Profiles of States as Fuzzy Sets: Methodological Refinement of Lateral Pressure Theory

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Abstract

One of the most serious challenges in international relations pertains to the theory and measurement of transformation and change. This paper proposes, and then develops a conceptual and methodological extension in the measurement of change within and across states as postulated by lateral pressure theory.

It argues, and shows, that by conceptualizing the profiles of states identified by lateral pressure theory using fuzzy logic, we can systematically and precisely locate and track relative changes in the distribution of states within and across profile spaces, across geographical regions, as well as over time. This may be an important step towards identifying and possibly anticipating changes in the configuration of states, including conflict-prone constellations, before they escalate into conflict or war. It may also improve our understanding of those regions of the world and help articulate the implications of significant geopolitical changes as they occur.

Keywords: lateral pressure theory, fuzzy sets, international relations, conflict prevention

Introduction

One of the most serious challenges in international relations pertains to the theory and measurement of transformation and change. This paper proposes, and then implements a conceptual and methodological extension in the measurement of change within and across states. By conceptualizing and then measuring the profiles of states identified by lateral pressure theory using fuzzy logic, we can systematically and more accurately locate and track changes in the distribution of states throughout the international system, as well as identify and possibly anticipate volatile and potentially destabilizing movements within and across profile spaces, geographical regions, as well as over time. Moreover, we show that by applying fuzzy logic to better understand the dynamics of lateral pressure may also allow a more accurate analysis of regions of the world where significant geopolitical changes are taking place.

This paper is in four parts. The first focuses on theory. We briefly sketch the main precepts of lateral pressure theory, summarize the literature on the subject to date, and highlight some implications for international relations theory. The second section deals with methodology. We present a way to operationalize and conceptually and methodologically refine lateral pressure theory by applying fuzzy logic to lateral pressure theory. The third section links theory and method. We articulate the methodological steps associated with the application of fuzzy set theory to lateral pressure theory in greater detail, and illustrate how this strategy can be used to precisely locate, visualize, and perhaps even anticipate the kinds of state constellations and trajectories lateral pressure theory postulates to be potentially conflict- prone. The fourth section summarizes and concludes.

1   Lateral Pressure in International Relations

1.1   The Importance of Three Master Variables

Lateral pressure refers to any tendency of individuals and societies to expand their activities beyond their established boundaries, - whether for economic, political, military, scientific, religious or other purposes (Choucri and North, 1975; Ashley, 1980; Choucri and North, 1989; Lofdahl 2002). In the context of the study of international relations, the theory of

lateral pressure was developed as an offshoot of the behavioral analysis of politics, reported early on in Russett(1972) and Tanter and Ullman (1972)among others. Lateral pressure theory seeks to explain the relationships between domestic *growth* and international *behavior* and puts forth specific propositions for why certain types of international behaviors or activities appear to be more prevalent for some countries than others.[1] Choucri and North (1972) first formulated the theory of lateral pressure, by postulating that the configuration of the modern state system, as well as the sources of conflict within and among them, is rooted in the uneven growth and development of three critical drivers: population, technology (knowledge and skills), and access to basic resources.[2]Shifts in these three variables are highly interactive. Increases in population and advances in technology, for instance, generate new demands for resources. Several strategies can then be pursued to satisfy these demands. Efforts at generating technology and resources within the borders of the state may be launched. If these prove unsuccessful or too costly, and domestic demands and capabilities surpass a certain threshold, the search for resources and technology typically expands beyond state borders.[3] While other scholars had signaled the importance of resources in international relations from different theoretical perspectives, such as Renouvin and Duroselle (1967), Aron (1967), and Morgenthau (1948), they did not fully articulate the systematic linkages between state attributes on the one hand, and behavioral patterns on the other, nor did they differentiate systematically among the various attributes of states in the international system.

In this regard, lateral pressure theory argues that the nature and mode of the expansion that is in fact undertaken is an important determinant of subsequent actions and reactions among states. Decisions on what bargaining and leverage modes to employ towards another state in the process are shaped in part by each side's real or perceived capabilities. The latter, in turn, greatly depend on the relative prevalence of population, technology, and

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[1]Lateral pressure is a relatively neutral concept similar to what Pitrim Sorokin (1957, 565) called economic expansion and economist Simon Kuznets (1966, 334-348) referred to more broadly as outward expansion. The strength of a country's lateral pressure is generally taken to correlate positively with its power as conventionally understood.

[2]Obviously, the three master variables are only one of many ways to conceptualize and measure uneven growth and development of states.

[3]Note, however, that a country will only act on its inherent disposition to reach beyond its borders to satisfy growing domestic demands, if it is capable of doing so. Many countries with populations whose basic needs are unmet lack the capabilities to reach beyond their borders, and thus do not engage in the activities generated by lateral pressure (Choucri and North 1975).

basic resources of that particular country, and are also influenced by its standing in relation to all other states in the international system.[4]

The historical record seems to suggest that states which (due to rapidly advancing technology, and thus comparatively high levels of capabilities and a real and perceived need for additional resources) generate the highest levels of lateral pressure and fight more wars per country than other states (Choucri and North 1989, North 1990).

Interestingly, other prominent scholars in the study of international relations, most notably Organski (1958), as well as Organski and Organski (1961), signaled the importance of population dynamics in international relations. More recent research has since extended these foundations (Organski and Kugler 1980; Kugler et al. 1984; Kugler and Lemke 1996, and Arbetman and Kugler 1997), with special emphasis on articulating theoretically and empirically concepts of the political capacity of states, all of which bear upon the propensity toward war. The emergent literature on the political capacity of states provided an added theoretical impetus for the development of the concept of state 'profile' within lateral pressure theory. It argued that specific state profiles tend to exhibit similar levels of political capacity. Whether and how the two may be causally linked remains an empirical question. We raise the issue here mainly to highlight key linkages across concurrent lines of research in the study of international relations.

The theoretical implication at this point is the implicit proposition that the concept of political capacity, as defined and measured by Organski and Kugler (1980) and Arbetman and Kugler (1996) is not orthogonal to, but rather supplements and provides some further differentiation of characteristics that may be derivative of state profiles. As of yet, whether and how the specific state profiles and their respective types of political capacity are related or may be causally linked remains an interesting empirical question. We raise the issue here mainly to highlight key linkages across concurrent lines of research in the study of international relations.

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[4]Also note that, while the dynamics of international conflict are rooted in internal stresses and processes, they can be exacerbated by modes of external reactions to internal stresses. In other words, there are feedback dynamics from the international system back to the domestic system which may then affect the internal disposition of, and/or the interactions among the master variables and propensities for internally induced pressures.

1.2 Behavioral Implications of Uneven Growth and Development

Accordingly, lateral pressure theory postulates that uneven growth and development of the three master variables — namely: population, resources, and technology — within and relative to other states has, under certain conditions, behavioral implications and can be an important antecedent condition for conflict and war. Lateral pressure, however, is seldom if ever a direct trigger for conflict and violence. The theory stipulates only that lateral pressure has the potential to magnify or activate conflict, and posits a set of intervening variables and a wider array of proximate stimuli as we will outline further below. Potentially conflict-prone intersections of interest abroad between states which are expanding their activities beyond their borders, for instance, are most likely to turn violent when relations between these states are already hostile, or at least one of them perceives the other as a rival, threat, or as overtly violent (Choucri and North 1989, 296)

The list of postulated immediate or proximate stimuli also includes subjectively generated perceptions, affects, and human decisions (Choucri and North 1989, 297). Leaders thus ultimately have a choice about which bargaining and leverage modes and strategies to employ towards other states. The nature of these bargaining and leverage modes greatly influences the outcome of an interaction. They introduce indeterminacy and deviation into an otherwise deterministic view of state action shaped solely by the constellation of the three master variables, or profiles, within and across countries (Choucri and North 1989).

