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THE POLITICAL ECONOMY OF INVESTMENT
IN HUMAN CAPITAL

by

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INTRODUCTION

The recent political history of Latin America has been characterized by frequent violent upheavals. From 1963 to 1979 coups have occurred in Argentina, Bolivia, Brazil, Chile, the Dominican Republic, Ecuador, Panama, Peru, Uruguay, and Nicaragua. There has also been a marked increase in both left and right wing violence throughout the continent. The most recent examples are El Salvador and Guatemala.

These political developments have called into question the hypothesis of modernization theory, that economic development and social modernization promote equality, stability, and democracy (Huntington, 1965; Bendix, 1967; and Tipps, 1973). A set of new theories have been proposed to suggest why the interactions among patterns of economic, social, and political change have not consistently led to democracy but appear rather to have resulted in a new pattern of political change--the emergence of bureaucratic authoritarianism (Collier, 1979). Hirschman (1979) argues that the relative speed of modernization generated by the first phase of import substitution in consumer goods industries led to unrealistic expectations concerning improvements in living standards and possibilities for economic reform. The exhaustion of opportunities for import substitution in consumer goods industries, and the consequent slowdown in growth, led to bitterly disappointed political expectations, which in turn created the ideological climate for the emergence of bureaucratic-authoritarianism.

The patterns of political and economic change in Latin America and elsewhere, which have been associated not only with political instability but with a sharpening of economic inequalities in the Third World (Adelman and Morris, 1973; Chenery, et al., 1974), have led to a reassessment of strategies for economic development and social modernization as well. A search for alternative, less unequalizing models of economic development has ensued (Adelman, 1973 and 1980; Adelman and Robinson, 1978; Chenery, et al., 1974; various World Development Reports). In particular, modernization through investments in education has come under increasing attack as a source of social and political imbalance (Adams, 1977; Dore, 1976; Bhagwati, 1973) and also as a source of inequality in the distribution of income and wealth (Bowles and Gintis, 1976; and Carnoy, 1974).

This paper examines the relationships between education, equity, and political stability through the use of catastrophe theory. Catastrophe theory is especially useful here because it is a mathematical framework appropriate for characterizing zones in which abrupt policy shifts are likely to occur and for distinguishing these from zones in which either gradual shifts or no shifts are probable. The socioeconomic determinants of instability are discussed in section 1. Section 2 presents the central concepts of catastrophe theory. The model is defined in section 3 and empirical data are examined in section 4. Section 5 presents some tentative results.

1. The socioeconomic determinants of abrupt changes in national economic ideology

The focus in this paper is on the economic and social conditions

under which abrupt major shifts in the goals of national economic policy are likely to occur. This is an interesting question to an economist, because in many developing countries, the pursuit of strategies leading to equitable economic growth requires such shifts in goals. (For a discussion of this see Adelman, 1973, 1974, and 1980.) The particular major tradeoffs we will consider in this paper are those between emphasis on accelerating economic growth, and increasing the equity of that growth.

The political processes which culminate in abrupt shifts in national economic policy objectives may or may not be violent, and they may or may not be associated with marked increases in prior political instability in the form of coups, demonstrations, major strikes, guerilla warfare, or even revolution. Certainly, the replacement of political leaderships by violent means is likely to be associated with abrupt shifts in economic policy orientation. But such abrupt shifts may also take place without a coup or revolution, in a successful or unsuccessful attempt to forestall the emergence of internal violence. While our concerns in this paper are therefore related to those political scientists writing on internal war (Eisenstadt, 1978; and Feierabend and Feierabend, 1972), they are not identical to theirs.

A simplified stylized model which specifies endogenously some of the conditions under which such abrupt shifts in national economic ideology are likely will be formulated below. The model will describe how the probability of shifts between primary emphasis on growth and primary emphasis on distribution varies as a function of socioeconomic

conditions. Since such shifts involve major changes in the socio-political complexion of government, they are likely to be abrupt. The kind of modeling framework required is therefore one which is capable of portraying at least one discontinuity. Since such shifts are not once-and-for-all shifts, but, in many countries, involve a sequence of shifts in one direction followed by a backlash and a subsequent policy reversal, the mathematical framework used must be capable of exhibiting more than one discontinuity. For this reason, the technique of catastrophe theory seems especially appropriate for delineating critical zones in our model.

The major hypothesis of the analysis is that abrupt shifts in economic policy orientation occur primarily as the culmination of a process of conflict over policy objectives. Such conflicts are precipitated by the emergence of widespread discontent within one or more cohesive socioeconomic groups. Dissatisfaction over the impact of economic policy arises either as a result of an actual deterioration in the absolute or relative economic or social position of the disaffected, or, more likely, as a consequence of disappointed expectations.

At first, the dissatisfaction may be latent. But at some point, it will get channeled into overt expressions of discontent with the current lines of economic policy and clamor for change in economic priorities. If, at this point, there is insufficient accommodation in actual policies and/or insufficient change in actual policy outcomes, the politically active population will become polarized into two major groups: a group consisting of the factions supporting

continuation of the current line, perhaps with some marginal adaptations, and another group comprising the factions wanting more fundamental change. Each side may attempt a mix of persuasion and intimidation, through "political awakening" campaigns and/or through various forms and degrees of internal violence. Alliances between internal factions and foreign interests and foreign powers may also form at this stage. The result will be greater polarization and radicalization. Two alternative outcomes now become possible: either a radical shift in policy emphasis will take place, or substantial repression will be used to postpone (perhaps indefinitely) the day of major change in policy priorities.

