The Emergence of Parties: An Agent-Based Simulation

Abstract: This paper implements an agent-based computer simulation to demonstrate that results from Downs, Duverger, Riker, and Sundquist can be seen as emergent consequences of five simple rules about iteratively forming coalitions and adjusting policy platforms. Using simulation, I create a distribution of agents who form coalitions within a political body. By modifying and omitting the basic rules, I compare the results from plurality and majority-seeking actors and from policy-seeking, office-seeking, and mixed-strategy coalitions. A set of simple rules implemented by agents with extremely bounded knowledge are sufficient to drive the classic median voter, two party system, minimum winning coalitions, and party realignment results in a single framework.

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"As in other departments of science, so in politics, the compound should always be resolved into the simple elements or at least parts of the whole."

Aristotle. The Politics. Book 1, Section 1.

The quest to understand complex political phenomena as the emergent features of basic political forces and fundamental actors reaches back to antiquity. However, most contemporary models of the interactions of parties treat them as unitary actors optimizing their power through strategic positioning in a landscape of voters. The framework in this paper understands parties as merely coalitions of coalitions.

Since coordinating on decisions is a prime function of political bodies, Kenneth Arrow's (1951) result that even rational voters with transitive preference rankings cannot guarantee transitive policy rankings poses a challenge to political science. The answer Thomas Schwartz (1989) provides to his question Why Parties? is that long and narrow coalitions can resolve inefficiencies resulting from many of the kinds of collective choices that Arrow describes. If the division of a political body into coalitions can diminish coordination problems and if a coalition itself is a political body subject to coordination problems, then I argue that we should expect politics to be characterized by nested coalitions.

However, the description of simple elements is insufficient for an understanding of the complex whole. Rules of interaction among particles govern physics and among words govern literature. With basic rules governing the formation and dissolution of coalitions and the movement of their policy platforms, this paper shows that simple rules of political interaction can account for a broad range of political phenomena.

In the first section, I describe the traditional models and results in the party formation and spatial voting literatures. The second section discusses the general framework for the models presented in the following four sections. Finally, I discuss the results of the investigation and propose an extended research agenda.

Traditional Approaches to Voting and Parties

Anthony Downs' (1957) classic An Economic Theory of Democracy presents a deductive argument about the strategy of parties and political actors in a two-party system. Downs borrowed economic assumptions of unified rational actors and spatial markets for his political analysis. The rational *homo politicus* 1) makes a decision when confronted with alternatives, 2) ranks preferences, 3) uses a transitive ranking, 4) always chooses the highest ordered preference, and 5) makes the same choice when presented with the same alternatives (Downs 1957, 6). However, the actors in Downs' model are not only individuals, they can be teams—coalitions with members that agree on all their goals (Downs 1957, 25). Because of this agreement, the team can be treated as a single entity for the purposes of the model. Downs defines a political party as a team seeking to control the governing apparatus by gaining office.

Downs also adopts the notion of spatial markets from economics and applies it to the ordering of political preferences. Voters prefer some point on the policy dimension and their utility for alternatives diminishes monotonically from that point (Downs 1957, 115). One interesting result that Downs presents is the tendency of parties to move toward the median voter (Downs 1957, 117). The logic is that if a left-wing party has 30% of the electorate and the right-wing party has 70% then, under the assumptions of the spatial voting model and the definition of party, the left party will move towards the center to garner a greater share of the votes. The right party must react and will also move towards the center. Eventually, the parties will converge on the median position. Duncan Black (1958) demonstrated this result formally in one dimension as the Median Voter Theorem.

Most of Downs' theory is developed in the context of the two-party system in America. Of course, two parties are not constitutionally mandated in the American system. But, Downs and others have argued that this is the natural result of a winner-take-all plurality electoral structure. The two-party result is frequently referred to as Duverger's Law. Although statements of the tendency towards two parties had been expressed eighty years prior to Maurice Duverger's publication, he is noteworthy for having collected the historical evidence as well as for distinguishing the hypothesis that proportional representation will lead to a multiparty system (Riker 1986, 26).

The reasoning of Duverger's Law is that when only one party can be elected, one challenger to the leader can be viable, but votes for additional challengers would be "wasted" (Downs 1957, 48). Gary Cox expands on this by noting that in addition to this strategic voting concern, a contributor may worry about other resources such as money and endorsements being wasted if they go to a candidate with no hope of winning (Cox 1997, 30). Cox's (1994) model of strategic voting shows that we would expect voters to remain with two or more challenging parties (as opposed to the leading party) only when there is a coordination problem and the challengers are expected to garner an equal number of votes. Otherwise, voters who like the challengers better than the leader improve their expected utility by switching to the party they think will come in second.

While we expect two parties in equilibrium, Downs notes that third parties occasionally arise to challenge the existing two. He cites the enfranchisement of the working class in late nineteenth century Britain as a cause for the rise of the Labour party against the traditional Liberal and Conservative parties (Downs 1957, 128). The changed importance of social cleavages or the emergence of new cleavages alters the political landscape and creates opportunities for new parties. The Labour party entered British politics to the left of the Liberals, who were unable to react to the changing times.[1]

James Sundquist's (1983) Dynamics of the Party System extends the discussion of what party changes might result from a change in social cleavages. His second chapter narrates the fictional tale of a town divided into the Progressive and Conservative parties. A new issue arises, whether to allow a saloon, and supporters and opponents are found in both existing parties. He describes five scenarios which might ensue: 1) no major realignment, 2) realignment of the two existing parties, 3) realignment of the existing parties through absorption of a third party, 4) realignment through replacement of one major party, and 5) realignment through replacement of both existing parties. Which of the scenarios occurs depends on the salience and positioning of the new issue and the existing cleavages, party leadership, and strength of party attachments. Sundquist argues his theory by looking at historical examples of new cleavages and their results. Part of Sundquist's argument is that realignment comes about not because of forming and reforming of coalitions of groups, rather from the reordering of individual attachments (Sundquist 1983, 41).

While Sundquist's argument is based predominantly on historical evidence from the American experience, William Riker's Theory of Political Coalitions uses a formal model to describe the dynamics of coalitions. In the first half of his book, he argues that political actors will create coalitions just as large as they believe will ensure winning and no larger (Riker 1962,

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[1] In fact, some argue that it is the social cleavages that cause the choice of electoral system. Thus, two major factions will select a single member plurality system to protect their interest while a society with numerous powerful factions will opt for a proportional or other multimember system (Cox 1997, 14-16).

