BAYESIAN MODEL OF THE EFFECT OF PERSONALITY IN PREDICTING DECISIONMAKER BEHAVIOR

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Abstract

Predicting a leader's actions must take the Subject's personality into consideration in addition to relevant situational variables. This paper presents a methodology that enables the analyst to reason through a prediction of a Subject's decision making, to identify assumptions and determinant variables, and to quantify each variable's relative contribution to the prediction, producing a graphical representation of the analysis with explicit levels of uncertainty. The analyst builds Bayesian networks that integrate situational information with the Subject's personality and culture to provide a probabilistic prediction of the hypothesized actions a Subject might choose. The model development process allows the analyst to systematically develop hypotheses regarding potential actions, determine the Subject's most likely strategic objectives, identify relevant situational variables, estimate probabilistic relationships between variables, and assess the Subject's standing on several personality variables. The methodology has been applied to over a dozen historical and prospective situations.

1 INTRODUCTION

One generalization that can be made about intelligence analysis is that it involves activities in which members of one group of people – analysts – make predictions about the activities of members of another group of people – foreign leaders or other decisionmakers. The decisionmaker determines the course of action to take, considering his or her objectives as well as a variety of situational constraints in a way that reflects his or her personality as well as cultural norms. The analyst must identify the relevant situational variables, specify the personal characteristics of the decisionmaker, and forecast how these factors interact to determine the chosen action.

Personal characteristics of the analyst may make it more or less difficult to produce an accurate prediction. Many cognitive limits and biases in prediction are both well-known and widely shared among both trained and naïve analysts. These biases – such as recency, halo, proximity, hindsight, and personalization – can produce systematic errors in predictions. (Hogarth, 1975; Fischhoff et al., 2005) In addition, prediction is often undertaken by a team of analysts with diverse backgrounds, working on a problem that will evolve over weeks or months and need periodic reporting. Consequently, the analysis process is subject to less widely discussed but influential social biases, such as those reflected in giving undue weight to the senior expert, the "party line" or published record, the analyst with the biggest fistful of cables, or with the most dazzling personality.

This paper describes an effort to develop tools that can assist analysts in making reasoned predictions about what key figures might do in specific situations. This effort, underway since 2001, addresses many of the concerns in recent critiques of the national intelligence process. The key purpose of our work is to create a method for modeling/predicting leader actions.

The following principles were the basis of this development effort:

- Viewpoints – the more the merrier, but make it systematic (combine many analysts with varying expertise, addressing both the situation and the

subject's personality and culture, and use a rigorous analytical method for integration);

- Intelligence as a process, not just as product – recognizing that intelligence consumers are their own analysts, engage the customer by using the model to manage the debate and questioning that often ensues when an analyst briefs a policy-maker – the modeling process enables different assumptions or alternative hypotheses to be tested on the spot;

- Continuous and real-time updating of the model – review and quantify relevant evidence and the associated probabilities for specific model variables, and explicitly inform the user when data may warrant changing judgments.

The paper describes the methods we have used to predict leader actions, based on a combination of situational variables and an assessment of the leader's personality. First, it describes the Bayesian network methodology and our modeling process that form the basis for forecasting leader actions. This methodology specifically addresses some of the individual cognitive biases that can degrade the quality of predictions. Second, the paper describes some of the most relevant research results that link a leader's personality to his or her actions and shows how these can be represented in the Bayesian framework. Third, it describes how the personality model is added to the situational model to minimize elicitation requirements and enhance the model's predictive capability. We believe that this development process, along with the underlying methodology, can reduce the impact of social biases on the accuracy of predictions. Finally, the paper summarizes the status of our work and describes some future directions that it may take.

2 MODELING METHOD AND PROCESS

The general problem of predicting someone's future action is exceedingly complex. Without even considering the task of identifying the determinative variables correctly, one must deal with uncertainty, human judgment about the problem logic, relative strength of specific variables and evidence, and the dependencies of some variables on others. When we add the requirement to enable updates to the prediction as new information becomes available, we realize there is only one method that matches the problem statement – Bayesian probability (Schum 1994).

Application of this modeling method provides a natural mechanism for surfacing assumptions, logic, and new evidence for the team working the problem. In addition, modeling software can capture an auditable history of the team's thought process and supporting evidence. This software solution alerts the analyst when certain thresholds are met within the model, indicating that the evidence may warrant changing one's beliefs.

