Trajectories of Development: A Test of Ecological–Evolutionary Theory*

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Abstract

To test a fundamental hypothesis of ecological–evolutionary theory, that technical and economic heritage affects current rates and patterns of development, Third World societies were classified as "industrializing agrarian" or "industrializing horticultural" on the basis of their dominant subsistence technologies prior to sustained contact with industrial societies and industrial technology, and then compared on five basic dimensions: (1) current levels of technological and economic development, (2) informational resources, (3) rates of economic growth, (4) vital rates, and (5) trade dependency. Predicted differences were found on all dimensions. Alternative explanations were explored and rejected, and it was also demonstrated that these differences were not explained by network position in the world economy or by recency of national independence. These findings suggest that the impact of techno-economic heritage on development merits further investigation.

What forces determine the trajectories of development of societies in the modern world? Why have some societies been so much more successful than others in achieving economic growth and higher standards of living for their citizens?

Various answers have been given to these questions in recent decades. Modernization theorists such as Parsons and Inkeles have stressed the importance of belief systems and values, following the early lead of

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Max Weber. World system and dependency theorists such as Wallerstein and Frank have emphasized the capitalist world economy, drawing on the ideas of Lenin. Developmental and ecological–evolutionary theorists have recognized a diversity of forces, but have attached greater importance than others to the effects of the indigenous technological and economic heritage of societies on their current levels, rates, and directions of development.

The aim of this paper is to test the validity of this important aspect of ecological–evolutionary theory. We propose to do this in three steps. First, we divide Third World nations into two categories that reflect a fundamental—though generally overlooked—difference in technological and economic heritage prior to sustained contact with industrial technology to see if it is associated with substantively and statistically significant differences in contemporary patterns of societal growth and development. Second, we examine the individual and joint effects of techno-economic heritage and current economic, diplomatic, and military interactions with other nations. This added step allows us to compare the magnitude of the differences produced by variations in techno-economic heritage of societies with the magnitude of differences produced by variations in the status of societies in the modern world system. Both world system and ecological–evolutionary theories posit that current patterns of interaction with other nations affect rates and directions of development, but world system theory (e.g., Wallerstein a, b) and some versions of dependency theory (e.g., Frank) are openly skeptical that the "stage" of technological development attained prior to sustained contact with industrial societies continues to have systematic and substantial effects on development independent of present status in the world economy or current dependent relations with industrial nations. Therefore, it is important to determine to what extent these internal/historical and external/contemporary factors have independent effects on rates and levels of socioeconomic development. Finally, we examine the possibility of alternative explanations of the empirical findings.

Industrializing Agrarian vs. Industrializing Horticultural Societies

René Dubos, the noted biologist, once wrote, "The past is not dead history; it is the living material out of which man makes the present and builds the future." This statement captures a fundamental insight of all evolutionary theories: *change is a cumulative process in which earlier developments influence the course of later developments*. This is as true of human societies as it is of the other populations that share the planet with us. To attempt to understand processes of change without taking into account the varying heritages of the entities involved is to invite trouble, or so ecological–evolutionary theory would lead one to believe.

Applying this principle to the study of the developmental trajectories of Third World nations in the modern era, ecological–evolutionary theorists have argued for the need to differentiate societies that started in the premodern era from an agrarian base and those that started from a horticultural base. Those societies that have not yet fully industrialized are referred to as "industrializing agrarian" and "industrializing horticultural" societies (Lenski, chap. 15). The former are societies whose members traditionally practiced plow agriculture, the latter, societies whose members traditionally practiced hoe and/or digging-stick horticulture.

For most highly urbanized sociologists, such a distinction may seem both arcane and unimportant. In fact, however, it is neither. The invention of the plow was an important development in farming and had many revolutionary social consequences (Childe). It enabled humans to harness the energy of animals to the work of food production; it enabled them to control, for the first time, the spread of weeds; and it enabled them to restore the fertility of soils by bringing within reach of the root systems of cultivated plants the nutrients that tend to sink beyond their reach, especially in semi-arid regions. All that meant larger crops, an expanding population, and under appropriate conditions, an expanding economic surplus. It also meant more permanent settlements, since fields could be kept permanently under cultivation (hence, the Latin, *agri cultura,* the cultivation of a field). No longer was cultivation limited to impermanent gardens, as in the practice of horticulture (*horti cultura,* the cultivation of a garden).

Looking to the preindustrial past, it is clear that the great majority of agrarian societies were substantially larger and more complex than most horticultural societies. The Incan Empire and the West African state of Songhay were probably the largest horticultural societies that ever existed and they had populations of no more than several million. In contrast, the Roman Empire, with its agrarian base, appears to have had a population of 70 million at one time and China reached a population of several hundred million before industrialization began to have any effect.

These differences in size are typical of the social and cultural differences between premodern horticultural and agrarian societies. Moreover, *many of these differences are highly relevant to the process of industrialization.* For example, urban communities (i.e., communities in which the majority of the inhabitants are freed from the necessity of producing their own foods and fibers) were widespread in agrarian societies, but were rare in horticultural ones. Linked with this, occupational specialization was far more complex and other forms of specialization (e.g., organizational, communal, regional) much more highly developed in agrarian societies. In addition, most agrarian societies had a literate minority from an early date, whereas this was rare in horticultural societies. Agrarian societies had standardized currencies; most horticultural societies did not. Agrarian societies had highly developed administrative bureaucracies with complex systems of record-keeping; horticultural societies did not.

One could easily extend this list, but it should already be clear that agrarian societies brought to the modern era many of the social and cultural resources that are essential if a society is to compete effectively in the world system and experience significant economic growth and development. In comparison, horticultural societies have been badly handicapped. Because of this, and because change is a cumulative process, ecological–evolutionary theory leads one to expect important, systematic, and predictable differences among Third World societies.

If ecological–evolutionary theory is correct, there should be substantial differences between industrializing agrarian and industrializing horticultural societies both with respect to their current characteristics and to their trajectories of development. As Figure 1 illustrates, industrializing agrarian societies were already much more developed by modern standards than were industrializing horticultural societies long before the onset of industrialization, and this difference should persist for some time after the beginnings of sustained contact with industrial societies. Ecological–evolutionary theory does not allow us to predict, however, whether the gap between the trajectories of the two sets of societies will increase, decrease, or simply persist, though there are reasons for expecting that *in the long run* (i.e., a century or more), the gap would decrease.

