# *Introduction*

The field covered in this book is very limited, and we approach it in this sense of modesty …. Its first applications are necessarily to elementary problems where the result has never been in doubt and no theory is actually required. At this early stage, the application serves to corroborate the theory. The next stage develops when the theory is applied to somewhat more complicated situations in which it may already lead to a certain extent beyond the obvious and the familiar. Here theory and application corroborate each other mutually. Beyond this lies the field of real success: genuine prediction by theory. It is well known that all mathematized sciences have gone through these successive phases of evolution.

(Von Neumann and Morgenstern 2007: 8).

We started this three-year project motivated by a long-standing puzzle in the literature on parliamentary democracies. Governments are responsible to parliaments and must maintain the support of a majority of legislators. The social choice tradition of theoretical work on this subject implies that governments should have a hard time not only getting into office but also staying there – because some legislative majority can always find a "better" alternative. We do sometimes see this type of instability – historically in Italy and recently in Israel, for example. Typically, however, governments do form and do stay in power, sometimes for quite a long time. In a nutshell, despite what some theorists have called "the generic instability of majority rule" (Schofield 1983), why do we not tend to observe this instability in a real world populated by living, breathing, politicians? And why does this stability sometimes vanish, flipping the world into a state where it becomes difficult to build and maintain a government?

   Work in the tradition of noncooperative game theory attacks this puzzle by describing it in terms of a radically simplified bargaining environment and making restrictive assumptions about actions

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available to senior politicians.[1] We ourselves have a hard time, how-ever, imagining that highly motivated, successful, and seasoned senior politicians – playing for the very highest stakes in the business – are bound by the assumptions found in these models. To take just one example, the most influential approach to this problem (Rubinstein 1982, Baron and Ferejohn 1989, Baron 1991, Ansolabehere, et al. 2005, Snyder, et al. 2005) simplifies the bargaining environment by assuming that some exogenous mechanism allows one, and only one, politician at a time to make a take-it-or-leave-it offer. Given an exog-enously imposed sequence of offers, the implication is that the first proposer (*formateur*) has a substantial advantage.

We do not, however, think it is in any way reasonable to assume that the most seasoned and sophisticated politicians in the business, doing the thing they most care about, sit quietly on their hands waiting for the talking stick to be passed in their direction. In contrast, we believe that – whether this happens in the cold light of day or in the dark shadows of what we think of as "backstage" – no senior politician can be banned from making any proposal to anyone at any time. Not only will several proposals typically be under consideration at the same time, no exog-enous mechanism can dictate the order in which these are considered. In short, assuming that an exogenously imposed *formateur* sequence exists might *theoretically* address the generic instability of majority rule, but does this at the cost of a model that does not *realistically* apply to the world we live in. Our approach here is to privilege the level of realism needed for a plausible description of government formation, recogniz-ing that this will result in complex theoretical models that may well be analytically intractable using traditional deductive methods. In doing this, we leverage two strands of previously published work.

The first strand implies that more realistic and complex strategic con-texts are, perhaps counterintuitively, more likely to produce structure and thereby prevent chaotic outcomes (Kollman, et al. 1992, 1998, Miller and Page 2009). In very simple settings, the intuition is that human actors will quickly see all possible courses of action and act in their own self-interest. In the context of majority voting over the mak-ing and breaking of governments, this underlies predictions of multiple

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[1] In the last few years, a number of very interesting studies have been conducted in this tradition, with a focus on providing an explanation for the empirical regularity of Gamson's law (Martin and Vanberg 2020, Cox 2021).

equilibria and cyclical majorities. Complex and difficult environments, in contrast, typically mean that it is hard for people to identify and evaluate every conceivable possibility in real time. This forces them to search for "good" solutions that are not provably the "best" and limits their ability to find counter-proposals, thereby enhancing stability.

The second strand flows from this and puts much more emphasis than many formal theorists on actual human behavior. In complex games, it can be difficult or impossible for real humans to figure out the perfectly optimal strategies assumed by most formal theoretic models. Canonical examples of such games – including bridge and poker – resist these purely deductive approaches. As a result, formal theorists often simplify games, thereby making it possible to assume that behavior consists of straightforward deduction. Recent advances in reinforcement learning in artificial intelligence (AI), however, allow researchers to attack complex games, in many cases achieving performance better than that of expert humans (Billings, et al. 2003, Brown, et al. 2017). Rather than simplifying the game of democratic governance so radically that it can be solved by backward induction, therefore, we set out here to explore effective – though not provably optimal – behavioral rules that scale to complex games.

