CHAPTER XX

Granular ABM Simulations for Operational Use: Forecasting and What-if Experiments with Models of Kandahar and Kunduz

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ABSTRACT

We will report and discuss results of an effort to adapt country-level modeling techniques developed in DARPA's Integrated Crisis Early Warning System (ICEWS) program to produce forecasts and analyses at a much more granular level, focusing on districts in Kandahar and Kunduz, Afghanistan. The challenge of this work in Afghanistan is not only to bridge theoretical models to operational needs at an appropriate level of granularity, but also to overcome modeling obstacles that are unique to Afghanistan, at least in comparison with the national models that were the focus of the ICEWS project. We will briefly describe our modeling methodology, including specific steps taken to account for the challenges listed above, before moving to a analysis of the results of our experiments. Findings and forecasts will be reported from baseline models of Kandahar and Kunduz provinces built with the most recent open-source data available as well as several "what-if" and "in light of" analyses that will explore counterfactual futures of Kandahar and Kunduz provinces associated with an ISAF drawdown, militia disarmament, and a string of political assassinations.

Keywords: agent-based modeling, Afghanistan, forecasting, social sciences, counterfactual

1 OPERATIONAL USE OF AGENT-BASED MODELING

One of the major tasks within the Human Social Cultural Behavioral (HSCB) modeling field is to find intersection points between social science research and operational needs of military commanders. While the fields of international and domestic conflict have a rich history in the social sciences, linking conflict theory with operational use has proven challenging. One of the major reasons for this difficulty results from the lack of correspondence between levels of analysis used in social science research and the needs of military commanders. Operational needs require a very precise rendering of actors, geography, and local politics. Attempts within the social sciences to understand and forecast conflict often fail to achieve the necessary granularity and precision. High-level theories that attempt to explain the onset, persistence, or cessation of destabilizing events often fail to meet the needs of operators tasked with assessing the likelihood of a rebellion in a particular country at a particular moment in time or identifying possible second and third order effects of such a rebellion.

As part of DARPA's Integrated Crisis Early Warning System (ICEWS) program, we developed models that sought to bridge the gap between social science capabilities and operational needs for seven countries in Southeast Asia. These models integrated well corroborated social science theories with a wide variety of country-specific data taken from quantitative data sets, qualitative and monographic reports, and input from subject matter experts. As a result, these models were able to successfully to produce rolling monthly forecasts about specific events of instability as well as answer specific questions about the nature of these events: the causal mechanisms driving the instability, the actors most likely to be involved, the short and long term effects, and possible ways to mitigate the instability. Additionally, the models were able to provide rapid and flexible what-if experimentation enabling operators to ask specific questions about the future of a country if the political environment changes. See Alcorn, Garces, and Hicken (2011) for an in-depth discussion of the modeling methodology and a specific case study of the simulation of Thailand in 2010. These forecasts and analyses focusing on specific events generated significant interest within the operational community precisely because model outputs finally began to align with operational needs.

2 CHALLENGES OF DISTRICT-LEVEL FORECASTING IN AFGHANISTAN

While the international community recognizes the *de jure* sovereignty of the Afghani government, anarchic conditions prevail in much of the country. The national government competes with local elites and tribal factions for legitimacy within the context of the conflict between the Taliban and the International Security Assistance Force (ISAF) and a political system saturated with corruption at every level. At this level of granularity, gathering both theories and data that are directly relevant to the problem becomes increasingly difficult. Although theories of

constructivism and identity-politics that form the theoretical core for our models apply to local interactions in Afghanistan where identities, be they religious, ethnic, tribal, or political, prove to be very important in politics, these identity groups are operating in a very different political environment than in our past work. As opposed to countries with relatively well institutionalized political systems, there are no clearly defined "rules of the game" in the way politics in Afghanistan is conducted. Weakness of national institutions leads to a concentration of politics at the local level as opposed to the national level. Few Afghans look to Kabul for political directives, opting instead to give political allegiance to tribal elders, district leaders or other local elites. One way we attempted to tackle this theoretical challenge was to adapt the Dynamic Political Hierarchy (DPH), which had been successful in our national ICEWS models, into a more granular district-level model of Afghanistan.

2.1 Theoretical Challenges

The Dynamic Political Hierarchy (DPH) is a set of routines implemented in PS-I that endogenizes the nature of political action by agents affiliated with different groups. The DPH identifies and monitors changing relationships among groups of agents based on the degree of overlap of identity affiliations for agents. Each agent has a set of attributes which may contain more than one "identity" (politically relevant affiliation). The DPH module then uses that information to update relations among groups to reflect changing propensities of different groups to challenge the political status quo with different intensities and different commitments to legality.