Translating the theory into testable propositions, ecological–evolutionary theory leads one to expect differences between industrializing agrarian and industrializing horticultural societies in (1) current levels of economic development, (2) literacy and information resources, (3) rates of economic growth, and (4) basic demographic patterns. Each of these subhypotheses will be tested with multiple indicators.

After that, we will see to what extent the two types of societies differ in terms of several key indicators of trade and economic dependency. One could infer from ecological–evolutionary theory that industrializing agrarian societies would be less dependent than industrializing horticultural societies, because of their greater technological and organizational resources, but that is not a strong inference and should not be considered a test of the larger theory.

Finally, we will compare the efficacy of the traditional subsistence technology variable with that of a measure of status in the world economy. In other words, we will compare the predictive power of the distinction between industrializing agrarian and industrializing horticultural societies with that of a network-derived distinction between semiperipheral and peripheral societies. This is *not* intended as a critical test and comparison

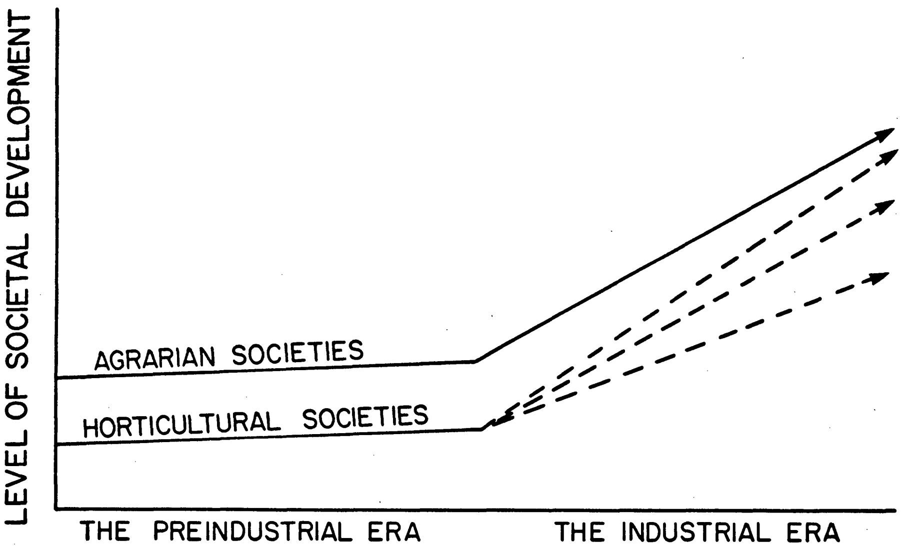

Figure 1. LEVELS AND TRAJECTORIES OF DEVELOPMENT OF INDUSTRIALIZING AGRARIAN AND INDUSTRIALIZING HORTICULTURAL SOCIETIES IN THE PREINDUSTRIAL AND INDUSTRIAL ERAS

of ecological–evolutionary with world system theory, since ecological–evolutionary theory readily acknowledges that the developmental trajectory of societies is influenced by external forces (e.g., the sociocultural environment) as well as internal forces. Rather, this comparison is designed to provide some idea of the *relative* strength of these two sets of forces, and also to indicate how much more of the variation among Third World nations can be explained by the addition of a second dimension. Certainly the argument that the techno-economic heritage of societies plays an important role in shaping current rates and directions of development in Third World nations would be strengthened if it could be demonstrated that it has significant effects *independent* of current position in the world system. Thus, this second stage of the analysis should be viewed more as a test of the power of ecological–evolutionary theory than as a test of world system theory. Following it, in the final stage of the analysis, we will discuss one alternative explanation of the findings and test for another.

Data and Methods

Fortunately, for purposes of analysis, Third World nations are relatively evenly divided between those which have a tradition of plow agriculture (N = 45) and those that have been dependent on horticulture (N = 32). In most cases, in fact, due to missing data for the dependent variables, the division is even closer to parity. The classification of individual societies is indicated in Appendix A. It will be noted that a small number of oil-exporting countries with agrarian traditions, such as Algeria, Iraq, and Venezuela, have been excluded from the analysis to avoid biasing the results in favor of the hypothesis. The smaller number of oil-exporting societies with horticultural traditions (e.g., Nigeria, Angola) have been retained. A number of other societies were excluded either because of their small size (e.g., Maldive Islands), lack of full political autonomy (e.g., Lesotho), or marginal status with respect to the independent variable (e.g., Ethiopia, Jordan, North Yemen). By excluding these cases, we believe we have provided a fairer and more rigorous test of the fundamental hypothesis. For our dependent variables, we have drawn data on a variety of indicators from three major data sets: (1) Taylor and Hudson, (2) *World Tables 1980*, compiled by the World Bank, and (3) Tsui and Bogue. Data sources and variables used are listed in each of the tables. We have also derived a measure of status in the world economy from Snyder and Kick.[1] The noncore blocks identified in their analysis were aggregated into semiperiphery and periphery statuses.

Dummy variable regression was used to test the hypotheses. Category means, the number of cases, the strength of the relationship, and the significance of differences are indicated in the tables.[2] And, in later stages of the analysis, zero-order and partial standardized regression coefficients were compared to determine the relative magnitudes and independence of the effects of status and heritage on the dependent variables. To make this possible, periphery and industrializing horticultural nations were coded 0 and semiperiphery and industrializing agrarian nations were coded 1.[3] The magnitudes of the standardized regression coefficients indicate the strength of the relationships, and the signs indicate the way in which semiperiphery and industrializing agrarian nations differ from periphery and industrializing horticultural nations on particular dimensions. The partial standardized regression coefficients are indications of how much *independent* impact status and heritage have on our dependent variables. In a final step, this method of analysis is applied to the subset of nations in the sample which achieved independence after 1940. This allows us to examine the effects of techno-economic heritage while simultaneously controlling for world system status and the political heritage of societies.

Before turning to our findings, we should note that our selection of societies for analysis stacks the cards against our hypothesis in another, even more important way. By excluding the fully industrial societies, we are excluding a set of societies that we know in advance have agrarian origins and differ dramatically from industrializing horticultural societies with respect to all of the dependent variables we will be examining. Thus, the tests we will make are in this regard even more rigorous and the results can be assumed to *underestimate substantially* the strength of the relationships actually involved.

Findings

According to the first subhypothesis, industrializing agrarian societies should differ significantly from industrializing horticultural societies in terms of a variety of indicators of level of technological and economic development. As Table 1 shows, this is, in fact, the case. Industrializing agrarian societies have greater population densities, larger proportions of their populations in large cities, greater GNPs per capita, greater rates of commercial energy consumption per capita, greater productivity (GNP and energy) per unit area, and higher proportions of their labor forces employed in industrial activity. With the exception of energy consumption per unit area, all the differences are significant at the .01 level and the amount of variation explained ranges from 11 to 36 percent.

