Political Dynamics Determined by Interactions Between Political Leaders and Voters

28th International Conference of the System Dynamics Society
July 25 - 29, 2010 -- Seoul, South Korea

Asmeret Bier, Michael Bernard, George Backus, Richard Hills

Sandia National Laboratories

Abstract

The political dynamics associated with an election are typically a function of the interplay between political leaders and voters, as well as endogenous and exogenous factors that impact the perceptions and goals of the electorate. This paper describes an effort by Sandia National Laboratories to model the attitudes and behaviors of various political groups along with that population's primary influencers, such as government leaders. To accomplish this, Sandia National Laboratories is creating a hybrid system dynamics-cognitive model to simulate systems- and individual-level political dynamics in a hypothetical society. The model is based on well-established psychological theory, applied to both individuals and groups within the modeled society. Confidence management processes are being incorporated into the model design process to increase the utility of the tool and assess its performance. This project will enhance understanding of how political dynamics are determined in democratic society.

Key words: political dynamics, elections, voting, cognitive model, system dynamics, confidence management

1. INTRODUCTION

The United States has often been engaged in partnerships with countries that have unstable, and often unpredictable, political systems. There is a need to gain better insight into the political dynamics that drive stability and instability in these countries of interest. Political dynamics depend largely on interactions between political leaders and the people they represent. Endogenous and exogenous factors may also have substantial influence on the political conditions and stability of such a system. By gaining insight into the dynamics underlying political trends, and by better understanding the potential outcomes of elections, a government can adjust its strategies to avoid undesirable outcomes or gain desirable ones. Unfortunately, there is currently no effective means to adequately simulate how individual leaders and the people they influence will behave with regard to possible internal and external stimuli.

It is asserted here that an accurate characterization of a society must include interactions between people under control, those exercising power, and external variables, such as actions of outside governments or changes in oil revenue (in countries dependent on oil). While tools exist to simulate societies, they have, thus far, been limited to gross behavioral models. Recently advancements in modeling of human behavior have made the simulation of the phenomena that maintain or transition the dominance of political parties possible. Understanding political dynamics is a key goal of this work. In pursuit of this goal, Sandia National Laboratories (Sandia) is developing a societal/leader modeling capability to simulate dynamics and potential higher order consequences associated with the election process.

The feedback-rich quality of political systems makes this an ideal case for system dynamics modeling in combination with cognitive modeling techniques. The cognitive portion of the model, which is consistent with system dynamics principles, simulates the key processes underlying how people make decisions and express behaviors. These behaviors affect other decision-makers, creating complex feedback loops within and between individuals and groups. Confidence management practices are being incorporated throughout the model building process to ensure that the model is as useful as possible in understanding potential political dynamics in a hypothetical society. The intent of this project is to provide a core platform for simulating political dynamics, as well as to serve as an example of how interactions between individuals and groups can be effectively modeled using a shared cognitive framework in combination with system dynamics.

2. THE MODEL

2.1. The Cognitive Framework

To accurately characterize individual and social political dynamics within a country, one must consider interactions between leaders, their constituencies, and political, economic, and environmental conditions. This model combines cognitive and system dynamics modeling techniques to simulate potential interactions between leaders and the electorate. The core of the cognitive-system dynamics model relies on a psycho-social framework that incorporates both well establish theories of human behavior and empirically derived data, which includes a spectrum of information, from cultural and social data up to specific knowledge of individuals. If knowledge at one level is unavailable, the system relies on information one level below. The model is designed to focus on electoral politics, concentrating on how government strategies and voting preferences affect each other in the presence of influences from the outside world.

The cognitive framework, which is consistent with system dynamics principles, simulates the key processes underlying how people make decisions and express behaviors. The cognitive framework is based on established psychosocial models of attitude formation, decision-making, affect, and planned behavior. The implemented behaviors chosen from potential actions conform to the theory of planned behavior, which maintains that behaviors are influenced by attitudes towards a specific behavior, subjective norms associated with acting out that behavior, and the perception that the behavior is within a person's control. This forms an action intention state, which typically drives the person's actual behavior (Ajzen and Madden 1986; Fishbein and Stasson 1990; Madden, Ellen, and Ajzen 1992).