An in-depth and theoretical discussion of the DPH is available in Lustick, Alcorn, Garces, and Ruvinsky (2010), but at a basic level the DPH divides different groups in society into four levels—Dominant, Incumbent, Regime, or System—based on their proximity to the center of political power. The dominant level is occupied by the group with the most political influence over society at that moment in time. The Incumbent level consists of those groups with strong political ties to the Dominant group. The Regime level includes groups that are somewhat alienated from the political center but maintain, for the most part, a commitment to contesting politics within a legal framework. Groups that are very alienated and potentially resorting to violent or other illegal forms of political contestation are found in the System level.

The DPH was developed during the ICEWS program to represent well institutionalized political systems at a national level. In countries with strong political institutions there tend to be pretty clear signals about which groups control different apparatuses of power and which groups are alienated or excluded. However, political institutions in Afghanistan are weak if they exist at all and there is little uniformity or agreement across districts and provinces about the relative position and strength of the various political groups. Political actions and allegiances exist in Afghanistan primarily at the local level.

In order to account for this in our models of Kandahar and Kunduz, we changed the structure of the DPH so that it would operate at an individual level instead of a

national level. Instead of calculating the DPH hierarchy in the context of all of the agents in a given model, it is calculated subjectively for each agent based on its local environment. This implies that agents can disagree on which group is dominant in a given moment in time and which groups should be considered the friends or foes. This granular implementation of the DPH also allowed for a more nuanced technique for operationalizing violence in the models. Attacks can originate from either the top of the political hierarchy (predatory violence) or the bottom of the hierarchy (subversive violence). These different operationalizations of violence represent the different reasons for attacks in the real world. For example, the Taliban can cause violence for predatory reasons (e.g. to eliminate challengers) or subversive reasons (e.g. to wear down the stronger enemy). The linked theoretical constructs of the DPH and violence help us to produce results, analysis, and visuals that are relevant at the operational level.

2.2 Data Challenges

Besides the theoretical challenges associated with a more granular agent-based model, we also encountered several challenges in collecting and using different types of data, both qualitative and quantitative. In order to build our model as accurately as possible, we had to find ways to gather low-level data on tribes, elite networks, parochial groups, small militias, and other armed groups. Open-source data gathering for the Afghanistan modeling project has been unique for us in at least two ways. First, due to the international presence and interest in Afghanistan there is a vast amount of different data sources available to us during the modeling process, many at very detailed levels of granularity. Second, due to the volatile situation on the ground in Afghanistan, much of the data we have is incomplete and conflicts with other data sets supposedly reporting the same type of information. We have had an opportunity to utilize much more granular data sources (most notably ethnic, tribal, and sub-tribal data) but with less confidence in the integrity of the input data than we have had in past modeling endeavors.

One of the implications of the increased granularity of provincial models is an increased importance of local elites and the networks in which they operate. This can be a particularly daunting challenge because information regarding these elites, their affiliations, their relative influence, and their connections to each other are extremely dynamic and are not regularly documented, particularly not in a data friendly format. Our strategy for tackling this problem has been to seek out recently published monographic studies that explore local politics and extract the important actors and the networks in which they operate. This process worked relatively well for the Kandahar model where studies by Carl Forsberg (2010) allowed us to create a very elaborate and well documented elite network in which we have a relatively high degree of confidence (though assassinations of three prominent leaders over the course of the modeling process served as a reminder of how dynamic the environment can be). In Kunduz, on the other hand, we were not able to find comparable studies and had to settle for a somewhat more abstract elite network.

Another major implication of more granular virtualization modeling is the

necessity to account for identity affiliations that affect local politics, even if their role on a national scale is minimal or does not get much attention. In the case of Afghanistan, tribal and sub-tribal affiliations are crucial factors when trying to understand political relations as well as support for ISAF or the Taliban insurgency. For this modeling effort we were fortunate to have access to GIS data that provided geo-spatial specifics about Kandahar and Kunduz. One problem, however, with the use of this data for geographic distribution of tribes is that they only provide details about the most prevalent tribal group in a given region. Particularly in urban areas, we know there is a distribution of tribal affiliation that is overlooked by the GIS information. In some cases, we were able to supplement the geographic data with other data sources that provide information about minority tribes, but this was generally the exception, not the rule.