We have developed models in two-day, facilitated meetings attended by analysts, model developers, and external subject-matter experts. The facilitator guides the participants through the steps in the development process (described in the following sections), elicits estimates of model parameters, and ensures that the requirements of the methodology are met. A second member of the modeling staff implements the model on the computer and takes notes. The model is projected onto a screen during the development process so that all participants are aware of the variables and relationships included in it. Both analysts and external experts provide the information and assessments that are incorporated into the model. The analysts usually provide critical information about the questions to be addressed by the model, while all participants provide the regional and Subject knowledge incorporated into the model.

The analysts' intelligence questions, the optional outcomes of interest – what will X do or what can we do to lead X to do Y – are debated at considerable length. The process usually takes four hours at the outset of a two-day session to define what the problem is in terms of one or more random variables and a set of mutually exclusive and collective exhaustive states for each. This first half day sets the motif – and some social norms – for the rest of the session. The mix of staff and outside panelists suggests that diversity of opinion and experience is desirable; it gives the staff permission and cover for bringing new or divergent views to the table. There is a lot of give and take about what kind of hypothesis variable(s) should we define: measured versus inferred once they have happened, under direct or indirect control of the leader, etc. We try to ensure that the states are exhaustive without using the catch all "everything else that is possible." We have found that this leads to major paralysis of analysis when it is time to assess conditional probability distributions with this as a condition.

The facilitator's behavior is critical in two respects. First, the technical aspects of applying Bayesian analysis must be guided by an expert – the international relations and political science educations of most analysts do not prepare them for this methodology. The challenges of helping the group to frame questions properly – consistent with probability theory – and to keep their engagement fresh while estimating large conditional probability tables are not trivial items. In addition, the

facilitator helps to keep the gate open to contrary data and judgments and healthy debate, to elicit contributions from all members, to challenge what everyone takes for granted, and to curb the natural tendencies of dominant actors to hog the stage and dictate the analysis – all while demonstrating respect for each contribution. It is important for this facilitator to be viewed as a neutral party; often this means someone from outside the organization.

As the session proceeds and the facilitator leads the team through identifying the key determinative predictors and indicators of the situational variables, much debate about key variables ensues. Projecting the model on a screen as it is being developed provides a way to focus the discussion on specific issues, data, and opinions, while avoiding unproductive *ad hominem* debates. In addition, it may provide an environment that can encourage greater participation from reticent analysts. Consensus may not be feasible, but the model makes it possible to locate specific areas of agreement and disagreement and to determine the implications of this disagreement on the outcome of the model. Where there is disagreement about critical model variables, the areas of disagreement can be used to specify the requirement for additional intelligence collection.

Throughout the session, a note taker records choices, issues and rationales for decisions to be included with the model as a history, which can help future users understand the logic underlying the model. At the end, we invite the group to review the model after a day or more – a process that can iron out wrinkles and spot deficits. Of course, many other social dynamics are managed in this process, but these are the highlights.

We illustrate the model development process described above using a hypothetical example based on actual models. In this example, the analyst must predict a leader's response to a national strike.

The fist step is to identify the possible leader responses. The states defined in this example are:

- Leave the country;
- Make concessions to end the strike;
- Hold a voter referendum in agreement to end the strike;
- Allow a regional organization to arbitrate the strike;
- Wait out the strikers; or
- Repress the strikers using violence when necessary.

We also define the leader's strategic objectives and develop a probabilistic relationship between the objectives and the hypothesized actions. The leader's objectives often range from "staying alive" to "becoming an international power". These states for the leader's objectives are clearly not mutually exclusive so we define the objectives variable to be the *primary* objective of the leader.

When a model is being developed, significant effort is made to identify possible situational variables that might change the outcome of the leader's decision. Once the possible situational events have been discussed and prioritized, key events are picked and added one at a time. After each variable is added, we conduct several "what if" analyses (changing situational outcomes) to see if the "model" makes sense in these different situations. In essence we are comparing the probability calculations based on their assessments with their gut instincts about what these values should be; coherence of judgments has often been written about as a strength of probability theory, we use it with the experts. (Lindley et al. 1979) When these analyses reveal errors or inconsistencies in the predicted probabilities, appropriate changes are made to the model. (Note, we have never seen this approach discussed in the literature but have found it critical for keeping the experts involved in the model building process. This approach builds there confidence about the credibility of the model while switching their tasks frequently so as to keep their minds fresh.) Additional variables are added with interspersed "what if" analyses, subject to the time constraints for the model development process. Figure 1 shows the national strike model with the added situational variables (one-and-a-half days of the two-day session are typically completed by this point.)

