Explaining Variance

Rethinking Social Causation

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Abstract

Political scientists typically conceive of causation purely in "mean-centric" terms: the statement "X causes Y" is taken to imply that an increase in the value of X changes the mean of the distribution of Y. This article challenges that point of view. Many independent variables of interest to students of politics have an effect by altering the *variance,* not the mean, of the distribution of the dependent variable. This form of causation is alien to methodology textbooks and greatly underappreciated in empirical work. Thinking about the causes of changing variance opens up a theoretical dimension that has heretofore been neglected; understanding the causes of changing variance can provide a more fine-grained empirical description of the political world.

Introduction

Political scientists have long puzzled over the meaning of causation. From Aristotle's distinction among formal, material, efficient, and final causes[1] to current discussions of probabilistic and counterfactual causation, we have struggled to put into uncontroversial language the nature of the relationship between the phenomena that we study and the things that bring them about.

At present, most empirically oriented political scientists have settled on a specific definition of causation that is "mean-centric" and at least implicitly counterfactual. This understanding of causation is central to our understanding of politics. It drives research design in books, dissertations and articles, and it establishes an essential criterion by which such works are judged: few are accepted for publication without having demonstrated some sort of causal effect, defined in these terms.

Our focus on the mean of the distribution of the dependent variable has been so complete that we have managed to overlook a simple fact of great importance: some causes produce changes in the *variance* of the distribution of a dependent variable. This form of causation, though understood in fields as diverse as biology and baseball,[2] is largely unknown in political science: to the extent that we notice changes in variance, we tend to treat them as a nuisance to be compensated for (with, for example, robust standard errors) rather than as a substantively interesting phenomenon to be studied.[3]

Theories that do or could have implications for variance, whether or not their authors explicitly recognize that fact, demonstrate that a wider appreciation of variance-altering causation would convey both theoretical and empirical advantages to students of politics. Thinking theoretically about variance-altering causes can increase a researcher's theoretical leverage by bringing to light hypotheses that might not have been recognized and can improve the quality of research by tightening the connection between indicators and concepts. Studying variance-altering causes empirically can provide researchers with a more accurate and thorough description of the social and political world than they would otherwise possess.

Toward that end, this article discusses the nature of variance-altering causes and offers a range of examples (or, if the authors have not recognized

[1] See the *Physics,* II, 3.

[2] See Gould (1996).

[3] Downs and Rocke (1979), *inter alia,* make this point in the specific case of heteroskedasticity in bivariate regression. The authors argue against statistical "quick fixes" to eliminate the effects of heteroskedasticity and argue that we should instead seek substantive meaning in the difference in variance.

the presence of a variance-altering cause, potential examples) that span the subfields of political science. It then discusses four different classes of causal mechanisms that can produce changes in variance. The article ends by examining the possibility of combining mean-altering and variance-altering causation to improve our understanding of social phenomena to an even greater degree, using the relationship between agents and structures, and in particular the example of Theda Skocpol's *States and Social Revolutions,* to illustrate the potential power of such syntheses.

Causes and Effects

Understanding the nature of causation has been a growth industry for centuries. Distinctions have been made between agent causation, which is purposive, and event causation, which is purely material. Causation has been understood as a "constant conjunction" between events (i.e., as necessary and sufficient conditions), as straightforward logical entailment, as conditions that are insufficient but necessary parts of a condition which is unnecessary but sufficient, as probabilistic relationships involving simple covariance, as a logical "do" operator, as complexity (in which either two causes produce an effect in conjunction or multiple, redundant causes exist for a single event), and as a counterfactual relationship (in which the effect would not have occurred in the absence of the cause)—just to name a few characterizations.[4]

In practice, most empirical studies in political science that examine cause-effect relationships conceive of such relationships as being mean-centric and counterfactual. By "mean-centric" I mean the following: Phenomena are measured, and the resulting data are recorded as variables. These variables have distributions. An "effect" is conceived of as a change in the mean of the distribution of the dependent variable, conditional upon a change in the value of the independent, or causal, variable.

This is, virtually without exception, the concept underlying the definition of causation and causal effects in social science methodology texts.[5]

[4]See Hume (1739); Goertz and Starr (2002); Mill (1865), Hempel (1962); Mackie (1965), Kim (1965); Suppes (1970), Eells (1991), Salmon (1998); Pearl (2000); Ragin (1987), Jervis (1997), Ragin (2000); and Lewis (1973) and Tetlock and Belkin (1996), respectively. The interested reader will find substantial additional background material on these subjects in Sosa and Tooley (2001) and Ruben (1993).

[5]At least, those that are empirically oriented. See e.g. Brady and Collier (2002, *passim*), Campbell and Stanley (1963, 64), Cook and Campbell (1979, 33), Fay (1996, 122), Frankfort-Nachmias and Nachmias (1996, 103-104), Gerring (2001), King, Keohane, and

The relationship between variables matters because the conclusions drawn from it are counterfactual: in the absence of the cause, all else being equal, the effect would not have occurred. Such a causal argument draws its empirical strength from the regularity of the statistical relationship in question and its explanatory power from the counterfactual nature of the hypothesis.

The discussion by King, Keohane, and Verba provides perhaps the clearest illustration. In their example, the causal effect of incumbency on the fraction of the vote received by a candidate for office is at issue, and the "mean causal effect" (β) is defined as the difference between the means of two distributions—one a distribution of vote fractions across multiple hypothetical elections with an incumbent candidate, and the other a distribution of vote fractions across multiple hypothetical elections with a non-incumbent candidate (76-81). Put more succinctly, $\beta = \mu_i^I - \mu_i^N$, where μ_i^X denotes the mean of the distribution of the dependent variable under condition X and the superscripts I and N stand for "Incumbent" and "Non-incumbent," respectively.[6]

Directing attention to the *distributions* of independent and dependent variables rather than to the values of particular observations was a major advance in the philosophy of science. It permitted researchers to focus on the causes of stochastic phenomena—those whose behavior can be analyzed statistically but not predicted precisely.[7] Because political outcomes can be stochastic, political scientists have been able to utilize the tools of statistics to great advantage.