A related challenge is the fact that while tribal dynamics are an important aspect of local politics in Afghanistan, there are subdivisions within tribes (sub-tribes, kinship networks, etc.) that are also very important to individuals but virtually impossible to find data about it in any comprehensive way. To address this challenge, we have included parochial groups in the models, which are not intended to correspond to particular groups, but which represent these low-level affiliations.

Lastly, small, armed groups, whether they are one of the many militias operating throughout Afghanistan or part of the insurgency, are a crucial element to political life in Afghanistan. Due to their relatively small size and high degree of mobility, however, these groups prove particularly challenging to incorporate into a virtualization model. As with information about the elite networks, we must rely almost entirely upon input from experts whether it is through surveys or through monographic studies (Forsberg, 2009) that have been published in the open-source community. These qualitative sources can give us a good sense of where the groups are operating but inevitably, the inputs to the model for groups such as these are best guesses based upon the information available.

3 RESULTS

The Kandahar and Kunduz models were each run one-thousand times to produce a distribution of counterfactual futures for each province. This distribution is used to draw conclusions about probable, possible, and plausible outcomes, analyze group behavior, and conduct what-if experiments. For more information on our experimental process, see Alcorn, Garces, and Hicken (2011).

3.1 Baseline

The initial distribution of 1000 runs for the Kandahar and Kunduz models are used to generate a baseline of model results that can be used to describe broad trends, compare between provinces, and help validate the model.

According to the model, in both Kandahar and Kunduz the Taliban as well as criminal and corrupt elements of society are the most dominant political forces.

They are somewhat more prevalent in Kandahar than in Kunduz, though they are countered by the strong presence of the International Security Assistance Force (ISAF) and the ANSF (Afghan National Security Forces) that are much stronger in Kandahar than in Kunduz. In Kunduz, the main political forces strong enough to oppose the Taliban are ethnic groups, particularly the Uzbeks, Tajiks, and Turkmen, that are competing for influence and power.

In order to validate our models, we asked an expert to create a ranking on metrics he created himself. We then operationalized these four metrics in our model and collected the results for each district in both Kandahar and Kunduz. We used this ranking to determine how accurately our model reflects the reality of the level of ISAF activity, level of Improvised Explosive Devices (IEDs), predation by official and unofficial security forces, and the presence of criminal and insurgent activity.

In Figure 1 below, we display the results of a Kendall's Tau matched pair comparison between the model output of the Kandahar and Kunduz models and the subject matter expert's assessment of these two provinces across the four metrics. This matched pair comparison ranks all of the districts in a given province on each metric according to our model output and according to the expert assessment, then compares our model ranking to the experts ranking. To do so, each district is compared to every other district and if the relative position of them is the same for our model and for the expert assessment (e.g. District A is ranked higher than District B by both measurements) it is a match. If the relative position of the two districts is different (e.g. the model ranks District A higher than District B, but the expert ranks District B higher than District A), it is a miss.

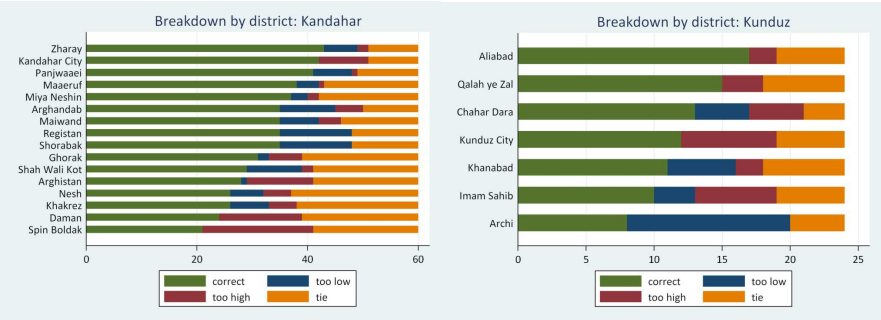


Figure 1. Kendall's Tau matched pair comparisons of Kandahar and Kunduz model output with a Subject Matter Expert's assessment

Misses are disaggregated in figure 1 to see whether we ranked the district "too high" or "too low" compared to the expert assessment. "Ties" occur when the expert ranked the two districts the same on a scale of 1-5 for a particular metric, so relational position can't be assessed. For Kandahar, 16 districts are assessed against each of the other 15 districts across 4 metrics, giving a total of 60 paired comparisons. In Kunduz, 7 districts are assessed against each of the other 6 districts across 4 metrics, giving a total of 24 paired comparisons.