The stylized story sketched above implies that the zone of potential policy instability is characterized by a polarization in the preferences of the population concerning desirable policy objectives. To endogenize an explanation of major shifts in policy priorities therefore requires specifying the socioeconomic conditions which give rise to a polarized society. One theory of political and economic change suitable for this purpose is Galtung's (1980) concept of "rank disequilibrium" as a precursor of social change.

In Galtung's theory, groups or classes are ranked on three scales representing economic, political, and social status. A group's relative status or rank may be the same on all three scales or it may differ from one scale to another. A group which does not have the same rank on all three scales is in "rank disequilibrium." According to the theory, individuals in rank disequilibrium will attempt to achieve rank equilibrium and in the process will become agents of

change in economic and/or political spheres. This framework finds two notable precedents in earlier literature: first, Schumpeter's account of the origins of the entrepreneur can be viewed as a subset of Galtung's theory, and, second, political theories of the marginal disaffected are closely akin to Galtung's discussion of the causes of political activism.

Galtung's concept of "rank disequilibrium" thus provides the link needed to operationalize our model. First, it is part of the explanation for the emergence of polarized societies and political unrest. Second, it is highly suggestive of appropriate variables to be considered when modeling polarized societies. In particular, we argue that "rank disequilibrium" is likely to be prevalent when levels of education are high and the distribution of income is inequitable. Such disequilibrium is then likely to exist for large numbers of groups in the society because the unequal distribution of income implies that access to economic opportunities is likely to be quite restricted. Under such circumstances, a large proportion of the educated (and therefore potentially politically participant) is likely to have higher social status than economic status. The educated who are socially and politically participant but economically marginalized will prefer a change in development strategy, while those who rank uniformly high on all three scales will prefer continuation of the present strategies.

In the above case significant conflict over appropriate development strategy is likely. The zone of polarization and of significant rank disequilibrium is therefore likely to include countries

characterized by moderate to high education levels and by concentrated income distributions. On the other hand, neither countries with high education and good income distribution, nor countries with very limited education are likely to be characterized by significant degrees of rank disequilibrium. At low educational levels, even if the distribution of income is poor, the educated elites will be well rewarded economically, socially, and politically. Similarly, in countries with high levels of education and with equitable distributions of income there should exist sufficient economic opportunities to enable the growing number of educated to be participant in all ways. The result is that nations characterized by either of these sets of circumstances should have only localized grievances with no major conflict over general policy orientation.

2. Technique of analysis

In this section only those concepts of catastrophe theory specifically required to construct our model will be introduced. For more comprehensive discussions of the technique, the reader is referred to several books: Woodcock and Davis (1978), written at an introductory level; Poston and Stewart (1978), written at an intermediate level; Zeeman (1977), written at an advanced level; and, of course, the original text by Thom (1975), which is best described as a philosophical discourse. Catastrophe theory is a very recent and controversial extension of calculus. For a discussion of the controversy surrounding its use see Zahler and Sussman (1977), Woodcock and Davis (1978), and Poston and Stewart (1978).

The theoretical constructs of catastrophe theory depend extensively on the use of differential geometry and topology. The principal insight underlying catastrophe theory is that the behavior of discontinuous relations and unstable equilibria can be understood by looking at one of a small number of polynomial forms that are themselves continuous. Thom originally identified seven polynomials for this purpose. In our application, we will first hypothesize the existence of a particular polynomial or catastrophe manifold that is consistent with current theories of economic and political change and will then empirically test its existence.

The general type of problem addressed by catastrophe theory is that of determining the characteristics of the set of solutions to an optimization problem. The graph of all solutions for all possible values of the coefficients of the function being optimized is known as the catastrophe manifold. What is of interest is not that the solution values change with the values of the coefficient of the functions optimized but rather that the number of solutions and the stability of the solutions can change. For example, for certain values of the coefficients there may exist two stable local maxima while for other values there may exist only one.

Two examples of catastrophe manifolds, the fold and the cusp, are presented below. The fold catastrophe is discussed because it is the simplest of the catastrophe manifolds and hence the best to use for pedagogical purposes. The cusp is discussed because it is the catastrophe manifold considered in this paper. Equation (1) represents a typical fold catastrophe:

$$(1) \quad F(x,a) = F_a(x) = \frac{1}{3} x^3 - ax,$$

where x is a variable representing the state space and a is a coefficient representing the control or environment space. Note that in equation (1) the coefficient a is also variable.

The corresponding catastrophe manifold is the set of all values of x that correspond to extreme points of $F(x,a)$. These satisfy the equation:

$$(2) \quad f(x,a) = x^2 - a = 0.$$

The graph of the catastrophe manifold specified in equation (2), the family of such functions, and the catastrophe map are displayed in Figure 1. The state space, X , in this case is represented by the vertical axis, and the control space, A , by the horizontal axis.

The catastrophe manifold is a parabola in X which shows that, corresponding to different values of a , there exist two critical points--one a maximum and one a minimum. When the control, a , is zero, the critical point is $x = 0$. This is a degenerate critical point because the second derivative is zero. If $a < 0$, then x^2 has no extreme points in the real plane. If $a > 0$, then we have $a = x^2$ and there are two symmetric values of x which satisfy the equation, namely $x = \pm \sqrt{a}$. When $x < 0$, $F_a(x)$ reaches a maximum because the second derivative of $F_a(x)$ is negative; and when $x > 0$, $F_a(x)$ corresponds to a minimum because the second derivative is positive. The family of functions graphs in Figure 1 demonstrate how the underlying function changes as the value of the parameter changes.

