

# PARTY COMPETITION

## AN AGENT-BASED MODEL

Michael Laver and Ernest Sergenti

New York University

Chapters of a draft manuscript for a book under contract to the  
*Princeton Studies in Complexity* series of Princeton University Press

Any and all comments are profoundly welcome

This is a work in progress: *please* do not cite without the authors' permission

Versions of this work have been presented at seminars at: Trinity College, Dublin; European University Institute, Fiesole; London School of Economics; University of Bologna; New York University; Columbia University; University of Michigan; Emory University; MIT; Yale University; Duke University; Florida State University; and at the following conferences: 19th International Joint Conference on Artificial Intelligence, Edinburgh 30 July - 5 August 2005; Conference on the Dynamics of Party Position Taking, Binghamton (March 23-24, 2007); Annual Meeting of the American Political Science Association, Chicago (August 30–September 2, 2007); Arrábida Workshop on Complexity and Political Simulation (July 8-9 2008).

Thanks are due for helpful comments from discussants and participants at all of these venues.

## CONTENTS

- Introduction (c5000 words)
1. Spatial dynamics of political competition (c4000 words).
  2. A baseline ABM of multidimensional, multiparty competition (c9000 words)
  3. Methods for interrogating agent based models (c10000words)
  4. Benchmarking the baseline model (c7750 words)
  5. Endogenous parties; interaction of diverse decision rules (c11000 words)
  6. Features of party decision rules (c11250 words)
  7. Evolutionary dynamics of decision rule selection (c8500 words)
  8. Non-policy factors in party competition (c8500 words)
  9. Party leaders with policy preferences (To be c8500 words)
  10. Calibrating and testing dynamic models of party competition (11000 words)
- Conclusion (5000 words)
- References (c 1500 words)

Electronic Appendix: Description of computer programs. One program for each modeling chapter (Ch 2-8), distributed for use and modification by readers, with discussion outline of how to use, expand and interrogate these models and develop new ones

# Introduction

A large part of politics in democratic societies is about the politics of representation. This has to do with how the needs and desires of ordinary citizens play a part in national decision-making, via the public representatives they choose in free and fair elections. A large part of representative politics is about party competition. This has to do with how a small number of organized political parties offer a distinctive and somewhat coherent set of options to voters, who then choose between alternative teams of public representatives. This is why understanding party competition is a core concern of people, be they professional political scientists or interested civilians, who care about politics in democratic societies.

This book is about party competition. More specifically, it is about *multi*-party competition, by which we mean competition for voters' support between more than two parties, opening up the possibility that no one party wins a majority of votes cast. Multiparty competition is much more common than is sometimes supposed. In the European Parliament elections of June 2009, for example, 25 different political parties competed for the support of voters in the United Kingdom – a country sometimes casually thought of as having a two or two-and-a-half party system. Eleven of these parties secured the election of at least one public representative.<sup>1</sup>

If we want to understand multiparty competition as a general political process rather than as a unique sequence of events in some particular country, then we need a theoretical model of this process. Such a model will be a simplified formal representation that captures what we consider to be the most important features of party competition and leaves out what we think is of little or no relevance. Our hope is that, by systematically manipulating moving parts of this model and carefully analyzing consequences of doing this, we gain useful intuitions about party competition in the real world. By “useful” in this context, we mean something that is a valid inference from the theoretical model, is non-obvious and is, at least *a priori*, plausible.

Theoretical models of party competition have become a major preoccupation of political scientists over the past few decades. We certainly did not decide to write this book because such models are in short supply. Almost all published models of party competition, however, tend to fall into either or both of two categories. They deal with two-party, not multiparty, competition; they are static, in the sense that they do not model politics as a continuously evolving dynamic process. We do not in the least belittle this work, much of which has been of high intellectual quality and some of which has added to our understanding of party competition. Our main *substantive* interests, however, and we believe the substantive interests of many others who want to understand party competition in democratic societies, concern aspects of party competition these models routinely leave out. We are interested in *multiparty* competition between parties in settings in which many different “dimensions” of policy are important to voters; and we do think

