ANALYSIS OF CONTEMPORARY LATIN AMERICAN POLITICAL HISTORY: AN APPLICATION OF CATASTROPHE THEORY

by

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I. THE BACKGROUND

Recently, the Third World has been characterized by a great deal of internal violence and by the emergence of a great many authoritarian regimes. Nowhere has this been more apparent than in Latin America where there have been more than 11 coups d'etat in the last 17 years. The purpose of this paper is to propose a model for analyzing some of the economic and social conditions that have led to these political tendencies. It is an extension of the work of Adelman and Hihn [1981] on political polarization and instability. In addition to the variables considered in the previous paper, the present one also includes the structure of the polity and the degree of political participation as conditioning variables. The model is applied to an analysis of the nature of political change in Latin America.

Existing models of political change and development are either incomplete or cannot be specified in an appropriate form for mathematical modeling or quantitative comparative analysis. Classical modernization theory originally argued that economic development and social modernization would lead to equality, stability, and democracy. This theory was shown by events to be erroneous. Contemporary modernization theory now states that only in the most advanced stages of development can one expect to find a high degree of correlation between economic development, equity, and political participation. Polarization of society and internal violence are not precluded at any point in the process of development, and their manifestations are very dependent on the specific set of growth and redistribution policies that are actually implemented [Adelman and Morris, 1973; Huntington, 1968; Feierabend, Feierabend, and Nesvald, 1969].
Classical Marxist theory emphasized the conflict between capital and labor. However, in Latin America, the major conflict was originally between rural and urban interests; more recently, it has been between efficiency and equity. The contemporary versions of Marxist theory emphasized the importance of international capital in inducing the political formations of developing countries. The modern versions of dependency theory and their extensions argue that, although it is true that countries are influenced to differing degrees by the actions and reactions of other nations, it is very unlikely that external forces can actually create the conditions for political polarization and instability unless the basic, underlying predisposition already exists. Outside forces—whatever their source—can only take advantage of endogenously created conditions within the country they are influencing. Contemporary Marxians thus focus on the interaction between the external environment and the internal structures.

Dahl [1971] discusses the forces which determine the likelihood of the formation of a stable polyarchy within a country. A political system that is a polyarchy is highly responsive to the preferences of its citizens. In comparison, a democracy is an idealized system that is perfectly responsive to all of its citizens. Dahl argues that the existence of a stable polyarchy depends on the historical sequencing of the emergence of political competition and political inclusiveness, the existing socioeconomic order, the level of development, the degree of inequality, the beliefs of political activists, and the influence of foreign powers. In a lengthy discussion of Argentinian politics, Dahl finds that it contains many of the preconditions for a stable polyarchy. He argues, therefore, that the main reason for the existence of an authoritarian government in Argentina is a general lack of belief in the value of a competitive political system. The problem with Dahl's analysis is that
his model does not provide a well-defined structure—it is only a collection of loosely connected pieces.

Huntington and Nelson [1976] divide the process of economic development into two phases. In Phase I, economic development is beginning, inequality increases, and a basis for political participation emerges. In this phase, the principal conflict is between equity and political participation. At this stage of development, countries can choose between a bourgeois and an autocratic model of political development. In the bourgeois model, political participation is extended to the middle class and, for a time, it leads to political stability. Huntington and Nelson claim that, since 1973, Colombia has been following this model.

Phase II occurs when the excluded group—either the lower or the middle class—begins to press for greater influence in setting policy goals. The principal conflict in this phase is between growth and political participation. At this point, the choice is between technocratic and bureaucratic authoritarianism. The technocratic model (e.g., the Southern Cone countries—especially Brazil and Chile) contains a cycle of declining political participation with the ever-present threat of a sudden large increase in popular demand for greater participation. The populist model (e.g., Peru or Argentina) has a cycle of ever-increasing political participation with the threat of an authoritarian coup d'etat. According to Huntington and Nelson, in this phase of development there exists the potential for political instability. What occurs depends on the specific historical context of each country. Huntington and Nelson claim that Brazil, Chile, and Argentina have shifted from populist to technocratic models and that Chile went from a bourgeois model in Phase I to an autocratic model in Phase II.
A bureaucratic authoritarian paradigm of political change in Latin America was first proposed by O'Donnel [1973] and has generated a substantial amount of interest [Collier, 1979]. The bureaucratic authoritarian model attempts to explain the emergence in Latin America of military–technocratic coalitions that favor increased technological expertise and rapid industrialization. No single author presents a truly representative statement of the many variants of the model that exist. Typically, in these models, bureaucratic authoritarian regimes emerge when countries exhaust their opportunities for profitable import substitution. The ensuing slowdown in internal economic growth and balance-of-payments crises lead to bitterly disappointed political expectations among a growing educated technical elite who form a coalition with the military aimed at creating a climate favorable to both domestic and foreign investment and the furthering of industrialization. Bureaucratic authoritarian regimes, therefore, favor conservative, growth-oriented policies which lead to a worsening of the distribution of income and to the securing of the economic position of the military and civilian technocrats.

Another theory of political and economic change is Galtung's [1980] concept of "rank disequilibrium" as a precursor of social change. In this theory, groups or classes are ranked on three scales representing economic, political, and social status. The relative status or rank of a group may be the same on all three scales or it may differ from one scale to another. A group that does not have the same rank on all three scales is considered to be in rank disequilibrium. According to the theory, that group will attempt to achieve rank equilibrium and, in the process, will become the agent of change in the economic or political sphere.

