size and real income growth, such models may not give accurate results. Moreover food demand projection models usually rely on aggregate, national-level data that do not contain sufficiently detailed information to estimate the structure of food demand at a disaggregated or regional level. As a result comprehensive studies of food demand that consider specific commodities and/or geographic regions are rare, especially in developing countries.

Indonesia is a country that is synonymous with regional diversity – economic, ecological, demographic and sociocultural – and there is necessarily no correlation between national trends and conditions in each of the provinces.[4] Like many developing countries, Indonesia is facing rapidly changing patterns of food consumption and production. Rising family incomes, economic reforms affecting commodity prices, changes in the size and mix of the population, and broad changes in other socio-demographic factors as well, are changing the structure of food demand and creating different food crop requirements. Yet little is known about the impacts of such changes on the future food needs of the country.

In this article we present an econometric model that can be used to

[1]See, for example, J.S. Sarma, *Cereal Feed Use in the Third World: Past Trends and Projections to 2000*, Research Report 57, IFPRI, Washington, DC, 1986; M.J. Yetley and S. Tun, *Projecting Food Demand: A Comparison of Two Methods*, Staff Report No AGES860516, ERS, USDA, Washington, DC, 1986; A.
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generate food demand projections for Indonesia under different policy scenarios. The model produces projections for each of four geographical regions: urban Java, rural Java, urban off-Java, and rural off-Java. Regional projections are then combined into national-level projections. Although the model can generate demand projections for total food and 17 different food categories, only national-level projections for certain key commodities are presented in the simulation results at the end of this article.

The structural model

Unlike other food demand projection models that are based on elasticities, the present model is a structural model, ie it is driven by food demand response parameters estimated from a consumption survey. The model inputs are assumptions about changes over time in the size of population groups, commodity prices, inflation and real total (food and non-food) expenditure. These assumptions can be tailored to each individual region and the model can simulate a large number of alternative policy scenarios.

The system of demand equations used to obtain the parameter estimates for the demand projections model was constructed assuming a three-stage budgeting process.[5] Households were assumed to first allocate their total current expenditure among four categories: food, housing, clothing, and other non-food consumption. The second stage involved the allocation of total expenditure on food among 10 broad food categories. Finally, a third stage involved the allocation of the expenditure on the *palawija* crops (non-rice cereals, roots and tubers) and meat–fish products to more detailed items within these two food categories.

The Linear Approximate Almost Ideal Demand System (LA/AIDS) was used to model the budgeting stages described above. Because demographic effects have been shown to be important determinants of household food expenditures,[6] a set of demographic variables was introduced into the model by translating the intercept term. A detailed description of the model and the translation process is given in Appendix 1.

Data sources and estimation

The available data from the 1987 national consumer expenditure survey (Susenas) were used to estimate the parameters of the structural model. This survey was conducted throughout the entire geographical area of Indonesia using a multistage sampling design that differentiated between urban and rural areas. At the final sampling stage a number of households was drawn from the selected primary sampling unit (PSU) in a systematic fashion.[7]

The demographic variables used were five age–sex categories into which every household member was classified. For the purpose of this study the information on individual households within each PSU was aggregated to obtain what hereafter is referred to as a representative household.[8] That is, average values of expenditures and demographic variables were obtained at the PSU level. This was done for two reasons: (i) to reduce the very large number of records involved to a smaller and more manageable number, and (ii) to alleviate, to some