Nevertheless, interactions within any dyad of states in the international system are conditioned in important ways by the profiles of the particular states involved (North 1990, 151). Thus, although state action and its outcomes are ultimately indeterminate and influenced by an array of proximate stimuli, uneven growth and development in the three master variables within and across states provides 'base-line conditions' and greatly influence the likelihood of, as well as set the stage for potentially antagonizing processes.[5]

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[5] Other scholars share this view. Gilpin (1987, 54-55), for instance, also stressed the importance of uneven growth and development, in ways that are entirely consistent with the precepts of lateral pressure, as is his articulated logic of unevenness in growth and development as a basis for comparing realist and Marxist logics relating uneven growth to political conflict and violence.

1.3 Intensifiers of Conflict Propensity

Lateral pressure theory postulates several conditions under which interactions between states in the international system appear to be particularly prone to escalate into conflict and violence.

First, *geography matters*. North (1990) hypothesizes that one of the reasons why many of the potentially conflict-prone power transitions that result from uneven growth and development actually pass unnoticed because the states involved are too far removed from each other. Conversely, shifts in the constellation of the three master variables within and across states which are in close proximity to each other in a particular region can be particularly destabilizing, even more so if those states perceive each other as rivals and competing for (global or regional) dominance.[6]

Second, *interactions between major powers* tend to be more conflict-prone, as they are typically the ones experiencing high degrees of lateral pressure due to high capabilities and demands for resources spurred by advanced levels of technology (Choucri and North 1989).

Third, *velocity matters*. The lateral pressure approach greatly emphasizes the importance of the velocity of movements of the three master variables within and across states as an indicator of war-proneness in the international system (North 1990, 150). The greater the speed of transformations, the greater the degree of instability and potential for conflict it generates.[7]

Fourth, state interactions are particularly conflict-prone where there are fundamental threats to life-supporting properties, and the *natural environment* of one or more of the contenders *is not resilient enough* to cope with stresses generated by social interactions or disruptive changes in social systems.[8]

In sum, therefore, accurately gauging the empirical likelihood of conflict between states using the lateral pressure approach is a tall order, as it involves effectively metricizing the master variables, operationalizing state profiles, and the resolution of inter- and intra-temporal inconsistencies in concepts and in measurement. Nonetheless, robust foundations

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[6]This so-called proximity hypothesis has been explored extensively. See for instance Diehl (1991), Bremer (1992), and Vasquez (1995).

[7]In their formulation of power transition theory, Organski and Kugler (1980) share this view. They surmise that rates of growth and development impact the probability for conflict, and that the likelihood of war correlates positively with the speed at which a challenger overtakes a dominant state.

[8]By life-supporting properties we mean attributes of the natural environment without which human life could not sustain itself, such as reasonably clean air, water, and the like.

for any empirical initiative are essential if it is to contribute to the current body of knowledge in international relations. In the following, we briefly summarize the literature on lateral pressure theory to date.

1.4 Evolving Literature: Highlights and Milestones

Early formulations, such as by Choucri and Bennett (1972), Choucri, Laird and Meadows (1972) as well as the empirical studies reported by various authors in Russett (1972) cumulated in a first full formulation of the theory by Choucri and North (1975). Subsequently, an empirical analysis of growth and development in Japan over the span of a century led to more detailed empirical analyses including extensive simulation and retrospective forecasting framed analytically in Choucri and North (1989), and tested quantitatively in Choucri, North, and Yamakage (1992).[9] Pollins and Schweller (1999) presented a more recent empirical test of the lateral pressure theory applied to U.S. foreign policy over time.

In terms of methodology, the dominant forms of inquiry into the theory of lateral pressure to date have been statistical analysis, econometrics, system dynamics and a wide range of simulation methods.[10]

A persistent dilemma remained, however. Research to date has focused on one or a select number of states and spanned relatively short time frames only, and thus by necessity obtained only a partial perspective on contexts, boundaries, and overall system configuration. To address this dilemma, Choucri and North (1993a, 1993b) defined a coherent framework of the 'global system,' and reasoned that that all states in the international system dispose of a certain share of the global total of population, resources, and technology. They argued that measuring the size and rate of growth of these shares relative to each other domestically and in relation to those of other states in the international system over time provides the needed methodology to determine state profiles as well as their relative capabilities, identify the potential challenges that each might face, and the implications for the landscape of states in an overall integrated global context. The formal definitions of state profiles in

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[9] Levy (1989) reviews the former piece as part of a comparative study of major theories of the causes of war.

[10] All rest on the assumption that the variables in question are measured accurately, reliably, and effectively, and that the robustness of functional relationships can be 'tested' through a range of formal and statistical (econometric, for example) as well as notional and relational methods (as in the case of system dynamics). And usually some type of error estimates or uncertainty bounds are made to indicate the extent of reliability attributed.

Table 1 shows the profile logic as a function of unequal shares of technology, resources, and population.[11]

According to this logic, for some countries, the share of the global total population is greater than their individual respective shares of technology and resources. Such countries can be referred to as population-intensive. The same logic holds with respect to the relative ordering of the other two variables for an individual country.

INSERT TABLE 1 HERE

The important point here is that the three master variables underlying state profiles are dynamic in nature, and as the magnitude of any one of them relative to any of the other two may change over time, profiles of individual states can also change over time. A change in profile essentially results from one or more of the shares of the global total of P, T, and R changing ranks. Figure 1 illustrates this anatomy of the profile spaces. It can be used to visualize movements of states within and across profiles, and provides the conceptual anchor for the application of fuzzy set theory to lateral pressure that follows.[12] We do not postulate a developmental process as a particular normative logic here, but only refer to the *change* in the relative positions of the master variables. This is the logic underlying the circular sequence of profiles shown in Figure 1.

INSERT FIGURE 1 HERE

The overall logic of Figure 1 holds, all other things being equal, irrespective of the rates of changes. Moreover, it can also be used as a tool to visualize velocity or acceleration, both potential intensifiers of conflict, in addition to the path of change of particular countries within and across profile spaces over time. In the context of Table 1, for any given state in any particular profile, changes in profile location always happen along the sequence in the

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[11]In this specification, Profile 3 and 4 are reversed from that of Lofdahl (2002) and Choucri and North (1993b) to show the relative 'positioning' of each of the master variables in an internally consistent way. This reversal does not affect the conceptual logic at all. North (1990: 122 ff) provides verbal descriptions of the ideal-type characteristics of the respective profiles. Subsequent and ongoing efforts towards empirical operationalization of profiles have since sharpened our understanding of his theory, and revealed some inconsistencies which still need to be addressed. We therefore do not replicate North's verbal accounts of profile characteristics here.

[12]Note that all axes in Figure 1 are time axes, with the center designating the first year for which data is available. Figure 5 further below shows a section of this circle in more detail.

circle, regardless of speed.[13]

Choucri and North also argued that the 'shares' concept allows for a better measurement of potential leverage and bargaining employed by states in dealing with each other, and of the degree of (potentially conflict-prone) lateral pressure they might, in turn, be generating.[14] It also provides an internally consistent empirical metric for normalizing shifts in master variables and hence a better anchor for measurement over time and across entities.

Ever since the introduction of the notion of 'global shares' as defined in Table 1 above by Choucri and North (1993b), a great deal of effort has been directed towards operationalizing lateral pressure theory, collecting and consolidating the data necessary to assign each state in the international system to a particular profile category, and tracking the movements of the three quantities that shape and shift them across time and space. Empirical data has also been compiled for other behavioral variables (such as trade, military expenditures, patterns of violent behavior, and so on) as well as a wide range of environmental variables that are regarded as illustrative of the impacts of human behaviors on natural systems.[15]While earlier computations of state 'shares' of individual master variables were done for one point in time, more comprehensive analyses using longitudinal data have since been undertaken, some results of which are reported below.