FIGURE 1
FOLD CATASTROPHE

FAMILY OF FUNCTIONS

CATASTROPHE MANIFOLD

CATASTROPHE MAP

The projection of the catastrophe manifold, $f(x,a)$ onto the control space A is known as the catastrophe map. Lines on the catastrophe map trace out the values of the control variable that correspond to the bifurcation set B . In the fold example above, the bifurcation set is the single critical point $X = 0$. This point separates the regions of A in which the catastrophe manifold does and does not exist. Such bifurcation sets are of special interest because they mark the boundaries in the control space between areas in which multiple solutions exist and those in which single or no solutions exist.

To discuss the dynamics of the fold catastrophe one must specify the nature of the optimization problem. In the case of a minimization of $F_a(x)$ all local maxima are unstable. For example, a point in the lower portion of the parabola in Figure 1 is unstable, and thus a small disturbance would result in a catastrophic leap from one extreme point to the other.

A second example, the cusp catastrophe, can accommodate two control or environmental factors and is the one chosen for use in our model. The family of functions describing the cusp catastrophe can be represented by

$$(3) \quad F(x,a,b) = F_{a,b}(x) = \frac{1}{4} x^4 - \frac{1}{2} bx^2 - ax$$

where x is a variable in the state space and a and b define the control or environment space.

The corresponding catastrophe manifold is:

$$(4) \quad f(a,b,x) = x^3 - bx - a.$$

Typical graphs of the cusp catastrophe manifold, family of functions, and catastrophe map are displayed in Figure 2. The intersection of the a and b axes is the origin. Possible functional forms are displayed adjacent to corresponding regions on the catastrophe map.

Differentiating equation (4) leaves $3x^2 - b$ which is the second derivative. When $b > 0$ and the absolute value of x is large relative to b then $3x^2 - b > 0$ and a given extreme point is a minimum. When $b > 0$ and the absolute value of x is small relative to b then $3x^2 - b < 0$ and a given extreme point is a maximum. When $b < 0$ then $3x^2 - b$ is always positive and all extreme points are minima. Therefore one finds that the upper and lower sheets of the manifold correspond to minima. Maxima exist only when the manifold is multisheeted; these correspond to extreme points close to the origin.

A wider range of possibilities makes the dynamics of the cusp catastrophe considerably more interesting than those of the fold. As in the earlier case, minimizing $F_{a,b}(x)$ will result in unstable maxima; for such points, the smallest perturbation would cause a leap to either the lower or upper surface. Movement in singlesheeted areas would always be smooth. Movement along the upper sheet will lead to a catastrophic leap if the bifurcation set is crossed as shown in Figure 2.

Under the simplest of dynamic rules abrupt changes in system state are only likely for points in the bifurcation set, B . For more complex dynamic rules abrupt change in system state are also possible anywhere the catastrophe manifold is multisheeted, or where multiple roots exist.

FIGURE 2 CUSP CATASTROPHE
CATASTROPHE MANIFOLD

3. The Model

In the discussion which follows, a model of the socioeconomic determinants of political instability is generated by applying the mathematical technique of catastrophe theory to the variables discussed in section 1. In this model a country at a single point in time is represented by a point in four-dimensional space; the four dimensions are:

1. level of education
2. degree of equality in the distribution of income
3. rate of economic growth
4. extent to which the pattern of economic growth is redistributive

The first two variables, education and income equality, identify the environment or control space while the latter two, rate of growth and redistributive emphasis, have been selected to characterize the economic strategy chosen in the policy space.

Since it is difficult to measure the redistributive orientation of a development strategy directly, we will need a proxy for this dimension. In selecting a proxy variable, we note that, depending on the nature of previous accumulation policies (Belassa, 1979), a tradeoff may arise between a pattern of production that is optimal from a growth maximizing perspective and one that is optimal from a distribution oriented perspective. In particular, if previous accumulation policies have stressed physical capital, the growth maximizing strategy will be capital intensive. The adoption of such a strategy will deteriorate distribution. If, on the other hand, previous

accumulation policies have emphasised investment in human resources, a labor intensive orientation will be consistent with a growth maximizing strategy. Such a strategy will not be inconsistent with an improvement in equity as well. Based on this line of reasoning, we have chosen the overall labor intensity of the economy as a proxy for the degree to which an economic growth strategy is redistributive. Such an identification between the poverty orientation of a project and its labor intensiveness is also used in the design of poverty oriented projects by the World Bank.

Linking the environment and policy spaces is the structure of policy preferences of those members of the society who are able to articulate their preferences. It will be assumed that, for each point in the environment space, there exists a frequency function representing the relative preferences for growth and equity of those individuals who are potential participants in the political process. More formally, the distribution of preferences is a frequency function over the policy space, Y , that measures the number of participant individuals who favor a specific focus for the development strategy. The use of distribution functions as a link between the state and environment spaces was first suggested by Zeeman (1977, 1979) and has been tailored for the present analysis.

The preference aggregation procedure implicit in the use of the distribution function could correspond to a one-person-one-vote rule defined on a continuum of actual choices. Or it could be a weighted voting rule. In neither case does the positing of the function imply that the government is democratic. The preferences could

be expressed in some voting procedures or exist only in latent form.

In general, the distribution of preferences will not be unimodal (see Figures 3A or 3C). If there is not a significant distance between the peaks of the distribution, as in Figure 3A, the distribution of preferences may be approximated by a single peaked function as in Figure 3B. If the preferences are relatively polarized, as in Figure 3C, then they must be approximated by a bimodal function as in Figure 3D. It will be assumed that only unimodal or bimodal distribution functions will be observed; if this is not the case, a higher order catastrophe must be used. When the preference function is unimodal one would expect to be in the stable region of the environment space, and when bimodal, in the unstable portion.