3 REPRESENTING LEADER PERSONALITY

A substantial body of research recorded in both the psychology and political science literature has focused on the cognitive processes leaders use to perceive and understand the political environment, predict the actions of adversaries, generate and evaluate courses of action, make and implement decisions, and receive and process feedback on the outcome of these decisions. This research has placed bounds on the rationality of human actors (Simon, 1957; Rosati, 2001) and has documented heuristics and their concomitant biases in perception (Jervis, 1976), understanding of uncertainty (Kahneman, Slovic, & Tversky, 1982), and social judgment (Nisbett & Ross, 1980). This research indicates that a leader's perceptions of the situation may be a more potent predictor of action than objective

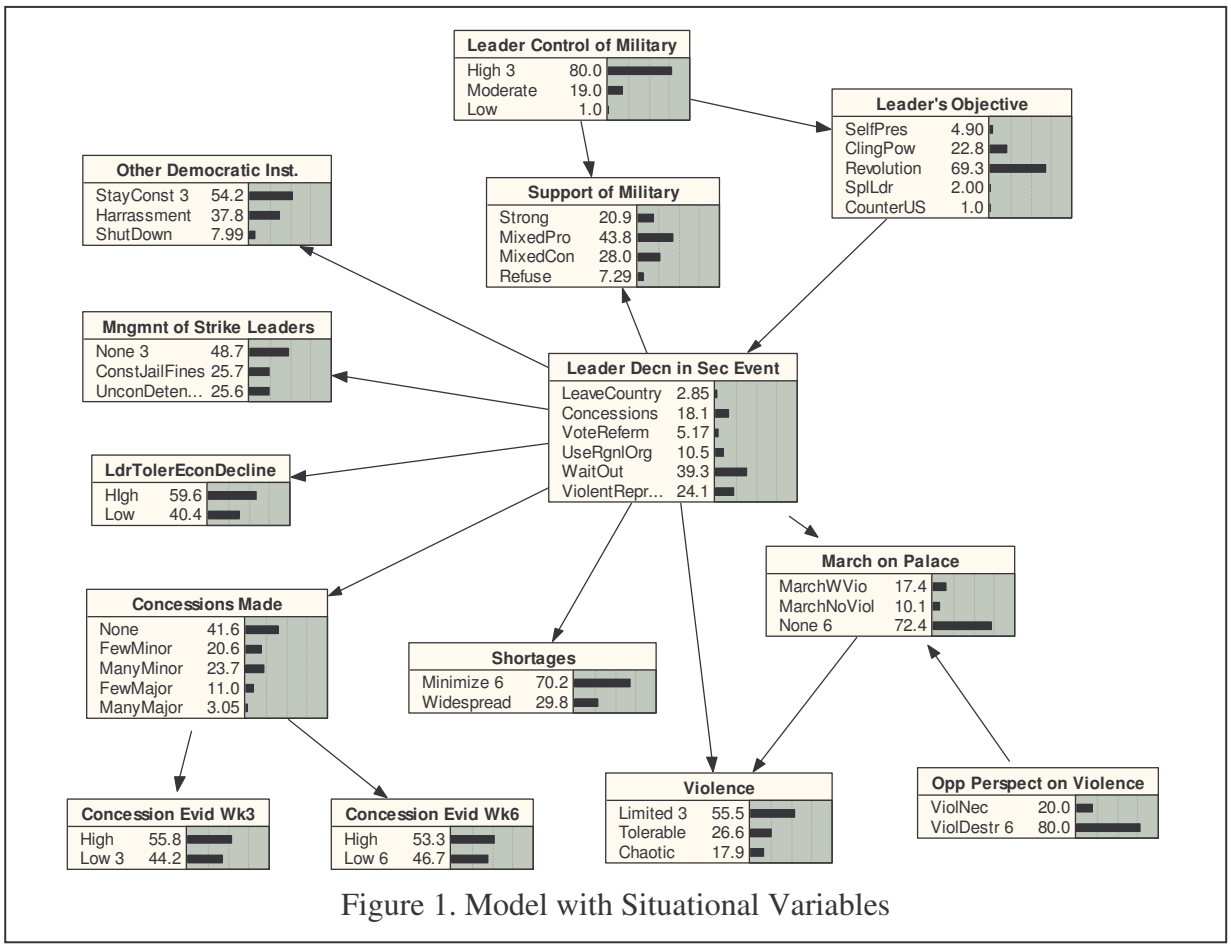

Figure 1. Model with Situational Variables

reality. It also suggests that methods to forecast leader policy decisions should consider such factors as beliefs, cognitive capacities, personality, and response propensities.