Clearly, the reasons that different Third World nations develop different political institutions and some countries evolve more politically participant politics than others is determined by history, traditional political culture,
traditional political institutions, influence of political entrepreneurs, international forces, and a wide range of economic and social variables. (See Huntington and Dominguez [1975] for a complete discussion of the reasons.) We will identify a small subset of the many and varied forces that have led to the present state of politics in Latin America and see the extent to which they can be used to explain contemporary Latin American political history. Because not all of the causal variables are presented, the relationships defined below should be considered as probabilistic statements; that is, in our model, if specific event A occurs, then it is highly probable that predictable event B will follow.

To improve our understanding of the forces mentioned above that are operative during the process of development, we require a theoretical framework that will permit comparative analysis. In presenting such a model, this paper incorporates the principal variables that are common to all of the paradigms. They include the degree of distributive equity and the variables that determine the degree and nature of the polarization of society. The relationships between these variables will be analyzed through the use of the logical structure imposed by the mathematical technique known as catastrophe theory.

Catastrophe theory is especially useful for our purposes because it is a mathematical framework that is appropriate for characterizing zones in which abrupt shifts in policy and structure are likely to occur and for distinguishing these from other zones in which only gradual shifts are probable.

The socioeconomic determinants of political change are discussed in Section II. Section III presents the central concepts of catastrophe theory. The model is defined in Section IV. In Section V, the model is used to analyze the recent political histories of several Latin American countries. Our findings are summarized in Section VI.
II. SOCIOECONOMIC DETERMINANTS OF POLITICAL CHANGE

We will analyze two distinct yet related phenomena: political instability and the formation of authoritarian regimes. Political instability is manifested as internal violence and often leads to revolution or coups d'etat. The occurrence of these events frequently depends on the charisma and capabilities of political entrepreneurs and their timing is, therefore, very difficult to predict. However, political instability is most likely to emerge in societies that are polarized about the appropriate goals and policies of the government. The greater the degree of polarization, the more probable it is that political instability will occur and that political change will not take place in an orderly fashion within existing institutions. A modifying factor which conditions whether institutions will break down or adapt is political participation. Political participation will not necessarily reduce the degree of polarization but will provide channels for communication through which compromises may be reached. The three major explanatory variables that will be included in our model are the level of education, the degree of inequity in the distribution of income and wealth, and the extent of political participation. These are some of the variables that are often considered in theories of political development and change. The first two variables determine the degree of polarization, and the third determines whether compromise policies can be pursued with any degree of stability.

It will be assumed that abrupt shifts in the economic ideology of government 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 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 unfulfilled expectations.

At first, the dissatisfaction may be latent. But at some point, it will be channeled into overt expressions of discontent with the current lines of economic policy and a clamor for change in economic priorities. If, at this point, there are insufficient accommodations in actual policies and/or insufficient changes in the outcome of actual policies, the politically active in the population will become polarized into different groups: one group consisting of factions supporting continuation of the current line—perhaps with some marginal adaptations—and other groups comprising factions that favor more fundamental changes. Each side may attempt a mix of persuasion and intimidation through "political awakening," campaigns, and/or 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.

Polarization and, according to Galtung [1980], rank disequilibrium are most likely to occur in countries that are characterized by moderate-to-high education levels, little political participation, and concentrated income distributions. On the other hand, significant degrees of polarization are unlikely in both countries with high levels of education, extensive political participation, and good income distribution and countries with very limited education and little political participation. At low levels of education, 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, equitable distributions of income, and good channels for participation, there should exist sufficient economic opportunities to enable the growing numbers of the educated to be participant in
all ways. Nations characterized by either of these two sets of circumstances should, therefore, have only localized grievances with no major conflicts over general policy orientation.

Not only do the politically participant members of a society have preferences with respect to the policy orientation of a regime but they also have preferences as to the nature of the institutions that will be used to implement these policies. The institutional structures of the political systems of different countries will be characterized by the extent of authoritarianism or competitiveness of their political systems.

Our model of the formation of authoritarian regimes will follow closely the work of Dahl [1971] who argues that the probability of the emergence of a stable polyarchy is directly related to the level of education and to the degree of inequality within a society. Dahl's argument will be extended to state that low levels of education are likely to correspond to closed hegemonic systems (i.e., regimes in which there is neither public contestation nor public participation) and high levels of education are likely to correspond to inclusive hegemonic systems (i.e., systems in which there is participation but not public contestation).

It is during times of stress that authoritarian regimes are most likely to appear [Collier, 1978]. The more polarized the society becomes, the more likely it is that authoritarianism will emerge in order to maintain the positions of groups that have attained political control. Our model produces this result because hegemonic regimes and polarization of societies are most likely to emerge when education level is high, income distribution is poor, and political participation is limited. Hegemonic regimes may be representatives of any of the several populist or technocratic models discussed by Huntington and Nelson [1976].
III. THE TECHNIQUE OF ANALYSIS: AN OVERVIEW OF CATASTROPHE THEORY

Shifts involving major changes in the sociopolitical complexion of government are likely to be abrupt. The kind of modeling framework required to portray them must, therefore, be capable of encompassing at least one discontinuity. Because such shifts are not once-and-for-all movements but, in many countries, involve sequences 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. Preferably, it should contain a zone of instability, within which oscillations in policy regimes are likely to take place. For this reason, the mathematics of catastrophe theory seem especially appropriate for use in the formulation of our model.

