Time Remembered:
A Dynamic Model of Interstate Interaction

Mark J.C. Crescenzi
Department of Political Science
University of North Carolina, Chapel Hill
Chapel Hill, NC 27599-3265
crescenzi@unc.edu

Andrew J. Enterline
University of North Texas
Department of Political Science
Denton, TX 76203-5340
ajenter@unt.edu

Penultimate Draft: February, 2000

The authors wish to thank Chad Atkinson, D. Scott Bennett, Paul F. Diehl, Erik Gartzke, Kristian S. Gleditsch, Håvard, Hegre, Jennifer Jerit, Timothy McKeown, Robert Muncaster, Thomas Oatley, Glenn Palmer, George Rabinowitz, Dina Zinnes, and the members of the Merriam Laboratory for Analytic Political Research at the University of Illinois, Urbana-Champaign for their comments, encouragement, and technical assistance. We used *Stata 6.0* to carry out our statistical analyses. We thank John Oneal and Bruce Russett for furnishing their data from Oneal and Russett (1997), as well as their command files. The views expressed herein and any remaining errors are solely the responsibility of the authors. The authors' last names appear in alphabetical order.

ABSTRACT

Over time, states form relationships. These relationships, mosaics of past interactions, provide political leaders with information about how states are likely to behave in the future. Although intuitive, this claim holds important implications for the manner in which we construct and evaluate empirically our expectations about interstate behavior. Empirical analyses of interstate relations implicitly assume that the units of analysis are independent. Theories of interstate interaction are often cast in the absence of historical context. In the following article we construct a dynamic model of interstate interaction that we believe will assist scholars in empirical and theoretical studies by incorporating a substantively interpretable historical component into their models of interstate relations. Our conceptual model includes both conflictual and cooperative components, and exhibits the basic properties of growth and decay that characterize dyadic relationships. In an empirical exposition, we derive a continuous measure of interstate conflict from the conflictual component of the model. We rely on Oneal and Russett's (1997) analysis of dyadic conflict for the period 1950-85 as a benchmark, and examine whether the inclusion of our measure of interstate conflict significantly improves our ability to predict militarized conflict. We find empirical support for this hypothesis, indicating that our continuous measure of interstate conflict significantly augments a well-known statistical model of dyadic militarized conflict. Our findings reinforce the assertion that historical processes in interstate relationships represent substantively important elements in models of interstate behavior rather than econometric nuisances.

INTRODUCTION

When Israeli Prime Minister Ehud Barak and Syrian Foreign Minister Farouk Sharaa traveled to Shepherdstown, West Virginia in December 1999 to restart the negotiations over the Golan Heights, the engagement between the two government representatives was the latest in a lengthy series of interactions between Israel and Syria. Even prior to the declaration by Israel of its statehood in 1948, Syria and its Arab League allies sought the destruction of the Jewish enclave and the unification of Palestine. During the Cold War, this pitched antagonism between Israel and its Arab neighbors generated nearly 100 militarized disputes, of which four qualified as interstate wars (Jones, Bremer, Singer, 1996; Singer and Small, 1994).[1] Thus, the interactions between the Israeli negotiators and their Syrian counterparts in Shepherdstown—a rare attempt at cooperation between the two countries—took place against a backdrop of protracted hatred and conflict.

Although the meeting in Shepherdstown might have demonstrated a willingness on the part of Israel and Syria to resolve their differences concerning the Golan peacefully, their bargaining did not occur in an historical vacuum. Rather, the strategies that the respective representatives of each state sought to pursue were, in part, a function of their history. The choices of the Israeli and Syrian delegates at the bargaining table and the likelihood of various outcomes were conditioned to some extent by the prior relationship between the two countries, a relationship that was nearly entirely characterized by conflict. Certainly, the claim that history is relevant to future interstate relations is perhaps obvious to the point of triviality. However, understanding *how* history influences present and future political interaction, as well as the degree to which this relationship obtains, remains a challenge for scholars interested in studying interstate relations.

The goal of this article is to develop the theoretical tools necessary to estimate historical relationships in world politics, as well as to emphasize the importance of modeling these effects explicitly in empirical estimations of these relationships. In building this model, we are guided by three objectives. First, we wish to develop a model of interstate interaction that captures historical dynamic processes. Second, the model we construct should be flexible enough to adapt to different historical processes, ranging from extreme animosity to extreme affinity. Finally, our model should accommodate linkages to the specification of statistical models without losing our ability to interpret the role of history in political behavior. We seek to understand how history provides a context within which states interact, and the capacity to separate this context from others (e.g., major power status, economic growth, dyadic democracy, or contiguity) lies in our ability to go beyond the generic assertion that history matters to specify historical relationships in order to assess their effect on interstate relationships.

PERSPECTIVES ABOUT THE DYNAMICS OF HISTORY IN WORLD POLITICS

The idea that interstate behavior is a process rather than a discrete series of events emerges from a long line of models of interstate reciprocity. In a research agenda initially established by Richardson (1960), a group of scholars employed a "stimulus-response" approach to investigate the link between leader perceptions and actions in the crises preceding the First World War (North, Brody, Holsti, 1964; Zinnes, 1968, 1976). Later, other scholars pursued similar strategies in modeling arms races more generally (Wallace, 1979; Diehl, 1985). Work in this area has continued in game theory (e.g., Axelrod, 1984; Axelrod and Keohane, 1986), time-series analyses of the superpower relationship (Ward, 1981, 1982; McGinnis and Williams, 1989), and Dixon's (1983) dynamic formulation of interstate affect. These initial analyses of reciprocity were later joined by a second wave of research addressing the dynamics of interstate cooperation and conflict (Goldstein and Freeman, 1990; Rajmaira and Ward, 1990; Goldstein, 1991, 1995; Kinsella, 1994, 1995; Oren 1994; Moore, 1995; Goldstein and Pevehouse, 1997; Rajmaira, 1997, 1999).

In a parallel body of work, scholars sought to explain patterns of "recurrent" conflict between states. This literature investigated the way in which outstanding issues between states conditioned the likelihood of subsequent militarized conflict (Diehl, 1992; Hensel, 1994), the link between strategic reputation and the behavior of states in subsequent crises (Leng and Wheeler, 1979; Leng and Walker, 1982; Leng, 1983, 1993), prior success in crisis bargaining as a predictor of subsequent bargaining strategy (Gelpi, 1997), and the impact of prior militarized conflict on the subsequent likelihood of dispute escalation (Maoz, 1984; Partell, 1997). Finally, the importance of militarized competitions as predictors of future interstate conflict is the centerpiece of a burgeoning literature on interstate rivalries, particularly those rivalries that are characterized as “enduring” (McGinnis, 1990; Goertz and Diehl, 1992, 1993, 1995, 1996, 1997, 2000; Huth and Russett, 1993; Lieberman, 1995; Thompson, 1995, 1998; Bennett, 1996, 1997a-b, 1998; Hensel, 1996; Diehl, 1998; Diehl and Goertz, 2000).

The findings in this broad body of work on interstate interaction reinforce our intuitive sense that conflict and cooperation occurring between pairs of states is a time-dependent process. That is, the occurrence of cooperation between two states at time t, for example, conditions the likelihood that cooperation will occur between these two states at time $t+n$. This claim that dyadic interstate interaction is temporally dependent has important implications for the way in which we theorize and formulate our hypotheses, as well as the way in which we specify our statistical models.

However, several characteristics of the current literature handicap our ability to study the dynamic qualities of interstate interaction. First, while the aforementioned literatures present the researcher with the advantage of modeling interstate behavior in a more dynamic fashion, this body of work has been spatially biased. The principal focus has been on the relations between subsets of states that are selected, a priori, for their specific characteristics, particularly the presence of conflictual relations.

Second, analyses reported in the rivalry literature primarily consider rivalry to be a discrete quality occurring between states. We argue, however, that rivalries are dynamic, and therefore continuous processes. Interstate rivalry does not turn on and off discretely; it evolves over time as a function of consistent behavior. The intensity of the rivalry and the rate at which it exacerbates or ameliorates is a function of the severity and frequency of conflict and cooperation that shape the history of dyadic behavior. Thus, a pair of states may increase or decrease the degree of its rivalry across time, and we argue that it is critical to model this dynamism explicitly.