Given that the phenomena of interest to political scientists can be characterized by distributions of data, however, there is no reason to limit our understanding of causal effects to changes in the means of such distributions. Subject to the same counterfactual interpretation, changes in the variance of the distribution may represent interesting phenomena as well.

A single example will serve to illustrate this point. The most famous assertion of the economist John Maynard Keynes (1936) was that the economic booms and busts produced by unfettered *laissez-faire* capitalism could be

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Verba (1994), Little (1991, 19-25), Nicholson (1983, 26), Pratt (1978, 70-71), and Stinchcombe (1968, 31). The essays in Brady and Collier (2002) and the chapters in Little (1991), it should be noted, explore an unusually wide range of understandings of causation, though most are compatible with this one (if only, as with deterministic causation, as a limiting case).

[6] It is worth noting that they make explicit mention of the variance of the causal effect on page 82; doing so is not the same as asserting, as I will, that in some cases a change in variance rather than a change in mean *is* the causal effect of interest.

[7] I am indebted to the *Oxford English Dictionary* (2nd. ed.) for this succinct formulation.

smoothed out via government management. By using fiscal and monetary policy to put the brakes on the economy when it was growing too quickly and spending to revive it when it was heading into a slump, Keynesians believed, government could produce relatively steady growth with only minimal deviations. The average rate of growth may well be unaffected; only the variation around that mean would change.

If, in fact, government activity were to alter the variability of economic growth without having an impact on the mean, then the causal effect of Keynesian intervention under our current understanding of causation would be zero. If we use "I" to denote "intervention," "NI" to denote "no intervention," and μ_g to denote the average growth rate, $\mu_g^I = \mu_g^{NI}$, so there is no causal effect at all: $\mu_g^I - \mu_g^{NI} = 0$. As the destitute citizens from previous Depressions would no doubt attest, such an understanding of a causal effect is impoverished.

The obvious remedy is to enrich it. Unlike the means, the variances of the pre- and post-Keynesian distributions of growth rates would differ. Therefore, it makes sense to create another, distinct definition and to separate it from the first by giving it a different symbol:

> A causal effect $\boldsymbol{\gamma}$ is equal to the difference between the variances of two distributions.

In this case, $\gamma = \sigma_g^{2(I)} - \sigma_g^{2(NI)}$.

Rethinking Social Causation

Thinking in terms of variance-altering causation opens up an entirely new theoretical dimension, one that has until now been largely neglected.[8] At present, the concept is absent from discussions of research design and social

[8] Although a detailed discussion would stray too far from the central theme of this discussion, it is nevertheless worth noting in passing that changes in variance are sometimes seen as interesting *in*dependent variables as well. For example, Alesina and Spolaore (1997) posit that increased heterogeneity of preferences will decrease the optimal size of political units in a region, Aron (1966) argues that homogeneous international systems (those in which states "belong to the same type" and "obey the same conception of policy" [100]) are more stable and less violent than heterogeneous systems, and students of interstate and intrastate violence have also examined the hypothesis that inequality of wealth (Muller and Seligson 1987; Sigelman and Simpson 1977) or landholdings (Midlarsky 1988) can be a source of conflict. To the extent that understanding the origins of such changes in variance is important, such studies reinforce the argument that a better understanding of variance-altering causation is needed.

causation, and only a very small minority of practitioners seem to have embraced it in their work. Even those political scientists whose theories do imply changes in variance, moreover, often seem unaware of the fact. This situation is due to a sort of Catch-22: in order to be recognized as causes, variance-altering causes must be made explicit, but in order to be made explicit they must first be recognized as causes.

In the sections that follow, therefore, I will discuss existing examples of variance-altering causation. In so doing I hope both to demonstrate that prominent examples exist in the literature and to prove that explicit theorizing about the sources of changing variance adds a new dimension to our understanding of politics and society.

Interstate cooperation and conflict. A very straightforward example of how a theory may predict a change in variance rather than in means comes from Robert Putnam's (1988) seminal discussion of two-level games, in which the permissiveness (or lack of same) of domestic coalitions within two states determines the range of possible bargaining outcomes between chiefs of government at the international level.

Figure 1 displays two scenarios. In the first, both chiefs of government are afforded substantial leeway by their domestic constituencies, perhaps as the result of domestic fragmentation or indifference. This situation is depicted as a large gap between the two countries' maximum, or most preferred, outcomes (X_M, Y_M) and the minimum outcomes that could be ratified (X_1, Y_1.) The model's prediction, strictly speaking, is that over multiple iterations such a set of preferences would produce a distribution of bargaining outcomes bounded by X_1 and Y_1.

In the second scenario, each country's constituency has restricted its set of acceptable bargaining outcomes considerably. As a result, the theory's prediction is now that over multiple iterations this new set of preferences would produce a distribution of bargaining outcomes bounded by X_2 and Y_2.

The theory is silent regarding the shape of the distribution of outcomes, but there is no reason to believe that the means of the two distributions would differ; indeed, it seems most plausible that they would be similar, if not identical. If $\mu_1 = \mu_2$, the "mean causal effect" of this change in domestic constraints would then be zero. Nevertheless, a causal effect is apparent: in the presence of restricted constraints, a wide range of outcomes—those between Y_1 and Y_2 and those between X_1 and X_2—has been precluded. Any chiefs of government who would have come to agreements in those regions

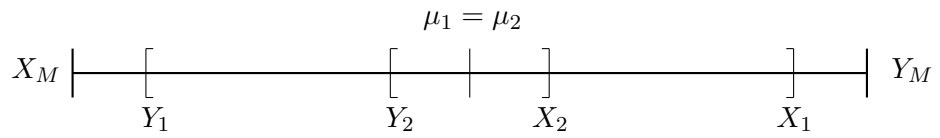


Figure 1: Hypothetical two-level game.

must either settle for a second-best outcome somewhere between X_2 and Y_2, inclusive, or arrive at no agreement at all. Either way, the variance of the distribution of outcomes should be smaller than it would have been in the first scenario, *ceteris paribus.*[9]

Theories of conflict, too, may give rise to hypotheses about changes in variance. Portrayals of war as a "costly lottery" have proliferated in recent years,[10] though the nature of combat itself is rarely modeled explicitly.[11] Lanchester's models of warfare are the main exception to this generalization.[12] The most straightforward version, the so-called "Square Law," posits that the changes in the fighting strengths of two sides (call them Red and Blue) will follow a simple pattern: $\frac{dB}{dt} = -rR$ and $\frac{dR}{dt} = -bB$, where R [B] represents the strength of Red's [Blue's] forces at a given time and r [b] represents the effectiveness of Red's [Blue's] fire on Blue [Red].

