VIRTHAI

A PS-I Implemented Agent-Based Model of Thailand as a Predictive and Analytic Tool[1]

In this paper we report on the deployment of "VirThai," a virtualization type agent-based model of contemporary Thailand, to produce predictions for events of political and policy interest over the course of 2011. Predictions are inferred from distributions of outcomes across large batches of counterfactual futures. We will assess the performance of the model as a forecasting tool, as a technique for understanding the mechanisms that drive political outcomes, and as a means for stimulating new insights or lines of reasoning among country experts.

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The three primary aims of science are description, explanation, and ultimately, prediction. We seek to describe accurately the features of phenomenon under study. From these descriptions and observations, we generate puzzles or questions that need explanation. We then try and discover those explanations—to understand why things look/behave/evolve the way they do. Finally, we draw on our models of how and why the world works as it does to generate predictions about how it behaves in other contexts (e.g. the future, under different conditions, with more or less of a given input, etc.).

Agent-based modeling has emerged as a tool with the potential to assist scientists in carrying out all three of these objectives. One of the challenges social scientists face is the complexity of our subject matter, making it difficult to describe, let alone explain, the phenomena in which we are interested. In principal, agent-based modeling provides researchers with the capacity to model complex relationships more accurately, capture the nuances of various theories more precisely, and evaluate the validity and predictive power of those theories more convincingly.[2] In short, for agent-based modeling to engage with and contribute to relevant debates in the social sciences and public policy it needs to be able to answer more complex, nuanced questions.

The challenge for modelers, of course, is that detailed and accurate representations of particular problems require added levels of complexity within the model, which in turn makes model analysis and explanation increasingly difficult. In Axelrod's words, "when a surprising result occurs, it is very helpful to be confident that we can understand everything that went into the model." As more and more theory and data are included in a model, more sophisticated methods of validation, verification, and explanation are required to meet the burden of scientific inquiry.

In this paper, we will demonstrate that it is possible to develop agent-based models that maintain a high level of model transparency while seeking to represent, explain, and predict policy relevant, highly specific, political events. To do this we will explore a virtualization[3] model of Thailand (VirThai). The purpose of the VirThai model is two-fold. First, the model is designed to make monthly forecasts of violent and non-violent instability in Thailand. Second, the model is designed to serve as an analytic tool that allows for in-depth exploration of the possible future of Thailand, the mechanisms that trigger instability, as well as a means to conduct "What-if" experiments to explore how model outputs change if our understanding of the current state of Thailand changes or under certain test conditions.

The first two sections of the paper are devoted to the model creation process and model results. We will briefly detail some of the social science theory that instructs the model as well as the data that animates it, although much of the process must be left out due to space constraints. Afterwards we will leverage various visualization techniques to analyze the results of our distribution, make forecasts for the future, and explore the mechanisms that drive the outcomes.

In the final section of the paper, we will turn a critical eye toward the model and model outputs, as well as the promise and limits of agent-based models more generally. We will explore what the model says about the future of Thailand, both what is probable and what

is improbable but noteworthy, to determine how the model succeeds or fails in contributing new and relevant information into expert debate about Thailand. What, if anything, can our model offer to Thailand experts? Can exercises such as this one do more than just describe, can they be useful tools in analysis and prediction? Finally, we will propose possible future developments that might enhance the areas where country virtualization agent-based models can contribute to academia and public policy and address shortcomings identified by this experiment.

MODEL CREATION

The VirThai model used in this experiment has been developed over the course of several years and draws upon extensive work done using the PS-I modeling platform.[4] At a fundamental level, the model is a product of an intersection between theoretical claims and empirical data. To build a model intended to virtualize Thailand, we must draw on social science theory at the individual level, the group level, and the societal level to begin to approximate emergent political outcomes at an appropriate level of granularity. The model is then animated by available data about Thailand ranging from census information, to election results, to NGO reports.

The model creation process is an imperfect science for several reasons. First, while many well-substantiated theories of social interaction and political behavior are available in the various fields of social science, few, if any, are comprehensive and sufficiently specific to be translated easily into any type of model. Theories often answer some questions while leaving others unanswered, or even unasked. Theories also tend to answer questions broadly, while remaining silent on questions of degree or intensity. Finally, a theory is often only one of several competing claims about how the world works.

Data, while more tangible than theory, can be problematic as well. Even in countries with effective data-gathering institutions, data releases occur at varying time intervals and provide only a partial picture of the country in question. In countries where data are either not released or not collected at all, the picture of the country is blurred even further. Case study research, input from subject matter experts (SMEs), and other techniques can be and is used to fill in the gaps, but these often face the same shortfalls that theoretical claims do.

In the face of these obstacles associated with operationalizing theory and collecting data, our VirThai model is our best approximation of Thailand according to the theory and data available to us. Just as two traditional social scientists might observe the same world, develop theories and make predictions that could differ, a different team of modelers might take the same body of available theory and data and produce a significantly different model. The advantage of a formal modeling platform is not that it eliminates the biases of the social scientists but that it renders the experimental process transparent. The data we use, theories we leverage, and operationalizations we design are available to replicate, critique, or alter. We have chosen agent-based modeling over other types of formal modeling because it leverages multi-agent interactions to allow for non-linear and emergent outcomes from the combination of theory and data.