Populating a more complex and realistic game with agents using behavioral rules that mimic those which might be used by expert humans, we find that in many settings, our model produces stable outcomes – Condorcet winning cabinets – not generic instability. This approach had been proposed, but not previously completed, by other scholars as a potential answer to similar puzzles in the social sciences. Douglas North emphasized the central role of behavior and complexity in his later work and saw this as one answer to the question of how institutions emerge (Denzau and North 2000, Munger 2020). Similarly, Elinor Ostrom focused on the use of heuristics to solve common-pool resource problems in complex environments (Ostrom 2010). Increased availability of computation and advances in reinforcement learning have now made this approach much easier to implement.

We were encouraged from our early work as part of this research program (de Marchi and Laver 2020) that not only showed that stable governments were possible but also allowed us to predict the length of negotiations – bargaining delays – during government formation. We took this as quite strong support for our approach. While there are *empirical* accounts of the duration of government formation

negotiations in parliamentary systems, there is no rigorous theoretical model explaining the empirical findings.[2] In our research, we took a direct output of our theoretical model – the likelihood of finding a Condorcet winner in each empirical setting – and used this as a measure of bargaining complexity to predict the length of negotiations. A purely analytical output of our theoretical model thus predicts a real-world dependent variable, providing evidence for our causal mechanisms.

The motivation for this book was to extend our model and use it to predict other important real-world outcomes that have resisted prior efforts. In particular, we were interested in predicting, on a case-by-case basis, which coalition is likely to form after elections in parliamentary systems. This is hard, given the huge number of different possible proposals for government. While making predictions is not the current fashion in political science, it is our belief that this is the best way to test the main implications of any theory. Predict an outcome of substantive interest and, as new data arrives, continually expose the theory to new tests. The composition of governments that form in parliamentary systems is a nearly perfect dependent variable in this sense. It is of enormous substantive interest and easily observable. There are a relatively large number of cases and new data are generated by every new election.

Even better for our purposes, government formation in parliamentary democracies is a complex strategic game played by highly motivated politicians. Our expectation is that if we can successfully analyze this, we most likely will be able to apply our model to other contexts in which bargaining occurs. Examples include alliance formation in the international system and intraparty bargaining in the US Congress.

Complex strategic models of the sort we investigate in this book, along with the behavioral algorithms we use to describe the decisions made by senior politicians, involve a large number of modeling choices. The choices could, in principle, limit the generalizability of our model and produce "curve-fitted" results. By focusing on predicting a real-world outcome such as government formation, we can, however, see if our model is general and examine the impact of different parameter values. *Theoretical* generalizability is increased by committing to an

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[2] The main arc of empirical work on the duration of negotiations starts with Diermeier and Van Roozendaal (1998) and continues with Martin and Vanberg (2003) to Golder (2010). On the general difficulty in linking theory and empirics in this area, see Diermeier, et al. (2003).

*empirical* target. Simply put, we are trying to fulfill Von Neuman and Morgenstern's original goal: "genuine prediction by theory." Of the universe of formal models we could write down about government formation, we are interested here in those that have a direct mapping to real-world political phenomena.

In this book, we describe both the methodology we used and the substantive results we derived. Methodologically, there are several good treatments on how to build computational social science models in the area of *empirical* work (Alvarez 2016). At present, however, there are few treatments of computational social science applied to *theory*.[3] We hope this book, and the availability of our code and data, will help to fill that gap.

