A CROSS-NATIONAL MULTI-DIMENSIONAL ANALYSIS OF SOCIOECONOMIC DEVELOPMENT, INCORPORATING TIME-SERIES DATA

PAUL E. PERRY

I. INTRODUCTION

ALTHOUGH a substantial number of cross-national studies have examined socioeconomic development from a multi-dimensional perspective (e.g., [1] [3] [22] [25] [26] [27] [29]), the data used has typically been based on measurement at a single point in time. The use of such static data may have been a methodological necessity; nevertheless it seems inappropriate when viewing development as a process of change over time. An essential feature of this study is the analysis of cross-national time-series data, with measurement spanning a twenty-year period at three separate points in time (circa 1950, 1960, 1970). Our intention is to provide a more appropriate means of looking at the broad processes of development from a multi-dimensional point of view.

This study uses time-series data to examine the interrelationships between several broad dimensions of development with respect to time order, spuriousness, and strength of association. These facets provide the basis for the development of a path model, where the temporal ordering of the variables has been empirically derived. The model can be viewed as the description of a part of the overall structure of interrelationships involved in the process of development. It is consistent with a view that development proceeds as a consequence of the changing interrelationships among a system of diverse components.

An additional feature of the use of time-series data lies in the ability to observe the actual paths of development of individual nations, over time, on various dimensions. This represents an improvement over static studies, where only the relative positions of individual nations can be observed (e.g., [29]).

II. CONCEPTUAL FRAMEWORK

While the multi-dimensional nature of development has been well-established empirically, there appears to be an absence of carefully defined and widely accepted frameworks which incorporate a broad range of socioeconomic variables.

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The framework adopted here, although somewhat limited in scope, allows development to be viewed in multi-dimensional terms, while facilitating the coherent operationalization of a large variety of developmental variables.

Our framework is based on the ecological complex as set forth by Duncan [6]. Simply stated, the ecological complex is comprised of four broad areas, including population, environment, technology, and organization; with a variety of more specific features subsumed under each part. Together, the parts are viewed as a functionally interdependent and equilibrium-seeking system; with an ecological account of social change being obtained by reference to the changes in each of the parts; and where the interdependence of the parts implies that a change in any one is likely to result in changes in the others [6, pp. 683–84].

Clearly, this framework is rather general in nature, and while it does not incorporate all conceivable aspects of development, it does appear to be useful for the purposes at hand. It divides a number of facets of development into conceptually distinct, yet interrelated realms, and in broad terms suggests that social change is a consequence of the changing interrelationships between a system of parts. The four parts of the ecological complex are briefly described below.

A. *Population*

Population characteristics are known to set limits on the nature of organized group life [13, pp. 78–79], and have been shown to be sensitive indices of social change [13, p. 104]. Numerous studies have found demographic factors to be closely associated with other aspects of development (e.g., [9] [22] [25] [27]). In this study, variables indicative of population size and growth, composition, and distribution and concentration have been included.

B. *Environment*

The environment is the medium of existence for a population; it includes all factors which are external to a population [14, p. 330], and which interact with it in some meaningful way [30, p. 6]. Within the natural environment, for example, features such as climate, terrain, and natural resources are included. Such factors are difficult to measure in a summary manner for cross-national analysis, but they do play an important role, among others, in the suitability of an environment for agriculture. Because of this, variables indicative of agricultural productivity have been included; recognizing that such variables, in part, also reflect the influence of technology and social organization.

Like the natural environment, the social environment consists of external factors that interact with a population; however in this case the reference is to interaction with other populations. Communication and trade with other nations bring new ideas, techniques, and materials, as well as supplementing the available natural resources. In fact, it has been suggested that as the reliance on exchange with other nations increases, the social environment actually displaces the natural environment as the most critical set of environmental factors [14, p. 332]. Hence, indicators of trade between nations have been included. Several studies have shown that such measures are closely associated with other facets of development [9] [11] [27].

C. *Technology*

Technology refers to a set of techniques employed by a population to gain sustenance from its environment, and to facilitate the organization of sustenance-producing activity [6, p. 682]. Increased levels of technology enhance the efficiency with which a population can adapt to its environment [21, pp. 46–47]. A number of facets of technology have been shown to be associated with different levels of development, particularly in the areas of energy use, transportation, communication, and agricultural production (e.g., [3] [8] [11] [22] [25] [26] [27] [29]). It is from these areas that we have taken our technological measures.

Technology also has a non-material side, being more than just physical artifacts and tools. It also involves the direct applioation of knowledge and ideas to the performance of various tasks. In order to tap at least part of this realm, several measures of educational level have been included.

D. *Organization*

An ecological view of organization focuses on the collective adaptation of a population to its environment [7, p. 135], with particular reference to the structure of sustenance-producing activities [6, p. 682]. In more conventional terms, this refers to the division of labor. Its structure has two important characteristics: (1) the distribution and degree of differentiation among activities, and (2) the degree of functional interdependence between activities. Only indicators of the first characteristic have been included in this study, since the measurement of interdependence is quite difficult; however the existence of interdependence is implied by the presence of differentiation [17, p. 265]. Substantial association between the division of labor and other aspects of development has been amply demonstrated (e.g., [8] [11] [25]).

Overall, the ecological complex provides a useful and reasonably comprehensive, if somewhat unusual, framework from which the process of development can be examined. It brings together elements of technology and organization, perhaps more typically conceptualized under the rubrics of industrialization or economic conditions, as well as components of a demographic and environmental nature.

III. DATA AND DIMENSIONS OF DEVELOPMENT

The data set of this study is comprised of sixty-three variables, from fifty-seven nations, measured at three separate points in time (circa 1950, 1960, 1970). The variables (Table I) are indicative of different areas of the ecological complex, with each variable being categorized under one of the four main parts. The data has been taken largely from U.N. sources.[1] We have tried to avoid variables

[1] The major sources of data include: United Nations, *Demographic Yearbook,* 1951–73 editions; United Nations, *Statistical Yearbook,* 1948–74 editions; International Labour

with highly inconsistent definitions, and those that would entail a high proportion of missing cases.

Bringing together a large set of comparable measures for several points in time is a formidable task which, of necessity, limits the number of nations under consideration.[2] Although more highly developed nations are somewhat over-represented, the fifty-seven nations span a broad spectrum of developmental levels.