THEORIES AND THEIR OPERATIONALIZATION

Before analyzing model results and their implications, it is important to highlight several of the most important theories that frame the VirThai model. The first and foremost of these is the broad body of constructivist identity theory which has emerged from the largely defunct primordialist/instrumentalist debate as the leading theory to explain identity. At its simplest, constructivism posits that "individuals possess multiple identities, that different identities become salient in different settings and that the salience of one identity vis-à-vis another is often a product of the bearer's own choosing."[5] In addition to reflecting personal preferences, the salience of a particular identity at a particular time is also a product of the "performance" of that identity in relation to others in a virtual marketplace of identities.[6] This fluidity of identity helps to explain observed real-world outcomes where group affiliations and identities are not fixed and can, in fact, change very rapidly. Identifying with the "Red Shirts" in Thailand, for example, was unheard of a decade ago, and yet is an integral part of Thai politics today. Constructivists also highlight the "sticky" nature of both personal preferences and "performance" as a crucial limiter of the fluidity of identity change. In this way constructivism can capably explain both the persistence of identity affiliations across time and the speed with which these affiliations can sometimes change.

A recurring challenge of translating informal theory

into formal models is how exactly to operationalize a given theory or set of theories when every rule needs to be precise and defined. As an example, the VirThai model operationalizes constructivist identity theory by generating landscapes of agents each with a repertoire of available identities. In aggregate, the size and locations of these identities reflect our understanding of their size and locations in Thailand according to the most recent data we have available. As the model progresses, agents interact with one another, proliferating, abandoning, and sharing identities as environmental conditions change.[7] In VirThai, we refer to a subset of agents affiliated (actively or latently) with one identity as a group. As these identity transformations take place, the size, location, and composition of groups at an aggregate level can change dramatically. These changes are measured over time as model outputs that translate into various political outcomes that can, we propose, be applied to Thailand.

While constructivist theory is centered around agent-level interactions, the VirThai model also utilizes a combination of theories relating to group-level interactions, specifically theories of cross-cutting cleavages[8], nested institutions[9], and dynamic loyalties[10]. These theories combine to create what we have called the Dynamic Political Hierarchy.[11] The Dynamic Political Hierarchy (DPH) leverages these three theories to endogenize a system of overlapping group affiliations that determine the intensity of political conflict. It is not the aim of this paper to discuss in depth the theories involved and the intricacies of the DPH operationalization, but a short introduction will be helpful. During each time step of a model run, every group in the landscape is assigned a position in one of five hierarchical levels based on each group's direct or indirect connection to the top of that hierarchy. The top of the hierarchy, or the Dominant level, is occupied by the group with the most political influence. All remaining groups are assigned to the Incumbent, Regime, System and Non-System level based on the degree of direct and indirect associations with the Dominant and subsequent levels. A group whose membership contains a supermajority of agents associating themselves with both the group in question and the Dominant group is placed in the Incumbent level. A group that is weakly connected to the Dominant group but maintains a supermajority of agents connected to either Incumbent groups or the Dominant group is placed in the Regime

level and so on (for definitions of these levels, see Table 1). A supermajority has been used in this case, instead of just a simple majority, as a more stringent requirement for a connection between two groups. In the case of a small majority, there remains room for substantial contestation within the group surrounding affiliations and relationships with outgroups. Requiring a supermajority ameliorates this problem somewhat by requiring a stronger consensus.[12] As the model runs, groups regularly move up or down within the DPH as relative group strength and the size of overlap between groups change.
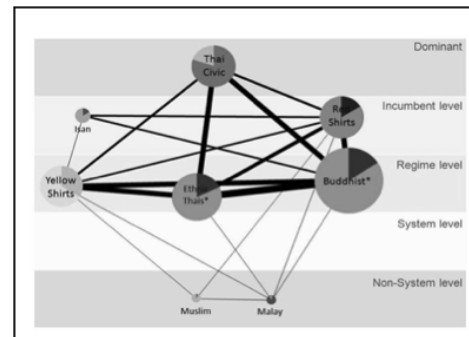

Figure 1

Figure 1 shows an example of the DPH for one time step in VirThai, represented as a network diagram. The vertical location of the center of each circle denotes where in the DPH that group is located (horizontal placement within a category is not instructive). The size of the circle represents the size of the group (how many agents are subscribed to the identity). The darker shaded portion of each circle represents the portion of the group currently mobilized (how many agents are activated on the identity). The thickness of the line between two circles represents the strength of the connection between the groups (how many agents are subscribed to both identities). The DPH assumes these different groups mobilize in different ways. Agents that consider themselves part of the top dominant or incumbent levels will lobby, those that consider themselves at the regime level will protest, and those below the regime level will attack (act violently). In the tradition of Juan Linz[13] and Ada Finifter[14], agents in a political landscape can move up and down in the hierarchy, demonstrating shifting degrees of loyalty to or alienation from the Dominant group, and choose different methods of contestation corresponding to different levels of that political hierarchy. This last example draws on a combination of theories involving

lobby, protest, and violence. Although the Dynamic Political Hierarchy dictates when agents should protest or become violent, it does not specify how those mobilizations are operationalized. A brief explanation of each of these mobilizations and other important terms relating to the Dynamic Political Hierarchy is found in the following table.

