Food Demand Analysis: A New Approach

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What we know I

- Malnutrition has been identified as the largest risk factor for the global burden of disease (Murray and Lopez 1997).
- Deficiencies in iron, iodine, vitamin A are the main manifestations of malnutrition in developing countries.
- In Paraguay, where a large part of the population suffers from malnutrition and lack of access to calories, an intense discussion on the design of a poverty reduction strategy has recently started. This paper aims at providing policy makers with information helping in such effort.

What we know II

- In South America there are two sectors of hunger:
  1. Sector A: extremely deficient food intake, quantitative hunger associated with specific qualitative insufficiencies (Venezuela, Columbia, Peru, Bolivia, Ecuador, Chile, the northeast and extreme south of Argentina, the western half of Paraguay and the northern half of Brazil);
  2. Sector B: quantitative sufficient food intake, specific hunger in certain nutritive staples,(midwest and south of Brazil, Paraguay to the east of the Paraguay River, Uruguay and the northeastern region of Argentina).

What we know III

- In South America the food intake imbalances are historically centered on the consumption of starchy substances, in the form of cereals, tubers and roots. Protein-rich food, such as meat, milk and eggs, virtually do not feature in people's diets, nor do fresh vegetables and fruits.

What we can do I

- Policy makers need to have a clear and precise picture of how income, food prices, and other relevant socio-economic characteristics affect the amount of nutrients available to households.

- The relationship between nutritional intake and total expenditure in poor countries is the link between economic development and the elimination of hunger and malnutrition.

- Food demand analysis is an essential tool in this regard.

What we can do II

- It is believed that income is a relevant variable for consumers choice and, consequently, to evaluate the difference in consumption behaviors.
- As income increases, people purchase more high-valued goods, but not necessarily more nutritive products [Strauss e Thomas, 1990].
- Moreover, the income/expenditure effect on demand makes possible the evaluation of public policies in peoples food habits.

How

- Traditional demand analysis, which primarily looks at food quantities consumed, can be extended to also yield macro and micronutrients and nutrient elasticities, when reliable food composition tables are available.

- Using household data and a demand systems approach, we estimate income, price, macronutrients and micronutrients elasticities of food.

- We assume that the knowledge of nutritional contents in different food groups has impacts on consumers choices of food they purchased and consumed.

Table: Selected Studies Pertaining to the Demand for Specific Nutrients

Researcher	Nutrients Considered	Socio-Demographic Factor Considered
Price et al. (1978)	10	Household Size, Region, Urb., Ethnicity
Akin, Guilkey, Popkin (1983)	5	Urbanization, In-come, Household Size, Race, Ethnicity
Chavas, Keplinger (1983)	12	Income, Ethnicity, Education, Household Size, Race
Scearce, Jensen (1979)	9	Urbanization, Income, Lifecycle Stage, Race, Household Size
Devaney, Fraker (1989)	7	Race, Ethnicity, Education, Employment Status, Region, Household Size, Urbanization
Basiotis et al (1983)	8	Household Size and Composition, Urbanization, Race, Income, Region

Literary Review

- Little research effort has been made by economists with respect to micronutrients.

- In much of the economic development literature, nutrition problems are practically synonymous to the inadequacy of energy as measured by the availability or consumption of calories (Subramanian and Deaton, 1996; Strauss and Thomas, 1995, 1998).

- Even though there is an abundance of estimates on the income elasticity for calories, empirical evidence on the micronutrient income elasticity is relatively scarce (Behrman, 1995).

Aim and Relevance of the Research

- Hardly any previous work has used a theory-consistent demand systems approach to estimate macronutrients and micronutirents elasticities of food consumed.

- Instead of assuming that prices and income directly influence the demand for nutrients, we assume that knowledge on nutritional values in differents food groups has an impact on consumers' choice of food they purchased and consumed.

Aim and Relevance of the Research

- The objectives of this study are:
    1. to investigate whether nutrients contents affect the demand for food, and
    2. if they do, in what fashion.