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Suryana, 'Consumption and demand for selected food in Indonesia', *Indonesian Agricultural Research and Development Journal*, Vol 10, 1988, pp 1–8.
[2]Sarma, *op cit*, Ref 1; Yetley and Tun, *op cit*, Ref 1.
[3]Suryana, *op cit*, Ref 1.
[4]H. Hill, Preface in H. Hill, ed, *Unity and Diversity: Regional Economic Development in Indonesia Since 1970*, Oxford University Press, Oxford, UK, 1990.
[5]A. Deaton and J. Muellbauer, *Economics and Consumer Behaviour*, Cambridge University Press, Cambridge, UK, 1980; S.M. Goldman and H. Uzawa, 'A note on separability in demand analysis', *Econometrica*, Vol 32, 1964, pp 397–398; S.R. Johnson, Z.A. Hassan and R.D. Green, *Demand Systems Estimation: Methods and Applications*, Iowa State University Press, Ames, IA, 1984; L. Phlips, *Applied Consumption Analysis*, North-Holland, Amsterdam, 1973.
[6]A.P. Barten, 'Family composition, prices and expenditure patterns', in P.E. Hart, G. Mills and J.K. Whitaker, eds, *Econometric Analysis for National Economic Planning*, Butterworth, Guildford, UK, 1964; D. Heien and G. Pompelli, 'The demand for alcoholic beverages: economic and demographic effects', *Southern Economic Journal*, Vol 55, No 3, 1989, pp 759–770; D. Heien, L.S. Jarvis and F. Perali, 'Food consumption in Mexico: demographic and economic effects', *Food Policy*, Vol 14, No 3, August 1989, pp 167–179; R.A. Pollak and T.J. Wales, 'Demographic variables in demand analysis', *Econometrica*, Vol 49, 1981, pp 1533–1551; S.J. Prais and H.S. Houthakker, *The Analysis of Family Budgets*, Cambridge University Press, Cambridge, UK, 1955; D.W. Price, 'The effects of household size and composition on the demand for food', in O. Capps, Jr, and B. Senauer, eds, *Food Demand Analysis: Implications for Future Consumption*, Department of Agricultural Economics, Virginia Polytechnic Institute and State University, August 1986.
[7]For a detailed discussion of the Susenas expenditure surveys see J.A. Dixon, 'The Susenas household expenditure surveys', Appendix C in W.P. Falcon, W.O. Jones and S.R. Pearson, eds, *The Cassava Economy of Java*, Stanford University Press, Stanford, CA, 1984; D.P. van de Walle, 'On the use of the Susenas for modeling consumer behavior', *Bulletin of Indonesian Economic Studies*, Vol 24, No 2, August 1988, pp 107–122.
[8]R. Ray, 'The testing and estimation of complete demand systems on household budget shares', *European Economic Review*, Vol 17, 1982, pp 349–369.

extent, the problem of non-consumption by individual households of certain food items during the time covered by the survey (one week for food items and one month and/or one year for non-food items).

All food items were classified into one of 10 food groups: rice, *palawija* crops, fruits, vegetables, meat and fish, eggs and dairy, fats and oils, sugar and spices, prepared and other food, tobacco and alcoholic beverages. Economic theory does not provide any guidance on the number or composition of food groups, and this decision is usually made on an *ad hoc* basis by the researcher. The construction of the food groups used in this study was influenced partially by past studies of the Indonesian food sector and by a classification reflecting the similarity of food items from a consumer's viewpoint.

Unit prices for all items were obtained by dividing the reported expenditure by the reported quantity. Quantity was not reported for all non-food items or for several food items (usually the so-called 'other' category within each food group) because these categories contained an assortment of different items that are measured in different units. Consequently the unit price could not be obtained in such cases.

A technique proposed by Heien and Pompelli[9] was used to impute the missing prices. This technique could not be used for the non-food categories in the first budgeting stage because the unit price was not defined for all non-food items. As proxies to unit prices we used the price indices reported by the Central Bureau of Statistics for major capital cities in most provinces of Indonesia. In order to express all prices in the same metric, both the unit price for total food (from the 1987 Susenas) and the price indices for the non-food categories were scaled by dividing each by its mean value.

In each budgeting stage, PSUs that did not report consumption of one or more commodities were not used in the estimation. Sample averages for the demographic variables and budget shares involved in each bugeting stage and region are reported in Table 1. The estimation was carried separately for each of the four regions using the SAS procedure Sysnlin and the method of Iterative Seemingly Unrelated Regressions (Itsur). Because the error variance–covariance matrix of the full model is singular, at each budgeting stage one equation was dropped from the estimation and its parameters were 'recovered' later using the adding-up restrictions. Itsur results in consistent parameter estimates and is asymptotically equivalent to the Maximum Likelihood Estimation technique which is invariant to the equation being dropped.[10]

Price and total expenditure elasticities for all budgeting stages and regions were computed using the estimated model parameters, the sample average values of the appropriate variables (Table 1), and the following formulae:

Own-price elasticity: $\varepsilon_{ii} = -1 + (\gamma_{ii}/w_i) - \beta_i$ (1)

Cross-price elasticity: $\varepsilon_{ij} = (\gamma_{ij}/w_i) - (\beta_i w_j/w_i);\ i \neq j$ (2)

Expenditure elasticity: $\varepsilon_i/_y = 1 + (\beta_i/w_i)$ (3)

A summary of the own-price and total expenditure elasticities for all budgeting stages and regions is given in Tables 2–5. In order to conserve space, cross-price and demographic elasticities are not reported here. However, these elasticities, and the parameter estimates as well, are available from the authors upon request.