Figure 4 is one example of an environment space consistent with the discussion in section 2. The shaded area, C, is the zone of polarization of preferences and would be where the preference distribution is bimodal. It corresponds to a moderate to high income inequality region combined with moderate to high levels of education. In this region there is a high likelihood that a portion of the educated population will be excluded from realizing economic rewards commensurate with their expectations. Those whose expectations are frustrated will favor more egalitarian policies, while those who are satisfied will favor continuation of existing policies. Thus, polarization of preferences is quite likely in this region.

Outside of area C there should not exist any significant conflicts over economic policy objectives. In the unshaded area, S_1 ,

FIGURE 3

THE PREFERENCE DISTRIBUTION FUNCTIONS

FIGURE 3A

FIGURE 3B

BIMODAL

FIGURE 3C

FIGURE 3D

FIGURE 4

there is no conflict because although distribution is unequal, the number of educated is quite small and is also part of the socioeconomic elite. In the unshaded area, S_2 , there is no conflict because the distribution of income is more egalitarian and education and unemployment opportunities are congruent.

As defined in the previous section, the catastrophe manifold is a graph of the extreme points of the function F . In the present model this corresponds to the peaks of the distribution of preferences of the potentially politically participant. This transition from a manifold defined on policy preferences to one defined solely on the peaks of the preference functions requires further clarification.

To clarify this transition, we employ here the concept of legitimacy gaps. In any polity, the structure of policy preferences embodies the norms by which government structures, government policies, and the government performance are judged. The relationship between these norms, on the one hand, and actual government performance, on the other, defines what one might call the legitimacy gap facing regimes (Apter, 1971). If one now attributes to the polity the objective of minimizing the average legitimacy gap,¹ this will give rise to the following observed political behavior: for a single mode distribution of preferences, the legitimacy gap can, on the average, be minimized by choosing a policy orientation corresponding to the peaks of the distribution. For a bimodal distribution of preferences, minimizing the gap implies that policies corresponding to the highest preference peak will be chosen and measures will be taken to mollify or pacify those who hold preferences corresponding to the lower peak.

A compromise policy (i.e., one that corresponds to the valley between the preference peaks) will not minimize the average legitimacy gap.² With either preference structure it therefore seems politically plausible to define the catastrophe manifold as the graph of the preference peaks only.

Naturally, political leaders can miscalculate in their reading of the preference map. Psychological theory implies that they are likely to miscalculate in the direction of ascribing more weight to preference peaks that correspond to the policy preferences of the elites with whom they interact and whose interests they most closely represent and identify with. It should also be remembered that policies can be misguided or can fail, and therefore that the economic conditions actually observed may not correspond to the existing policy orientation. In the empirical test, it will be assumed that in general, the two policy goals and policy outcomes are highly correlated. This assumption will, of course, lead to a quite stringent test of our hypothesis.

The catastrophe manifold that corresponds to the catastrophe map that was defined in the discussion of the environment space is a cusp catastrophe and is displayed in Figure 5. In the graph of the cusp catastrophe, the boundary of the zone C is the bifurcation set which encompasses all of the distributions with degenerate extreme points. Zone C is the set of points in the environment that corresponds to bimodal distribution functions. This is represented in the manifold by multiple layers above C which show that there are several values of X that are extreme points of the preference density function. Outside of zone C, the distribution is unimodal; therefore, the manifold

FIGURE 5
C U S P C A T A S T R O P H E

has only one layer and there is only one value of X that corresponds to an extreme point. The labeling on the catastrophe manifold implicitly defines some function, h , where $x = h(y)$, such that the upper left hand corner corresponds to low growth and high labor intensity; the lower left hand corner corresponds to high growth and high labor intensity; the upper right corresponds to low growth, high capital intensity, and the lower right is high growth, high capital intensity.

It should also be noted that the standard cusp illustration in Figure 4 represents merely one possible configuration. A wide range of transformations can shift and rotate the manifold in the environment space while still producing results consistent with the theory presented above. For example, our argument would not be significantly altered by a transformation causing the conflict zone to rotate 45° to the right.

The preceding theoretical discussion leads to several testable hypotheses. First, it implies that it is primarily in the set of points C in the environment space that sudden dramatic shifts in economic policy will occur. As specified above, zone C corresponds to countries with a highly educated population and medium to poor distribution. In such countries, groups favoring redistributive labor intensive growth policies will conflict with those wanting to follow a capital or resource intensive growth strategy. Which policy is observed will depend upon what group has gained power. In zone C , we therefore expect to find that countries quite similar in their educational levels and income distributions differ sharply in their

growth and labor intensity policy configurations. Also, any countries that have made dramatic shifts in development strategies should be in C or should have moved into C before political instability appears.

Secondly, the theory implies that more or less uniform development strategies are followed by countries outside of zone C in the environment space. Countries with low education and good distribution of income (S_1 in the environment space) should all pursue medium to low growth, labor intensive strategies. Countries with low education and poor distribution should be medium to low growth with resource or capital intensive production. Finally, countries with high levels of education and good distribution should be medium to high growth with labor intensive production.

It should be noted that the policy *preferences* are not directly observable. Therefore in the empirical section of this paper, the catastrophe manifold will be tested on the *actual* policy choices made by countries. As indicated earlier, this will lead to a quite stringent test of our hypothesis.

4. The data

In the preceding discussion four variables were identified: the growth rate and the labor intensity of the economy, which define the policy space, and the distribution and the level of education, which characterize the environment space. The list of countries used consists of all Third World nations for which a complete set of observations could be attained. The data is reported in Table 1, together with sources and methods of derivation. Whenever possible, the data selected was for the year 1970.