In order to represent different aspects of the ecological complex, and hence different dimensions of development, a number of composite indices were derived from the sixty-three variables. The use of composite indices has several advantages. First, it enhances validity, given that each part of the ecological complex covers a rather broad domain which would be difficult to adequately represent with a single variable. Second, reliability is improved, since the combination of individual variables helps reduce the effects of measurement error commonly found in cross-national data. Finally, composite indices are of value in dealing with missing data, in as much as a combination of variables reduces the probability of any given nation being excluded from analysis because it is missing information on a single variable.

Factor analysis has been used to derive the composite indices. However, unlike most cross-national research using the technique, a purely inductive approach has not been followed. Instead, four separate analyses were executed, one for each of the sets of population, environmental, technological, and organizational variables. This somewhat unusual approach permits the conceptual distinctions between the four ecological areas to be maintained, while at the same time allowing the factor analyses to identify empirically distinct dimensions within each broad area.

Office, *Yearbook of Labour Statistics*, 1949–74 editions; Food and Agriculture Organization of the United Nations, *Production Yearbook*, 1952–72 editions; United Nations, *Compendium of Social Statistics, 1967* (1968). Other sources, of less importance, used mainly to reduce the amount of missing data include: A. Banks, *Cross-Polity Time-Series Data* (Cambridge, Mass.: M.I.T. Press, 1971); K. Davis, *World Urbanization, 1950–1970*, Vol. 1 *Basic Data for Cities, Countries, and Regions* (Berkeley: Institute of International Studies, University of California, 1969); N. Ginsburg, *Atlas of Economic Development* (Chicago: University of Chicago Press, 1961); N. Keyfitz and W. Flieger, *World Population and Analysis of Vital Data* (Chicago: University of Chicago Press, 1968); U.S., Agency for International Development, *Population Program Assistance* (Washington, D.C., 1970); C. L. Taylor and M. C. Hudson, *World Handbook of Political and Social Indicators* (New Haven: Yale University Press, 1972); Food and Agriculture Organization of the United Nations, *World Crop Statistics: Area, Production and Yield* (1966).

2 The nations included in this study are: Algeria, Argentina, Australia, Austria, Barbados, Belgium, Belize, Brazil, Bulgaria, Canada, Chile, Colombia, Costa Rica, Cyprus, Czechoslovakia, Denmark, Dominican Republic, Egypt, El Salvador, Fiji, Finland, France, West Germany, Greece, Guatemala, Guyana, India, Ireland, Israel, Italy, Japan, South Korea, Luxembourg, Mauritius, Mexico, Morocco, Netherlands, New Zealand, Nicaragua, Norway, Pakistan, Panama, Philippines, Poland, Portugal, South Africa, Spain, Sri Lanka, Sweden, Switzerland, Thailand, Trinidad and Tobago, Turkey, United Kingdom, United States, Venezuela, and Yugoslavia.

TABLE I

FACTOR LOADINGS FROM FOUR FACTOR ANALYSES OF ECOLOGICAL VARIABLES

Population Variables	F1	F2	F3	F4
Rate of natural increase	(0.956)	0.153	−0.007	−0.178
Youth dependency ratio	(0.935)	0.140	−0.008	−0.243
Dependency ratio	(0.918)	0.114	−0.017	−0.209
Child-woman ratio	(0.915)	0.144	−0.055	−0.224
Crude birth rate	(0.871)	0.386	−0.009	−0.249
Rate of population increase	(0.835)	−0.047	−0.113	0.096
Old age dependency ratio	(−0.733)	−0.227	−0.043	0.324
Crude death rate	0.078	(0.898)	−0.004	−0.271
Male life expectancy at birth	−0.434	(−0.804)	0.024	0.327
Female life expectancy at birth	−0.510	(−0.758)	0.014	0.346
Infant mortality rate	0.377	(0.752)	−0.015	−0.317
Pop. density per ha of arable land	−0.053	−0.054	(0.875)	0.164
Agr. workers per ha of arable land	0.159	0.167	(0.763)	−0.197
Population density per sq km	−0.164	−0.007	(0.696)	0.147
% urban, 100,000 or more	−0.234	−0.224	−0.010	(0.878)
% rural	0.359	0.317	0.092	(−0.762)
% urban, 20,000 or more	−0.070	−0.153	0.167	(0.760)
Population size	−0.066	0.466	0.090	0.130
Index of urban primacy	0.337	−0.253	−0.211	−0.429
Variance explained	47.2%	13.0%	10.4%	6.8%

Environmental Variables	F1	F2	F3
Imports+exports per capita, U.S.$	(0.952)	−0.149	0.199
Imports per capita, U.S.$	(0.948)	−0.145	0.150
Exports per capita, U.S.$	(0.934)	−0.151	0.247
Goods unloaded, metric tons per 1,000	(0.809)	0.005	0.071
Wheat yields, 100 kgs per ha	(0.790)	−0.211	−0.422
Maize yields, 100 kgs per ha	(0.653)	(−0.613)	−0.205
Rice yields, 100 kgs per ha	0.090	(−0.827)	−0.112
Average calories per capita	0.480	(−0.647)	−0.101
Goods loaded, metric tons per 1,000	0.320	0.167	0.604
Iron ore prod., metric tons per 1,000	0.325	−0.129	0.516
Arable land, ha per capita	−0.192	−0.465	0.455
% of total land that is arable	0.606	0.095	−0.371
Variance explained	44.6%	13.5%	9.2%

The factor analyses have been based on a principal components solution with othogonal rotation, where the rotation of factors has been confined to those with eigenvalues equal to or greater than one, a common convention [24, p. 362]. In each analysis, data from all three points in time have been factored together, permitting the location of individual nations on each dimension, at each point in time.

Table I summarizes the results. Over the four factor analyses, eleven dimensions were identified, with ten of dimensions appearing to be rather conceptually clear; that is, the higher loading variables on each of these factors tend to form

TABLE I (Continued)

Technological Variables	F1	F2
Telephones per 1,000	(0.953)	0.056
Total vehicles per 1,000	(0.941)	0.206
Passenger vehicles per 1,000	(0.938)	0.181
Newsprint consumption per capita	(0.913)	0.116
Energy consumption per capita	(0.891)	0.146
Steel consumption, kgs per capita	(0.891)	0.105
Domestic mail per capita	(0.881)	0.035
Electrical energy production, kws per 1,000	(0.862)	−0.004
Tractors per 1,000	(0.857)	0.083
Electrical energy, install, cap., kws per 1,000	(0.853)	−0.056
Commercial vehicles per 1,000	(0.838)	0.293
Daily newspaper circulation per 1,000	(0.783)	−0.065
Tractors per 1,000 ha of arable land	(0.689)	−0.173
University enrollment per 1,000	(0.683)	0.305
Secondary school enrollment per 1,000	0.622	0.311
Railroad freight volume per capita	0.603	0.274
% in primary school of those 5–14 years	0.019	(0.687)
% in secondary school of those 15–19 years	0.114	(0.654)
Primary school enrollment per 1,000	0.007	0.374
Variance explained	59.7%	6.9%

