THE IMPACT OF INCREASING FOOD SUPPLY ON HUMAN NUTRITION IMPLICATIONS FOR COMMODITY PRIORITIES IN AGRICULTURAL RESEARCH AND POLICY

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Malnutrition, primarily calorie and protein deficiencies, has been widely recognized for some time as a serious problem among low income groups of the population of many developing countries. However, only recently has improved human nutrition become an important part of development goals in most of these countries. As more emphasis is placed on equity and welfare in overall development plans, improved nutrition is gradually being accepted by government planners and politicians as a worthwhile goal in itself. Furthermore, the importance of health and nutrition for human capital formation and the resulting implications for economic growth has gained wide recognition during recent years. As a result, activities with the direct aim of expanding food production, such as certain agricultural research and public policy, frequently consider improved human nutrition as one of their final goals.

While the inmediate objective of production oriented agricultural research and public policy may be to expand food production, such objective may be viewed as a means to reach some set of final goals, one of which possibly being improved human nutrition The challenge to the decision-maker in production oriented research and policy then becomes one of choosing among alternative strategies in such a way as to attempt to maximize the contribution to the final goals for any given amount of resources available. For this purpose information is needed on (1) expected relative contribution of alternative strategies to the achievement of specified goals and (2) program and associated costs of each alternative.

Little is known about the relative nutritional impact of alternative agricultural research and policy strategies. There is a tendenc, to consider the increase in total nutrient supply as a measure of the improvement in human nutrition. But increases in nutrient supply will make a positive contribution to human nutrition only if the consumer would be deficient in the particular nutrient in the absence of the supply increase. Nutrient supply increases of equal magnitude, but originating from different commodities, may have different impacts on human nutrition because the distribution of the additional supply among consumer groups differs. Hence, to establish commodity priorities in research and policy aimed at expanding food production for the purpose of improving human nutrition in the most effective way, it is essential to estimate not only expected increases in nutrient supply, but also what proportion of the supply increase will be consumed by deficient consumer groups and the resulting adjustments in the consumption of other foods

Production oriented agricultural research and policy is frequently commodity specific and priorities need to be established at two levels· (1) choice of commodities and (2) choice of activities within commodities. Ramalho de Castro and Schuh developed and empirically tested methodology aimed at assisting in establishing commodity priorities in research on the basis of expected distribution of benefits between producer and consumer sectors and among factors of production within the producer sector.

The purpose of this paper is to indicate an approach to economic analysis that may help establish commodity priorities in agricultural research and public policy if improved human nutrition is a goal. Thus, the paper supplements the Ramalho and Schuh methodology by providing a means for estimating the distribution of supply increases among urban consumer groups and the resulting nutritional benefits. The issue of criteria for establishing priorities between improved urban nutrition and other goals is not treated.

A model is developed to estimate the nutritional impact of expanding the supply of any one of the foods currently available to the consumer [1]. On the basis of this model, an empirical analysis is carried out with sample data from Cali, Colombia. This paper presents the model, briefly describes the data requirements and sample characteristics, summarizes the empirical findings and discusses the utility and limitations of the model for establishing nutrition oriented priorities in agricultural research and public policy.

THE MODEL

The model is based on neoclassical demand theory. It is presented in two parts The first part refers to the estimation of a price elasticity of demand matrix for each of a number of income strata and for the market as a whole. The second part deals with the distribution of a hypothetical supply increase of any one good among these income strata, the resulting adjustments in consumption of all other goods and the impact on calorie and protein nutrition.

Price Elasticity Matrix

A complete price elasticity of demand matrix was estimated for each of the income strata using the methodology developed by Frisch. Assuming want independence among the commodities or groups of commodities considered, Frisch provides a method for estimating a complete set of direct and cross price elasticities of demand on the basis of income elasticities, budget proportions and the flexibility of money.

Let $\frac{v}{w} = \frac{\delta w}{\delta a} \frac{a}{w}$ be the flexibility of money, where w is the marginal utility of money income and a is money income. Then, the direct and cross price elasticities of demand for income stratum m may be estimated as

$$(1) \qquad e_{ii}(m) = -E_i(m) \left[A_i(m) - \frac{1- A_i(m) \ E_i(m)}{\frac{v}{w(m)}} \right]$$

and

$$(2) \qquad e_{ij}(m) = -E_i(m) \ A_j(m) \left[1 + \frac{E_j(m)}{\frac{v}{w(m)}} \right], \quad i \neq j$$

respectively, where e_{ii} is the direct price elasticity of demand for good i, e_{ij} is the cross price elasticity for good i with respect to good j, E_i and E_j are the income elasticities for goods i and j, respectively, and A_i and A_j are the budget proportions spent on goods i and j.