KEY TERMS

Identity	Used, in a constructivist sense, to denote different groups or politically relevant actors. VirThai contains 31 identities, of which we will focus on 11 of the most important.
Dominant	The top level of the Dynamic Political Hierarchy, occupied by the group with the most political strength at that moment in time.
Incumbent	The second level of the Dynamic Political Hierarchy, occupied by groups that strongly support or may even be in coalition with the Dominant group.
Regime	he third level of the Dynamic Political Hierarchy, occupied by groups that are somewhat estranged from the Dominant group, but still support the established legal order.
System	The fourth level of the Dynamic Political Hierarchy, occupied by groups that are discontented with the current legal order and may resort to violence in an attempt to overturn it.
Non-System	The fifth level of the Dynamic Political Hierarchy, occupied by groups alienated from the cultural system itself, seeking more revolutionary change, often resorting to violence to achieve these ends.
Lobby	A mild form of mobilization used by agents who consider themselves part of the Dominant or Incumbent groups when they are dissatisfied with the current state of affairs.
Protest	A somewhat severe form of mobilization used by agents who consider themselves part of the Dominant or Incumbent groups when they are dissatisfied with the current state of affairs.

Attack	A severe form of mobilization used by agents who don't consider themselves part of the Dominant group, or any of the Incumbent or Regime groups. Attacks target other agents with violence, severely destabilizing the area surrounding the target when the attack is successful.
Violence	Violence appears in three forms within the VirThai model. 1) Local Violence: A severe form of mobilization used by agents who don't consider themselves part of the Dominant group, or any of the Incumbent or Regime groups that severely destabilizes the local neighborhood of the violent agent. 2) Remote Violence: The result of Attacks (described above), causing violence in the local neighborhood of the agent that is targeted. 3) Dominant Violence: The result of a retaliatory response by the Dominant group, targeting an agent who has recently engaged in Protests or Attacks.

Table 2

DATA

The landscape of the VirThai model is generated using Geographic Information System (GIS) data such that provincial boundaries are present in the model and preserved even while the size of the provinces are adjusted for population size.[15] Data pulled from sources such as the decennial Thai census, the 2007 legislative election returns, international indices, economic reports, etc. are then flowed into model ensuring that each of the model provinces reflects the data available about the real world province in terms of the number, size, and influence of different groups. This data is then supplemented by SME input and internal decisions about groups and characteristics of the different provinces that aren't easily found in available datasets, such as locations of military deployments, levels of national support, or size of the state bureaucracy. Taken together, the data and expert input create a landscape that is representative of the social and political configuration of relevant groups in Thailand at the present time.

The largest and most salient groups in the VirThai model include Buddhist, Thai Ethnic, Isan, Thai National (or Civic), Red Shirts, Yellow Shirts, and Malay, as well as other smaller political parties, ethnicities, and religions. Other groups represent other professional interests such as State/Bureaucratic, Business, Criminal/Corrupt, and Military. Below is a list of the most important groups in the VirThai model along with a brief description of what they represent and their relative strength at time=0 for our distribution. It is important to remember that these groups are not mutually exclusive; any agent may associate themselves with many of these groups.

Group Name	Description	Average Influence at t=0 (December 1, 2010)[16]
Thai National	Represents the group of people that actively support and advocate for the concept of a strong, unified Thai nation without explicit conditions on who is in power.	678.03
Thai Ethnic	Represents all ethnic Thais, according to data from the most recent census.	477.36
Buddhist	Represents all Buddhists, according to data from the most recent census.	447.15
Red Shirt	Represents the supporters of the United Front for Democracy Against Dictatorship (UDD), a political movement closely aligned with former Prime Minister Thaksin Shinawatra's Thai Rak Thai party and the People's Power Party that followed.	296.79
State/ Bureaucratic	Represents the network of elites that have spent their entire careers in the upper echelons of Thai political life as well as those with close ties to the monarchy.	138.80
Yellow Shirt	Represents supporters of the People's Alliance for Democracy (PAD), originally an opposition group to Thaksin that continues to be involved in politics in opposition to the Red Shirts and in strong support of the monarchy.	94.77
Military	Represents the military presence within Thailand, both politically in Bangkok and supporting the monarchy as well as deployed in the Deep South.	80.54
Isan	Represents the largest non-Thai ethnic group located primarily in the Northeast.	63.1
Business	Represents the economic elites and business interests within Thailand.	57.01
Malay	Represents the ethnic Malay population the Deep South of Thailand that is the driving force behind the violence in the region.	43.43
Criminal/ Corrupt	Represents criminality and corruption within the political system that has the ability to rapidly displace other local interests.	34.22

Table 2

Any of these groups have the ability to become dominant, though only Buddhist, Thai Ethnic, National, Red Shirt, and Yellow Shirt do so with any regularity. The Buddhist and Thai Ethnic groups may at first seem to be politically irrelevant due to the overwhelming prevalence of each in Thailand, but we argue that even the groups which all (or nearly all) agents consider themselves a part of play a significant role in the political environment of a given country. While Buddhism and Thai ethnicity rarely play an explicit role in Thai politics, political discourse would almost certainly be different if these groups were smaller or did not exist. Both Buddhist and Thai Ethnic dominance are characterized by broad political support and very low levels of instability. Virtually all agents accept the present authority and are happy to abide by the "rules of the game" when expressing grievances. The National group can have many interpretations (and in fact does in Thailand), with many groups claiming dominance and legitimacy in the name of nationalism. Red Shirt or Yellow Shirt dominance is characterized by a bitterly divided, partisan Thailand.