Organizational Variables	F1	F2
% in agricultural industries	(0.980)	−0.093
% in primary industries	(0.977)	−0.105
% in tertiary industries	(−0.901)	−0.080
Index of dispersion among industries	(−0.890)	−0.074
% wage and salary earners	(−0.879)	0.120
% in secondary industries	(−0.834)	0.422
% in service industries	(−0.823)	−0.205
% in manufacturing industries	(−0.782)	0.466
% employers and own workers	(0.690)	0.395
Index of relative size of productive assocs.	−0.608	0.293
% of total population, economically active	−0.203	(0.966)
% of females, economically active	0.026	(0.847)
% of males, economically active	−0.144	(0.727)
Variance explained	57.6%	19.7%

a meaningful group. Brackets have been placed around the higher loadings, using a cut-off of approximately 0.650.

Four dimensions were found among the population variables, with the first being comprised of variables indicative of fertility and population growth. We have simply labeled it fertility. The second factor is associated with several variables which reflect levels of mortality; the third is closely associated with several measures of density; while the fourth factor is closely related to levels of urbanization.

The analysis of environmental variables yielded three dimensions. The first dimension is highly associated with several measures of international trade, while on the second two measures of agricultural productivity and average daily calorie intake have high loadings. The two factors have been respectively labeled trade and agricultural production. The third environmental factor is not particularly clear from a conceptual point of view, and none of its loading exceed 0.604. Therefore, it was excluded from all subsequent analysis.

Only two technological dimensions were identified. The first is very powerful, and largely involves variables from the realms of communications, transportation, and energy. It has been labeled technology. The second factor is associated with two educational measures.

The last factor analysis was of the organizational variables, and it produced two dimensions. Several measures of the distribution and degree of differentiation among sustenance-activities load highly on the first factor, while three labor force participation measures load highly on the second. The two dimensions have been respectively labeled the division of labor and labor force participation.

Composite scores have been derived for the fifty-seven nations, for each of the ten dimensions, at each of the three points in time. A procedure outlined by Rummel [24, pp. 441–42] was followed, using only the higher loading variables (those bracketed in Table I). With this procedure the selected variables are standardized and then weighted by the square of their factor loadings.[3] All of the variables representing a given dimension are then summed for each case and divided by the number of available variables. In most instances, this procedure takes care of the problem of missing data.

The resultant scores permit the location of individual nations on each dimension. Because each nation has a separate score for each of three points in time, the progression of individual nations can also be observed. This specific facet of our study appears to be particularly unique.

IV. RELATIONSHIPS BETWEEN DIMENSIONS

The three criteria of causality in non-experimental situations have guided our analysis [2, p. 42]. Simply stated, the variables must tend to occur together (i.e., have substantial association); the time order between the variables must be established; and it must be determined whether the relationship between any two variables is essentially direct, or alternatively, a function of a common relationship with other variables.

A. *Association*

Only seven of the ten composite indices were found to have substantial correlation coefficients with each other (Table II). The three indices with low intercorrelations are density, education, and labor force participation, having average correlations (with the other nine indices) ranging from 0.05 to 0.26. The remain-

3 Because several of the dimensions have variables with negative loadings, it was necessary to retain the original signs of the unsquared loadings.

TABLE II

CORRELATION COEFFICIENTS BETWEEN TEN COMPOSITE INDICES OF DEVELOPMENT

Indices	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
(1) Fertility	0.52	−0.05	−0.48	−0.53	−0.75	−0.63	−0.14	−0.61	−0.69
(2) Mortality		0.03	−0.57	−0.52	−0.58	−0.57	−0.16	−0.72	−0.26
(3) Density			0.06	0.12	0.03	−0.08	−0.02	−0.01	0.07
(4) Urbanization				0.47	0.66	0.66	0.18	0.80	0.16
(5) Trade					0.57	0.77	0.08	0.68	0.22
(6) Agric. prod.						0.71	0.13	0.65	0.44
(7) Technology							0.14	0.74	0.31
(8) Education								0.21	0.04
(9) Div. of labor									0.17
(10) Labor force part.									

ing seven indices, however, have correlations ranging from 0.47 to 0.80, and all subsequent analyses have focused on these measures.

B. *Form and Time Order*

The form of each bivariate relationship (among the seven indices) was considered by examining each of the twenty-one possible scattergrams. Each scattergram depicts the joint distribution of two developmental indices; and since every nation is measured at three separate points in time, the progression of individual nations can be observed. In effect, each scattergram can be viewed as a bivariate continuum of development, illustrating how individual nations have developed over a twenty-year period.

If the distributions are to be regarded as developmental continua, it is desirable that each scatter of points form a relatively narrow band, running from low to high levels of development on both indices. Furthermore, the progression of individual nations over time should be in the direction of higher developmental values. In most instances these criteria are met, with the only notable exceptions occurring on the fertility dimension, where it is common to find increases between 1950 and 1960.[4] This situation, however, is consistent with world fertility trends during the period; and in the long run, most of the nations in the data set do exhibit movement towards lower levels on the fertility index.

Limitations of space preclude the presentation of all twenty-one scattergrams; selected examples, however, are shown in Figures 1 to 8. Limited space also precludes the labeling of point in these examples, although this was carried out in the actual analysis.

A large proportion of the scattergrams exhibit very distinct curvilinear forms, making it possible to infer time order between certain pairs of indices. These curvilinear forms result from the tendency for major changes in one index of a pair to occur in time prior to major changes in the other. For example, consider the curve which is evident in Figure 1, the relationship between the division of

4 We assume that lower values on the fertility index (as well as on the mortality index) are indicative of higher levels of development.