---

<sup>1</sup> In order of their relative success, these were: Conservative Party; UK Independence Party; Labour Party; Liberal Democrats; Green Party; British National Party; Scottish National Party, Plaid Cymru, Sinn Féin, Democratic Unionist Party; Ulster Unionist Party.

of politics as a continuously evolving dynamic process, rather than as something that settles at some static equilibrium to be perturbed only by random shocks. Pursuing these matters sets us some serious theoretical challenges. As we show in Chapter 1, dynamic models of multiparty competition are, in a formal sense, analytically intractable. They are not just “difficult” to solve, it can be shown formally that they cannot be solved using conventional analytical techniques.

Analytical intractability of the resulting models does not make us any less interested in trying to understand multiparty competition as an evolving dynamic process. Furthermore, we argue that this very intractability gives us an important insight about how to move forward. While intractability *for analysts* of dynamic multiparty competition is of purely academic interest, its intractability for real humans engaged in real party competition is of great substantive significance. If analysts can’t use tractable formal models to identify optimal courses of action in this setting, *neither can real people making real decisions about real party competition*. These people do still need to make decisions about what to do in this intractable setting, however. They may thus use informal rules-of-thumb when they make their choices, rather than best-response strategies that can formally be proved optimal. This in turn suggests we use the theoretical approach of *agent-based modeling* to study multiparty competition in an evolving dynamic system, rather than the formal analytical game theory that underpins a lot of previous work on party competition. In this book, therefore, we develop and analyze a portfolio of agent based models (ABMs) of various aspects of multiparty competition in modern democracies.

Agent based modeling involves analyzing interactions between decision-makers (agents) who use informal decision rules to choose actions, quite possibly selecting these rules from a diverse portfolio of possibilities. ABMs are “bottom up” models that, typically, assume settings with a fairly large number of autonomous decision making agents. Each agent uses some well-specified decision rule, and there may well be considerable diversity in the decision rules used by different agents. The modeling exercise is designed to investigate the outcomes that emerge when these agents interact with each other. ABMs involve computing the outcomes of these interactions if, as is typically the case, the underlying model is intractable; but they do not, of their essence, involve *electronic* computers. One of the most influential early ABMs, which analyzed housing segregation, was specified and implemented by Thomas Schelling in the 1970s by scattering coins and then moving them around on what amounts to a large chess board (Schelling 1978). Analyzing long-running interactions between large numbers of agents in complex settings is computationally very challenging, however, and ABMs only came into their own in the era of fast and cheap electronic computers, running powerful and easy-to-use software designed to facilitate agent-based modeling. We ourselves developed, tested and sketched outputs from the models we present in each chapter in this book using cheap personal computers running NetLogo, a freely-downloadable software package for agent based modeling that can be easily used by anyone familiar with simple programming. Agent based modeling is thus not only a powerful modeling tool, but is empowering and accessible for anyone interested in understanding complex social interactions. Recognizing this, all our models are programmed

in NetLogo and made freely available on our website, in the hope that interested readers will use and experiment with them, then go on to extend and improve them.

All good things come at a price. The price paid for using computational as opposed formal analytical models, and thus for using agent-based modeling, is that computation involves calculating model outputs for particular parameter settings. An analytical result, if it is general, is a beautiful thing that it is good for all valid parameter settings. Strictly speaking, computational results are only good for those parameter settings that have actually been investigated. Inferences about parameter settings than have not been investigated – and thus more general theoretical inferences we might want to draw from the model – are, in effect, interpolations. This is why we *never* use computational methods when analytical results are available for the substantive problem that interests us.