In this form, the Lanchester equations are deterministic: one side or the other will lose with certainty. It is possible, however, to add a stochastic element by modeling r and b not as constants but as distributions. John W. R. Lepingwell has noted that doing so should have at least one empirical implication: increasing the number of combatants on a given side should decrease the variance of the distribution of the effectiveness (1987, 130). Accordingly, chance should play a smaller role in determining the outcome of conflicts between large armies than it does in determining the outcome of conflicts between small ones. As a result, once relative size and (average) effectiveness have been controlled for, smaller armies should experience

[9] This is by no means an ironclad prediction: it could be the case that all first-level players always arrive at an agreement at μ, in which case the variance of the distributions in both scenarios would be zero. For the prediction to hold, the conditions enumerated below (p. 20) must hold as well.

[10] See, e.g., Fearon (1995) and Wagner (2000).

[11] For exciting recent exceptions see Smith and Stam (2001) and Grigorian (2003).

[12] See Taylor (1983) for exhaustive details.

greater variation in combat outcomes than larger ones.

Evolutionary political dynamics. Some of the most straightforward examples of variance-altering causation in political science come from theories that rely on evolution as their engine of change. In most of these cases, the posited result of the process in question is a decrease in the variance of the phenomenon of interest. Hendrik Spruyt (2001) lists a number of examples:

> Some of the most influential literature in political science suggests that international competition will lead to high degrees of uniformity in institutions and similarity of policies. Rivalry in security affairs will weed out those states that are too feeble to defend themselves or that engage in policies that jeopardize their own security. Globalization and economic competition will relegate inefficient nations to secondary status. ... Less competitive forms of government and less successful economic policies will be selected out. The result will be institutional convergence. (110)

Spruyt's list is by no means complete. One of the more interesting literatures involving the role of evolution in politics is one to which Spruyt himself has contributed: that on the process by which variation in forms of governance since the Middle Ages decreased until the modern nation-state emerged as the political unit of choice. Spruyt (1994) posits three evolutionary engines—economic, sociological, and competitive—as the sources of change. Other prominent accounts in the same body of literature include Charles Tilly's (1990), which emphasizes military competition, and the complex adaptive systems approach of Lars-Erik Cederman (1997), which focuses on the role of the offense-defense balance and the proportion of non-status-quo political entities in the system.[13]

One of the most prominent literatures in recent years has to do with the emergence and eventual universalization of uniform norms of internal and international behavior. Robert Axelrod (1984, 1986) makes the seminal argument for an evolutionary approach to the study of norms. Martha Finnemore and Kathryn Sikkink (1998), in a thorough review of this literature, describe three stages in the "life cycle" of a norm: that in which it emerges, a period during which a "norm cascade" occurs, and a period

[13] Cederman and Kristian Gleditsch (2002) formalize an evolutionary model of regime change with a transition rule based on the regime types of states in the immediate vicinity; the result is an increase in the variation of regime type over time.

of internalization. The transition from contestation to consensus involves a dwindling of normative variation across states.

Political economy. Students of institutions, too, are interested in the effects of political institutions on the variance of particular phenomena. The essays in Sven Steinmo, Kathleen Thelen, and Frank Longstreth's (1992) volume on historical institutionalism, for example, discuss the constraining (or, conversely, enabling) role of institutions on a variety of phenomena, from employment policy to unionization to welfare policy.[14] Writing about Britain, Peter A. Hall (1986) makes the point that changes in mean economic performance are not the only phenomenon of interest when studying the politics of economic policy: "Aggregate economic performance... is only one aspect of the problem. We should also ask if there have been any significant differences in the distributional consequences that followed from Labour and Conservative austerity?" Hall concludes that

> While Labour policy narrowed income differentials across the population, Conservative policy has widened the disjunction in material well-being between the affluent and the poor, between those in work and those without it, and between those with considerable power in the labor market by virtue of wealth or skills and those without such power. (123-124)

Put less eloquently, one of the effects of the policies of Labour governments has been to narrow the distribution of incomes within a country, while one of the effects of the policies of Conservative governments has been to widen it.

Income inequality has been the subject of intense scrutiny by students of political development, many of whom find the sources of inequality in the form of the state. Some focus on the comparative developmental advantages across different regime types,[15] while others focus on variation within a given regime type, as with the "varieties of capitalism" literature.[16] Throughout, measures based on the variance of the distribution of income are utilized.[17]

[14] These are Weir (1992), Rothstein (1992), and King (1992), respectively.

[15] For a general discussion see North (1990); for a specific application see e.g. Olson (1993).

[16] Here see Hall and Soskice (2001).

[17] The difference between the tenth and the ninetieth decile of the distribution is one indicator; the Gini index, measuring the degree to which the distribution deviates from perfect equality, is another.

The state. Peter Gourevitch nicely summarizes the constraining role that the institution of the state can play:

> Structure... affects the possibility of realizing certain policies. Examples abound. The types of taxes the Italian state can raise are limited by the weakness of the state bureaucracy; the types of industrial policies Britain can pursue are limited by the fragmented character of banking and industry; French *dirigisme* is surely facilitated by the position of the grand corps there; American energy policy is not likely to be some carefully orchestrated scheme which must get through Congress in toto or not at all. (Gourevitch 1978, 904)

In each case, the impact of the state's structure is not to privilege one particular option but rather to widen or narrow the range of options available to political elites. Across a large number of cases, the result should be a change in the variance in the distribution of outcomes.