Assuming that all consumers are faced with the same market for any one commodity, the average per capita direct and cross price elasticities of demand for good i was estimated as the weighted average of the strata elasticities using quantity of good i consumed by stratum m and relative proportion of total population found in stratum m as weights

$$(3) \quad e_{ij} = \frac{\sum_{m=1}^{n} e_{ij(m)} \; Q_{i(m)} \; N_{(m)}}{\sum_{m=1}^{n} Q_{i(m)} \; N_{(m)}}$$

where

$e_{ij(m)}$ = direct or cross price elasticity of demand for stratum m

$Q_{i(m)}$ = quantity consumed per capita of commodity i in stratum m.

$N_{(m)}$ = population of strata m

The assumption of want independence implies that the marginal utility of one good is independent of the quantity consumed of any other good for which want independence is assumed Hence, if want independence is assumed for all goods, direct additivity of the utility function is implied, i.e. $u(q_1, q_2, \ldots, q_n) = u_1 \; (q_1) + u_2 \; (q_2) + \ldots + u_n \; (q_n)$ (George and King, p. 23). However, the goods are still related through the budget constraint, hence want independence does not imply the much stronger assumption of demand independence. While, as argued by Frisch, some goods, such as electricity and Swiss cheese, can safely be regarded as want independent, the assumption is obviously not valid for all goods. It may be possible, however, to group the bundle of goods available to the consumer in such a way as to obtain little or no want independence among groups (Bieri and de

Janvry). Where this is possible, the Frisch scheme may then be applied to estimate group elasticities. Assuming that the consumer budget is first allocated among such groups and then, the amount allocated to each of these groups is allocated to individual goods within the particular group, the two stage maximization process may provide elasticity estimates for the individual goods (de Janvry, Bieri and Núñez). However, in addition to the cross sectional data needed to estimate income elasticities, time series data are needed to estimate price elasticities. The applicability of the two stage maximization process is limited because of the scarcity of reliable time series data. Such scarcity is particularly pronounced in cases where elasticities are needed by income strata.

No reliable time series data on prices and quantities were available for the present study. Hence, the two stage process could not be applied. On the other hand, since the primary purpose of the study was to develop and empirically test a methodology for estimating the nutritional impact of supply expansions and not to estimate price elasticities per se, it was felt that direct application of the scheme developed by Frisch would provide sufficiently accurate elasticity estimates. This supposition was supported by the actual estimates obtained, all of which fall within expected magnitudes. However, the assumption of want independence is not likely to be valid for all goods considered, hence the empirical results of this study should be interpreted with caution.

Change in Calorie and Protein Intakes

This part of the model quantifies the change in calorie and protein intakes by income strata caused by an externally introduced shift in the supply curve of any one of the food commodities or groups of food commodities considered. The model estimates the distribution among strata of the additional supply of the food for which the supply curve is shifted and the resulting adjustments in the consumption of all other foods. The model consists of a set of recursive equations. Assuming that all consumers are faced with the same market in which perfect competition exists and that prices and quantities for all foods are in equilibrium before the shift in the supply curve, the model estimates the new equilibrium for prices and quantities for all foods utilizing an iterative procedure [2]

If the initial market equilibrium price for commodity i is P_i^o, the new equilibrium price P_i^1 after shifts in the supply and/or demand curves is estimated as (Pinstrup-Andersen and Tweeten, p. 538)

$$(4) \quad P_i^1 = P_i^o \left[1 - \frac{\Delta S_i - \Delta D_i}{(e_{si} - e_{ii})\, Q_i^o} \right]$$

where

ΔS_i = horizontal shift in supply curve of commodity i.

ΔD_i = horizontal shift in demand curve of commodity i.

e_{si} = price elasticity of supply for commodity i.

e_{ii} = market price elasticity of demand for commodity i.

Q_i^o = initial equilibrium quantity of i.

Using a similar procedure, the new quilibrium quantity of commodity i (Q_i^1) is estimated as·

$$(5) \quad Q_i^1 = Q_i^o + \Delta D_i + \frac{\Delta S_i - \Delta D_i}{1 - (e_{si} / e_{ii})}$$

Applying these two equations, the change in price and quantity of commodity i due to an externally introduced shift in the supply curve (and no change in the demand curve) is estimated as follows

$$(6) \quad P_i^k = P_i^{k-1} \left\{1 - \left[B/(e_{si} - e_{ii})\right]\right\}$$

and

$$(7) \quad Q_i^k = Q_i^{k-1} \left\{1 + B / \left[1 - (e_{si}/e_{ii})\right]\right\}$$

where

$k=1,$

$B = \dfrac{\Delta S_i}{Q_i^{k-1}}$ = The horizontal shift in supply curve as a proportion of initial quantity.