47). This notion of “minimum winning coalitions” (also known as the “size principle”) has been disputed on theoretic (Hardin 1976) as well as empirical grounds (Hinckley 1972). But, the notion that winning coalitions will still be constrained in size remains important (Koehler 1975).

In the second half of his book, Riker (1962, 133) modifies the n-person game of Von Neumann and Morgenstern (1944) into an n-set partition of the voting members. He uses this partition model to describe strategy at the step before a winning coalition is established. While the dynamics of the final step are interesting and tractable within game theory, Riker’s model shares a limitation with Downs. We get little understanding of the internal dynamics of coalitions and parties. For Downs, the party is a unified team. For Riker, the partition is a divisible set, but the theory describes very little of the workings within the set.

A general theory of politics should give insights into the competition and coordination among political actors, be they individuals, factions, or coalitions. If political science concluded that the internal politics of the Democrats in the Congress had no importance, then we could treat them as a unified actor and theories in the tradition of Downs or Riker could be adequate. But, if the debates between Blue Dog Democrats and the Congressional Black Caucus interact with the debates between Republicans and Democrats as a whole, then we need a theory that can accommodate intra- as well as inter-group conflict.

One might respond that this is a straw-man conflict, that the answer to the question "Do Parties Matter?" is "No," and that having individual members of Congress as the unit of analysis would solve the problem. But, as Schattschneider (1960) contended the organized beat the unorganized. Coalitions struggle to form a united front, using Schwart'z solution to the problems described by Arrow, precisely because there are gains from coordination. This paper presents a framework for the dynamics among intra- and inter-coalitional conflict and cooperation.

The Framework

In order to escape the limitations of the frameworks of Downs and Riker, this paper proposes a view of parties as coalitions of coalitions. Empirically, political observers back to the ancients have described political bodies as factional. By iterating Riker's concept of a divisible set we can see that the nation divides into parties, the parties divide into coalitions, and the coalitions divide into sub-coalitions. Alternatively, we can say that coalition building is essential to the coordination game of politics and that voters build proto-coalitions, which form coalitions, which form parties, etc.

To construct a theoretical framework for the study of nested coalitions I propose two types of actors: voters and coalitions. The "voters" in my framework represent a unified enfranchised constituency acting in accordance with the principles of Downs' *homo politicus* as discussed above. Since I am intending a generic political framework, we could imagine the voters to be a single person with a vote (e.g. a citizen, committee member, or legislator) or a Downsian "team" that is entering the voting process with a unified agenda, set of ideal points, and method for decision making (e.g. a party, coalition, or interest group).

In this framework, the voters are the enfranchised, fundamental, and indivisible unit. The "coalitions" are the aggregate unit. The coalition in this model has no vote or existence in its own right; rather it embodies the aggregate preferences of its members. Though an aggregate, the coalition also functions with the same Downsian rules of rationality that face the voter *homo politicus* described above. We could think of these coalitions as analogous to Riker's proto-coalitions, or as coalitions of parties, interest groups, or elites. When a coalition is independent (e.g. it is not a member of a larger coalition), I will describe it as a "party," following Schwartz's (1989) reasoning.

Now, imagine a committee composed of eleven voters as described above. This committee must decide upon a budget for a new school that is between $0 and $100,000. Each voter has an ideal point (like the Downsian spatial model described above) and the voter's utility from an adopted policy diminishes monotonically as a function of the distance between the policy point and the voter's ideal point. Consistent with the framework described above, we can imagine that the voters will form coalitions as part of the process of arriving at a decision.

In this paper, I operationalize a series of thought experiments about coalition formation and dynamics with an agent-based computer simulation. In each section, I describe the rules for the model, a run of the model, the motivation for the rules, and the results of the model. I begin with a simple, relatively static one-dimensional model and present increasingly complex models that culminate with a richer, dynamic two-dimensional model. Going step by step in this fashion illustrates the strength of computational modeling as an iterative process as well as hopefully facilitating the readers' intuition about the function of each of the pieces.

Model 1: Policy-Seeking Coalitions

Rule 1: If possible, <u>form a coalition</u> with your closest neighbor and set your ideal point at the policy space centroid of the voters in the coalition.

Rule 2: <u>Stop forming coalitions</u> when your coalition has *enough* votes.

The simulation for Model 1 takes the spatial voting framework described above and gives the actors two rules to apply repeatedly. I will first describe one run of the simulation and then describe the rules and the motivation for the rules. Figure 1a illustrates eleven voters (V0-V10) with ideal points distributed along a one-dimensional policy space[2]. Voter 5 prefers to spend

[2] Note that the framework in this paper follows many of the classic models in assuming a spatial model that is purely in the world of ideas rather than incorporating geography. As such, it

close to $0 on the new school and Voter 9 prefers to spend close to $100,000. In this simulation, their ideal points are drawn randomly from a uniform distribution. Interested readers can follow along with this first simulation by implementing the rules with pen and paper.

Since the voters know that their committee is going to make a policy, each decides to try and form coalitions with the closest other voter. If the two voters agree that they are the closest to each other, then they can form a coalition. In Figure 1b, we see the new coalitions. Voters 9 and 10 both agreed that the other was the closest other voter in the issue space. They have formed Coalition 14 and set its ideal point at the mean of their individual ideals. Voter 5 wanted to form a coalition with its closest neighbor, Voter 8, but Voter 8 had Voter 2 (partially hidden) as its closest neighbor. Since Voters 5 and 8 did not agree about being closest neighbors, they did not form a coalition. But, Voters 2 and 8 did agree that they were closest neighbors and formed Coalition 15. As a result, Voter 5 did not join any coalitions during the first iteration of the model.

Figure 1c shows the result of another iteration of this process. Coalition 15 joins with Voter 5 to form Coalition 17. The policy point for Coalition 17 is set at the mean of the positions of Voters 2,5, and 8 (the weighted mean of Voter 5 and Coalition 15). Coalitions 11 and 12 join to form Coalition 16. In Figure 1d, Coalitions 16 and 17 have joined to form

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sacrifices the many important features of political competition that emerge from the fact that politics is embedded in an actual context where political actors must attend to a geographically limited set of constituents or to constituents that have regional interests that vary due to issues of location. For an agent-based modeling approach that factors in a role for geographic constraints, consider Synder and Ting (2002).

Coalition 18. And, Coalitions 13 and 14 have joined to form Coalition 19. Since, Coalition 18 has seven voters supporting it that policy point is enacted.