Substantively, we are happy to report that our initial results are encouraging; we feel we have achieved our main goals. The models we present here are able to predict: which governments form after an election, how long negotiations take during this process, and how long these governments are likely to last. One issue that deserves attention is that we, unfortunately, do not have other existing research with which to compare our findings. Prior theoretical work has not typically aimed at these targets. It is our hope, however, that by providing a first step in prediction, other researchers will build new models, improving on what we have done here and measuring their progress against our baseline. One way in which science progresses is when a community of researchers uses common benchmarks to compare the performance of models, linking theory to empirics.[4]

In addition to success at prediction, we also have a set of substantive insights that are distinct from earlier research. Loosely, earlier work typically argues that government formation:

  i. is led by a proposer with considerable advantages in bargaining;
 ii. involves short negotiations where the first proposal is accepted;
iii. tends to result in minimum winning coalitions (not single-party, minority, or surplus governments);[5] and
 iv. at most considers government policy on one or two latent "dimensions."

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[3] The exception is Laver (2020a, 2020b), which is focused on agent-based models.
[4] For an overview, see www.nsf.gov/sbe/ses/polisci/reports/pdf/eitmreport.pdf.
[5] A minimal winning coalition has enough members to exceed the winning threshold (e.g., a simple majority) but without any surplus members.

Our results on the birth and death of governments in parliamentary democracies show that:

  i.   senior politicians make and are aware of multiple proposals;
 ii.   negotiations may be lengthy, depending on the modeled complexity of the strategic environment;
iii.   negotiations may result in minority, minimum winning, or surplus governments; and
 iv.   policy matters a great deal and parties negotiate over high-dimensional joint policy programs. Logrolling is a central part of this, and parties with negatively correlated saliences over policy have an advantage in forming coalitions.

Crucially, we link the endless "governance cycle" of elections, government formation, and government survival into an integrated modeling architecture and show that even when governments form, they are not all equally successful in negotiating a joint policy program. Salient and contentious issues may be left unresolved (tabled) and may, at some point in the future, be forced onto the agenda by an exogenous shock. Since such shocks cause legislators to think again about whether they prefer some alternative to the incumbent, the survival of governments refers directly to the (implied) process of government formation. This allows us again to connect a key output of our formal model directly to an empirical model of government durations. This expands on an approach pioneered by Lupia and Strom (1995) in two ways: It generalizes from three to any number of parties and multiple issue dimensions; it models an explicit mechanism that explains the role of unanticipated shocks in bringing down governments.

Finally, we show that the behavior of senior politicians is not only quite complex but poorly described by backward induction (the algorithm employed by noncooperative game theorists). We explore the strategic capabilities of senior politicians by building two quite different types of models, grounded in different behavioral assumptions. The first is an agent-based model, which uses relatively sophisticated rules of thumb – heuristics – to model behavior. The second is an AI approach based on reinforcement learning, which allows agents to teach themselves how to play the game and find "near-Nash" strategies. We find that the performance of both models is similar, which indicates that senior politicians – even though they are experts in their

domains, have access to professional staffs, and are playing for high stakes – may not be fully strategic and instead use sophisticated heuristics to make decisions.

We, therefore, model senior politicians as people who, if they wish to be successful while playing a complex game, are what we call "functionally" rational. They are clearly very good at finding *effective* strategies. Given the enormous complexity of their strategic environment, however, being successful also means recognizing that it makes no sense – indeed is functionally *irrational* – to obsess on finding *perfectly optimal* strategies.

We have left many questions on the table for future work. For example, we are able to "back out" from our model unobservable features of decision-making by party leaders, including their relative taste for the perks of office or the policy outputs of government. We also hope to explore which empirical settings have more policy-motivated party leaders given that this is a crucial link in a representative democracy between elected officials and the constituents they represent. In this book, we avoid detailed case-specific work and focus on general results, but differences surely exist between settings. An alternative use of our model is to calibrate it closely to some particular setting of interest and use it to power a theoretically structured case study. This could, for example, help us understand why some countries – Greece during the debt crisis or Israel today – enter into periods of instability.

## How to Use This Book

We intend this book to serve two purposes. The first is substantive: We investigate the governance cycle in parliamentary democracies and provide a new benchmark for understanding which types of cabinet are likely to form after elections. The second is methodological: We provide a computational social science approach to building complex games and the reinforcement learning algorithms necessary to play them.

To present this in a readable format, we confine technical details (and some philosophical asides) to *Technical Appendices* at the end of the book, referring to most chapters. Readers interested in the nitty-gritty of our models, replicating what we have done, or the detailed motivation behind some of the choices we have made, will hopefully find answers here.