Jack Snyder's (1991) examination of the domestic sources of expansionist state behavior makes this point quite clearly. Snyder makes firm predictions about the foreign policies of democratic systems (moderate) and cartelized systems (overexpansionist) but concludes that far more variance is to be expected in the case of unitary decision makers: "The logic of unitary rule does not impel a Hitler toward overexpansion, but likewise it does nothing to check him." (54)[18] The results of Snyder's case studies bear out this point.[19]

Along the same lines, Philip Roeder (1984) ranks five separate periods in Soviet history along two dimensions—amount of competition for power and degree of consolidation of authority—and on the basis of those rankings predicts, among other things, the degree of risk-acceptance of Soviet foreign policy. "Risk-acceptance" is conceptualized as the amount of variance in the state's foreign policy activity. The author's data demonstrate conclusively that, as he had hypothesized, the Primatial period (the only one to combine

[18] Similarly, Susan Allen (2001) argues that the institutional structure of the state will determine the predictability of its vulnerability to withstand economic sanctions: democracies will be relatively vulnerable, but the vulnerability of autocratic states will vary to a much greater degree.

[19] While states overexpand eight times in the eight cartelized periods that they experience and engage in moderate behavior six times in six democratic periods, the variation in the behavior of unitary states is greater: six cases of moderate behavior and two of overexpansion out of eight unitary periods. See p. 311 for a summary.

high competition for power with highly consolidated authority) exhibited far greater risk-taking behavior than did other periods.[20]

Similarly, George Tsebelis (1999) examines the effects of large coalition governments on policy stability, conceptualized as the ability of the government to pass "significant" laws. Tsebelis' theory implies that a small ideological range among the most extreme parties is necessary but not sufficient for the passage of a large number of such laws: governments with little ideological distance among extreme parties may pass quite a few or none at all, but the number passed by highly polarized governments will be vanishingly small. Hence his second hypothesis—that the "ideological range of a coalition negatively affects the variance in the number of significant laws."[21]

System structure. Some international relations literature focuses on the constraining effects of the structure of the international system, which drive states toward uniformity of outcomes. Such arguments are not properly institutional, for it is typically the *absence* of institutions that gives the international environment its causal power. Efforts have been made to claim them for evolutionary theory[22]—a natural fit given the emphasis on structure—but the low death rate of states calls into question the relevant selection mechanism.

Kenneth Waltz's (1979) famously confusing concept of the structure of the international system falls into this category. Structure, in Waltz's conceptualization, has an effect not on outcomes on average but on the variance of the distribution of outcomes:

> "[Structures] work to keep outcomes within narrow ranges. ...
> [S]tructure designates a set of constraining conditions. ... [S]truc-

[20]The test utilized was a simple equality-of-variance test on data from the Conflict and Peace Databank (COPDAB), on which see Azar (1993).

[21]This sort of relationship is more complex than an equality-of-variance test envisions, but it can be modeled with what Harvey (1976) calls a *multiplicative heteroskedasticity* model, which can be adapted to a wide range of circumstances. Just as the mean is typically modeled in standard regression, $Y = \beta X + \varepsilon$, where β is a vector of parameters to be estimated and X is a vector of independent variables, so we can model the variance: $\sigma^2 = e^{\gamma Z}$, where Z is the vector of independent variables that cause a change in the variance of Y and γ is the vector of parameters to be estimated. One might also envision quantile regression for such an application (Buchinsky 1998), given that the variances of some distributions are not particularly well-behaved. Alternatively, in a standard regression model in which the variance is thought to be a function of a single independent variable, simple weighted least squares could be utilized (Greene 2000, 512-513).

[22]See e.g. Sterling-Folker (2001) and Thayer (2000), the former on both realism and neo-realism as well as liberalism, the latter more narrowly realist.

> tures limit and mold agents and agencies and point them in ways that tend toward a common quality of outcomes even though the efforts and aims of agents and agencies vary." (73-74)

It is perhaps not very clear exactly *which* outcomes are kept within narrow ranges, or how changes in structure have an impact on those ranges, but a change-in-variance interpretation is surely warranted in this case. Moreover, the requirements of such an interpretation—in this case, a well-defined dimension along which behavior varies—would clarify the theory immensely, adding both to its utility and its falsifiability. It may well be the case, for example, as no less a realist than Thucydides suggests, that the behavior of weak states is more constrained by their environment than is the behavior of strong states;[23] if so, strong-state behavior should vary more than weak-state behavior, assuming that some concrete metric can be found.

A. F. K. Organski and Jacek Kugler (1980) relate the structure of the international system more directly to Great Power war: "Clearly, the necessary but not sufficient conditions for major war emerge only in the rare instances when power parity is accompanied by a challenger overtaking a dominant nation." (179) A sample drawn from time periods in which these two conditions are absent should, if the authors are correct, yield no variation on the variable of interest, Great Power war, whereas a sample drawn from periods in which both conditions are met should exhibit at least some.[24]

Belief systems. At the level of the individual, Philip Converse's "constrained belief systems" (1964) are constrained in the sense that they produce answers to related survey items that covary more than the answers produced by unconstrained belief systems. Concern with the variance of survey responses has survived within the political science literature for decades. John Zaller (1992, 65), for example, argues that better-informed people will tap into a more homogeneous set of considerations when answering survey questions and therefore will give more consistent answers to survey questions over time than will their less-informed peers, and Michael Alvarez and John Brehm (1995) demonstrate that cognitive dissonance increases variance on survey responses by showing that conflicting core beliefs about the role of women and the sanctity of life produce higher variability in responses to sur-

[23] This is an interpretation of the Athenians' famous assertion, in the Melian dialogue, that "the strong do what they have the power to do and the weak accept what they have to accept."

[24] In fact, they do, as the next sentence demonstrates: "The odds of a war in this very reduced subset are 50 percent."

vey questions about abortion than do non-conflicting core beliefs.[25] Moreover, the idea has traversed subfield boundaries; in a recent study, William Zimmerman (2002) uses survey data to demonstrate that Russian elites possess belief systems that are more constrained than those of attentive publics, which in turn are more constrained than those of the mass public.