The preceding figures and text narrate a single run of Model 1. Each time a simulation is run in Model 1, the computer randomly distributes eleven voters' ideal points in a one-dimensional policy space. The computer then applies Rule 1 "If possible, form coalitions…" iteratively until, under Rule 2 "Stop forming coalitions…," a coalition has formed with a sufficient number of votes. The threshold for the sufficient number of votes is a parameter set by the user of the software. In the example above, the threshold was set at 50% of the total votes and Coalition 18 stopped applying Rule 1 when it had a majority. The user can also instruct a coalition to stop the process when it has a plurality. In this paper, the effect of both the majority and plurality rules will be studied.

The concept of forming coalitions in Rule 1 reflects the factional nature of politics described above. The assumption is that political actors will form coalitions with those who are most similar on the issues. A rational actor will find it is easiest to achieve policy goals by banding with those who have the most similar policy goals. This is observable by studying the relationship between coalition membership, declared values, and vote history in a political body (Laver and Budge 1992). Vote trading may appear to be an exception, but a rational actor will only vote against their preference on issue A in exchange for a vote on issue B if they value gains from issue B more highly. As such, vote trading can still be understood as the result of a decision based on a generalized form of the proximity model, as will be discussed below.

Setting the coalition's policy point at the mean of the voters' ideal points is a simple heuristic. If two voters know that they have the most similar ideal points and that all of the other voters will be forming coalitions to control policy, then the pair has a strong incentive to come to an agreement quickly. The mean of their ideal points is the point at which their contract curves intersect and their utility from the adoption of coalition's policy point would be equal. The next two models will allow for subsequent actions to adjust the coalition's policy point, but we are best off understanding the implications of the initial assumptions first.

The iterative process of forming coalitions of coalitions and setting the policy point of the new coalition at the centroid of the members is essentially a clustering algorithm from statistics. Cluster analysis groups entities into subsets on the basis of their similarity across a set of attributes (Lorr 1983, 11). Bernard Grofman has applied this method to study parties in a multiparty framework where proximate parties are iteratively combined into proto-coalitions building a hierarchy of proto-coalitions (Grofman 1982). The method has been shown useful for understanding the role of policy preferences on coalition formation in multiparty systems (Laver and Budge 1992) (chapters applying this method to Ireland, Norway, Sweden, Denmark, Germany, Luxemborg, Belgium, Denmark, Italy, Israel, and France), in the European Parliament (Laver 1997), and among interest groups appearing before the United States Congress (Jenkins-Smith et al. 1991).

The stopping rule (Rule 2) embodies the concept that the aggregate utility of a coalition with sufficient votes to determine policy will decrease if they add an additional member to the coalition. This is similar to arguments made by Riker (1962, 47)[3] and Schwartz (1989). To test alternative assumptions, the user of the simulation can vary the requirement for a sufficient number of votes. In the simulations presented below, I instructed the coalitions to stop forming

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[3] An important difference between my framework and Riker's (1962, 108-123) is that he allows for "side payments." In my model, the coalitions simply apply their heuristic rules to try and obtain a beneficial policy.

new coalitions once they had achieved a majority (the first set of results) or a plurality (the second set).

It is important to note that the majority and plurality versions of Rule 2 are not equivalent to majority rule and plurality rule in electoral systems. In all of the models in this paper the winner is the coalition with the most votes – an electoral rule known as the winner-take-all plurality rule. Versions a and b of the models differ in that coalitions are either pursuing the absolute size of a majority of the vote share or the relative size of a plurality of the vote share.

There is a debate in political science regarding the extent that political actors are policy-seeking or office-seeking. For instance, this is one of issues studied in Laver and Budge's (1992) work using cluster analysis in European parliaments. The coalitions in Model 1 can be described as policy-seeking coalitions in the sense that they do not move their policy point once it is established. They may form a new coalition with a new policy point, but an existent coalition will not adjust the policy point to entice additional members and increase the probability of winning. The simulation becomes static once all of the coalitions have formed, since none will move their policy points.

To examine the consequences of the thought experiment described above, I randomly generated one thousand initial distributions of eleven voters each and their ideal points. For each of the thousand runs, I then instructed the computer to repeatedly implement the Policy-Seeking Coalition rules until no new coalitions formed. I then repeated the experiment using one hundred runs that each contained one hundred and one voters.

All coalitions other than the winning coalition will constantly want to form coalitions, because Rule 2 has not been satisfied. However, when the winning coalition satisfies Rule 2, the rest of the coalitions will quickly find that they are unable to form new coalitions and the model will appear static. The winning coalition will not agree with any other coalition to form another coalition, because of Rule 2. The subordinates of the winning coalition have already formed coalitions with their nearest neighboring coalitions. And, any other free coalitions (parties, or coalitions that are not members of another coalition) will find that there are no other free coalitions to join with because they do not both agree that the other is nearest to them.

The first output of the model I examined was the number of parties. As I indicated above, parties in this model are coalitions that are not members of another coalition, like Coalitions 18 and 19 in the figures above. However, in this simulation as in American politics, not all parties are viable contenders. Many political systems have a number of parties that make the ballot, but are unable to elect a representative or seriously affect policy (Cox 1997). To calculate the number of viable parties, I use the reciprocal of the Hirschman-Herfindahl index: number of viable parties $=1/\sum_{i=1}^{n} v_i^2$, as suggested by Laakso and Taagepera (1979), where v_i is the share of the votes for independent coalition i. For each simulation run in this paper, I calculate the number of parties and the number of viable parties.

Model 1-a: One Issue Dimension

Rule 1: If possible, form a coalition with your closest neighbor and set your ideal point at the policy space centroid of the voters in the coalition.

Rule 2. Stop forming coalitions when your coalition has a *majority*.

In the simulation where the stopping rule is a majority, 71.3% of the eleven voter runs ended with two parties, 25.4% of the runs ended with three parties, 3.1% ended with four parties, and 0.2% ended with five parties. Since many of the runs ended with individual voters who had not joined a coalition because they were so far from the others, we would expect the viable parties' calculation to be different. These individual voters are treated as a "party" unto themselves. Using the Laakso measure, we had one viable party 6.6% of the time, two parties 90.2% of the time, and 3.2% of the runs had three viable parties.[4] Of the one hundred runs of Model 1-a where there were 101 voters, two parties emerged 96% of the time (counting either using the total parties or the viable parties measure).

Model 1-b: One Issue Dimension

Rule 1: If possible, form a coalition with your closest neighbor and set your ideal point at the policy space centroid of the voters in the coalition.

Rule 2. Stop forming coalitions when your coalition has a *plurality*.