Finally, in the past 10 years the "dyad-year" has become the dominant unit of analysis in large-N, quantitative analyses of interstate relations (e.g., see Bremer, 1992, 1993; Maoz and Russett, 1993; Oneal and Russett, 1997; Remmer, 1998). While large-N studies offer the researcher benefits in terms of sample size, this mode of analysis again lends itself to an over-reliance on the conceptualization of interstate behavior as a series of discrete events or interactions between pairs of states. Historical processes, once the centerpiece of several research agendas in world politics, are treated as temporal dependence to be accounted for statistically but not interpreted substantively. We find this approach counterintuitive; a situation in which we are throwing the proverbial baby out with the bathwater.[2]

For example, Beck and Tucker (1996) and Beck, Katz, and Tucker (1998) address this issue of temporal dependence in statistical models with discrete dependent variables. While the time-series literature contains a number of statistical corrections for temporal dependence, or autocorrelation,[3] Beck, et al., furnish an attractive remedy—the "logit spline" model—for accounting for temporal dependence in research designs involving the use of binary dependent variables in time-series–cross-sectional research designs. The influence of the Beck, et al. approach on the current literature, particularly studies of militarized interstate conflict, is already marked (e.g., see Oneal and Russett, 1997, 1999; Clark and Hart, 1998; Henderson, 1998).

Although we support the importance of properly specifying econometric models that would otherwise violate the assumptions upon which these models are based, our concern with the recent emphasis on econometric corrections is that these techniques *dispose* of theoretically and substantively important information. If the historical relationship is theoretically important, then the researcher needs to be able to interpret the role of this history empirically. Rather than seeking to expunge these properties from the data matrix, scholars should consider them to be theoretically meaningful contributions to the general conclusion. Therefore, the tools we develop below are *not* intended to compete with the recent techniques intended to address issues of temporal dependence. Rather, they are designed to offer scholars a theoretical alternative that enables them to evaluate the substantive importance of historical events.

THE AGENDA

Why is it important to shift the current treatment of history in the literature from econometric correction to a theoretically informed concept? Three answers to this question serve to motivate this study. First, the evolving historical relationships between states are complex processes that vary from dyad to dyad. The aforementioned techniques do not sufficiently approximate these dynamic processes given our level of knowledge about these relationships. As such, we remain convinced that scholars need not rely only on naïve methods, such as employing lagged values of the dependent variable or auto-regressive error correction techniques, to incorporate historical context into their empirical and formal models. Second, even if the econometric corrections continue to become more sophisticated, as exemplified by the Beck, Katz, and Tucker and the Rakenrud and Hegre (1997) approaches, the historical relationship between two states provides crucial information about the future interaction of those states. Third, dyadic histories are composed of considerably more information about state interactions than what can be found solely in prior information reflected in the dependent variable, and we can exploit this information to improve our ability to understand which elements of the past affect future interstate relations.

This information is relevant for many of the theories of international conflict. In the action-reaction models introduced by Richardson (1960), for example, one state's reaction to another's military spending is determined in part by two parameters, threat and grievance. These two parameters are often set as initial conditions by the researcher, or considered as variables in the analysis of the model. The historical relationship between the two countries is a logical source of information for setting the initial conditions of such a model. Other dimensions of the relationship may also be relevant, but the concepts of threat and grievance are almost certainly influenced by the past. Similarly, Zinnes and Muncaster (1984) provide a systemic model that emphasizes the dynamics of hostility and the occurrence of war. One of the "primitive variables" employed in their analysis is the notion of a hostility level. The level of hostility in the system is defined by the "intensity of hostility that … nations 'feel' towards any other nation in the defined system at the time t, without regard to initiator or target" (1984:188). In their study, Zinnes and Muncaster formulate the relationship between the dynamics of hostility, escalation, and war, but the hostility level variable plays a key role in many components of their model.

More recently, strategic models have become central to the research agenda in world politics. Specifically, scholars are increasingly turning to a body of game-theoretic models of incomplete or imperfect information in order to understand strategic interactions between states. These models are frequently structured such that an initial move made by the "state of nature" determines a key characteristic, or type (e.g., "dove" or "hawk"), for one or both states. This determination of type is private information, and opponents know only the probability distribution from which nature draws its move. Thus far, scholars have been reluctant to explore the underlying source(s) driving the distribution of player types from which nature selects. Again, our intuition is that the historical relationship between the two states is a useful source of information for the initial parameters of a game-theoretic representation of interstate interactions. For example, the historical relationship may inform the initial beliefs of the states (prior to any updating.) Our argument here is not intended to detract from the structure and analysis of the strategic model. We simply suggest that the initial conditions of any model have significant bearing on the conclusions that one draws from that model.

It is important to note here that the modeling process we engage in below is slightly different from the two types of models discussed in the previous paragraph. Our goal is to use some basic tools of dynamic modeling to develop a concept, and thus we do not provide a causal model of interstate conflict or cooperation. Instead, we develop a model capturing the historical record of interstate relationships.

We assert that this model provides important contextual information for the study of world politics, with the understanding that this assertion must eventually be reconciled with the empirical record.

How are we to achieve the goal of developing empirical measures of interstate behavior that are dynamic, generalizable, and may be used to inform other models or as explanatory variables in large-N, cross-national empirical analyses? We must first make progress in identifying the causal mechanism(s) that translate individual events in an interstate relationship into an "interaction history." In other words, it is not enough to simply posit that patterns of recurrent conflict and cooperation are crucial to understanding and predicting interstate behavior. We must also explicate the way in which interstate interaction is processed by states over time.

Embracing a strategy of rigor at the conceptualization stage will pay dividends when translating the concept of an interaction history into this empirical form. Using basic properties of growth and decay, we develop a model that integrates the complexity of aggregating events over time. This approach allows us to generate a concept of interaction that is intuitive, continuous, and, perhaps most important, independent of any specific data source.

To demonstrate the viability of this model as a foundation for deriving measures of interstate behavior that address the issues of dynamism, generalizability, and flexibility, in the final section of this article we use the data and logit model advanced by Oneal and Russett (1997) in their study of the causes of dyadic militarized interstate dispute involvement for the period 1950-1985. In brief, we show that the variable we derive from our dynamic model, *Conflict Interaction Level*, has a significant effect on the subsequent presence of militarized interstate disputes. This finding renders support for the hypothesis central to the reciprocity, recurrent conflict, and rivalry literatures. Our empirical analysis also reveals that the variable *Conflict Interaction Level* ranks high on a hierarchy of variables linked to interstate conflict with respect to its effect on the probability of dispute involvement, thus significantly augmenting our ability to predict the occurrence of this interstate behavior in a multivariate analysis.

More broadly, we demonstrate the importance of dynamic modeling, and the empirical measures we derive from these types of exercises, for the quantitative study of world politics. The development of these types of models furthers our ability to investigate interstate relations in world politics. Incorporating this knowledge into our econometric models enables us to study the substantive impact of the dyadic historical relationship along with the standard variables of interest without losing valuable information. Lastly, we show that incorporating dynamic measures of interstate behavior into the dominant approach to the study of quantitative interstate behavior—i.e., large-N, cross-national dyadic studies—is viable with, but not limited to, data that are currently available to the field.

THE DIMENSIONS OF INTERSTATE RELATIONS

The first step in building our model involves identifying the basic dimensions of interstate behavior. Regardless of whether the researcher is concerned with reciprocity or interstate rivalry, for example, we can identify a general set of concepts that will serve as a foundation for our dynamic model of interstate interaction. The reciprocity literature focuses on the longitudinal properties of cooperative and conflictual behavior. The recurrent conflict literature suggests that issues that are outstanding between states, such as territorial claims, as well the relative importance of an issue, affect the likelihood of subsequent interactions between pairs of states. In defining the subset of dyads that they label "enduring rivalries," Goertz and Diehl (1993, 1995, 2000) rely on indicators of the frequency and temporal distribution of conflictual interactions between states; the more frequent the militarized interactions between pairs of states across a lengthier period of time, the greater the likelihood that an enduring rivalry is present.[4]

Despite their distinct theoretical and methodological traditions, these literatures rely on a common set of dimensions in order to characterize these interstate relationships. Together, these dimensions reflect the fundamental characteristics of a portfolio of events occurring between two states over time. Specifically, interstate relationships can be characterized by four general dimensions that we draw, in part, from Goertz and Diehl's (1993:159-160) distillation of the "COW [Correlates of War] definition" of interstate rivalry:

- *Accumulation*. For pairs of states with a history of frequent interaction, the interstate relationship should be well defined and further interaction should have a decreasing marginal effect. Conversely, in a dyad with a history characterized by infrequent interaction, the relationship is weakly defined and further interaction should have an increasing marginal effect;

- *Temporal Distance*. The temporal distance between these interactions affects the interstate relationship. For example, the relationship between a pair of states that engages in two events separated by 20 years is different from that of a pair of states that engages in two events within a single year. If two events are temporally proximate, the states involved are less likely to have focused their attention elsewhere after the first event when the second occurs. In the case of two events separated by 20 years it is far more likely that these events will be treated as independent from one another by the states involved than they would be in the case in which both events transpire in the same year;

- *Degree*. Interstate interaction is also a function of the extent, or degree, of the cooperative and conflictual interactions that occur between pairs of states. Thus, interstate interactions characterized by the trading of verbal threats to restrict immigration are different in degree than states that engage one another in a militarized clash. Similarly, interstate interactions characterized by the mutual lowering of tariffs on a specific commodity are different in degree from interstate interactions in which a pair of states agrees to form an economic union; and

- *Rate of Change*. An interstate relationship may become more or less intense across a given period of time. Moreover, a relationship does not cease at the point in time when the final

> interaction "event" occurs. Rather, it diminishes gradually with the continued absence of further interaction. This reversion, or decay, towards neutrality is equally applicable to a cooperative or conflictual relationship. This "memory" aspect of interstate relationships is evident in the difficulty states experience in attempting to stimulate a cooperative relationship with a state with which they have had a history of militarized conflict, as illustrated by the interactions between Israel and Syria in Shepherdstown discussed above. Whether cooperative or conflictual, the impact of events on the relationship between two states is likely to be a negative function of time.