In addition, the framework models and simulates behaviors associated with cognitive dissonance. Cognitive dissonance theory proposes that a state of tension occurs whenever a person simultaneously holds two cognitions (i.e. beliefs or attitudes) that are psychologically inconsistent (Festinger 1957; Festinger 1964; Festinger and Carlsmith 1959). According to the theory, there are relationships among cognitions, such as consonance and dissonance. Ideas that are consistent, such as "I like apples" and "apples are great tasting", are consonant. Thoughts that are inconsistent, such as "I smoke cigarettes" and "cigarettes can kill smokers", are dissonant. Dissonance produces an unpleasant motivating state that promotes attitude change to achieve or restore consonance. According to cognitive dissonance theory, one can consider more than two cognitions at a time, with some cognitions potentially being more important than others. The importance of cognitions can influence dissonance. Cognitive dissonance theory suggests that dissonance is influenced by the proportion of dissonant and consonant cognitions and the importance of the cognitions.

The objective of this framework is to identify a unified, theoretically consistent, psychosocially plausible model of decision-making that applies to both individuals and groups. We believe that core cognitive processes can be represented at both the individual and societal levels. The prototype model simulates political dynamics based on interactions between individual candidates and aggregations of voters. These interactions are driven by behaviors of each of the actors. Each cognitive entity in the prototype model is affected by different cues, which come from environmental conditions or from the behaviors of decision-makers in the model. The cues are transformed into behaviors using the cognitive framework. Each cognitive entity uses the same process to make decisions. An overview of the cognitive framework, suggested by the aforementioned psychological theory, is shown in figure 1.