RESULT

The VirThai model generates 1000 counterfactual futures, each calibrated to a start date of December 1, 2010 through a process we have termed "whittling", the results of which can be analyzed to gain insights into the both the probable and the plausible political outcomes in Thailand for the next year.[17] Given the volatile recent history of Thailand and the ongoing conflicts both between the Red Shirts and Yellow Shirts and in the Deep South, one of the important places to begin analyzing our results involve the likelihood of protests and attacks over the course of the next year.[18]
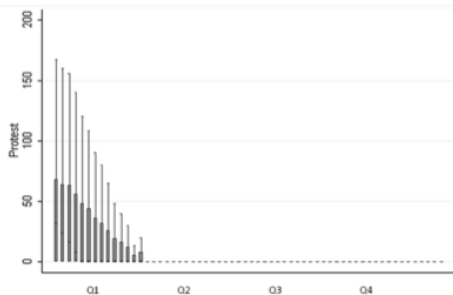
Reading these charts: *For the box plots in Figures 2 and 4, the "box" represents the range from the 25th percentile to the 75th percentile (also known as the interquartile range or IQR), with the median marked. The "whiskers" extend for 1.5x the IQR. Any values found above 1.5x the IQR are considered outliers and designated by points in Figure 4. Figure 3 is a frequency plot of the outliers and extreme outliers that are left out of Figure 2.*

The above chart shows a series of box plots representing the distribution of protest values over the course of the next year. One trend that emerges is that the risk of very severe levels of protest increases as the year progresses. There are more than three times as many instances of severe protest (extreme outliers in Figure 3) by the last time step of the run compared with the first. Interestingly, while the risk of severe protest is lowest during December 2010, the median protest levels are highest here and quickly drop to zero. In terms of stability forecasts, this would suggest that in the very near term, the prospect for at least some protest activity is high, but the likelihood of very severe protest is minimal. From Quarter 2 to Quarter 4, there is a divergence with an increase in the likelihood of both very high levels of protest and no protest at all.
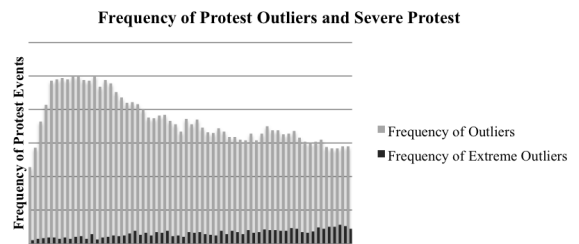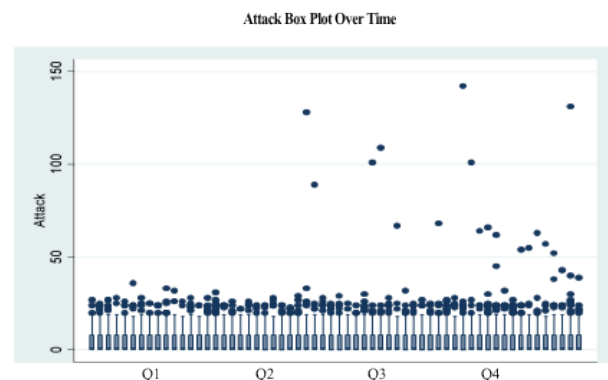

Figure 3

Figure 2

Figure 4

If we look at the box plots for attacks, we can again observe an increasing trend in the likelihood of high levels of instability, although these are clearly very rare cases. The consistency of the median and 75th percentile of attacks across time is a result of the consistency of the Muslim-Malay insurgency in the Deep South. According to our model, the insurgency is an intractable problem that none of the likely emergent political structures in Thailand are capable of solving within the next year.

Delving more deeply into the model results, we can begin to explain this pattern of increasing instability. Across the entire distribution of runs, there are five major groups that dominate the political and social environment and each has a unique impact on the nature of political mobilization and the levels of instability in Thailand. Table 3 below shows each of these groups, how often they appear in the distribution and the mean levels of protest and attack associated with each.