External events, too, can prompt changes in variance of beliefs within a group. Matthew Gabel (1998) examines, in part, the variability of survey responses, in this case on items regarding levels of support for membership in the European Union; Gabel hypothesizes (p. 11) that context-specific factors like differential press coverage could introduce unequal error variance across the respondents in his multiple-country, multiple-year study.[26] Ephraim Yuchtman-Yaar and Tamar Hermann (1998) examine the beliefs of Israelis regarding the legitimacy of various forms of protest before and after the assassination of Yitzhak Rabin and found that the assassination produced a marked and lasting decrease in variance in those attitudes.

Summary

In each of the cases listed above, examining the variances of distributions of characteristics or phenomena of interest has produced a richer and more nuanced description of the political world than a mean-centric paradigm would have permitted. The variability of international bargaining outcomes, trends toward uniformity of institutions, policies, and norms, the ambivalence of beliefs on topics from abortion to membership in the European Union—all are interesting phenomena in their own right.

At the same time, such phenomena often go unnoticed, or are mentioned only in passing, by the authors who examine them. The essays on two-level games in Evans, Jacobson, and Putnam (1993), for example, typically examine only the issue of whether agreements were possible or impossible in light of domestic constraints; the implication of greater variation of outcomes in the presence of looser constraints is never discussed. Waltz's structural theory of international politics remains opaque in large part, one suspects, because he is hard-pressed to articulate clearly the effects of system structure on the variance of outcomes—a task that would require, first of all, a lucid discussion of the dimension(s) along which variance is limited. And so on.

Those few instances in which practitioners do recognize changes in variance as a substantively interesting phenomenon stand out as flashes of in-

[25] See also Alvarez and Brehm (1997), Alvarez and Brehm (1998), and Alvarez, Brehm, and Wilson (2003).

[26] In these cases, heteroskedastic probit rather than heteroskedastic regression is utilized.

sight in an otherwise-darkened arena. Steady, sustained illumination will no doubt reveal quite a bit more. Toward that end, researchers interested in studying changes in variance would benefit from a discussion of the sorts of causal mechanisms that can produce changes in variance. The next section addresses this need.

Changing Variance: Causal Mechanisms

Does a phenomenon that produces a change in variance really qualify as a cause? In one (perhaps overly simplistic) sense, it must: if a change in variance is a recognizable phenomenon, it must either be *sui generis* or the result of some cause. Since few people would argue the former position, then something must have caused it, and that fact itself is evidence that causes can produce changes in variance.

Nevertheless, absent explicit logical foundations, the mechanism by which variance-altering causes produce effects is unclear. A full account of variance-altering causation must provide such foundations. The examples listed above both offer some suggestions for what those foundations must look like and what some of their logical pitfalls might be. In the rest of this section I will discuss four causal mechanisms (or families of causal mechanisms) that can produce changes in variance—differential impact of causal variables, evolutionary dynamics, simple additive variance, and optimization subject to constraint—and address some qualifications about how they might be used in practice.

Differential Impact of Causal Variables

Some theories that posit changing variance do so because they assert that an independent variable's causal impact will vary depending on the value of the dependent variable. To offer a straightforward example, Hall's examination of British economic policy suggests that the impact of Conservative policies varies depending on the location of the individual along the dimension of wealth: for the rich, Conservative policies increase wealth, whereas for the poor Conservative policy decreases it.

The general form of such an argument might be that the distribution of some variable at a given time period is altered by some cause in such a way that the individual observations take on different values at the next time period than they had at the previous one, but that the impact of the cause, and therefore the degree to which (and possibly the direction in which) they

are altered, is proportional to their original values.[27]

Applied to Hall's example, this explanation would suggest that prior to Conservative rule, the British population had a certain distribution of wealth (the initial distribution); the advent of Conservative government (the cause) had the effect of changing that distribution by moving people up or down the income scale; that the direction and magnitude of that movement are directly proportional to the individual's original location—the rich get richer, the poor get poorer; and that the resulting distribution of wealth has a higher variance than did the original. The key to an explanation of this sort is a theoretical justification for the differential impact of the cause on the initial distribution.

Ecological Causal Inference?

This causal mechanism raises an intriguing question: Is this an example of mean-altering or variance-altering causation? In defense of the latter case, the variance of the distribution of incomes obviously increases. In defense of the former case, however, one could argue that the means of the distributions of income of various subpopulations (people in the same tax bracket, say) are being altered to different degrees and in different directions. The same question is raised in reverse by studies that use country-by-country measures of the variance of some distribution (the Gini index, for example) as the dependent variable in a standard regression equation: Are the phenomena of interest changes in the variances of distributions or a change in the mean of the distribution of the variances of distributions?

As these examples should demonstrate, this is an ecological issue; the "either-or" dichotomy is a false one. Just as atoms (which behave deterministically) consist, in part, of electrons (which behave stochastically), so too might large-scale effects consist of many smaller-scale effects. It detracts nothing from either understanding of causation to note that variance-altering causation at one level may consist of mean-altering causation at another, or vice-versa.

It is nevertheless true that some perspectives add more to our knowledge than do others and might plausibly be preferred for that reason. Knowing the effects of Conservative or Labour policy on people in different tax brack-

[27]The most straightforward mathematical illustration is one in which $Y_{t+1} = Y_t + C$ and $C = Y_t - \bar{Y}_t$; the result is that the mean of the distribution remains constant from t to $t+1$ while the standard deviation doubles. The proportionality of C to Y_t ensures that the gaps between observations, and therefore the variance of the subsequent distribution, will increase.

ets may tell us more about the economic effects of partisanship than does knowing their effects on the economy as a whole.[28]

Moreover, examining the data at the lowest possible level of aggregation may be preferable because lower-level effects might cancel one another out in aggregate data. A small change, or no change at all, in the variance of the distribution of national income could very well mask considerable volatility at the individual or group level. If—as the "varieties of capitalism" literature, cited earlier, suggests—governments are undergoing policy convergence toward a small number of types, the mean value of the variance of some distribution (say, the geographical dispersion of authority, where low variance indicates high centralization) across countries may remain constant even if subgroups of states are converging. Changes in variance at one level, therefore, might not be reflected in changes in mean at another.