The distinction between analytical and computational methods should not be overdrawn, however. A longstanding set of observations that compare models of computation with systems of formal logic, collectively known as the “Curry-Howard isomorphism”, shows us that computer programs and formal proofs are in essence the same things (De Groot 1995). Both take a set of explicit premises and manipulate these, using some system of formal logic, to prove theorems based on these premises. Consider, for example, the area,  $A$ , of a circle radius  $r$ . It is well-known that we can prove analytically the proposition:  $A = \pi \cdot r^2$  for *any* positive real  $r$ . We can also prove  $A = \pi \cdot r^2$  for *any given* positive real  $r$  by various computational methods. With *infinite* computing power at our disposal, we could prove  $A = \pi \cdot r^2$  for *any* positive real  $r$ . This would not be an “elegant” proof according to certain standards of elegance, but now we are talking about aesthetics. With less-than-infinite computing power, we can sample a huge number of positive real values of  $r$ , compute  $A$ , and will show in every single case that  $A = \pi \cdot r^2$ . We can draw the *statistical* inference, at a specified level of confidence, that  $A = \pi \cdot r^2$  for any positive real  $r$ . If for some reason it happened that we could not prove analytically that  $A = \pi \cdot r^2$ , then this computational/statistical inference would be immensely valuable to us. If we wanted to increase our confidence in this inference, we could simply do more computing and sample more values of  $r$ . Of course, we can never be *perfectly* confident in this conclusion. We can show that  $A \neq \pi \cdot r^2$  when  $r = 2.0000001$  and  $2.0000002$ ; you could claim it is possible  $A \neq \pi \cdot r^2$  when  $r$  is set between these values, at  $2.00000005$ . Strictly speaking, this is true. We can however show statistically, with access to enough computing power, that the *probability* of this exception is extraordinarily small. Furthermore, we can drive down this probability to as low a level as makes you feel happy – simply by doing more computing.

This is an issue we take very seriously indeed in this book since we do want our computational results to have what amounts to the same scope and precision as those derived from analogous analytical work. We address this by specifying careful procedures for systematically varying parameter settings and rigorous methods for estimating model outputs of interest associated with these settings. If we carefully design and execute our computational work in this way, then the scope and precision of our results depends only the volume of computation we are willing and/or able to deploy. Since we wanted our own results to have the

same scope and precision as typical results from formal models in this field, we were both willing and able to deploy a huge amount of computing power, taking advantage of the Harvard-MIT high-performance cluster in order to do this. An important consequence of this is that we are confident that the computational results we present in this book can be “taken to the bank”, in the formal statistical sense that, if we were to do very much more computing, or if many other people were to repeat our procedures, essentially identical results would arise. Thus, while this is above all a book about the substantively fascinating topic of multiparty competition, it is also an exercise in how to use computational methods in general, and agent-based models in particular, in a way that allows us to draw confident general conclusions.

We just claimed that agent based modeling is an empowering intellectual technology. We hold firm to the belief that theoretical models are never ends in themselves, but intellectual tools designed to help us understand substantively important real world problems. We noted that the substantively important real world problem that interests us is the dynamics of multiparty competition. And we argued that the traditional formal modeling technology is not a good tool to help us understand this, since the resulting models are analytically intractable, with consequences for analysts and more importantly for real humans making decisions in these settings. This book is essentially about what agent based modeling empowers us to think about, if we want to think about the dynamics of multiparty competition. We start simple and build an increasingly complex model of party competition that deals with a range of substantive matters we have wanted to think about for a long time, but haven’t really been able to think about in a systematic way before, given problems of analytical intractability.

### **Plan of campaign**

Chapter 1 sets up the problem and elaborates the arguments we made above. We use results from a subfield of geometry, dealing with “Voronoi tessellations” (tilings), with powerful applications in many disciplines. Largely unnoticed by political scientists, this work addresses a problem of “competitive spatial location” that is directly analogous to the problem of dynamic competition between a set of political parties competing with each other by offering rival policy programs. Two formal analytical results from this field are of particular importance in this book. The first is that the problem of competitive spatial location is formally intractable in more than one dimension, implying that there are no formally provable best-response strategies for this. This is an important and widely recognized justification for deploying computational methods, and the study of Voronoi tessellations is a major subfield in *computational* geometry. The second result (which we discuss in Chapter 4) is very widely used in digital image processing, to take just one example. A set of  $n$  points arranged so as to generate a “centroidal Voronoi tessellation” (CVT) is an “optimal representation” of the space in which these points are located. By this we mean that the *aggregate* distance between all points in the space and their closest generating point can never be less than when the  $n$  generating points are arranged in a CVT. If we think that voters are more satisfied at election time, the closer is the policy position of their closest party to their own ideal policy, then this implies axiomatically that the electorate as a whole is most satisfied when

