

Political Parties and Electoral Landscapes

KEN KOLLMAN, JOHN H. MILLER AND SCOTT E. PAGE*

We study the relationship between voters' preferences and the emergence of party platforms in two-party democratic elections with adaptive parties. In the model, preferences of voters and the opposition party's platform determine an *electoral landscape* on which the challenging party must adaptively search for votes. We show that changes in the underlying distribution of voters' preferences result in different electoral landscapes which can be characterized by a measure of *ruggedness*. We find that locally adapting parties converge to moderate platforms regardless of the landscape's ruggedness. Greater ruggedness, however, tempers a party's ability to find such platforms. Thus, we are able to establish a link between the distribution of voters' preferences and the responsiveness of adaptive parties.

An enduring concern of political science research is the extent to which electoral processes encourage political parties to respond to voters' preferences. For some, parties carry out policies in the interests of their core electoral or financial supporters.¹ For others, especially those using spatial election theories, parties take policy positions in order to appeal to as many voters as possible.² The latter group of researchers, relying on the assumptions of most spatial models that parties position themselves in an ideological or issue space to maximize some party goal like the probability of election, would seem to be centrally concerned with the distribution of all voters' preferences. This distribution for any given political system should directly influence party strategies and perhaps subsequent government policies. Downs, for example, referring to his single dimensional spatial model, claims 'the distribution of voters is a crucial

* Kollman, Department of Political Science and the Center for Political Studies, University of Michigan, Ann Arbor; Miller, Department of Social and Decision Sciences, Carnegie Mellon University, Pittsburgh; Page, Division of Humanities and Social Sciences, California Institute of Technology. The authors wish to thank Roger B. Myerson, David Austen-Smith, Tim Feddersen, Jeffrey Banks and Stan Reiter for helpful comments. This research was supported by grants from Sun Microsystems, the Center for Mathematical Studies in Economics and Management Science and the National Science Foundation (SBR-9409602, SBR-9410948, and SBR-9411025). Computer programs are available from the authors upon request.

¹ For example, see Maurice Duverger, *Political Parties* (New York: Wiley, 1963); Douglas A. Hibbs, *The American Political Economy* (Cambridge, Mass.: Harvard University Press, 1987); Thomas Ferguson, *Golden Rule: The Investment Theory of Party Competition and the Logic of Money-Driven Political Systems* (Chicago: University of Chicago Press, 1995).

² See Anthony Downs, *An Economic Theory of Democracy* (New York: Harper & Row, 1957); James Enelow and Melvin Hinich, *The Spatial Theory of Voting* (Cambridge: Cambridge University Press, 1984).

determinant molding a nation's political life ... [and] major changes in it are among the most important political events possible.³

Unfortunately, though spatial models have provided a useful framework for understanding some aspects of party competition, they have difficulty accounting for how party strategies in a two-party system like the United States should change when voters' preferences change and why challenger parties lose elections to incumbent parties. Downs originally asserted that in a single-dimensional space unimodal preference distributions lead parties to adopt similar or identical platforms, while bimodal distributions cause parties to adopt dramatically different platforms.⁴ Later models modified Downs's conclusions. If complex preferences become compressed down to a single ideological dimension, regardless of modality, then parties converge towards moderate, or even identical platforms.⁵ Moreover, with more than one issue dimension, two-party systems have single-point equilibria only if voters are distributed symmetrically – a severely restrictive condition.⁶ If voters are distributed asymmetrically, equilibrium sets, such as the top-cycle, uncovered, or minmax sets, can be large, or even encompass the whole space.⁷ McKelvey has addressed the connection between preference distributions and the outcomes of electoral competition.⁸ He formalizes a bound on the size of the uncovered set as a function of the amount of asymmetry of voter preferences. His result states that less symmetry leads to a larger uncovered set. Therefore, a party with the capability of locating in the uncovered set has greater freedom to select platforms, creating the interpretation that less symmetric voter ideal points allow rational parties to select less moderate platforms.

The 'chaos' results from McKelvey and Schofield also show that under quite general conditions majority-supported policy proposals include the entire space of policy positions.⁹ Therefore, a challenging party, under some conditions, can

³ Downs, *An Economic Theory of Democracy*, p. 140.

⁴ Downs, *An Economic Theory of Democracy*, p. 118.

⁵ Enelow and Hinich, *The Spatial Theory of Voting*.

⁶ Charles Plott, 'A Notion of Equilibrium and Its Possibility Under Majority Rule', *American Economic Review*, 79 (1967), 787–806.

⁷ See Richard D. McKelvey, 'Intransitivities in Multidimensional Voting Models and Some Implications for Agenda Control', *Journal of Economic Theory*, 12 (1976), 472–82; Gerald Kramer, 'A Dynamical Model of Political Equilibrium', *Journal of Economic Theory*, 15 (1977), 310–34; Peter Ordeshook, *Game Theory and Political Theory* (Cambridge: Cambridge University Press, 1986); Norman Schofield, Bernard Grofman and Scott Feld, 'The Core and the Stability of Group Choice in Spatial Voting Games', *American Political Science Review*, 82 (1988), 195–211.

⁸ Richard D. McKelvey, 'Covering, Dominance, and the Institution-Free Properties of Social Choice', *American Journal of Political Science*, 30 (1986), 283–314.

⁹ McKelvey, 'Intransitivities in Multidimensional Voting Models and Some Implications for Agenda Control'; Norman Schofield, 'Instability of Simple Dynamic Games', *Review of Economic Studies*, 45 (1978), 575–94. Specifically, McKelvey shows that the top-cycle set encompasses the entire space of platforms. This result pertains to the aggregation of preferences, and not the performance of a particular democratic institution.

always find a winning platform in a multi-dimensional issue space, and we would not expect systems of competing, fully-informed rational parties to converge to stable platforms. Note also that a further implication of the full information, optimizing assumption is that a challenging party can always defeat an incumbent.

In this article, we shall demonstrate with a formal model how, under plausible assumptions, the behaviour of political parties changes when voters' preference distributions change, and that incumbent parties can often win elections because challenger parties cannot 'find' optimal platforms. Following our earlier work, we use a model of two-party competition where parties are adaptive organizations competing for votes in a multi-dimensional issue space.¹⁰ Parties respond to popularity polls by incrementally adapting their platforms. Our model explores the ability of parties, facing a variety of voters' preference distributions, to find winning platforms. We consider classes of voter preference distributions that vary in the level of ideological consistency and the strengths (or intensity) attached to moderate and extreme positions.