These arguments suggest, in short, that neither mean-altering nor variance-altering causes should be given any sort of causal priority, but that a good case can be made that epistemological priority should go to the cause operating at the lowest observable level of aggregation.

Evolutionary and Quasi-Evolutionary Dynamics

Evolutionary explanations of politics share, at least ideally, two defining processes which together permit us to infer whether or not a change in variance should occur. The first of these processes is internal: over time, the distribution of one characteristic of a group has a tendency to spread, typically as a result of some internal trait of the entities that comprise the group (random genetic variation being the exemplar). The most straightforward version of a process of this sort might be a simple random walk. The result of this process, if unimpeded, is a general increase in variance over time.

The second process—or, rather, family of processes—is typically environmental rather than internal, and processes that fall into this category mitigate (and sometimes reverse) the increased variance that results from the first. These processes may involve selection, socialization, learning, or any number of phenomena that mimic the effects of these. Their effects, simply, are to alter the characteristics of individuals by subjecting them to conditions under which only a certain range of realizations of those characteristics—long or short beaks for finches, sooty coloration for pep-

[28] As the previous footnote suggests, such a situation could be modeled without too much difficulty; OLS, with the appropriate modifications, could capture the effects of a parameter that varies with a given variable (Kennedy 1985, 74-76), and regime-switching and random-effects models could also be profitably employed.

pered moths, or *realpolitik* behavior for states—is optimal, desirable, or possible.

Regardless of the source of change over time, environmental processes take on a few characteristic forms. One is a *drift,* a situation in which selection pressures push the individuals in question farther along the given dimension over time. Another environmental element that can be relevant is a *barrier,* an upper or lower limit to variation.[29] It is also possible that individuals in later time periods or generations are drawn toward some *optimal point,* either because it better serves their needs or because it is more appropriate in some way; Finnemore and Sikkink's discussion of norms and Waltz's discussion of realist behavior are good examples. These processes are illustrated in Figure 2.[30]

The result of the combination of internal and environmental processes may be an increase *or* a decrease in variance, depending on which prevails.[31] It may even, as with the case of a drift toward a barrier illustrated in Figure 2, produce an increase in variance followed by a decrease. For the most part, since it is difficult to demonstrate that an exact value for the parameters of any of these processes follows logically from a given set of premises, we are hard-pressed to determine analytically whether variance will increase or decrease over time. There are some exceptions, but for the most part the question of which tendency prevails must be resolved by data rather than logic.

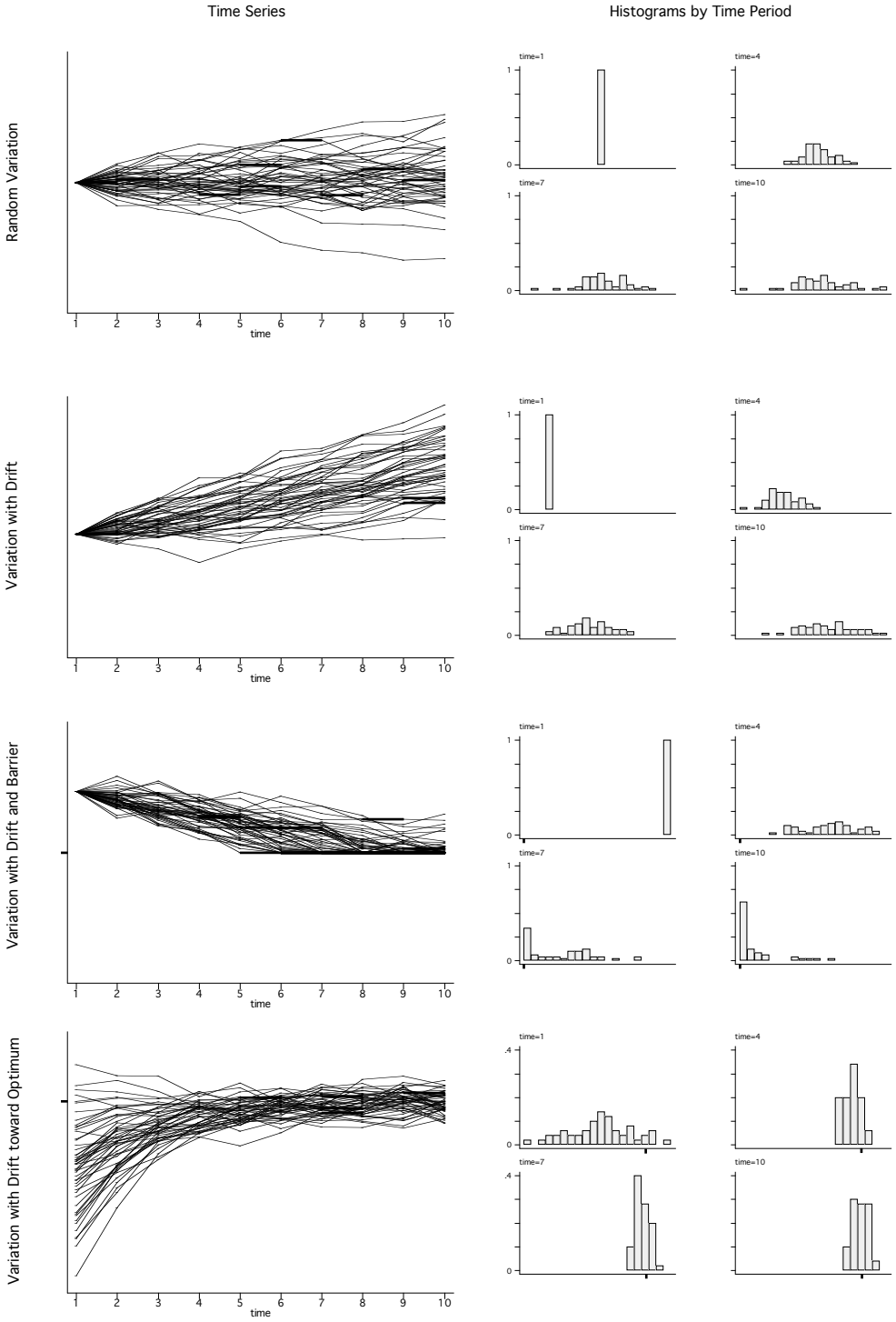
Evolutionary examples from the political science literature have a tendency to focus on the environmental process rather than on the adaptive or

[29]Gould (1996, 54-55) refers to these as "walls." See also Goertz (1994).