party policy positions are arranged in a CVT. Since we feel that the “representativeness” of any party system is an important substantive matter, this formal result gives us an important benchmark for the most representative possible set of  $n$  party policy positions.<sup>2</sup>

Chapter 2 specifies our “baseline” ABM of dynamic multiparty competition, which derives from a previous paper published by one of us (Laver 2005). This assumes voters, all of whom have policy preferences, support the political party that offers the policy package closest to the one they would most prefer. The dynamic system at the heart of our model is that voters support their “closest” party in this sense; that party leaders adapt the policy packages they offer in light of the revealed pattern of voter support; that voters reconsider which party they support in light of the revealed pattern of party policy packages; and that this process continues forever. This recursive model describes policy-based party competition as a complex system and our baseline model specifies three decision rules that party leaders may deploy when they choose party policy positions in such a setting. These rules are: Sticker (always keep the same position); Aggregator (move policy to the centroid of the ideal policy positions of your current supporters); Hunter (if your last policy move increased your support, make another move in the same direction; else change heading and move in a different direction). These rules model, in a simple way: an “ideologically intransigent” party leader who *never* changes party policy, no matter how unpopular this might be; a “democratic” party leader who always adapts the party position to the preferences of *current* supports; a “vote-seeking” party leader who is always looking for *new* supporters and does not care what policies must be chosen in order to do this. These decision rules were specified in Laver (2005); the innovation in this chapter concerns our assumptions about the preferences of voters. Rather than assuming a single coherent voting population with a perfectly symmetrical multivariate normal distribution of ideal policy positions, we now assume that electorates comprise a number of distinct subgroups. We further assume that, while voters tend to interact socially with members of their own subgroup, they do not tend to interact with members of other subgroups. There are reasons to believe that patterns of social interaction *within each subgroup* result in the evolution of ergodic normal distributions of voters’ ideal points, but combining subgroups into an aggregate voting population means that the distribution of ideal points in the aggregate voting population will tend not to be a perfectly symmetric. As we show in subsequent chapters, this more generic assumption about voter preferences can make a significant difference.

Chapter 3 develops our methods for designing, executing and analyzing suites of long-running computer simulations that generate stable and replicable results. The methods we use depend on the particular stochastic processes generated by our models. Thus a party system in which all party leaders are Stickers is axiomatically always in steady state. We know from a result in computational geometry that any  $n$ -party system in which all party leaders are

---

<sup>2</sup> The analogous problem in digital image processing is to find the most representative set of  $n$  points (party positions) to represent a much more detailed image comprising  $m$  points (voters). More generally, a CVT can be seen as a “best” simple representation of any spatially structured dataset.

Aggregators always evolves from any arbitrary policy configuration to one in which party positions are arbitrarily close to a deterministic steady state that is a centroidal Voronoi tessellation. And we know axiomatically that, if all party leaders are Hunters, then the party system will never be in steady state – though we also show that all party system outputs of interest nonetheless evolve over the long run to fluctuate around some stationary mean. Given an appropriate method for estimating party system outputs of interest, we can then specify “how much” computing we need to do to measure outputs at some specified level of precision. In systems with party leaders using the Hunter rule, for example, it transpires we need very much more computing than has been reported in most previously published work on similar topics.

Having specified and deployed our methods, we report our benchmark results in Chapter 4. Perhaps the most striking of these concern party system representativeness. As noted, we know axiomatically that party system representativeness is optimized when all party leaders use the Aggregator rule for setting party policy positions. We can now measure how much less representative are the typical evolved configurations of party policy positions that emerge when party leaders use the vote-seeking Hunter rule. It transpires that these are significantly less representative, identifying what we feel is an intriguing paradox of representation. Contrary to what we might take as a naïve received wisdom about the effects of party competition in representative democracies, the evolved configuration of party policy positions is *not* particularly representative when party leaders compete with each other to find the most popular party policy positions.