Having defined the components of dynamic nature of an interstate relationship, we now turn to formalizing a model that incorporates these four dimensions into a single concept.[5]

A DYNAMIC MODEL OF INTERSTATE INTERACTION

At the core of our concept of interstate interaction is the assertion that the occurrence of an event between two states represents *growth* in the relationship based on this new information, and the absence of events is characterized by *decay*, or change that results from the lack of new information. These processes of growth and decay are functions of the four dimensions of an interstate relationship outlined in the previous section (i.e., accumulation, temporal distance, degree, and rate of change). In the following subsections, we develop our model of interstate relationship change based on these basic processes of growth and decay and the four dimensions addressed above. Having done so, we combine these two processes into a single, dynamic representation of an interstate relationship, something we refer to as the *Interstate Interaction Model*.

Growth: The Emergence of an Interstate Relationship

The driving force behind the emergence of an interstate relationship is the repeated occurrence of events, regardless of whether these events are conflictual or cooperative. Thus, we include in our model a change in interstate interaction whenever an event between two states is observed. This change, or shock, is shaped by two of the four dimensions of interstate interaction that we outline above. The *degree* of interaction plays an integral role in determining the impact of the shock. As the *degree* of interaction increases, so does its impact on the overall relationship. Second, the impact of these interactions on the interstate relationship is tempered by the elapsed time, or *temporal distance*, since the previous event occurred. Together these two dimensions are represented in the following functional form for a pair of states, or dyad,

$$i_t = i_{t-1} + \beta_1 \frac{\text{Degree}_t}{\text{Temporal Distance}_t}, \qquad [1]$$

where i_t is the *Interaction Level* for a particular dyad for any given time period, t, i_{t-1} is the dyad's *Interaction Level* in the previous period, and β_1 represents a weight that the researcher can introduce into the function.[6] *Temporal Distance*$_t$ is the duration since the previous interaction, and *Degree*$_t$ accounts for the extent of the interaction achieved by two states during an interaction. The functional form represented in equation [1] introduces shocks to i_t whenever interactions occur. The shock is intensified by the *degree* of the interaction, but dampened by an increase in the temporal distance from the previous interaction event.

It is evident from the research on reciprocity that the two basic building blocks of interstate interaction are the general categories of conflict and cooperation. Thus, the functional form expressed in equation [1] may be used to model conflictual and cooperative interactions between states. Optimally, we might model these two behaviors within a single function by giving conflictual and cooperative shocks different directional qualities as follows:

$$i_t = i_{t-1} - \beta_1\left(\frac{\text{Degree of Conflict}_t}{\text{Conflict Temporal Distance}_t}\right) + \beta_2\left(\frac{\text{Degree of Cooperation}_t}{\text{Cooperation Temporal Distance}_t}\right), \quad [2]$$

where *Degree of Conflict*$_t$ and *Degree of Cooperation*$_t$ reflect the degree of cooperation and conflict in the event, respectively, and *Conflict Temporal Distance*$_t$ and *Cooperation Temporal Distance*$_t$ represent the elapsed time since the last conflictual and cooperative events, respectively. Thus, this functional form introduces negative shocks to i_t whenever conflict between the two states occurs, and positive shocks to i_t whenever cooperation between the two states transpires.[7] Together, these shocks comprise the mechanism by which growth plays a role in changing interstate relationships. Regardless of the type, the shock provides new information to the relationship based on new events that occur between the two states. With growth so defined, we now move on to the issue of how interstate relationships change in the absence of such new information.

Decay: The Diminishing Effect of Time

The second fundamental process we wish to capture in our conceptualization of interstate interaction is the manner in which hostilities (or friendships) diminish over time. Here we incorporate the notion of the *rate of change*, as well as *temporal distance*, and the *accumulation* of events, into the process of decay in an interstate relationship. As argued above, in the absence of interaction between two states, the relationship should dissipate. With respect to conflict, this argument follows the "time heals all wounds" logic. In the absence of continued cooperation, past cooperative events should have a decreasing effect on the relationship, akin to the "what have you done for me lately" logic. As such, in the absence of activity in a dyad, an interstate relationship tends toward a state of neutrality. It is important to note that our underlying assumption here is that in order for an interstate relationship to become more contentious or more cooperative, new events must occur. That is, in the absence of new activity, the relationship cannot continue to escalate or even maintain a constant level of hostility or friendship.[8] As a first step in approximating these arguments, we have chosen to apply a simple decay function to the *Interaction Level* from the previous time period (i_{t-1}).[9] Such a function constantly drives the value of *Interaction Level* toward zero (neutrality) over time. Given the basic structure of a decay function, the next step is to explore how the rate of this decay may vary across space and time.

We formulate the rate of this decay function using two components. First, we assume that as the interval of inactivity for a dyad increases, so does a relationship's rate of dissipation. Stated differently, as two states enjoy a longer period of peace, they forget their conflictual past at a faster rate. Similarly, the longer two states endure without cooperating, the more rapidly they forget their cooperative past. Secondly, the interaction history in a given relationship is central to the ability of states to "forget the past." That is, as the total accumulation of interactions within a dyad increases, the rate of decay for the dyadic relationship (in the absence of interaction) decreases. The logic behind this piece of the model is that as two states develop a history of frequent conflict or cooperation, their propensity to forget past behavior diminishes. Together, these processes are modeled in the following fashion:

$$i_t = \left[e^{-\alpha \left(\frac{\text{Event Temporal Distance}_t}{\text{Event History}_t + 1} \right)} \right] i_{t-1}, \qquad [3]$$

$$0 < \alpha,$$

where the decay function operates on i_{t-1}, *Event History*$_t$ is the accumulation of occurrences of conflict and cooperation between the dyad up to time t (the denominator is adjusted by adding a constant, so that it never assumes a value of zero), *Event Temporal Distance*$_t$ represents the time that has passed since the last event (either cooperative or conflictual), and the parameter α weights the relative impact for the two factors. Here, we hold α to be positive, in order to ensure a decay toward neutrality. The exponential decay is accelerated by increases in *Event Temporal Distance*$_t$, but is decelerated by increases in *Event History*$_t$.[10]

Combining this decay process with the growth process developed above (see equation [2]) results in the following equation:

$$i_t = \left(e^{-\alpha\left(\frac{\text{Event Temporal Distance}_t}{\text{Event History}_t + 1}\right)} \right) i_{t-1} - \beta_1 \left(\frac{\text{Degree of Conflict}_t}{\text{Conflict Temporal Dist.}_t} \right) + \beta_2 \left(\frac{\text{Degree of Cooperation}_t}{\text{Cooperation Temporal Dist.}_t} \right), \quad [4]$$
$$0 \le \alpha$$

Thus, when assessing i_{1986}, for example, one would first apply this decay function to i_{1985} and then determine whether or not any new conflict or cooperation occurs in 1986 that would result in negative or positive shocks for that interstate relationship.[11]

As it stands in equation [4], the model generates interaction levels ranging from –∞ to +∞. Our final task requires translating these values into a more intuitive range. As such, we use the following transformation to bind the value of *Interaction Level* to a specific range:

$$\begin{aligned} &\text{If } \ i_t \ge 0, \text{ then } I_t = \frac{i_t}{i_t + \gamma}, \\ &\text{If } \ i_t < 0, \text{ then } I_t = \frac{-i_t}{i_t - \gamma}, \\ &\gamma > 0 \end{aligned} \quad [5]$$

This transformation accomplishes two objectives. First, it restricts the value of I_t to a range of –1 to +1, thereby providing an intuitive structure to the model. Values of I_t that are close to a value of -1 reflect the strongest enemies, values of I_t that are close to a value of 0 reflect neutrality, and values of I_t close to +1 reflect the strongest friendships. Second, the s-shaped functional form used in equation [5] creates a tapering effect such that as I_t increases towards +1 (or -1), larger shocks are required to continue such growth. Thus, the same shock will have a larger impact when I_t is close to 0 than when it is close to +1.