When the stopping rule for coalitions is a plurality, the results differ, but there is still a strong tendency towards two parties. Counting all independent agents in the eleven-voter model there were two parties 44.2%, three parties 23.3%, four parties 20.4%, five parties 7.1%, six parties 3.4%, and seven parties 1.5% of the time. Using the viable parties measure, I found one party in 0.9%, two parties in 50.9% of the runs, three parties in 29.5%, four parties in 12.7%, five parties in 4.6%, and 1.4% of runs had five parties. The results when using 101 voters in the model were similar, with 57% of the runs yielding two viable parties, 25% yielding three, 11% yielding four, and 4% yielding five viable parties.

The prediction of Duverger's Law is not as convincingly supported under the plurality stopping rule, but still satisfied in around half of the cases. The coalitions in the simulation, unlike real coalitions, are not looking ahead to see the consequences of their actions. Not only is programming such artificial intelligence challenging, it reduces the elegance that comes from the simple assumptions presented in this simulation. Thus, coalitions in Model 1-b will stop

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[4] While the Laakso calculation of viable parties returns a decimal value, I am rounding to the nearest integer for the purposes of this paper.

merging if they have a plurality during that step of the simulation, which may cost them a plurality at the end of the simulation. Despite this lack of foresight, the simple iterative process of coalition formation illustrates the structural tendency toward two parties even without foresight or strategy.

One long-standing question about Duverger's Law is whether it is deterministic or probabilistic. Riker (1986) argues that this was left ambiguous because Duverger himself was uncertain. Models 1-a and 1-b suggest that in a one dimensional issue space with actors who only seek after policy, Duverger's Law is probabilistic.

Model 2: Office-Seeking Coalitions

Rule 1: If possible, form a coalition with your closest neighbor and set your ideal point at the policy space centroid of the voters in the coalition.

Rule 2. Stop forming coalitions when your coalition has *enough* votes.

Rule 3. If your coalition is not the winning party, move your policy point closer to the closest actor who is not a member of your coalition.

Rule 4. Defect and join the closest coalition if the coalition you currently belong to is no longer closest to you. If your coalition has *enough* votes, then simply defect.

Initially, Model 2-a runs like Model 1-a illustrated above. Coalitions form iteratively until one has a majority. However, in Model 2 once Coalition 18 has a majority, all of the other coalitions (including Coalition 18's subordinates) begin competing for additional voters in an attempt to gain the majority. To continue the previous narrative we can imagine that Coalition 19 realizes it risks losing the vote. Unlike the Coalition 19 in Model 1-a, this coalition is willing/able to move its policy point to attract new voters and win the election. In Figure 2a, Coalition 19 determines which actor is closest to its policy point (Voter 4) and moves the policy point half of the distance from its original position to Voter 4's ideal point.[5] Similarly, Coalition 13 also identifies Voter 4 as the closest actor that is not a subordinate or superior and moves half the distance from its original position to Voter 4's ideal point. And, Coalition 12 moves towards Voter 0.

Figure 2b shows the result of a series of moves by Coalition 19 towards Voter 4. Voter 4 thus defects to Coalition 19 as a result of Rule 4 since it is the closest coalition. At the same time, Coalition 18 and 19's subordinate coalitions have been moving their policy points in attempts to add members. Coalition 14 is now approaching Voter 4 as well.

In Figure 2c, we see that the partially obscured Voter 1 has defected to Coalition 19. Coalition 19 now is the winning coalition and Coalition 18 has begun to move its policy point to try and regain its winning status. In Figure 2d, Coalition 18 is converging upon Voter 1 to regain its support and its subordinates are following as they also attempt to gain additional voters. By time period 24 in Figure 2e, all of the Coalitions have converged upon the ideal point of Voter 1, the median voter.

The assumption behind Rule 3 is that coalitions who are not winning will try and entice members from the winning coalition. Similarly, Riker describes the second feature of his theory of strategy as follows: "For the proto-coalitions lacking an advantageous position when others have it, the main task is to minimize or eliminate the advantage of others (Riker 1962, 47)." The resulting process of offer and counter-offer is also akin to the assumptions of the "bargaining

[5] Each time a coalition moves, it traverses half of the distance between its current position and the closest non-member. In a series of moves similar to Zeno's paradox, a coalition starting at position 1 and moving toward a voter at position 0 will first move to 0.5, then to 0.75, and then to 0.875, etc.

set" described by Auman and Maschler (1964). If actors are rational and value outcomes, then we would expect them to act strategically to achieve those outcomes. By moving their policy points closer to non-members, coalitions entice defection.

Riker's (1962, 47) initial setup, like Model 1, precludes resigning a coalition that one has joined. And, as I have done in Model 2 with Rule 4, Riker discards this assumption so that he can develop a dynamic theory of coalitions. As a Downsian *homo politicus*, an actor in this model ranks the alternatives presented by the various coalitions and chooses the coalition with the closest policy point. If the actors in Model 1 can be described as policy-seeking, we could describe the actors in Model 2 as behaving like office-seeking politicians. Rather than simply forming a coalition and sticking with it whatever the outcome, the actors in Model 2 will move their policy points in an attempt to become the winning coalition.

Riker (1962, 47) also argues for the second part of Rule 4, that a sub-coalition with sufficient votes should shed the excess voters that come with coalition membership. By defecting when a sub-coalition would independently have sufficient votes to win, it can determine the policy point most advantageous to its own members without considering the other members in the larger coalition. Similarly, a real sub-coalition with sufficient power may desire independence if its superior coalition is failing to bring benefits to the members of the sub-coalition. Model 2-a implements this concept by allowing sub-coalitions to become independent parties when they have a majority. However, since plurality is a relative rather than absolute concept, it is much more difficult for sub-coalitions to estimate when their defection would be sufficient to enable them to successfully defect.[6] As such, actors in Model 2-b will only defect to the closest coalitions; the sub-coalitions will not become independent.

Model 2-a: One Issue Dimension

Rule 1: If possible, form a coalition with your closest neighbor and set your ideal point at the policy space centroid of the voters in the coalition.

Rule 2. Stop forming coalitions when your coalition has a *majority*.

Rule 3. If your coalition is not the winning party, move your policy point closer to the closest actor who is not a member of your coalition.

Rule 4. Defect and join the closest coalition if the coalition you currently belong to is no longer closest to you. If your coalition has a *majority*, then simply defect.

Model 2-b: One Issue Dimension

Rule 1: If possible, form a coalition with your closest neighbor and set your ideal point at the policy space centroid of the voters in the coalition.

Rule 2. Stop forming coalitions when your coalition has a *plurality*.

Rule 3. If your coalition is not the winning party, move your policy point closer to the closest actor who is not a member of your coalition.