In the model, preferences of voters and the opposition party's platform determine what we call an *electoral landscape* on which the challenging party adaptively searches for votes. We show that changes in the underlying distribution of voters' preferences result in different electoral landscapes that can be characterized by measures of *ruggedness* and *slope*. We find that locally adapting parties converge to moderate platforms regardless of the landscape's characteristics. However, we also find that greater ruggedness, which is correlated with less slope, restricts a party's ability to find such platforms. This leads to greater platform separation. Thus, we are able to establish a link between distributions of voters' preferences and the responsiveness of adaptive parties.

ADAPTIVE PARTIES

In contrast to standard spatial models, parties in the real world may not act 'as if' they are fully informed and capable of selecting an optimal platform. To account for party limitations, we consider parties that locally adapt from their current platform. There are several justifications for this assumption. First, a party may have limited information and foresight about voter preferences, so its search for new platforms may be severely restricted. Secondly, a party may be tethered to policy positions for ideological reasons, including the constraints of party activists and contributors.¹¹ Thirdly, voters may be wary of a party that moves across the ideological spectrum quickly in search of votes. Finally,

¹⁰ Ken Kollman, John H. Miller and Scott E. Page, 'Adaptive Parties and Spatial Elections', *American Political Science Review*, 86 (1992), 929–37.

¹¹ See, for example, John Aldrich, 'A Downsian Spatial Model with Party Activism', *American Political Science Review*, 77 (1983), 974–90; Randall Calvert, 'Robustness of the Multidimensional Voting Model: Candidate Motivations, Uncertainty and Convergence', *American Journal of Political Science*, 29 (1985), 69–95; John Aldrich and Michael McGinniss, 'A Model of Party Constraints on Optimal Candidate Positions', *Mathematical and Computer Modeling*, 12 (1989), 437–50.

organizations tend to adhere closely to established norms and codes of behaviour and thus are unlikely to engage in large platform changes.¹²

The picture that emerges is one of parties gathering information and choosing the best among those platforms that are 'close' to their existing platforms. In this respect our model is similar in spirit to Schofield, who demonstrates with a formal model that among winning platforms a dense trajectory always exists.¹³ That is, one can always find a sequence of close platforms that will lead a political party from one winning platform to the next. Thus, one might think that even with incrementally-changing parties the less than satisfying conclusions inherent in the full information, rational choice models still hold. In Schofield's model parties incrementally advance the *incumbent's* platform, where in our model parties amend their own historically determined platform. It follows that if parties begin with platforms that are not spatially close to one another, then our model and Schofield's model may lead to very different dynamic trajectories.

To understand adaptive party behaviour, we follow the approach suggested by Holland and Miller and analyse the behaviour of parties using artificial adaptive agents (AAA).¹⁴ Using AAA models, we can investigate the relationship between optimization and adaptation. AAA models allow us to create an 'artificial world' in which we can explore systems of flexible, well-defined agents, and quickly generate, refine and test new hypotheses. In these models, one attempts to discover the generic patterns of system behaviour that emerge due to the adaptation.¹⁵

Once one accepts the notion that parties are limited in their ability to find appealing platforms, new research questions emerge. The local environment facing each party – the link between small modifications in a party's platform and the number of votes the party receives – now becomes central.¹⁶ As parties adapt new, nearby platforms in an attempt to capture votes, they alter the environment facing the other party. In this article, we investigate the dynamic interplay of platforms. What routes do the parties follow? Do they 'move' towards similar places in platform space? Do they ever get stuck on local optima? How quickly do they move? How normatively appealing are the

¹² This is widely observed in research on organizational behaviour. For an early report, see Robert Dahl and Charles Lindblom, *Politics, Economics, and Welfare* (New York: Harpers, 1953).

¹³ Schofield, 'Instability of Simple Dynamic Games'

¹⁴ John Holland and John H. Miller, 'Artificial Adaptive Agents in Economic Theory', *American Economic Review, Papers and Proceedings*, 81 (1991), 365–70.

¹⁵ In the complex systems literature, these resulting patterns of system level behaviour are often referred to as emergent phenomena.

¹⁶ The preferences of voters and the opposition party's platform determine the number of votes a party receives.

resulting outcomes – are the platforms selected by adaptive parties better than arbitrarily chosen platforms?

THE MODEL

Following standard spatial models, our voters have perfect information about parties' platforms. Each voter attaches an integer valued strength and ideal position to each issue. Strength measures the issue's relative importance to the voter. A voter considers an issue irrelevant if the voter's strength is equal to zero on that issue. The ideal position denotes the voter's most preferred policy.

Thus, an integer valued vector of length $2n$ (where n equals the number of issues) fully characterizes a voter's preferences. There are $k \in \{0, 1, \dots, k-1\}$ positions on each issue and $s \in \{0, 1, \dots, s-1\}$ strengths. The utility to a voter from a party's platform, $y \in \{0, 1, \dots, k-1\}^n$, equals the negative of the squared weighted Euclidean distance, with weights determined by strengths. Let s_{ji} denote the strength and x_{ji} the ideal point of the j th voter on the i th issue. A voter's utility from platform y is then given by

$$u_j(y) = - \sum_{i=1}^n s_{ji}(x_{ji} - y_i)^2.$$

A voter casts a ballot for the party whose platform generates the higher utility, and the party obtaining the most votes wins the election.

We begin an electoral sequence with the creation of two randomly assigned initial party platforms. These are referred to as party ideal points. One party is arbitrarily chosen to be the incumbent, and its platform remains fixed during the first election. During the campaign prior to each election, the challenger party tests platform variations using polls of randomly selected voters.¹⁷ After this polling, the challenger party chooses the platform that maximizes its expected vote total. The parties then compete for election and the winning party becomes the fixed incumbent (at its current platform location) for the next election. The losing party becomes the challenger and (from its current platform location) undertakes polls in order to determine a winning platform. Often parties fail to locate winning platforms after the finite campaign. If so, the incumbent remains, and the challenger adapts another new platform. This sequence of adaptations and elections continues through several elections.