The elasticities reported in Tables 2–5 exhibit a substantial degree of

[9]Heien and Pompelli, *op cit*, Ref 6.
[10]R.A. Pollak and T.J. Wales, 'Estimation of the linear expenditure system', *Econometrica*, Vol 37, 1969, pp 611–628.
[11]See also A. Deaton, 'Price elasticities from survey data: extensions and Indonesian results', Woodrow Wilson School, Princeton University, May 1988 (mimeo); J.A. Dixon, 'Food consumption patterns and related demand parameters in Indonesia: a review of available evidence', 1982 (mimeo); J.A. Dixon, 'Use of expenditure-survey data in staple-food-consumption analysis: examples from Indonesia', in A.H. Chisholm and R. Tyers, eds, *Food Security: Theory, Policy, and Perspectives from Asia and the Pacific Rim*, Lexington Books, Lexington, MA, 1982.

Table 1. Sample averages of demographic variables and budget shares by region, 1987 Susenas.

	Urban Java	Rural Java	Urban off-Java	Rural off-Java
Demographic variables				
Average number of:				
children < 10	1.0255	1.0209	1.2725	1.3652
females 10–19	0.5900	0.4655	0.6706	0.5443
females 20+	1.3536	1.2097	1.3084	1.2088
males 10–19	0.5481	0.4967	0.7218	0.5791
males 20+	1.2557	1.1023	1.3173	1.1393
Budget shares				
Food–non-food sector				
food	0.5471	0.6753	0.5833	0.7325
housing	0.2144	0.1652	0.1952	0.1208
clothing	0.0341	0.0384	0.0518	0.0509
other	0.2045	0.1211	0.1698	0.0958
Food sector				
rice	0.2141	0.3033	0.2305	0.3133
palawija crops	0.0653	0.0997	0.0487	0.0698
fruits	0.0500	0.0444	0.0586	0.0547
vegetables	0.0833	0.0938	0.0870	0.0887
meat and fish	0.1303	0.0838	0.1893	0.1501
eggs and dairy	0.0624	0.0335	0.0613	0.0320
fats and oils	0.0441	0.0530	0.0443	0.0519
sugar and condiments	0.0845	0.0949	0.0885	0.0984
prepared and other food	0.1797	0.1154	0.1081	0.0608
tobacco, etc	0.0863	0.0782	0.0836	0.0804
Palawija crops				
cereals	0.0877	0.2646	0.2009	0.3384
roots and tubers	0.1699	0.1843	0.2650	0.3378
beans and nuts	0.7424	0.5511	0.5342	0.3238
Meat and fish products				
red meats	0.3118	0.2130	0.2430	0.2061
poultry	0.2476	0.2542	0.1572	0.1890
fresh fish	0.3170	0.2955	0.4998	0.4084
dried fish	0.1236	0.2374	0.0100	0.1965

variability among the four regions.[11] For instance, the demand for rice appears to be highly price inelastic in urban areas and moderately inelastic in rural areas. *Palawija* crops and prepared food appear to be price elastic in all regions except urban Java. With few exceptions, the expenditure elasticities are almost the same across the four regions.

Demand projections

For each of the four regions, food demand projections are generated for both total food and 17 other food commodities by combining the estimated demand response parameters from the structural model with population projections and assumptions about the future course of commodity prices and real total expenditure. The projections generated by the model are (i) at the representative household level: budget

Table 2. Food–non-food sector: own-price and total expenditure elasticities, 1987 Susenas.