[30]Random variation is modeled quite simply as $Y_{t+1} = Y_t + \varepsilon$, $\varepsilon \sim \mathrm{N}(0, 1)$. Variation with drift is modeled by adding a constant, c, at each time period: $Y_{t+1} = Y_t + c + \varepsilon$, $\varepsilon \sim \mathrm{N}(0, 1)$, $c = 1$. A lower bound or wall $Y_{\underline{w}}$ is incorporated so: $Y_{t+1} = Y_t + c + \max(\varepsilon, (Y_{\underline{w}} - Y_t))$, $c = -1$, $\varepsilon \sim \mathrm{N}(0, 1)$, $Y_{\underline{w}} = 0$. Note that the resulting distribution is skewed. If c were positive and the drift were therefore toward an upper bound, $\min(\varepsilon, (Y_{\bar{w}} - Y_t))$ would be used instead. Drift toward an optimal point Y_p with fractional rate of adjustment β is modeled as $Y_{t+1} = Y_t + \beta(Y_p - Y_t) + \varepsilon$, $\varepsilon \sim \mathrm{N}(0, 1)$, $\beta = 0.4$, $Y_o = 7.5$. In the lower two series, the barrier and the optimum, respectively, are denoted by thick tickmarks. Modeling changes in the variance of time-series data can be accomplished with autoregressive conditional heteroskedasticity (ARCH) estimators.

[31]It may, in fact, be quite difficult to determine which trend is prevalent. Movement of a distribution along a given dimension could be driven by a drift or produced by purely random variation in proximity to a natural lower bound. Daniel W. McShea (1993, 1994) describes and illustrates three tests useful in such situations. The first is based on the behavior of the minimum of the distribution, the second involves a longitudinal study of the direction of variation of offspring from parents, and the third involves examining the skew of the distribution of a random subsample of cases. The latter test utilizes the only hypothesis of which I am aware that is based on the *third* moment of a distribution.

Figure 2: Changes in variance as a result of evolutionary dynamics



randomizing one; as Spruyt (2001) properly points out, doing so only tells half of the story.

Simple Additive Variance

In some cases, possession of a given trait by an individual implies one distribution of a given characteristic, while possession of a second trait implies another distribution. In such cases, some authors have pointed out—not unreasonably—that the possession of both traits should imply a third distribution of the characteristic in question, one with a greater variance than either of the first two. To take a simple textbook example: A group of retirees earn income both from Social Security and from the 401k plans to which they contributed while working. Assuming the two are independent, the monthly distribution of Social Security wages ($\mu = \$350$, $\sigma^2 = \$50$) and the monthly distribution of 401k wages ($\mu = \$500$, $\sigma^2 = \$60$) can simply be added together to produce the distribution of wages from both sources ($\mu = \$850$, $\sigma^2 = \$110$).

This sort of straightforward additive process is evident in, for example, Alvarez and Brehm's study (cited above) of conflicting core beliefs and attitudes on abortion. The basic idea is that belief in women's rights would produce a distribution of opinion that lies mostly toward the pro-choice end of the spectrum, belief in the sanctity of life would produce a distribution of opinion that lies mostly toward the pro-life end of the spectrum, and belief in both would produce a more centralized distribution of opinion with a wider variance, reflecting the ambivalence of the respondents. The authors argue that

> some in the public may not find that their underlying beliefs are conflictual, and that determining their position on a policy issue is relatively simple. These people would not be ambivalent about the issue, and we would expect their responses to survey questions about the issue to reflect this lack of ambivalence. Others, though, might find the conflict between these underlying beliefs quite profound, and that the conflict complicates their ability to determine their preferences about a particular policy. These citizens are ambivalent about the issue, and their survey responses about the policy should reflect that ambivalence. (1060)

Specifically, "individuals who possess strong attachments to both of the underlying core principles" (of women's rights and the sanctity of life) "should

have a harder time making a decision about abortion; hence they should have a greater error variance." (1065)

Caveats

It is worth noting that the assumption of the independence of the two component distributions is crucial: if they are negatively correlated, the conclusion might not follow. The variance of the distribution that results from adding the two distributions together is the sum of the variances of the individual distributions, plus twice their covariance. Therefore, if the covariance of the two distributions is negative and greater in absolute value than the variance of one of the distributions, adding the two together actually *decreases* the variance of the other distribution.

An example helps to illustrate the point. Imagine that the two distributions from the retirement example are perfectly negatively correlated because the Social Security Administration adjusts its payments to take into account 401k income. A recipient of $600 per month from a 401k would receive $250 from Social Security, a recipient of $500 per month from a 401k would receive $350 from Social Security, a recipient of $400 per month from a 401k would receive $450 from Social Security, and so on. If this were to be the case, the variances of the two distributions would cancel one another out, and the distribution of monthly incomes would be a spike at $850 per month, with no variance at all.[32]

It is also worth noting that the bounded nature of survey responses render the additive-variance model problematic if the two responses in question imply distributions with means that tend toward the same end of the spectrum. Under such circumstances, variance might even be expected to decrease rather than increase due to the effects of boundaries at the endpoints of the continuum of opinion.

[32] How might this be relevant to the question of abortion attitudes, for example? The two distributions in question might plausibly be negatively correlated if they were contrasting positions (as Alvarez and Brehm argue they are) and if people who take extreme positions on one issue are more likely than usual to take extreme positions on other issues (that is, if some people are generically more opinionated than others). Both seem at least plausible. Conversely, one might make the case, based on the generic tendency of people to seek to reduce cognitive dissonance, that the two distributions should be positively correlated, because those who take an extreme position in favor of one position will tend to take a neutral or negative position on the other.