Adaptive Search Techniques

Our parties adapt to polling information using three benchmarks of adaptive behaviour: *random search*, *hill-climbing* and a *genetic*

¹⁷ In Kollman, Miller and Page, 'Adaptive Parties and Spatial Elections', parties were able to poll all voters.

algorithm.¹⁸ Random search generates multiple platforms in the neighbourhood of the existing platform and chooses the platform that receives the most votes against the incumbent. If none of the new platforms performs better than the party's existing platform, the party sticks with its existing platform. Under random search, every new platform generated is considered one unit of campaign length. Hill-climbing operates on a single platform rather than a population of platforms. At each step, the algorithm randomly generates and tests a new platform in the neighbourhood of the current platform. If the new platform is better than the current one, it becomes the new current platform. This process continues with each generation and test of a platform counting as one unit of campaign length. A genetic algorithm is a population based adaptive search algorithm that mimics evolutionary learning.¹⁹ A genetic algorithm begins with a randomly generated population of platforms similar to the party's existing platform. These platforms are then selectively reproduced, biased towards those that fare better against the incumbent party's platform. A random subset of the reproduced platforms then undergo an exchange of sequences of positions (crossover) and arbitrary changes on some positions (mutation). The platforms are then tested against the incumbent's platform and a new cycle of reproduction and modification is begun. Each application of the algorithm is referred to as a generation, and the number of generations corresponds to two units of campaign length. For each algorithm, we experimented with campaign lengths of between ten and one hundred.

The three adaptive techniques offer plausible analogues to party search behaviour. Random search represents a party that chooses the best candidate from among volunteers. (Incidentally, the random search algorithm is not a flattering metaphor for party decision making, but we believe that it offers a possible lower bound on organizational intelligence.) Hill-climbing is intended to represent a party that fine-tunes the policy positions of its candidate using polling results and focus groups. The genetic algorithm approximates the process of a political party undergoing internal debate over policy positions. Candidates borrow ideas from each other and win or lose primaries based on how they match up against the incumbent. Occasionally an activist introduces a new idea.

¹⁸ Our use of three different search algorithms ensures more robust results. We have chosen algorithms that satisfy two criteria. First, they have been widely used in discrete nonlinear optimization, which provides us with prior information on their performance. Secondly, as we suggest in the next section, each algorithm represents a plausible description of how parties might select platforms.

¹⁹ John Holland, *Adaptation in Natural and Artificial Systems* (Ann Arbor: University of Michigan Press, 1975).

Preference Distributions

We consider two major classes of preference biases on individual voters: those where voters maintain varying levels of consistency across ideal policy positions, and those where voters have systematic variations in issue strength. More specifically, we alter individual voters' preferences, (1) by correlating voters' ideal positions on different issues and (2) by correlating a given issue's strength and ideal position.

Correlating a voter's ideal positions on different issues alters what we call a voter's ideology. A single voter can have a *uniform* ideology, where ideal positions are randomly determined from uniform distributions for each issue, or a voter can have a *consistent* ideology, where ideal positions for that voter are correlated across issues. To create consistent ideologies, we randomly assign an *ideological base* to each voter and require that all ideal positions on other issues for that voter lie within one position of the base.²⁰ For example, if the ideological base for a voter is 3, then all ideal positions for that voter lie in the set {2,3,4}.²¹

We also consider three types of correlations between strengths and ideal positions: *independent*, *centrist* or *extremist* preferences. With independent preferences, a voter's strengths on issues are (on average) statistically independent of the voter's ideal positions on issues. Centrist preferences occur when a voter attaches greater strengths to issues with moderate ideal positions, and extremist preferences occur when voters attach greater strengths to those issues with extreme ideal positions. To illustrate, consider the case of nine positions {0,1, ..., 8} per issue and three strengths {0,1,2}. Centrist voters assign high strength ($s = 2$) to issues with ideal positions {3,4,5}, low strength ($s = 1$) to issues with ideal positions in {1,2,6,7}, and no strength ($s = 0$) to issues with ideal positions {0,8}. In extremist preference distributions, voters attach greatest strength to issues on which they have extreme ideal positions. Issues with ideal positions in {0,1,7,8}, receive high strength ($s = 2$), issues in {2,3,5,6} receive low strength ($s = 1$), and an issue with ideal position {4} is considered by the voter to be irrelevant ($s = 0$). Since there are two types of

²⁰ We recognize that ideologies are often thought of as social phenomena, so another way to model ideologies is to have groups of voters with correlated preferences. That is, voter A's position on issue i could be correlated with voter B's position on issue i . We do not model this here, although it is a worthwhile extension of this research. Instead, voters here have individual ideologies, where correlations across issues are strictly within individual voters. So voter A's position on issue i is correlated with voter A's position on issue j .

²¹ If a voter's ideal base position lies on the boundary, in this case either 0 or 8, then all other ideal positions are within one position of the ideal base position but only in one direction. We also experimented with another version of ideological voters. For these voters, we randomly selected an initial issue (issue 1) and its ideal position, and then required the next issue (issue 2) to have an ideal position within plus or minus one of the previous issue's ideal position. In turn, a voter's ideal position on issue 3 had to be within one of her issue 2 ideal position and so on. The results for this type of ideological preference proved indistinguishable from those generated by the consistent ideology described here.

TABLE 1 *Voter's Preferences Can Vary According to Ideology and Distribution of Strengths*

Type of ideologies	Types of strength distributions
Uniform (random distribution of ideal points)	Independent (random distribution of strengths)
Consistent (correlated ideal points)	Centrist (moderate ideal points are weighted)
	Extremist (extreme ideal points are weighted)

ideologies and three types of strength-ideal position correlations, we consider six possible distributions of voter preferences (see Table 1).

As should be evident, these kinds of preferences are neither complete nor empirically verified examples of political attitudes. Rather, they are polar cases suggesting a range of biases voters might have when they decide how to vote. Our extremist voters place substantial weight on certain subsets of issues on which they take extreme views. One may think of abortion or gun control activists in the United States as extremist voters: the competing parties' positions on these voters' pet issue has a huge impact on whom these voters support. In contrast, our centrist voters place little weight on issues on which they have extreme views. For example, on issues such as the reciting of the Pledge of Allegiance, funding for the arts, or the personal life of a party's candidate, voters may prefer positions outside the mainstream and yet not attach much weight to these issues.