	Food	Housing	Clothing	Other
		Own-price elasticities		
Urban Java	−1.091	−0.573	−0.091	−0.515
Rural Java	−0.935	−1.491	−0.386	−1.797
Urban off-Java	−1.104	−0.880	0.025	−1.127
Rural off-Java	−0.978	−0.826	−0.935	−1.300
		Total expenditure elasticities		
Urban Java	0.884	1.067	1.083	1.226
Rural Java	0.885	0.963	1.191	1.630
Urban off-Java	0.846	1.029	1.403	1.374
Rural off-Java	0.904	1.010	1.272	1.578

Table 3. Food sector: own-price and total expenditure elasticities, 1987 Susenas.

	Rice	*Palawija*	Fruits	Vegetables	Meat and fish	Eggs and dairy	Fats	Sugar and condiments	Prepared and other food	Tobacco, etc
						Own-price elasticities				
Urban Java	−0.119	−0.731	−0.704	−0.682	−0.613	−0.615	−0.829	−0.816	−0.963	−0.838
Rural Java	−0.711	−1.574	−0.641	−0.891	−0.752	−0.692	−1.170	−0.796	−1.017	−1.028
Urban off-Java	−0.177	−1.166	−0.710	−0.859	−0.780	−0.674	−0.939	−0.780	−1.075	−0.743
Rural off-Java	−0.432	−1.314	−0.672	−0.765	−0.766	−0.775	−0.995	−0.720	−1.096	−0.775
						Total expenditure elasticities				
Urban Java	0.346	0.773	1.131	0.915	1.002	0.834	0.617	0.775	1.485	0.983
Rural Java	0.443	0.833	1.389	0.988	0.928	0.999	0.696	0.851	1.782	1.061
Urban off-Java	0.257	0.938	1.345	0.915	0.897	0.739	0.792	0.807	1.503	1.183
Rural off-Java	0.482	0.789	1.563	1.095	1.015	0.943	0.896	0.981	1.682	1.157

shares, total expenditure, and growth rate in total consumption, and (ii) at the regional level: growth rate in both total expenditure and total consumption. The procedures for computing these results are described in Appendix 2.

Regional projections are combined into national projections using a weighted average scheme with the weights being the 1985–95 average population shares of Java and off-Java in the total population of Indonesia. These weights were normalized and set to 1 for urban and rural off-Java and 1.4876 for urban and rural Java.

The population figures used in the model were obtained from population projections published by the Indonesian Central Bureau of Statistics[12] (up to 1995) and from World Bank projections thereafter.[13] In the absence of information on the future course of commodity prices, the food demand projections reported here are based on a constant-real-prices scenario with all prices increasing by 6% annually (the expected average inflation rate). This assumption, although restrictive, is usually justified by the fact that generally little is known about the future course of commodity prices. The implications of a constant-real-price scenario are detailed in Appendix 3. Finally, real total expenditure was assumed to grow at 5% annually.

[12]Biro Pusat Statistik, *Proyeksi Penduduk Indonesia: Per Provinsi*, Jakarta, Indonesia, February 1988.
[13]K.C. Zachariah and M.T. Vu, *World Population Projections 1987–88 Edition: Short- and Long-Term Estimates*, Johns Hopkins University Press, Baltimore, MD, 1988.

Table 4. *Palawija* and wheat sector: own-price and total expenditure elasticities, 1987 Susenas.

	Cereals	Roots and tubers	Beans and nuts
		Own-price elasticities	
Urban Java	−1.495	−0.745	−0.920
Rural Java	−1.308	−1.102	−0.854
Urban off-Java	−1.130	−0.915	−0.974
Rural off-Java	−1.062	−0.930	−0.806
		Total expenditure elasticities	
Urban Java	1.371	0.793	0.699
Rural Java	1.475	0.852	0.525
Urban off-Java	1.144	1.063	0.801
Rural off-Java	1.005	0.822	0.546

Table 5. Meat and fish sector: own-price and total expenditure elasticities, 1987 Susenas.