Indicators of informational resources also reveal that industrializing horticultural societies are markedly behind their agrarian counterparts (see Table 2). Lower literacy rates, smaller secondary school enrollments, and fewer newspapers indicate substantial deficiencies at the most basic information processing levels. Furthermore, the total absence of scientific journals suggests even greater disparities at more advanced levels of information accumulation and dissemination. Taken together, they are evidence of sizeable differences in the basic informational infrastructure and in the potential for technological development and growth. Given the great importance that ecological–evolutionary theory attaches to the informational resources of societies, we should not be surprised to find comparable differences in economic growth rates.

Indeed, average annual rates of growth in GNP and GNP per capita parallel the differences in informational resources (see Table 3). One feature of our data that merits special attention is the unanticipated divergence in the trends in the two sets of societies. The rate of economic growth was *higher* in industrializing agrarian societies in the 1970s than in the 1960s (contrary to what world system/dependency theories might lead one to expect). In contrast, however, the rate of economic growth in industrializing horticultural societies was *lower* in the more recent decade than it was in 1960–70.

The reason or reasons for this are unclear and ecological–evolutionary theory cannot claim to have anticipated it. It is a serendipitous finding, but one that clearly merits closer study.[4] Various hypotheses suggest themselves. One possibility is that the differences reflect the lesser ability of industrializing horticultural societies to compete under more stringent

Table 1. LEVELS OF ECONOMIC AND TECHNOLOGICAL DEVELOPMENT

Indicator	Industrializing Agrarian	Industrializing Horticultural	Summary Statistics
Pop. density 1965 Mean 50.70	72.17 (45)	20.51 (32)	R^2=.140 P<.001
Pop. cities 100,000+ Mean 12.01	17.04 (45)	4.94 (32)	R^2=.264 P<.001
GNP/capita 1977 US $ Mean 636.15	798.16 (38)	408.15 (27)	R^2=.112 P<.006
ENC/capita 1965 Mean 299.88	443.47 (43)	106.94 (32)	R^2=.120 P<.002
ENC/area 1965 Mean 2.33	3.97 (43)	.13 (32)	R^2=.051 P<.051
GNP/area 1965 Mean 1084.1	1718.47 (45)	192.03 (32)	R^2=.118 P<.002
Pct LF indust 1977 Mean 15.55	19.84 (37)	9.43 (26)	R^2=.358 P<.001

(Number of Cases), Variables and Sources

Taylor and Hudson: Density, Population Per Square Kilometer 1965: V16; Percentage of Population Living in Cities of 100,000 or More 1965: V38; ENC/Capita 1965, Energy Consumption Per Capita in Kilograms Coal Equivalent: V157; ENC/Area 1965, Total Energy Consumption in Metric Ton Equivalents (V153), Divided by Total Area in Square Kilometers (V12): V153/V12*100; GNP/Area 1965, Total Gross National Product in Million U.S. Dollars (V165), Divided by Total Area in Square Kilometers (V12): V165/V12*100;

World Bank: Gross National Product Per Capita 1977 in U.S. Dollars: Series I Economic Data Sheet 1; Percent Labor Force in Industry 1977, Series IV, Table 5.

economic conditions of the kind that developed in the 1970s. Alternatively, this may reflect the increasing withdrawal from industrializing horticultural societies of the kinds of human capital represented by former colonial administrators and businesses (for reasons already indicated, their withdrawal would be less serious in industrializing agrarian societies). Whatever the reason, or reasons, differences in the techno-economic heritage of societies seem to be implicated.

One other feature of Table 3 that merits comment is the difference between the two types of societies with respect to the impact of population growth on per capita economic growth. In industrializing horticultural societies, especially during the 1970s, most of the benefits of eco-

Table 2. INFORMATIONAL RESOURCES

Indicator	Industrializing Agrarian	Horticultural	Summary Statistics
Literacy 1965 Mean 33.42	50.45 (34)	14.13 (30)	R^2=.452 P<.001
Adj schl enrl 1977 Mean 28.14	38.16 (38)	13.50 (26)	R^2=.307 P<.001
Newspapers/1,000 Mean 34.53	50.92 (38)	6.23 (22)	R^2=.186 P<.001
Scientific journals Mean 53.70	91.89 (45)	0.00 (32)	R^2=.113 P<.003

(Number of Cases), Variables and Sources

Taylor and Hudson: Literacy Rates 1965: V102; Newspapers Per 1,000 Population: V86; Scientific Journals, Total Number of Scientific and Technical Serials Published: V184;

World Bank: Adjusted Secondary School Enrollment Ratio 1977: Series IV, Table 4.

Table 3. ECONOMIC GROWTH RATES

Indicator	Industrializing Agrarian	Horticultural	Statistics
GNP growth rate 60-70 Mean 4.72	5.03 (37)	4.30 (27)	R^2=.032 P<.155
GNP/C growth rate 60-70 Mean 2.07	2.40 (37)	1.63 (27)	R^2=.050 P<.076
GNP growth rate 70-77 Mean 4.57	5.52 (37)	3.27 (27)	R^2=.201 P<.001
GNP/C growth rate 70-77 Mean 1.95	3.04 (37)	.45 (27)	R^2=.295 P<.001

(Number of Cases), Variables and Sources

World Bank: Average Annual GNP Growth Rate 1960-70, 70-77: Series I Data Sheet 1; GNP Per Capita Growth Rate 1960-70: (1+GNP GR 60-70/1+Pop GR 60-70)-1; GNP Per Capital Growth Rate 1970-77: 1-(1+GNP GR 70-77/1+Pop GR 70-77)-1; Pop GR, Average Annual Population Growth Rate: Series I Economic Data Sheet 1.

nomic growth were wiped out by population growth. During the 1970s, 86 percent of the benefits of economic growth were lost merely because of population growth. In contrast, only 45 percent of the gains of industrializing agrarian societies were lost in this way. As a result, the growth rate in GNP per capita in these societies was *nearly seven times greater* than in industrializing horticultural societies. Thus, it is clear that the ability of societies to control population growth is a critical intervening variable mediating an important aspect of the relationship between a society's techno-economic heritage and its pattern of economic growth and development.