Different readers may, therefore, choose to take different paths through the Chapters (C) and Technical Appendices (T) of this book.

*Readers interested in substantive findings*: C2, C3, C5, C6, C7.
*Readers familiar with the literature on government formation*: T2, C3, T3, C4, T4, C5, T5, C6, T6.
*Readers interested in reinforcement learning applied to complex games*: C2, T2, C3, T3, C4, T4, C5, T5, C6.

Finally, readers can find all our code and data online at *https://github .com/stormslayer*.

# 1 | *Governance, Complexity, Computation, and Rationality*

In a referendum held on June 23, 2016, a majority of British voters chose to leave the European Union (EU): "Brexit." This was a big political shock. David Cameron, pro-EU Prime Minister of a Conservative majority government, who had called the referendum confidently expecting to win, resigned. He was replaced on July 13, 2016 by Theresa May, who pledged to lead Britain out of the EU: "Brexit means Brexit." The Conservative Party, however, was deeply polarized over EU membership. May encountered vigorous internal opposition from a minority faction of hard-line "Spartans" to her proposals for a negotiated settlement with the EU. The Spartans preferred to walk away from the EU, with no deal, on World Trade Organization terms.

Vexed and frustrated by the Spartans, encouraged by a substantial opinion poll lead over the opposition, and against much of the advice she was receiving, May called a snap election on June 8, 2017, a mere two years after the previous election had given the Conservatives a majority. Her hope and expectation were for a Conservative majority large enough to destroy the leverage of the Spartans. The result was another shock … and a catastrophe for May. The Conservatives, far from gaining seats, lost thirteen seats and their legislative majority. May was forced to negotiate terms with the Democratic Unionist Party (DUP) of Northern Ireland for their support of a minority Conservative government. This was a particularly fraught option, since trade across the land border between Northern Ireland and the Republic was of extraordinary concern to the DUP, yet perhaps the most contentious aspect of Brexit. The leverage of the Spartans, furthermore, was increased rather than diminished. May was unable to win approval for *any* deal with the EU and resigned with effect from June 7, 2019.

She was replaced as Prime Minister by Boris Johnson. Johnson, however, did no better than May at getting a Brexit proposal through the House of Commons, and his government was subjected to a series of

humiliating legislative defeats on the issue. In response, he called another snap election on December 12, 2019. The Conservatives won this with a comfortable majority, allowing Johnson to form a single-party majority government and, finally, drive through a Brexit settlement with the EU.

This book is about what we call the *governance cycle* in parliamentary democracies, illustrated in striking terms by the recent British political history we summarized. This is a never-ending cycle consisting of elections, followed by government formation, followed by the need for governments to sustain themselves in office in what is typically a hostile environment, followed eventually by the resignation or defeat of the government, and ultimately by more elections. The cycle then repeats itself in an environment subjected to a continuous stream of unanticipated shocks.

The governance cycle takes a particular form in parliamentary democracies, where the executive serves at the pleasure of the legislature. New governments can form only with the explicit or implicit consent of a majority of legislators. Incumbent governments fail if a majority of legislators withdraw this support. The crucial political consequence of this type of constitutional regime is that voters choose legislators, who in turn choose, support, and can dismiss the executive, including a chief executive typically known as Prime Minister.[6] There is no practical separation of powers between the legislature and a directly elected executive as there is, for example, in the United States. Parliamentary democracies are democracies because people indirectly choose their governments when they vote in legislative elections – choosing legislatures that make and break governments.

Most European countries are parliamentary democracies, and most of these use some form of proportional representation for legislative elections. It is rare for any one party to win more than half the popular vote. Thus, it is also rare for a single party to command a legislative majority and so be in a position to make and break governments unilaterally. All of this means that the making and breaking of governments in parliamentary democracies *typically requires negotiations between senior members of different political parties.*

The governance cycle in parliamentary democracies, therefore, involves an endlessly iterating sequence of three key processes,

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[6] In a bicameral legislature, it is the lower house, elected on the principle of one person, one vote, which chooses and supports the executive. The prime minister is sometimes called chancellor (as in Germany and Austria).