Rule 4. Defect and join the closest coalition if the coalition you currently belong to is no longer closest to you.

With the ability to strategically move issue positions and defect, the support for Duverger's Law becomes even stronger. After 1,000 runs of Model 2-a with eleven voters, we have two parties 93.5% of the time and three parties 6.4% of the time, just by counting independent agents. With the Laakso calculation for viable parties, we have one viable party 11.2%, two viable parties 88.7%, and three viable parties 0.1% of the time. The third parties are typically voters who are so far on the extreme of the issue dimension that they never join a coalition. Running Model 2-a with 101 voters leads to two parties 100% of the time using either the total count or the viable parties count.

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[6] Solutions to this problem of building expectations are described in the discussion section below.

For Model 2-b, the tendency toward two parties is strong, but not as strong as with a majority stopping rule. Counting independent coalitions and starting with eleven voters, we have one party 43.4% of the time, two parties 53.5% of the time, three parties 0.9%, and 2.1% where there were four independent coalitions. By the viable parties measure, we have one party in 49.5% of the cases, two parties in 48.4% of the cases, and 2.1% of the runs resulting in three parties. When using 101 voters, we have 51% of the runs leading to a single party and 49% leading to two parties (counting either total and viable parties).

In this setup, I also tabulated two additional dependent variables. First, I noted the number of times that the parties converged to one issue position. Second, I noted the frequency of convergence upon the median voter. My expectation was that the two top-level coalitions (parties) would converge on the median voter.

With Model 2-a and eleven voters, the parties converged on the issue position of the median voter in 87.1% of the runs. The remaining portion had one or two viable parties and one or two extreme individual voters. In such cases, the viable party or parties converged on the median of their membership, ignoring the extreme individual voters. Running the model with 101 voters led to a convergence on the median voter 99% of the time.

In Model 2-b with eleven voters, when there were two or more parties, the two main parties converged on a single position that was the median voter 86.9% of the time. In the cases where all of the voters ended up in one party, competition during coalition formation still lead the party to be near of the position of the median voter 79.0% of the time. When the simulation used 101 voters, a two party system converged on the median voter 95.9% of the time and 78.4% of the single party systems had the parties ideal point at the median voter.

This result fits with the expectations of the Median Voter Theorem as proven by Duncan Black. The two assumptions for that proof are 1) a single issue and 2) voters with single peaked preferences (Hinich and Munger 1997). This simulation meets both assumptions. However, the simulation is different in that voters have bounded rationality. In the Median Voter Theorem, the voter is contemplating all of the alternative proposals. For this model, a voter is only aware of the closest coalitions.

The convergence on the median despite the bounded rationality of the actors in this simulation is an example of an "emergent property." An emergent phenomena "(i) can be described in terms of aggregate-level constructs, without reference to the attributes of specific [micro-level agents]; (ii) persists for time periods much greater than the time scale appropriate for describing the underlying micro-interactions; and (iii) defies explanation by reduction to the superposition of 'built-in' microproperties of the [system]" (Lane 1992, 3). Here the aggregate-level construct is a convergence upon the median voter that persists longer than the micro-level decisions of the voters and coalitions to defect and to move. The convergence at the median in this model comes about by the interactions of the micro-level decisions (see Schelling 1978).

While Holland (1998, 5) correctly rejects "surprise" as a critical element of emergence, he does note that surprise often guides us to emergent phenomena. I did expect that the parties would converge on the median voter as a result of their competition. The unexpected consequence of the simulation was that <u>all</u> coalitions converge on the same point. A top-level coalition without a majority moves toward the closest agent that is not a member. The winning coalition does not move until it has lost its majority, then it reacts by moving towards the closest non-member.

Each of the sub-coalitions is also employing the same strategy. As the simulation continues, all the coalitions converge on the median voter as can be seen in Figure 9. The result is an emergent property of this model and an interesting function of the interaction of the individual decisions (Cederman 1997, 51; Holland 1998). Also, note that since the two parties are asymptotically converging on the same position, the winning party is arbitrary and both parties will cycle as winner.

Model 3: Strategic Coalitions

Rule 1: If possible, form a coalition with your closest neighbor and set your ideal point at the policy space centroid of the voters in the coalition.

Rule 2. Stop forming coalitions when your coalition has a enough votes.

Rule 3. If your coalition is not the winning party, move your policy point closer to the closest actor who is not a member of your coalition.

Rule 4. Defect and join the closest coalition if the coalition you currently belong to is no longer closest to you. If your coalition has enough votes, then simply defect.

Rule 5. If you are a coalition and have lost or gained a member, recenter the policy point in your current membership.

Model 3 adds one rule to Model 2. While losing coalitions in Model 2 will move anywhere to gain an additional voter and coalitions in Model 1 will not move from the centroid of their membership, coalitions in Model 3 employ a simple strategy and retrench their positions when their membership has changed. In Figures 3a-3c, we see the same initial setup from the illustrations of Model 1 and 2 above running with Rule 5. At Time 22, Coalition 19 has moved to gain Voter 4. In Figure 3b, Coalition 19 obeys Rule 5 and recenters itself in its new constituency.[7] At Time 24, having lost Voter 4, Coalition 19 again moves the policy point to gain Voter 4 back.

[7] When a coalition recenters itself it does so with an average of its constituent members' (coalitions and voters) current policy points weighted by the votes they represent.

Rule 5 implements a simple strategy on the part of the coalition. If it is losing members, it retreats back to the center of its constituency. If it is gaining members, it consolidates the gain by returning to the center of its constituency. The strategy reduces the probability that the coalition will get so far from its members that they all defect to a competitor.

In real world politics, candidates frequently adjust their policy to entice new members or consolidate the constituency. For instance, many analysts noted Republican Presidential Candidate George W. Bush's changes in rhetoric as he attempted to gain moderate voters with his "compassionate conservatism" or stave off defections by conservative Republicans. A politician obeying the rules of Model 1 would have to hope that public opinion supported her policies since they are unchanging. A politician obeying the rules of Model 2 would risk defections by extreme members of the coalition as she moved toward the median voter. The first model reflected policy-seeking coalitions and the second reflected office-seeking coalitions. In Model 3, the coalitions reflect a mixture of strategies that is probably closer to the real world.

Model 3-a: One Issue Dimension

Rule 1: If possible, <u>form a coalition</u> with your closest neighbor and set your ideal point at the policy space centroid of the voters in the coalition.

Rule 2. <u>Stop forming coalitions</u> when your coalition has a *majority*.

Rule 3. If your coalition is not the winning party, <u>move your policy point</u> closer to the closest actor who is not a member of your coalition.