The logic behind this functional form is that at higher levels of interaction we expect to see further interaction, and we wish to force the model into requiring more extensive events in order to increase the degree of interaction further; interaction, regardless of type, has a diminishing effect on the extent of an interstate relationship. The parameter, γ, determines the rate of ascent (or descent) from zero to the +1 (or -1) bound. Larger values for γ decrease the rate of change for I_t.[12] This flexibility allows the researcher to customize the bounding function.[13]

As a whole, the model incorporates all four dimensions of change in interstate relationships under the structure of growth and decay. This conceptualization of interstate relationships goes beyond much of the previous work to integrate cooperation and conflict, and intuitively addresses the issue of event intensity. By defining this interaction dynamic formally, we provide a model that is straightforward, flexible, continuous, and data-independent. Using this model, researchers can study either conflict or cooperation, or both. As such, it is an important alternative to treating the dynamic properties of interstate relationships as autoregressive error. Rather than parsing the dynamic properties of interstate relations from the data, this model allows us to incorporate these dynamics explicitly into formal and empirical analyses of the study of international relations. More importantly, our model of interstate interaction is born of theoretical propositions concerning the basis of interstate relationships, not empirically derived. Thus, it is not contingent on any one data source, but is intended to accommodate a range of data sources on interstate interaction appropriate for a particular research question and from a data source of the researcher's own choosing.

Up to this point, we have focused on deriving a dynamic model of general interstate interaction. We turn now to an illustration of how this model may serve as a platform for generating measures of interstate interaction that are useful for empirical analysis. Given this task, the next step necessitates that we operationalize a measurement representing the interaction level concept. While we develop both the positive and negative shock dimensions in the *Interstate Interaction Model* formulated above (see equation [4]), our derivation of a specific measurement, as well as the empirical analysis, will focus solely on the negative (conflictual) shocks in dyadic behavior.[14]

The impetus behind our decision to restrict our focus solely to conflictual behavior is a function of the current literature as well as the availability of data. As it stands, the conflict processes literature relies heavily on the Militarized Interstate Dispute (MID) data set including the temporal period 1816-1992 (see Jones, et al., 1996), and for illustrative purposes we wish to maintain some consistency with previous research.[15] Furthermore, we would like to demonstrate the feasibility of constructing a measure of interstate interaction based on the information currently available to the scholarly community. The construction of measures reflective of a full-fledged operationalization of *Interaction Level*—i.e., employing the cooperative and conflictual elements identified in equation [4]—awaits explication in subsequent research.

AN APPLICATION: DYADIC INTERACTION AND MILITARIZED DISPUTES

The model that we outline in the previous section is designed to accommodate a range of data on interstate cooperation and conflict. Given the reasoning that we cited above, however, in the remainder of the paper we focus our efforts on the conflict dimension of the model. In doing so, we address our second task involving the testing of a primary hypothesis in the reciprocity, recurrent conflict, and rivalry literatures: *that past interstate conflict positively affects the likelihood of current interstate conflict*. However, our intent in the following exercise is not simply to show that history matters, but rather to demonstrate that history makes substantively important contributions to our models designed to predict the occurrence of interstate conflict. That is, we wish to model these effects up front, rather than control or expunge them from our data series. Indeed, as we have identified above, some research agendas in world politics focus on this very aspect of interstate behavior—how history shapes subsequent relationships.

Research Design

Our dual empirical interests of testing the aforementioned hypothesis and measuring the general contribution of our addition to a fully specified empirical model of interstate conflict necessitates that we conduct our analysis on a data sample that affords us an empirical benchmark.[16] Below, we rely on the

Oneal and Russett (1997) data as our benchmark. These data draw on the Correlates of War (COW) interstate system membership list compiled by Singer and Small (1994) and employ the *non-directional relevant dyad-year* as the unit of analysis.[17] The data sample includes information on the militarized interstate conflict behavior and a set of covariates for 827 dyads for the period 1950-1985. Although we refer the reader to Oneal and Russett's article (1997:273-277, especially Table 1) for the details regarding variable operationalization, the set of covariates they employ include the following dyadic indicators familiar to the literature in conflict processes: *democracy*, *alliance*, *contiguity*, *capability ratio*, *economic growth*, and *economic interdependence*. The data matrix compiled by Oneal and Russett (1997) contains a grand total of 19,722 complete records available for empirical analysis. Before proceeding with our empirical analysis we discuss below some issues pertaining to the operationalization of the dependent variable and our measure of interstate interaction.

Variables

Dispute Involvement

Oneal and Russett (1997:273) rely on the COW Militarized Interstate Dispute (MID) data (v2.10) to operationalize their dependent variable, *Dispute Involvement*.[18] This variable is scored a value of 1 when a dyad is involved in one or more disputes (origination and ongoing) in given non-directional dyad-year and 0 otherwise.

Conflict Interaction Level

In addition to the set of covariates furnished in the Oneal and Russett data set, our primary focus concerns the contribution of a measure of interstate interaction to a fully specified model of interstate behavior. The task before us, then, is to translate the conflict component of the *Interstate Interaction Model* (see equation [4]) into an operational indicator that in turn may be specified in a statistical model. Given the information available to us in the MID data set, we proceed by translating equation [4] in the following manner:

$$i_t = \left(e^{-\left(\frac{\text{PeaceYears}_t}{\left(\left(\text{PrevDisp}_t + 1 \right) \right)} \right)} \right) i_{t-1} - \left(\frac{\sum_i^n \text{HostLev}_{ti}}{\text{PeaceYears}_t} \right), \quad [6]$$

where i_t is the *Conflict Interaction Level* between two states for a given year, t, i_{t-1} is the previous year's conflict interaction level, *HostLev*$_t$ is the occurrence and severity of a militarized dispute for the given year t,[19] and *PeaceYears*$_t$ is the amount of time that has elapsed since the dyad last became involved in a dispute. For years in which more than one dispute occurs between a dyad (n>1), *HostLev*$_t$ is aggregated across all disputes in that year.[20] With respect to the terminology in the model developed above (see equation [4]), *PeaceYears*$_t$ corresponds to *Event Temporal Distance*$_t$ and *Conflict Temporal Distance*$_t$ (which in this case are the same), *PrevDisputes*$_t$ is a measure of *Event History*$_t$, and *HostLev*$_t$ is the operationalization of *Degree of Conflict*$_t$.[21] Equation [6] is then transformed using equation [5] to obtain a normalized *Conflict Interaction Level*, I_t, for each dyad-year in the Oneal and Russett sample. We lag *Conflict Interaction Level* one dyad-year in order to avoid problems of causal circularity, a transformation resulting in a variable we refer to as *Conflict Interaction Level*$_{t-1}$. Descriptive statistics for the entire set of covariates are reported in Table 1.[22]

Table 1 about here

In Figure 1, we illustrate the behavior of conflict interaction levels for a sample of three dyads from the post-WWII period: India–Pakistan, Guyana–Brazil, and Argentina–United Kingdom. By illustrating the time-series properties of *Conflict Interaction Level* for each of three dyads, our intent is to demonstrate the sensitivity of this measure to qualitative differences between dyads exhibiting very distinct conflict histories. The *Conflict Interaction Level* for the Guyana–Brazil dyad is representative of a pair of states with a militarized interaction history that is characterized by infrequent and isolated militarized conflict. Indeed, the Guyana–Brazil dyad reflects no evidence of long-term animosity between these two states. Conversely, the *Conflict Interaction Level* for the Argentina–United Kingdom dyad reflects a relationship that is characterized by recurrent and severe conflict anchored in the Falklands War (1982). In addition, the Argentina-United Kingdom dyad is also illustrative of an interstate relationship that is punctuated by extended periods of peace between conflictual events, as evidenced by the near neutrality of the *Conflict Interaction Level* during the period 1959-1975. Finally, the *Conflict Interaction Level* for the India–Pakistan dyad illustrated in Figure 1 reflects an interstate relationship that exhibits chronic animosity during the period 1950-92. As such, the India-Pakistan dyad characterizes an interstate relationship that the rivalry literature identifies as an enduring rivalry (see Goertz and Diehl, 1995, 1998, 2000).