The demographic patterns that underlie the differences in per capita economic growth rates are shown in Table 4. Fertility rates are significantly higher in industrializing horticultural societies than in industrializing agrarian societies and this is true even when age composition ef-

Table 4. DEMOGRAPHIC RATES

Indicator	Industrializing Agrarian	Industrializing Horticultural	Summary Statistics
Crude birth rate 1960 Mean 45.26	43.41 (43)	47.90 (30)	R^2=.148 P<.001
Crude birth rate 1977 Mean 39.97	34.89 (43)	47.26 (30)	R^2=.440 P<.001
Total fertility rate 1968 Mean 5.93	5.67 (45)	6.32 (30)	R^2=.123 P<.002
Total fertility rate 1975 Mean 5.49	5.11 (45)	6.06 (30)	R^2=.185 P<.001
Crude death rate 1960 Mean 20.16	16.22 (43)	25.79 (30)	R^2=.498 P<.001
Crude death rate 1977 Mean 14.26	10.80 (43)	19.22 (30)	R^2=.556 P<.001
Child mortality 1960 Mean 27.98	20.67 (43)	39.21 (28)	R^2=.537 P<.001
Child mortality 1977 Mean 17.03	10.86 (44)	26.38 (29)	R^2=.576 P<.001
Life expectancy 1977 Mean 54.08	59.75 (44)	45.77 (30)	R^2=.524 P<.001

(Number of Cases), Variables and Sources

World Bank: Crude Birth Rate 1960, 1977, Crude Death Rate 1960, 1977, Life Expectancy 1977: Series IV, Table 2; Child Mortality (ages 1-4) 1960, 1977: Series IV, Table 3.

Tsui and Bogue: Total Fertility Rate 1968, 1975 (Appendix A, Table 1).

fects are taken into account (see Total Fertility Rate). What is especially striking about Table 4 is the magnitude of most of the R^2 values.

As we inferred from Table 3, industrializing agrarian societies have been far more successful than industrializing horticultural societies in bringing fertility under control. In fact, in the horticultural societies in our sample, there was almost no decline in the crude birth rate during the nearly two decades from 1960 to 1977 and age-specific fertility declined only half as much as in industrializing agrarian societies. The implications of this for economic growth and development and for raising standards of living are difficult to exaggerate. Vast resources have been consumed in educating and otherwise supporting large populations of youthful dependents, many of whom cannot be employed productively when they reach adulthood. Moreover, with declining levels of infant and child mortality, more will survive to become adults.

Predicted differences are also present in a number of measures of trade dependency. Cross-sectional differences in proportion of GNP constituted by trade, diversity of export commodities, and diversity of trading partners indicate that industrializing horticultural societies were more dependent than industrializing agrarian societies, though the relationship with the last indicator failed to reach significance (see Table 5).

In Table 5, we again find evidence of a growing divergence between industrializing agrarian and industrializing horticultural societies. During the period from 1961 to 1977, the rate of commodity concentration dropped from 59 percent to 48 percent in the former, but rose from 63 to 68 percent in the latter. These trends were strong enough to transform statistically nonsignificant differences in the 1960s into a difference that was significant at the .001 level in 1977.

In seeking to explain this difference, one is reminded of world system and dependency theories and their assertions about the growing economic dependence of Third World societies in the world economy. Judging from the data on commodity concentration rates in these societies in the years from 1961 to 1977, it would appear that world system and dependency theories have greater relevance for industrializing horticultural than for industrializing agrarian societies. While some industrializing agrarian societies have undoubtedly experienced greater commodity concentration during this period, the majority clearly have not.

This brings us to our next question: To what extent are the effects of techno-economic heritage and world-economic status independent of one another? To answer this important question, we will compare the individual and joint effects of these factors on the dependent variables we have already examined. As noted in the introduction, both ecological–evolutionary and world system/dependency theories expect the current status position and pattern of economic and political interactions of societies to have effects on development. However, ecological–evolutionary

Table 5. TRADE DEPENDENCY

Indicator	Industrializing Agrarian	Industrializing Horticultural	Summary Statistics
Trade/GNP 1965 Mean 43.48	35.97 (35)	53.58 (26)	R^2=.099 P<.013
Concent exp comm 1965 Mean .33	.29 (35)	.38 (26)	R^2=.078 P<.029
Concent exp recvrs 1965 Mean .21	.19 (35)	.24 (26)	R^2=.058 P<.062
Commodity concent 1961 Mean 60.58	58.62 (38)	63.05 (30)	R^2=.009 P<.434
Commodity concent 1965 Mean 58.16	56.47 (38)	60.30 (30)	R^2=.007 P<.498
Commodity concent 1970 Mean 56.07	51.13 (38)	62.33 (30)	R^2=.055 P<.054
Commodity concent 1977 Mean 56.83	47.68 (38)	68.41 (30)	R^2=.177 P<.001

(Number of Cases), Variables and Sources

Taylor and Hudson: Total Trade as a Percentage of Gross National Product Circa 1965: V181; Concentration of Export Commodities 1965: V182; Concentration of Export Receiving Countries: V183;

World Bank: Commodity Concentration 1961, 1965, 1970, 1977: Series III, Table 8.

theory also predicts that techno-economic heritage will have additional effects on levels and trajectories of development. As comparison of columns 1 and 2 in Table 6 reveals, for those cases in which we have data on both, the zero-order effects of techno-economic heritage are usually stronger (24 out of 30 comparisons) than the effects of position in the world system. Furthermore, these generally stronger effects of techno-economic heritage, though somewhat reduced when the world system dummy is introduced, persist (compare column 3 with column 1). As might be expected from this pattern, cross-tabulation shows world system position and heritage to be only moderately associated (r = .31). Although almost all of the semiperiphery societies are industrializing agrarian (13 out of 14), the periphery is almost evenly divided between industrializing agrarian and industrializing horticultural societies (31 and 24, respectively).