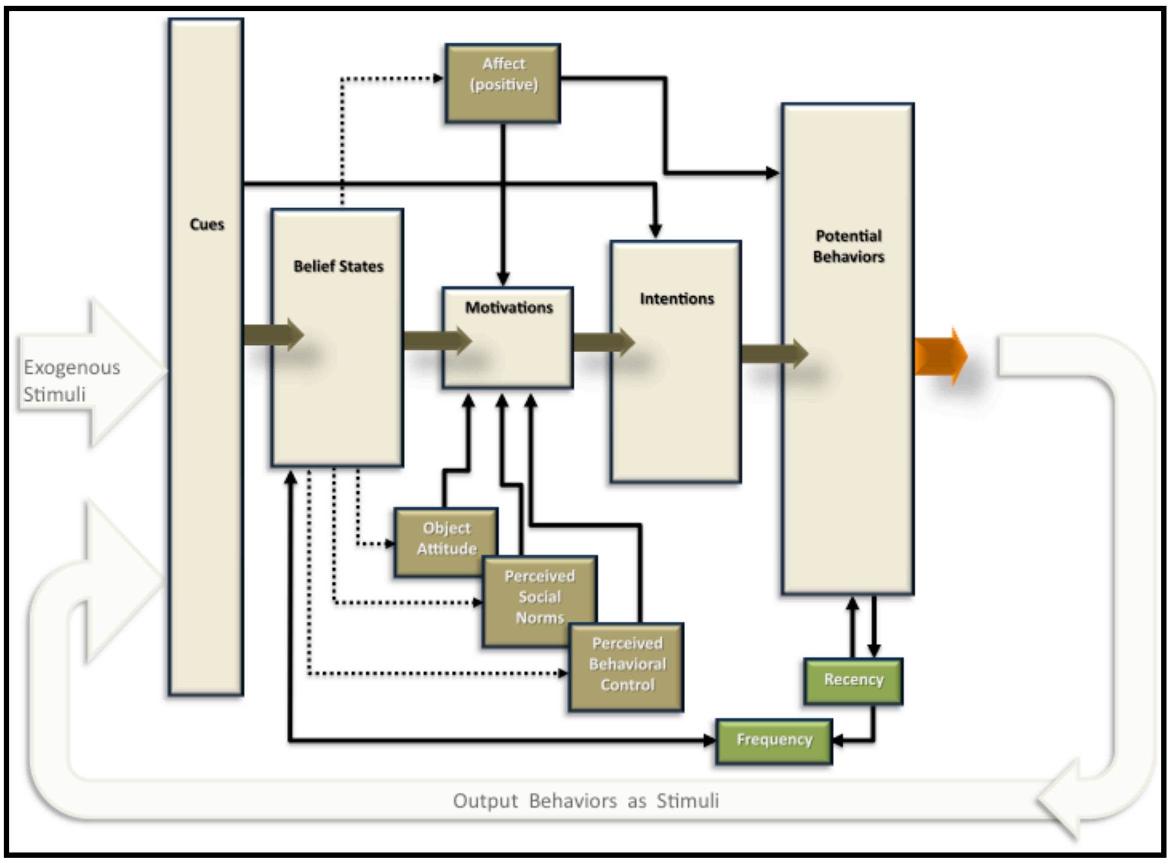

Figure 1: Bounded knowledge and decision making

The model includes a calibrated, systems dynamics socio-political framework with behavioral decision simulation within populations and governments. It incorporates cultural, institutional, economic, and political distinctions. The system dynamics aspect will include logic for detailed intra- and inter-regional interactions, as well as aggregate rest-of-world feedback dynamics. A calibrated framework combines selected economic data and societal index sources to allow model parameterization and long-term global modeling capability. Currently, no existing macroeconomic or societal model addresses security dynamics or coordinated kinetic and nonkinetic intervention. Methods developed at Sandia, combined with new verification and validation approaches under development at Sandia can, however, provide robust behavioral response simulations (Backus and Glass 2006; Sterman 2000). The foundation of these methods come from Nobel Prize winning work of Daniel McFadden on qualitative choice theory, which accurately portrays human decision making, and by Clive Granger on cointegration, which determines those variables that affect decisions with enduring or transient significance.

Physical and economic behavioral implications are readily simulated using conventional simulation methods such as system dynamics (Sterman 2000), engineering (Gershenfeld 1998), and economics (Hendry 1993). Societal and economic realities are the consequence of behavioral decisions. The simulation and understanding of these processes is only recently possible. Decisions are part of the process of making choices. All behaviors are the consequence of choices made. McFadden (1982) pioneered the use of (psychologically framed) qualitative choice theory (QCT). QCT quantitatively determines the importance people place on information, tastes, beliefs, and preferences when making decisions. Robust parameterization of QCT is often based on data readily obtainable in the field. Other techniques can further determine the correct functional representation of the QCT utility formulation for the problem at hand (Keeney and Raiffa 1976).

2.2. Interactions between Voters, Candidates, and their Environments

The prototype model simulates the interactions between candidates and voters to determine the dynamics of the political system. Voters are separated into different groups depending on their socioeconomic status and political leanings. The cognitive framework determines the attitudes and behaviors of each candidate and group of voters with inputs determined by the political, economic, and social conditions within the political system. These conditions are in turn affected by the behaviors of all of the cognitive entities. The high-level structure of one potential prototype model design is shown in the sector diagram in figure 2.