Model Specification

We assume that households' food demand is ifluenced by three group of variables:

1. Price and Income;
2. Nutritional quality of food consumed;
3. Household Demographic charchteristics.

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Model Specification

Let's see how we can incorporate nutritional quality in the Utility function.

Fisher and Shell [1971] in their work, stated that quality change occurs in one good only, good 1. Higher quality gives higher utility; so we can incorporate the quality parameter directly in the utility fucntion, i.e:

$$u = u(q_1, ..., q_n, \theta) \tag{1}$$

where θ is a measure of the specification of good 1.
Using the scaling method, Fisher and Shell obtained:
Cost function: $y = c(u, p_1, p_2, ..., p_n, \theta) = c(u, p_1/\theta, p_2, ...p_n)$

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Demand function: $q_1 = (1/\theta)g_1(p1/\theta, p_2, p_n)$ and

$$q_i = g_1(p/\theta), p_2, ..., p_n) \text{ for } i \neq 1$$

Here, nutrients contents are assumed to reflect food quality and the scaling relation between quantity and quality variables is relaxed. Under these assumption, the consumer choice problem can be written as:

$$q_i = q_i(p_1, ..., p_n, a_{11}, ...a_{1k}, ...a_{n1}, ...a_{nk}) \qquad (2)$$

subject to $\sum p_i q_i = y$
with $a_i = (a_{i1}, ...aik)$ treated as a vector of measures of different nutrients in food.

Model Specification II

- The consumer utility generated from food is not only a function of the quantity consumed but also a function of levels of nutrients embodied in the food consumed

- The demand equations satisfying (2) have the form:

$$q_i = q_i(p_1, ..., p_n, a_{11}, ...a_{1k}, ...a_{n1}, ...a_{nk}, y) \qquad (3)$$

Model Specification III

- The effect of a nutrient can be related to the substitution effects generated by price changes

$$\partial q_i/\partial a_{jk} = -(1/\lambda) \sum_h s_{ih} \upsilon_{jk} \qquad (4)$$

where:

$\lambda = \partial u/\partial x$ is the marginal utility of income;

$s_{ih} = (\partial q_i/\partial p_h) + q_h(\partial q_i/\partial x)$ is the Slutsky substitution effect with utility held constant;

$\upsilon_{hjk} = \partial(\partial u/\partial q_h)\partial a_{jk}$ is the effect of the nutrient on marginal utility.

How to Model it

- One of the widely used functional form derived from utility maximization is the Linear Expenditure System (LES). Several reason are usually invoked to make use of the LES:
    1. it has straightforward and reasonable interpretation;
    2. it is one of the few systems that automatically satisfy all the demand theoretical restrictions;
- This kind of system does not allow for inferior goods and all of them behave as gross complementary goods

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How to model it II

- The estimation of the LES is difficult due to nonlinearity in the coefficients, which enter the formula in a multiplicative form. Some iterative approaches have been developed to overcome this difficulty (*Two-Stage Procedure* and *Full Information Maximum Likelihood Technique*)

- We follow a different approach, choosing a theoretically consistent demand system with the least theoretical restrictions imposed on the parameters.

- We estimate a *LinQuad incomplete demand system* derived from a quasi expenditure function, following *Fabiosa and Jensen* [2003] who mention several advantages of LinQuad over other complete systems.

Let $q = [q_1, q_2, , q_n]'$ be a vector of commodities of interest,
$p = [p_1, p_2...p_n]'$ the vector of corresponding prices;
$x = [x_1, x_2, ...x_m]'$, the vector of other goods with the respective
price vector $z = [z_1, z_2, ...z_m]'$, and let y represents total
expenditures, hence total income represents total expenditures as :

$$y = (\sum_{i=1}^{n} q_i p_i + \sum_{i=1}^{n} a_n) + \sum_{i=1}^{m} x_i z_i \qquad (5)$$

