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Nutrition as an Index to Relative Economic Development

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Investigation of nutrition as a reliable measure of relative economic development.

Fourteen specific indices were grouped and combined to make six general indices. Subjected to the Kendall test of concordance, they were found to measure the same basic phenomenon that, on examination, appeared to be symptomatic of economic development and, therefore, reliably combined into a single index. A nutrition index was then compiled for specific countries in terms of gross calories per capita per day and adjusted to age structure, climate and quality of diet. All countries for which information was available were ranked by this nutritional index and tested against the economic development index. The two measures were found to have a Spearman Rank Correlation of $r_s = .871$, indicating a high correlation.

It is difficult, if not impossible, to directly measure economic development as a total phenomenon. We can, however, measure the indices that are or appear to be symptomatic of economic development. The hypothesis to be tested in this paper concerns the usage of nutrition as an index to relative economic development.

In this study, a number of indices were used. Each index measured some specific economic or social factor that is indicative of a degree of total development. These factors were tested to discover if they were in such agreement that they might be said to measure the same phenomenon, i.e. relative degree of economic development. These factors to be known as the field, were summed, ranked and tested against nutrition, termed the master index, to discover if nutrition measured the same basic phenomenon as the field.

Individual nations gather and report data at their own discretion and these reports are accepted by the United Nations without verification. For many countries the material can hardly be called comparable. Individual nations, each using their own definitions and systems of sampling, arrive at their statistics with varying degrees of accuracy, honesty and thoroughness. The degree of accuracy is a function of a systematic error as certain countries are, through their greater economic or intellectual resources, much more thorough and reliable in the gathering of statistical data than other countries that are less well endowed. Not only can the statistical reliability and validity of many of the latter countries be open to question, but a further bias is introduced by the limitation of available data. This bias results from the systematic exclusion of countries that do not report statistics.

There is an interrelation between the production of a society and the consumption of this production to provide the power to produce more (Cipolla, 1962:ch. 3). On this basis, nutrition, as the supplier of individual power, was chosen as the master index to be ranked and tested. Fourteen indices were reduced to a field of six factors, shown in Table I. These factors, when ranked, were tested against the ranked nutritional data. For each aspect contained in the field an attempt was made to derive a factor from two or more indices, each of which measured different aspects of a single phenomenon, i.e., economic development. This was done in order to eliminate errors and minimize anomalies in the material. In the case of gross national products, this step was not taken because of the general use of this index. In the

TABLE 1*

Country	1 Energy	2 Population	3 Transportation	4 Education	5 Economy	6 Gross Nat'l. Prod.
Australia	5	2	2	3	5	8
Ireland	12	15	4	8	17	25
United States	1	3	3	6	1	1
United King.	3	1	10	1	4	2
Switzerland	10	10	8	5	9	14
France	9	13	7	10	8	3
Canada	2	6	1	12	6	6
Israel	15	4	20	13	12	30
Finland	11	17	11	7	11	18
Argentina	13	8	16	14	14	12
Belgium	4	7	6	4	7	9
Netherlands	8	5	12	9	10	11
Sweden	6	11	5	2	3	10
W. Germany	7	9	9	11	2	4
Greece	20	16	19	17	21	22
Chile	14	12	14	16	15	27
Italy	16	14	13	15	13	7
Brazil	18	19	26	22	22	15
Yugoslavia	17	24	15	18	16	16
Turkey	22	30	24	24	23	13
Peru	21	23	23	23	24	26
Portugal	19	18	18	20	18	23
Ghana	26	28	22	26	27	31
Iraq	24	29	27	30	19	29
Egypt	23	21	30	25	25	19
Nigeria	31	22	28	31	31	20
Pakistan	29	25	29	28	29	17
Algeria	25	27	21	27	20	24
Ceylon	28	20	17	19	28	28
Thailand	30	31	31	21	30	21
India	27	26	25	29	26	5

These 31 countries are the total universe for which complete data were available.

* All factors derived from Ginsburg, *Op. Cit.* See Text for method of derivation.

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case of the transportation factor, four indices appeared necessary for adequate description.

Column 1 Table I shows the relative ranking of the nations with respect to energy consumption. This ranking was derived by plotting the per capita commercial energy consumption against the per capita gross energy consumption, calculating the regression line as either a first or second degree curve, and then projecting each point perpendicularly to the regression line. Finally, the countries were ranked in highest to lowest order. Ties were recorded as ties and assigned the appropriate range of ranks.

By the angle and location of the regression line, the proportion of control exerted by each axis is changed. The location of any particular point, in the final ranking, is influenced by the two indices in a ratio that is determined by the total universe as plotted. The greater the deviation on one axis from the regression line of a particular point, the greater the increase or decrease, with regard to the other axis, in rank on the regression line.

A curved line, however, has an added quality. After the position of the line is fixed, the relative influence of the two indices changes with the different attitudes of the curve. As an example, in a parabola, the portion of the curve which asymptotically approaches the bordering axis, is primarily controlled by the axis it is approaching.