Thus far we have treated the set of competing political parties as gifts from Nature. We move beyond this in Chapter 5, defining a model of endogenous party “birth” and “death” (Laver et al. 2010; Laver and Schilperoord 2007) that has the implication that the set of surviving political parties is endogenous to the system of party competition. We now also model competition between party leaders using different decision rules, extending work on this using computer “tournaments” (Fowler and Laver 2008). All of this requires us to extend our model to define: a *de facto* survival threshold for political parties; an updating regime that specifies how voters feel about the party system today, given what happened today and how they felt about the system yesterday; a distinction between “campaign ticks” of the model, during which party leaders make choice that do not have long term consequences for their survival, and “election ticks” that do have a bearing of party survival. The resulting more realistic model of party competition with endogenous parties is *evolutionary*, describing a *survival-of-the-fittest* environment in which more successful parties survive and less successful parties do not. Since the model’s party survival threshold is specified in terms of vote share, and since the Hunter rule is quite effective at finding votes, it is not surprising that party leaders using Hunter rules tend to prosper in this environment, relative to party leaders using decision rules not designed to increase vote share. This does however add a twist to the paradox of representation identified in the previous chapter. Party leaders using the Aggregator rule, which we know enhances representation, may find it hard to survive in an evolutionary environment in which party survival depends on maintaining some threshold vote share.

Up to this stage in the argument, we have been extending, improving and generalizing previously published work based on three simple decision rules (Sticker, Aggregator, Hunter) for selecting party policy positions. We break completely new ground in Chapter 6, defining new “species” of vote seeking decision rule (Predator and Explorer), and specifying both these and existing rule species in terms of a set of parameterized rule “features”, including satisficing and speed of adaptation. Predator rules, specified in a flawed form in Laver (2005) and redefined by us here, in essence attack the closest more successful party by moving their policy position towards it. Explorer rules are generalizations of “hill climbing” algorithms. Explorers randomly poll positions in some local policy neighborhood during campaign ticks – moving on an election tick to the best position they found during the campaign. The net result of these extensions is that we now consider competition between party leaders who may choose from one of 111 different decision rules (strictly, parameterizations of rule-agent pairings). This dramatically expands the state space of our model and forces a major modification in the method we use to estimate characteristic model outputs. Substantively, now that three distinct vote-seeking rules are in contention, our results show that the Hunter rule species, formerly dominant, performs less well than the vote-seeking Predator and Explorer species. Which particular vote-seeking rule species is most effective at winning votes, however, depends critically on parameters of the competitive environment, in particular the party survival threshold. When this threshold is high and the number of surviving parties is consequently low, Predator rules are clearly the most effective. When the threshold is low and the number of surviving parties is consequently high, Predator rules perform poorly. Now, if there are several surviving Predators in the system and one of these is performing well, then it tends to get attacked by other Predators. This is an excellent example of the important general principle that, when agents deploy decision rules chosen from a heterogeneous set of possibilities, how decision rules perform in competition *with themselves* is just as important as how well they perform in competition with other rules.

The simulations we report in Chapter 6 contain another result we feel is very important, concerning what happens when *satisficing* and maximizing rules are in competition with each other. We identify and explain well-defined circumstances in which satisficing vote-seeking rules, which mandate doing nothing at all until party support falls below some “comfort threshold”, systematically outperform maximizing rules, which are always seeking more votes. Provided the party leader’s comfort threshold is above the survival threshold, and in settings where differ party leaders use a heterogeneous set of decision rules, satisficing parties can exploit short-run steady states that typically emerge during the evolution of party competition, during which their vote share is above long run expectations for one reason or another. Maximizing parties, always looking for more votes, never do this and always perturb any short run steady state, even when this is “paying off” above long run expectations. This is a very good example of the classic “exploitation-exploration tradeoff” that features in the reinforcement learning literature (Sutton and Barto 1998). In an evolving dynamic setting such as this, maximizing rules always explore, looking for more, and never do what satisficing rules can do, which is to sit back and exploit good short term situations. We feel this is one of the more

striking conclusions in this book. It is the type of insight that can only be derived from a *dynamic* model of party competition. Substantively, it explains the long-run survival of parties using satisficing decision rules which, even in a dynamic environment, may maintain the same policy positions for relatively long periods of time.