P_i^1 and Q_i^1 would be the final equilibrium price and quantity, for good i, respectively, if $e_{ji}=0$ or $e_{ij}=0$ for all $j \neq i$ where e_{ij} is the cross price elasticity of demand for commodity i given a change in the price of j. Furthermore, if $e_{ji}=0$ for all $j \neq i$, the equilibrium prices and quantities for all other commodities would remain unchanged. However, neither e_{ji} nor e_{ij} can be expected to equal zero. Hence, the initial change in P_i will cause a shift in the demand curve for all other commodities (j). The resulting new equilibrium prices (P_j^1) and quantities (Q_j^1) are estimated as follows

$$(8) \quad Q_j^k = Q_j^{k-1} \left\{ (1 + p_i\, e_{ji}) \left[1 - (1 - e_{sj}/e_{jj})^{-1} \right] \right\}$$

and

$$(9) \quad P_j^k = P_j^{k-1} (1 + p_i\, e_{ji}) / (e_{sj} - e_{jj})$$

where

$k = 1$

$p_i = (P_i^k - P_i^{k-1}) / P_i^{k-1}$

and $j=1,\ldots,22$ excluding i, $j \neq i$

The changes in prices and quantities of j, i e. commodities different from commodity i cause a shift in the demand curve for commodity i unless $e_{ij}=0$ for all j The new equilibrium price and quantity for i is given by

$$(10) \quad Q_i^k = Q_i^{k-1} \left\{ 1 + \sum_{j=1}^{n} p_j \, e_{ij} \left[1 - (1 - e_{si}/e_{ii})^{-1} \right] \right\}$$

and

$$(11) \quad P_i^k = P_i^{k-1} \left[1 + \sum_{j=1}^{n} p_j \, e_{ij} \, (e_{si} - e_{ii})^{-1} \right]$$

where:

$k = 2$ and $p_j = (P_j^1 - P_j^o)/P_j^o$, $j \neq i$, $j=1$, . 22 excluding i. This iterative procedure continues by replacing current value of superscript k by $k+1$ until a steady state is reached ($k=r$) i e. equilibrium for price and quantity for all commodities. In the empirical analysis discussed later, the steady state for most commodities was reached for $k \leq 3$.

Having estimated the new market equilibrium, the model proceeds to estimate the distribution among strata of the quantity changes for each commodity. The final quantity of commodity j obtained by stratum m ($Q^r_{j(m)}$) is estimated as

$$(12) \quad Q^r_{j(m)} = N_{(m)} \, N^{-1} \, Q^o_{j(m)} \left[1 + p'_i \, e_{ji(m)} + p'_j \, e_{jj(m)} \right]$$

where

$j = 1,\ldots,22$ excluding i, $m = 1,\ldots,5$, $i \neq j$

$N_{(m)}$ = number of consumers in stratum m.

N = total number of consumers.

$P'_i = (P^F_i - P^O_i) / P^O_i$

The final quantity of commodity i obtained per capita in stratum m ($Q^F_{i(m)}$) is given by

$$(13) \quad Q^F_{i(m)} = Q^O_{i(m)} \left[1 + \sum_{j=1}^{n} p'_j \, e_{ij(m)} + p'_i \, e_{ii(m)} \right]$$

where $j \neq i$

The direct impact on per capita calorie ($C_{i(m)}$) and protein $PR_{i(m)}$ intake in stratum m is estimated as

$$(14) \quad C_{i(m)} = \left[Q^F_{i(m)} - Q^O_{i(m)} \right] c_i$$

where

c_i = calorie content per unit of commodity i,

and

$$(15) \quad PR_{(m)} = \left[Q^F_{i(m)} - Q^O_{i(m)} \right] pr_i$$

where

pr_i = protein content per unit of commodity i

The indirect impact is

$$(16) \quad C_{j(m)} = \sum_{j=1}^{n} \left[Q^F_{j(m)} - Q^O_{j(m)} \right] c_j$$

and

$$(17) \quad PR_{j(m)} = \sum_{j=1}^{n} \left[Q^{r}_{j(m)} - Q^{o}_{j(m)}\right] pr_{j}$$

where

$j \neq i$, and the net impact is

$$(18) \quad C_{m} = C_{i(m)} + C_{j(m)}$$

and

$$(19) \quad PR_{(m)} = PR_{i(m)} + PR_{j(m)}$$

DATA SOURCES AND SAMPLE CHARACTERISTICS

Data on quantities consumed and prices paid for each of 22 foods or groups of food as well as family incomes, size and age distribution were collected from a sample of 230 families selected from the population of Cali, Colombia, using a stratified random sampling procedure. Each family was visited during February, 1969, and again in August, 1970.[3] For various reasons, about 30 per cent of the families included in the first survey could not be included the second time. These families were replaced in the sample by randomly selected families living in the same part of town. Five strata were established on the basis of family incomes and the sample size for each stratum was proportional to the population among strata. Table 1 shows selected characteristics of the sample families.

EMPIRICAL RESULTS

Income Elasticities and Budget Proportions

The income elasticity for each food was estimated for each of the five income strata on the basis of cross sectional data within each stratum. The consumers within each stratum were faced with essentially the same price for any given food commodity. Furthermore, little variation in tastes and preferences was expected among consumers within a given stratum. Hence, the income elasticities were estimated simply by regressing per capital real income on per capita quantity consumed within each stratum. The estimated income elasticities were consistent with expectations. Foods of animal origin ("luxury goods") tended to have higher income elasticities than staple foods. All the foods show a decreasing income elasticity for increasing incomes, becoming negative for certain staples in high income stratum. The methodology used to estimate price elasticities is only valid for non-negative income elasticities. Hence, where negative estimates did occur, a value of zero was used for estimating price elasticities, resulting in zero value price elasticities

Beef, accounting for 10-12 per cent of total incomes in all strata, was the largest single food expenditure for all strata. The budget proportion spent on most of the other food items decreases for increasing incomes. In addition to beef, basic grains, primarily rice, maize and beans, account for a considerable amount of the consumer budget particularly in the low income strata. Tables showing income elasticities and budget proportions may be obtained directly from the authors.