Thus, we have observable demand equation for the commodities of
interest (q), however demand equation that represents other
commodities is not observable. Thus, the observable demand
equation has the form:

$$q = h(p, a, z, y) \qquad (6)$$

Using the adding-up property, the demand for commodities in other goods, can be represented as follow:

$$x_i \equiv h_i(p, a, z_i, y) \equiv [y - p'h(p, a, z_i, y)]/z_i \qquad (7)$$

Integrability conditions for [6] give us an expenditure fuction consistent with the LinQuad demand system, i.e.

$$E(p, z, \theta) = p'\alpha + p'Ca + 0.5p'Bp + \delta(r) + \theta(z, u, r)e^{(\gamma p)} \qquad (8)$$

where, θ is the constant of integration, a represents the nutrients contents, and α, γ, C and B are the conformable matrix of parameters. Through Shephard's lemma we derive specific Marshallian demand:

$$q_i = \alpha_i + B_i p + C_i a + \gamma(y - p'\alpha - p'Ca - 0.5p'Bp) + \xi_i \quad (9)$$

However, most household demographic variables are either dummy variables or have zero values; therefore, we modified the intercept term, α_i with $(\alpha_i + \sum\limits_i \phi_i r_{ih})$.

The own-price elasticities, cross-price elasticities, income elasticities and nutrients elasticities are calculated as follow:

$$\epsilon_{ii} = \frac{\partial q_i}{\partial p_i} * \frac{\overline{p}_i}{\overline{q}_i} = \left[b_{ii} - \gamma_i \left(\alpha_i + \sum_j b_{ji} p_j \right) \right] * \frac{\overline{p}_i}{\overline{q}_i} \qquad (10)$$

$$\epsilon_{ij} = \frac{\partial q_i}{\partial p_j} * \frac{\overline{p}_j}{\overline{q}_i} = \left[b_{ij} - \gamma_i \left(\alpha_j + \sum_j b_{jk} p_k \right) \right] * \frac{\overline{p}_j}{\overline{q}_i} \qquad (11)$$

$$\eta_i = \frac{\partial q_i}{\partial y} * \frac{\overline{y}}{\overline{q}_i} \text{ and } N_i = \frac{\partial q_i}{\partial a_i} * \frac{\overline{a}_i}{\overline{q}_i} = [c_i - \gamma_i \sum_i c \overline{p}_i]$$

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Data

About the Data

- Data used in this research comes from the *Enquesta Integrada Des Hogares* 2001 (EIH), nationally-representative cross-sectional household survey. It was taken under the General Directorate of Statistics, Surveys and Censuses and MECOVI supervision.

- The Mecovi (*Measurement of Living COnditions in Latin America and the Caribbean*) is a regional program of technical assistance for capacity building to improve the household surveys to measure living conditions and poverty in Latin America and the Caribbean.Jointly launched in 1996 by IDB, World Bank and UN-ECLAC.

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Data

- The sample is composed of 8131 households. The consumption section involved only 2862 households. The survey was aimed at private households located in the urban and rural areas, all across the country.

- The data includes the money value, the quantities and type of food purchased by the household over a one-week period (December-February).

- The food consumption was aggregated in the following groups for the demand demand system estimation:
  1. Cereals and Bakery, Roots,Fruits and Vegetables, Dairy Products and Eggs, Oils and Fats, Read Meat, Other Meat and Sausage, Sugar, Salt and Spices, Other food and canned food, Beverages.

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Data

- Seven nutrients were included in this study: Carbohydrates, Fats, Proteins, Vitamin A, Iron, Cholesterol, Digestible Fibers.

- For the analysis other socio-demographic variables have been used: Household size using equivalence scales, Head family age, Head family activity, level of education of the HH, average birth weigh of the chikdren in the household.

- Then, a series of dummy variables were constructed: Female Household Head, Household who speak Guarani, Household who are in extreme poverty conditions, Household with at least one baby who was born underweight.

Data

- Income variable was constructed as follow:we include Agricultural Wage, Non-Agricultural Wage, Household Assets, Pension, Remittances, Occasional Income, Income coming from other sources.