Hermann (1999) has attempted to characterize the interactions among several personal variables related to the actions of political leaders: (a) Belief that one can influence or control events, (b) need for power, (c) conceptual complexity, (d) self-confidence, (e) task focus and problem solving vs. relationship building, (f) general distrust and suspicion, and (g) in-group bias. These variables were combined to define leadership styles organized around the following three questions.

How do leaders react to political constraints in their environment? Do the respect or challenge them?

How open are leaders to incoming information? Conversely, how selective are they in their use of information to guide their actions?

What are the leaders' reasons for seeking their positions? Are they driven internally or by relationships with their constituencies?

For example, according to Hermann (1999) leaders' reactions to political constraints are determined by their belief that they can control events and their need for power. Individuals who are high in both of these traits are more likely to challenge constraints that the political environment places on them. Conversely, individuals who are low on these traits will tend to respect constraints. Individuals who are high in one trait, but low in the other will also tend to challenge constraints, but may not be as comfortable or successful in doing so.

Psychological research has demonstrated that personality variables describe differences between individuals on both cognitive and non-cognitive dimensions. Although there are many potential attributes that can characterize individual differences, a substantial body of research has shown that five general personality dimensions can summarize most of these traits. In a review of the literature on personality structure, Digman

(1990) summarized the growing concurrence within the psychological community regarding opinions concerning the structure of the concepts of personality, as well as in the language of personality. Early efforts to define a taxonomy of personality attributes have let to the development of a general structure that has unified several earlier theories. The result of this research, termed the five-factor model of personality, provides general personal variables with the potential to predict behaviors that are of interest to this project.

The five-factor model reflects the relationships among the most commonly used psychological dimensions. Factor analysis of these measures resulted in the identification of a common five-factor solution. These are the five factors which when taken together they provide a good approximation of what personality structure represents.

Extraversion. Extraversion is characterized by a social rather than a misanthropic personality. The extravert is outgoing rather than introverted and expresses confidence rather than timidity.

Agreeableness. This factor is indicated by general friendliness, rather than indifference to others. The agreeable individual is docile rather than hostile and is compliant to others' wishes.

Conscientiousness. Conscientiousness is the most ambiguous of the five factors. It can be seen as educational achievement or as will or volition.

Neuroticism. This factor reflects anxiety and dependence, rather than adjustment or independence. The scale for this factor is often reversed so that the factor assesses emotional stability.

Openness. Openness is a reflection of an inquiring intellect. Individuals who are high on this factor tend to be flexible and rebellious, rather than conforming and subdued.

Our approach to account for leader personality combined these two approaches from political science and psychology. After a detailed review of the personality literature and a consensus session with some of the leading researchers, we identified the following variables from the political psychology literature: positive image of others, internal locus of control, need for power, conceptual complexity, general distrust and suspicion, and acceptance of risk. (Sticha et al., 2000) From the personality researchers within psychology, the emphasis was on the five-factor model (Costa and McCrae, 1985). Our early attempts at model building demonstrated that the leadership analysts were more familiar and comfortable with the concepts from political science than the five-factor model. However, the five-factor model has substantial research backing it up, as well as validated assessment instruments. In an effort to synthesize user acceptance and empirical foundations, we decided to integrate the two sets of personality factors.

Psychologists at HumRRO related the 30 facets from the five-factor model of personality to the six leadership variables from political science/political psychology. The facets are the second tier elements of the five-factor model; each of the five factors has six facets. Table 1 shows the relationships established between the two models. A minus sign (-) to the left of a facet indicates an inverse relationship between that facet and the corresponding leadership variable.

The second major element of the personality model is the incorporation of data and associated error. There are several ways to report and assess data. The NEO (a commercially available personality test with a form for knowledgeable informants) is a well-known, validated measure of the facets. Profiler+ (Young, 2001) is a content-analysis approach that analyzes first-person verbalizations according to Hermann's (1984) personality theory of leadership. Finally, HumRRO psychometricians developed a short, third-party evaluation form based on our variables. The estimated error of each kind of assessment is considered in the model.

The third major element of the personality model specifies how it should be connected to specific hypotheses about leader actions. To make this connection, we created a set of intervening variables from the political psychology literature that help express the relationship of traits to actions. The following six intervening variables link actions to personality, in that they can be considered to be both action characteristics and behavioral proclivities.