More important for our purposes, the partial standardized regression coefficients (columns 3 and 4) clearly indicate that the effects of techno-economic heritage are not simply due to differential position in the

Table 6. ZERO-ORDER AND PARTIAL STANDARDIZED REGRESSION COEFFICIENTS OF DEPENDENT VARIABLES REGRESSED ON WORLD SYSTEM AND ECOLOGICAL EVOLUTIONARY DUMMY VARIABLES

Indicator		Zero-order EET	Zero-order WST	Partial EET	Partial WST	
		Economic and Technological Development				
Pop density	1965	.346**	.404***	.245*	.329**	N=69
Pop cities	100,000+	.485***	.343**	.419***	.215ns	N=69
GNP/capita	1977	.314*	.075ns	.324*	-.031ns	N=59
ENC/capita	1965	.348**	.143ns	.337**	.035ns	N=67
GNP/area	1965	.324**	.250*	.273*	.167ns	N=69
ENC/area	1965	.216ns	.129ns	.194ns	.067ns	N=67
Pct LF ind	1977	.568***	.262*	.540***	.086ns	N=59
		Informational Resources				
Literacy	1965	.657***	.445***	.571***	.243*	N=57
Adj sch enr	1977	.509***	.277*	.468***	.138ns	N=58
Newsp/1000	1965	.406**	.348**	.336**	.256*	N=55
Sci jrnls	1965	.321**	.271*	.262*	.191ns	N=69
		Economic Growth Rates				
GNP GR	60-70	.252ns	.201ns	.208ns	.132ns	N=58
GNP/C GR	60-70	.288*	.261*	.226ns	.185ns	N=58
GNP GR	70-77	.501***	.091ns	.530***	-.086ns	N=58
GNP/C GR	70-77	.585***	.164ns	.597***	-.036ns	N=58
		Demographic Rates				
CBR	1960	-.358**	-.405***	-.258*	-.325**	N=65
CBR	1977	-.633***	-.435***	-.552***	-.265**	N=65
TFR	1977a	-.513***	-.363**	-.444***	-.229*	N=66
CDR	1960	-.703***	-.403***	-.639***	-.205*	N=65
CDR	1977	-.742***	-.372***	-.693***	-.163ns	N=66
Chld mort	1960	-.722***	-.459***	-.641***	-.261**	N=65
Chld mort	1977	-.765***	-.430***	-.698***	-.214**	N=65
Life exp	1977	.707***	.381**	.652***	.184*	N=66
		Trade Dependency				
Trade/GNP	1965	-.311*	-.222ns	-.267ns	-.133ns	N=56
Com conc	1965	-.304*	-.342**	-.214ns	-.271*	N=56
Cnc ex r	1965	-.278*	-.357**	-.180ns	-.298*	N=56
Com cnc	1961	-.093ns	-.241ns	-.015ns	-.236ns	N=60
Com cnc	1965	-.105ns	-.192ns	-.047ns	-.177ns	N=60
Com cnc	1970	-.292*	-.259*	-.231ns	-.182ns	N=60
Com cnc	1977	-.445***	-.424***	-.342**	-.311*	N=60

[a] Interaction term is significant at .05: EET=.384**, WST=.452ns, Interaction=-.733* (Source: World Bank). Dummy Variable Codes: EET, Industrializing Horticulture=0, Industrializing Agrarian=1; WST, Periphery=0, Semiperiphery=1.

ns=nonsignificant
*significant .05
**significant .01
***significant .001

world system. In only five instances does a significant relationship with heritage drop below significance when the world system dummy is introduced, and four of these involve measures of trade dependency. On the other hand, in eight cases relationships with the world system measure are rendered nonsignificant by the introduction of the heritage dummy. However, lest we attribute undue importance to significance values, it should be noted that most of the regression coefficients for both variables retain the correct sign and considerable magnitude when the other factor is introduced. And only in the case of Total Fertility Rate does a significant interaction effect indicate non-additivity. Thus we conclude that in this analysis *we have not simply applied an ecological–evolutionary label to a world system difference*: the ecological–evolutionary hypothesis has clearly passed this additional test.[5] In fact, the generally stronger association of the dependent variables with heritage than status, and the observed relationship of heritage with dependency indicators, together with ecological–evolutionary theory's acknowledgment of the effects of sociocultural environment, makes the evidence for techno-economic heritage's importance and ecological–evolutionary theory even more convincing.

Alternative Explanations of the Findings

Before concluding that ecological–evolutionary theory is supported by the data analyzed in Tables 1–6, one other issue needs to be addressed. Skeptics will note that the distinction between industrializing horticultural societies and industrializing agrarian societies comes close to paralleling the distinction between sub-Saharan African societies and other Third World societies. This raises the possibility that while the differences we have identified are real, they may reflect the operation of mechanisms other than those specified by ecological–evolutionary theory. For example, they may reflect the influence of environmental factors or of differences in political heritage.

With respect to the first of these alternative explanations, we would note that far from contradicting ecological–evolutionary theory, it is quite consistent with it. As the label "ecological" suggests, this theory treats relations between societies and their environments as of the utmost importance.[6] Moreover, there is ample evidence that the "failure" of sub-Saharan societies to adopt plow agriculture was not a failure at all, but an unavoidable response to constraints imposed by the biophysical environment in the preindustrial era (Farmer; Meggers; Watters). As Farmer has noted, horticulture constitutes "an adaptation to tropical soil conditions under which continuous cultivation may be highly dangerous in the absence of advanced techniques for conserving soil and maintaining soil fertility" (203). He goes on to say that "it is significant in this connection, that

European settlers in Brazil have, in some areas, taken to [horticulture]." It might be added that even in the twentieth century, European colonists in most parts of sub-Saharan Africa found it difficult or impossible, even with the aid of modern industrial technology, to introduce plow agriculture, and what was difficult with the aid of modern technology would have been impossible without it. In addition, as William McNeill has shown, disease has historically been far more of a hindrance to societal development in Africa than elsewhere.

Hence, far from contradicting ecological–evolutionary theory or providing a basis for an alternative explanation of our findings, the close association of industrializing horticultural societies with sub-Saharan Africa provides support for another important aspect of the theory. Longstanding differences in the biophysical environment in various parts of the world provide the explanation of why horticultural societies in some parts of the world (e.g., Europe and Asia) successfully made the transition to plow agriculture in the premodern era, while those in Africa did not. Figure 2 specifies the links between the environmental factor, the horticultural–agrarian distinction, and the divergent developmental trajectories of modern Third World societies as hypothesized by ecological–evolutionary theory.

Before leaving this subject, it might be noted that the practice of horticulture survived into the twentieth century in other parts of the world besides sub-Saharan Africa. This is true of all of Papua New Guinea as well as various areas in southeast Asia and Latin America. In southeast Asia and Latin America, however, horticulture has coexisted with plow agriculture in modern nation-states in which plow agriculture displaced it centuries ago as the economically dominant form of farming at the national level.[7] In a future paper, we plan to examine these hybrid societies to determine whether they constitute a separate category within the Third World with a distinctive developmental trajectory of their own.

