Income and Nutrition: Welfare Indicators and Proxies

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Abstract: An exploratory analysis based on 120 countries indicates that more widely available general economic development indicators can predict a large share of variations between countries with respect to longevity (an overall indicator of nutritional and health state and of the share of the population that is malnourished) The successful predictors include GNP per caput, calorie availability to requirements ratio, and the share of agricultural population in total population. Those variables explain 87 percent of the variation between countries with respect to life expectation at birth.

Introduction

A growing awareness of welfare objectives for development planning and analysis has led to a rising interest in welfare indicators that could be derived from forward-looking planning and analysis. Welfare indicators are of high potential value in agricultural planning, including the policies and programmes for the reduction or elimination of malnutrition.

Chronic malnutrition is very closely tied to poverty, and, in many situations, poverty is closely linked with a highly unequal income distribution. At the same time, most planning and analytical models for agricultural and economic development do not contain explicit income distribution mechanism components; they thus postulate only average incomes in the future because building income distribution mechanisms into already complex models increase their complexity and the resources required for their construction. The need to approximate the status of nutrition-related welfare of future populations under various economic scenarios is, nevertheless, strongly felt. Thus, as part of the Food and Agriculture Program at the International Institute for Applied Systems Analysis (see Parikh and Rabar, 1981, for the objectives and approach of the Program) for the Basic Linked System (BLS) of national agricultural policy models of world agriculture, an attempt was made to find substitute means by which at least some indication of the extent of hunger and malnutrition in the future, under various policy scenarios tested, could be obtained.

Attention was focussed on two indicators of welfare: the percentage of population that is malnourished and the average life expectancy at birth. The latter is, in a sense, the most aggregated indicator of well-being and reflects nutrition, health, and many other factors lying behind differences in average longevity among countries.

This paper describes the analysis and its results aimed at estimating the relationships between performance measures (usually available in policy simulation models such as the BLS) and malnutrition and longevity. Having those estimates will enable us to make projections of malnutrition and longevity on the basis of relatively easily available indicators.

Conceptual Framework

The rationale for our approach comes from the hypothesis that income and its distribution, through a set of intervening variables, strongly influence the nutritional level of the population and its longevity in a given country. The main variables are shown in Table 1 as being linked by a simple causal flow from left to right.

Underlying the causal flow scheme is the hypothesis that the calorie availability to requirement ratio can be predicted on the basis of income, income distribution, and urbanization. Similarly, the basic variables can explain a large share of the variation between countries with respect to infant mortality rates and number of people per physician. In turn, the intermediate variables are proxies for nutritional level indicators and for general health service levels and thus can be expected to predict hunger and longevity. The basic variables may be somewhat intercorrelated but they still contribute individually to the explanation of the welfare indicator differences.

Table 1—Causal Influences on Malnutrition and Longevity

Basic Variables	⇒ Intermediate Variables	⇒ Welfare Indicators
GNPC	CALAR	HUNGRY
DISTR	IMR	LEB
NAPTOT	POPDR	

[Notes: Variables are defined below. ⇒ = direction of causal influence.]

Statistical Estimation

An important limitation of the analysis stems from the cross-country nature of the data, which assumes that the present differences between countries provide good indicators for the behaviour of a given country as it moves over time. That may be too heroic an assumption. A number of countries that have gained sudden wealth recently (e.g., oil exporters) have not yet had time to build the infrastructure and to achieve educational levels that would be "appropriate" for their income and calorie intake levels. Also, curves that relate income and mortality have been shifting over time; i.e., progress in medicine and other areas permits longer life in later time periods for a given income level.

The analysis in this study was done on cross-country data from both developing and developed countries. The greatest number of observations for individual variables was 120 and the least was 49 because of lack of data on or nonexistence of hunger (malnutrition) in the richer countries.[2] The variables are:

LEB: Life expectancy at birth, in years.