	Red meats	Poultry	Fresh fish	Dried fish
		Own-price elasticities		
Urban Java	−0.510	−0.734	−0.975	−1.002
Rural Java	−0.581	−0.789	−0.889	−1.002
Urban off-Java	−1.107	−0.977	−1.234	−0.815
Rural off-Java	−0.915	−0.720	−1.140	−1.125
		Total expenditure elasticities		
Urban Java	0.955	0.887	1.071	1.142
Rural Java	0.664	0.690	1.019	1.191
Urban off-Java	0.575	0.769	1.039	1.057
Rural off-Java	0.741	0.684	1.145	1.280

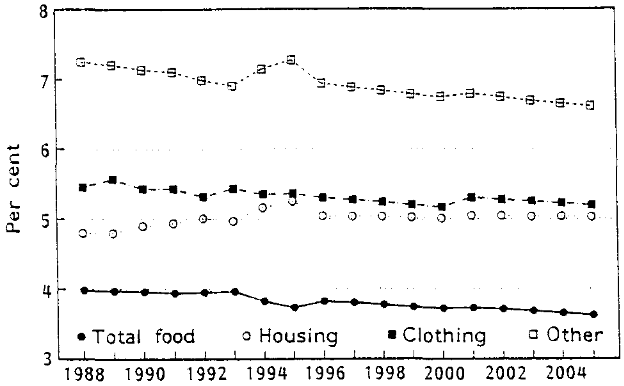


Figure 1. Annual growth in total consumption: food–non-food sector.

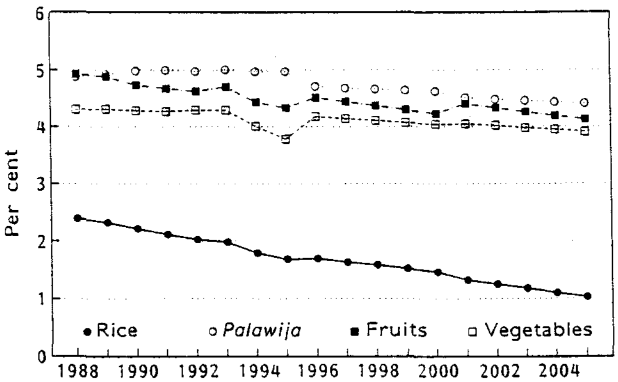
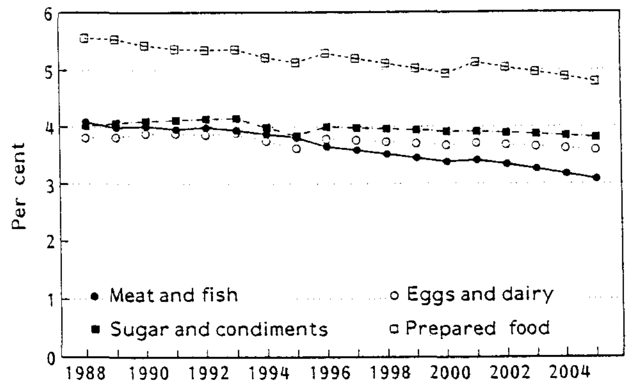


Figure 2. Annual growth in total consumption: food sector commodities.



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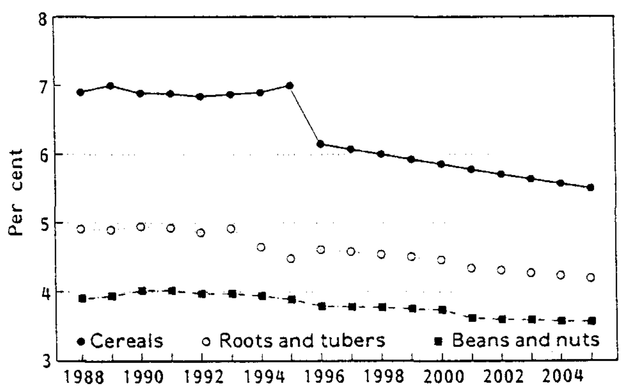

Figure 3. Annual growth in total consumption: *palawija* crops.

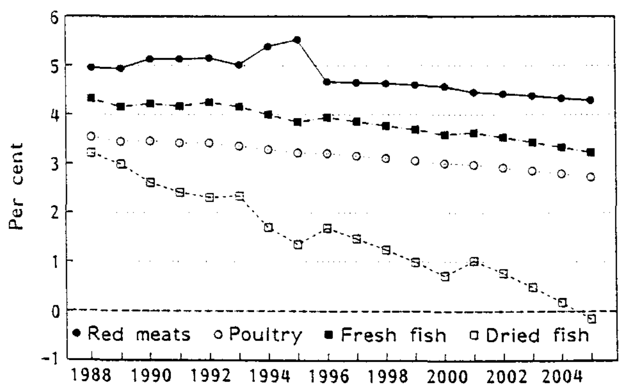

Figure 4. Annual growth in total consumption: meat and fish products.