According to this metric, our models have performed reasonably well. In Kandahar, no district has more than 33% misses with many districts displaying a match rate of well over 50% compared to the expert assessment. In the case of Spin Boldak, our worst performing district, some of the disagreement between model output and the expert assessment can be attributed to the fact that significant cross-border influence from Pakistan affects Spin Boldak. In the model, this is represented by Taliban influence and instability in Spin Boldak, however the expert did not incorporate cross border influence in his assessment of the district.

The Kunduz model also performed well on this metric, despite having a small sample size of districts. Only the district of Archi has a greater number of misses than correct paired comparisons. Data scarcity helps to explain the weaker success rate of the Kunduz model, particularly in Archi. Kunduz is a province in Northern Afghanistan and until recently was not a primary focus of American or NATO attention. This means far less data has been collected and far fewer experts are publishing detailed monographs on the situation in Kunduz. Upon reviewing the expert assessment, it became clear that the expert was aware of Archi's increasingly prominent role as a Taliban command and control center. Despite extensive research during our model creation process we did not uncover this information, which led our model to consistently underpredict the metrics in this district.

3.2 What-if?

One of the comparative advantages of our modeling framework is the ability to change one parameter in the initialization of our model and rerun the simulation. In July and August of 2011, three major powerbrokers in Kandahar were assassinated, one of whom, Wali Karzai, was the half-brother of the President of Afghanistan and governor of Kandahar (Rubin and Shane, 2011). His far-reaching influence in the legal and illegal side of Afghan politics was well known, and we would expect his assassination, along with the other two key figures, to impact political dynamics in Kandahar.

In a second experimental condition, we removed the agents associated with the International Security Assistance Force (ISAF) in order to operationalize a drawdown of US and International Forces in Kandahar (Landler and Cooper, 2011). As opposed to the assassination example which demonstrates how the models can be used to respond quickly to changes on the ground beyond the control of operators, simulating a drawdown of US forces is an example of how the models can be used to test policy outcomes before they are implemented.

After running the model in the baseline and two experimental conditions (see figure 2), we analyzed the data and found that the group that suffered most between the baseline and assassination conditions was criminal/corrupt while the groups that benefited the most were ISAF, Afghan National Army (ANA), and Afghan National Police (ANP). The criminal/corrupt group is mostly centered on the government elite network in Kandahar, and its weakening represents a reduction in the influence of the elites. On the other hand, a separate network of elites representing the influence of ISAF in the province benefits greatly from the assassinations.

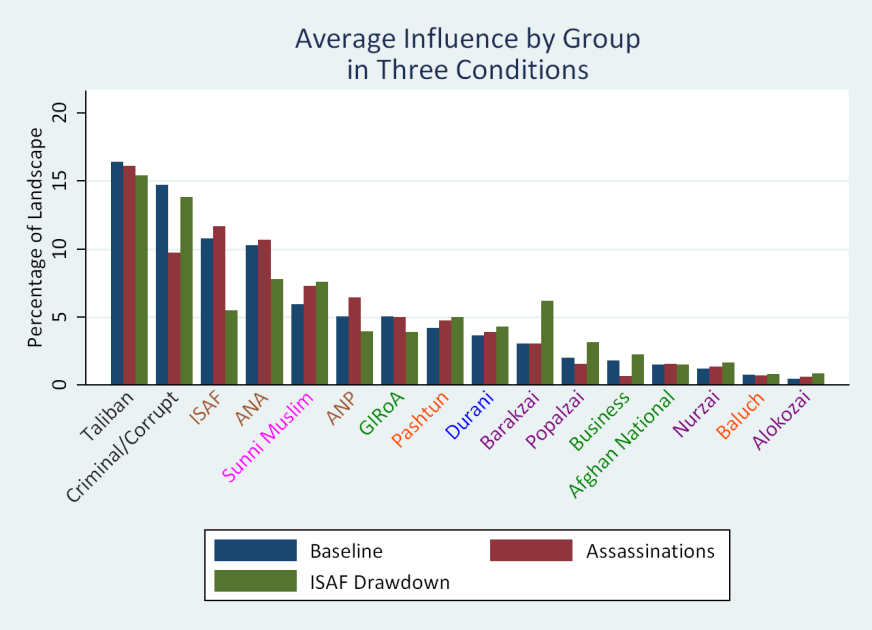
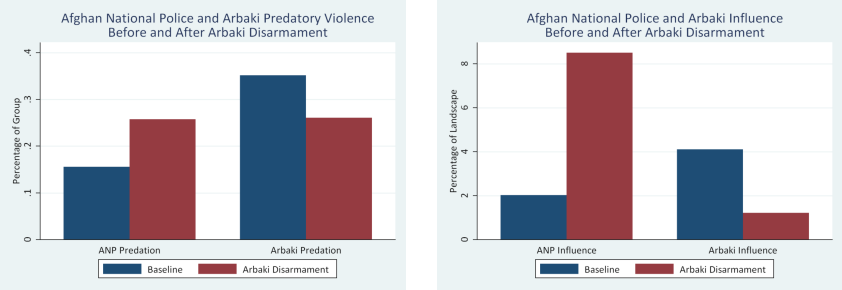