MONEY FLEXIBILITY

Bieri and de Janvry report a number of estimates of the flexibility of money for various countries and time periods. These estimates range from -0 61 to -3 90. No such estimate was available for Cali or Colombia either for the population as a whole or by income strata

Solving equation (1) for $\frac{v}{w}$, we get·

$$(20) \quad \frac{v}{w} = \frac{\Gamma_i \left[1 - \Lambda_i \, F_i\right]}{e_{ii} + \Lambda_i \, \Gamma_i}$$

Hence, the flexibility of money can be estimated on the basis of the income elasticity and the direct price elasticity for one good and the budget proportion spent on that good No reliable estimate of price elasticities by income strata for Cali was available prior to this study Hence, to estimate $\frac{v}{w}$ by income strata it was necessary first to estimate e_{ii} for at least one good for each income strata using an alternative method.

As explained above, data on quantity consumed, prices and incomes were collected from the sample households for two points in time. Six highly standardized food commodities (rice, beans, tomatoes, oranges, sugar and cooking oil) were chosen for a priori estimation of direct price elasticities. The change in quantity consumed and price for each of these foods between the two surveys and the change in incomes were estimated for each income strata. It was assumed that the change in quantity consumed was due exclusively to changes in own price and incomes.

The expected impact of income change on consumption was estimated on the basis of the income elasticity estimates from cross sectional data and the remaining change in consumption was attributed to price change, thus providing an estimate of direct price elasticity. This procedure for obtaining a priori estimates of direct price elasticities is somewhat crude, primarily because no cross price effects were considered. However, we may assume that cross elasticities are small, although not zero Hence, it was felt that the approximations of actual direct price elasticities provided by the procedure were sufficiently good -and certainly the best available, given the data constraints- for the purpose of estimating money flexibility. Furthermore, the fact that all a priori estimates fall within expected ranges for the particular commodities indicates considerable confidence in the method.

Using equation (20), the flexibility of money was estimated for each income strata as a simple average of the estimates obtained from each of the six food commodities (Table 2).

No significant difference of the estimated $\overset{v}{w}$ among strata was found [4]. The magnitude of $\overset{v}{w}$ as estimated here is similar to estimates from Chile for the period 1952-63 and United States for the period 1923-41 and 1948-56 while it is considerably below estimates from Argentina and certain other countries (Brieri and de Janvry, p 44). In general, the estimated $\overset{v}{w}$ is below what would be expected on the basis of most previous estimates for other countries Furthermore, the estimates are inconsistent with Frisch's conjecture that the absolute value of $\overset{v}{w}$ decreases as the level of real income increases This study does not provide an acceptable explanation for this inconsistency but points out the need for additional empirical study on the relationship between $\overset{v}{w}$ and income levels within a given society De Janvry, Bieri and Núñez found statiscally significant fit when regressing estimates on $\overset{v}{w}$ from various countries and time period on real incomes using a constant elasticity equation. However, such inter-country comparisons, although highly useful, suffer from the usual problems of choosing exchange rates that reflect real differences in purchasing power Furthermore, inter-country differences in preferences not due to income levels are likely to influence marginal utility of money and the magnitude of the money flexibility. Hence, at equal real incomes, the money flexibility is likely to differ among countries. Correlation among countries between preferences on the one hand and income levels on the other, may bias the results of inter-country comparisons

PRICE ELASTICITIES

A complete price elasticity matrix was estimated for each stratum and for the market using equations (1), (2) and (3) The estimated direct price elasticities are shown in Table 3 (complete direct and cross price elasticity matrices may be obtained from the authors). All estimates fall within expected ranges As would be expected, the direct price elasticity for all goods increases for increasing income, and a considerable difference between the elasticity estimated for high income groups and that for low income groups was found for most commodities

NUTRITIONAL IMPLICATIONS

The model shown by equations (6) - (19) was run for a hypothetical shift in the supply curve for each of the 22 commodities considered (i=1,.. ,22) maintaining the supply curves for the other 21 commodity constant A horizontal shift in the supply curve equal to 10 per cent of current supply of commodity i was arbitrarily selected and the resulting net effects on protein and calorie intakes were estimated. No reliable estimates of the price elasticities of supply were available for the 22 commodities. It may be expected, however, that the supply elasticity is close to zero in the short run for most of the commodities while it is likely to be larger but less than one for the intermediate and long run [5]. Supply elasticities equal to zero, one and two for all commodities were chosen for estimation While the absolute impact of a shift in the supply curve of a certain commodity on net calorie and protein intakes is sensitive to the magnitude of the supply elasticities, the relative impact among commodities does not depend greatly on the magnitude of the supply elasticities. Hence, since this study is primarily focused on relative impacts, the choice of supply elasticity is of little importance as will be shown in the final part of the paper

Three indicators were used to estimate the nutritional impact of shifting the supply curve of each of the commodities (1) the percentage of the total supply increase of commodity i consumed by nutrient deficient income strata, (2) the change in per capita calorie and protein intake by deficient strata, and (3) the percentage reduction in total calorie and protein deficiencies.