2 Metrics, Methods, and Research Design

In terms of metrics and methods, this paper focuses on two specific aspects of ongoing research into the dynamics of lateral pressure. First, it quantitatively operationalizes the three master variables, and thus identifies profiles empirically, and shows the distribution of

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[13]To be sure, if changes in master variables are very rapid, yearly data of the global shares of P, T, and R, and thus, the profile of a country may be too "coarse" to reflect all profiles along the trajectory the country traveled through to get from one profile in year (t) to another in year (t+1). This does not mean, however, that the country skipped an adjacent profile. It would simply mean that yearly shares data was not adequate to pick up the steps along the circle a country traveled through between non-adjacent profile spaces. We will illustrate the visualization of velocity in Section 3.2, further below.

[14]This concept of 'share' and its quantitative rendering is to be distinguished from the notion of 'relative gains' in the context of realist theory and the debates engendered in the field. Despite some commonalities, the major difference lies in the holistic view of 'shares' whereby the value of each state-ownership for each of the master variable is computed relative to the global total for that variable.

[15]Most notably, Lofdahl (2002) analyzed what he called "environmental lateral pressure." Moreover, Kamiya and Wils (1998)showed the dynamic interconnections among population, resources and technology, and Wils, Kamiya, and Choucri (1998) empirically tested the relationship between profiles and patterns of external behaviors including propensities for conflict and violence.

states across profile groups, as well as transformations in the global landscape *across* profiles over time.

Second, it measures the degree of 'belonging' to the respective profile at a given point in time in order to precisely determine empirically the distribution of states within each profile group and across profile spaces. By applying fuzzy logic to the longitudinal empirical profile data at hand, it then determines the extent to which individual states shift location within the profile spaces as shown in Figure 1 above. Earlier formulations of the theory of lateral pressure did not address the issue of changes in the distribution of states within profile groups, nor does the related literature in quantitative international relations, as reviewed briefly above, provide generic or specific guidelines for addressing this distributional issue, theoretically or empirically. This is where we find applications of fuzzy sets to provide an important contribution to the overall tools of inquiry in the field.

2.1 Profiles of States: Empirical Analysis

In line with theoretical assumptions, the measures for technology, population, and resources for a given state have been calculated as shares of the global total of the respective variable in any particular year. While measuring population is relatively straightforward, operationalizing resources and technology within and across states is much more difficult. As a first approximation, and with the appropriate caveats and limitations in mind, territorial size has been chosen as a proxy for the amount of resources available to a country, and GNP

as a proxy for the level of technology.[16]

To illustrate, Table 2 shows the profile labels and how the six categories are derived from the respective size of their global shares of T, R, and P for select countries at one point in time.

INSERT TABLE 2 HERE

Whereas Table 2 presents the location of six countries in different profile groups at one point in time only, Table 3 lists another set of countries which have changed their profile over time, between 1971 and 1991.[17]

INSERT TABLE 3 HERE

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[16]North (1990, 120) delineates the rationale and limitations of the decision to operationalize the master variables in this manner in more detail. This logic is supported by Kindleberger (1962) and to some extent by Renouvin and Duroselle (1967) as well as by Aron (1967) and Sprout and Sprout (1957). We clearly appreciate the limitations of our selection of indicators for technology and resources. More accurate proxies for the level of technology of a country include the number of patents, publications, inventions, and recognized innovations in a given country, among others. Such observations, however, can be collected only for countries that track these variables, or in which the respective behaviors are manifest in the first place. Using these proxies for technology would thus have severely limited our spatial domain, and effectively prohibited the meaningful calculation of global shares. However, we have *some* confidence in our proxy in spite of its limitations, given that, interestingly, the correlation between GNP and the aforementioned alternative proxies of technology is generally quite high, at over 0.75. The dilemmas associated with measuring "resources" are at least as complex as those related to "technology". Area, or territory, is clearly an indicator of limited value - Kindleberger (1962) notwithstanding. Whereas for a key resource such as oil, the correlation between area and oil production is indeed high for some countries (notably, well over 80 percent for the oil exporting countries), it is much lower for the broader spatial domain our research encompassed. The nature of the relationships changes, clearly, as we consider different resources individually (such as, for instance, minerals, or water). In the absence of an agreed-upon and robust aggregate indicator for all resources, we consider area a good choice, given its clarity and transparency, despite its obvious limitations. It also affords us the broad temporal and spatial coverage needed to calculate meaningful global share values and identify trends over time.

[17]Table 2 and 3 provide data from a sample of countries only, to show how profiles are defined and how some change locations across profiles, respectively. The selection of countries shown here is arbitrary. The tables are for illustrative purposes only, and not intended for probabilistic statistical interpretation. The data from which the profile computations shown in Table 2 and 3 are derived are from the World Bank (World Development Report, World Tables, various years), the International Monetary Fund, and United Nations Statistics (various years). Since this research effort was initiated long before the availability of electronic files, the data were at first compiled manually, each observation checked for consistency across sources, and basic (pre-web) accuracy checks and rechecks were undertaken. Since then, such data have been made available electronically, and downloading now greatly facilitates updating. Recently, the United Nations has integrated most of its own and related international agency information in single web sites, serving as a common portal, but also as a centralized location of records. See Ward (2004) for a review and analysis of the United Nations statistical system. Note, once again, that our research design required that we obtain empirical data for all three master variables, for all countries, for any one given year. By definition, global shares, and then profile categories, as shown in Table 2 and Table 3 could only be computed if data were gathered for the entire global spatial domain to begin with. By necessity, therefore, these country-specific observations are a function of adopting an overall global perspective.

If we compare the observations for each variable and country at these two separate points in time, we gain insights into transformation and change. For instance, we observe clearly that some countries change their profile locations within the overall global system over time, while others do not. Table 3 shows only cases in which shifts in the ranking of master variables, and thus changes in profiles, occurred between 1971 and 1991.

By completing the first task in this paper, namely representing state profiles empirically, we have now provided the necessary foundations for turning to the second task, namely measuring the distribution of states within profile spaces.

2.2 Fuzzy Logic and Lateral Pressure Theory

2.2.1 Value of Fuzzy Set Theory

Exploring fuzzy set theory as a tool to systematically measure and track unevenness of growth of states within and between profile categories is an important step in helping improve understanding of the dynamics of conflict and, by extension, perhaps also of ways in which conflict may be mitigated or prevented altogether. Toward this end we first briefly retrace the evolution of fuzzy logic, and delineate the characteristic features of fuzzy sets and ways in which fuzzy logic differs from conventional logic. We then consider its strengths as a tool for the analysis of transformations and change in international relations.

Fuzzy set theory evolved as an alternative to conventional bivalent logic which is based on the Aristotelian law of the "excluded middle", which assumes that every proposition must be either completely true or completely false. Following Plato, Hegel, Marx, and Engels, Jan Lukasiewicz challenged this view, and introduced a three-valued logic where the third value is assigned a numeric value between "true" and "false." His concept was later extended to infinite-valued logic. Fuzzy logic, developed by Lotfi Zadeh (1973) almost four decades ago, is predicated on this idea of a fine-grained gradient within the true/false realm. Zadeh introduced the concept of fuzzy set defined as a class of objects with a continuum of grades of membership. Such a set is determined by a membership characteristic function that assigns to each object belonging to it a degree of membership value ranging between zero and one.