Measures of Party Performance

In the results section, we analyse the formation of platforms when adaptive parties face voters with various preference distributions. Ultimately, we want to know how parties, in their efforts to attract votes, move across the platform space. To facilitate this analysis, we measure party movement and platform responsiveness in a variety of ways. Over the series of elections, we trace the trajectory of winning party platforms based on several measures. In the definitions, we refer to the platform y_{median} , which consists of the median position on each issue. For example, if 3 is the median position on issue 2 then $y_{\text{median}, 2}$ is set equal to 3.

Separation equals the Euclidean distance between the current platforms of the two parties.

Distance from Median equals the Euclidean distance between the winning party's platform and y_{median} .

Centrality of a platform y equals

$$\frac{\sum_{j=1}^V u_j(y_{\text{median}})}{\sum_{j=1}^V u_j(y)}$$

where V equals the number of voters.

This normalization sets $\text{centrality}(y_{\text{median}}) = 1$. Though we attach no normative significance to the median itself as an outcome, higher centrality means that the platform is closer to the weighted centre of voters' preferences. Centralities close to 1 represent strong utilitarian outcomes. Note, however, that centralities across different distributions of voters' preferences cannot be compared directly because each new distribution of voters, with assigned biases, generates a distinct centrality distribution.

THE ELECTORAL LANDSCAPE

Adaptive parties attempt to improve their vote totals by searching locally over the space of platforms. Recall that the percentage of the vote a platform receives depends on the incumbent's platform and the preferences of the voters. To explain adaptive parties' responses, we rely on the notion of an electoral landscape. Like geographic landscapes, electoral landscapes have points of high and low elevation. By assigning each platform an elevation equal to the percentage of the vote won by the platform, we can interpret party behaviour as a search for (electoral, not necessarily moral!) high ground.

Notions of electoral landscapes are implicit in models with fully-informed, rational parties, but the landscapes' underlying structures are usually ignored.²² In rational choice models, agents are able to perform vast surveys of the landscape and to move immediately to the point of highest elevation. In our model, agents are only able to look locally and must move slowly. Thus, the explicit details of the landscape become an important feature of our model.

Adaptive parties' knowledge of the electoral landscape is constrained in two ways. First, they poll only a sample of the electorate and not all voters. Therefore, a platform's elevation, as perceived by the party, may differ from its actual elevation. Of particular importance is the error caused by sampling results in the incorrect ranking of two platforms, as when an actual decrease in votes is perceived as an increase, or vice versa. Secondly, adaptive parties do not have estimates of all platforms. In the simulations we discuss, the number of polls never exceeds one hundred, which, in each case, represents substantially less than 1 per cent of all platforms.

Figures 1 and 2 provide intuition on the impact of the electoral landscape on

²² The work of McKelvey, 'Covering, Dominance, and the Institution-Free Properties of Social Choice', and that of Schofield, 'Instability of Simple Dynamic Games', are notable exceptions.

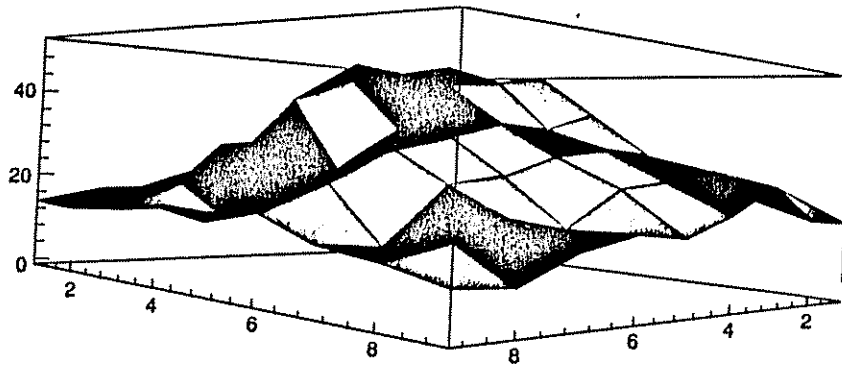


Fig. 1. Electoral landscape with centrist preferences

platform formation. These figures represent projections of two issue dimensions (from a multi-dimensional problem) on to a voting landscape for centrist and extremist preferences respectively. Also, these are polar cases, as every voter in each figure is either centrist or extremist. The axes represent different platform positions on issues 1 and 2 (with all other issue positions fixed). The altitude gives the percentage of the vote received by the party if it advocates the corresponding pair of issue positions. In our model, a party finds itself locating somewhere on the plane, and it is allowed to perform local searches for better platforms. Hill-climbing parties, for example, take a sequence of random 'steps' and move when the new location is higher than the old. If the landscape is smooth with a single peak, then such steps would quickly lead parties to the peak. If, however, the landscape is rugged, such steps could cause parties to be trapped on isolated local peaks, unable to cross adjacent valleys and ascend to superior platforms. It follows that we may see in the latter case adaptive parties with substantial platform separation.

We conclude this section with a description of the formation of electoral landscapes. Our intention is to provide intuition as to how variations in the distribution of voter preferences alter the slope and the ruggedness of electoral landscapes. Note that the biases described on pp. 145-6 are assigned to individual voters' preference profiles. However, when they are assigned to a significant proportion of voters, they distort electoral landscapes in specific ways.