In this section, only those concepts of catastrophe theory specifically required to construct the 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.
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 coefficients of the functions being 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 butterfly, 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 butterfly is discussed because it is the catastrophe manifold considered in this paper.

Equation (1) represents a typical fold catastrophe:

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

where \( x \in X \) is the single-state variable and \( a \in A \) is the coefficient and control variable. The corresponding catastrophe manifold, \( f(x, a) \), is the set of all values of \( x \) that corresponds to extreme points of \( F(x, a) \). These satisfy the equation

\[ f(x, a) = x^2 - a = 0 \]  

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

The catastrophe manifold is a parabola in $x$ which shows that, correspond—
ing to different values of $a$, there exist two critical points—one maximum and
one 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
graphs in Figure 1 demonstrate how the underlying function changes as the
value of the parameter changes. The bifurcation set is the set of points in
the environment space that corresponds to degenerate extreme points. $B$ is the
bifurcation set. For the fold catastrophe, the bifurcation set consists of a
single point. In this example, it separates the environment space into two
spaces. One corresponds to the existence of two extreme points and the other
corresponds to no points (see Figure 1).

A second example, the butterfly catastrophe, consists of one state vari—
able, $x \in X$, and four coefficients ($a$, $b$, $c$, and $d$) which define the control
or environment space, $A = (a, b, c, d)$. The control space now consists of
four dimensions, and $a_1 \in A$ denotes one point in the four-dimensional
control space. The family of functions describing the butterfly catastrophe
can be depicted by

$$F(x, a_1) = F_{a_1}(x) = \frac{1}{6} x^6 - \frac{1}{4} dx^4 - \frac{1}{3} cx^3 - \frac{1}{2} bx^2 - ax. \quad (3)$$
FIGURE 1

FOLD CATASTROPHE

FAMILY OF FUNCTIONS

CATASTROPHE MANIFOLD

CATASTROPHE MAP
The corresponding catastrophe manifold is
\[ f(x, a) = x^5 - dx^3 - cx^2 - bx - a. \] (4)

The butterfly catastrophe is a five-dimensional manifold and, therefore, cannot be illustrated graphically. Instead two- and three-dimensional level surfaces will be drawn.

Figures 2a through 2f contain a set of catastrophe maps with the coefficients c and d held constant at different values. They demonstrate how changes in c and d result in variations in the bifurcation set. Control variable d is referred to as the butterfly factor because, when d > 0, it bifurcates the cusp into three cusps as illustrated by the difference between catastrophe maps 2b and 2e. Control factor c is referred to as a bias factor because it determines whether or not the bifurcation set is symmetrical around the origin. This is illustrated by the differences between Figures 2a through 2c and 2d through 2f. To further elucidate the properties of the butterfly catastrophe, we will examine in greater detail the manifolds that correspond to catastrophe maps 2b and 2e.

Typical graphs of the catastrophe manifold, family of functions, and catastrophe map corresponding to 2b are displayed in Figure 3. The intersection of the a and b axes is the origin. Possible functional forms are displayed adjacent to corresponding regions on the catastrophe map. This manifold is known as the cusp catastrophe and illustrates the fact that the lower order catastrophes are special cases of the higher order catastrophes.

Setting c equal to 0 and differentiating equation (4) leaves \( 5x^4 - 3dx^2 - b \) as the second derivative. When \( b > 0 \) and the absolute value of \( x \) is large relative to \( b \), \( (5x^4 - 3dx^2) - b > 0 \) and a given extreme point is
FIGURE 2

CATASTROPHE MAPS

FOR BUTTERFLY CATASTROPHE

2a  2b  2c

d < 0  c = 0  c > 0

2d  2e  2f

d > 0
FIGURE 3
CUSP MANIFOLD

CATASTROPHE MAP with FAMILY OF FUNCTIONS:
a minimum since d is defined to be strictly less than zero. When b > 0 and the absolute value of x is small relative to b, \((5x^4 - 3dx^2) - b < 0\) and a given extreme point is a maximum. When b < 0, \((5x^4 - 3dx^2) - b\) is always positive and all extreme points are minima. Therefore, 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 this catastrophe manifold considerably more interesting than those of the fold. As in the earlier case, minimizing \(F_{a1}(x)\) will result in unstable maxima; for such points, the smallest perturbation would cause a leap to either the lower or upper surface. Movement in single-sheeted areas will always be smooth. Movement along the upper sheet will lead to a catastrophic leap if the bifurcation set is crossed as shown in Figure 3.

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

Typical graphs of the catastrophe manifold, the family of functions, and catastrophe map 2e of the butterfly catastrophe are illustrated in Figures 4a through 4f (to be referred to as a butterfly manifold). As before, the intersection of the a and b axes is the origin; and possible functional forms are placed adjacent to corresponding regions on the catastrophe map. The principal distinction between the two manifolds is that when \(d > 0\), depending on the values of a and b, one, two, or three stable extreme points are possible. The existence of the third extreme point often represents a compromise position between two extremes; and, hence, the middle sheet is usually referred to as
FIGURE 4

BUTTERFLY MANIFOLD

Pocket of Compromise

MINIMA

MAXIMA

MINIMA

4a

4d

4b

4c

4e

4f

a

b

g
the pocket of compromise. It should be noted that many authors are primarily referring to the functions depicted in Figures 4a through 4f when using the term butterfly catastrophe.