Fuzzy logic differs from classical probability theory in that it does not determine whether and how likely a given statement is true or false, but rather the *degree* to which a statement

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is true or false. Fuzzy logic deals with the degree of membership. In contrast to conventional logic, which deals with crisp Boolean true/false dichotomies, fuzzy logic attempts to encompass situations in which the distinction between true and false is fuzzy, and a partial truth, a gradient within the true/false realm can be established. In contrast to conventional set theory, fuzzy set theory accommodates partial membership in a set, and assigns a degree of membership value ranging from zero (designating non-membership) to one (designating full membership).It is also important to bear in mind that fuzzy logic is similar, but not identical to probability theory. Whereas probability refers to the likelihood that something is true, fuzzy logic establishes *the degree* to which something is true, or within a membership set.[18] Classic logicians tend to deny the need for accommodating this "fuzzyness," and attribute it to imprecise definitions of terms.[19]

Ultimately, our judgment on whether fuzzy logic can be gainfully applied to reality seems to hinge upon what we perceive to be the nature of truth and falsity. If 'true' and 'false' are in fact discrete categories, more precise definitions will eliminate any perceived fuzzyness that fuzzy logic may otherwise capture.[20] If they are not, however, fuzzy logic provides a useful tool to understand and metricize the shades of membership among seemingly mutually exclusive sets. In traditional probability theory, for instance, only one of the two statements "The weather is hot," and "The weather is cold" can be true. The weather, in other words, can belong to either the hot set or the cold set, but not both at the same time. In fuzzy set theory, by contrast, both statements can be true at the same time, with different degrees of truthfulness.

This ability of fuzzy logic to accomodate intermediate shades which cannot be adequately captured with discrete exlusive categories is especially relevant to the study of international

[18]For a more detailed account of the circumstances under which fuzzy sets are applicable and the differences between probability and fuzzy sets see Kickert (1978) and Dubois and Prade (1993).

[19]A frequently used illustration of the dispute between formal logicians and proponents of the usefulness of the fuzzy set approach uses the color palette, and goes as follows: Imagine a color that appears to be predominantly green to some people, even though it has some blue hues, whereas others categorize the same shade as predominantly blue, while perhaps acknowledging that it looks somewhat greenish, as well. Fuzzy set theory accommodates this 'fuzzyness' by assigning membership degree values, to designate the extent to which the given hue is a member of set of 'blue' and 'green', respectively. Formal logicians, by contrast, often argue that the difficulty of assigning the hue to either color category arises merely as a result of imprecise definitions of the respective sets. If 'blue' and 'green' were precisely defined, they argue, as any hue which consists of no less than 80 percent of the respective color particles, for instance, we would have no difficulty assigning the given blue-greenish hue to either one of the color categories, and be able to state that it is, by virtue of our definition, exclusively a member of one category.

[20]This point has been made by Haack(1979).

relations, given the inherent ambiguities with content and context. As Cioffi-Revilla (1981: 130) notes, there are numerable collections of objects in international relations worth analysis which defy any exact definition of boundary, such as the set of "developed states", "powerful states", as well as the set of "U.S. policy objectives". The intrinsic fuzzyness of these sets does not stem from imprecise measurement, and thus cannot be solved by an arbitrary increase in measurement accuracy, but is a result of the inherent fuzzyness of international relations and foreign policy, and human thought, more generally.[21]

2.2.2 Relevance to Lateral Pressure Theory

Fuzzy logic is particularly appropriate to model situations that are characterized by inherent ambiguities or fuzzy transitions, such as smooth and unnoticeable drifts among states of affairs that cannot be captured accurately by imposing discrete, clearly distinguishable categories at any point in time. [22] Shifts of countries within and among profile categories as described in lateral pressure theory seem to fall into this realm since the theory assumes only that all share some common features, namely meeting the criteria for belonging to a particular 'profile', but not that that all states in any one category are identical to each other. No other insights or inferences are put forth or drawn from the formal definition of profile. North (1990, 121) especially cautioned that, despite the notion of six discrete profile categories, movements among and within them should be conceived of as dynamic, and happening along a continuum, rather than as abrupt jumps from one discrete state to another. Fuzzy set theory thus seems particularly appropriate for systematically and coherently measuring change in terms of the speed and direction of movements of states within and across the profile spaces.

By conceptualizing the profiles of states identified by lateral pressure theory using fuzzy logic, we can systematically and precisely locate and track relative changes in the distribution of states within and across profile spaces, geographical regions, as well as over time. This may be an important step in identifying and possibly anticipating changes in the configuration of states, including conflict-prone constellations, before they escalate into conflict

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[21]See Cioffi-Revilla (1981) for a more extensive explanation and examples of fuzzyness in international relations.

[22]Applications of fuzzy logic are not very common in the international relations literature. Notable exceptions include Cioffi-Revilla (1981), Sanjian (1992, 1998, 1999, 2001, 2003), and Seitz (1985).

or war.[23]

3 Application of Fuzzy Set Concepts, Method, and Analysis

3.1 Fuzzy Set Formulation

To formulate the concept of state profile, let t_{ij}, p_{ij}, and r_{ij} be the measures of technology, population, and natural resources respectively for country i (i=1..c) at time j (j=1..t). For a given i and j (say, i=1; j=1), let T_{11}, P_{11}, and R_{11} be the proportions of country 1's technology, population, and natural resources respectively during t=1.

$$T_{11} = \frac{t_{11}}{\sum_i t_{i1}}$$

$$P_{11} = \frac{p_{11}}{\sum_i p_{i1}}$$

$$R_{11} = \frac{r_{11}}{\sum_i r_{i1}}$$

For any given year, based on their T, P, and R shares, we can identify the profile category of each state *across* all states in the international system as represented in the database. Using fuzzy set theory, we can then locate and compare states *within* one profile category according to their respective distance to an adjacent profile category by assigning a membership degree value to each state. In fuzzy set theory, membership degree values range from [0,1], with 1 designating full membership in a category (in our case a state located in the center of a profile space) and a value close to 0 designating near non-membership in

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[23]Membership degree values can also be used to compare countries within the same profile, and draw valuable lessons on how certain strategies may be replicated by other members of the same category some developed that may be readily applied to others in the same category who may want to follow a similar trajectory to escape the predicaments associated with certain profiles. The underlying assumption here is that some profiles are more desirable than others, and that, unless it already belongs to a desirable category, every state in the international system ultimately aspires to transform its profile into one of these "better" ones. A brief glance at the lists of members of the respective profiles in Table 2 further below does in fact suggest a correlation between profile membership and what we would commonly label as 'quality of life' the respective countries afford the people living within their borders. Although this issue is an intriguing subject that certainly merits further inquiry, we do not address it here. North (1990), as well as forthcoming research deals with this matter extensively, as well as with related questions on common developmental trajectories, and the ways in which one could launch more countries along these paths to a better future.

a category (which in our case would be a state located close to the order to either one of the two adjacent profile categories in the circle shown in Figure 1 above). A low value for membership degree value thus means that the respective country may soon change profiles, since only minor changes in master variables would lead to such a change.[24]

A fuzzy set S can be defined through a function: $\mu_S: C \to [0,1]$ that maps the elements of the universe C (here, the universe of all countries) into $[0,1]$. μ_S is the *membership function* of a fuzzy set. For example, for countries that fall into the category of profile 1,the set $S_1 = \{x \in C \mid P(x) = 1\}$ is defined using the membership function. Figure 2 illustrates this function, assuming a triangular distribution.[25]

INSERT FIGURE 2 HERE

In Figure 2, the complete triangle in the center represents the membership function for profile=6, defined as one in which the global share of technology is greater than the one of population, which in turn is greater than the global share of resources $(T > P > R)$. The incomplete triangle for profile 5 $(T > R > P)$ is shown to the left, and the one for profile 4 $(P > T > R)$ to the right.[26] A change from profile 5 to profile 6 implies that R and P switch ranks. Therefore, somewhere prior to the switch to profile 6, the value of $(R - P)$ starts decreasing until it eventually reaches zero. At this very point, the switch between the two variables takes place. Once the switch occurs, the value of $(P - R)$ increases. Along the way, $(T - P)$ starts decreasing in value until it, too, reaches zero. This is the point at which a switch from profile 6 to profile 4 takes place. If we assume the distribution to take the shape of a symmetric (equilateral) triangle, the highest membership degree value occurs mid-way in between these points, where $P = \frac{T-R}{2}$.