Figure 1 about here

Method

The dichotomous nature of our dependent variable, *Dispute Involvement*, leads us to conclude that using an ordinary least squares (OLS) method to estimate the relationship between the dependent and independent variables is inappropriate (King, 1989, Liao, 1994). As an alternative, we resort to logistic regression, a technique designed to estimate relationships between variables when the dependent variable is discrete. Furthermore, it is also the statistical model that Oneal and Russett (1997) employ in their analysis of dispute involvement, and thus we wish to retain consistency with their method of analysis.

In estimating these logit models, our initial concern is with the direction and statistical significance of the variable *Conflict Interaction Level* as it pertains to the dependent variable, *Dispute Involvement*. Specifically, since the hypothesis we wish to test asserts that past conflict interaction will increase the likelihood of subsequent dispute involvement, we seek to confirm or disconfirm this relationship. In addition, we are also interested in the extent to which our inclusion of the variable *Conflict Interaction Level* improves the overall statistical performance of our logit models. That is, we would like to determine whether we are statistically significantly better at predicting the dependent variable, *Dispute Involvement*, by including the variable *Conflict Interaction Level*$_{t-1}$ in our logit specification.[23] In conducting this "competition" between a logit model including the measure of conflict interaction (i.e., the "saturated" model) and a logit model excluding this measure (i.e., the "restricted" model), we rely on the *likelihood ratio test* (King, 1989) to assess the relative goodness of fit of these models.

Analysis

Our empirical analysis proceeds in five stages. First, we replicate a representative model from Oneal and Russett's study. Second, we re-estimate the Oneal and Russett specification, but include the variable *Conflict Interaction Level*$_{t-1}$, in order to allow us to determine whether there is empirical support for the hypothesis that a dyad's past militarized dispute behavior affects the probability of current dispute origination. In addition, we resort to the likelihood ratio test statistic to determine whether the inclusion of our measure of conflict interaction, *Conflict Interaction Level*$_{t-1}$, significantly improves the ability of the fully specified model formulated by Oneal and Russett (1997) to predict dyadic militarized interstate conflict.[24]

Third, for the sake of comparison we remove the variable *Conflict Interaction Level*$_{t-1}$ from the model and re-estimate the model including the "logit-spline" specification formulated by Beck, et al. (1998). Fourth, we estimate a fully saturated model containing all of the covariates specified by Oneal and Russett, the Beck, et al. logit-spline covariates, and *Conflict Interaction Level*$_{t-1}$ in order to assess the statistical and substantive importance of our theoretically-based measure, *Conflict Interaction Level*$_{t-1}$, relative to the statistical correction proposed by Beck, et al. Finally, we demonstrate the relative importance of the variable *Conflict Interaction Level*$_{t-1}$ for the prediction of militarized disputes.

We report the results of our logit analyses in Table 2. Model (1) is a replication of the best performing logit model reported by Oneal and Russett.[25] Next, in model (2) we estimate a logit model in which we introduce the variable that is of primary interest, *Conflict Interaction Level*$_{t-1}$ to the original model specified by Oneal and Russett. Inspection of the coefficient estimating the impact of *Conflict Interaction Level*$_{t-1}$ on *Dispute Involvement* reveals a highly statistically significant and negative relationship ($p<.001$). Indeed, the coefficient for *Conflict Interaction Level*$_{t-1}$ suggests that as the past conflict interaction level within a dyad intensifies (becomes more negative, given our scaling of conflict from 0 to –1) the log odds of a dispute origination occurring in the current period increase. A survey of the remaining variables indicates that coefficients for some of the covariates become insignificant when we include *Conflict Interaction Level*$_{t-1}$ in the logit specification. Specifically, the coefficients for the variables *Democracy*$_H$ and *Democracy*$_L$**Contiguity* attenuate to insignificance in our revised model. Furthermore, in every case the magnitudes of the coefficients attenuate with the introduction of *Conflict Interaction Level*$_{t-1}$. In sum, model (2) suggests empirical support for the general hypothesis advanced in several literatures: *dyadic militarized conflict begets dyadic militarized conflict, while dyadic peace begets dyadic peace*.

Table 2 about here

Our second task involves determining whether the introduction of the variable *Conflict Interaction Level*$_{t-1}$ into the logit model significantly improves the overall ability of the set of covariates to predict the dependent variable. We can determine whether this is the case by calculating a likelihood-ratio test statistic between the results reported for models (1) and (2). Estimating a likelihood ratio test requires that the models of interest be "nested" (Long 1997). In terms of the models reported in Table 2, model (1) is nested in model (2). Calculating a likelihood ratio test between models (1) and (2) reveals that the addition of the variable *Conflict Interaction Level*$_{t-1}$ significantly improves our ability to predict the dependent variable, *Dispute Involvement* (p<0.0001).[26]

For the purposes of comparison, were are interested in comparing the performance of the variable *Conflict Interaction Level*$_{t-1}$ specified in model (2) to Beck, et al.'s logit spline. Model (3) re-estimates the Oneal and Russett model (model 1) while incorporating Beck, Katz and Tucker's correction. Consistent with their analysis (Beck, et al., 1998, 1277), the logit-spline correction attenuates the statistical significance for several of the causal variables that were estimated to be statistically significant in model (1). While we cannot directly compare models (2) and (3) because neither model is nested within the other, we can indirectly compare the two approaches by estimating a fourth model including both the variable *Conflict Interaction Level*$_{t-1}$ and the logit-spline covariates. Due to the fact that models (2) and (3) are nested within model (4), we can perform a pair of likelihood ratio tests to determine whether either approach (i.e., *Conflict Interaction Level*$_{t-1}$ versus logit-spline) renders the other approach unnecessary from an econometric standpoint.

Perhaps it is telling to point out that both the variable *Conflict Interaction Level*$_{t-1}$ and the variable *PeaceYrs* from the logit-spline correction are negative and statistically significant in model (4); that is, neither variable overpowers the other in the model and we can conclude that these two variables do not represent identical information. Our first likelihood ratio test compares model (3) (the logit-spline model without the *Conflict Interaction Level*$_{t-1}$ variable) and model (4) (the saturated model) to test whether the *Conflict Interaction Level*$_{t-1}$ variable improves our ability to predict ongoing disputes. The test results ($\chi^2(1) = 142.17$, $p(\chi^2) < 0.001$) indicate that, even when using the logit-spline technique, the *Conflict Interaction Level*$_{t-1}$ variable significantly improves the performance of the saturated model.

The second likelihood ratio test compares model (2) and model (4) to determine if the logit-spline correction improves upon a model that includes the *Conflict Interaction Level*$_{t-1}$ variable. Similar to the previous likelihood-ratio test, the results ($\chi^2(4) = 759.17$, $p(\chi^2) < 0.001$) indicate that the inclusion of the logit-spline correction improves upon our ability to predict ongoing disputes. In short, we find here that both the theoretical variable advanced in this paper and the econometric correction advanced by Beck, et al. prove to be important additions to the model of dispute origination proposed by Oneal and Russett.

These findings also underscore our position that the variable *Conflict Interaction Level*$_{t-1}$ and the logit-spline parameters are not in direct competition with one another. Rather, these two pieces of information are different, but not necessarily incompatible, approaches to assessing the impact of temporal history on interstate relations. We maintain that our approach offers interpretive advantages over the Beck, et al. approach that are independent of this competition. This is less a critique of the Beck, et al. econometric technique than it is an understanding that the two approaches serve different purposes. The econometric technique is designed to enable the researcher to obtain the correct parameter estimates for the variables of interest, while our approach is designed to include the historical relationship among this list of variables that are of substantive interest. As such, we do not envision these approaches as mutually exclusive.

Next, we turn to estimating the relative impact of several of the covariates reported in model (2) on the log odds of dispute origination. By doing so, we are able to estimate the relative impact of each independent variable on the origination of militarized interstate conflict and we can determine the substantive importance of including the variable *Conflict Interaction Level*$_{t-1}$ in our predictive model of interstate behavior. In Table 3, we report each covariate's impact on the probability of *Dispute Involvement* as measured in percentage change. Specifically, we calculate the percentage change in the probability of an involvement in a militarized interstate dispute based on two values for each covariate, the maximum and minimum values as reported above in Table 1. In terms of the maximum values of the covariates, it is clear that when set to their maximum values, the covariates *Democracy Score*$_L$, *Capability Ratio, Growth*$_L$**Contiguity* and *Conflict Interaction Level*$_{t-1}$, each exert a negative influence on the probability of a dyad becoming involved in a militarized dispute. Recall, that at its maximum the value of *Conflict Interaction Level*$_{t-1}$ is 0, or neutrality (given the complete –1 to +1 range if we were to include cooperative events.) Therefore, when a dyad achieves neutrality, the probability of a dispute involvement decreases by about 7%. Alternatively, the percentage change corresponding to the variable *Capability Ratio* suggests that when there is considerable disparity in the capabilities held by each state in a dyad (i.e. one state is vastly more powerful than its dyad partner), the probability of the dyad engaging in a dispute is reduced by 100%.