Dominant Group	Frequency of Time steps	Percentage of Time steps	Mean Protest	Mean Attack
Red Shirt	1752	2.92	205.95	8.4
Yellow Shirt	1373	2.29	205.78	4.5
State	920	1.53	291.74	6.6
National	26959	44.93	16.81	3.5
Thai Ethnic	15942	26.57	0.56	3.4
Buddhist	12996	21.66	0.00	3.2
Total	**59942**	**99.90**	**23.19**	**3.6**

Table 3

The first thing to note is that there are three dominant groups that account for 93% of the distribution (Buddhist, Thai Ethnic, and National) while Red Shirt, Yellow Shirt, and State groups' dominance accounts for about seven percent. Each of these dominant groups has different levels of instability (mean levels of protest and attack) associated with their dominance. Red Shirt, Yellow Shirt, and State dominance are characterized by high levels of protest while Buddhist and Thai Ethnic dominance are characterized by low levels of protest. The mean level of protest for Thai National dominance is in between these two extremes. State dominance is associated with the highest mean for protest, most likely because it has the potential to alienate both the Red Shirt and Yellow Shirt groups. Half of the time State is dominant, the Yellow Shirts are still part of the regime level but drop to the system level the other half of the time, while the Red Shirt group is always in the system level. When both Red Shirts and Yellow Shirts are in the system level, the probability for mass protest is very high.

Red Shirt dominance uniquely displays a particularly high mean level of attacks, almost twice as much as any of the other dominant groups, with the exception of State. Not only is the mean level of attacks high when Red Shirts are dominant, but they are also the dominant group during all of the instances where attack levels are greater than forty (see Figure 4).

Figure 5 displays the percentage of the distribution that each dominant group accounts for over time. We can see that the early part of the year is predominantly National dominance, though both Buddhist and Thai dominance account for significant percentages of the distribution. The likelihood of Red Shirt and State dominance increases over time whereas Yellow Shirt dominance decreases, although all three groups are a very small portion of the distributions. Given our previous findings that Red Shirt and State dominance is characterized by much higher mean level of attacks than the rest of the distribution, we can reasonably surmise that the upward trend in severe attacks and protest over time is a result of the increasing likelihood of Red Shirt or State dominance as we move through 2011.

Understanding the nature and likelihood of extremely severe levels of attacks and protest only explains a small portion of our distribution, though a particularly important part of it. The overwhelming majority of the distribution is characterized by Buddhist, Thai Ethnic, or Thai National dominance. The first two are very stable outcomes, with almost no protest and only violence in the Deep South. Thai National dominance, on the other hand, is an instructive case in terms of instability and accounts for the plurality of the distribution.
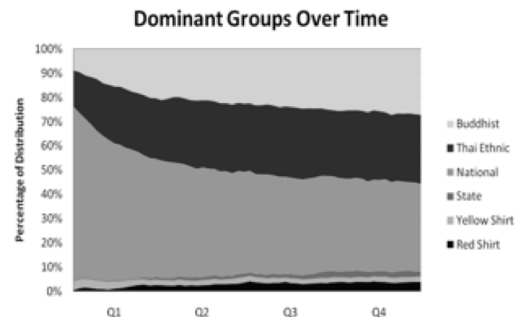

Figure 5

EXPLORATION OF THAI NATIONAL DOMINANCE

According to Table 3, there is a medium amount of protest when Thai National is dominant compared to other dominant groups, but Figure 6 shows the high degree of variation in stability that exists within the DPH combinations when the Thai National group is dominant.

The stability metric used above is an index combining different amounts of protest, violence, and lobby into four broad categories of stability: Calm, Intense Politics, Instability, and Severe Instability. We find that in more than 50% of our trajectories, the Thai National group has successfully gained the support of both the Red Shirts and the Yellow Shirts, keeping both in the incumbent level. When this is the case, instability is very rare. However, if the Thai National group fails to incorporate sufficiently the Red Shirts, Yellow Shirts, or both into their governing project, thus allowing them to fall into the regime or system level, the prospects for stability become bleaker. The effect of loss of support among the Yellow Shirts tends to be more severe than the effect of Red Shirt defection. Losing the support of both groups increases the likelihood of instability even more. Avoiding instability is extremely unlikely if either group is disenfranchised enough to fall to the system level. Figure 6 shows that within the cases where the National group is dominant, there is wide variation as to what violence, protest, and lobby will look like depending where the Red Shirt and Yellow Shirt groups can be found in the DPH. Assuming both groups can be kept in the incumbent level, relative peace can be found, but if both groups drop, severe instability is likely.