Fig. 1. Division of Labor and Technology

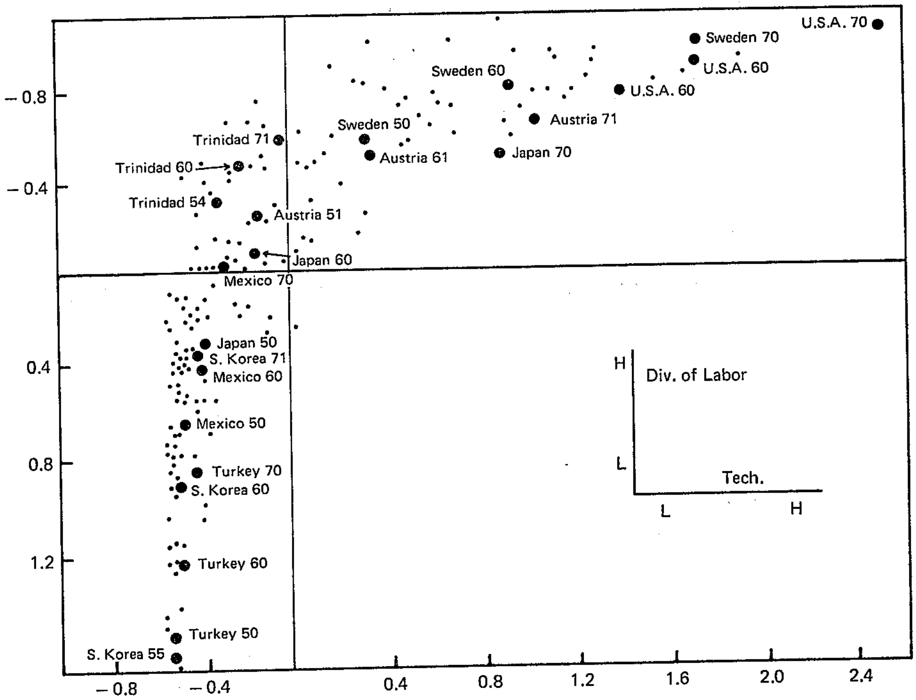


Fig. 2. Division of Labor and Trade

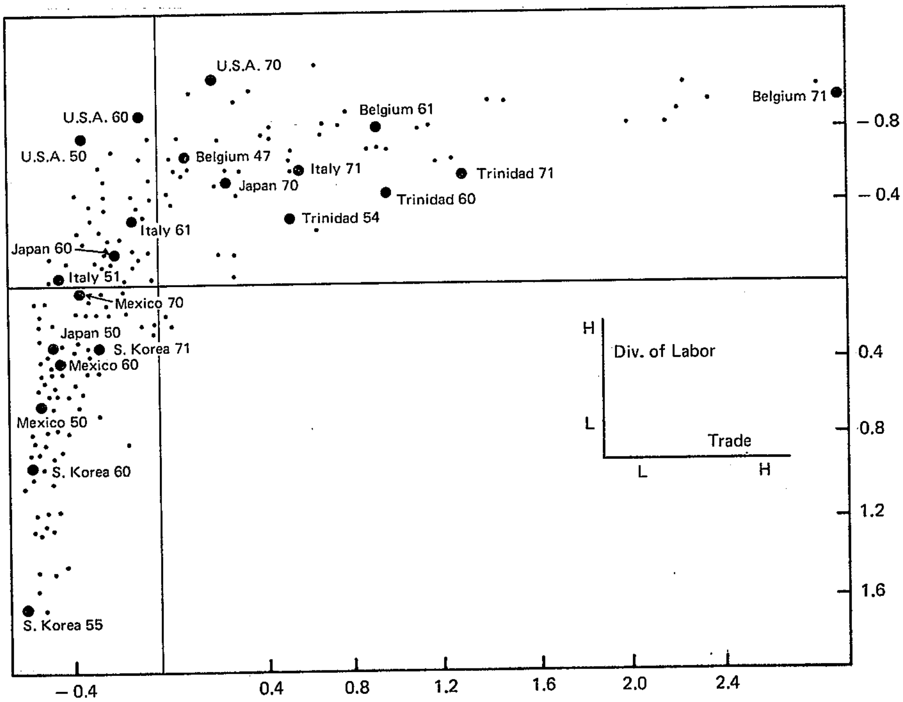


Fig. 3. Fertility and Technology

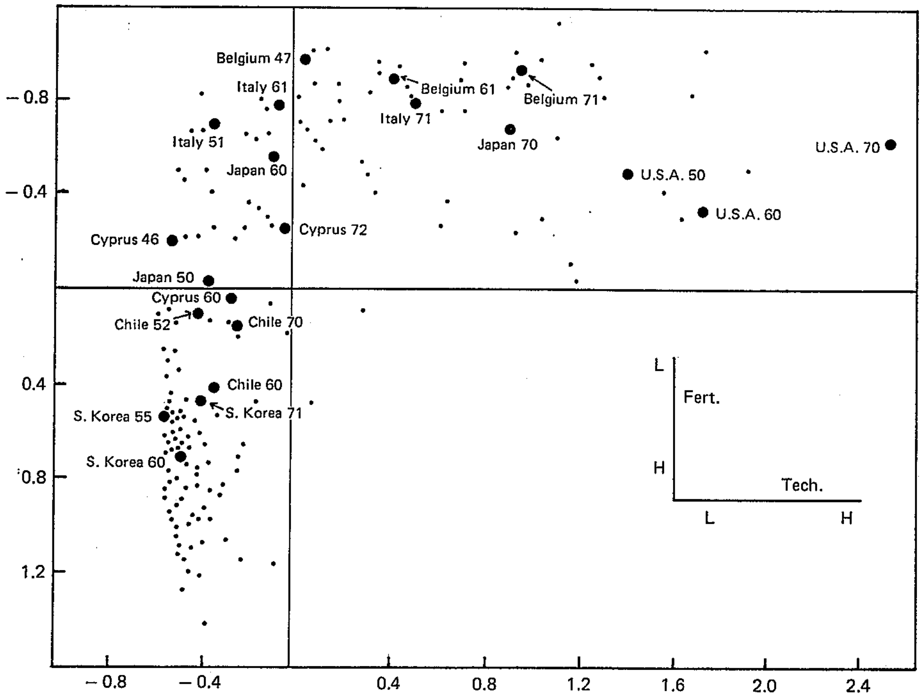


Fig. 4. Mortality and Agricultural Production

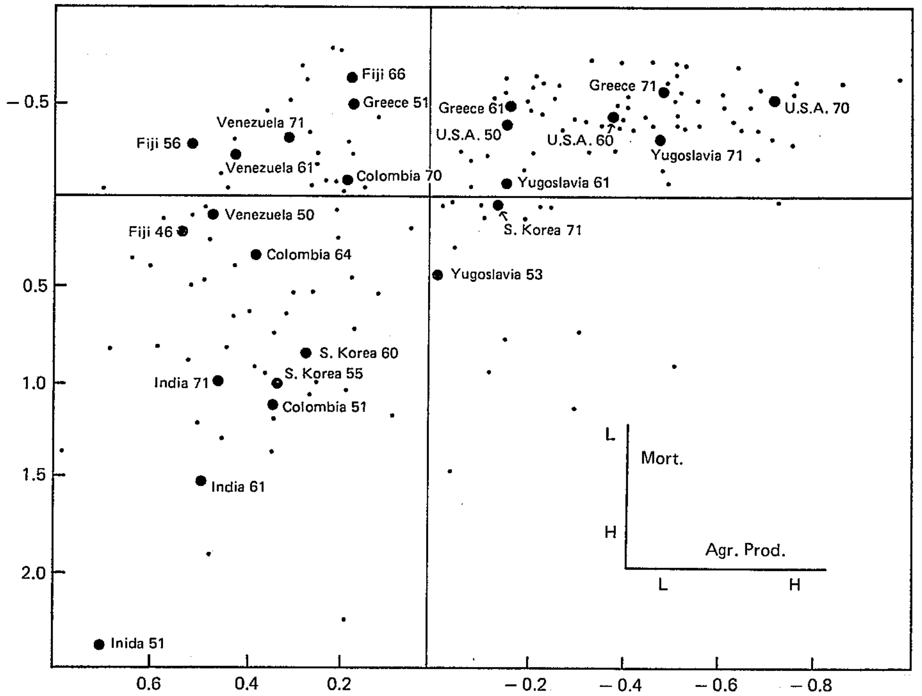


Fig. 5. Urbanization and Technology

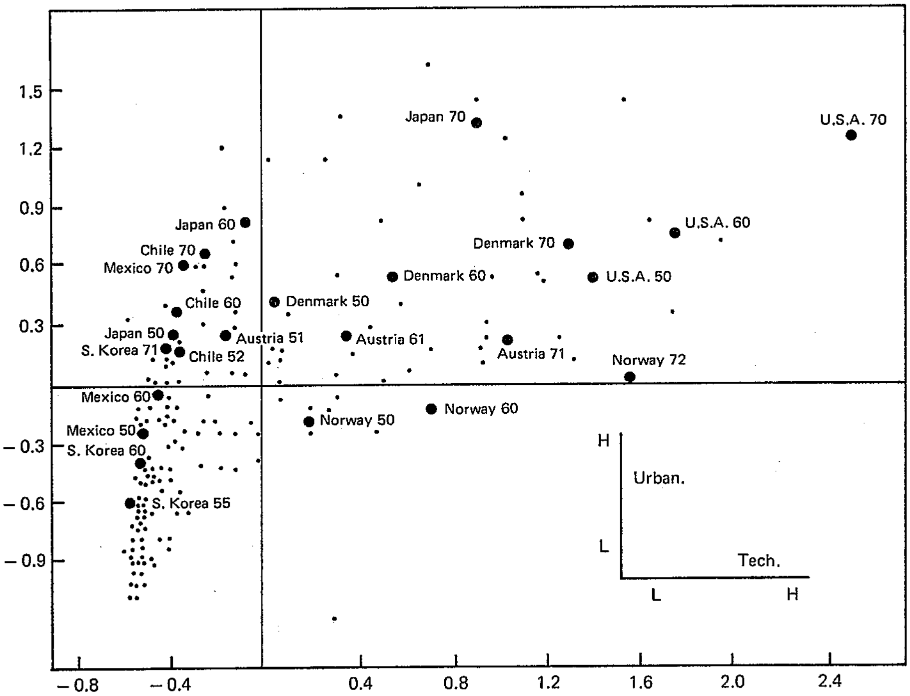


Fig. 6. Mortality and Division of Labor

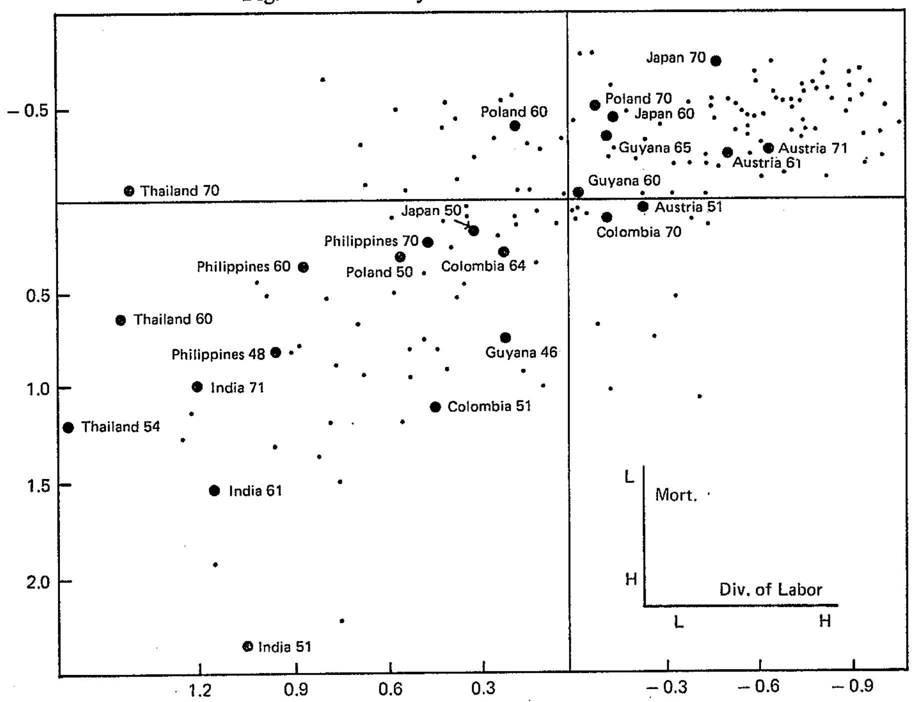


Fig. 7. Agricultural Production and Fertility

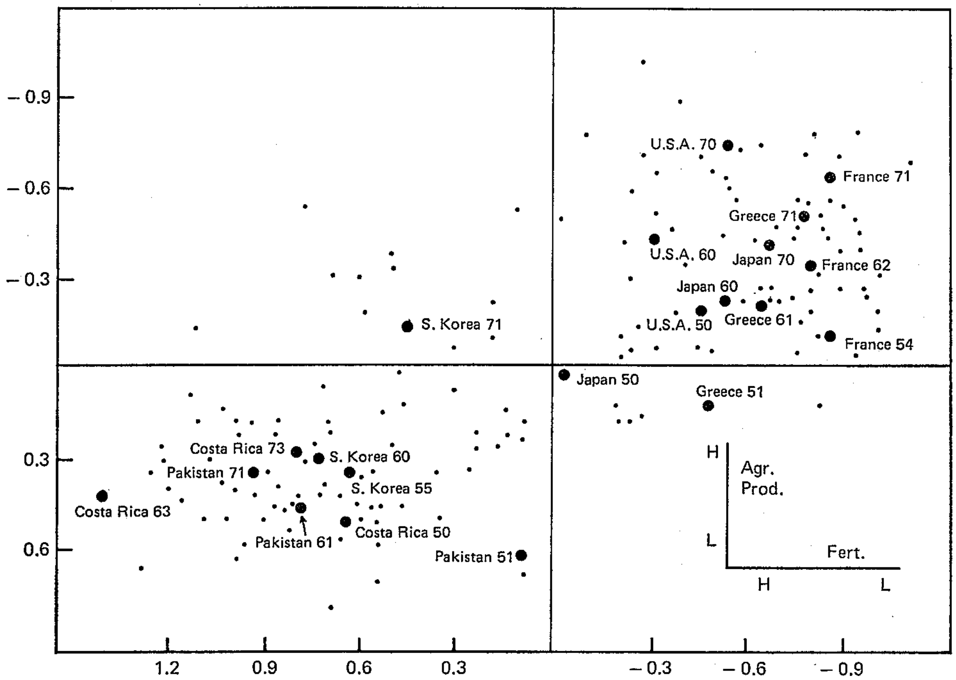
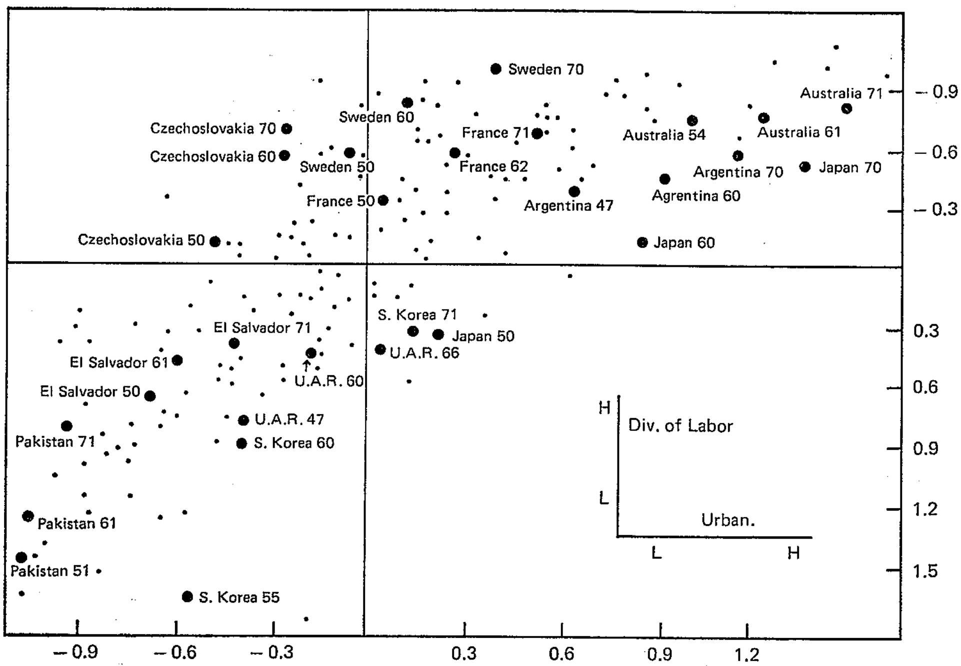


Fig. 8. Division of Labor and Urbanization



labor and technology. During the twenty-year period, nations located near the lower end of the continuum, such as Mexico, experienced change largely in terms of the division of labor. On the other hand, nations near the higher end of the continuum, for example the United States, experienced change largely in terms of technology. There are also nations, such as Japan, which experienced substantial change on both indices, and hence make a turn which connects the two disparate trends.