- Conflict versus cooperation (regarding opponents);
- Follow through required versus not required;
- Consistent with position versus not consistent;
- Unilateral versus collaborative (regarding colleagues);
- Substantive versus protocol; and
- Challenges constraints versus no challenges.

Table 1. Linkage Between Two Personality Models

Political Psychology	Facets from 5-Factor Model
Positive Image of Others	Positive Emotion (Extraversion) Trust (Agreeableness)
Internal Locus of Control	(-) Vulnerability (Neuroticism) (-) Depression (Neuroticism) Assertiveness (Extraversion) Competence (Conscientiousness) Self-Discipline (Conscientiousness)
Need for Power	(-) Compliance (Agreeableness) Achievement Striving (Conscientiousness) Assertiveness (Extraversion)
Conceptual Complexity	Openness to Ideas (Openness) Openness to Values (Openness) Openness to Actions (Openness)
General Distrust & Suspicion	(-) Trust (Agreeableness) Angry Hostility (Neuroticism) (-) Warmth (Extraversion) (-) Compliance (Agreeableness)
Acceptance of Risk	Openness to Actions (Openness) (-) Anxiety (Neuroticism) (-) Deliberation (Conscientiousness) Excitement Seeking (Extraversion) (-) Vulnerability (Neuroticism)

HumRRO, along with Intelligence Community psychologists estimated the quantitative relationship between the personality traits and the six behavioral proclivities; these correlations are embedded in the model. When we model a particular decision, we draw dependencies between hypothesis (decision) node and the action characteristics, thus specifying which proclivities are relevant to the decision. The process recognizes that not every proclivity relates to a particular set of hypothesized actions.

4 ADDING PERSONALITY

To incorporate the Subject's personality into the model, the analyst must assess the Subject's position on personality measures and relate the variables representing action characteristics (or behavioral proclivities) to the hypothesized actions. The relationships between measures, personality variables, and linking variables are fixed, based on previous research, analyses by HumRRO researchers, and estimates by Intelligence Community psychologists.

Figure 2 shows the resulting model after personality was incorporated. The situational model (on the left) is connected to the personality model (on the right), using four of the six action characteristics. Each link between the hypothesis node and one of the action characteristics is associated with a conditional probability table that describes how the hypothesized actions differ with regard to that specific characteristic. The fact that two characteristics were not linked to the hypothesis node indicates that the actions did not differ with regard to those two characteristics. In addition, the analysts enter as much personality information as is available on the Subject. The assessments of the analysts are shown by the probability distributions in the personality nodes on the right side of Figure 2. The results of this effort modify the action probabilities from the ones that were based on situational factors only.

5 PERFORMING "WHAT IF" ANALYSES

"What if" analyses are defined as tests of a model made by setting model parameters to see (a) how the changes in antecedent variable affects the outcome, and (b) if the results at that setting make sense. In addition, comparisons are made across multiple "what if" tests to see how changes in antecedents affect the relative results of the model from different settings and how they may make relative sense.