This interesting dynamic when National is dominant is a result of the unique, malleable nature of the national group in Thai society. Since the Red Shirt and Yellow Shirt groups are nearly mutually exclusive and regionally confined, they tend to alienate other groups in Thailand very easily, producing high levels of instability. The National group, on the other hand, can be found in a number of different types of agents, overlapping with different political parties or ethnic groups. This allows it to have a strong bridging capacity, keeping two opposing groups in the incumbent level when it is dominant. On the other hand, the group is fluid enough that it can identify more strongly with one side or the other and cause a huge shift in the political environment, leaving out either the Red Shirt or Yellow Shirt groups. In extreme cases, it can even alienate both groups. Due to this variable nature, model behavior when the National group is dominant ranges from protests by either the Red Shirts or the Yellows Shirts, protest by both groups, or no protest at all. Because of the importance of the coalition that can be built around the National group, there may be steps policymakers can take to help strengthen these ties from Nationalists to both the Red Shirts and the Yellow Shirts (one could imagine a cross-color party of national reconciliation, for example, forming to compete in the upcoming elections). In the absence of Buddhist or Thai political mobilization, a strong coalition built around the National group is a much more stable alternative to highly partisan domination. National group is a much more stable alternative to highly partisan domination.
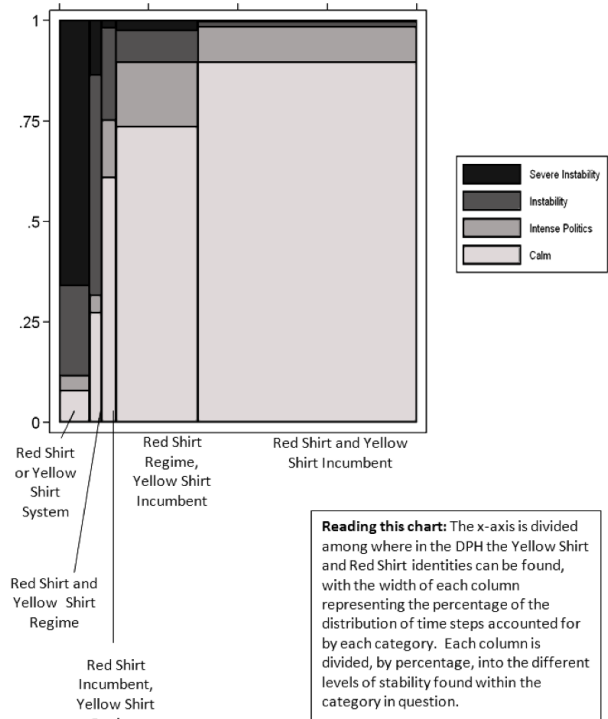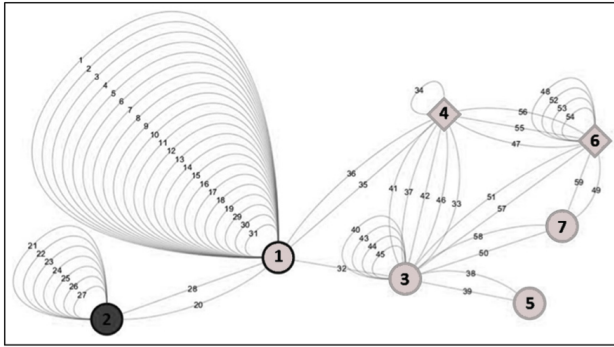

Figure 6

Figure 7: The nodes represent different DPH combinations of the most important groups in the Dynamic Political Hierarchy. The lines are the current time step, moving from one node to the next (labels are the time step number). The shade of the nodes represent the dominant identity (light – Red Shirt, dark – Thai Ethnic) and the outline represents whether the National group is in the regime or system level (dark – Regime, light – System). The diamond nodes on the top right are those that display very high levels of violence. Each time step represents about one week.

EXPLORATION OF RED SHIRT DOMINANCE

While our model suggests that the likelihood of very high levels of instability is extremely rare over the course of the next 12 months in Thailand, we can investigate the nature of these rare but high-impact events. Out of a distribution of 60,000 time steps, there are only [19] times that we observe more than 40 attacks in one time step. Notably, each of these 19 cases resembles each other in several important ways:

1) The Red Shirts are the Dominant group
2) The Isan are in the Incumbent level
3) The Yellow Shirts are in the System level
4) The Thai Nationalists are in the System level

An example of the circumstances of when this occurs will be outlined in detail below, but a broader introduction is required first. The Dynamic Political Hierarchy, which was briefly explained in the beginning of this paper, classifies groups and agents into different levels of the hierarchy and dictates the way in which these groups and agents petition for change when angry. Under normal circumstances, instability generated from the groups towards the bottom of the hierarchy (System and Anti-System levels) is mitigated somewhat by the connections that those groups have with the upper levels of the hierarchy. However, a measure of polarization19

exists that identifies when the top of the DPH (Dominant and Incumbent levels) and the bottom of the DPH (System and Non-System levels) are highly reinforced[20] and the indirect connection[21] between top and bottom is relatively tenuous. When this condition is true, agents ignore the indirect connections that would otherwise serve to mitigate violence, allowing for the possibility of very high levels of instability. Under normal circumstances, the Thai National group serves as an indirect connection between the Red Shirt and Yellow Shirt poles of Thai society, along with the Buddhist and Thai Ethnic groups. However, when the Red Shirts fail completely to incorporate Thai Nationalism, the indirect link between Red Shirts and Yellow Shirts is weakened to a point that Yellow Shirts will act violently in their opposition. This is what occurs in the example in Figure 7 as well as each of the other cases where we observe very high levels of violence.

Figure 7 is a single trajectory of Thailand where we see high amounts of violence during the year. The trajectory starts at node one, where the Red Shirts are dominant and there is relative stability. The situation stays this way for nineteen time steps before the Ethnic Thais grow powerful enough to become dominant at node two. After seven time steps, the Red Shirts become dominant again and the Thai National group is still well connected to the Red Shirts for three time steps (node 1). By time step 32, the Thai National group has become less connected to the Red Shirts and a political shift has occurred where the National group is no longer helping to mitigate conflict in the same way the Buddhists and Ethnic Thais do. The result of this severe disconnection and polarization between Red Shirts and the Thai National group is a severe risk of high levels of violence. The remainder of the run is very unstable, moving quickly through several different DPH configurations and passing through nodes four and six where levels of violence are as much as 100 standard deviations above the mean.