Figure 2. Average influence by group in Kandahar under three experimental conditions (Colors indicate group-types)

In the second experimental condition where the ISAF elite network is weakened and the groups that benefit are mostly tribal (namely the Barakzai and Popalzai tribes) and not surprisingly, ISAF, ANA, and ANP all suffer from the parameter change. Although the Taliban and corrupt group weakened very slightly, their continued presence helps highlight the endemic influence in Kandahar. The increased influence of the tribal groups is most likely because the tribal network is in the best position to take advantage of the power vacuum left by ISAF.

Although the parameter-change may not change the dynamics in the model during every run, there may be telling differences between the baseline and experimental conditions that help us understand or at least hypothesize about the real world. In Kunduz, we ran a similar set of experimental conditions testing the ISAF Drawdown as well as a more specific condition operationalizing the drawdown of local militias in Kunduz known as arbaki. The arbaki are local militias found in Northern Afghanistan serve as an unofficial security force in the absence of strong ISAF and ANSF presence, but are notorious for corruption, kidnappings, theft, and killings. Afghanistan government officials have attempted to either disband these groups or integrate them into the Afghan National Police with limited success (Rivera, 2011). Our experimental condition sought to explore the effects of weakening the Arbaki influence and shifting a portion of that influence to the ANP.

In the arbaki disarmament condition, the ANP benefits greatly from the integration of these illegal militia units into their formal command structure. No other group sees any growth in influence as a result of disarming the arbaki, with the exception of a slight increase in the Taliban's influence. In the second condition, on the other hand, the ISAF drawdown leads to a decrease in both influence of



Taliban and corruption as political strength shifts towards the ethnic groups in Kunduz.

Figure 3. Comparison of predatory violence and arbaki influence between baseline and disarmament conditions

Figure 3 further investigates the arbaki disarmament by comparing predatory violence and arbaki influence between the baseline and experimental condition. The chart on the left compares the per capita predation of the ANP and a combination of the arbaki groups in the baseline and the arbaki disarmament condition and on the right we are comparing the influence of the two groups in each condition. On the left, note that the shifts in per capita predation are of about equal magnitude (ANP increase matches arbaki decrease), so the overall predatory patterns of these two groups combined is not changing significantly. However, the right chart shows a disproportionate increase in ANP influence, compared to the decrease in arbaki influence. So while the per capita predation stays relatively steady, we see a 21% increase in absolute predation in the arbaki disarmament runs, due to the spike in ANP influence.

4 CONCLUSIONS

The task of forecasting political outcomes is an imperfect science and always will be. Social science theory attempts to explain some of the mechanisms that drive political outcomes and data are collected in vast quantities to provide as much information as possible to an interested researcher. However, these theories will always fall short of explaining definitively why things occur and leave uninvestigated a great portion of human interactions. Collected data is flawed and incomplete, inevitably leading to only an approximation of reality. The purpose of forecast modeling then, in our opinion, is not to aim for the holy grail of perfect

prediction but to provide users (experts, analysts, operators) with a tool that helps them think systematically about the future. Considering a distribution of possible outcomes with varying likelihood instead of point predictions or a small sample of idiosyncratic scenarios is one step in this direction. What-if capabilities that allow users to change model inputs and re-run experiments to observe how forecast distributions change encourage flexible thinking about the future and contingency planning. Model validation and transparency allow for users to trust in the theory, data, and operationalizations that form the foundation of the models. In the end, though, a forecasting tool is not useful unless it aligns with users' needs. If models are designed to be tools for an operator to use, instead of an exercise in social science research, they have to speak to particular problems in specific regions at precise moments in time.

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