For most of the commodities, the national-level annual growth rates for total consumption were projected to year 2005 and are reported in Figures 1–4. These growth rates reflect both the expected changes in the demographic profile of Indonesia and the assumed growth rate for real total expenditure. According to these projections, total food consumption will grow at an annual rate of 3.5–4% during the entire projection period (Figure 1). This rate, substantially lower than the growth rates in non-food consumption, is rather high and it is probably due to the fact that Indonesia's population is expected to continue growing well into the next century.

The annual growth rates in the demand for specific food commodities are shown in Figures 2–4. Like the growth rate in the demand for total food, the annual growth rates in the demand for most food commodities remain high, around 4–5%, during the entire projection period. Only the growth rates in the demand for dried/preserved fish and rice exhibit a substantial decline. The growth in the demand for dried/preserved fish even becomes negative by the end of the projection period, which means that total consumption will start declining around 2005.

Rice consumption trends are of central importance in the design of food and agricultural policies in Indonesia. According to these projections, the annual growth rate in rice consumption will drop below 2% somewhere around 1993 and below 1.5% at the end of the century. This rate is projected to drop to the neighbourhood of 1% at the end of the projection period. For policy makers concerned with maintaining Indonesia's rice self-sufficiency, these results suggest that rice production will most likely have to grow at an average annual rate slightly above 2% to meet the trend in consumption growth.

The livestock industry is receiving increased attention from policy makers as Indonesia enters the 1990s, mainly for two reasons: (i) the livestock sector is frequently seen as a crucial component of agribusiness development in general, and (ii) the use of domestically produced crops as inputs into the livestock industry has increasingly been seen as an economically efficient way of adding value to primary agricultural production. The results presented here show substantial growth in the demand for red meat, poultry and fresh fish throughout the projection period, so the domestic demand for meat products could become an important source of rapid growth for the livestock industry in Indonesia.

Cereals (mostly corn), roots and tubers are considered rice substitutes and are major sources of calories in the Indonesian diet. Substantial growth in the demand for these commodities is projected during the entire projection period. Similarly, high growth is also projected throughout in the demand for fruits and vegetables, sugar and condiments, eggs and dairy, and prepared food. Overall, these projections suggest that the demand for food commodities in Indonesia will continue growing at a substantial rate during the next 15 years.

Conclusions

A flexible food demand projection model for Indonesia has been presented in this article. Unlike other projection models that are based on national-level data, this model generates demand projections for a disaggregated set of food commodities at the regional level. National-level projections are then obtained by averaging out regional projections. The model is flexible, ie it can easily be used to examine the effects of many different policy scenarios on food demand trends, and it can be a very useful analytical tool for evaluating the effects of such policy simulations. The multicommodity nature of the model, in particular, enables the policy analyst to study the importance of own- and cross-price effects on food consumption projections.

The model was used to project food consumption in Indonesia to the year 2005 using a constant-real-prices scenario. The projections generated by the model under this scenario indicate that the demand for most food commodities in Indonesia will continue growing at a relatively fast pace during the next 15 years. Consequently self-sufficiency in rice and other major food commodities would require that substantial increases in the production of food crops and livestock products be achieved in the future.

Appendix 1

Assuming weak separability, the Marshallian demand equations for commodities in the rth budgeting stage can be written as

$$x_{ri} = g_{ri}(P, y) = f_{ri}(P_r, y_r) \quad \text{(A1.1)}$$

where x_{ri} is the demand for commodity i ($i = 1,2,\ldots,n_r$) in the rth stage ($r = 1,2,\ldots,R$), P is the vector of all commodity prices, P_r is the vector of prices for the commodities in the rth stage, y is total expenditure, and y_r is expenditure on all commodities in the rth stage.