REFLECTIONS ON THE PROMISE AND POTENTIAL LIMITS OF AGENT-BASED MODELS

One of the allures of agent-based models is that they will eventually enable researchers and policymakers not only to explain the past, but also probabilistically predict the future. How far does VirThai take us towards that goal? Put slightly differently, while it is clear that subject matter experts have something to offer agent-based

modelers (they help provide the information necessary to define and populate the model, and then interpret and validate the results) can agent-based models offer anything useful for non-modelers, particularly subject matter experts? Can a population of scholars who are already deeply familiar with and knowledgeable about a given case learn anything new or useful from VirThai or similar agent-based models? Or do these models simply represent a more complicated way to generate the same old conclusions?

Given that our team consists of both agent-based modelers and a political scientist who works on Thailand, we are in a good position to provide some tentative answers to these questions. To begin with we want to echo the point that many others have made about the virtues of inducing social scientists/subject matter experts to be more explicit and precise than might otherwise be the case. First, as discussed above, engaging with a model requires social scientists to carefully examine the hidden assumptions in their work. Second, building the model forces one to clearly specify the causal mechanisms and observable implications of a given theory. Finally, populating the model obliges scholars to systematically define the strategic landscape (e.g. who are the actors, what are their interests, and what are the constraints they face). We have certainly found this to be the case in building VirThai. The groups described above, for example, are the product of lengthy discussions about the important actors in Thai society, their relative size and power, and their relationship to one another. Much of the scholarship on contemporary Thai politics talks in terms of mutually exclusive groups—e.g. Red Shirts, Yellow Shirts, Thai Muslims. The recognition that each of the members of these groups has multiple affiliations is a useful corrective, and invited us to think more carefully about relationships between these affiliations, and the factors that strengthen some over others. For example, most Yellow Shirts are also Buddhists and Thai Nationalists. Which of these groups is associated with a greater risk of conflict and what affects which group becomes dominant in a given time period?

Faced with the same information, other scholars would no doubt make somewhat different decisions than we have on many of these issues. But one of the virtues of agent-based models is that we can adjust our models to take into account differences of opinion among scholars, rerun the models, and then compare the results. Is there a difference of opinion among Thai scholars about how close the links are between the Yellow Shirts and State officials? We can run simulations where everything is the same except the relationship between these two groups and see what changes. The ability for us to systematically analyze the counterfactual seems to us to be a chief advantage of agent-based models over other approaches (e.g. thought experiments, comparative statistics) where, despite our best efforts, ceteris is never paribus.

In addition to these advantages, what we hope is that agent-based modeling will allow us to actually make better predictions. So, how well does our VirThai model perform in that regard? Since the model has generated predictions for the coming year we won't know for sure until the year unfolds. Assessment is also complicated by the fact that VirThai generates the predictions about the likelihood of certain types of conflict, rather than specific point predictions. That said, the model passes the plausibility test. The results were generally consistent with what our subject matter expert expected, given his knowledge of Thai politics. While ultimately we might wish to generate surprising predictions—states of the world that SMEs have not anticipated—at this stage we find this consistency reassuring. Our models predict, and our subject matter expert confirms, that one of most potentially volatile political arrangement in the year to come are those that find the Red Shirts in sole control of the government— with the Yellow Shirts and possibly State interests on the outside looking in. Yellow Shirt ascendance is also destabilizing, but slightly less so than Red Shirts. Thailand will almost certainly be holding elections this year. Our model suggests, then, that a clear-cut Red or Yellow Shirt victory would likely trigger instability.

While in the main the predictions generated by VirThai were not surprising, they nonetheless invited additional theorizing and analysis by the subject matter expert to account for some of the nuances the models uncovered. For example, why is it that the Yellow Shirt dominance is less destabilizing than Red Shirts? Our subject matter expert hypothesizes that this difference is due to the fact that when the Yellow Shirts are in power State and Nationalist interests are less likely to be in the system or non-system camp, and this is indeed the case. Arguably the most volatile political arrangement is one in which State interests are in sole control. When this occurs we see the highest level of protest activity,

but fewer attacks than when either the Red Shirts or Yellow Shirts are in power. This scenario is consistent with a coup by Thailand's conservative forces which would shut out all other political actors and thereby trigger protests across the political spectrum. The fact that severe instability is less likely than under Red or Yellow dominance, reflects the fact, our subject matter expert hypothesizes, that State interests can command the support of the security forces—thus discouraging anything beyond protest activity.

From this explanation, we can infer three hypotheses that we can evaluate using our simulation data. 1) When State-interests are dominant we should see the most unrest when Yellow and Red identities are hostile to the State 2) When State-interests are dominant the ties between Yellow and Red shirts should strengthen. 3) When State-interests are dominant the military should be in a supportive position. As this discussion suggests, agent-based models may be particularly useful for generating hypotheses (particularly interactive or contingent hypotheses) for further testing.