In the case of the energy factor the two indices have much the same effect together and singly. A country, however, with a high gross energy consumption rate but a low commercial energy consumption rate, can be shown by the angle of the regression line to have a lower rank than a country with a high commercial energy consumption rate but a lower gross energy consumption rate. This factor, then, is a measure of energy consumption with a higher value placed upon commercially used energy.

The population factor, Column 2, Table 1 was ranked in the same manner. The variables used were the per cent of non-agriculturally active population plotted against the urban population expressed as the per cent of the total population in cities over 20,000. The former is taken as an expression of that portion of the population engaged in secondary and tertiary industry. The latter is the portion of the population living in major cities. Thus, we have a ratio of non-farm population to urban population. The two are strongly linked and serve as an indicator of the urban industrial base of the countries.

The transportation factor, Column 3, Table I, was ranked on the basis of four indices: two referring to road transport and two to rail transport. First a scattergram was constructed placing millions of freight ton-kilometers per railway kilometer against railway kilometers per person to population distance. Millions of freight ton-kilometers measures rail communication by taking the number of tons carried, multiplying that by the number of kilometers each ton was carried and dividing by the total number of kilometers in the rail net. The resultant measure is a measure of the intensity of use of the rail net rather than the intensity of the net itself. The railway kilometers per person to population distance is derived by the division of the number of rail kilometers by the total population and dividing this quotient by the average distance from one member of the population to his nearest neighbor. Thus, a characteristic of the population density is taken into consideration, not just the area or the population of the country. This measure, then, shows the availability of the rail net to the population, distributed. When these two are plotted against one another and projected to the regression line, we have a ranking showing the intensity of rail use and its availability to the population with respect to density.

A scattergram was also constructed plotting road kilometers per 100 square kilometers against road kilometers per 100,000 population. Thus the position of a point is influenced by the density of population as well as the availability of roads. The rail index was multiplied by the road index for each country. The transportation factor is the ranked product of these two values, as measured along the regression line.

The education factor, Column 4, Table I was derived by plotting daily newspaper circulation per 1,000 population against literacy as a per cent of the total adults. The regression line, in this case, was a strongly curved parabola. For the low ranking countries, the values for the newspaper circulation index are tightly clustered at very low levels while in high ranking countries, the literacy rate is clustered at very high levels. The two indices together, however, are well spread. They represent a measure of the declared ability to read and the actual willingness to read a publication reporting daily happenings.

The economy factor, Column 5, Table I was measured by plotting steel consumption in tons per 1,000 population against raw materials as a per cent of exports. The first, steel consumption, measures the development of the heavy industrial base of the country. As a measure of the input it contains both the commercial and capital investment, i.e., the portion of the steel for consumer goods and that which is reinvested in the economy of the country for production through the construction of industrial facilities. Raw materials as a per cent of exports represent a measure of the output. This becomes a qualitative measure, in that it measures the technological development of a country by indicating the proportion of the total exports that are not processed in the country of origin.

The final factor making up the field was gross national products, Column 6, Table I. Gross national products is said by Ginsburg (1961) to be "widely recognized at present to be the best single measure of economic development for given countries" (p. 18). This factor takes the increase of national wealth for a country during one year and assumes it to be equally distributed among the population. Ginsburg discusses the difficulties of its use quite ably and arrives at the con-

clusion that this is a useful index indeed. In this paper, this measure is used as presented by Ginsburg.

Individually, then, each factor measures several aspects (indices) of a particular phenomenon. These factors, however, are neither particular nor isolated but the result of interrelations. When we consider the energy factor, the two indices of gross energy consumption and commercial energy consumption are closely interrelated and are measures of aspects of the same phenomenon. If, then, the indices making up a factor respond simultaneously, it can be inferred that the changes may primarily be a result of close association that the indices have by virtue of measuring portions of a single whole. Much the same argument can be applied to each of the groups of indices employed to rank each factor. For example, while there are any number of different aspects of population characteristics, the two that were selected for integration express a particular aspect of population. If any other indices had been chosen the description of the population as a whole would have been different. The two selected indices, nevertheless, combined to represent something more basic than each represents individually. Operating together, they measure a ratio between urban dwelling and non-farm employment. These are neither mutually exclusive nor inclusive; they overlap and are interrelated. This particular example of the population factor is argued here as the illustration of the argument per se, valid for the process of arriving at all the other factors each of which will not be argued specifically.

The population factor, when ranked highest to lowest, can be reasoned to be an aspect of economic development. Those countries that we would consider to be developed rank higher on the list than those we would consider to be underdeveloped. Further inspection of Table I reveals that the same observation is generally true regarding all the six factors that may be measures of different attributes of economic development but need not be. If we can prove that these factors were drawn from the same universe then by applying to the factors the same argument as used above for the indices, it could be said that they are symptomatic of an underlying phenomenon which, in this study, is economic development. The field of six factors was tested by the Kendall test of concordance (chi² of ranks). Basically this test is an index of the difference between our data and data in which there is perfect agreement (Siegel, 1956: 229-39). This test yielded a chi² of 149.9. At the .001 level of confidence and with 30 degrees of freedom a chi² of 59.7 would be significant (Fisher and Yates, 1948: 33). Therefore, the results are significant and we can say with confidence that they all measure, by different aspects, the single phenomena of economic development.