In our judgement, fourteen of the twenty-one scattergrams exhibit distinctly curvilinear forms (Figures 1 to 6 are examples). For each of these fourteen pairs of indices, an inference of time order has been made. While such inferences may be unusual, they appear to have an empirical basis which is reasonably sound. In brief, the scattergrams suggest that major changes (decrease) in the mortality index tend to precede in time, major changes in all six of the other indices; major changes in technology tend to follow major changes in all of the other indices except trade; and major changes in trade tend to follow major changes in all of the other indices except technology. This leaves essentially linear relationships between technology and trade, and between the division of labor, fertility, agricultural production, and urbanization. In effect, there are three temporal stages, with mortality in the first stage; the division of labor, fertility, agricultural production, and urbanization in the second; and technology and trade in the third.

At this point, it may be instructive to note the resemblance between our analysis and the cross-national research of Takamori and Yamashita [29]. The six composite indices which they created appear to be roughly comparable with four of the indices developed here; furthermore, there are striking similarities of form, point spread, and order of nations between the equivalent scattergrams of both studies.[5]

There are, however, significant differences between the two studies. The most important, perhaps, is the fact that Takamori and Yamashita used data which were measured at only one point in time (circa 1970). Thus, on strictly empirical grounds, there is no basis for inferring that their scattergrams illustrate "development paths." Their scattergrams suggest what the form of such paths might be if time-series data were used, but they do not illustrate the paths. This, they recognized, since their conclusion notes that the examination of development paths would be more appropriate with time-series data [29, p. 144]. On the other hand, our scattergrams clearly illustrate paths of development because time-series data have been used. Thus, our analysis in a sense replicates and expands upon the work of Takamori and Yamashita.[6]

[5] To the extent that the composite indices of different studies can be compared, it appears that Takamori and Yamashita's indicator of "standard of living" is similar to our index of mortality; their indicator of "urbanization" is similar to our index of urbanization; their indicators of "economic activities and cultural level" are similar to our index of technology; and their indicators of "industrialization and agricultural proportion" are similar to our index of the division of labor.

[6] The work of Takamori and Yamashita did not come to our attention until after we had completed most of our analysis.