For the present, suffice it to note that Papua New Guinea, the one non-African nation in our industrializing horticultural category, provides substantial support for the thesis that horticulture—not Africa—is the critical variable responsible for the pattern we have found. On 15 of the 25 variables for which data were available, Papua New Guinea more closely approximated the means for industrializing horticultural societies shown in Tables 1–5 than the means for industrializing agrarian societies (see Appendix B). More importantly, when redundant and repetitive measures are eliminated (i.e., when three of the four fertility measures are eliminated), Papua New Guinea conforms to the industrializing horticultural profile on 8 of 11 variables, with one variable (fertility) yielding mixed results.

The most striking fact concerning Papua New Guinea, however, is that its developmental trajectory in the last twenty years has been the

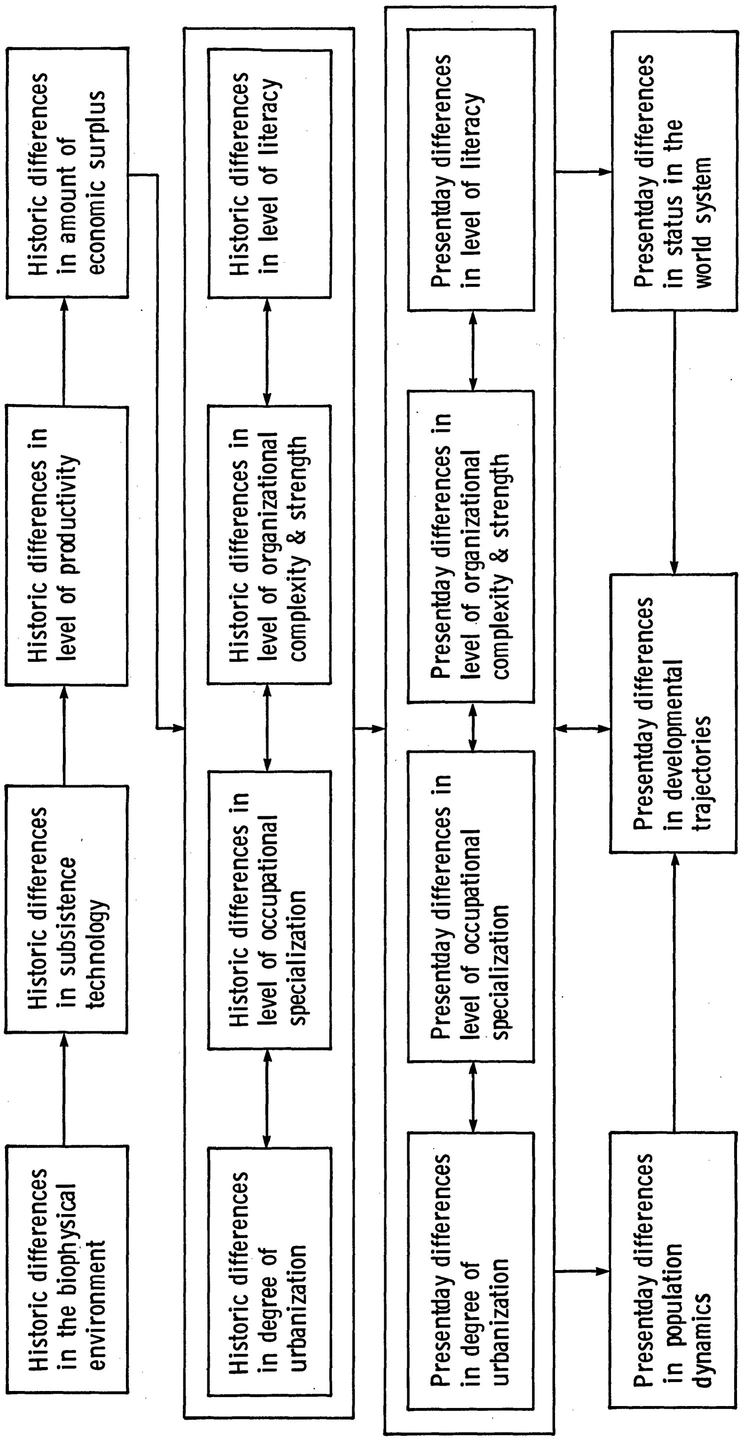

Figure 2. AN ECOLOGICAL-EVOLUTIONARY MODEL TO EXPLAIN DIFFERENCES BETWEEN INDUSTRIALIZING HORTICULTURAL AND INDUSTRIALIZING AGRARIAN SOCIETIES IN THE CONTEMPORARY WORLD

trajectory of an industrializing horticultural society, not an industrializing agrarian society. For example, its GNP growth rate declined from the 1960s to the 1970s, as did its per capita GNP growth rate. On the other hand, its crude birth rate and total fertility rate hardly declined at all, and its level of export commodity concentration followed a curvilinear path. In short, all of these important trends are what one would expect of an industrializing horticultural society. While too much should not be made of a single case, the evidence from Papua New Guinea contradicts the thesis that Africa, rather than a horticultural heritage, is the explanation for the differences shown earlier in Tables 1–5.

It should also be noted that merely to invoke the African locale of most industrializing horticultural societies *explains nothing*. The real question is: What is it about Africa that produces the patterns we have found? The value of ecological–evolutionary theory, in our opinion, is that it provides an explanation grounded in a much more general theory and is not simply an *ad hoc* explanation contrived to account for a single set of findings. The explanation may be incorrect, but it is an explanation grounded in a general theory: merely to invoke the Africa/non-Africa distinction is not.

Another alternative that has been suggested is that our findings reflect differences in the *political heritage* of regions occupied by horticultural societies as contrasted with those occupied by agrarian societies, with the former coming under European colonial control more often than the latter. Once again, it should be noted that this does not contradict ecological–evolutionary theory, but it is only what should be expected in view of the far greater development of the state in the preindustrial era in agrarian societies (hence, their greater ability to resist European colonialism). Nevertheless, it is possible that the period of colonial control further retarded the development of horticultural societies.

To test this possibility, we selected those nations in our sample that achieved independence after 1940 and replicated the analysis. This date was chosen because most former colonies have only gained independence since World War II. Thus, comparisons based on this criterion are essentially comparisons among a set of nations, all of which were once colonies. This selection procedure eliminated only one case from the industrializing horticultural category, but it eliminated more than half of the industrializing agrarian cases.