Setting $c = 0$ and differentiating equation (4) yields $5x^4 - 3dx^2 - b$, which can be rewritten as $(5x^2 - 3d)x^2 - b$, where $d > 0$. When $b > 0$ and the absolute value of $x$ is large relative to $b$ and $d$, $(5x^2 - 3d)x^2 - b > 0$ and a given extreme point is a minimum; otherwise, $(5x^2 - 3d)x^2 - b < 0$ and extreme points are a maximum. This corresponds to functions similar to those in Figure 4b. When $b < 0$ and $5x^2 > 3d$, the second derivative is always positive and all extreme points are minima as in Figure 4a. When $5x^2 > 3d$, the properties depend upon whether or not $b$ is large enough to offset $(5x^2 - 3d)x^2$. Depending on the specific values of the control factors one can visualize functions such as 4a or 4c.

In our application, we will first hypothesize the existence of a butterfly catastrophe manifold consistent with the theory of economic and political change sketched in the previous section and will then exhibit its existence empirically by analyzing the experiences of Latin American countries in the light of this model.

IV. THE MODEL

In the following discussion, a model of the socioeconomic determinants of political change is developed in an application of the mathematical technique of catastrophe theory. In this model, a country at a single point in time is represented as a point in a five-dimensional space. The five dimensions of the space are (1) the level of education, (2) the degree of inequality in the distribution of income and wealth, (3) the extent of political participation, (4) the degree of hegemony, and (5) the extent to which the pattern of economic development is redistributive.
The first three variables (education, income inequality, and political participation) identify the environment space. The rationale for their use to characterize the environment space has been discussed in Section II and will not be repeated here. The last two variables—the degree of hegemony and the extent of redistributive emphasis—have been selected to characterize the institutional structure and ideology of a government and will be referred to as the polity space.

Linking the environment space and the polity space is the distribution of 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 exist frequency functions representing the policy and institutional preferences of the population. Various political organizations embody different combinations of positions along these two dimensions.

Formally, the distribution of preferences is a frequency function over the polity space that measures the number of individuals who favor a specific focus for development strategy and view a particular institutional structure as being legitimate for its implementation. This distribution is defined for each point in the environment space. The use of distribution functions as a link between the state space and the environment space was first suggested by Zeeman [1977, 1979] and has been tailored for use in the present analysis.

The preference aggregation procedure implicit in the use of the distribution functions could correspond to a one-person, one-vote rule or it could be a weighted-voting rule. The positing of the existence of the preference distribution functions does not imply that the government is democratic. Preferences could be expressed in some voting procedures, in terrorist activities, or they could exist only in latent form.
In general, the distribution of preferences will not be unimodal (see Figure 5a or 5c). If the distance between the peaks of the distributions is not significant (as in Figure 5a) the distribution of preferences may be approximated by a single-peaked function as in Figure 5b. If the preferences are extremely polarized (as in Figure 5c) they must be approximated by a bimodal function as in Figure 5d. If preferences are polarized but a substantial portion of the population prefers a compromise position (as in Figure 5e) then the preferences will be approximated by a trimodal function as in Figure 5f.

It will be assumed that only three types of distribution functions will be observed in practice: unimodal, bimodal, and trimodal. When the distribution of preference functions is unimodal, one would expect the polity to be in the stable region of the environment space and, when it is bimodal or trimodal, in one of the unstable portions.

In the proposed model, it is assumed that the degree of equity and the extent of education interact to determine the structure of the distribution of preferences. The third dimension of the environment space, the degree of political participation, modifies the effects of different education-equity combinations. When there is a low level of political participation, channels are few for information flow and public participation in decision making; therefore, extreme polarization is likely. When there is a high level of political participation, there exist numerous channels for the flow of information and influence. Therefore, extreme polarization is less likely to occur, and the probability of the existence of stable compromise policies is greatly increased. At the same time, however, since individuals have more information, they will be less tolerant of a lack of economic opportunities for any given level of education.
21.

FIGURE 5
THE PREFERENCE DISTRIBUTION FUNCTIONS

ACTUAL FREQUENCY:

MODEL APPROXIMATION:
Figure 6 is an example of an environment space consistent with the discussion in Section II for the case of a low level of political participation. Area $C_1$ is the zone in which preferences are polarized; that is, where the preference distribution is bimodal. It corresponds to moderate- to high-income inequality combined with moderate to high levels of education. In this region it is very likely that a portion of the educated population will be precluded from realizing economic and political rewards commensurate with its expectations. Those whose expectations are frustrated will favor more egalitarian policies, and those who are satisfied with their status will favor the continuation of existing policies. Thus, polarization of preferences is quite likely to occur in this region. In addition, the more polarized the preferences (as with high levels of education and poor distribution of income and opportunities) the more likely is the emergence of an authoritarian regime.

Outside of area $C_1$ there should not exist any significant conflicts over economic policy objectives. In area $S_1$ there is no conflict because, although distribution is unequal, the number of educated is quite small and the educated are a part of the socioeconomic elite. In zone $S_2$ there is no conflict because the distribution of income is more egalitarian and education and employment opportunities are congruent.