HUNGRY: Percentage of the population with calorie intake levels of less than 1.2 basic metabolic rate.

GNPC: GNP per caput in 1981 US dollars.

CALAR: Calorie availability as a percentage of requirements estimated by FAO food balance sheet information for availability and FAO/WHO nutritional standards for minimum average requirements.

IMR: Infant mortality rates up to age one, in number of deaths per 1,000 live births.

POPDR: Number of people per physician.

NAPTOT: Nonagricultural population as a percent of total population, serving as an indicator for the level of urbanization.

DISTR: Share of total GDP received by the lowest income 40 percent of the population, serving as indicator for income distribution.

The following alternative variables were tried and discarded: calorie intake per caput per day instead of *CALAR*; child mortality rate instead of *IMR*; per caput central government health expenditures instead of *POPDR*; and share of urban population in the total instead of *NAPTOT*. Although location in specific world regions may have an otherwise unexplained influence, the regionally disaggregated analysis did not succeed in showing that. The analysis confirmed, however, that using pooled regional data does not violate assumptions about their belonging to the same overall population.

The final set of equations chosen was selected on the basis of explanatory power, agreement with hypothesized relationships, and statistical significance of the individual regression coefficients.

Statistical Results

Equations predicting welfare indicators:

(1) $LEB = -35.632 + 1.760\, l_n GNPC + 15.323\, l_n CALAR + 0.217\, NAPTOT$, $[R^2 = 0.871, D.F. = 104]$
        $(-2.16)** \quad (2.37)** \qquad (3.87)*** \qquad\quad (6.39)***$

(2) $HUNGRY = 103.910 - 0.798\, CALAR$, $[R^2 = 0.6395, D.F. = 49]$
        $\qquad\qquad\quad (12.07)** \; (-9.131)***$

Supplementary equations on intermediate variables:

(3) $IMR = 598.37 - 10.279\, l_n GNPC - 87.193\, l_n CALAR - 0.746\, NAPTOT$, $[R^2 = 0.774, D.F. = 104]$
        $(5.71)*** \quad (2.18)** \qquad (3.46)*** \qquad\quad (3.45)***$

(4) $POPDR = 4.638 \cdot 10^{-4} - 1.163 \cdot 10^{3}\, NAPTOT + 7.304\, NAPTOT^2$, $[R^2 = 0.7446, D.F. = 114]$
        $(18.16)*** \qquad (-11.36)***$

[Note: Numbers in parentheses show t-statistics with the level of significance shown as ** = 5 percent and *** = 1 percent.]

Equation *(1)* shows that longevity is strongly related to the logarithms of *GNPC* and *CALAR* and that the functional relation is significant for all the variables. *NAPTOT* affects *LEB* much more than *CALAR* and *GNPC*, capturing the importance of health services as reflected in *NAPTOT* for improving *LEB*. Even so, some "out-liers" occur on the upper side of the *LEB* curve—countries that have above average health services and where income distribution and nutrition policies are aimed at reducing hunger and malnutrition (the best examples being Sri Lanka and China).

NAPTOT, as a proxy for the level of urbanization, is closely related to *GNPC* but provides substantial further explanation of longevity differences between countries. *NAPTOT*, together with *CALAR*, takes care of some of the influences coming from the differences in income distribution between countries. *DISTR* was tried widely in a number of equations, but its predictive power proved to be very low, and, in addition, it is available only for a small number of countries. Those various estimates of income distribution may be less valid than what one may expect from them.

POPDR has also been used in many of the fitted equations as a linear or quadratic component, and its contribution to the explanatory power of most equations is high. However, *POPDR* is not available as an independent variable from the BLS; neither are independent projections of it available. The only opportunity for us to estimate it for the future would thus involve using *GNPC* and *NAPTOT* as predicting variables. Doing so would lead to the inclusion of those variables twice among the predictors, and, for that reason, *POPDR* was dropped from the final selection of equations predicting *LEB* and *HUNGRY*. Later, *POPDR* is discussed as a good indicator of health services, reflecting its close relationship to income and urbanization levels.