INSERT FIGURE 3 HERE

[24]To be sure, low membership degree values do not mean that profile changes are imminent. In some cases, master variables may change very little over time, and thus in fact not 'travel the distance' that would effect a change, even though that distance may be very short.

[25]Membership functions are defined using appropriate distributions, depending on the domain at issue. They may, for instance, be bell-shaped, trapezoid, or triangular. We tested the empirical distribution of data points and found a triangular distribution to be a good approximation for our domain.

[26]Note that the representation of three profiles in one diagram serves illustrative purposes only. Strictly speaking, Figure 1 is misleading, because the horizontal axis in the graph is meant to denote the variable at the center of the respective profile inequality, which is not the same for the three profiles shown. The main distribution of interest, profile 6, is juxtaposed $(T > P > R)$ with the two adjacent distributions (profile 5 $(T > R > P)$ to the left, and profile 4 $(P > T > R)$ to the right for illustrative purposes only. The remaining profiles can be represented analogously.

In Figure 3, consider the left half of the triangular distribution represented by the triangle ABC with P and μ as the horizontal and vertical axes, respectively.[27] Assume the height of the triangle (namely, the length (BC)) to be 1, representing the maximum value of the membership function (μ). The base of the triangle, (AC), is of length ($\frac{T+R}{2} - R$). Now, consider any point on the base of the triangle (for instance, E) and the corresponding triangle ADE. If $P = p$ at E, the base length of ADE is of length (AE), or ($p - R$). Therefore, for any point P on the horizontal axis between A and C, the length is ($P - R$).

We know

$$\frac{length(BC)}{length(AC)} = \frac{length(DE)}{length(AE)}$$

i.e.,

$$\frac{1}{\frac{T+R}{2} - R} = \frac{length(DE)}{P - R}$$

i.e..

$$length(DE) = \frac{P - R}{\frac{T-R}{2} - R}$$

Length(DE) is the membership value at E. Similarly, we can calculate the membership degree value at any point in the range $P = \frac{T+R}{2}$ and $P = T$. We can then represent the membership function for countries in profile=6 as:

$$\mu_{S6}(T, P, R) = \begin{cases} 1 & \text{for} \quad P = \frac{T-R}{2} \quad \text{(maximum membership)} \\ \frac{P-R}{\frac{T-R}{2}-R} & \text{for} \quad R \leq P < \frac{T+R}{2} \quad \text{(towards 5)} \\ \frac{T-P}{T-\frac{T+R}{2}} & \text{for} \quad \frac{T+R}{2} < P \leq T \quad \text{(towards 4)} \\ 0 & otherwise. \end{cases}$$

By symmetry, we can write the membership functions for the other profiles as follows:

$$\mu_{S1}(R, P, T) = \begin{cases} 1 & \text{for} \quad P = \frac{R+T}{2} \quad \text{(maximum membership)} \\ \frac{P-T}{\frac{R+T}{2}-T} & \text{for} \quad T \leq P < \frac{R+T}{2} \quad \text{(towards 3)} \\ \frac{R-P}{R-\frac{R+T}{2}} & \text{for} \quad \frac{R+T}{2} < P \leq R \quad \text{(towards 2)} \\ 0 & otherwise. \end{cases}$$

---

[27]Note that since we only show one profile here, we can now label the horizontal axis as representing its center variable, namely P.

$$\mu_{S2}(P, R, T) = \begin{cases} 1 & \text{for} \quad R = \frac{P-T}{2} \quad \text{(maximum membership)} \\ \frac{R-T}{\frac{P+T}{2}-T} & \text{for} \quad T \leq R < \frac{P-T}{2} \quad \text{(towards 4)} \\ \frac{P-R}{P-\frac{P+T}{2}} & \text{for} \quad \frac{P+T}{2} < R \leq P \quad \text{(towards 1)} \\ 0 & \textit{otherwise.} \end{cases}$$

$$\mu_{S3}(R, T, P) = \begin{cases} 1 & \text{for} \quad T = \frac{P+R}{2} \quad \text{(maximum membership)} \\ \frac{T-P}{\frac{P+R}{2}-P}; & \text{for} \quad P \leq T < \frac{P+R}{2} \quad \text{(towards 1)} \\ \frac{R-T}{R-\frac{P+R}{2}} & \text{for} \quad \frac{P+R}{2} < T < R \quad \text{(towards 5)} \\ 0 & \textit{otherwise.} \end{cases}$$

$$\mu_{S4}(P, T, R) = \begin{cases} 1 & \text{for} \quad T = \frac{R+P}{2} \quad \text{(maximum membership)} \\ \frac{T-R}{\frac{R+P}{2}-R} & \text{for} \quad R \leq T < \frac{R+P}{2} \quad \text{(towards 2)} \\ \frac{P-T}{P-\frac{R+P}{2}} & \text{for} \quad \frac{R-P}{2} < T \leq P \quad \text{(towards 6)} \\ 0 & \textit{otherwise.} \end{cases}$$

$$\mu_{S5}(T, R, P) = \begin{cases} 1 & \text{for} \quad R = \frac{T+P}{2} \quad \text{(maximum membership)} \\ \frac{R-P}{\frac{T+P}{2}-P} & \text{for} \quad P \leq R < \frac{T+P}{2} \quad \text{(towards 6)} \\ \frac{T-R}{T-\frac{T+P}{2}} & \text{for} \quad \frac{T+P}{2} < R \leq T \quad \text{(towards 3)} \\ 0 & \textit{otherwise.} \end{cases}$$

Using the membership functions stated above, we calculate membership degree values

for all states and years in the database.[28] Table 4 shows membership degree values for a selection of countries in each profile category, in descending order of magnitude for 1991. As illustrated in Figure 4, countries with a high membership degree value are located in the middle of their respective profile space, whereas those that have lower degrees of membership are located closer to the border to an adjacent profile space.[29] Figure 4 shows the distribution of countries in Profile 3 and 5 for 1991 in the circular profile space. Due to their high membership degree value, the Bahamas, for instance, are located almost squarely in the middle of the space of profile 5, whereas the United States are situated much closer to the border of an adjacent profile space. While this by itself does not imply that a US profile shift into an adjacent profile is imminent, it does indicate that in the case of the US, the changes in master variables needed to trigger a profile shift are smaller than the ones for the Bahamas.[30]

INSERT TABLES 4 AND 5 HERE

INSERT FIGURE 4 HERE

3.2 Fuzzy Sets and the Challenge of Conflict Prevention

Applying fuzzy logic to lateral pressure theory can further our quest for conflict prevention, by providing a systematic and coherent method to precisely locate and visualize movements

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[28]One minor issue still needs to be resolved. Our calculation of the membership degree values rests on the assumption that the value for each of the individual three master variables R, P, and T does in fact vary over time. Given the 'coarse' nature of the data, this assumption, however, is not universally true for specific metrics that we have used. As described above, R is operationalized using land area as a proxy, which generally does not vary dramatically. More recently some work on the territorial changes of countries opens the possibility for capturing potential variations in R. See for example Tir et al. (1998). For profiles which have R as the middle variable (namely, profiles 2 and 5), we thus cannot expect dispersion with respect to R. Consequently, our assumption of a triangular distribution does not hold in these cases. Given the rather invariant nature of the R measure, we expect the distribution for these profiles to have the shape of a vertical line instead, resting on a single point on the horizontal axis. Although we cannot assume a triangular distribution, we can still use the expressions we derived above to calculate meaningful membership degree values. In cases where the vertical line is to the left of the center (that is, the mid-point between P and T), a small value of $(T - R)$ for profile 2 and $(R - P)$ for profile 5 signifies that we are closer to the boundary of the adjacent profile to the left (namely, profiles 4 and 6, respectively). If we normalize this distance to lie between 0 and 1, we can interpret the value in the exact same way we do the membership degree values for the other four profiles.