Rule 4. <u>Defect</u> and join the closest coalition if the coalition you currently belong to is no longer closest to you. If your coalition has a *majority*, then simply defect.

Rule 5. If you are a coalition and have lost or gained a member, <u>recenter</u> the policy point in your current membership.

Model 3-b: One Issue Dimension

Rule 1: If possible, <u>form a coalition</u> with your closest neighbor and set your ideal point at the policy space centroid of the voters in the coalition.

Rule 2. <u>Stop forming coalitions</u> when your coalition has a *plurality*.

Rule 3. If your coalition is not the winning party, <u>move your policy point</u> closer to the closest actor who is not a member of your coalition.

Rule 4. <u>Defect</u> and join the closest coalition if the coalition you currently belong to is no longer closest to you.

Rule 5. If you are a coalition and have lost or gained a member, recenter the policy point in your current membership.

After one thousand runs with eleven voters, Model 3-a had 94.2% with two parties, 5.6% with three parties, and 0.2% with four parties. Using the viable parties measure, Model 3-a had one viable party 11.4% of the time, two viable parties 88.4%, and three viable parties 0.2%. The same model using 101 voters led to two parties 99% of the time (98% viable). Model 3-b, with the plurality rule, resulted in one party 31.0% of the time, with two 64.4%, with three 2.6%, and four 1.8%. With the viable parties measure, Model 3-b had one party in 37.8% of the runs, two parties in 59.9%, and three parties in 2.2%. The 101 voter version of Model 3-b led to a two party system (by both total and viable party measures) 97% of the time.

In both versions of Model 3, the competition for voters combined with the recentering strategy resulted in more dynamic systems. Rather than the static results of Model 1 and the asymptotic convergence of all coalitions on the median voter in Model 2, Model 3 represents a dynamic model of competition between coalitions and among sub-coalitions. Thus, it escapes the flatness of models by Riker and others that represent only inter-coalition competition and not intra-coalition dynamics. Instead, Model 3 shows patterns of long stability in the dominant parties that can shift quickly in a manner that appears similar to the self-organized criticality described by Per Bak (1996) or reminiscent of the collapse of states in the work of Lars Erik Cederman (1997).

I also noted the frequency of median voter and convergence results with Model 3-a. While in Model 2 the parties converged their policy points on the median, some of the runs in Model 3-a had the coalitions competing for some other voter. In 64.3% of the runs with eleven voters, the coalitions were competing over the median voter. The model with 101 voters was more complex as coalition would often emerge that represented a central group of voters and the two main parties would compete for this central coalition. As the central coalition shifted allegiance, ten or so voters would typically defect along with it.

These differences between the smaller and larger versions of the model led to differing positions of the policy platform relative to the median voter. With only 11 voters, the inter-party competition leads the parties to have ideal points near the median voter of the electorate (30.0% within 5 units, 56.6% within 10 units). However, with 101 voters, a mix of inter-party and intra-party competition drives parties closer to the median voter of the party. The addition of new coalitions and voters causes the party to return to the center of its membership more frequently (Rule 5). Because the median voter of the electorate was often contained within a larger coalition that defected to the new winning party, the center of winning party would then be between the median voter of the electorate and the median of the original party. However, since subcoalitions with sufficient voters can defect to form their own parties, a party that ventures too far from its base will be overtaken by one of its subordinate coalitions.

The results for Model 3-b were similar with 48.6% of the runs with eleven voters competing over the median voter and approximately sixty percent of the runs of 101 voters competing for a coalition of ten or fewer voters. And, similar to Model 3-a we find that the model with only eleven voters tends to be have the winning parties policy points located closer to the median voter of the electorate, while the model with 101 voters tends to result in models with policy point closer to the median of the winning party.

We can see the persistence of the two-party and median voter results even with varied assumptions. In the first, second, and third sets of simulations, two parties usually emerged as a result of the rule that the coalitions would continue to form new coalitions until they had sufficient votes. The two-party result was even more likely in the second and third sets when the coalitions were allowed to compete and move their issue positions based upon strategic concerns.

The importance of the median in politics is also supported in the second and third simulations. When the coalitions compete with each other for voters, they must move towards the middle of the electorate. Again, it is interesting to see that we can achieve a median voter result without the information assumptions of the median voter theorem. Voters and coalitions making simple alliance decisions based upon proximity can also force policy toward the median even when they are not aware of all of the possible platforms.

Model 4: Strategic Coalitions in a Changing Issue Space

Model 4-a: Two Dimensions – Varying the Salience of the Second Issue Dimension

Rule 1: If possible, form a coalition with your closest neighbor and set your ideal point at the policy space centroid of the voters in the coalition.
Rule 2. Stop forming coalitions when your coalition has a *majority*.
Rule 3. If your coalition is not the winning party, move your policy point closer to the closest actor who is not a member of your coalition.
Rule 4. Defect and join the closest coalition if the coalition you currently belong to is no longer closest to you. If your coalition has a *majority*, then simply defect.
Rule 5. If you are a coalition and have lost or gained a member, recenter the policy point in your current membership.

In Models 1-3, the distance in the one-dimensional issue space X from Coalition A to B could be evaluated as the absolute value of differences in their policy points: $|x_A - x_B|$. To measure the distance between A and B in a multidimensional issue space, we can use the vector form $SED(\mathbf{a},\mathbf{b}) = \sqrt{[\mathbf{a}-\mathbf{b}]'[\mathbf{a}-\mathbf{b}]}$ where **a** and **b** are vectors of A and B's positions on the issues and SED is the simple Euclidean distance. In Model 4, I represent the addition of a new issue to the political arena by using the weighted Euclidean distance formula

$WED(\mathbf{a},\mathbf{b}) = \sqrt{[\mathbf{a}-\mathbf{b}]' \mathbf{W}_i [\mathbf{a}-\mathbf{b}]}$ and changing the weight of the second dimension from zero to a new value. I run the simulations with matrix $W = \begin{bmatrix} 1 & 0 \\ 0 & 0 \end{bmatrix}$ for 25 steps and then change to $W = \begin{bmatrix} 1 & 0 \\ 0 & w \end{bmatrix}$, where w is a constant representing the new weight for the second issue dimension.

James Sundquist's (1983) argument in Dynamics of the Party System is that newly salient issues may cause the parties to realign. Having constructed and tested a framework for coalition formation, I wanted to test Sundquist's argument and study how salient a new issue would need to be to cause realignment in this simulation framework. Sundquist's method was to analyze a number of historical cases in the United States and whether new issues caused realignment. Here, I will simulate the introduction of new issues and classify the resulting political alignments.