Let us begin with the case of a single voter and a projection of policy preferences onto a two-dimensional issue space. In Figure 3, v is the ideal point for the single voter and y_i denotes the incumbent's fixed platform. Using the voter's utility function we can draw an indifference ellipse (I-ellipse), such that for all points on the I-ellipse the voter achieves utility equal to that given by y_i . Given the utility function the voter achieves greater utility from platforms that are closer to v , thus the challenger will win the vote if and only if its platform

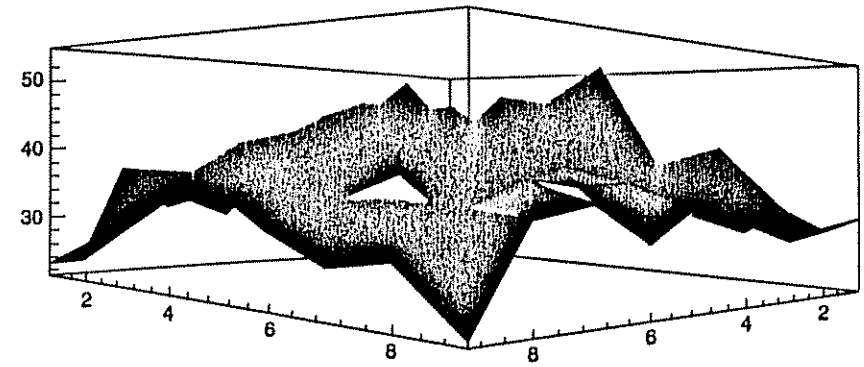


Fig. 2. Electoral landscape with extremist preferences

is contained within the I-ellipse. An I-ellipse, I_0 , is shown in Figure 3 for the case when the two platforms offer the voter identical utility on the issues not projected on the diagram. If the incumbent's platform offers a different utility level on the issues not projected, then the I-ellipse can be easily adjusted to reflect this differential (it will lie interior of I_0 if the issues not projected favour the incumbent and exterior of I_0 if they favour the challenger).

Now, to form the electoral landscape, draw the appropriate I-ellipse for each voter in relation to the incumbent party. The elevation of each platform is given by the percentage of all possible I-ellipses that contain the platform. One could

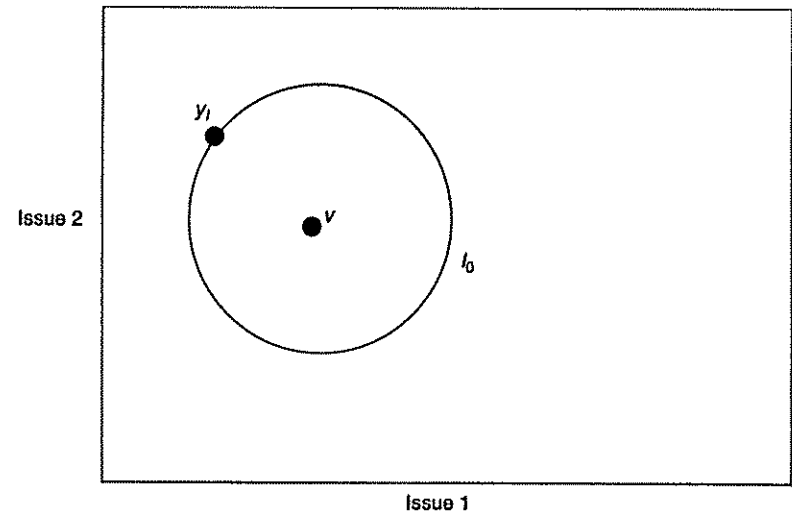


Fig. 3. Independent preferences

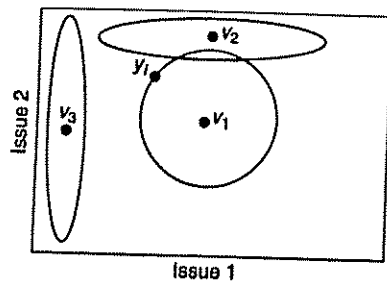


Fig. 4a. Extremist preferences

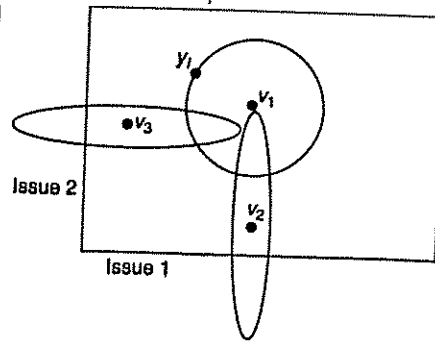


Fig. 4b. Centrist preferences

view the creation of the landscape as a process by which the interior of each I-ellipse is coated with a thick layer of paint (signifying a vote for the challenger). Areas of great elevation (i.e. with many layers of paint) correspond to regions of the issue space which attract many votes. Thus, the peaks and valleys of the landscape are created by the 'stacking up' of I-ellipses.

Different preference biases among individual voters create distinct I-ellipses and, perforce, fundamentally different electoral landscapes. For example, high strength for a particular issue implies I-ellipses that are elongated along the other issue dimension. That is, with high strength a voter prefers that policy stay close to the voter's ideal position on that issue, while compromising on other less important issues. Under extremist preferences, the high strength issues are those with ideal points near the edge of the diagram, and thus one would expect to find elongated I-ellipses (running parallel to the nearest edge) in these areas (see Figure 4a). Under centrist preferences, the I-ellipses will elongate for those ideal positions near the middle of the axis. These I-ellipses will elongate parallel to the other issue axis (see Figure 4b).

As extremist and centrist preferences imply very different I-ellipses they also imply very different landscapes. With extremist preferences, the I-ellipses result in numerous areas of high elevation that are sparsely distributed across the landscape (near the corners). This is because the elongated I-ellipses for voters will overlap in the corners, and these landscapes will therefore have substantial ruggedness. Centrist preferences create landscapes that have a lot of overlap occurring across the middle of the two axes. This tends to create landscapes with a single, central peak. Independent preferences have less regularity than the other two types we consider, as strengths and ideal points are not correlated. Thus, the shape of the I-ellipses are unconstrained by the voter's ideal point. This results in a landscape formed by combining voters of all different types of characteristics, and thus one can think of a convolution of the various landscapes types discussed above, along with other forms of asymmetric I-ellipses not discussed here.

Finally, we want to consider landscapes formed by ideologically consistent voters. Our analysis is simplified by the fact these voters each have ideal positions that are near one another on each issue: their ideal points lie along or near the n -dimensional diagonal. Since our centrist and extremist preferences both tie the strength to the ideal point, such voters will have ideal points with similar strengths, and therefore will have circular I-ellipses. The radius of a given I-ellipse for centrist voters will be large towards the extremes and small towards the centre, and the opposite for extremist voters. Further, the compression of the voter ideal points along the diagonal forces the regions of the landscape away from this diagonal to be relatively low and smooth. Thus, ideologically consistent voters should dampen the ruggedness across these landscapes. Moreover, the structure of these landscapes should result in parties rapidly finding the the diagonal and then slowly adapting along this ridge.