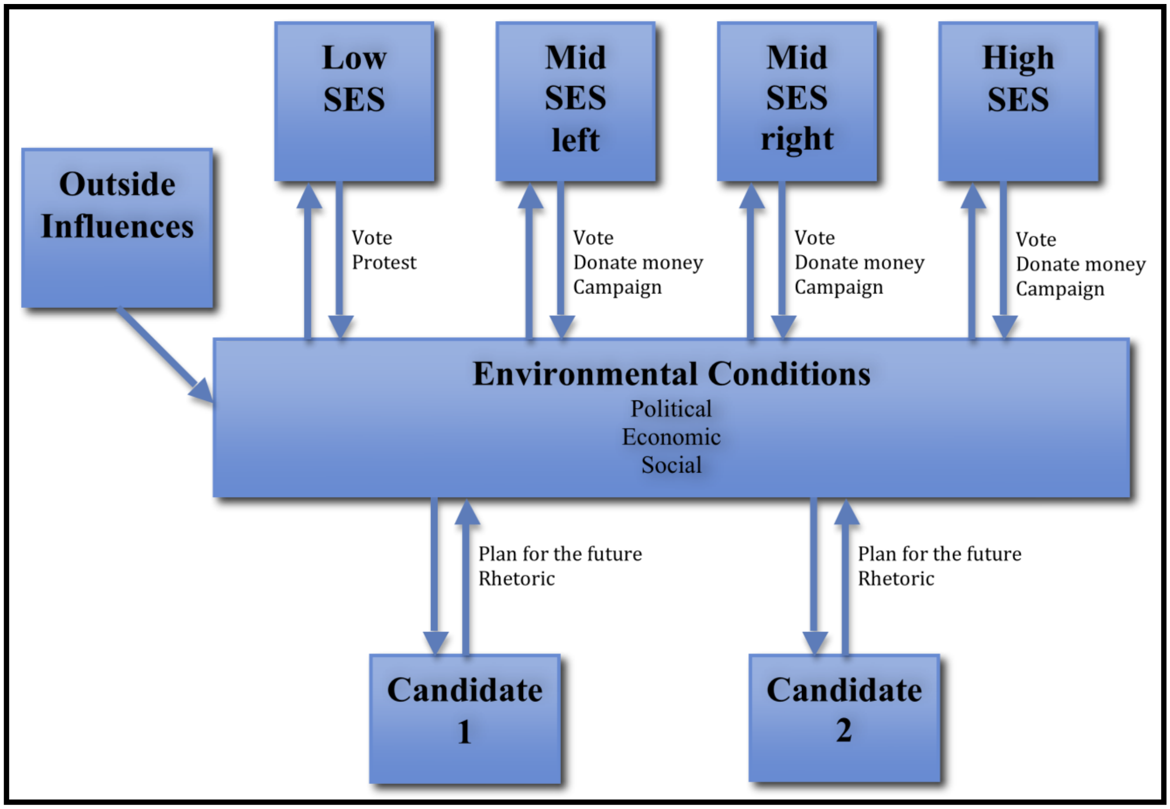

Figure 2: Sector diagram of the prototype model

The interactions that each cognitive entity has with its environment depend on the cues that it is receptive to and its potential behaviors, both of which are identified by the structure of the prototype model. Some cues are shared between cognitive entities, while others apply only to one or a subset of entities. Violent crime rates, for example, are likely to affect all decision-makers in the modeled society. Each entity will process this information differently, and different behaviors will result from each entity's cognitive framework.

The potential behaviors of each cognitive entity focus on political actions. Voters can affect change through voting, campaigning, monetary support for a particular candidate, or voting. Political candidates react to environmental conditions and voter behaviors primarily through policy decisions. They may alter their support of suppression of societal disorder, measures that help the poor, non-corruption policies, economic policies, nationalistic sentiment, government intrusion into citizens' personal lives, levels of policing, media control, or other policies.

An example of how these relationships might affect the political system is shown in figure 3. If the low socioeconomic status (SES) population becomes less satisfied with the current government, they are more likely to protest against the government. This leads to more dissatisfaction with the government, among not only low, but also high SES voters. More protests would also lead the government to strengthen its commitment to law and order, which would increase the high SES population's satisfaction. This higher satisfaction would cause the high SES population to increase campaigning and monetary support to the current government, further strengthening the government's commitment to law and order. This strengthened commitment from the government would, however, increase the perception throughout the society that the government emphasizes maintaining the status quo. While this is a good thing for the high SES population, it will decrease the low SES population's satisfaction with the government even further. The government thus has a large incentive to keep the low SES population satisfied. One way that they might do this is to build low income housing, which decreases the perception that the government wants to maintain the status quo, and may keep the low SES population from becoming dissatisfied with the current government.