[29]The profile categories in the Table have been reshuffled to reflect the sequence in which they actually appear as illustrated in Figure 1.

[30]The graph is for illustrative purposes only. The other profile spaces could be visualized analogously.

of states within and across profiles, and thus allow analysts to explore potentially conflict-prone constellations, and help identify, possibly even anticipate them before they become (or are perceived to be) destabilizing and threatening.

3.2.1 Visualization Trajectories within and Across Profile Spaces

INSERT FIGURE 5 HERE

Figure 5 illustrates how membership degree values can be used to visualize movements of states within and across profiles over time by mapping them onto (a relevant section of) the circular sequence of profiles shown in Figure 1.[31] The membership degree value provides information on the distance of a certain state from the core of its profile space. If we consider the entire set of countries that are located within a profile (at any point in time), then the distribution of countries within the profile space provides some indication of propensities for change in the international system.[32] Table 2 above indicates, for instance, that the Bahamas were situated very close to the core of profile 5, whereas the United States, while sharing the same profile, were much closer to the border of an adjacent profile.[33]

INSERT FIGURE 6 HERE

To use another case, Figure 6 illustrates the trajectory of Venezuela from 1971 to 1991, calculated using its membership degree function presented above, and mapped onto the full circle of profiles.[34]

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[31]All axes in Figure 5 are time axes, (although for the sake of visual clarity, only one of them is labeled as such).

[32]To be sure, if the membership degree value of a particular country and year places it close to the border of the profile space, we do not know whether it is going to cross that border in the near future. But we do know that, given its location, only a small change in one of its master variables would result in such a shift.

[33]Note that the membership degree value by itself, however, does not tell us whether it was close to the border to profile 3 or profile 6. We can easily derive this information, however, by reviewing the respective initial calculations of the membership degree values as outlined on page 14 above, and map the trajectory of any given country within and across profile categories over time.

[34]The radius of the circle corresponds to the time axis in the graph, with the earliest year staring in the center and the latest year located along the perimeter of the circle. One 'tree-ring' corresponds to two years. To enhance visual clarity, the graph shows 1969 as the starting year (in the center of the circle) and 1993 as the end year (at the top rim). Data were available for 1971 to 1991, which is why the trajectory does not start in the center and ends inside the circle. The choice of cases as illustrations in this section is arbitrary, and guided mostly by the clarity with which they display the respective trends. In principle, however, any country that moved within and/or across profiles in the years for which data is available could be used as illustration here.

The representation in Figure 6 not only provides information on the trajectories of states within and across profiles over time, but also indicates the *velocity* of the movement, which we listed earlier as one of the factors that lateral pressure theory identifies as magnifiers of instability. Analogously to the concept of angular velocity in physics, the size of the *angle* between two consecutive points with respect to the center of the circle corresponds to the speed of the movement within and/or across profile categories.[35]

The case of Iran, as shown in Figure 7, is an example of very rapid movements in master variables that lead to a potentially destabilizing leap across two profile boundaries in a single year.

INSERT FIGURE 7 HERE

As indicated by the wide angle between the data points for 1987 and 1988 (the former located on the 4th widest "tree ring" of the circle, and the latter one half of a tree-ring further out), Iran changed from a profile 5 to a profile 1 between 1987 and 1988, effectively sweeping across the entire space of profile 3 within a single year. The year in which this leap occurred, 1987, was in fact marked by great turmoil in Iran. One may correctly caution that the leaps recorded in Figure 7 may have been a consequence, rather than a cause of the destabilizing events that occurred. We are in fact not positing a deterministic causal logic here, but aim to expand the arsenal of analytical tools for scholars of international relations.

Our task is primarily to identify, systematically measure and track developments that lateral pressure theory postulates as antecedent conditions for conflict and violence. Even though we are unable, and thus do not claim to predict with any degree of accuracy whether and when these developments escalate into violence, membership degree values provide us with a method to visualize trends, highlight their nature, and thus may help focus our attention, policies, and resources on areas that appear to be most vulnerable to conflict. This method can also be used to visualize the trajectories of several states located within a particular region, and to assess whether states that are growing unevenly are located in

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[35]Note that the angles here are not absolute, since they depend on the 'sweep' between any given two consecutive points with respect to the center of the radial diagram, which represents the starting year, and is thus determined arbitrarily. However, we can compare two different angles in this diagram, as they are both based on the same center.

the same geographic region, and thus cause for concern, or whether destabilizing power transitions are distributed 'more safely' across states that are far removed from each other.

3.2.2   Anticipating Profile Shifts

Since profiles are defined by the relative location of the master variables, which in turn shape the demands and capabilities of states, anticipating shifts in profiles provides a degree of predication for changes in demands and capabilities that can be expected. By computing the membership degree values for individual states within each profile group, we are able to precisely locate the position of each state across a profile space, and to closely track the *direction and velocity* of the state's movements over time. Long-term trends in the international distribution of states can, at times, therefore be discernible before profile changes actually take place and are empirically observable, and the nature of the anticipated shift may well signal the potential modes of external activities that are likely to occur.

INSERT FIGURE 8 HERE

To illustrate this, Figure 8 shows the case of Japan from 1952 to 1962. We can see that membership degree values followed a downward trend several years prior to an eventual profile shift which occurred in 1958.

Of course, anticipation does not mean forecasting; and effective forecasting may be particularly daunting, even impossible, where shifts in master variables underlying profile change are extreme or very rapid, as was the case for Iran as illustrated in Figure 7 above. Where master variables move gradually, however, membership degree values appear to be reasonably accurate in forecasting potentially destabilizing trends.

4   Conclusion

This paper aimed at refining both conceptualization and measurement of change in the international system. Using the theory of lateral pressure as a case in point, we (a) operationalized the master variables, (b) computed the individual state profiles throughout the international system, and (c) used fuzzy set theory to refine the 'profile space' and thus our ability to locate and track states within and across each of the profile groups. Conceptualizing profile categories as fuzzy sets, we believe, is a promising avenue for extending and

refining lateral pressure theory, as fuzzy set theory enables us to precisely and systematically locate and track potentially destabilizing shifts, both over time and across geographical space.

In closing, a final caveat is in order. Clearly, profile shifts per se do not predetermine state actions and their outcomes. The behavioral implications of uneven growth and development postulated by lateral pressure theory are yet to be fully articulated and explored as more comprehensive data becomes available, and more detailed theoretical specifications are made. Nonetheless, developing tools to empirically and precisely locate and track areas that are potentially vulnerable to turmoil is a valuable first step in the quest for understanding, and potentially reducing conflict and war propensities across the globe.