For the simulations in this study, I started with 101 voters. At the beginning of each run, the voters were given issue positions on two issues. The first issue had a salience of one and the second issue initially had a salience of zero. Thus, agents would build their coalitions based only upon positions on the first issue dimension. When plotted on a two-dimensional space, the coalition formation looks strange compared to the previous simulations. In Figure 4a, long lines connect actors who are close on the x-axis and distant on the initially irrelevant y-axis.

To test the realignment hypothesis, I let the coalitions form based upon the single issue and then let them compete until the run had gone through fifty iterations. This was sufficient time for two major parties to emerge and compete meaningfully. At Time=50, I noted the agent ID numbers of the two top-level coalitions (the parties). At Time=51, I increased the second issue's salience for all agents from zero to a new value. The second issue could be half as salient, equally salient, 1.5 times as salient, or twice as salient as the existing first issue. I then let the simulation run for 50 more iterations. At time=100, I noted the agent ID numbers of the top-level coalitions and their division of the issue space. Figure 4b illustrates the same model in Figure 4a, but after the issue dimension on the y-axis has been weighted equally to the issue dimension on the x-axis. Model 4-a has the same rule set as 3-a, but runs in two dimensions and with 101 voters. I ran the model one hundred times for each of the four values of the new issue salience.

The first of Sundquist's scenarios is that the new issue will cause no major realignment. To quantify realignment, I defined the line of cleavage as a line running perpendicular to the line that connects the centroids of the membership of the two main parties. Initially, with only one salient issue, the line of cleavage is always perpendicular to the x-axis (Note the dotted line in Figure 4a). I coded a major realignment as a move of the line of cleavage 45 degrees in either direction (See Figure 4b.) If the new issue did not cause the line of cleavage to change at least 45 degrees, I considered it to not be a major realignment for this study. Thus, I was able to approximate Sundquist's first and second scenarios with a coding scheme and the model.

Sundquist's third scenario is realignment through the absorption of a third party. Although an important scenario in American politics, the computer model is unable to capture this type of realignment. In Model 4-a, the assumption is that agents defect to another coalition when the other coalition is closer than the current superior. The coalitions only become independent when they have a majority. As a result, the emergence of a new third party becomes unlikely since a potential third party needs to be able to garner a majority before it breaks away.[8]

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[8] However, third parties occasionally did emerge in the simulation despite this severe restriction. Typically, the new third parties either became one of the two major parties or were dismantled

Because of the difficulties with anticipating a plurality discussed above, I was unable to test the realignment scenarios with the plurality rule.

Sundquist's fourth and fifth scenarios involve realignment through the replacement of one or two of the existing parties. In this simulation, I coded a change of a top-level coalition as the change of an existing party. Such a change occurred when a member coalition was able to command a majority and could defect from its top-level coalition. Frequently, change at the top happened when the top-level coalition had moved toward the center of the electorate and all of its member sub-coalitions defected to one of the member sub-coalitions.

In the simulation, a change in party was not always accompanied by a major realignment. As a result, I coded the number of parties that were different at time 100 than time 50 (either 0, 1, or 2) and whether there had been a major realignment. This meant that each run of the simulation would fall into one of six categories:

Sundquist Revisited

1. No major realignment -- Sundquist's first scenario.
2. No major realignment, replacement of one party.
3. No major realignment, replacement of two parties.
4. Major realignment of the existing parties -- Sundquist's second scenario.
5. Major realignment, replacement of one party -- Sundquist's fourth scenario.
6. Major realignment, replacement of two parties -- Sundquist's fifth scenario.

This categorization roughly matches Sundquist's theory and does a fair job of describing the patterns that emerge in the simulations. To study realignment as a function of the change in issue salience, I ran four sets of simulations with one hundred runs each. For each simulation, I

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after only a few steps. While I could have coded such events under Sundquist's third scenario, the requirement that the defecting party have a majority is so different from his model that I decided it would not be sensible to twist Sundquist's conception this way.

noted the alignment and agent ID numbers of the parties at Time=50 and again at Time=100. The new issue salience from Time=50 on was 0.5, 1.0, 1.5, and 2.0 for the respective four sets of simulations. Thus, the first set of runs had a new issue that was half as important as the existing issue and the fourth set of runs had a new issue twice as important.

As Table 1 shows, the introduction of a new issue that is only half as important as the existing issue leads to a major realignment in 10.5% of the runs. It also tends to leave the existing parties in power. The introduction of a new and equally important issue, however, causes realignment in 26.6%. A new equally important issue also caused one of the existing parties to be replaced in 59.6% of the runs. As we might expect, a new issue that is 1.5 or 2.0 times more important than the existing cleavage leads to a major realignment in most cases. Such dramatic shifts also undo the existing parties. When the new issue is twice as important as the existing issue, only a third of the cases result in the both parties maintaining their rule.

I also gathered data on the size of the winning coalitions from Model 4-a and the prior models to compare with Riker's prediction of a minimum winning coalition. With one hundred and one voters, the minimum winning coalition would be fifty-one. As Figure 5 shows, the minimum winning coalition prediction was supported in 10% of the runs. The tendency toward a minimum winning coalition is another interesting emergent feature of the models, with an intensity that varies depending on the particular model. Model 1-a and 1-b lead to minimum winning coalitions 10% of the time when there are 101 voters. But, Model 1-a has 51% and Model 1-b has 35.3% minimum winning coalitions if there are only 11 voters. Model 2-a ends up with minimum winning coalitions 100% of the time and Model 2-b 48% of the time with 101 voters, and 88.8% or 48.3% if there are only 11 voters. Like Model 1, Model 3-a and 3-b have low portions of minimum winning coalitions (12% and 13%) with 101 voters, but the portions are larger when there are only 11 voters (64.3% and 48.6%). While the portion of simulations that lead to exactly the minimum winning coalition varies, the competition with the other party drives the winning coalitions close to the minimum size possible in the vast majority of the simulations.

Discussion

As the previous sections demonstrate, the interaction of coalitions through basic rules is able to capture the essential results of the classical models of party dynamics. Although extremely simplified, this paper shows that two parties can emerge from basic rules about winning and competition. The paper also shows that the median voter result can be obtained in the context of bounded rationality through the micro-motives of individual voters and coalitions.