RESULTS

In an effort to ensure robust findings, we ran simulations of the model for all six combinations of preference distributions over a range of parameter values. In the findings presented in this section, we analyse the model when there are ten issues ($n = 10$), nine positions per issue ($k = 9$), three strengths per issue ($s = 3$), and campaigns of length 40.²³ Strengths and positions are correlated as in our earlier description of the model. The results presented are from an environment with 2,501 voters and in which parties' polls sample a random selection of 251 voters.²⁴ All of the results reported here appear robust to reasonable changes in the parameter values.

To foreshadow the results, we find that adaptive parties evolve moderate platforms that are spatially separate from one another across all types of preference distributions. We also find that platform evolution, in particular the type of platform and speed of convergence, does depend on the underlying preference distribution. Our analysis unfolds in two stages. We first show that variations in preferences result in fundamentally different electoral landscapes. Then we find a link between landscape characteristics and adaptive party behaviour.

We characterize electoral landscapes according to two characteristics, *ruggedness* and *slope*. Ruggedness equals the percentage of positions in the interior which are one-dimensional local maxima or minima. A platform has a one-dimensional local maximum (minimum) on an issue i at interior position

²³ These parameters were chosen to be consistent with existing empirical research, although they are within ranges where we observed no qualitative changes in outcomes. For example, we experimented with campaign lengths between 10 and 100. We also considered ideological parties: those that (contingent on winning the election) try to stay close to their initial 'ideal' platform. (See Kollman, Miller, and Page, 'Adaptive Parties in Spatial Elections.') The results for ideological parties generally agree with those reported here.

²⁴ These numbers create a sampling error of approximately 5 per cent.

k if, when holding the rest of the platform unchanged, no increase in votes occurs when altering issue i 's position to either $k + 1$ or $k - 1$. Intuitively, more ruggedness should lead to slower adaptation, as parties are more likely to get trapped in local optima.²⁵ We consider two measures of slope, both of which rely on the notion of a 1-neighbour platform. The set of 1-neighbours of a platform y consists of those platforms which differ from y by exactly one position on exactly one issue. The average slope of a landscape equals the average difference (in absolute value) in vote total between a platform and its 1-neighbours. The gradient equals the average maximum vote difference between a platform and its 1-neighbours. We found ruggedness and both measures of slope to be inversely related. Given this inverse relationship; hereafter, we focus our discussion on the ruggedness of landscapes.²⁶

Figure 5 gives the average ruggedness across the different types of preference distributions. The preferences can be listed in order from those that form the most to the least rugged landscapes as follows: *Independent-Uniform*, *Independent-Consistent*, *Extremist-Uniform*, *Extremist-Consistent*, *Centrist-Uniform*, and *Centrist-Consistent*.²⁷ The intuition outlined in the previous section appears valid: centrist preferences form landscapes that are the least rugged while independent preferences form the most rugged landscapes. Consistency of preferences appears to reduce ruggedness across all landscape types. Note that as the parties evolve their platforms, ruggedness tends to decline, with consistency of preferences mitigating this reduction. With these measures of landscape characteristics we can now analyse party behaviour.

A central finding is that adaptive parties tend to move towards moderate platforms regardless of the distribution of voters' preferences and the search algorithm employed. Figure 6 illustrates this result for hill-climbing parties.²⁸ For all types of preferences, adaptive parties, even when limited to sample polls of voters, quickly move to regions of high social utility. In every case, by the fourth election winning parties' platforms were located within the top 1 per cent of all platforms as measured by centrality. This tendency to adapt platforms of high social utility does not imply complete platform convergence. The resulting platforms, although close to the median, often advocate positions that are away from the median on particular issues.

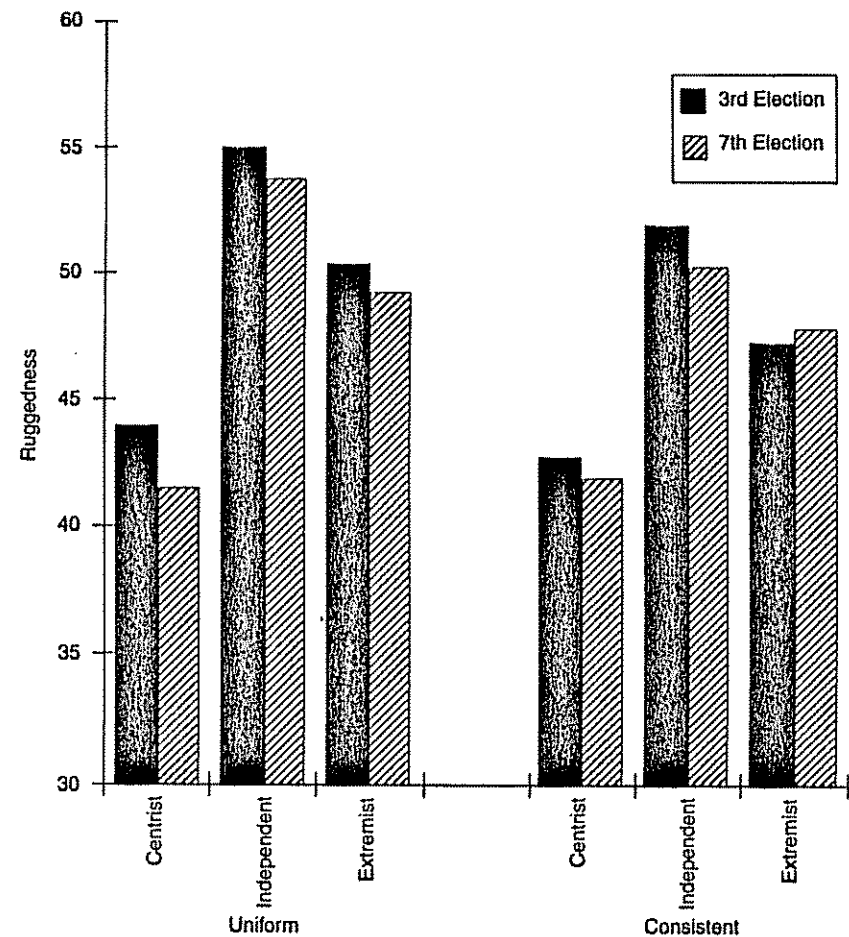


Fig. 5. Average ruggedness for fifty trials of hill-climbing parties at third and seventh elections

Party platforms also maintain a degree of spatial distance from one another (see Figure 7) and do not appear to lock into 'equilibrium' positions. Though party platforms tend towards moderate regions, they continually wander these neighbourhoods. Moreover, the rate at which parties adapt towards the central region, as well as the region's spatial radius, vary according to the electoral landscape. This second feature echoes McKelvey's theoretic result (discussed in our introductory section) and can be observed in Figure 7 with the flattening of the lines at different levels of separation.²⁹

²⁹ McKelvey, 'Covering, Dominance, and the Institution-Free Properties of Social Choice'.