In countries with high levels of political participation, the nature of the conflict zone is likely to be substantially different. This is because communication channels between different segments of the society and between the society and the polity create the potential for compromise policies or trimodal preference distributions. The catastrophe manifold most appropriate for these conditions is the butterfly catastrophe discussed in Section III (see Figures 2b and 2e).
FIGURE 6

ENVIRONMENT SPACE

For Low-Level Political Participation

EDUCATION

INEQUALITY OF INCOME
A reasonable position for the catastrophe map corresponding to high levels of political participation is displayed in Figure 7. Areas $S_1$ and $S_2$ are stable as before. Area $C_1$ corresponds to polarized bimodal distributions and is the same as area $C_1$ in Figure 6. What makes this catastrophe map different is the existence of areas $C_2$, $C_3$, and $C_4$. Area $C_2$ represents education and distribution combinations that correspond to a trimodal distribution. This means that, while there are polarized segments of the society, there also are many individuals who support "middle of the road" policies creating the potential for compromise regimes. In countries with low levels of political participation, the same combinations of education and equity would correspond to the existence of polarized societies. In area $C_3$, there are bimodal distributions with trade-offs between redistributive and moderate policies and between moderate and nonredistributive policies. The distance between modes in zones $C_3$ and $C_4$ is significantly smaller than it is in $C_1$ (cf. Figure 4).

As explained in Section II, a catastrophe manifold is a graph of the extreme points of a function for all possible combinations of different values of the coefficients. In the present model, this corresponds to a graph of the peaks of the preference distributions. The specification of the catastrophe manifold in terms of preference peaks can be justified by assuming that the objective of the polity is to minimize the average legitimacy gap, defined as the gap between the norms by which government structure and policy are judged and the actual performance of the government [Apter, 1971]. If governments aim at minimizing the legitimacy gap, the following political behavior should emerge: for a single-mode distribution of preferences, the legitimacy gap is, on the average, minimized by choosing a policy orientation corresponding to the peak of the distribution. For a bimodal distribution of preferences,
FIGURE 7

ENVIRONMENT SPACE

For High-Level Political Participation

EDUCATION

INEQUALITY OF INCOME
minimizing the gap implies that policies corresponding to the higher preference peak will be chosen the most often and that measures will be taken to mollify or pacify those whose preferences correspond to the lower peak. For such a distribution, a compromise policy (i.e., a policy that corresponds to the valley between the preference peaks) will not minimize the average legitimacy gap because it is unstable. If the distribution is trimodal, however, a compromise policy corresponding to the middle mode could potentially minimize the legitimacy gap.

For all three types of preference distributions, it is, therefore, reasonable to define the catastrophe manifold as the graph of only the preference peaks. If 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 side will create a complete shift because of the weight associated with that one vote. For example, consider a seesaw that is perfectly balanced; removing any weight from one side will cause the other to touch the ground.

The catastrophe manifolds corresponding to the catastrophe maps defined in the discussion of the environment space belong to the class of the butterfly catastrophes. They are displayed in Figures 8a and 8b. In the graphs of the two catastrophe manifolds, the boundary of the C zones is the bifurcation set which encompasses all of the distributions with degenerate extreme points. The C zones are the set of points in the environment that correspond to bimodal or trimodal distribution functions. They are represented in the manifold by multiple layers above the C zones which show that there exist several extreme points of the preference-density function. Outside of the C zones, the distribution is unimodal; therefore, the manifold has only one layer and there is only one value of X that corresponds to an extreme point.
FIGURE 8

THE CUSP AND BUTTERFLY MANIFOLDS OF THE BUTTERFLY CATASTROPHE

(a) Cusp Manifold for Low Level Political Participation

(b) Butterfly Manifold for High Level of Political Participation
The point, a, in the front left-hand corner of Figure 8(a) lies within the area that corresponds to countries which are likely to be polyarchies. The lines from that point project in the two directions of increasing hegemony. The front right-hand corners of the cusp manifold correspond to countries that are likely to be relatively hegemonic. The top sheet of the manifold contains countries that may be expected to have nonredistributive policies and to follow a technocratic model as discussed by Huntington and Nelson [1976] and, hence, to be less participant. The lower sheet, which contains countries that are likely to follow relatively redistributive policies, includes countries that follow a populist model [Huntington and Nelson, 1976] and, hence, are relatively more participant but still have minimal public contestation.

Our specification of a model of political change implies that the principal conflict within a society concerns economic policies and that individuals favor specific institutional structures to the extent they believe that their personal policy goals are likely to be achieved by means of those structures. Therefore, the degree of hegemony—our index of institutional structure—has a significantly more continuous relationship to the environment space than does the degree of redistribution.

The preceding theoretical discussion leads to several testable hypotheses. First, it implies that it is primarily in zones C and C1 in the environment space of Figure 8 that sudden dramatic shifts in economic policy will occur. As specified above, these zones contain countries with a highly educated population and medium-to-poor distribution of income and opportunities. In such countries, groups favoring redistributive growth policies will conflict with those that prefer to follow a capital- or resource-intensive growth strategy. Which policy is instituted will depend on
which group has gained power. In the $C_1$ zones, we expect to find that countries with similar educational levels and income distributions differ sharply in their configurations of redistributive policy but differ less sharply in their institutional structures. Also, any country which has made dramatic shifts in development strategy should have been in (or should recently have moved into) area $C_1$ before political instability appears.