As shown in Table 4, two of the five strata are deficient in protein and one is deficient in calories. Assuming that changes in nutrient intakes influence nutrition only if a nutrient deficiency exists--either before or after the change--increased or decreased protein and calorie intake influence nutrition if it occurs in strata I and II and stratum I for protein and calories, respectively. Changes in protein and calorie intakes in other strata will influence nutrition only if the changes result in deficiencies.

The average daily per capita intake of calories and protein for the sample as a whole was estimated to be 119 and 112 per cent of requirements (Table 4). Hence, no additional food would be needed to fulfill calorie and protein requirements if available food were distributed according to needs. This situation clearly points out the inadequacy of average data as a measure of nutritional status.

Table 5 shows the proportion of the supply increase obtained by deficient strata. As might be expected, a relatively small proportion of an increase in the supply of meats, eggs, milk and certain grain legumes would be consumed by protein and calorie deficient groups. Hence, efforts to improve human nutrition through the expansion of the supply of these commodities would entail a considerable "waste" of nutrients. For example, 71 per cent of the protein generated from an increase in beef production would be "wasted" in a nutritional sense, while this would be true only for 58 per cent of the protein from additional bean production

The direct, indirect and net effects on per capita calorie and protein intakes for deficient and non-deficient strata are shown in Tables 6 and 7 To save space, only the estimates obtained for supply elasticity equal to zero are shown. It should be noted that the net effect decreases for increasing supply elasticity (only a few commodities are shown. Estimates for all the commodities may be obtained from the authors)

The net effect is determined by the increase in consumption of the food for which the supply curve was shifted (i) -the direct effect- and the resulting adjustment in the consumption of all other foods (j) -the indirect effect-. Hence, the net effect is estimated as the sum of the changes in consumption of all foods, brought about by a shift in the supply curve of one of these foods

The net impact on per capita calorie intakes among caloric deficient strata is relatively high for basic staples such as cassava, maize and rice, while beef, maize and rice provide the largest impact on per capita protein intake among deficient groups. The nutritional waste associated with an increase in the supply of meats, milk, lentils, peas, tomatoes and fruits is illustrated by the greater increase in per capita calorie and protein intakes among non-deficient groups. However, in spite of the waste, a certain percentage increase in beef supply provides a larger net impact on protein intake among protein deficient groups than an equal percentage increase of any other single food. The large negative indirect effects within deficient strata associated with increases in the supply of certain foods is a result of high direct price elasticities (absolute value in excess of 1.0) for these foods, severe budget constraints and relative nutrient contents When the supply of one of these foods increases, total consumer outlay for the food increases However, since a large portion of the household budget is already commited to food, outlays for other foods tend to decrease as reflected by cross elasticities, the net result being a smaller nutritional impact than that reflected by the increase in the supply of a certain food. Increasing the supply of certain foods may actually reduce total protein and calorie intakes among deficient groups because the absolute value of the negative indirect effect exceeds the direct effect. Increasing the supply of peas and tomatoes was found to reduce total calorie intake by deficient groups, while protein intakes would decrease by increasing supplies of oils and fats.

The actual reduction in calorie and protein deficiencies that can be expected from supply expansions of the magnitude considered here are small (Table 8). If supply elasticities are equal to zero, a ten per cent increase in the production of maize or rice would reduce calorie deficiencies by 16 - 18 per cent and protein deficiencies by 8 -9 per cent. A similar percentage increase in beef production would reduce protein deficiencies in strata I and II by 6 and 15 per cent, respectively. As supply elasticity increases the nutritional impact of a shift in the supply curve diminishes. If supply elasticities are equal to one, a ten per cent increase in the production of maize or rice would reduce calorie deficiencies by 5 -6 per cent and protein deficiencies by 2-4 per cent.

In view of the fact that the quality of protein consumed plays a major role in determining the nutritional level, it was attempted to analyze the impact on the intake of the three essential amino acids lysine, methionine and trytophan. It was found, however, that the diets contained more of these amino acids than required at all income levels. Hence, for the family as a unit it appears that quantity of protein is more important than quality, for the population studied. However, an analysis of the intra-family food distribution is required to determine the relative scarcity of quantity vs. quality of protein among the most vulnerable groups infants, young children and pregnant women

UTILITY FOR ESTABLISHING COMMODITY PRIORITIES

The empirical findings of this study clearly point out that relative increase in total nutrient supply is a poor indicator of relative nutritional impact. The "nutritional waste" as defined earlier, differs considerably among commodities. Furthermore, the adjustment in the consumption of foods, other than the one for which supply is increased, is of considerable importance in determining the final nutritional implications.