Against this field the master index nutrition was tested. Nutrition, see Table II, was measured by the following refinement for each country: First the gross calories per capita per day, Column 1, Table II (Ginsburg, 1961:30), were corrected for the age structure of the population. The reports published by the United Nations list gross calories per capita per day only, but, because persons of different ages have different levels of food intake which are generally based on different body weights or metabolism characteristics, a supply of statistically hidden calories is available to an active person. To correct for this, the population was factored to standard age groupings. The group 14 and younger was considered to be children and the group 65 and older, elderly. The group over 14 and under 65 was considered to be the adult, economically active, class. Among them were distributed the "extra" rations available because of the lower requirements of the two other classes. The number of adults was divided by the number of children. This yielded the ratio of adults to children or the number of adults among whom the theoretical surplus from children can be distributed. The same was done for the adult-over-elderly group. Next, the calories per capita per day for each country was multiplied by .40 because the diet of an elderly person is reduced by 40 per cent from that of an adult (Keys, 1950:19, 20). This product was divided by the quotient of the adult over elderly. The same was done again using .23 as the reduction for a child (Keys, 1950:25-27). The quotients shown in Column 2, Table II, represent the number of calories hidden in reports but which actually can be added to the typical adult calorie intake.

Next the calories (corrected for age structure) were adjusted to a standard mean annual temperature of 50°.

TABLE II *

Country	1 Calories	2 Age	3 Climate	4 Nutrition	5 Final Value
United States	3100	631	78	900	4709
Canada	3070	615	−154	800	4331
Argentina	3350	507	0	400	4257
Brazil	2585	567	194	200	3546
Chile	2682	526	67	400	3675
Peru	2600	473	195	200	3468
Belgium	2930	504	0	800	4234
Finland	3100	559	−78	700	4281
France	2920	548	73	800	4341
Greece	2650	415	133	500	3698
Ireland	3510	734	0	700	4944
Italy	2580	409	65	500	3554
Netherlands	2890	558	0	700	4148
Portugal	2460	418	128	400	3401
Sweden	2950	492	−148	800	4094
Switzerland	3240	443	0	800	4563
United Kingdom	3290	552	0	800	4642
West Germany	2990	436	0	600	4026
Yugoslavia	2710	454	58	300	3532
Thailand	2020	454	152	100	2726
Ceylon	2050	423	154	100	2727
India	2000	386	150	100	2636
Pakistan	2125	575	159	100	2959
Algeria	1920	450	96	300	2766
Egypt	2300	436	115	200	3051
Iraq	2350	638	115	100	3203
Israel	2880	577	144	700	4301
Turkey	2650	505	133	200	3488
Australia	3240	616	243	900	4999
Ghana	2500	329	188	200	3217
Nigeria	2250	517	169	100	3036

* See text for the derivation of the factors.

This was done by approximating the mean annual temperature from the average annual high, adding the average annual low and dividing by two. The difference between the determined value of the average annual temperature and 50° was established and a correcting factor, shown in Column 3, Table II, was computed at the rate of five per cent per 10° change (Keys, 1950: 22).

A number of descriptive studies of nutrition were consulted and found to be, generally, of little use. Simmons (1944-54) and the *FAO Work Sheets,*[2] however, were of great help. The former is a descriptive work on the country by country incidence of various diseases, including deficiency diseases. The latter gives the components of the diets of typical inhabitants of a country in calories and grams by class of foodstuff. On the basis of these studies, the countries were assigned a rating number of 1-10 to represent the standards of nutrition. This was multiplied by 100 in order to obtain a suitable weight, Column 4 Table II, and added to the gross calories per capita per day plus correction for age structure, plus or minus the correction for temperature. Thus the nutritional factor, Column 5 Table II, used to rank the countries for nutritional standards, was estimated.

The six factors in Table I making up the field were then summed across and ranked by the sums of their ranks. A Spearman Rank Correlation was computed for the nutrition factor and the field (Siegel, 1956:202-13). This yielded an r_s of .871 indicating that the two are highly correlated and means that the nutrition factor is a valid indicator of the relative economic development. The indices used in this study had to be gross for reasons that are inherent in the statistical data available. It can be stated, nevertheless, that on the basis of this inquiry the nutritional factor by itself may serve as an *indicator* of the general economic development of a country and with further refinement might be substituted for the field of indices.

[2]*Food Balance Sheets,* 1958. Food and Agriculture Organization of the United Nations, Rome. This is the average of 1954-1956; since the writing of this paper the average 1957-1959 has been published (1963). A cursory comparison reveals no major changes.

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