Second, the model implies that more-or-less-uniform development strategies and institutional structures exist in countries outside of $C$ zones in the environment space. Countries with low levels of education and a relatively equitable distribution of income would, in our model, be expected to pursue redistributive growth strategies under closed hegemonic regimes. Countries with low levels of education and poor distribution of income are likely to follow nondistributive policies and to be governed by closed hegemonic regimes. Finally, countries with high levels of education and good distribution of income would be expected to have redistributive policies and to be polyarchies.

Third, regimes that follow compromise policies are likely to exist for any length of time only in countries with high levels of political participation. Moreover, countries that fall into positions in the catastrophe manifold corresponding to high levels of political participation are, in general, likely to have competitive political systems.

We will now examine these propositions by comparing them with the recent histories of Latin American countries.
V. ANALYSES OF RECENT POLITICAL HISTORIES OF LATIN AMERICAN COUNTRIES

To demonstrate the usefulness of catastrophe manifolds as the basis for models of political instability and of the structure of the polity, we will discuss the historical patterns that have been followed during the last 20 years by 15 Latin American countries: Argentina, Bolivia, Brazil, Chile, Colombia, Costa Rica, Ecuador, El Salvador, Honduras, Mexico, Nicaragua, Panama, Peru, Uruguay, and Venezuela. These are the only Latin American countries for which income-distribution data are available for some years from 1960 through 1980. The data underlying the discussion are summarized in Table 1. The environment spaces of the catastrophe manifold corresponding to the hypothesized location of the bifurcation set with the countries sketched in are depicted in Figures 9a and 9b. In a previous paper [Adelman and Hihn, 1981], a nonparametric test was performed on a cusp catastrophe manifold without distinguishing among countries by their levels of political participation. It indicated that a location of the bifurcation set corresponding to the one hypothesized in Figure 9 is not inconsistent with data for the 1960s describing a larger set of developing countries. Here we apply a different test to an extension of the theory contained in that paper. For the Latin American countries for which data at two different points in time are available, we compare, case by case, the actual dynamics with those suggested by our model.

To begin the discussion, we identify four countries as prototypal: two with high levels of political participation throughout the period 1960–1980 (Costa Rica and Venezuela, Figure 9a) and two with low levels of political participation (Brazil and El Salvador, Figure 9b). During the past 20 years there has been a general decline in popular political participation throughout
<table>
<thead>
<tr>
<th>Country</th>
<th>Income distribution</th>
<th>Education</th>
<th>Channels for political participation</th>
<th>Policy orientation</th>
<th>Structures of polity</th>
<th>Coups d'etat since 1960</th>
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<tr>
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<td>60</td>
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<tr>
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<td>D-</td>
<td>21</td>
<td>38</td>
<td>+</td>
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</table>

a/ Based on the income share of the poorest 40 percent of all households; for 1960 data, see Jain [1975]; for 1970 data, see Adelman and Hihn [1980]. "A" is income share above 15 percent; "B," between 14.0 and 15.0 percent; "C," between 13.0 and 14.0 percent; and "D," between 8.0 and 13.0 percent.

b/ Number enrolled in higher education as a percentage of the population aged 20 to 24 years [World Development Report, 1980].

c/ The symbol "+" indicates relatively high levels of political participation; the symbol "-" indicates relatively low levels of political participation. (See, for example, Adelman and Morris [1960 and 1973] or Gastil [1978]).

d/ The letter "R" indicates redistributive policy; "R-," slightly redistributive; "NR," nonredistributive; and "NR-," slightly nonredistributive (computed).

e/ The letter "A" is hegemony; "B," less hegemonic; "C," near polyarchy or polyarchy; "+" and "-" denote a greater or lesser degree of hegemony.

f/ Blanks indicate data not available.

g/ Dashes indicate that there have been no coups d'etat since 1960.
FIGURE 9

ENVIRONMENT SPACES

With Plots of Approximate Positions of Selected Latin-American Countries circa 1977

(a) High-Level Political Participation

(b) Low-Level Political Participation
Latin America. Two of the few countries that have remained polyarchies are Costa Rica and Venezuela. (See Adelman and Morris [1973] and Gastil [1978].)

Costa Rica has had a parliamentary system of government since 1889 with only two brief interruptions; the most recent occurrence of political instability was in the late 1940s. The media are private and free from government interference. Elections appear to be fair since the party in power was re-elected to the presidency only once in the period 1949-1974. The distribution of income has, in general, been improving: the income share of the poorest 40 percent of households went from 13.0 percent in 1961 to 14.6 percent in 1971 [Jain, 1975]. In 1961, the income distribution in Costa Rica was the same as it was in Chile in 1968. A shift of government support toward the raising of cattle in the late 1960s through the mid-1970s most likely worsened the distribution of income; however, this policy was reversed recently. Generally speaking, therefore, the goals of the government have been redistributive. The level of education, as measured by enrollment rates in higher education, is among the highest in Latin America [Adelman and Hihn, 1981].