In addition to the relative nutritional impact, as estimated here, relative cost of research, policy and related activities needed to facilitate the supply expansion must be estimated, in order to establish commodity priorities with highest nutritional impact per unit of resource invested in such activities It should be noted that changes in production costs need not be considered here since they will be reflected in the supply elasticity, which in turn participates in determining the new market equilibrium [6].

While the research and policy costs are to be estimated for each individual project, three alternative cost assumptions are made here to illustrate how the information presented may complement estimated research and policy costs in establishing commodity priorities

The three assumptions are that (a) an equal percentage increase in the supply of any one of the foods considered can be obtained at equal costs, (b) an equal increase in the supply of any one of the foods measured in terms of quantity (weights) of the food can be obtained at equal costs, and (c) a given amount of calories and protein, respectively, can be supplied from any one of the foods at the same costs The commodity priorities for each of the assumptions are shown in Tables 9 and 10, for supply elasticities equal to zero and one The priorities are established an the basis of relative reduction in calorie and protein deficiencies expected from the increase of the supply of any one of the commodities, where the supply increases correspond with the above three alternatives assumptions. The underlying numerical estimates are shown for assumption (a) only (Table 8).

Depending on the relative cost of research and policy measures needed to facilitate supply expansions among the various commodities, this analysis shows that rice, oilseed, cassava and potatoes would provide the most effective means for improving calorie nutrition in the population studied, and beef, beans and maize would be most effective in meeting protein nutrition goals.

Maize appears among the five priority commodities for all costs assumptions and supply elasticities, whether calorie or protein nutrition is the goal. Hence, under any of the cost assumptions considered here, it appears that high research and policy priority should be placed on that commodity if both calorie and protein nutrition are goals

As the supply elasticity increases, expanding supplies of commodities with high absolute direct price elasticities such as beef and to a lesser extent beans become more important in fulfilling nutritional goals while expanding supplies of commodities with low absolute price elasticities such as cassava become less important. This phenomenon is explained by the sharper price drop of commodities with high absolute price elasticity of demand and the resulting larger quantity response to the magnitude of the supply elasticity. However, the magnitude of the supply elasticity does not greatly influence relative commodity priorities

FINAL COMMENTS

The present analysis has attempted to demonstrate how economic analysis may provide guidelines for establishing commodity priorities in agricultural research and production oriented public policy if improved human nutrition for the urban population is a goal [7]. The analysis assumes that the expanded food supply resulting from the research and policy activities is in excess of increases in food demands at current prices caused by factors such as increased consumer incomes and population, i.e. such demand increases are expected to be fulfilled in the absence of the proposed activities If this is not the case, thus research and public policy is needed partly to meet demand increases at current prices, the present analysis would apply only to the supply expansion in excess of demand expansions at current prices.

It appears from the empirical analysis that the problem of malnutrition in the population studies is basically one of absolute poverty among certain groups. While new technology resulting in shifts in the supply curve and reduced prices are important to improve human nutrition, the full potential of such technology for improving human nutrition is reached only if accompanied by rapid increases in incomes among low income consumers. Available quantities of food were estimated to be sufficient to provide an adequate calorie and protein diet for all sample members. Yet, even when using average family data, considerable deficiencies were identified. It is likely that much more severe deficiencies would have been detected if data were obtained on intra-family food distribution.

However, even though malnutrition in many cases might be reduced or eliminated through a more even distribution of incomes and/or food, such redistribution is likely to be slow, at best, and it appears that improved information on nutritional implications of alternative agricultural production research and policy measures may contribute to improved human nutrition even in the absence of such redistribution.

The authors of this article do not suggest that improved nutrition be the sole goal of agricultural research. We do suggest, however, that there exists an urgent need for developing and empirical testing of methodology useful to assist in establishing commodity priorities in research and public policy where improved human nutrition is one of the final goals. It is hoped that this analysis provides a modest contribution to such efforts.

Table 1. Selected Descriptive Characteristics of the Sample Families

	Strata				
	I	II	III	IV	V
Income range US$/family/month	0-42.4	42.5-56.5	56.6-113.0	113.1-169.5	169.6-up
Average family income US$/month	29.44	56.39	89.49	161.41	382.33
Average per capita income US$/month	4.99	8.95	13.16	25.62	58.82
Average per capita expenditures on food US$/month	4.32	5.87	8.37	12.79	20.39
Percent of income spent on food	86.6	65.5	63.7	49.9	34.7
Number of families interviewed	46	42	80	32	30
Number of persons in families interviewed	270	264	544	201	200
Distribution of persons on strata (%)	18.3	17.8	36.8	13.6	13.5

Table 2. Estimated Money Flexibility Coefficients by Income Stratum

Stratum	Money Flexibility
I	-0.9445
II	-0.9878
III	-0.9619
IV	-1.0071
V	-1.0497
Sample Mean	-0.9902