Whereas the traditional models of Downs, Black, Duverger, and Riker described above assume their political actors, this model has allowed the actors to emerge as a consequence of the limited knowledge and scope of actions available to voters. Lars-Erik Cederman's (1997) model of Emergent Actors in World Politics was motivated in part by the failure of models that treated nation-states as indivisible units and failed to explain their dissolution. Similarly, conventional models that treat domestic political actors as unified agents fail to give us insight into the internal and local politics that drive larger organizations.

Riker describes the process of making a decision in a group as a "process of forming a subgroup which, by the rules accepted by all members, can decide for the whole (Riker 1962, 12)." This claim is a good general description of politics and the problems we face as political scientists. But, if we ignore the problems that exist in forming subgroups, we can miss much of what makes politics, politics.

Previous attempts at agent-based modeling of parties have suffered this same problem. Many models have just assumed the political entrepreneurs and had them compete in a landscape of voter preferences (Kollman et al. 1992; Johnson 1998a; Johnson 1998b; Lomborg 1997). Another group of models employs the Tiebout (1956) mechanism which allows individuals to choose their group membership based upon the public goods provided by that group (Adams 1999; McGann 1999; Kollman et al. 1997). Both the voter landscape and Tiebout classes of models have ignored the intra-coalition dynamics that are the core of the framework in this paper.

The dynamics of intra-coalitional politics have been posited as a driving force behind the evolution of cognition in humans and other highly social animals (Schreiber 2007). Chimpanzees (de Waal 1998), hyenas (Engh et al. 2005), and dolphins (Connor et al. 2010) all demonstrate evidence of intra-coalitional dynamics. This complexity is believed to force a cognitive arms race in which mental capacities must evolve to deal with the dynamic social conditions (Orbell et al. 2004).

One common feature between my framework and other agent-based models is the assumption of bounded rationality. Game theoretic models typically assume complete information. The agent-based approach demonstrated in this paper is able to achieve similar results with less strenuous assumptions. While we may arrive at similar results with both types of models, assuming that all the agents share the same information (e.g. about the range of political platform choices) presents us with a less developed picture than models in which that information is generated within the system.

For instance, Riker's proof of the size principle has been criticized as being only true in the "rarified class of super-symmetric games and their asymmetric counterparts" (Hardin 1976, 1210). Part of Hardin's argument is that Riker constructs his model such that all winning coalitions have an incentive to contract down to their minimal winning size. In my framework, the competitor coalitions only know that they are not winning and that they can gain advantage by moving their platforms towards the closest non-members. The tendency toward the minimal winning coalition thus emerges from the competition with other agents.

While the bounded rationality and simple decision rules and actions available to the actors in this model are able to show patterns that we would expect from a political body, an easy critique of the model is that the assumptions are too simplified. However, a body of work by scholars such as Gerd Gigerenzer (2007) suggests that heuristics are often the only way to deal with highly dynamic and complex choice environments. Gigerenzer demonstrates that such simple rules will often outperform models that are more rational or that have greater levels of information available. Economists like Colin Camerer (Camerer et al. 2004) contends that cognitively simple models fit the empirical data far better than models of full information and rational choice. And, in previous tournaments where agent-based models competed for electoral victories, the winning algorithm used a satisficing, rather than maximizing approach (Fowler and Laver 2008). One of the longer term goals of this project is to present a framework in which a variety of models of political cognition can be evaluated in the context of competing nested subcoalitions.

As is, the agents only exist in a one and then a two-dimensional issue space. However, the framework has been built so that adding additional dimensions involves only inputting a bigger number into the parameter for issue dimensions. As many authors have noted, the dimensionality of the issue space in real electorates is probably enormously large (Hinich and Munger 1997; cf. Poole and Rosenthal 2000).

One criticism of the game-theoretic spatial models that this framework might answer is the homogeneity of actors. While this paper has focused on actors that are formed through political processes, it has made uniform assumptions about their preference structures and rules of interaction. The a and b versions of each model allowed agents to pursue either a majority or plurality. Since the stopping rule is a parameter, we could randomly assign the coalitions different thresholds at which they would be content with their vote share. As the coalitions competed we could study whether a particular threshold was more or less likely to lead to victory. It would also be good to evaluate whether the findings in this paper are robust across other changes in the stopping rule.

In this paper, all of the agents in a simulation have followed the same rule set. What would happen if coalitions formed with Rules 1 and 2, competed with coalitions who also obeyed Rules 1- 4 and coalitions who obeyed Rule 1-5 (see Laver 2005 for a similar approach)? My expectation was that office-seeking coalitions would eliminate the policy-seeking coalitions (Mayhew 1974). Preliminary investigation has shown far more complex results with the policy-seeking coalitions dominating the periphery of the electorate and office-seeking coalitions dominating the core.

This model also has the potential to be extended with diverse values on issue salience and issue separability. Currently, all of the agents have the exact same weights on the issues and see none of the issues as related. The use of a weighted-Euclidean distance matrix in the program means that future explorations about the impact of salience and separability will be possible. One particular problem I am interested in modeling is to allow the coalitions to send messages to voters persuading them (probabilistically) to change their issue positions and their issue weight matrix (see Zaller 1992). This would simulate campaign effects and might provide some marriage between the public opinion and spatial voting models.

Another interesting extension to the model would be use of more sophisticated decision-making. Currently, the actors deterministically implement the rules; making choices about coalition formation, defection, and policy change based only on simple rules. Proper utility functions and adaptive strategies would allow me to put the agents into a variety of electoral systems to test the robustness of this framework. Could the basic grammar of coalition formation, defection, and policy change described in this paper when combined with adaptive agents be sufficient to model actor behavior in first-past-the-post, multi-member district, and proportional electoral systems? Could such a model accurately approximate politics with multiple levels of interaction like the formation of parties within European nations and their coordination in the European Parliament?

Testing such models will involve exploring empirical data. Empirical data could be input into the model instead of simply using random numbers for the issue positions. For instance, the data used as the basis of the cluster analysis studies described above could be input into this model. Or voter ideal point estimates drawn from campaign contributions (Bonica 2010) could be fed in. I would then make a comparison between changes in issue positions over time in the model and with empirical data.[9] As Hayek notes, testing complex models and their pattern predictions with empirical data is both possible and valuable. We can study the general conditions assumed in the model and verify the patterns the model predicts (Hayek 1967, 63).

[9] On this front, it is interesting to note the similarities in dynamics between the Poole-Rosenthal nominate scores over time and the dynamics of the computational model in this paper.

Given the useful insights that relatively static techniques like game theory and cluster analysis have provided into coalitions, we should expect that further exploration of the problem with emergent actor models will at a minimum build on our previous answers. The hope, however, is that this type of modeling will prompt the kind of questions that were not even apparent with the existing models.

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