TABLE III

ZERO-ORDER CORRELATION COEFFICIENTS AND FIRST-ORDER PARTIAL CORRELATION COEFFICIENTS OF LESS THAN 0.30

Correlation Coefficients between:	Zero-Order Correlations	First-Order Partials
Mortality and fertility	0.52	
Controlling div. of labor		0.15
Controlling agric. prod.		0.16
Controlling technology		0.25
Mortality and agric. prod.	−0.58	
Controlling div. of labor		−0.22
Mortality and urbanization	−0.57	
Controlling div. of labor		0.02*
Controlling agric. prod.		−0.11
Mortality and technology	−0.57	
Controlling div. of labor		−0.08*
Controlling agric. prod.		−0.27
Mortality and trade	−0.52	
Controlling div. of labor		−0.06*
Controlling agric. prod.		−0.28
Controlling technology		−0.16
Div. of labor and fertility	−0.61	
Controlling agric. prod.		−0.24
Controlling technology		−0.28
Div. of labor and agric. prod.	0.65	
Controlling urbanization		0.27
Controlling technology		0.26
Div. of labor and trade	0.68	
Controlling technology		0.26
Fertility and urbanization	−0.48	
Controlling mortality		−0.26
Controlling div. of labor		0.02*
Controlling agric. prod.		0.03*
Controlling technology		−0.12
Fertility and technology	−0.63	
Controlling agric. prod.		−0.21
Fertility and trade	−0.53	
Controlling div. of labor		−0.20
Controlling agric. prod.		−0.19
Controlling technology		−0.09*
Agric. prod. and trade	0.57	
Controlling div. of labor		0.23
Controlling technology		0.05*
Urbanization and technology	0.66	
Controlling div. of labor		0.15
Urbanization and trade	0.47	
Controlling mortality		0.25
Controlling div. of labor		−0.17

TABLE III (Continued)

Correlation Coefficients between:	Zero-Order Correlations	First-Order Partials
Controlling fertility		0.29
Controlling agric. prod.		0.15
Controlling technology		−0.08*

* Partials indicative of essentially indirect relationships.

C. *Spurious Relationships*

The calculation of first-order partial correlation coefficients for each pair of indices among the seven, controlling in turn for each of the remaining indices, has been used to determine whether the relationship between any two indices is essentially direct, or alternatively, a function of a common relationship with other indices. Partial correlation coefficients with values at, or near, zero were taken as indicative of essentially indirect relationships, using 0.10 (1 per cent variance explained) as an arbitrary cutting point (see [4, pp. 337–43]).

Limitations of space preclude the presentation of all of the 105 partial correlation coefficients, although those of less than 0.30 (9 per cent variance) are shown in Table III. Only eight of the partials were found to be of 0.10 or less (they are asterisked in the table). Bearing in mind that all of the zero-order correlations are at least 0.47 (22 per cent variance) in magnitude, the partial correlations with coefficients of 0.10, or lower, clearly indicate relationships that have been greatly weakened by the introduction of the effects of a third index.

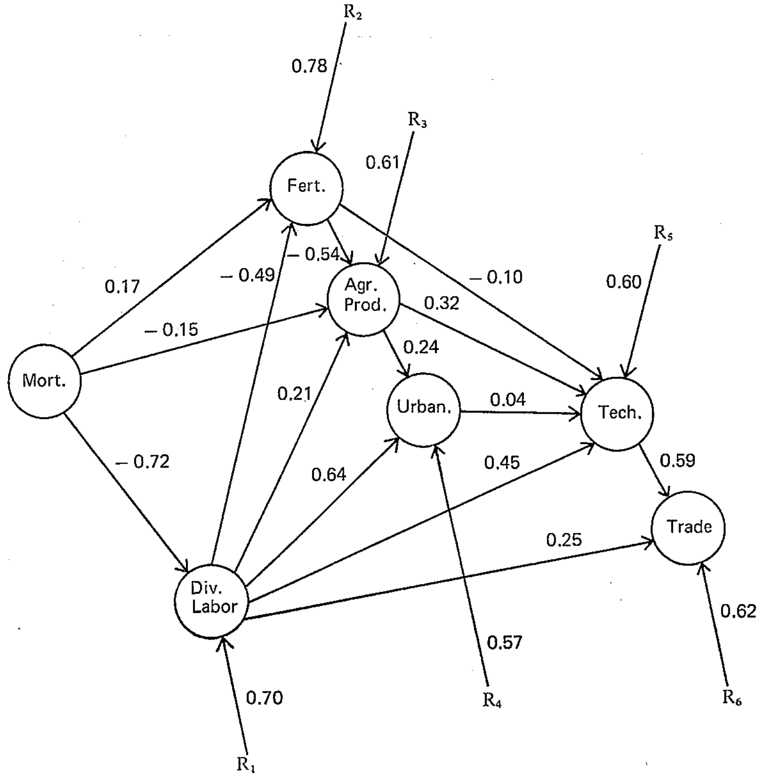
The eight partial correlation coefficients of 0.10, or less, suggest that seven of the twenty-one possible bivariate relationships are essentially indirect. These relationships include mortality and urbanization, mortality and technology, and mortality and trade, when the division of labor is controlled; urbanization and fertility, when either agricultural production or the division of labor is controlled; and urbanization and trade, agricultural production and trade, and fertility and trade, when technology is controlled.

V. A PATH MODEL OF DEVELOPMENT

In order to enhance the utility of the preceding analysis, a path model of development was constructed (see Figure 9). This model incorporates the time order found between the seven indices; it indicates which of the relationships were found to be essentially direct (non-spurious); and it shows the magnitude of the effect of one index upon another. In essence, it provides an empirical description of how the seven socioeconomic indices were found to be interrelated during the twenty-year period under consideration.

The most difficult aspect of constructing such a model lies in the determination of the overall temporal (or causal) structure. Our interpretation of the scattergrams (see Section IV) provided part of the answer, but a problem was presented by the lack of directionality among the four indices of the second stage, and the two indices of the third; the lack of directionality among such endogenous variables

Fig. 9. Path Model of Seven Indices of Development, Circa 1950 to 1970



is not completely compatible with the requirements of path analysis (see [15] [16]). In order to derive a path model, some means of specifying directionality among the indices of each of these stages had to be found.

This problem was approached by taking a closer look at the seven scattergrams previously judged to be essentially linear in form. Particular attention was given to the form of the development paths for individual nations within each scatter of points, with the aim in mind of coming to a decision regarding temporal precedence, however slight that precedence might be. The structure of Figure 9 reflects the judgements that were made.

The division of labor has been placed prior to the other three indices of the second stage. This position is also supported by the role it was found to have as a significant control variable with respect to the relationships between mortality and several other indices.

Fertility has been placed after the division of labor, being followed in turn by agricultural production, and then urbanization. This sequence is further supported by the role of agricultural production as a significant control variable between fertility and urbanization.

Finally, in the third stage, technology has been placed prior to trade. Once again, the role of technology as a significant control variable, between trade and several antecedent indices, lends support to this position.