Most of the concepts used in the analysis must be understood in relative terms, since what are high levels of education, labor productivity (the inverse of labor intensity), and income inequality for countries at low levels of economic development are at best moderate levels for countries at intermediate or high levels of development. This means that the actual numerical values must be normalized by reference to the country's level of development, to make the numbers internally comparable. In all cases, except for the distribution of income, the normalization was accomplished by using the Chenery-Syrquin regressions (1975) to derive the "normal" values of the respective variables for each country, given its level of per capita GNP and its population size. Then, the ratio of the actual value of the variables to its "normal" value was computed. It is this ratio which was used in the analysis.

The level of education was defined as the ratio of the actual school enrollment rate in primary and secondary education relative to that of a typical country at its level of per capita GNP and population.

The distribution of income was represented by the income share of the poorest 40% of national households (Jain, 1975). In the original data sources, some of the data was reported by economically active population; some by income recipient; some by total population; some by households. Since these sources of incomparability may lead to erroneous country rankings, all of the data was converted to a uniform definitional base. For a few countries income distribution data for the same years was available for two or more definitions.

The data for these countries was used to estimate regressions relating one income share of the poorest 40% of households to, say, the share of the poorest 40% of income recipients (or economically active, or total population). The coefficients of these regressions were then used to adjust the reported data to a household basis. The income share of the poorest 40% was then normalized by level of socioeconomic development³, as reported in Table 2.

The labor intensity of the economy was represented by the reciprocal of the ratio of an index of the actual average product of labor to the predicted value of the average product of labor based on the Chenery-Syrquin regressions for labor productivity. To abstract from the effect of the sectoral composition of output, these ratios were computed by broad sector of economic activity. They were then aggregated into a single index by using the actual country shares of each sector in GNP as weights.

The only variable not normalized is the growth rate which was measured as the exponential growth rate of gross domestic product at factor costs in constant prices for the years 1960-1977 (United Nations, 1980). When data had not been reported for the whole time period the largest sequence available between 1960 and 1977 was used.

5. Results

The best procedure for testing the model would be to estimate the position of the catastrophe manifold via a nonlinear regression. Unfortunately, this is a difficult task because the sample size is small and the estimating equation is both nonlinear and nonconvex in

TABLE 1

LIST OF DATA, BY COUNTRY: SOCIOECONOMIC DEVELOPMENT LEVEL (SED) ⁴

COUNTRY	Education ^b 1970	Income Distribution ^d year	Growth Rate ^o 1960-70	Labor Intensity ^u 1970
Low SED ⁴				
Gabon	1.14	9.6 ^e 1968	13.3 ^p	1.47
Ivory Coast	0.69	11.9 ^e 1970	8.3	2.13
Kenya	0.87	10.7 ^e 1969	5.3	3.69
Morocco	0.55	16.3 ^f 1967	6.4	0.99
Niger	0.24	25.8 ^f 1960	3.8 ^q	2.83
Senegal	0.47	6.8 ^g 1960	3.4 ^r	1.52
Sudan	0.51	15.0 ^h 1969	2.1	1.59
Medium SED ⁴				
Bolivia	1.06	12.9 ^h 1968	5.8	1.56
Ecuador	1.06	5.8 ^j 1970	4.9	1.04
Honduras	0.93	7.3 ^k 1968	4.9	1.15
India	1.31	13.1 ^k 1968	3.3	0.99
Indonesia	1.72	19.4 ^e 1971	5.8	0.93
Iran	0.76	na ^f	10.9	1.06
Iraq	0.75	8.9 ^f 1956	9.3	1.40
Pakistan ^a	0.92	7.4 ^k 1964	6.0	0.93
Phillipines	1.63	11.9 ^k 1971	5.4	0.95
South Africa	0.84	4.8 ^g 1965	5.4	1.34
Sri Lanka	1.82	17.9 ^k 1970	4.4	0.93
Thailand	1.05	13.2 ^k 1962	6.9	1.93
Tunisia	1.05	12.8 ^e 1970	6.7	1.25
High SED ⁴				
Argentina	0.82	16.6 ^k 1961	4.0	0.97
Brazil	0.93	9.1 ^e 1970	6.8	1.10
Chile	1.10	13.0 ^k 1968	4.15 ^s	1.11
Colombia	0.97	11.2 ^e 1970	6.3	0.90
Costa Rica	1.01	16.4 ^e 1971	6.6	1.00
El Salvador	0.98	12.3 ^h 1969	6.0	1.01
Israel	0.94	20.2 ^m 1975	7.8 ^t	0.97
Jamaica	1.04	8.2 ^k 1958		1.14
Mexico	0.87	10.28 1969	6.2	1.18
Nicaragua	0.76	10 ⁿ 1966	6.2	1.09
Panama	0.95	15.5 ^e 1970	5.8	1.05
Peru	1.01	8.2 ^e 1970	5.5	1.11
South Korea	1.28	17.7 ^k 1970	8.6	0.93 ^v
Taiwan	1.07	22.3 ^k 1972	10.1	0.97 ^v
Turkey	1.06	9.3 ^k 1972	6.5	1.33
U.A.R. (Egypt)	0.93	15.1 ^e 1964	4.4	1.01
Uruguay	1.01	14.2 ^k 1967	0.0	1.01
Venezuela	0.85	9.1 ^j 1971	4.3	1.05

FOOTNOTES TO TABLE 1

a) The Pakistan observations also include Bangladesh.

b) The educational index is the ratio of the reported student enrollment ratio in primary school and in secondary school to the predicted student enrollment ratio on the basis of country population and gross national product per capita. The predicted values are from Chenery and Syrquin (1975) and the country data is from the UNESCO Statistical Yearbook 1978.