Table 3 Estimated Direct Price Elasticities by Strata

Commodity	Strata I	II	III	IV	V	Average[1]
Beef	-1 457	-1.305	-0.993	-0.692	-0.499	-0.839
Pork	-1.887	-1.608	-1.119	-0.823	-0 698	-1.011
Eggs	-1.343	-1.227	-1.262	-0.754	-0.349	-0.925
Milk	-1.788	-1 621	-1.121	-0.642	-0 201	-0.771
Rice	-0.426	-0 399	-0 397	-0.262	-0.187	-0.354
Maize	-0.630	-0 548	-0.441	-0.000	-0.000	-0.445
Beans	-0.812	-0.778	-0.649	-0 453	-0.251	-0.600
Lentils	-0.897	-0.903	-0.734	-0.620	-0.428	-0.641
Peas	-1.132	-1.128	-0.757	-0.585	-0.517	-0.698
Other grains	-0.869	-0.496	-0.389	-0.291	-0.253	-0.478
Potatoes	-0.410	-0.417	-0.312	-0.000	-0.000	-0 255
Cassava	-0.226	-0.279	-0.246	-0.000	-0.000	-0.187
Vegetables	-1.117	-0.986	-0.877	-0.379	-0.199	-0.685
Tomatoes	-1.169	-1.247	-0.997	-0.463	-0.278	-0 824
Plantain	-0 530	-0 486	-0 395	-0.000	-0.000	-0.376
Oranges	-1.389	-0 962	-0.789	-0.644	-0.293	-0.694
Other fruits	-1.293	-1.203	-0.847	-0.670	-0.500	-0.749
Bread & Pastry	-0.651	-0.558	-0.327	-0.243	-0.000	-0.310
Butter and Margarine	-2.792	-2.225	-1.499	-0.693	-0.395	-1.082
Sugar	-0.320	-0.296	-0.295	-0.203	-0.091	-0 245
Cooking oils and fats	-0.838	-0.814	-0 581	-0.298	-0.141	-0 507
Processed food	-1.850	-1.416	-1.295	-0.673	-0 430	-0.904

1/ Weighted average using total quantity consumed by strata as weights.

Table 4. Estimated Calorie and Protein Intakes and Deficit or Excess by Strata

	Strata I	II	III	IV	V	Average
Estimated daily intake of calories per capita	1904	2119	2510	2831	3836	2552
Intake in percent of requirements[1]	89	99	117	132	178	119
Estimated daily intake of protein per capita (grams)	44.6	51 6	64.6	81.1	126.4	69.2
Intake in percent of requirements[1]	72	83	104	131	204	112

[1]/ Based on estimated requirements for Colombia (Williamson *et. al.*)

Table 5. Percent of Supply Expansion Expected to be Consumed by Calorie and Protein Deficient Strata

Foods for which Supply is Increased	Percent of Increase Consumed by	
	Calorie Deficient Strata	Protein Deficient Strata
Beef	12.1	28 7
Pork	11.1	29.4
Eggs	12.5	32 1
Milk	12 0	28.7
Rice	20.2	40.3
Maize	27.8	54.7
Beans	19.1	42.2
Lentils	7.9	21.9
Peas	8.0	22.1
Potatoes	27.5	58 8
Cassava	30.4	62.9
Vegetables	19.5	40.3
Tomatoes	21.1	40.6
Plantain	25.7	55.3
Oranges	12.4	29.4
Bread and Pastry	25.0	50.2
Sugar	20.1	37 6
Oils and Fats	17.2	39.3

Table 6. Change in Per Capita Calorie Intakes caused by a ten per cent Increase in the Supply of any one of the Foods, for Fs = 0

Foods for which Supply is Increased	Deficient Strata			Non-Deficient Strata		
	Direct	Indir.	Net	Direct	Indir.	Net
Beef	14.56	-6.49	8.07	23.65	0.99	24.64
Milk	6.17	-3.04	3.13	10.14	0.37	10.51
Rice	36.10	6.89	42.99	31.82	-1.03	30.79
Maize	38.21	0.07	38.28	22.24	-2.22	20.02
Beans	7.77	0.29	8.06	5.27	-0.01	5.26
Peas	0.23	-0.67	-0.44	0.59	0.16	0.75
Potatoes	10.86	4.21	15.07	6.38	-2.63	3.75
Cassava	17.29	5.79	23.08	10.07	-11.16	-1.09
Vegetables	2.57	-1.62	0.95	2.36	0.27	2.63

Table 7. Change in Protein Intakes (Grams/Capita) caused by a ten per cent Increase in the Supply of any one of the Foods for Es = 0

Foods for which Supply is Increased	Deficient Strata			Non- Deficient Strata		
	Direct	Indir.	Net	Direct	Indir.	Net
Beef	1.41	-0.15	1.26	1.98	0.07	2.05
Milk	0.42	-0.08	0.34	0.59	0.04	0.63
Rice	0.79	0.16	0.95	0.66	-0.07	0.59
Maize	0.94	-0.02	0.92	0.44	-0.09	0.35
Beans	0.57	0.01	0.58	0.44	0.00	0.44
Peas	0.06	-0.02	0.04	0.13	0.01	0.14
Potatoes	0.24	0.06	0.30	0.10	-0.10	0.00
Cassava	0.09	0.05	0.14	0.04	-0.35	-0.31
Vegetables	0.10	-0.03	0.07	0.08	0.02	0.10