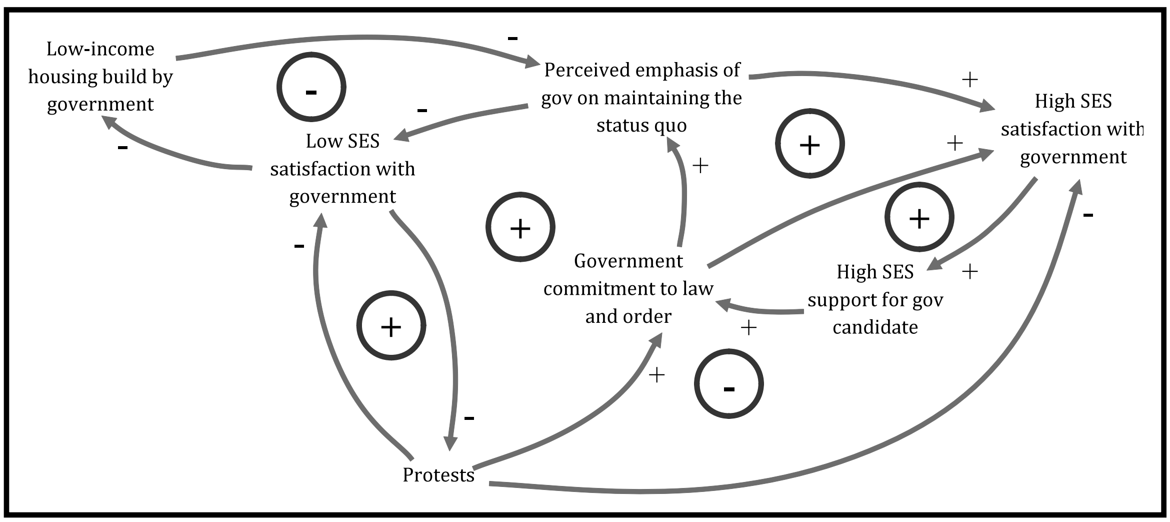

Figure 3: Causal loop diagram of protest-driven dynamics in the prototype model

3. CONFIDENCE MANAGEMENT

This project incorporates confidence management, a collaborative assessment of the model and its development process that will take place throughout the lifetime of the project. This component of the project is designed to inform model builders and end users about the level of confidence they should have in the model, as well as identifying potential improvements that could strengthen this confidence. Confidence management consists of a suite of techniques, with categories including documentation, verification, validation, uncertainty quantification, and sensitivity analysis.

One major component of confidence management is documentation. All major components of the project will be documented. Capability requirements for both the model and project were documented to provide an overview of the project expectations. The design of the model will also be documented. This will include the justification for the chosen structure of the model, including background theory from the fields of psychology, system dynamics modeling, and other applicable subjects. It will also include an explicit account of assumptions made, as well as documentation of all confidence management activities. The documentation will also include a description of the sources of data used to define the model structure and parameters.

Verification is used to determine whether the computer model is an accurate mathematical representation of the mental model on which it is based. Extreme value tests and integration error tests (Sterman 2000) are examples of verification methods that are commonly used in system dynamics modeling. This project will use extreme value tests to look for implausible behaviors caused by certain ranges of parameter values. To test the accuracy of the code used for numerical integration, the code will be applied to benchmark problems. To test for integration error, the model will be simulated once with the standard time step (dt), once with the time step cut in half, and once with the time step cut by another factor of two. The simulations will then be compared and tested for convergence.

Validation tests whether the model is an accurate representation of the real world. Behavior reproduction (Sterman 2000) is a good example of a validation technique. Face validation, by both the project team and subject matter experts, is the first step in the project validation process. Throughout the model building process, the model will be shared and assessed by the group for reasonableness. Diagrams of model structure, including stock and flow and causal loop diagrams, will be created to help with this process. Historical data will also be used to cross-validate the model. A subset of this data will be used to populate the model, and results will be compared to remaining data to determine the effectiveness of the calibration data set. The final validation methodology planned for the project is docking. The model is being developed in stages, with a different version of the model developed at each stage. We plan to take advantage of this feature by comparing results of these different models.