c) 1965, Chenery and Syrquin (1975)

d) The obtainable data on income shares is very heterogenous. The bases used are households, economically active population, income recipients, and total population. The data is converted to a common definitional basis by estimating regressions relating the different conceptual bases and applying the coefficients of these regressions to the reported data. All data was converted to the income share of the poorest 40% of national households by the following regression:

$$H = ax + u$$

where:

H is the percentage of national income accruing to the poorest 40% of households

x is the percentage of income accruing to the poorest 40% by other definitions

a is the correction factor

u is a disturbance term

e) Estimated from data on income recipients, Jain (1975).

f) Estimated from data on economically active population, Adelman and Morris (1978).

g) Estimated from data on total population, Jain (1975).

h) Adelman and Morris (1973).

j) Estimated from data on economically active population, Jain (1975).

k) Jain (1975).

m) Urban households, Ginor (1979).

n) Chenery and Syrquin (1975), source and basic definition not clear.

o) Calculated as the exponential growth rate of gross domestic product by cost structure in constant prices. United Nations, Office for Development Research and Policy Analysis, Computer printout, (1980).

p) 1960 - 1976

q) 1963 - 1968

r) 1962 - 1967

Footnotes to table 1 continued

s) 1960 - 1974

t) For the years 1960 to 1973 the growth rate of gross domestic product at constant market prices is 5.5 while for 1960 to 1977 the growth rate is 2.72, which shows a sharp drop in gross domestic product over the last seven years. This most likely reflects both a policy shift and a policy failure.

u) Labor intensity is a ratio of an index of the actual aggregate average productivity of labor to the predicted value of the index on the basis of country gross national product per capita. The country data is from World Bank (1976) and the predicted values are from Chenery and Syrquin (1975). The index was calculated as

$$AP_I = \sum_i \frac{q_i}{q} \cdot w_i$$

where:

q_i = output of the i^{th} sector divided by the amount of labor in the i^{th} sector

q = total output divided by total labor supply

w_i = output share of i^{th} sector to total output

This index was used because of the way the data was reported in both sources.

v) 1973 labor figures, Taiwan Agricultural Yearbook 1974.

DEFINITION OF INCOME INEQUALITY

Socio-Economic Development	Income Share of the poorest 40 percent			
	High	Moderately High	Moderately Low	Low
LOW	ABOVE 17.0	17.0-14.0	14.0-10.0	10.0-0
MEDIUM	Above 20.0	20.0-16.0	16.0-12.0	12.0-0
HIGH	Above 17.0	17.0-14.0	14.0-12.0	12.0-0
INDEX SCORES	0-.48	.48-.96	.96-1.48	1.48-2.0

Source: Computed

TABLE 2

the coefficients. In lieu of a formal estimation procedure, a technique proposed by Hildebrand, Laing, and Rosenthal (1977), to be denoted HLR, for empirical testing of models based on ordinal data will be used. It is not being suggested that this is the only manner in which the proposed model can be validated but that it is one reasonable method.

In the HLR procedure data are summarized in a table that describes the possible relationships between the dependent (state) variables and the independent (environment) variables. Hypothesis testing is based on a comparison of theoretically generated outcomes to the pattern of the actual observations.

The idea behind the statistical test proposed by HLR is that the number of errors resulting from a theory is meaningless without a reference of comparison. For example, if the relative frequency of error observations were .25, is that good or bad? Obviously there is no way in which that question can be answered without comparing the result to some benchmark. To determine the appropriate benchmark HLR poses the question: Can a joint distribution that is just the product of the marginal distributions explain the pattern of observations better than a joint distribution based on the proposed theory? If it can, then the model does worse than a theory that simply assumes the data is randomly generated and, therefore, should be rejected. HLR use this concept to formulate the following test statistic:

$$\nabla = 1 - \frac{\sum_i \sum_j W_{ij} P_{ij}}{\sum_i \sum_j W_{ij} P_i P_j},$$

Where:

W_{ij} is an error cell indicator, and that $A_{ij} = 1$ if the ij^{th} cell is an error cell and $W_{ij} = 0$ if it is not.

P_{ij} is the frequency of observations in the ij^{th} cell or in the i^{th} category of the state space and the j^{th} category of the environment space.

$P_i = \sum_j P_{ij}$ is the marginal frequency for the i^{th} category of the state space.

$P \cdot j = \sum_i P_{ij}$ is the marginal frequency for the j^{th} category of the environment space.

To further clarify computation of the χ^2 statistic, a 2x2 example is presented here. In this example, the environment space consists of two zones or categories: inside the cusp area (C) and outside the cusp area ($\bar{C}$). The state space also consists of two categories: observations that are homogeneous (H) and those that are nonhomogeneous, ($\bar{H}$).

A group of observations are defined to be homogeneous when countries with similar positions in the environment space also are within a local neighborhood in the policy or state space. In the data set, such a case is represented by Taiwan and Israel; these two countries have similar values for the education index and distribution of income and are also both high growth countries with identical labor intensities of .97. Similarly, a group of observations are defined to be nonhomogeneous if for similar positions in the environment space they are not within a local neighborhood in the policy space. In the data, Colombia and Mexico present such a case: they have identical positions in the environment space but Colombia has a very low labor intensity (.90) while Mexico has a labor intensity (1.18) well above

average. The theory predicts that countries outside of the conflict zone should have homogeneous policies and countries inside the conflict zone should have nonhomogeneous policies. Table 3 contains a display of this version of the theory. The unshaded cells are error cells.