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Appendix with Figure and Tables

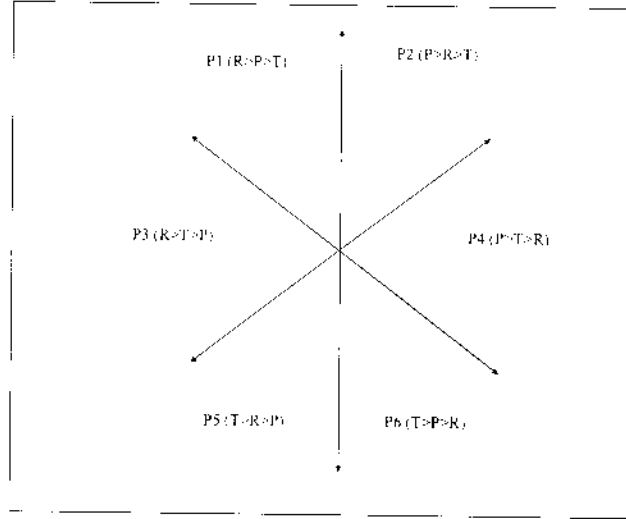| Profile 1:	Resources > Population > Technology
Profile 2:	Population > Resource > Technology
Profile 3:	Resources > Technology > Population
Profile 4:	Population > Technology > Resources
Profile 5:	Technology > Resources > Population
Profile 6:	Technology > Population > Resources

Table 1: Profile Definitions

Figure 1: Logic of Sequence in Profile Change

Profile Label	Master Variable Relationships	Country	P (%Share of Global)	T (%Share of Global)	R (% Share of Global)
1	$R > P > T$	South Africa	0.70935	0.45285	0.81982
2	$P > R > T$	China	20.98435	1.93621	6.44351
3	$R > T > P$	Canada	0.49836	2.54025	6.69809
4	$P > T > R$	North Korea	0.40509	0.24851	0.08093
5	$T > R > P$	United States	4.61278	25.58309	6.29288
6	$T > P > R$	United Kingdom	1.05082	4.33693	0.16437

Table 2: Illustrating Profile Categories and Global Shares of T, R, and P (1991)

Country	Profile Label		P (% of Global)		T (% of Global)		R (% of Global)	
	1971	1991	1971	1991	1971	1991	1971	1991
Kenya	1	2	0.32	0.46	0.06	0.04	0.39	0.39
Korea, Republic of	4	6	0.88	0.79	0.32	1.25	0.07	0.07
Oman	1	3	0.02	0.03	0.01	0.04	0.14	0.14
Thailand	2	4	1.00	1.04	0.24	0.41	0.34	0.35
Turkey	2	4	0.98	1.05	0.45	0.46	0.52	0.52
Venezuela	3	1	0.30	0.36	0.44	0.25	0.61	0.61

Table 3: Illustrating Changes in Profile Categories and Global Shares of T, R, and P (1971 and 1991)
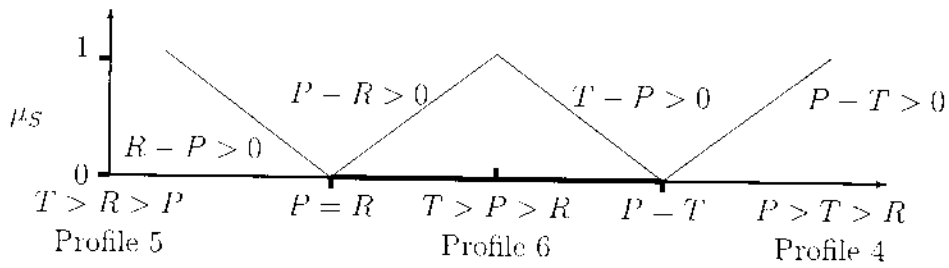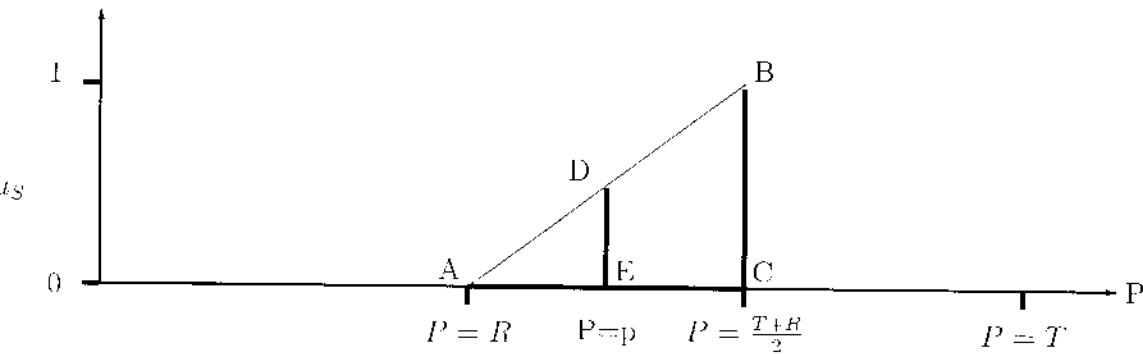

Figure 2: Triangular distribution for Profile 6

Figure 3: Left half of the triangular distribution for Profile 6

Profile 1 $R > P > T$		Profile 3 $R > T > P$		Profile 5 $T > R > P$	
Country	MDV	Country	MDV	Country	MDV
Lao, PDR	0.95	Iceland	0.70	Bahamas	0.98
Madagascar	0.91	Canada	0.66	Norway	0.71
Equatorial Guinea	0.79	Saudi Arabia	0.46	Finland	0.59
Peru	0.78	Australia	0.42	United Arab Emirates	0.44
Yemen, Rep.	0.78	Oman	0.27	Sweden	0.35
Cameroon	0.75			New Zealand	0.17
Zimbabwe	0.67			United States	0.16
Venezuela	0.63				
South Africa	0.60				
Chile	0.60				
Colombia	0.57				
Tanzania	0.56				
Solomon Islands	0.54				
Panama	0.52				
Guinea-Bissau	0.51				
Nicaragua	0.45				
Paraguay	0.44				
Uruguay	0.42				
Brazil	0.40				
Papua New Guinea	0.39				
Mali	0.36				
Algeria	0.35				
Niger	0.32				
Bolivia	0.31				
Congo	0.28				
Belize	0.26				
Argentina	0.25				
Central African Rep.	0.25				
Chad	0.24				
Iran, Islamic Rep.	0.20				
Guyana	0.18				
Burkina Faso	0.17				
Mauritania	0.9				
Botswana	0.05				
Suriname	0.02				
Gabon	0.02				

Table 4: Membership Degree Values within Profiles, 1991

| Profile 6 | | Profile 4 | | Profile 2 | |
| $T > P > R$ | | $P > T > R$ | | $P > R > T$ | |
Country	MDV	Country	MDV	Country	MDV
Greece	0.95	Hungary	0.96	Togo	0.99
Malta	0.91	Grenada	0.94	Morocco	0.97
Portugal	0.84	St. Lucia	0.89	Ghana	0.95
Barbados	0.82	Mauritius	0.85	Mexico	0.94
Puerto Rico	0.78	Dominica	0.73	Malawi	0.93
Korea, Rep	0.77	St. Vincent	0.71	Lesotho	0.90
Cyprus	0.62	Jamaica	0.48	Tunisia	0.86
Israel	0.60	El Salvador	0.29	Gambia, The	0.82
Hong Kong	0.59	Trinidad and Tobago	0.20	Sierra Leone	0.80
Singapore	0.56	Thailand	0.18	Egypt, Arab Rep.	0.74
Seychelles	0.53	Philippines	0.02	Syrian Arab Rep.	0.72
United Kingdom	0.42	Bangladesh	0.01	Swaziland	0.62
Spain	0.40			Nigeria	0.56
Netherlands	0.40			Costa Rica	0.56
Belgium	0.38			Indonesia	0.56
Italy	0.37			Cambodia	0.51
Bermuda	0.31			Honduras	0.51
Germany	0.29			Cape Verde	0.50
France	0.27			Guatemala	0.50
Japan	0.27			China	0.47
Austria	0.26			Nepal	0.46
Ireland	0.26			Sao Tome and Principe	0.44
Denmark	0.25			Fidji	0.36
Luxembourg	0.20			Pakistan	0.35
Switzerland	0.19			Benin	0.34
Qatar	0.14			Kenya	0.31
				Ethiopia	0.31
				Burundi	0.27
				Malaysia	0.21
				Turkey	0.20
				Rwanda	0.15
				Haiti	0.14
				Senegal	0.13
				India	0.12
				Romania	0.10
				Cote d'Ivoire	0.10
				Ecuador	0.09
				Comoros	0.09
				Dominican Rep.	0.04
				Sri Lanka	0.04