Table 8. Reduction in Calorie and Protein Deficiencies Caused by a ten per cent Increase in the Supply of any one of the Foods for Es = 0 (per cent of total Deficiency)

Food for which Supply is Increased	Calories (Strata I)	Protein Strata I	Protein Strata II
Beef	3.42	5.75	14.71
Pork	1.00	1.32	4 23
Eggs	0.33	1.21	3.46
Milk	1.33	1.49	4.13
Rice	18.72	5.80	8.56
Maize	16.22	5.46	8.65
Beans	3.42	2.99	6.15
Lentils	0.48	0.52	1.73
Peas	-0.19	0.17	0 48
Potatoes	6.39	2.24	2.02
Cassava	9.78	1.90	-4.48
Vegetables	0.40	0.29	0.77
Tomatoes	-0 15	0.00	0.01
Plantain	9.64	1.15	1 63
Oranges	0.86	0.75	0.77
Bread and Pastry	5.29	2.07	3.46
Sugar	17.64	1.44	0.87
Oils and Fats	8.55	-0.11	-0.29

Table 9. Suggested Commodity Priorities, if Improved Calorie Nutrition is the Goal

Order of Priority	Cost Assumption (a)		Cost Assumption (b)		Cost Assumption (c)	
	$E_{si}=0$	$E_{si}=1$	$E_{si}=0$	$E_{si}=1$	$E_{si}=0$	$E_{si}=1$
1	Rice	Rice	Oilseed	Oilseed	Cassava	Potatoes
2	Sugarcane	Maize	Sugarcane	Maize	Potatoes	Cassava
3	Maize	Sugarcane	Maize	Rice	Maize	Maize
4	Cassava	Plantain	Rice	Beans	Plantain	Plantain
5	Plantain	Oilseed	Wheat	Wheat	Sugarcane	Beans

Table 10. Suggested Commodity Priorities, if Improved Protein Nutrition in the Goal

Order of Priority	Cost Assumption (a)		Cost Assumption (b)		Cost Assumption (c)	
	$E_{si}=0$	$E_{si}=1$	$E_{si}=0$	$E_{si}=1$	$E_{si}=0$	$E_{si}=1$
1	Beef	Beef	Beans	Beans	Maize	Maize
2	Rice	Maize	Wheat	Beef	Rice	Rice
3	Maize	Rice	Maize	Wheat	Wheat	Wheat
4	Beans	Beans	Rice	Maize	Beans	Beans
5	Potatoes	Potatoes	Beef	Rice	Eggs	Eggs

FOOTNOTES

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1/ Only the nutritional impact due to change in calorie and protein intakes is considered in the model Possible impact due to changes in other nutrients and interactions among nutrients is ignored.

2/ The model is static in the sense that no shifts in the demand curves can occur except those due to changes in prices of other goods brought about by the initial shift in the supply curve and subsequent adjustments, i.e. consumer incomes, tastes, preferences and other potential demand shifters are assumed constant.

3/ The first survey was conducted by a Michigan State University marketing research team headed by Kelly Harrison Upon completion of the project the team kindly made available to CIAT data useful for the present study The second survey was conducted by CIAT. Results of the MSU analyses and a detailed explanation of sampling procedures are reported by Riley et. al

4/ The 95 per cent confidence limits for the sample mean were 0.8933 and 1.087 . $\frac{v}{w}$ = 1.0 was used in all subsequent calculations

5/ The short run is defined here as the period not exceeding that occuring between production decision and the resulting impact on supply

6/ Since this analysis considers only one goal improved human nutrition, the implications for other possible goals such as the distribution of benefits between consumer and producer sectors and among production factores are not discussed here. For a discussion of these relationships see Ramalho de Castro and Schuh.

7/ Although not treated in this article, implications for human nutrition among the rural population, may be equally or more important and offers, in our opinion, another highly disregarded but potentially rewarding area of economic study.

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Pinstrup-Andersen, Per, Norha Ruiz de Londoño and Edward Hoover-- The impact of Increasing Food Supply on Human Nutrition Implications for commodity priorities in agricultural research and policy.

A procedure is developed to estimate the nutritional implications of alternative commodity priorities in agricultural research and policy. The model estimates the distribution of supply increases among consumer groups, the related adjustments in total food consumption and implications for calorie and protein nutrition. Findings from an empirical application of the model to the population of Cali, Colombia suggest that relative increase in total nutrient supply is a poor indicator of relative nutritional impact because both nutritional waste and consumer adjustment in total food consumption are a function of the commodity from which the additional nutrients are obtained. American Journal of Agricultural Economics,

Key words human nutrition, agricultural research priorities, research resource allocation, income distribution, price elasticities.

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