- Quality adjusted prices were used to estimate food demand functions. The correction of composite goods unit values is needed to adjust quality. This is a consequence of the aggregation of goods into commodity bundles. Consumption of aggregated commodities reflects combined choices of both quantity and quality, and, in consequence the matching between quantity and prices is more complex.

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Data

$$UV = f(price, quality) \tag{12}$$

- *Assumption*: since real prices are unknown, we assume that unit values variation is reduced when examining smaller regions, and the variability itself can be explained by the quality side of the above function.

- Quality can be modeled as a function of several socio-demographic determinants.

- In the above equation price can be approximated by dummies representing provinces, and the level of urbanization, resulting in:

Data

$$price = \beta_0 + \sum_{i=1}^{130} \beta_i PD_i + \beta_{131} UD + v_i. \tag{13}$$

Since quality is affected by socio-economic factors, such as: household size, age structure as well as gender of the households, age and level of education of households head, we assume that:

$$quality = \beta_0 + \beta_1 HS + \beta_2 HAS + \sum_{i=3}^{5} \beta_i EDUC_i + \\ + \beta_6 FemalHead + \beta_7 DLanguage + u_i. \tag{14}$$

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Data

Substituting (12) and (13) into (11), we get:

$$UV = \beta_0 + \sum_{i=1}^{130} \beta_i PD_i + \beta_{131} UD + \beta_{132} HS +$$

$$\beta_{133} HAS + \sum_{i=134}^{136} \beta_i EDUC_i + \beta_{137} FemalHead +$$

$$\beta_{138} DLanguage + u_i$$

Statistics

Unit Values Variance-to-Mean Ratios

	Prov.11	Prov.12	Prov.13	Prov.14	National Level
Cer	0,743	0,588	1,058	0,109	229,475
Roots	0,146	0,124	0,130	0,127	54,332
Fru and Veg	0,151	0,155	0,144	0,722	7,161
Eggs and DP.	0,709	0,634	0,796	0,722	106,024
	Prov.72	Prov.74	Prov.77	Prov.88	National Level
O and F	0,796	0,665	0,669	0,577	1,717
RMeat	0,308	0,309	0,246	0,218	386,786
OMeat	0,194	0,204	0,003	0,173	460,998
Sweets	6,079	6,730	5,484	1,315	10,370
	Prov.112	Prov.123	Prov.129	Prov.165	National Level
Salt	0,407	0,428	0,343	0,590	33,688
O Food	0,263	0,267	0,244	0,241	3,080
Bev	2,717	2,684	3,095	5,190	8,678

Share of Budget spent of food groups

Food groups	National	Urban	Rural	I	II	III	IV
						Quartile	
Cereals	20.04%	18.49%	22.23%	23.78%	21.53%	18.50%	16.35%
Roots	5.18%	3.61%	7.39%	7.44%	5.79%	4.24%	3.22%
Fruits and Veg.	14.90%	16.49%	12.65%	12.26%	13.86%	16.16%	17.32%
Eggs and DP	13.42%	15.37%	10.66%	12.05%	12.37%	14.12%	15.14%
Oils and Fat	3.40%	2.18%	5.12%	4.88%	3.93%	2.79%	1.98%
Red Meat	18.03%	18.06%	17.99%	15.84%	19.69%	19.83%	16.76%
Other Meat	7.05%	6.57%	7.74%	7.04%	6.17%	6.86%	8.13%
Sugar	4.37%	3.76%	5.22%	5.06%	4.65%	4.13%	3.62%
Salt and Spices	1.51%	1.43%	1.62%	1.74%	1.41%	1.51%	1.37%
Other Food	2.60%	3.40%	1.46%	1.82%	2.26%	2.63%	3.67%
Beverages	9,52%	10,64%	7,91%	8,08%	8,32%	9,21%	12,45%
Total Food	**46.96%**	**55.52%**	**40.91%**	**59.33%**	**53.83%**	**44.39%**	**30.28%**