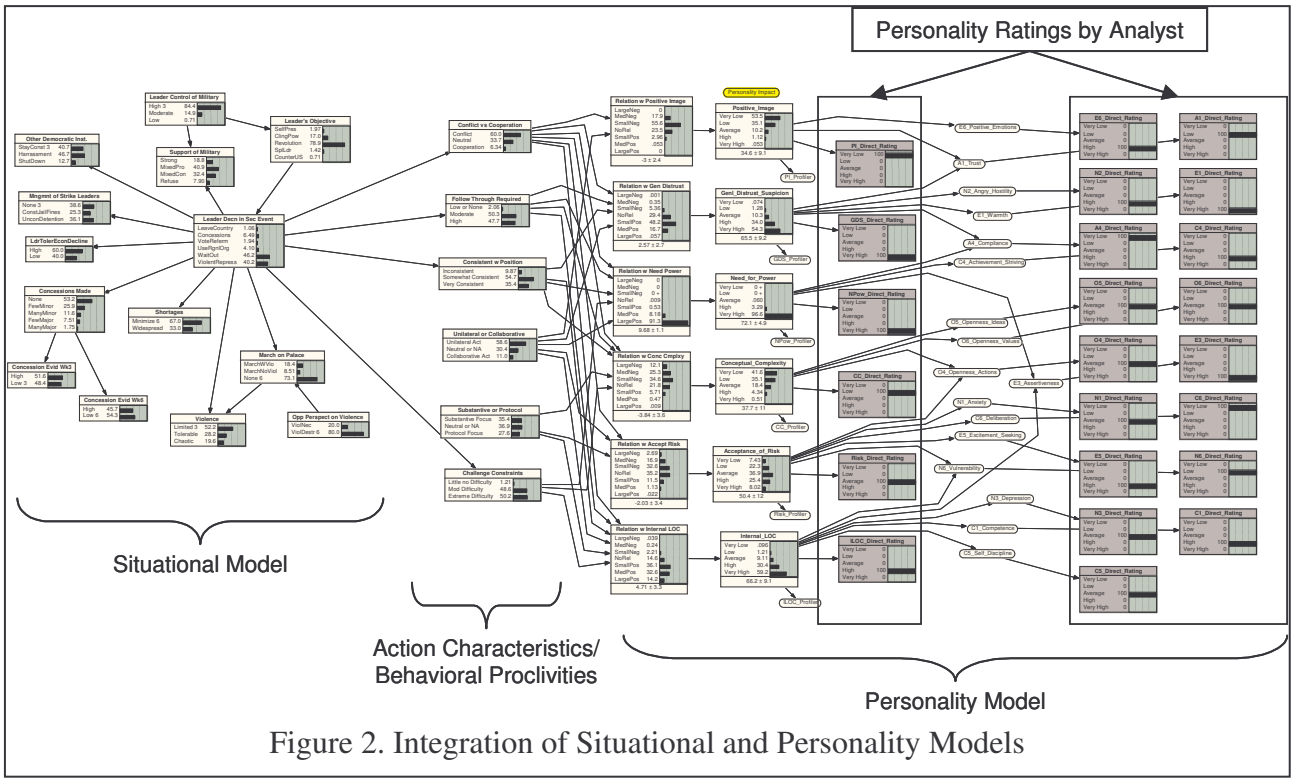

Figure 2. Integration of Situational and Personality Models

For example, we would move the probability setting on one of the situation variables from one extreme to another to observe the impact on the probabilities of the hypothesis. We would also compare the results of this analysis to those for other variables, first singly to observe the relative magnitudes of effect one variable makes with respect to the others. Then we compare the effects introduced by interactions among the situation variables. When we find results that do not make sense, we check for changes in the probability tables that would produce the results the analysts feel make sense. Sometimes, the analysts desire to make the changes to the probability tables; other times, they prefer to leave the probability tables as they were since they make more sense than the desired results. The software is very flexible in handling these calibrations and instantaneous in revealing results of multiple "what if" propositions.

6 ASSESSING THE SENSITIVITY OF VARIABLES

In most Bayesian network software implementations, the user can designate a node and calculate the mutual information between the selected node and other nodes, one at a time. This calculation identifies (based on the mutual information metric) the relative impact that changes in the probabilities of other notes will have on the probabilities of the designated node.

7 SUMMARY AND CONCLUSIONS

In the last two years we have built the following models while working with teams of intelligence analysts and expert consultants:

- Invasion
- National strike
- Domestic threat *
- Missile testing
- Support for Global War on Terrorism
- Dispute over contested territory
- Peace/cease-fire negotiation *
- Use of WMD *
- Monetary devaluation *
- Establishment of a new caliphate*
- Operational planning in a terror cell*

Those models marked with an asterisk (*) are forward-looking models for which the answer was not known when the model was built. The models vary in many ways:

1. The number of hypothesis nodes (discussed earlier),

2. The number and complexity of causal relations from nodes addressing US and other major country actions to the hypothesis nodes,
3. The number of relations between perceived reactions of the US and other major powers and the hypothesis nodes, and
4. The number and complexity of indicator variables that have arcs entering them from the hypothesis nodes

We plan to compare the predictions of these models to actual events to estimate the validity of the models. The models without asterisks were post-dictions of historical events. Although these models cannot be validated in the same sense as the forward-looking models, we will investigate the extent to which a model of a historical event can be applied to a similar situation with a different Subject.

Some of these models have proven very useful and resulted in published papers for consumers within the intelligence community. Other models have less useful. No group has said the model building process was a waste of time.

The APOLLO program, underway for four years now, is currently delivering a software-based tool to intelligence analysts that supports the development of Bayesian network models to address a wide range of situations in which a leader is making a decision, the effects of which will evolve over several weeks/months. A library of models has been under development during this time period as a proof of concept and as a resource for analysts to use as part of bootstrapping their efforts. The models span many different topic areas (invasions, national strikes, missile testing, weapons of mass destruction, and economics).

Acknowledgements

The authors wish to thank the anonymous reviewers and all of the experts who have participated in this process.

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