Table 3

ENVIRONMENT SPACE

		C	$\bar{C}$	
STATE SPACE	H	3	4	7
	$\bar{H}$	3	2	5
		6	6	12

The numerator of the ∇ statistic is the frequency of error observations. It is the total number of observations in error cells divided by the total number of observations; using the values in Table 3, the numerator is calculated as:

$$1(3/12) + 0(4/12) + 0(3/12) + 1(2/12) = .41\bar{6}.$$

(Only error cells receive a nonzero weight.)

To calculate the denominator of the ∇ statistic requires a series of random drawings from a marginal distribution that is representative of the state space. HLR propose using the marginals as computed from the data. While this is a reasonable choice for the comparison distribution, there is no inherent reason that other distributions are not also appropriate. Another distribution that is often used in a test of this kind is a uniform distribution. Both of these distributions will be used in reporting the results.

As an example of the steps in the computation of the denominator of the ∇ statistic consider the set of observations inside the cusp. There are six observations in the cusp category. For the marginals based on the data there are seven out of twelve observations that could be either homogeneous or error observations. Therefore there are $6(7/12) = 3.5$ expected errors if the marginals are independent. The complete set of computations is:

$$1(6/12)(6/12) + 0(6/12)(6/12) + 0(6/12)(6/12) + 1(6/12)(6/12) = .5$$

and the ∇ statistic is:

$$1 - \frac{.416}{.5} = .166.$$

When the uniform distribution is used for comparison, then the observations are equally distributed as six homogeneous and six non-homogeneous. The computations are:

$$1(6/12)(6/12) + 0(6/12)(6/12) + 0(6/12)(6/12) + 1(6/12)(6/12) = .5$$

and the ∇ statistic is:

$$1 - \frac{.416}{.5} = .166.$$

In this case the frequency of expected errors is the same for both the uniform and estimated distributions.⁴ This is a coincidence. The interpretation of the results is that there is a 16.6% reduction in the number of errors. To evaluate the statistical significance of this result requires computing the variance. This is a tedious computation and will not be completed for this example, though it is carried out for the actual test.

The last technical note is that the range of the statistic is from 1.0 to $-\infty$, rather than, like R^2 , from -1 to $+1$. For example, if there are no observable errors from the theory then $\nabla = 1 - \frac{0}{x} = 1.0$ and if there are no predicted errors then $\nabla = 1 - \frac{x}{0} = -\infty$. The interpretation of a negative ∇ is that the theory results in a larger number of error observations than a theory that simply assumes the data has been randomly generated by two independent distributions.

The test results need to be interpreted in the light of the fact that the ∇ statistic can be negative.

To implement the HLR procedure for our model the data reported in Table 1 must be converted into ordinal categories (i.e., high, medium, low). This was accomplished by defining regions of equal probability based on a normal probability distribution with mean and variance calculated from the observations (See Table 4 for the definitions of the ordinal categories for each variable). Both the level of education and the growth rate are divided into three equal probability segments (greater than .44, less than $-.44$, and between .44 and $-.44$ standard deviations). The distribution of income and labor intensity index are divided into five equal probability segments (greater than .84, between .84 and .25, between .25 and $-.25$, between $-.25$ and $-.84$, and less than $-.84$ standard deviations).

The data is summarized in Table 5. Across the top of the chart are the fifteen different positions in the environment space ranging from low education and high income share for the poorest 40% of households, to high level of education and low income share for the poorest 40% households. Down the left hand side are the fifteen different positions in the policy space ranging from high labor intensity, low growth; to low labor intensity, high growth. Reading this table is straightforward; for example, the first column corresponds to high income share, low level of education. There are three countries in this zone of the environment space. In the policy space these are ranked as medium-high labor intensity, low and average growth; and low labor intensity, low growth.

TABLE 4

VARIABLE	MEAN	STANDARD DEVIATION	O R D I N A L C A T E G O R I E S		
			Unusually Low	Average	Unusually High
EDUCATION	.973	.308	<.837	.837-1.11	>1.11
GROWTH RATE	5.96	2.46	<4.88	4.88-7.04	>7.04

VARIABLE	MEAN	STANDARD DEVIATION	O R D I N A L C A T E G O R I E S				
			Low	Med. Low	Average	Med. High	High
DISTRIBUTION OF INCOME*	1.197	.524	<.757	.757-1.07	1.07-1.33	1.33-1.64	>1.64
LABOR INTENSITY ^t	1.28	.382	>1.60	1.60-1.38	1.38-1.18	1.18-.96	<.96

Source: Computed from Table 1: Definition of Catagories in Text.

Notes: * The distribution of Income variable was normalized to a 0-2 scale.

^t Fifty percent of the variance resulted from the Kenya observation which distorted the categories. In calculating the reported standard deviation it was not included.

To use the chart in Table 5: for empirical verification of a theory is also a relatively direct procedure. To begin with, the theoretical arguments in section 1 and 3 have certain implications with respect to the position of the bifurcation set and a corresponding pattern of observations. For example, if a zone is inside the bifurcation set then one would expect the countries to have nonhomogeneous policies because the underlying distribution of political preferences should be bimodal and hence the societies are polarized. An example would be for countries in the same environment zone to have noncontinuous and markedly different labor intensities such as either medium-low or medium-high, but not including average labor intensities. On the other hand, if the zone is outside the bifurcation set, the observations should be homogeneous because the distribution of policy preferences is unimodal. An example is for all countries in the same environment category to have the same labor intensity such as medium-low.

One bifurcation set consistent with the previous theoretical discussion is drawn in Figure 6. A pattern consistent with this location for the bifurcation set is displayed in Table 6 and Table 5 (shaded cells).