Assuming that the bifurcation set is stable and positioned as hypothesized in Adelman and Hihn [1981], the combination of income distribution, political participation, and education would have placed Costa Rica before 1961 just inside of the bimodal region. This is consistent with the occurrence of the coup d'etat of 1948. The steady improvement of income distribution since then has moved Costa Rica from a potentially unstable position in Figure 9a to somewhere in area $S_2$ of that figure which, as argued in Section IV, corresponds to the zone of stable countries with primarily redistributive policies and polyarchical institutions.
Venezuela, also, is governed by a parliamentary system. It has had a functioning system of elections since 1958 and a private and, in general, free press. Before 1958, Venezuela was unstable and was governed by several authoritarian regimes. Recently, there has been some internal violence; but, by Latin American standards, it has been well below average intensity. The level of education is high. The income share of the poorest 40 percent of households was fairly constant from 1960 to 1970. At about 9.5 percent [Jain, 1975] it is one of the lowest in Latin America. These combined characteristics clearly place Venezuela inside of the bifurcation set. However, in view of its steadily improving popular political participation, Venezuela is most likely in the zone of compromise of area $C_2$ in Figure 9a. Countries in this zone have primarily open governments and can have either slightly redistributive, compromise, or slightly nonredistributive policy goals. Shifts between these goals can be obtained without drastic changes in political institutions although such changes are not ruled out. With the large oil revenues of the last few years, Venezuela seems to have been making a shift toward increasing economic and social equity. If this continues, Venezuela should have a good chance of moving uneventfully out of the unstable zone into stable area $S_2$.

One of the reasons Venezuela has been able to maintain an electoral system since 1960 is that, while the share of income accruing to the poorest group has been quite low, the middle-income groups have controlled the largest share of income. This income-distribution pattern conflicts with that of most of its neighbors who have had large concentrations of income in the richest 5 percent of their populations. In the 1950s and earlier, Venezuela had little popular political participation. For present levels of education and income distribution, its 1950 characteristics would have placed it in the polarized preference area $C_1$ of Figure 9b; this assignment for the year 1950
is consistent with the political instability experienced by Venezuela throughout the first half of the 20th Century.

Two countries that have had little political participation since 1960 are Brazil and El Salvador [Adelman and Morris, 1973; Gastil, 1978]. Brazil experienced a coup d'état in 1964. It is usually argued that the coup d'état was brought on through mismanagement by the previous regime. However, at that time, there was also a significant shift from redistributive to markedly non-redistributive economic policies. This fact is documented easily by the fall in the income share of the poorest 40 percent of income recipients from 10.3 percent in 1960 to 8.1 percent in 1971 [Jain, 1975]. This decline appears to have continued throughout the early 1970s [Fishlow, 1972]. Brazil now has a bureaucratic authoritarian government in which the elected officials are heavily influenced by the military. The media are private; however, they are presently under self-censorship. There was an increase in repression and internal conflict throughout the 1970s with a possible abatement in repression since that time.

Clearly, the polarization of Brazil during the last 20 years places it squarely inside of zone $C_1$ in Figure 9b. During the 1960s the government increased the nonredistributive nature of the economy, which further polarized the society and forced a need to increase government control and repression to maintain stability. It is interesting to note the differences between Brazil and Venezuela which both have low shares of income for their poorest citizens. Among the countries studied, in Brazil, unlike in Venezuela, the middle-income groups receive close to the smallest share of income and the richest 5 percent of the population receive the largest share. Although there are other distinctions, political participation and income distribution are clearly major components in explaining the differences in the recent political histories of the two countries.
El Salvador has a constitutional political system. Nevertheless, in the last two elections, it has been clear that the government has manipulated the results of the ballot. The media are private; in times of crisis, however, there is censorship. The last coup d'etat was in 1960. During the past few years there has been increasing internal imbalance and violence which have led to the present crisis of 1980-81. The distribution of income appears to have been fairly stable or improving. The share of income accruing to the poorest 40 percent of the economically active population was 11.6 percent in 1961; in 1969, it was 12.4 percent [Jain, 1975]. Adelman and Morris [1973] consider that El Salvador had poor popular political participation in the early 1960s, and Gastil [1978] believes that participation within the country was poor in 1977.

In terms of our model, El Salvador is in zone C1 of Figure 9b. Because of the existence of both left- and right-wing violence in El Salvador, it now appears that the government is in the trough of a bimodal preference distribution and is trying to maintain compromise policies but lacks a center support group. Our model predicts that, unless another dimension not considered in this paper is brought into play, the existing government will be replaced by either an authoritarian, right-wing government or an authoritarian, left-wing government. The present government would have to increase the level of repression even further if it were to stay in power. There is a very slight chance that a call for open elections—which in terms of the model would represent an increase in political participation—would make it possible to maintain a compromise policy. But the existing polarization is so great that it is probably too late for that to occur.

Colombia and Mexico are the only other Latin American countries that have maintained significant degrees of political participation. Both appear
to be politically comparable to other countries in area $C_2$ of Figure 9a. They have similar relatively poor income distributions which were either stable or worsening throughout the 1960s, and both have fairly low levels of education. Colombia has a significantly greater degree of political participation, a functioning polyarchy, and it is presently following a center-to-redistributive economic policy. Colombia also has more internal violence. Mexico is either a near-polyarchy or, more probably, a highly inclusive hegemony, and it has clearly been following a nonredistributive development path. Mexico is probably very close to leaving the zone of compromise and could face some serious political problems in the next few years. Colombia, on the other hand, should be able to follow a more equitable development strategy and to enter stable zone $S_2$ of Figure 9a if political leaders select the proper policies.