Optimization Subject to Constraint

Another form of causal relationship that can imply changes in variance is optimization subject to constraint. Generically, one or more actors must choose a position or a policy along a continuum, but some segment or segments of the continuum are not available to them due to some constraints inherent in the environment. Assuming that a few fairly straightforward conditions are met, the constraints influence the variance of the distribution of outcomes.

The most obvious example of this phenomenon is that of two-level games: rational agents (chiefs of government) with a set of exogenously-given incentives must arrive at some sort of mutual agreement within the constraints imposed by an additional agent (legislatures). As the constraints imposed by the legislatures relax, the distribution of bargaining outcomes is free to expand. The constraining influence of the state itself plays a similar role in the theories of state behavior espoused by, for example, Gourevitch, Snyder, and Roeder.

What requirements suffice to ensure that changing constraints will produce changes in variance?

1. In at least one case, optimization absent constraints would have produced an agreement outside of the range bounded by the constraints.

2. In all cases described by 1., the outcomes are either nonevents (i.e., no agreement in a two-level game) or are closer to the mean of the distribution of observed events, on average, than the original outcomes would have been.

3. In all cases not described by 1., the presence of constraints does not alter the outcome.

The first requirement ensures that the constraints are relevant in some cases: if, for example, chiefs of government were always to arrive at an agreement at μ in Figure 1, the variance—zero—would be the same regardless of the presence or absence of constraints. The second requirement describes what happens to positions or agreements that are precluded by constraints. Imagine, for example, that the constraints in Figure 1 were Y_2 and X_1, but the vast majority of outcomes fell in the middle of the spectrum, between Y_2 and X_2. This condition states that two chiefs of government who would have preferred an agreement just to the left of Y_2 cannot instead choose an agreement at X_1. If utility functions are convoluted enough to permit such

an outcome, no narrowing of variance can be ensured. Finally, the third condition simply ensures that the rest of the distribution of outcomes—those that fall within the boundaries—are unaltered by the presence or absence of constraints. If they were altered, for some reason, the resulting relationship of unconstrained variance to constrained variance would be entirely indeterminate.

Unifying Causal Understandings: Agents and Structures

Another advantage of thinking of causal effects in terms of changing variances is that it opens the door to theoretical synthesis. Some events may only be understandable as the results of both mean-altering and of variance-altering causes; if so, the ability to model situations in which more than one kind of cause is at work is critical.

I will briefly discuss one interesting example of a class of theories that incorporates both changes in means and changes in variances: those that describe the relationship of agents to structures in politics. David Dessler summarizes this relationship as follows:

> [T]he "agent-structure problem"... emerges from two uncontentious truths about social life: first, that human agency is the only moving force behind the actions, events, and outcomes of the social world; and second, that human agency can be realized only in concrete historical circumstances that condition the possibilities for action and influence its course. ... These truths impose two demands on our scientific explanations: first, that they acknowledge and account for the powers of agents; and second, that they recognize the causal relevance of "structural factors," that is, the conditions of action. The "agent-structure problem" refers to the difficulties of developing theory that successfully meets both demands. (Dessler 1989, 443)

How might this distinction relate to means and variances? One (admittedly speculative) interpretation would go as follows. Quite a few of the authors who posit variance-altering causes do so in discussions of some kind of structure—either the structure of the international system (Waltz), state structure (Gourevitch, Roeder, Snyder, and Tsebelis), or the structures of individual belief systems (Converse, Zimmerman, and Alvarez and Brehm).

In contrast, changes in the average behavior of agents within the constraints provided by structure can be conceived of as changes in means. To take a single example from the list provided by Gourevitch, if the strength of state bureaucracy determines the ability of states to tax (and is therefore related to variance in taxation), other factors—ideational, ideological, psychological, etc.—may well determine whether those states that *can* tax will actually do so.

A clear example of such a relationship comes from Theda Skocpol's (1979) seminal work on the role of the state in social revolutions: the strength or weakness of the state, both in terms of its administrative and coercive capacity and its position in the international system, determines its ability to suppress social revolution and therefore the latitude afforded to potential revolutionary groups. When structure permits, the solidarity of the agents determines the probability of revolution. Structure therefore determines the expected variance in revolutionary behavior (none in strong states, some in weak ones) and the degree of village autonomy and solidarity in weak states has an impact on the mean.[33]

It should be emphasized that much of what is considered revolutionary about Skocpol's work comes directly from this combination of structure and agency. In contrast to Marxist or liberal theories of societal change, which emphasize classes and individuals as the main forces driving change, Skocpol "brought the state back in" by emphasizing both the power of the state as an autonomous actor and the interactive nature of state-society relations (Evans, Rueschemeyer, and Skocpol 1985). One wonders how many other prominent theoretical innovations of this type await discovery.

Conclusion

This article has attempted to make the case for a new understanding of causal relations: the variance-altering cause, one that produces a change in the variance rather than the mean of the distribution of the dependent variable. This understanding of causation, though not unknown in practice, is completely alien to discussions of causation and research design. It has provided an array of examples of variance-altering causation from the political science literature and has described four separate causal mechanisms

[33]The agent-structure story could also be told from the opposite point of view: structure (say, of the state) determines the mean level of some characteristic (say, propensity for revolution), while the characteristics of the agents determines how little or how much variation around that mean should be expected. I am grateful to Hillel Soifer for this interpretation.

that can bring them about.

The idea of variance-altering causation is not conceptually problematic, as the examples cited and the causal mechanisms described herein demonstrate, and it offers substantial "value added." Thinking about the variability of variables rather than just their central tendencies, and by extension thinking about the conditions under which that variability might change, literally opens up a new dimension to discussions of politics. In purely statistical terms, it offers a far more detailed summary of a distribution of interest than does the mean alone. In the realm of description, accordingly, it offers researchers the opportunity to provide a more detailed depiction of the phenomena that we study. In many cases, the variance represents a quantity that is substantively as interesting as, if not more interesting than, the mean. Thinking about variance and how to test hypotheses related to variance also holds out the promise of enhanced leverage in theory-testing. In short, the inclusion of variance-altering causation in the collective lexicon of political science should both widen the range of hypotheses that can be tested and substantially enrich our ability to understand phenomena of interest to us.

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