The model we specify in Chapter 6 generates a survival-of-the-fittest evolutionary environment. In Chapter 7, we extend this to take account of the possibility that new political parties, when they first come into existence, do not select decision rules at random but instead choose rules that have a track record of past success. We do this by adding *replicator-mutator dynamics* to our model, according to which the probability that each rule is selected by a new party is an evolving but noisy function of that rule's past performance. Pure replicator dynamics would be intensely path-dependent in a stochastic setting. There is a high probability that the party system will "lock in" to a situation in which only one decision rule is ever used, and which particular rule this is may depend on chance events early in the model run. Accordingly, we specify a replicator-mutator system according to which, if a decision rule is selected for use by a new political party, there is some finite probability of a random "mutation" that results in some other rule actually being used. Such systems are axiomatically not path dependent since there is always some probability, however tiny, of a sequence of random mutations that shocks the system from any state to any other state. Estimating characteristic model outputs, when positive feedback enters our dynamic model because party leaders choose decision rules according to a system of replicator-mutator dynamics, creates new methodological challenges. Having addressed these challenges, the simulation results we report in Chapter 7 show that adding positive feedback to the probabilities that new party leaders choose any particular decision rule in effect magnifies all of the effects we find in Chapter 6. This is not particularly surprising, but what *is* substantively significant about our findings is that it is very rare that one decision rule drives out all others over the long run. While the diversity of decision rules deployed by party leaders is drastically reduced, and while a particular decision rule is typically prominent at any given time, it remains the case under the replicator-mutator system that party systems in which party leaders use different decision rules are sustained over substantial periods.

All of the discussions of party competition in Chapter 1-7 assume the only thing voters care about is the set of party policy positions on offer. In Chapter 8, we take account of the possibility that voters also care about various perceived "non-policy" attributes of political candidates – such as competence, charisma, honesty and many other things besides. These matters are dealt with in what have become known as "valence" models of party competition in which voters, when they make their choices, balance utility derived from each candidate's non-policy valence against utility derived from the candidate's policy position. We again find useful theoretical results in the mathematics of Voronoi tessellations, since valence models of party competition generate what are known as "power diagrams".<sup>3</sup> Notably we find, axiomatically, that lower-valence party leaders might not even vote for themselves when their policy position is

---

<sup>3</sup> These arise from adding a valence (power) constant to a quadratic policy distance.

close to that of another party with a higher valence leader! The great contribution of valence models has been to explain why all parties do not converge on the center ground, since these models imply that higher valence parties tend to go the center while lower valence parties will be forced to steer well clear of these, and take more peripheral policy positions. It should be noted that parties *never* all converge on the center ground in our *dynamic* models, with or without non-policy party valence. Nonetheless, we replicate the findings of traditional static valence models, with two very important twists. The first twist concerns the interaction between valence and satisficing. High valence parties that use satisficing rules do not necessarily go to the center, since they stop moving when they achieve a satisfactory vote share even if they are not close to the center, while lower valence parties still tend to steer well clear of them. The second twist is that it is really quite difficult in our evolutionary environment to sustain a mix of parties with widely different valences over the long run. Crudely speaking over the long run, lower valence parties tend to die and higher valence parties tend to survive. We feel that this finding suggests a fundamental reappraisal of valence models as currently specified. These are essentially static models that show a snapshot of the party system at a given time; but the tendency of low valence parties to disappear in an evolutionary setting suggests that these snapshots are not dynamic equilibria that can be sustained over time.