Sensitivity analysis is used to determine which model inputs have the largest affect on model outputs. It can be used to identify where data collection resources should be directed, to learn about the fundamental structure of the model, and to identify leverage points where intervention can have a substantial and robust effect of results. Uncertainty quantification, a related technique, is concerned with uncertainty in model results. We plan to conduct uncertainty and sensitivity analyses on the prototype model using Sandia-developed, publicly available software called Dakota. Uncertainty quantification and sensitivity analysis will also be woven into data collection efforts, to assure that uncertainty in the model is defined as much as possible.

Acknowledgements

Sandia is a multiprogram laboratory operated by Sandia Corporation, a Lockheed Martin Company, for the United States Department of Energy's National Nuclear Security Administration under Contract DE-AC04-94AL85000.

7. WORKS CITED

Ajzen, I., Madden, T.J. (1986). Prediction of goal-directed behavior: Attitudes, intentions, and perceived behavioral control. *Journal of Experimental Social Psy-chology, 22,* 453-474.

Backus, G.A. & Glass, R. (2006). *An agent-based model component to a frame-work for the analysis of terrorist-group dynamics.* Sandia National Laboratories, Technical Report: SAND2006-0860.

Ben-Akiva, Moshe, and Steven Lerman. 1985. Discrete Choice Analysis: Theory and Application to Travel Demand. MIT Press: Cambridge, Massachusetts.

Bernard, M.L., Xavier, P., Wolfenbarger, P., Hart, D., & Waymire, R., Glickman, G. (2005). Psychologically plausible cognitive models for simulating interactive human behaviors. *Proceedings of the Human Factors and Ergonomics Society 49th Annual Meeting.* Orlando, FL.

Bernard, M, Backus, G., Glickman, M., Geiseler, C., & Waymire, R. (2009). Modeling Populations of Interest in Order to Simulate Cultural Response to Influence Activities. In *Social Computing and Behavior Modeling.* H. Liu, J. Salerno & M. Young. [Ed.].

Boslough, M., Sprigg, B.J., Backus, G.A., Taylor, M., McNamara, L., Fujii, J., Murphy, K., Malczynski, L., & Reinert, R. (2004). *Climate change effects on in-ternational stability: A white paper.* Sandia National Laboratories, Technical Re-port, SAND2004-5973.

Engle, R.F. &. Granger, C.W.J. (1987). Co-integration and error correction repre-sentation, estimation, and testing, *Econometric, 55*, 251-276.

Engle, R.F., & Granger, C.W.J. (1991). *Long-Run Economic Relationships: Read-ings in Cointegration*, Oxford University Press, Oxford, UK.

Fishbein, M., & Stasson, M. (1990). The role of desires, self-predictions, and per-ceived control in the prediction of training session attendance. *Journal of Applied Social Psychology, 20,* 173-198.

Forsythe, C. & Xavier, P. (2002). Human emulation: Progress toward realistic synthetic human agents. *Proceedings of the 11th Conference on Computer-Generated Forces and Behavior Representation*, Orlando, FL.257-266.

Gershenfeld, N.A. (1998). *The Nature of Mathematical Modeling*. Cambridge University Press.

Keeney, R.L., and Raiffa, H. (1976) *Decisions with Multiple Objectives*. John Wiley & Sons, New York, NY.

Hendry, D. F. (1993) *Econometrics: Alchemy or Science?* Blackwell Publishers, Cambridge, UK.

McNamara, L.A., et. al, (2008). *R&D for Computational Cognitive and Social Models: Foundations for Model Evaluation through Verification and Validation, Sandia National Laboratories*, Technical Report: SAND2008-6453.

McFadden, D. (1982). "Qualitative Response Models," in *Advances in Economet-rics.* Ed. Werner Hildenbrand, Cambridge University Press, New York.

Sterman, John. 2000. Business Dynamics: Systems Thinking and Modeling for a Complex World. McGraw-Hill: Boston, Massachusetts.

Train, Kenneth. 1986. Qualitative Choice Analysis: Theory, Econometrics, and an Application to Automobile Demand. MIT Press: Cambridge, Massachusetts.

Train, Kenneth. 2009. Discrete Choice Methods with Simulation. 2nd Edition. Cambridge University Press: New York, New York.