To avoid undue repetitiousness, most of the information from this reanalysis is summarized in Table 7, which parallels Table 6. In this table, the first column indicates the effects of techno-economic heritage controlling for political heritage, and the third column indicates the effects of techno-economic heritage controlling for both political heritage and current status in the world system. The magnitudes of the standardized regression coefficients in both of these columns are generally greater than

Table 7. ZERO-ORDER AND PARTIAL STANDARDIZED REGRESSION COEFFICIENTS OF DEPENDENT VARIABLES REGRESSED ON WORLD SYSTEM AND ECOLOGICAL EVOLUTIONARY DUMMY VARIABLES FOR NATIONS INDEPENDENT AFTER 1940

Indicator		Zero-order		Partial		
		EET	WST	EET and	WST	
		Economic and Technological Development				
Pop density	1965	.574***	.556***	.398**	.363**	N=44
Pop cities	100,000+	.507***	.334*	.451**	.115ns	N=44
GNP/capita	1977	.235ns	-.037ns	.391ns	-.267ns	N=35
ENC/capita	1965	.357*	.062ns	.452*	-.179ns	N=42
GNP/area	1965	.477**	.301*	.432**	.092ns	N=44
ENC/area	1965	.363*	.137ns	.404*	-.078ns	N=42
Pct LF ind	1977	.676***	.277ns	.783***	-.183ns	N=35
		Informational Resources				
Literacy	1965	.741***	.551***	.624***	.222ns	N=41
Adj sch enr	1977	.625***	.296ns	.632***	-.014ns	N=35
Newsp/1000	1965	.583***	.377*	.523**	.121ns	N=35
Sci jrnls	1965	.356*	.463**	.172ns	.380*	N=44
		Economic Growth Rates				
GNP GR	60-70	.328ns	.403*	.138ns	.322ns	N=35
GNP/C GR	60-70	.387*	.375*	.255ns	.225ns	N=35
GNP GR	70-77	.520**	.316ns	.510**	.016ns	N=35
GNP/C GR	70-77	.621***	.325ns	.656***	-.060ns	N=35
		Demographic Rates				
CBR	1960	-.500***	-.322*	-.457**	-.083ns	N=40
CBR	1977	-.733***	-.497**	-.651***	-.157ns	N=40
TFR	1977a	-.615***	-.391*	-.559***	-.113ns	N=41
CDR	1960	-.771***	-.552***	-.663***	-.206ns	N=40
CDR	1977	-.762***	-.605***	-.614***	-.284*	N=40
Chld mort	1960	-.817***	-.630***	-.671***	-.279**	N=40
Chld mort	1977	-.801***	-.632***	-.647***	-.294**	N=40
Life exp	1977	.736***	.534***	.626***	.223ns	N=41
		Trade Dependency				
Trade/GNP	1965	-.176ns	-.227ns	-.079ns	-.186ns	N=37
Com conc	1965	-.197ns	-.361*	-.011ns	-.355ns	N=37
Cnc ex r	1965	-.490**	-.348*	-.424*	-.127ns	N=37
Com cnc	1961	-.249ns	-.177ns	-.222ns	-.046ns	N=36
Com cnc	1965	-.218ns	-.168ns	-.182ns	-.060ns	N=36
Com cnc	1970	-.396*	-.287ns	-.348ns	-.081ns	N=36
Com cnc	1977	-.449**	-.442**	-.288ns	-.272ns	N=36

[a]Source: World Bank
Date of Independence: Taylor and Hudson: V300 (from anks)
Dummy Variable Codes: EET, Industrializing Horticulture=0, Industrializing Agrarian=1; WST, Periphery=0, Semiperiphery=1.

ns=nonsignificant; *significant .05; **significant .01; ***significant .001.

they were in Table 6 (significance values are, of course, affected by the reduction in sample size), and the patterns of relationship are virtually the same. It appears, therefore, that rather than diminishing or disappearing, the associations of our dependent variables with techno-economic heritage are even stronger when this important feature of political heritage is controlled.[8]

Conclusions

In this paper we have sought to test a set of interrelated hypotheses derived from ecological–evolutionary theory. These hypotheses are based on the premise that the techno-economic heritage of the distant past (i.e., the preindustrial era) affects the level of development of industrializing societies today and also their trajectories of development. Specifically, industrializing horticultural societies were predicted to have: (1) lower levels of technological and economic development, (2) more limited informational resources, (3) lower rates of economic growth, (4) less favorable demographic patterns, and perhaps also (5) greater tendencies toward trade dependency than their industrializing agrarian counterparts. Each of these hypotheses was confirmed with multiple indicators. In addition, it was shown that the effects attributed to techno-economic heritage are not merely the result of current status in the world economy. The internal/historical experience of societies appears to have strong, independent effects on development.

These findings contradict the view (implicit in the widespread use, *without qualification,* of such terms as "the Third World," "the LDCs," and "the periphery") that industrializing societies are a homogeneous group except for secondary characteristics and developmentally unimportant idiosyncratic differences. This view ignores an important cleavage within the Third World that profoundly affects both the level of development of societies and their prospects for development.

Before concluding our analysis, we considered two alternative explanations of our findings. In one case, we were able to show that the introduction of a control for differences in political heritage did not eliminate, or weaken, basic relationships; if anything, they were strengthened. In the other case, we concluded that the strong association between the practice of horticulture and the sub-Saharan region neither contradicts ecological–evolutionary theory nor provides a more satisfactory explanation. The persistence of horticulture south of the Sahara, long after its displacement by plow agriculture in neighboring areas from which diffusion could easily have occurred, is best explained, according to agricultural experts, as a response to environmental constraints. In summary, the data support a three-stage ecological–evolutionary model in which (1) historic differences in the biophysical environment gave rise to historic differences in subsistence technology, which (2) caused differences in the social and economic development of societies in the premodern era, which (3) caused similar or parallel social and economic differences in the latter half of the twentieth century.

Additional research will be necessary to test all of the implications of this model, but clear and compelling evidence has been offered here of its importance and utility in accounting for significant variations in current levels and rates of development in the Third World. Moreover, several lines of evidence suggest that its importance is *increasing* rather than declining, as one might have expected of a variable reflecting conditions of the distant past. Thus, Dubos' assertion that the past is not dead history, but living material out of which people make the present and build the future, finds striking confirmation in the developmental trajectories of Third World societies.