The Marshallian demand equations (in share form) for the LA/AIDS demand system are:

$$w_{ri} = \alpha_{ri} + \sum_{j=1}^{n_r} \gamma_{rij}\ln(p_{rj}) + \beta_{ri}\ln(y_r/P_r) \quad \text{(A1.2)}$$

where $w_{ri} = (p_{ri}X_{ri})/y_r$ is the budget share of the ith commodity, p_{rj} is the price of the jth commodity, and P_r is Stones's price index, ie

$$\ln(P_r) = \sum_{k=1}^{n_r} w_{rk}\ln(p_{rk}). \quad \text{(A1.3)}$$

A set of demographic variables was introduced into this model by translating the intercept term, ie it was assumed that

$$\alpha_{ri} = \alpha_{ro} + \sum_{s}^{S} \alpha_{ris}D_s;$$
$$i = 1,2,\ldots,n_r \quad \text{(A1.4)}$$

where the D_ss denote demographic variables. The resulting model was

$$w_{ri} = \alpha_{ro} + \sum_{s}^{S} \alpha_{ris}D_s + \sum_{j=1}^{n_r} \gamma_{rij}\ln(p_{rj}) + \beta_{ri}\ln(y_r/P_r) \quad \text{(A1.5)}$$

and it was estimated with the following theoretical restrictions imposed in each budgeting stage:

Symmetry:
$\gamma_{rij} = \gamma_{rji}$ ($r = 1,2,\ldots,R$; $i \neq j$ for $i,j = 1,2,\ldots,n_r$)

Homogeneity:
$\sum_{j=1}^{n_r} \gamma_{rij} = 0$ ($r = 1,2,\ldots,R$; $i = 1,2,\ldots,n_r$)

Adding-up:
$\sum_{i=1}^{n_r} \alpha_{rio} = 1$; $\sum_{i=1}^{n_r} \alpha_{ris} = 0$;
$\sum_{i=1}^{n_r} \gamma_{rij} = 0$; $\sum_{i=1}^{n_r} \beta_{ri} = 0$
($r = 1,2,\ldots,R$; $s = 1,2,\ldots,S$; $j = 1,2,\ldots,n_r$).

Appendix 2

The food demand model projections are made in terms of changes in the budget share of each food commodity from a base year as follows (subscript r has been dropped for clarity): From equation (A1.5) we can write the base year budget share as

$$w_i^o = \alpha_{io} + \sum_s \alpha_{is}D_s^o + \sum_j \gamma_{ij}\ln(p_j^o) + \beta_i[\ln(y^o) - \ln(P^o)] \quad \text{(A2.1)}$$

and the budget share for some future year as

$$w_i^* = \alpha_{io} + \sum_s \alpha_{is}D_s^* + \sum_j \gamma_{ij}\ln(p_j^*) + \beta_i[\ln(y^*) - \ln(P^*)] \quad \text{(A2.2)}$$

Subtracting (A2.1) from (A2.2) yields

$$(w_i^* - w_i^o) = \sum_s \alpha_{is}(D_s^* - D_s^o) + \sum_j \gamma_{ij}[\ln(p_j^*/p_j^o)] + \beta_i\{[\ln(y^*/y^o)] - [\ln(P^*) - \ln(P^o)]\} \quad \text{(A2.3)}$$

which is the projected change in the budget shate of the ith food commodity between the base and future year. The future year values of the demographic variables, prices and total expenditure used in equation (A2.3) can be expressed in terms of the corresponding base year values as follows:

$$D_s^* = (1+\pi_s)D_s^o$$
$$\text{or } (D_s^* - D_s^o) = \pi_s D_s^o \quad \text{(A2.4)}$$
$$p_j^* = (1+\delta_j)p_j^o = \delta_j^* p_j^o$$
$$\text{or } (p_j^*/p_j^o) = 1+\delta_j = \delta_j^* \quad \text{(A2.5)}$$
$$y^* = (1+\sigma)y^o = \sigma^* y^o$$
$$\text{or } (y^*/y^o) = 1+\sigma = \sigma^* \quad \text{(A2.6)}$$