Table 5: Membership Degree Values within Profiles. 1991
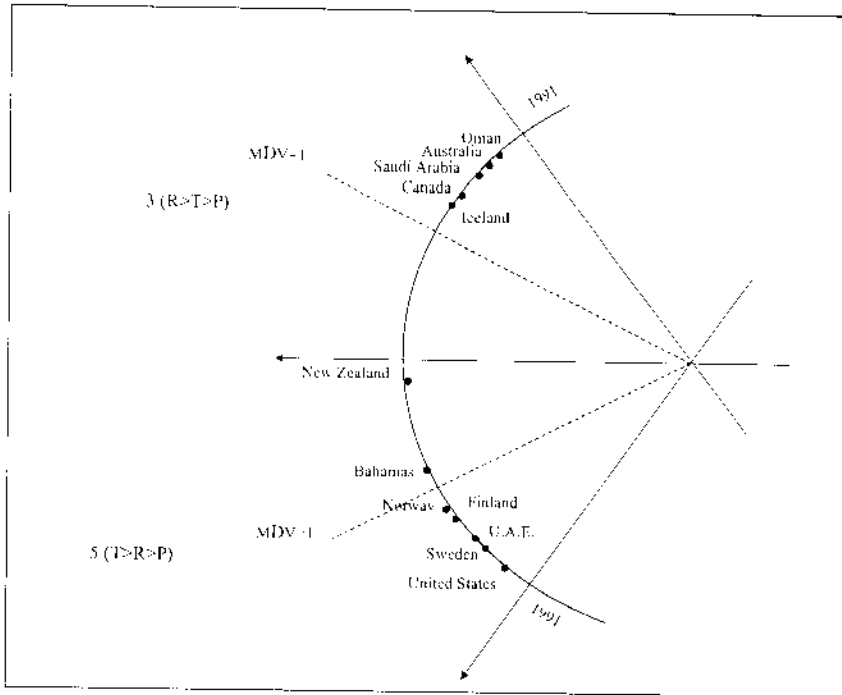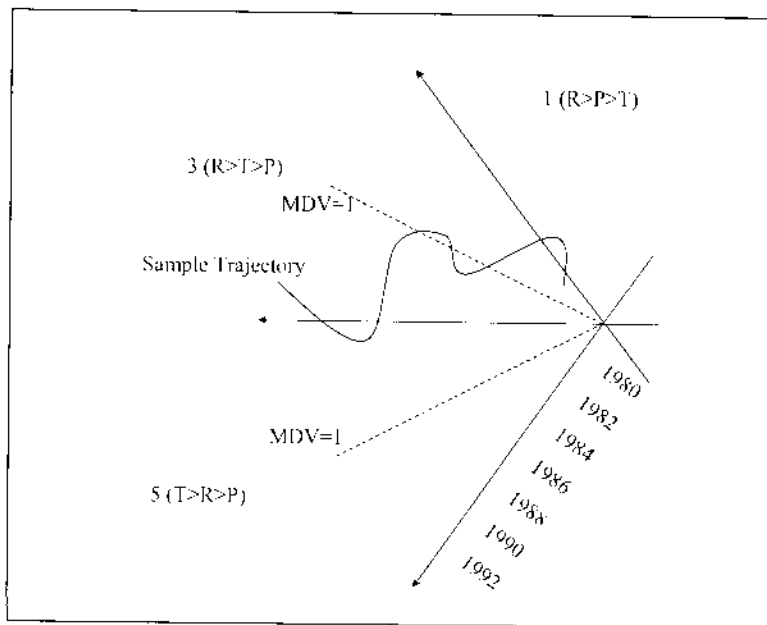
Figure 4: Countries in Profile 3 and Profile 5 in 1991

Figure 5: Illustrative Inter-temporal Trajectory Within and Across Profiles

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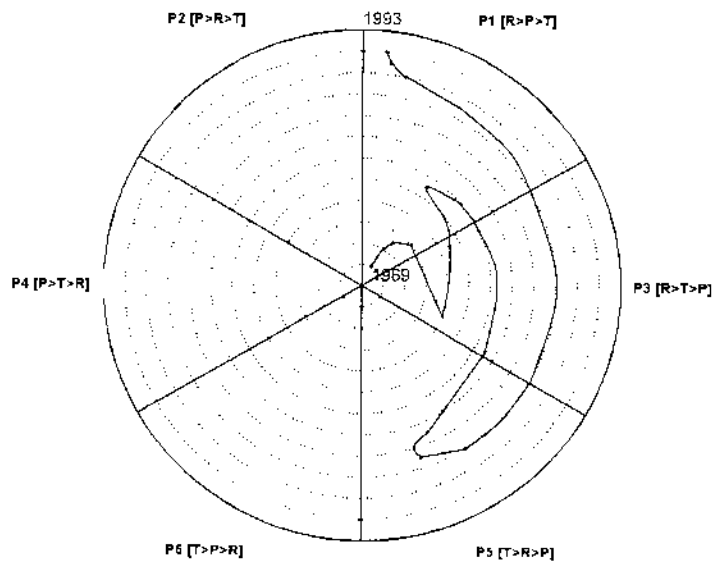Figure 6: Trajectory of Venezuela, 1971-1991
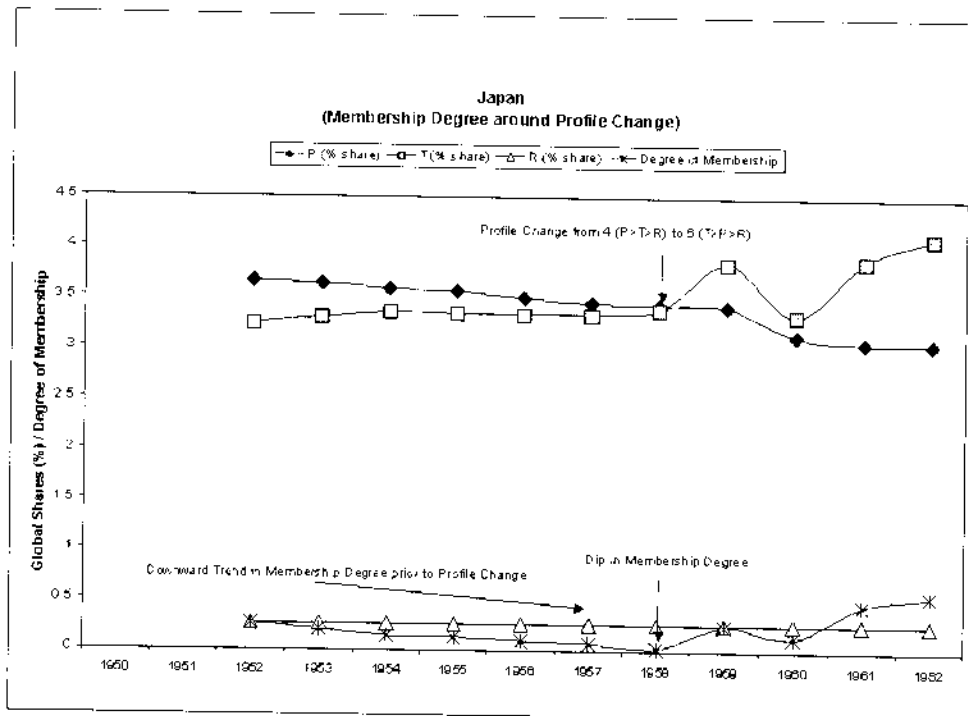

Figure 7: Trajectory of Iran (1971-1991)

Figure 8: Membership Degree Value Prior to Profile Change for Japan