Notes

1. Questions and doubts have been raised concerning Snyder and Kick's identification of statuses in the world system. Bollen's analysis suggests that six nations may have been misclassified (too high). However, only one of these, Taiwan, falls into one of our industrializing categories, and therefore, this problem is minimal for our analysis. A second, more fundamental criticism concerns the variables Snyder and Kick used to blockmodel. Nemeth and Smith argue that world system and dependency theories emphasize *economic* relations—particularly trade relations—and that Snyder and Kick erred by including treaties, diplomatic exchanges, and military interventions. In their own blockmodel analysis, Nemeth and Smith concentrate exclusively on trade relations. Rankings from the two analyses are substantially, but not highly, correlated, and the correlations are weakest for the noncore industrializing nations examined here ($rho = .72$, $p = .001$, $n = 80$ for all common cases; $rho = .58$, $p = .001$, $n = 69$ when the Nemeth/Snyder "core" is excluded; $rho = .39$, $p = .001$, $n = 62$ when the Snyder/Kick "core" is excluded). To take this more serious criticism into account, we replicated our analyses using the Snyder/Kick blocks with the Nemeth/Smith blocks.
2. Significance levels in this analysis do not indicate the generalizability to a population of the differences observed, since the data are not a probability sample. They are more nearly a population. As Blalock (241–3) notes, however, in such cases significance values indicate the probability that observed category differences could be the result of random assignment of cases to categories, and, therefore, indicate the likelihood that observed relationships are due to chance.
3. Industrial (core) nations were excluded and the individual blocks were aggregated into semiperiphery and periphery statuses according to Snyder and Kick's discussion (1110–6). For a listing of nations in the statuses, see Snyder and Kick or Nolan (a, b).
4. It is also interesting to note the fact that the impacts of techno-economic heritage and world system status vary in these two time periods. World system status and techno-economic heritage have impacts of similar magnitude on per capita economic growth rates in 1960–70, but quite different impacts in 1970–77. As Tables 6 and 7 show, in 1960–70 the zero-order effects for world system status are each significant, but the partials, though in the appropriate direction, are non-significant. For 1970–77 per capita economic growth rates, the impact of techno-economic heritage is much greater than that of world system status. As

Tables 6 and 7 reveal, only the zero-order coefficients for techno-economic heritage are significant, and when both are entered as predictors the partial coefficients for techno-economic heritage increase while those of world system status almost vanish. A very similar pattern was found in analysis using the Nemeth/Smith blocks, so this is not an idiosyncrasy of the Snyder/Kick measure of world system status. There appears to be a real strengthening of the impact of techno-economic heritage in the more recent period.
5. Reanalysis with Nemeth and Smith's blocks strengthens, rather than weakens, the effects of the ecological–evolutionary dummy variable. With the exception of the trade dependency measures, the Nemeth/Smith blocks generally have weaker relationships with the dependent variables. Further, where the Nemeth/Smith blocks have greater associations, they do not diminish the effects of the ecological–evolutionary dummy any more than Snyder and Kick's blocks do. This is the case even when the "optimum" blocks are used. In other words, as suggested by their original analysis, the greatest contrasts are produced when the "strong" semiperiphery is contrasted with the combined "weak" semiperiphery and periphery blocks. Given the fact that Nemeth and Smith classified fewer cases, and their blocks appear to have weaker effects, we have chosen to present the results using the Snyder and Kick blocks in the tables. Results of the analysis with Nemeth/Smith blocks are available from the authors.
6. It might be noted that the concept of "environment," as used in ecological–evolutionary theory, includes *both* the biophysical *and* the sociocultural—which is why we said previously that ecological–evolutionary theory shares with world system theory the expectation that the current pattern of economic and political interaction of societies and their relative status in the world system will have effects on development.
7. In southeast Asia and Latin America, horticulture has generally survived in hill country and in other regions unsuited to plow cultivation, and is practiced by subsistence farmers. Farmers in the lowlands, who produce for markets, generally practice plow agriculture.
8. Reanalysis with the Nemeth/Smith blocks provides additional support for the effects of the ecological–evolutionary dummy; the results are almost the same as those in Table 7.

Appendix A. Cases in the Analysis

INDUSTRIALIZING AGRARIAN MAXIMUM N = 45

Haiti, Dominican Republic, Jamaica, Trinidad and Tobago, Mexico, Guatemala, Honduras, El Salvador, Nicaragua, Costa Rica, Panama, Colombia, Guyana, Ecuador, Peru, Brazil, Bolivia, Paraguay, Chile, Argentina, Uruguay, Morocco, Tunisia, Turkey, Egypt, Syria, Lebanon, Afghanistan, China, Taiwan, North Korea, South Korea, India, Pakistan, Burma, Ceylon (Sri Lanka), Nepal, Thailand, Cambodia, Laos, North Vietnam, South Vietnam, Malaysia, Philippines, Indonesia.

INDUSTRIALIZING HORTICULTURAL MAXIMUM N = 32

Mali, Senegal, Dahomey, Mauritania, Niger, Ivory Coast, Guinea, Upper Volta, Liberia, Sierra Leone, Ghana, Togo, Cameroon, Nigeria, Gabon, Central African Republic, Chad, Congo People's Republic, Zaire, Uganda, Kenya, Tanzania, Burundi, Rwanda, Somalia, Angola, Mozambique, Zambia, Rhodesia (Zimbabwe), Malawi, Malagasy Republic, Papua New Guinea.

(Note: cases are listed within categories according to their RSS country code, see Taylor and Hudson, 1–2.)

Appendix B. VALUES FOR PAPUA NEW GUINEA (COMPARE WITH TABLES 1 TO 5)

1.	Population density, 1965	4.7
2.	Population in cities of 100,000+	0
3.	GNP/capita, 1977	$510
4.	Energy consumption/capita, 1965	74
5.	Energy consumption/area, 1965	0.35
6.	GNP/area, 1965	$18
7.	Adjusted school enrollment, 1977	12.9
8.	Scientific journals	0
9.	GNP growth rate, 1960-70	6.5
10.	GNP/capita growth rate, 1960-70	4.1
11.	GNP growth rate, 1970-77	5.0
12.	GNP/capita growth rate, 1970-77	2.5
13.	Crude birth rate, 1960	44
14.	Crude birth rate, 1977	42
15.	Total fertility rate, 1968	5.86
16.	Total fertility rate, 1975	5.82
17.	Crude death rate, 1960	23
18.	Crude death rate, 1977	17
19.	Child mortality, 1960	32
20.	Child mortality, 1977	19
21.	Life expectancy, 1977	47.7
22.	Export commodity concentration, 1961	56.9
23.	Export commodity concentration, 1965	50.8
24.	Export commodity concentration, 1970	53.4
25.	Export commodity concentration, 1977	55.7

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