Using Stones's price index with the base year budget shares yields

$$\ln(P^o) = \sum_j w_j^o\ln(p_j^o) \quad \text{(A2.7)}$$

and

$$\ln(P^*) = \sum_j w_j^o\ln(p_j^*) = \sum_j w_j^o\ln[(1+\delta_j)p_j^o] \quad \text{(A2.8)}$$

from which we obtain

$$[\ln(P^*) - \ln(P^o)] = \sum_j w_j^o\ln(1+\delta_j) \quad \text{(A2.9)}$$

Substituting (A2.4)–(A2.6) and (A2.9) into (A2.3) and solving for w_i^* yields the equation that is used to compute the projected budget shares for the representative household in the future period:

$$w_i^* = w_i^o + \sum_s \alpha_s(\pi_s D_s^o)$$

$$+ \sum_j \gamma_{ij}\ln(1+\delta_j) + \beta_i\{[\ln(1+\sigma)] - [\sum_j w_j^o\ln(1+\delta_j)]\} \quad (A2.10)$$

Using these projected budget shares it is possible to estimate future expenditure and quantity consumed. For the representative household, expenditure (e_i) is obtained as the product of the budget share and total expenditure, and quantity consumed (x_i) is obtained by dividing expenditure by the price. Hence, the growth rate of household expenditure and consumption respectively is given by

$$(e_i^*/e_i^o) - 1 \quad (A2.11)$$

$$(x_i^*/x_i^o) - 1 = [(e_i^*/p_i^*)/(e_i^o/p_i^o)] - 1$$
$$= \{[e_i^*/(1+\delta_i)p_i^0]/(e_i^o/p_i^o)\} - 1$$
$$= [e_i^*/e_i^o(1+\delta_i)] - 1 \quad (A2.12)$$

Regional expenditure (E_i) and total consumption (X_i) are computed by dividing the corresponding quantity for the representative household by the household size to obtain estimated per capita quantity and multiplying the result by the number of people in the region. Hence the gowth rate of regional expenditure and total consumption respectively is given by

$$(E_i^*/E_i^o) - 1$$
$$= [(e_i^*/Z^*/H^*)/(e_i^oZ^o/H^o)] - 1$$
$$= (e_i^*Z^*H^o/e_i^oZ^oH^*) - 1 \quad (A2.13)$$

$$(X_i^*/X_i^o) - 1$$
$$= [(x_i^*Z^*/H^*)/(x_i^oZ^o/H^o)] - 1$$
$$= (x_i^*Z^*H^o/x_i^oZ^oH^*) - 1$$
$$= \{[(e_i^*/p_i^*)Z^*H^o]/[(e_i^o/p_i^o)Z^oH^*]\} - 1$$
$$= \{[e_i^*Z^*H^o]/[e_i^*(1+\delta_i)Z^oH^*]\} - 1 \quad (A2.14)$$

where Z is the population size of the region and H is the size of the representative household. It can be seen that the growth rates of the regional quantities are functions of the corresponding quantities for the representative household, the growth rate in population and (inversely) the growth rate in the size of the representative household.

Appendix 3

The implications of a constant-real-prices scenario can be traced as follows: Constant-real-price imply $(p_i^*/P^*) = (p_i^o/P^o)$ or $(P^*/P^o) = (p_i^*/p_i^o)$ for all i, ie $\delta_1^* = \delta_2^* = \ldots = \delta_n^*$ or $\delta_1 = \delta_2 = \ldots = \delta_n = \delta$. Because budget shares add up to 1,

$$\sum_j w_j^o\ln(1+\delta_j) = [\ln(1+\delta)](\sum_j w_j^o)$$
$$= \ln(1+\delta) \quad (A3.1)$$

and by using the homogeneity restriction

$$\sum_j \gamma_{ij}\ln(1+\delta_j)$$
$$= [\ln(1+\delta)](\sum_j \gamma_{ij}) = 0 \quad (A3.2)$$

Therefore, under a constant-real-prices assumption, equation (A2.10) reduces to

$$w_i^* = w_i^o + \sum_s \alpha_s(\pi_sD_s^o) + \beta_i[\ln(1+\sigma)] - \ln(1+\delta)] = w_i^o + \sum_s \alpha_s(\pi_sD_s^o) + \beta_i\ln[(1+\sigma)/(1+\delta)] \quad (A3.3)$$

This expression makes it clear that price effects are absent under a constant-real-prices scenario, ie the projected budget shares depend on the growth rate in the demographic variables (α_ss), real total expenditure (σ) and inflation rate (δ).