²⁵ Ruggedness is a perhaps the simplest measure of the complexity of a landscape. For a discussion of the complexity of discrete function spaces and alternative complexity measures, see Scott E. Page, 'Two Measures of Difficulty', *Economic Theory*, 8 (1996), 321-46.

²⁶ The inverse relationship can be verified by measuring the correlation coefficients between the two measures of slope and ruggedness. For example, with hillclimbing parties after the fourth election the correlation coefficient between average slope and ruggedness was -0.245 for landscapes formed by voters with Independent-Uniform preferences. Similar results hold for other preference distributions.

²⁷ Only the differences between centrist and other distributions are statistically significant at 95 per cent.

²⁸ Similar results hold for parties who adapt using genetic algorithms and random search.

We also find that adaptive parties cannot always locate winning platforms. The probability of winning decreases with the number of elections, from approximately 100 per cent of the time in the first election down to approximately 25 per cent (on average) by the tenth election. While optimization models often include explicit assumptions about incumbency advantages, here such an advantage emerges as a natural outcome of the adaptive search process. As the platforms evolve, the landscape facing each party changes. As shown above, our examples indicate that there is some decrease in ruggedness, which would imply that it is easier for adaptive parties to travel around the landscape without getting trapped on local peaks. However, our examples also show that the slope is decreasing over time, implying greater difficulty in increasing vote totals for a given platform alteration.

Figures 6 and 7 also indicate that landscape characteristics affect adaptive party behaviour. Linking the behaviour observed in these figures with the underlying landscape characteristics, we find that in general, landscapes with lower ruggedness allow faster adaptation to more moderate platforms that are closer to one another. Thus, centrist preferences will cause competing parties to adapt very moderate platforms that are near one another, while independent or extremist preferences keep party platforms spatially separated with less moderation. In general, the more rugged the landscape the more likely parties are to get caught on local optima. However, consistent preferences among voters have a marked impact on convergence patterns, with convergence rates stalling around the fourth election period. These results are in accordance with the intuition developed in the previous section.

Several other characteristics of the platforms deserve attention. One question regarding consistent voters was whether they compel parties to adapt their platforms towards more consistent positions. If so, parties would converge to platforms with symmetric positions across all of the issues. We find little support for this hypothesis in our numerical simulations: adaptive parties do not become significantly more consistent when adapting on landscapes formed by consistent voters.³⁰

We now turn to disparities in the relative performances of the search algorithms. We know that the three algorithms differ in their abilities to adapt on rugged landscapes. Genetic algorithms have been promoted by many researchers primarily because they perform well on complex, nonlinear problems.³¹ Similar to other population-based search techniques, genetic algorithms identify and attempt to exploit patterns present in good solutions, in this case good platforms. It comes as no surprise that on more rugged landscapes

³⁰ To test this we introduced the following measure of consistency: $c(x) = 1 - \{var(x)\}/Maxvar$, where $var(x)$ is the variance of the positions in the platform x , and $Maxvar$ equals the highest possible platform variance. Consistency always lies on the unit interval and varies inversely with the variance in the platform's positions. We found no significant differences in the consistency of platforms for parties confronting consistent and uniform ideologies.

³¹ Holland, *Adaptation in Natural and Artificial Systems*.

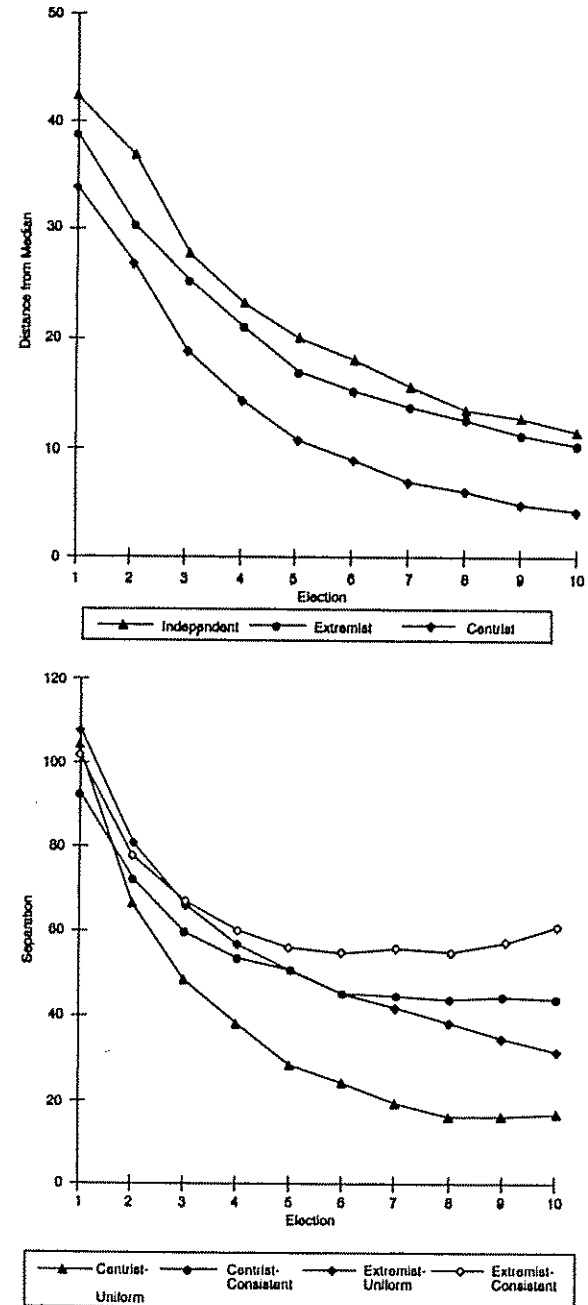


Fig. 6. Average distance from median for fifty trials of hill-climbing parties and uniform preferences
 Fig. 7. Average separation for fifty trials of hill-climbing parties

the genetic algorithm performs comparatively better than the other two techniques. Hill-climbing parties often get caught at a local optimum, never visiting more attractive regions of platform space. Finally, though random search adapts most slowly on a simple single-peaked landscape, it often outperforms hill-climbing on more rugged landscapes because it samples a larger number of initial points before taking its step, so it is more likely to take high payoff paths initially.³² Our examples show that parties whose behaviour is characterized by a genetic algorithm adapt more quickly away from their initial platform than do those using hill-climbing or random search. Nevertheless, by the tenth election, all types of parties have adapted approximately the same distance away from their initial platforms.