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Statistics

Daily PerCapita Macronutrients and Micronutriens intake

	National	Urban	Rural	Quartile			
				I	II	III	IV
Pc proteins	73.92	84.41	60.14	36.76	61.23	83.49	110
Pc fat	77.48	75.38	80.24	57	76.21	83.21	91.51
Pc carbohydrates	337.25	359.79	307.63	206.38	313.15	385.79	431.96
Pc vitamin A	694.26	900.41	423.50	211.81	526.53	795.02	1199.45
Pc iron	19.07	21.77	15.53	8.83	16.37	21.86	28.32
Pc Cholest.	83.15	115.22	37.77	25.57	63.12	104.72	139.26
Pc Fibers	10.74359	12.18	8.71	6.80	10.92	13.17	12.09

Nutrients Elasticities

Nut.	Cer.	Roo.	FVeg.	ED.	OaF	RMeat	OMeat	Sug.	SSp.	OFood
Pro.	0.02*		0,026	0.104*	1.003*	0.0127*	0.093	0.542*	0.942*	-0.052
Fat	-0.01*		0.306	-0.025	0.022*	-0.016*	0.0216	-0.357*	0.128	-0.211
Carb.	0.08*	0.014*	0.012	0.020		0.025	-0.389	0.017*	0.003	0.184
AVi.		0.104*	0,018*	0.007*				0.034	0.002*	0.0062
Chol.				0.001	-0.001	-0.003*	-0.003*	-0.012	-0.0415	
Iron	0.020*	-0.12	0.002*	0.0691		0.0111	-0.044	0.0382	0.296*	0.935
Fib.	0.014*	0.063	-0.017	-0.117		1.059	0.425	-0.882	-0.318*	0.111

Statistically different from zero at $\alpha = 0.005$ level.

Income and Price Elasticities (own and cross)

								Price Elasticities
Food Groups	Inc. El.	Cer.	Roots	FV	E and Dp	O and F	RMeat	OMeat
Cereals.	0,036	**-0,504**	-0,003	0,008	-0,009	0,040	0,041	-0,052
Roots	0,038	-0,018	**-0,114**	-0,007	-0,010	-0,039	0,015	-0,020
Fruits and Veg.	0,153	0,096	0,000	**-0,498**	0,030	0,043	-0,001	0,004
Eggs and Dairy Product	0,097	-0,061	-0,003	-0,008	**-0,277**	0,079	0,066	0,049
Oils and Fat	0,010	-0,028	-0,002	-0,017	-0,004	**-0,118**	0,009	0,008
Red Meat	0,060	0,025	0,008	0,009	-0,017	0,061	**-0,205**	-0,073
Other Meat	0,126	-0,215	-0,007	-0,001	-0,023	0,098	-0,244	**-0,642**

Conclusions

- The estimated Marshallian own-price elasticities indicate a strong price responsiveness of food demand in Paraguay. Household demand responses to price are mainly driven by substitution effects.

- Roots are complement with rice. But Fruits and Vegetables and Red Meat are substitute for cereals. But cereals is complementary with other meat. Oils and Fat are substitue for Red Meat and Other Meat.

- The signs of all income and price parameters are consistent with the expectations: positive and less then unity income elasticity, negative own-proce elasticities, small cross-price elasticities

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- The own nutrient demand elasticitiy shows the percentage change in the demand for a food group due to a one percent change in the particular nutrients found in the food item. The previous table shows that own-nutrients had either a positive or negative impacts on the demand for the 11 food groups.

- Of the 57 own-nutrients elasticities we found, 14 were negative. A positive (negative) elasticity estimates indicates that the nutrient increases (decreases) the demand for food in the group in question.

- For example, proteins had a positive impact on the consumption of daily products, and fat content in red meat had a negative impact on the consumption of red meat. Proteins had also a positive impact on the consumption of cereals.

- These findings show how nutrients play an important role in the demand for food. The approach used in this study can be quite usefull, and the results are quite promising. That could mean that consumer, even from developping countries, may learn the function of nutrients and make more informed food consumption choices.