While we look in Chapter 8 at voters who care about more than policy, we look in Chapter 9 at party leaders who care about their own private policy preferences, as well as about winning votes. In the spirit of our model of endogenous party “birth”, introduced in Chapter 5, we take the preferred policy position of a party leader as the founding policy position of his or her party, and note that these founding policy positions will tend to be somewhat more eccentric<sup>4</sup> than the policy positions of the set voters as a whole. We introduce a trade-off parameter to specify the way in which party leaders trade off their own policy preferences against winning more votes and find that, the more party leaders care about policy, the more eccentric their parties policy positions tend to be. In an intriguing echo of our findings on satisficing in an evolutionary setting, and in contrast to our findings on valence differentials, we find that party leaders who care only about their own personal policy preferences and not at all about their parties’ vote shares do *not* tend to die off when forced to compete with party leaders who care only about vote share. We conjecture that this striking finding arises from the fact that *the ideal points of surviving party leaders are endogenous in an evolutionary setting*, since each surviving party leader was once a new entrant into the system at a policy position for which there was demonstrable voter “demand”. Leaders who stay close to this founding party policy position continue to satisfy the demand that originally caused the party birth. They also effectively, though not intentionally, forestall new party births in this region of the policy space – specifically the Voronoi region containing the party’s current supporters, noting that new entrants in the Voronoi region of an existing party axiomatically reduce the support share of this party

---

<sup>4</sup> Note that we define the “eccentricity” of policy position  $p$  in this book technically, as the Euclidean distance of  $p$  from the center of the distribution of voter ideal points.

Having set of our theoretical models of multiparty competition in the first eight chapters of this book, we investigate the empirical plausibility of these models in Chapter 10. Confronting theoretical models with empirical data is of course a central part of the definition of political science as a “science”. For all that, it is much easier said than done, and it is even harder to do than usual when the models concerned are dynamic models with many parameters whose values are not directly observable in the real world. We thus face serious problems of model *calibration*, of finding parameter settings for our theoretical models that plausible correspond to those in the real party systems being modeled. Calibration problems are compounded by a shortage of *high quality time series data* on key party system outputs of interest. **More on this when there are more results ...**

Our fundamental interest in this book is multiparty competition, seen as an evolving dynamic system. Our fundamental intellectual objective is to explore some of the puzzles about this that can be addressed using techniques of agent-based modeling. Substantively, while the reader will be the ultimate judge of this, we do feel that agent-based modeling empowers us to tackle interesting and important questions that cannot be addressed so fruitfully using traditional modeling techniques. Methodologically, we do feel that carefully designed and executed computational work can generate results that have a scope and precision equivalent to those generated by traditional analytical techniques. Given this, our sincere hope is that we open an intellectual window for at least a few readers, who will take the ideas and suggestions in what follows and improve them beyond all recognition.

## REFERENCES

- De Groote, Philippe, ed. 1995. *The Curry-Howard Isomorphism*. Louvain: Academia-Bruylant.
- Fowler, James H., and Michael Laver. 2008. "A tournament of party decision rules." *Journal of Conflict Resolution* 52 (1):68-92.
- Laver, Michael. 2005. "Policy and the dynamics of political competition." *American Political Science Review* 99 (2):263-81.
- Laver, Michael, and Michel Schilperoord. 2007. "Spatial models of political competition with endogenous political parties." *Philosophical Transactions of the Royal Society B: Biology* 362:1711-21.
- Laver, Michael, Ernest Sergenti, and Michel Schilperoord. 2010. "Endogenous birth and death of political parties in dynamic party competition." In *Modelling Natural Action Selection*, ed. A. Seth, T. Prescott and J. Bryson. Cambridge: Cambridge University Press.
- Schelling, Thomas C. 1978. *Micromotives and macrobehavior*. 1st ed. New York: Norton.
- Sutton, R. S. , and A. G. Barto. 1998. *Reinforcement Learning: An Introduction*. Cambridge, MA: MIT Press.