Turning to the calculations reported in the right-hand half of Table 3 wherein we examine the impact of the covariates when set to their respective minimums, some very intriguing information emerges. In particular, our calculations indicate that while non-contiguous dyads are 48% less likely to engage in a dispute, each of the remaining covariates has a positive impact on the probability of a dispute involvement. Perhaps most striking are estimated effects of the variables *Growth*Contiguity* and *Conflict Interaction Level*$_{t-1}$. Indeed, contiguous dyads in which negative dyadic growth rates obtain experience an increase in the probability of a dispute involvement of up to 1,699%. Similarly, the measure that we have derived from our dynamic model of interstate interaction, the variable *Conflict Interaction Level*$_{t-1}$, increases the probability of a dyad engaging in a dispute involvement by up to 1,781%. These findings underscore the importance of including this information in the standard specification of dyadic militarized conflict. Finally, as an alternative method of illustrating the impact of conflict interaction on dispute involvement, in Figure 2 we plot this probability across the range of values for the variable *Conflict Interaction Level*$_{t-1}$. In short, as the conflictual interaction between two states increases (becomes more negative), the probability of a dyadic militarized dispute involvement increases markedly.

Table 3 and Figure 2 about here

CONCLUSIONS

Our empirical analysis of the conflict interaction variable derived from our dynamic model of interstate interaction leads to several conclusions. First, we find empirical support for the hypothesis advanced at the outset of the paper that past interstate interaction is an important predictor of current behavior. Second, from a purely statistical standpoint, the empirical analysis demonstrates that inclusion of the variable *Conflict Interaction Level*$_{t-1}$ significantly increases our overall ability to predict the probability of interstate conflict. Moreover, the information contained in this variable is not reflected entirely in the purely econometric approach advanced in Beck, et al., (1998).[27]

Third, the variable *Conflict Interaction Level*$_{t-1}$ makes an important substantive contribution to our ability to predict the occurrence of interstate conflict, and is relatively more significant in its independent impact on the probability of militarized interstate dispute involvement relative to the independent effects exhibited by several standard control variables, such as dyadic democracy and relative capability. Fourth, our analysis convinces us that, based on this general model of interstate interaction, we can develop measures of interstate behavior capturing the dynamic, memory-oriented aspect of dyadic interaction with information about interstate behavior currently available to the field. Finally, in demonstrating the viability of our model for empirical analysis, we resort to data contained in the MID data set. However, these data represent only one *type* and *source* of interstate interaction. We remain convinced that in future research it may prove even more advantageous to incorporate data on cooperative and conflictual behaviors simultaneously in a full-fledged measure of interstate interaction, as well as drawing on more than one source of data to inform empirical operationalizations of these models.

It is evident to us that the quantitative literature on conflict processes is becoming increasingly oriented toward the analysis of interstate interaction as a series of discrete events. However, the notion that interstate interactions may be represented as discrete phenomena is inconsistent with the evidence of the dynamic qualities of interstate relationships identified in the early work on arms races and interstate action-reaction, more recent research on interstate reciprocity, recurrent conflict, and rivalry, and our intuition as scholars of world politics. A dynamic approach to studying interstate interaction provides a firmer basis for prediction, allowing us to incorporate these dynamic properties more explicitly as both explanans and explandums in the statistical models that we specify. Doing so affords the researcher the ability to avoid the nettlesome issue of using interstate behavior, such as militarized conflict, as a case selection device in order to identify a subset of dyads which in turn are then studied for their conflict behavior. Instead, interstate behavior such as rivalry can be conceptualized and operationalized as a continuous property across the universe of dyads. This approach provides the researcher with explanatory leverage that is not afforded by the use of econometric techniques to control for temporal dependence.

In the end, we anticipate that some scholars will find our conceptualization of interstate interaction too simple. We submit that absent from our model are several dimensions that may be relevant to the characterization of interstate relationships, such as the incorporation of political leaders' perceptions of friends and enemies as suggested by Thompson (1995, 1998), or the identification of the issues forming the foundation of an interstate relationship, as urged by Bennett (1996). Yet, we must begin somewhere, and we believe that the model of interstate interaction that we propose herein accomplishes precisely what models political behavior are designed to do: *provide a general theoretical platform from which individual scholars may make modifications as necessitated by their research questions*.

More importantly, building models to match what our theories and our intuition suggest is an international environment replete with dynamic interactions between states will compel us to incorporate these properties directly into our statistical analyses. Ultimately, adding this dynamism back into our empirical investigations will serve to fortify our ability to make predictions about political behavior. We consider our efforts as merely the first salvo of what we hope will be a fruitful "second generation" of dynamic models of interstate interaction. As such, we hope that this exercise stimulates researchers to unify competing research agendas toward the goal of obtaining a firmer grasp of causality in interstate relations.

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TABLE 1. Descriptive Statistics

Variable	Mean	Std. Dev.	Minimum	Maximum
Allies	—	—	0	1
Capability Ratio	161.681	435.299	1	7775.63
Conflict Interaction Level$_{t-1}$	-0.045	0.173	-0.99	0
Contiguity	—	—	0	1
Democracy Score$_H$	4.740	7.135	-10	10
Democracy Score$_L$	-3.574	6.884	-10	10
Democracy$_L$*contiguity	-1.183	4.293	-10	10
Dyadic trade-to-GDP ratio$_L$	0.002	0.008	0	0.177
Economic Growth Rate$_L$	0.780	3.359	-26.49	15.32
Growth$_L$*contiguity	0.197	2.118	-26.49	15.32
Trend, dyadic trade-to-GDP ratio$_H$	0.0001	0.015	-0.221	0.355

TABLE 2. Models of Dispute Involvement, 1950-85

Variable		*Model 1* [a]	*Model 2*	*Model 3*	*Model 4*
Conflict Interaction Level$_{t-1}$	β		**-4.069**		**-1.694**
	SE_β		0.117		0.141
Democracy Score$_L$		**-0.078**	**-0.053**	**-0.060**	**-0.050**
		0.012	0.012	0.012	0.012
Democracy Score$_H$		**0.036**	0.006	**0.024**	0.013
		0.006	0.007	0.006	0.007
Economic Growth Rate$_L$		**0.088**	*0.052*	0.028	0.020
		0.024	0.022	0.020	0.020
Allies		**-0.703**	**-0.414**	**-0.327**	**-0.285**
		0.083	0.099	0.099	0.104
Contiguity		**1.830**	**0.977**	**0.899**	**0.654**
		0.127	0.140	0.135	0.142
Capability Ratio		**-0.0024**	**-0.001**	**-0.0019**	**-0.0014**
		0.0005	0.0003	0.0004	0.0003
Dyadic trade-to-GDP ratio$_L$		**-84.139**	*-39.745*	-22.359	-16.923
		20.800	15.752	13.560	13.126
Trend, dyadic trade-to-GDP ratio$_H$		**-9.414**	**-8.172**	-3.499	-3.265
		2.593	3.170	2.999	3.175
Democracy$_L$*contiguity		*0.028*	0.029	0.015	0.018
		0.015	0.016	0.016	0.017
Growth$_L$*contiguity		**-0.165**	**-0.140**	**-0.091**	**-0.091**
		0.023	0.026	0.025	0.025
Constant		**-3.898**	**-4.081**	**-0.865**	**-1.452**
		0.118	0.120	0.137	0.152
PeaceYrs [b]				**-1.115**	**-0.887**
				0.053	0.055
χ^2		**562.46**	**1986.77**	**1864.28**	**2094.04**
Log likelihood		-3186.11	-2548.48	-2239.98	-2168.8939
Pseudo R^2		0.114	0.291	0.377	0.397

Note: N = 19,772. Bold = p < .001; Italics = p < .01. All significance levels are two-tailed.

[a] Model 1 is a replication of Oneal and Russett (1997, 282, Table 4) Eqn. 7.

[b] The spline coefficients are not reported.

TABLE 3. Impact of the Covariates on the Probability of Ongoing Disputes

Covariate	Max.	Predicted p	%Δ	Min.	Predicted p	%Δ
Democracy $Score_L$	10	0.0161	-50	-10	0.045	39
Allies	1[a]	—	—	0	0.048	49
Contiguity	1[a]	—	—	0	0.012	-62
Capability Ratio	7775.6	0.0000	-100	1	0.038	17
Dyadic trade-to-GDP $ratio_L$	0.177	0.0000	-100	0	0.035	9
Trend, dyadic trade-to-GDP $ratio_H$	0.355	0.0019	-94	-0.221	0.170	422
$Growth_L$*Contiguity	15.3	0.0040	-88	-26.49	0.585	1699
Conflict Interaction $Level_{t-1}$	0.0	0.0273	-16	-.985	0.612	1781

Note: The baseline probability from Table 2, model (2), is 0.0166. We compute this probability by setting all covariates to their means, except for the covariates *Allies* and *Contiguity*, which we set to 1 (max).