DISCUSSION

To summarize our findings, the ability of adaptive parties to locate winning platforms depends on the ruggedness and slope of electoral landscapes. We find that extremist and independent preferences lead to landscapes that slow party convergence more than centrist preferences, and that consistent ideologies tend to lead to slower party convergence. Moreover, locally adapting parties can often become temporarily stuck at local peaks, and thus may be unable to defeat an incumbent. These findings appear to hold for a wide range of parameter values.

The electoral landscapes formed by extremist preferences or consistent ideologies may explain some reluctance by contemporary American parties to budge from platform positions. When voters attach greatest strength to those issues on which they take extreme views, or when ideologically consistent voters loom large in campaigns, parties appear to converge slowly to moderate positions. On issues where voters attach more significance to centrist positions, parties appear to adapt quickly to similar, moderate positions. By relating different preference distributions to party behaviour, our model can lead to more fundamental theories of elections. Moreover, relationships between preferences and outcomes should lend themselves to empirical testing.

Consider, for example, the position-taking behaviour of parties in the United States: they alter their messages to appeal to different sets of

³² Hill-climbing and random search are similar in that they both randomly sample from their current best-known position and move to better positions. The difference is that random search first samples a large number of neighbouring points and then takes the best one, while hill-climbing samples sequentially and moves as soon as a better point emerges. Thus, for a given number of samples, hill-climbing will be able to move further uphill if there is a smooth single-peaked landscape. However, if the landscape is rugged, hill-climbing can take off in the wrong direction and get stuck, while random search will move more slowly, but each step has a much higher probability of having a greater increase in value. Note that when there are few uphill directions, both algorithms behave in a similar manner.

voters;³³ they maintain policy distances from each other on some issues (such as abortion and gun control), and converge to similar positions on other issues (such as foreign policy and social security); and they appear to modify their platforms when voters' preferences for policies change.³⁴ Spatial voting models have not fully succeeded in explaining such phenomena, while our model can suggest how such outcomes may occur.

While different preference patterns alter the convergence rates of party platforms, convergence results in spatial voting models with adaptive parties seem relatively robust to changes in voters' preference distributions. Even under conditions that slow convergence (such as increased ruggedness), parties take fairly moderate platforms within a few elections. Thus, our findings are consistent with Downs's analytical intuition that in two-party democratic elections rational parties tend to move towards moderate platforms.

At the same time, this article relates to quite a few rational choice models that predict some party separation. Rational choice explanations of policy divergence within the American two-party system include the influences of party activists,³⁵ voter uncertainty,³⁶ campaign contributions,³⁷ third-party threats,³⁸ endogenous preferences³⁹ and expectations about voter preference changes.⁴⁰ Our model is unique in a number of respects, however. First, our model is multidimensional and has the potential to develop empirical predictions concerning different degrees of party divergence across policy issues. Secondly, we assume adaptive parties and focus attention on how voters' preferences shape the decision-making environment for these kinds of parties. Thirdly, because of our methodology, we can analyse the dynamic processes of party competition as they unfold, rather than just end-states or equilibria. Finally, we have great flexibility in testing alternative assumptions. The robustness of rational actor models can be tested with more flexible AAA

³³ Benjamin Page, *Choices and Echoes in Presidential Elections* (Chicago: University of Chicago Press, 1978); Earl Black and Merle Black, *The Vital South: How Presidents Are Elected* (Cambridge, Mass: Harvard University Press, 1992); Katherine Tate, *From Protest to Politics*, 2nd edn (Cambridge, Mass: Harvard University Press, 1994).

³⁴ Norman H. Nie, Sidney Verba and John R. Petrocik, *The Changing American Voter* (Cambridge, Mass: Harvard University Press, 1976); James L. Sundquist, *Politics and Policy: The Eisenhower, Kennedy, and Johnson Years* (Washington, DC: Brookings Institute, 1968); Thomas Ferguson and Joel Rogers, *Right Turn* (New York: Hill and Wang, 1986); Leon Epstein, *Political Parties in the American Mold* (Madison: University of Wisconsin Press, 1986).

³⁵ Aldrich, 'A Downsian Spatial Model with Party Activism'.

³⁶ Calvert, 'Robustness of the Multidimensional Voting Model: Candidate Motivations, Uncertainty and Convergence'.

³⁷ David Baron, 'Electoral Competition with Informed and Uninformed Voters', *American Political Science Review*, 88 (1994), 33-47.

³⁸ Martin Osborne and Al Slivinski, 'A Model of Political Competition with Citizen-Candidates', *Quarterly Journal of Economics*, 111 (1996), 65-96.

³⁹ Elisabeth R. Gerber and John E. Jackson, 'Endogenous Preferences and the Study of Institutions', *American Political Science Review*, 87 (1993), 639-56.

⁴⁰ Morris Fiorina, *Retrospective Voting in American National Elections* (New Haven, Conn.: Yale University Press, 1981).

modelling techniques, and in this case, our model clarifies and extends the previous (multi-dimensional) results of Kramer, McKelvey and Schofield.

Although the notion of adaptive parties competing on an electoral landscape contrasts with the more traditional notion of rational parties optimally locating in an issue space, we view the two approaches as complementary. Especially when models become complex, and analytical solutions become difficult or impossible to derive, numerical experiments offer a helpful alternative. We envision these techniques as having the potential to open up new areas for investigation and as a complement to traditional methods.