Chile and Peru went from high levels of political participation to low levels from 1960 to 1977. In the mid-1970s, both countries also shifted from redistributive to clearly nonredistributive repressive bureaucratic authoritarian regimes. It could be argued that, previously, Peru was in zone $C_2$ and Chile was in zone $C_1$ of Figure 9a. They have now moved into zone $C_1$ of Figure 9b and have highly polarized societies and the potential lying under the surface for violent political instability.

Since 1960, Bolivia, Ecuador, Honduras, and Nicaragua have all been in zone $C_1$ of Figure 9b. They have had poor political participation and relatively poor income distributions [Jain, 1975]. As predicted, Bolivia and Ecuador have had approximately seven coups d'état during the last 20 years and have switched back and forth from slightly redistributive to slightly non-redistributive economic policies. In 1980, Nicaragua went from an increasingly repressive authoritarian, nonredistributive regime to an authoritarian, highly
redistributive regime. Honduras had coups d'état in 1963, 1972, and 1975 which appear to have resulted in policy changes from slightly redistributive to slightly nonredistributive orientations.

The remaining countries to be discussed are Argentina, Panama, and Uruguay. They do not appear to fit the model quite as well as do the countries discussed above. Based on the share of income accruing to the poorest 40 percent of households and on their education levels, all three countries belong in area $S_2$ of Figure 9b. This means that they should be stable regardless of their levels of political participation. However, all three countries have had coups d'état within the last 15 years. But while, in all of these countries, the share of income accruing to the poorest over prolonged periods of time is not bad by Latin American standards, in Argentina and Panama the share accruing to the technocratic elites and to the middle classes has been rather small. The redistributive struggle in these two countries has, therefore, been over redistribution from the very rich to the educated elites rather than from the upper income groups to the poor. It should be noted in this context that it is the educated elites who suffer the most from slow growth. Their attempts to secure a larger share of the pie, therefore, take the form of a revolt against economic mismanagement rather than, as with the poorest, a revolt over access to land and jobs. The political histories of Argentina and Panama, therefore, still fit our model if account is taken of the equity of the entire distribution of income, not only of the share going to the poorest.

Argentina is a bureaucratic authoritarian polity with a relatively equitable distribution of income, and it has high levels of education. However, the income share accruing to the 80-95 percentile is low relative to that of most other Latin American countries. This means that many of the technical
elite are not being as highly rewarded as are their counterparts in other Latin American countries. Also, while there are no post-1970 data, there is reason to suspect that the distribution of income to the poorest has been deteriorating since the institution of recent policies that have been nonredistributive. Terrorism and violence as a means of censoring the Press have increased. During the last 40 years, Argentina has suffered from a low rate of growth caused by simultaneous mismanagement of the economy and frequent changes in economic policy. These have lead to oscillations between slightly redistributive and wholly nonredistributive policy orientations.

Panama has an authoritarian government which has recently been permitting the expression of opposition viewpoints. But, whereas the poorest members of society are relatively well rewarded, the income share for the middle-income group is unusually low. Therefore, the distribution of income is not as equitable as it appears on the surface. Compared with other Latin American countries, Panama had unusually high ratios of school enrollment throughout the 1970s (see Table 1). Before the coup d'etat in 1968, the level of education was significantly lower than it is now and the income distribution was less equitable than it is at the present time. These data would have placed Panama in the early and mid-1960s to the back and right of Figure 9b. Combined, these conditions have generated the stresses that have created the pressures for the incumbent politicians to maintain a hegemonic regime. It should be noted that, at the present time, Panama appears to be fairly stable.

The last country for comparison is Uruguay which has a bureaucratic authoritarian polity. It had a relatively equitable distribution of income across the whole spectrum of the population and a high level of education in 1967. The position assigned to Uruguay in Figure 9b \( (S_2) \) is based on 1967 income distribution data. Therefore, its economic and social participation do not provide a source for explanation of the change in political institutions.
Huntington and Nelson [1976] argue that, for countries in the later stages of development, the significant political conflicts are more likely to be over choices between growth and political participation rather than between equity and political participation. This theory appears to be very applicable to the political and economic developments in Uruguay and Argentina. Both countries have experienced economic mismanagement and very low growth rates. The 1973 coup d'etat in Uruguay appears to have been over extremely low growth rate and general mismanagement which our model has not been designed to capture. However, it should be noted that the closing of the Uruguayan General Assembly in 1973 did not, at first, lead to any significant changes in orientation of the economic policy. Therefore, in a certain sense, our model is correct. It is only the major policy changes that occurred later that are now resulting in a significant reduction in the income share that is being accrued to the working class.

V. CONCLUSIONS

The present study is an initial exploration into the uses of catastrophe theory for the explanation of the socioeconomic origins of political instability. It incorporates, in simplified form, the major ideas inherent in existing paradigms of political science; and it provides a vehicle for modeling mathematically some aspects of comparative politics. The model was validated in an application to the analysis of the political history during the past 20 years of 15 Latin American countries.

It appears that there exists significant empirical support for the proposed theory. However, the results should be considered as suggestive rather than as conclusive. Also, more experience with the application of catastrophe manifolds to the social sciences is needed to ascertain their ultimate usefulness as tools for the analysis of socioeconomic and political phenomena.
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FOOTNOTE

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