[a]These variables are already set to their maximum values in the baseline calculation, and therefore we do not record change in probability.

FIGURE 1. Three Dyad Sample, Post-WWII Period

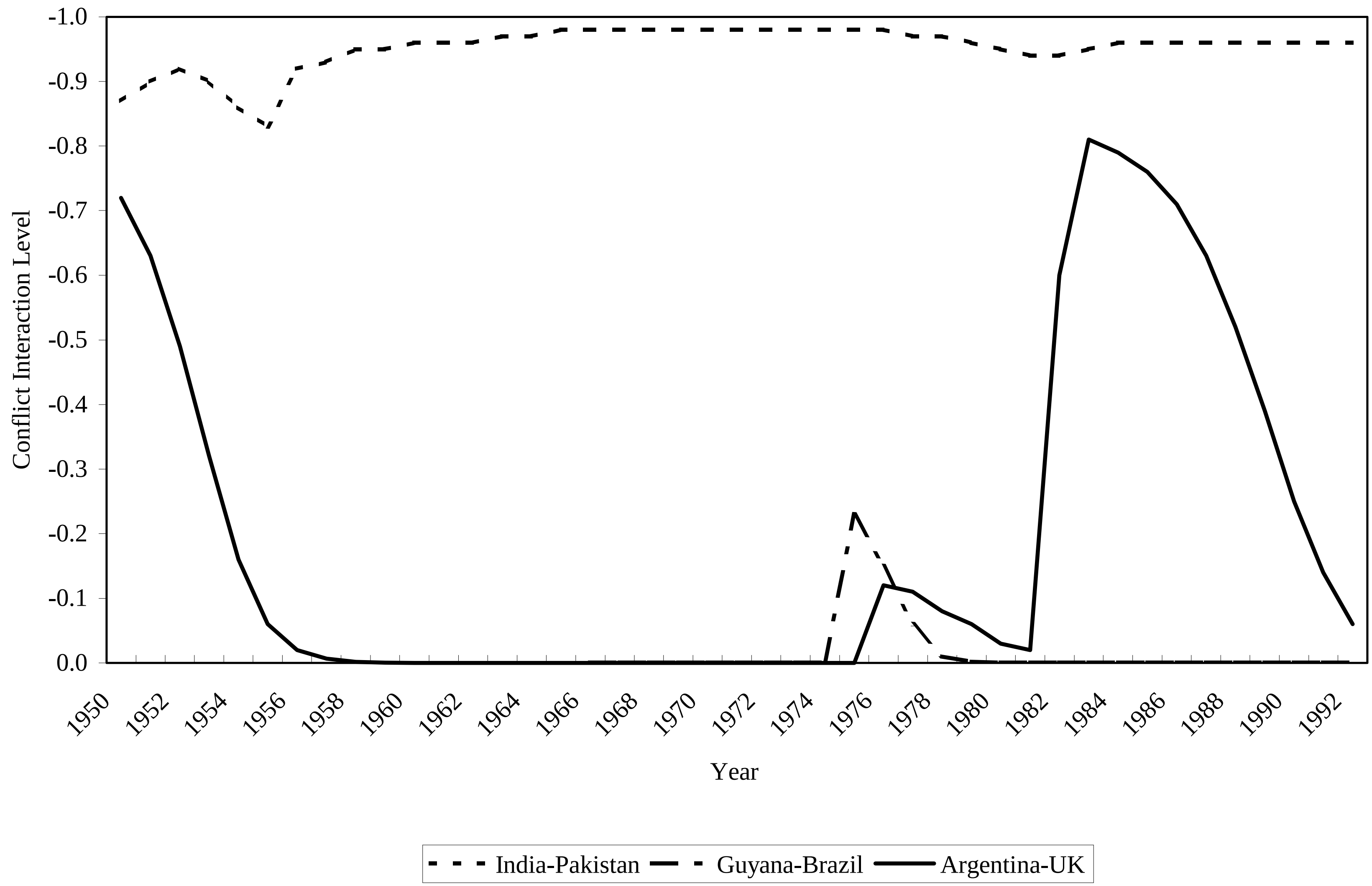
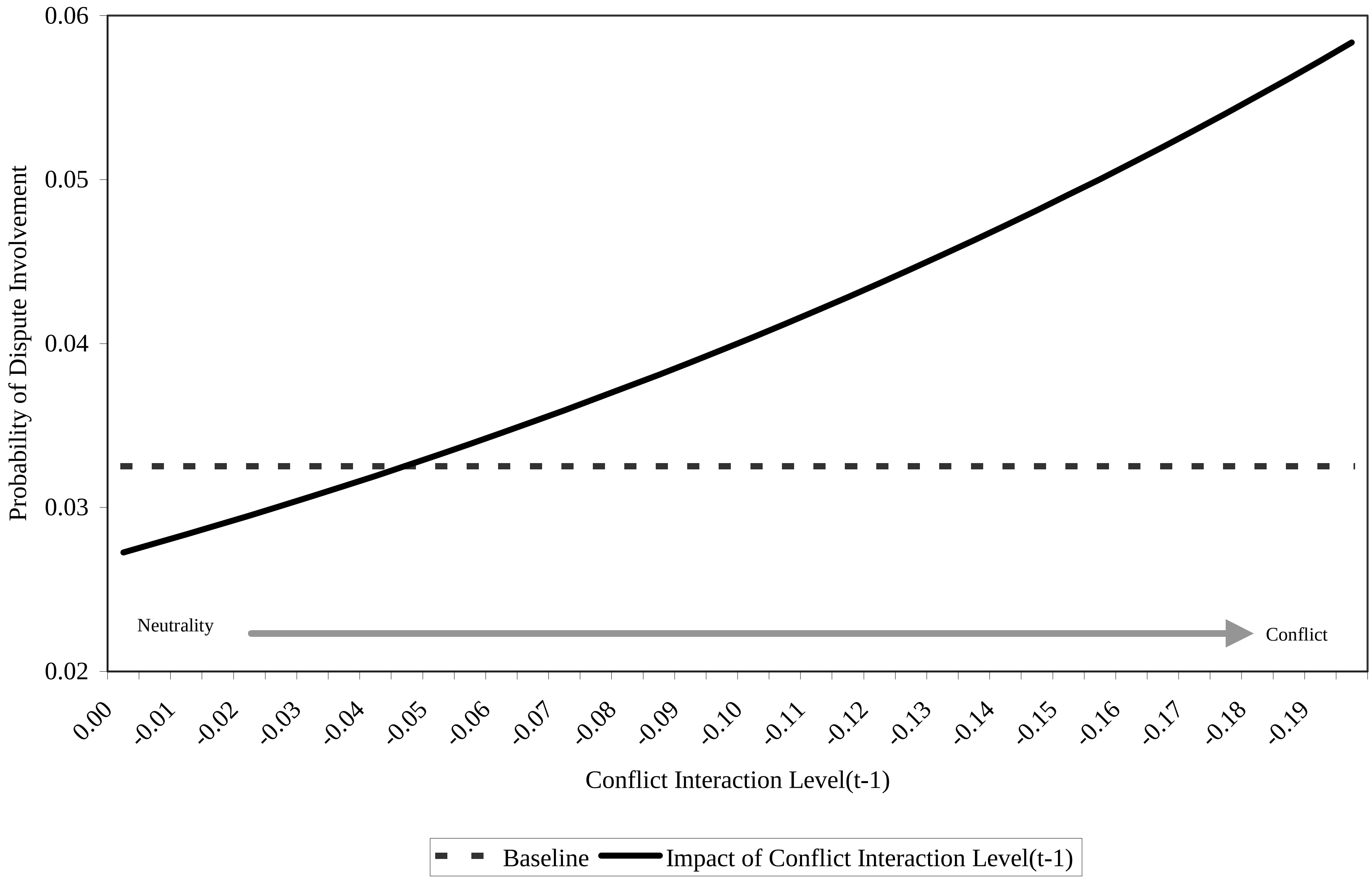


FIGURE 2. Impact of Conflict Interaction Level(t-1) on Probability of Dispute Involvement(t)



ENDNOTES

[1] Here, we define Arab neighbors to mean any state with a Correlates of War (COW) state number >=600 and < 700. The interval we consider is 1948-1992. The COW state membership list (version 1997.1) is available from the following URL: http://pss.la.psu.edu/intsys.html.