Equation *(2)* has a lower goodness of fit than equation *(1)* and uses only one predicting variable. Attempts to include other variables have failed, as their close collinearity with *CALAR* created results with wrong signs on the coefficients and many of them had nonsignificant t-statistics. The low R^2 may be due partly to hunger only existing in any significant amount in the lower income countries or in countries with medium incomes but large income disparities.

One of the main disappointments in the analysis came from the practical inability of the income distribution variable *DISTR* to provide an increase of predictive power when added to *CALAR* or to *GNPC*. *CALAR* apparently already reflects fairly strongly income distribution influences on average calorie intakes per caput, which may be explained as an effect of the upper, biologically-based ceiling on calorie intake, which in turn reflects the influence of unequal income distribution on the average level of *CALAR,* with rising inequality depressing *CALAR*. Interestingly, the relation of *HUNGRY* to *GNPC* turned out to be even weaker, and, while adding *DISTR* to *GNPC* raised the R^2 from 0.30 to 0.39, the t-statistics are very low for both regression coefficients.

While they could not be used directly in the equations predicting *LEB* and *HUNGRY,* the variables *IMR* and *POPDR* can shed some further light on the relationships involved. *IMR* is often used as a proxy for the degree of malnutrition because, in countries with high *IMR*, people suffer from poverty and hunger. *IMR* and *LEB* are highly correlated, and, once again, *NAPTOT* affects *IMR* the most. A 10-percent increase in nonagricultural population will decrease *IMR* by 75, whereas when calorie availability increases from 90 percent to 120 percent or GNP/caput increases from $1,000 to $2,000, *IMR* decreases by about 25.

Although the problems of using *POPDR* referred to earlier made us exclude it from the final equations, the analysis has shown some interesting features of the relationship between *POPDR* and *GNPC*. Above 12,000 persons per physician and below 400 persons per physician, *POPDR* and *GNPC* are not related, which is why some observations have been dropped from the tail ends. *NAPTOT* alone is a better predictor of *POPDR*, as it seemingly combines both income effects and urbanization effects, which are closely related.

CALAR is directly available as an output from the BLS model but under an assumption of unchanged income distribution patterns. *GNPC* and *NAPTOT* showed the most influence on *CALAR*, but *DISTR* also had statistically-significant regression coefficients, though its contribution to R^2 was small.

For practical application of the results in the BLS, the residual errors between fitted and actual values were retained and used as country-specific dummy estimates for the future.

Implications of the Results

Though the analytical effort has been on a limited scale and more of an exploratory nature, the results are interesting. One notable result is that it may be worthwhile not to insist on "dethroning" *GNPC* as a major welfare indicator but to make more imaginative use of it in conjunction with other welfare-oriented indicators. *LEB* may be one of those, as it is eminently suitable for integrating the effects of a large number of important welfare components, nutrition and health being the most prominent.

Emerging from this study are a number of areas that deserve future investigation. To strengthen the potential use of alternative welfare indicators, one needs to include time as an analytical dimension and to estimate time-series-based functions and combine them with results of cross-country analysis, and one could go deeper into the factors that seem to be behind the out-liers, thus leading to higher explanation.

The long-run need is to generate more reliable time series of the best and widest available welfare indicators and to build up over time a sound "mapping" of their interrelationships so that, given the unavoidable gaps in data even in the future, more reliable statements can be made about expected welfare results of projected or planned development.

Notes

[1]International Institute for Applied Systems Analysis.
[2]The information on life expectancy at birth, GNP/caput, income distribution, ratio of calorie availability to requirements, infant mortality rates, and population numbers per physician came from the World Bank (1981). Levels of urbanization are from FAO (1981), and the percent of the population malnutrition is from FAO (1977).

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