The test results are reported in Table 7. For how to compute the variance and justification of the use of a t-distribution, see Hildebrand, Laing, and Rosenthal (1977, ch. 6).

The theory as specified in Table 6 has an error reduction of .532 using a uniform marginal distribution and of .378 using the computed marginal distribution. Both results are significant at the

LEVEL OF EDUCATION:		LOW					AVERAGE					HIGH									
LABOR INTENSITY:		INCOME SHARE OF LOWEST 40% HOUSEHOLDS																			
		High	Medium	High	Average	Med.Low	Low	High	Med	High	Average	Med.Low	Low	High	Med.High	Average		Med.Low	Low		
HIGH	G R O W T H	Low											1					1			
		Average						1 1					1	1				4			
		High											1					1			
MEDIUM HIGH	G R O W T H	Low	1							2	1	2				1	7				
		Average	1				1				2	4 1			1	9					
		High				1				2				1				4			
AVERAGE	G R O W T H	Low																0			
		Average	1					2										3			
		High																0			
MEDIUM LOW	G R O W T H	Low	1		1						1						2				
		Average	1			1			1			1			1			1			
		High	1			1			1			1			1			2			
LOW	G R O W T H	Low	1															1			
		Average					1 1										2				
		High	1														1				
Marginal Distribution			3	1	1	1	4		4	2	2	1	1	3		3	0	0	3	0	38

Source: Computed. The shaded cells are those cells predicted by the theory. Unshaded cells are error cells.

TABLE 5

TABLE 6

LOCATION IN ENVIRONMENT SPACE	EDUCATION: L O W • M E D I U M • H I G H															
	INCOME DISTRIBUTION:															
	High	Med. High	Average	Med. Low	Low	High	Med. High	Average	Med. Low	Low	High	Med. High	Average	Med. Low	Low	
PREDICTED LOCATION IN POLICY SPACE	LABOR INTENSITY	MH	MH	MH ML	MH ML	MH ML	MH	MH	MH ML	MH ML	MH ML	H	na	na	MH ML	na
	GROWTH	vL A	vL A	vL A	A H	A vH	A vH	A vL	A vL	A vH	A vH	A vH	na	na	A vH	na

MH means medium-high
 ML medium-low
 vL Unusually Low
 vH unusually High
 na not available
 A average

Source: Computed

TABLE 7
TEST RESULTS

REFERENCE DISTRIBUTION	STATISTIC	STANDARD DEVIATION	95% Confidence Interval
Computed Frequencies	.378	.105	.165-.590
Uniform	.531	.101	.327-.735

Source: Computed

99% level. This means that given the proposed theory, there are 53% or 38% fewer errors observed than would be expected if the data had been produced by two statistically independent variables. In evaluating these results it should be remembered that for the test it has been assumed that all countries achieve their desired policies. This assumption introduces a quite stringent restriction on the testing procedure, since our theoretical model was specified in terms of policy zones while our test is formulated in terms of observed policy outcomes. Also, it will be recalled that the test results could have assumed negative values. Viewed in this light, improvements of the magnitude observed with our theory lend it strong support.

6. Conclusion

The present study offers an initial exploration into the uses of catastrophe theory in explaining the socioeconomic origins of political instability. The results should be considered suggestive rather than conclusive. In general, it does appear that there exists significant empirical support for the theory proposed. However, more work needs to be done to validate the theory and on the use of catastrophe manifolds in the social sciences to see if they actually will prove to be new and useful tools for analysis.

This paper considers only two sources of abrupt changes in policy orientation: the level of education and the distribution of income. As discussed in section 1 there are a number of other systemic sources that could create demands for dramatic policy change and lead to possible political instability. The other sources may cause

countries, stable with respect to the level of education and distribution of income, to be unstable and could also stabilize countries considered here to be unstable. One example of the former is the recent violence in South Korea, where it can be argued that the instability is caused by political rather than by economic imbalances. Another example is Argentina, where it can be argued that the instability has been caused by mismanagement of the economy, and does not reflect disagreement over overall development strategy.

One key real world test of the results is provided by countries with education and income distribution combinations that lead to observations that correspond to the trough of the bimodal probability distribution function. If the catastrophe manifold is positioned as specified above, then Turkey, South Africa, and Tunisia lie in the trough of the bimodal distribution and should be potentially very unstable. In the case of South Africa, the instability will most likely lead to a violent change, as exemplified by Namibia. Tunisia, because of extensive political networks, will most likely make the transition smoothly, but there is a good chance of a marked increase in social unrest in the next few years. This increase in instability appears to be occurring already with the rise of new potential parties which, as of yet, have not been officially recognized (Countries of the World, 1980). Another interesting case is Indonesia, which was very unstable in the middle sixties, but more recently has shifted to a more labor intensive and equitable development strategy, and therefore, if our theory is correct, has become stabilized.

FOOTNOTES

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¹A more complicated model would allow for the use of power or have an authoritarian dimension. In that case the legitimacy gap need not be minimized because power can be used to maintain what could be viewed as a disequilibrium position.

²If the bimodal distribution is perfectly symmetrical around the minimum point, then each side will balance the other. However, taking one vote from one side and moving it to the other will create a complete shift because of the weight associated with that one vote. For example, consider a seesaw that is perfectly balanced; then removing any weight from one side will cause the other to touch the ground. This is not necessarily true if trimodal distributions are allowed. That case corresponds to a butterfly catastrophe, and stable compromise policies are possible.

³The term socioeconomic development is defined as an aggregate of GNP and other indications of social and economic modernization. For a complete discussion of the variables and how the countries were ranked see Adelman and Morris (1971).

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