[2] We should note, however, that there have been efforts from within this “discrete conflict” tradition to study interstate conflict from a more dynamic, process-oriented approach. In particular, see the contributions to the volume edited by Bremer and Cusack (1995).

[3] See, for example, the Cochrane-Orcutt and Hildreth-Lu procedures (Pindyck and Rubinfeld, 1991).

[4] Diehl and Goertz refer to this method as one that is grounded in “time-density” criteria. We argue that there is an element of operational circularity in this criteria, a schema in which the authors propose a set of empirical criteria for differentiating between "isolated," "proto," and "enduring" dyadic rivalries. Specifically, the framework is formulated such that the classification of a rivalry at time *t-1* is, in part, a function of a dyad's behavior at times *t and t+n* (Goertz, 1998). According to Goertz and Diehl (1995:33), “an enduring rivalry is a competition between states that involves six or more militarized disputes between the same two states over a period of 20 years.” They classify the interactions between the United States and the Soviet Union, for example, as an enduring rivalry *beginning* in 1946 (see Table 1, 1992:156). The sixth dispute between these two states, however, does not occur until 1957 (#26, 1948; #1286, 1949; #50, 1953; #208, 1953; #200, 1955; and #607, 1957). Thus, this time-density framework “backcodes” from the year in which the six-dispute threshold is reached to include those years in which a *future* enduring rivalry is actually passing through the "isolated" and "proto" stages. Therefore, researchers employing this framework are likely to confront the problem of circularity if they use Goertz and Diehl's variable for measuring the presence or absence of enduring rivalry as an independent variable to predict militarized conflict. See also Gartzke and Simon (1999) for a treatment of extant coding schemes for identifying interstate rivalries.

[5] We owe a special debt of gratitude to Chad Atkinson, Dina Zinnes, and Robert Muncaster of the Merriam Lab for their contributions and encouragement during the development of this model.

[6] This parameter weights the impact of the shock on $\underline{i}_t$. It may be the case that researchers will have a theoretical motivation for adjusting $\underline{\beta}$.

[7] Indeed, one could build multiple shocks for each phenomenon. These shocks are then weighted by their β parameters to equilibrate their maximum and minimum values. For example, if the conflict shock ranges from 0 to 10 and the cooperative shock ranges from 0 to 5, the parameters would be set to a 1:2 ratio. While this does not completely assuage the problems related to the ordinal character of such information, it constrains the behavior of both shocks to the same range.

[8] This assumption places our approach in contrast to the punctuated equilibrium models discussed in Cioffi-Revilla (1998) and Diehl (1998).

[9] Similar approaches to modeling the decay properties of conflict history are employed by Hegre, et al. (1997) in their study of regime changes and civil war, by Partell (1997) in his study of dispute escalation, and by Raknerud and Hegre (1997) in their study of the hazard of interstate war.

[10] An anonymous reviewer suggested an inverse relationship between *Event History* and *Event Temproal Distance*, arguing that memory fades quickly at first and then slows down and that as events accumulate the decay function increases. We constructed this alternative model and put it through the same operationalization and empirical analysis as the original model. An informal comparison between our model and the reviewer's alternative indicates that (given the data and methods used herein) the original model outperforms the alternative.

[11] This example assumes that the temporal unit of analysis is the calendar year. However, the model is flexible in that it can incorporate any level of temporal aggregation (e.g., days, months, decades), as long as this level remains consistent across shocks and throughout the entire analysis.

[12] For example, if γ is set to 0.1, then an unbounded score (i_t) of 0.1 translates to a bounded score (I_t) of 0.5. If γ is set to 1, however, then the same unbounded score translates to a bounded score of 0.09.

[13] We should note that the decision to use the bounding function resides with the researcher, based upon how the researcher conceptualizes the accruement of interstate interaction.

[14] In this vein, see Rioux (1998) and Bolks (1998) for continuous measures of interstate threat.

[15] We are aware that alternative data sources (e.g., the WEIS [Goldstein, 1992], COPDAB [Azar, 1984], or the *International Crisis Behavior Project* [ICB] [Brecher and Wilkenfeld, 1997; Wilkenfeld and Brecher, 1997] data sets) provide different information regarding interstate behavior. However, our primary purpose in the empirical analysis that follows is simply one of explication; the model that we present is flexible enough to rely on any number of sources of interstate behavior as determined by the researcher.

[16] From our perspective, benchmark data have three important qualities. First, a benchmark contains a set of covariates that the literature accepts as approximating a fully specified model on interstate conflict. Second, these data are used in published research. Finally, that these data are in the public domain.

[17] A *nondirectional* dyad analysis assesses the qualities of covariates as they obtain conjointly. *Relevant dyads* are those dyads in which the states comprising a dyad are either geographically contiguous or at least one member of the dyad qualifies as a major power according the to the COW definition (Singer and Small, 1994). See the discussion of relevant dyads in Oneal and Russett (1997) and Maoz and Russett (1993).

[18] The dispute data are available from the following URL: http://pss.la.psu.edu.

[19] In years in which more than one dispute occurs, the total number of disputes per year is obtained. $HostLev_t$ is only a satisfactory measure of dispute severity on two counts. From a theoretical standpoint

one may desire to weight military actions by costs, such that instances of "use of force" without battle deaths are less significant than are instances of "use of force" where battle deaths are incurred by one, or both, of the parties to a dispute. From an empirical standpoint, the modal category of behavior in the MID data is "use of force" ($HostLev_t$=4), which, it turns out, represents a rather inclusive category of actions by states, with the inclusion of fishery disputes involving third parties, reconnaissance over-flights, and low-level uses of force, for example, in addition to the more familiar formal military engagements. Initially, we intended to compensate for this problem by incorporating "fatality levels" in an additive or multiplicative transformation with $HostLev_t$, but we were ultimately discouraged from doing so given the ordinal nature of the two variables. Thus, we argue that the error component contained in $HostLev_t$ is a constraint imposed upon us by the dispute data, not by the continuous measure of conflict interaction that we construct herein.

[20] This is denoted by indicating i disputes, and summing all severity scores over all i disputes for a given dyad-year. For example, assume that in one year a dyad engages in three disputes with *HostLev* scores of 3, 4, and 5, respectively. We simply add these three scores together to get a total *HostLev* of 12 for that dyad-year.

[21] Given no theoretical or operational motivation to do otherwise, we assign a value of 1 to the α, β, and γ parameters.

[22] We calculated the conflict interaction levels for the universe of non-directional dyad-years contained in Tucker's (1996) "Dyad Hard: The Interstate Dyad-Year Dataset," (v2.1) for the period 1816-1992. Therefore, when analyzing the Oneal and Russett benchmark data, we rely on the value for the variable $Conflict\ Interaction\ Level_{t-1}$ in the year 1949 to inform the analysis in year 1950 and so forth for the remainder of the 1950 to 1992 period. The conflict interaction levels for the universe of non-directional dyad-years for the period 1816-1992, as well as the data and command files employed in our benchmark tests reported herein, are available from the authors upon request.

[23] For examples of this comparative theory testing approach to the study of interstate conflict, see Bremer (1992, 1993, 1996) and Bennett and Stam (1998).

[24] Our empirical analyses were carried out in *Stata 6.0* (StataCorp 1999).

[25] We determine "best performing" by simply comparing the log likelihood values for all of the models Oneal and Russett estimate on the sample containing 19,772 observations (the largest sample available for analysis.) According to these criteria the best performing model is specified in Table 4, equation [7] of their article (1997:282). We are grateful to Oneal and Russett for providing their data and command files.

[26] We use the likelihood-ratio test specified in King (1989:84-5), $\mathfrak{R}=2(\ln L^*-\ln L_R^*)$, where $\mathfrak{R}$ is the likelihood ratio test statistic, $\ln L^*$ is the log-likelihood of the unrestricted model, and $\ln L_R^*$ is the log-likelihood of the restricted model. With respect to the comparison between models (1) and (2), $\mathfrak{R} = 2((-2548.48)-(-3186.11)) = 1275.27$, and we are able to reject the hypothesis that the inclusion of *Conflict Interaction Level*$_{t-1}$ makes an insignificant contribution to the overall predictive capacity of the model ($p<0.0001$, df=1). We also conduct a more stringent test by including a lagged dependent variable in both models (1 and 2), with similar results that lead to the same conclusion enabling us to reject the null hypothesis.

[27] Furthermore, we find that the measure we derive from the dynamic model of interstate interaction is important despite the fact that we have *not included* information about cooperative actions that might have occurred between these dyads. Incorporating these cooperative actions would likely reduce the error component in the variable and therefore do a better job of predicting the dependent variable, dispute involvement.