The judgements of time order noted above are more tenuous than those that were described in Section IV, and hence must be interpreted more cautiously. They, nevertheless, have some empirical basis. We stress this because it is in the area of time order that our path diagram most notably differs from those that are typically found in the social science literature. In most path diagrams, the temporal (or causal) structure is derived in an a priori manner, either from theory, or on some intuitive basis. Spuriousness may be tested for, and path coefficients calculated, but the temporal structure is rarely, if ever, verified from actual data. Our model is different in this sense, since its temporal structure has been empirically derived.

Several kinds of information should be considered when examining Figure 9. The order of the indices, moving from left to right, indicates the temporal precedence of change; starting with declines in mortality and ending with increases in trade. This portion of the diagram is based on our interpretation of the scattergrams, with some secondary support from the analysis of partial correlations. A single-headed arrow connecting two indices signifies a direct, non-spurious relationship. Where two indices are not immediately connected with an arrow, this indicates that the relationship was found to be essentially indirect. The numbers entered on the arrows are standardized path coefficients; in essence, standardized partial regression coefficient, or betas. They indicate the relative magnitude of the effect that a particular antecedent index has upon a given index, when all of the other antecedent indices are controlled [15] [16]. Arrows coming from outside the seven indices are from residual terms, representing the variance unexplained by variables in the model [15] [16].

VI. INTERPRETATION OF THE PATH MODEL

The antecedent position of the index of mortality in Figure 9 appears to be consistent with the theory of demographic transition (see [5, pp. 55–56]), bearing in mind that the model only covers a twenty-year period. According to this theory, major declines in mortality tend to occur prior to major fertility declines, as well as prior to the achievement of relatively high levels of socioeconomic development (see [19, p. 100]). Figure 9 clearly illustrates such a sequence of events.

The demographic transition also suggests that declining fertility tends to occur in close temporal proximity with changes in other facets of development. This idea seems to be supported by the fact that we found close temporal relationships between the index of fertility and the indices of agricultural production, urbanization, and the division of labor.

The structure of the relationships in Figure 9 also imply that changes in the division of labor may play an important role in bringing about a fertility transition. This follows from the intermediate position of the division of labor, between mortality and fertility, and the rather substantial effect that the division of labor has upon fertility. Such a structure is in accordance with those who have argued that major declines in fertility can come about only within the context of structural changes in the labor force (e.g., [18]).

Going a step further, the model suggests that changes in the division of labor may also have a rather general and significant effect upon the overall process of development. Consider that the division of labor is the only index found to have non-spurious relationships with all of the other indices; that its position in the model is essentially antecedent; and that its effects upon subsequent indices are generally quite substantial. In one sense, this justifies the prominent place that the organization of sustenance-activities has been accorded in much of the ecological literature; however, it is somewhat inconsistent with those that have viewed the division of labor largely in terms of a dependent variable (e.g., [10] [13]).

The model shows that declines in the fertility index have a substantial effect upon agricultural production, and a rather modest effect upon technology. Agricultural production is also affected by mortality, but the effect is much smaller. Agricultural production, in turn, has a moderate effect upon technology, in keeping with those who have suggested that industrialization is dependent upon inputs from agriculture (e.g., [12, pp. 94–95] [23, p. 8]); as well as a moderate effect upon urbanization, which is reasonable in light of the needs of a larger urban population for greater amounts of food. The division of labor also affects urbanization, to a rather substantial degree, and this makes sense given that a highly urbanized population is impossible so long as a nation's labor force remains relatively undifferentiated and primarily engaged in agriculture.

Although the very small direct effect of urbanization upon technology may seem puzzling at first, it can be understood if it is put in the context of over-urbanization (see [20] [28]), and considered together with the substantial effect of the division of labor upon both urbanization and technology. Over-urbanization is a phenomena thought to be evident in some developing countries, manifesting, in part, a disproportionate concentration of the urban population in low productivity, tertiary activities [20, p. 203]. In contrast, the earlier experiences of many western nations are thought to have involved a greater proportion of the urban labor force in secondary type activities. If this is the case, then it is logical to find, as the model suggests, that urbanization has only a very slight *direct* effect upon technology, while the division of labor has a very substantial effect. For the twenty-year period covered in this analysis, at least, it is not increasing urbanization, per se, which has had a major impact upon technology, but rather, changes in the division of labor which have had a substantial impact upon both of these indices.

The location of technology in Figure 9, near the end of the temporal sequence, can be understood if the variables that comprise it are considered. Although this analysis has not included the usual summary measures of economic level, such as GNP or GDP per capita, other studies (e.g., [3] [22] [25] [26] [29]) have shown that such measures are highly associated with the kinds of variables that make up the technology index. Thus, this index can be viewed as a kind of surrogate measure for the average level of material well-being within a nation. With this in mind, the model shows how high levels of communication, transportation, and energy use come about as a consequence of changes in the five antecedent indices, particularly the indices of agricultural production and the division of labor.

Trade is the last index in the temporal sequence of the model. Both technology and the division of labor have a direct effect upon it, with the effect of technology being greater. If higher levels of technology, and an increasingly differentiated labor force, generate both a greater capacity to produce exportable goods, and a greater need for a wider variety and larger amount of imports, then these relationships with respect to trade are reasonable.

VII. CONCLUSION

Although this analysis has been primarily descriptive, it has gone a step beyond most multi-dimensional studies of socioeconomic development by incorporating time-series data. The path model, which was empirically derived, not only provides a description of the magnitude of the effects among several dimensions of development, but a description of the time order of the relationships as well. Our treatment of time order has in a sense been rudimentary, but it certainly provides an improved means by which the broad processes of development can be described, and hence ultimately understood.

The structure of the model points to the relative importance of different factors at certain stages in the process of development, with the division of labor apparently playing an exceptionally important role. The model also lends support to several conceptual schemes involving various facets of development, such as the demographic transition and over-urbanization. Overall, a complex sequence of development is suggested by the model; where changes in certain factors tend to occur before changes in others, and where the factors that change later in the temporal sequence tend to be dependent, at least in part, on the changes in certain antecedent factors.

This study has certain limitations which should be noted. First, the analysis has not incorporated all of the conceivably relevant dimensions of development; our efforts have focused rather exclusively on macro-level factors. Second, the actual pace of change itself among the various dimensions has not been considered, nor have we looked at the possibility of feedback between the different indices of the model. The most obvious area of improvement, however, lies in the desirability of analyzing data that goes farther into the past, covering a greater period of time, and hence increasing the potential for generalization. Obtaining such data would be rather difficult, and it most certainly would mean a smaller set of nations and variables, but it also would appear to be a worthy task for the future.

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