This discussion also raises, though, one of the potential limits of agent-based modeling. Unlike formal modeling or regression analysis we as yet lack a simple toolkit to help us decide whether a hypothesis or a model should be retained or rejected. The probabilistic nature of the predictions generated by agent-based models complicates the question of falsifiability. What would constitute falsifiability in the context of our VirThai predictions? Must we observe outcomes that do not appear anywhere in the models' predictions (e.g. the Muslim group becoming dominant). If most, but not all, models predict conflict if the Red Shirts come to power, and we observe Red Shirts but no conflict, what are we to conclude about the model's utility and predictive power? In general, is model success determined by identifying the possible, plausible, or probable futures for a given country? This can be especially complicated when some of the metrics we use are not easily distinguishable (or even immeasurable)

in the real world and only one out of the many possible futures can ever be observed. At the least, our model clearly has the ability to spur discussion and invite analysis into the causal mechanisms and theoretical assumptions made about Thailand in our model.

Another challenge that limits the utility and application of agent-based models at present is the difficulty at seeing exactly why different states of the world diverge. While the transparency of agent-based models in the building and design stage is admirable, we are still developing the ability to drill down and trace exactly why a Red Shirt victory leads to more violence in one run, but less in another. A large part of this challenge lies in visualization of the model, as well as its inputs and outputs. Data visualization is clearly difficult when users are dealing with a multidimensional output of 1,000 possible futures of a given country. Some of the visualization methods have been presented here, but these are only solutions to specific challenges, not a general solution that can be used to visualize any aspect of the model. Transparency of the model also requires detailed documentation of not only the technical algorithms used in the model, but also the theories employed. The translation of a theory or even multiple theories into an algorithm used by agents is a difficult process to explicitly and comprehensively document.

Finally, VirThai, and agent based models more generally, have some way to go before they can truly allow a user to conduct experiments—e.g. disturb the environment and watch what unfolds. Translating discrete actions or events into the model's parameters is not always a straightforward process. How do we model the death of the King? A pardon of Thaksin? A split in the Democrat Party? As the power and sophistication of agent-based models continues to grow, we must pay equal attention to building algorithms that consistently and effectively translate user-generated actions into parameters the model can use.

ENDNOTES

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2 Not all agent-based modelers agree that modeling complexity with complex models should be the aim. Robert Axelrod, in his introductory work on agent-based modeling, recommends that modelers employ the KISS (Keep It Simple Stupid) principle when developing agent-based models designed to enrich our understanding of fundamental, real-world processes. He even claims that "although agent-based modeling employs simulation, it does not aim to provide an accurate representation of a particular empirical application."

3 For information on the difference between abstraction or virtualization models, see Ian S. Lustick and Dan Miodownik, "Abstractions, Ensembles, and Virtualizations: Simplicity and Complexity in
Agent-Based Modeling," Comparative Politics, January 2009. Vol. 41, No. 2, pp. 223-244.

4 The model is an amplification and extension of previous models, featured in Lustick, Ian. "PS-I: A User-Friendly Agent-Based Modeling Platform for Testing Theories of Political Identity and Political Stability." Journal of Artificial Societies and Social Simulation, 5 (3) 7. <http://jasss.soc.surrey.ac.uk/5/3/7.html>. Lustick, Ian, Dan Miodownik, and Roy J. Eidelson. "Secessionism in Multicultural States: Does Sharing Power Prevent or Encourage It?" American Political Science Review, Vol. 98, No. 2, May 2004. Lustick, Ian. "Secession of the Center: A Virtual Probe of the Prospects for Punjabi Secessionism in Pakistan and the Secession of Punjabistan." Journal of Artificial Societies and Social Simulation, 14 (1) 7, <http://jasss.soc.surrey.ac.uk/14/1/7.html>.

5 Posner, Daniel N., "The Institutional Origins of Ethnic Voting", Paper delivered at the 1998 Annual Meeting of the American Political Science Association, Boston, September 3-6, 1998, p. 4.

6 Brubaker, Rogers, Nationalism Reframed: Nationhood and the National Question in the New Europe, Cambridge: Cambridge University Press, 1996.

7 While these types of interactions are prominent in the constructivist identity theory literature, precise rules are rarely if ever specified, leading to modelers making decisions about exactly how easily an agent is willing to acquire a new identity, relinquish an old identity, or actively promote an identity from within its repertoire.

8 Robert Alan Dahl, A Preface to Democratic Theory (Chicago: Chicago University Press, 1963); Erik Allardt, and Yrjö Littunen, Cleavages, Ideologies, and Party Systems; Contributions to Comparative Political Sociology (Helsinki: Academic Bookstore, 1964); Ralf Dahrendorf, Class and Class Conflict in Industrial Society (London: Routledge, 1959); Seymour Martin Lipset, "Some Social Requisites of Democracy: Economic Development and Political Legitimacy," The American Political Science Review, Vol. 53, No. 1 (Mar., 1959), pp. 69-105; Georg Simmel, Conflict and the Web of Group Affiliations, Translated by Kurt H. Wolf and Reinhard Bendix (Glencoe, IL: Free Press, 1955); and Michael Taylor and Douglas Rae, "An Analysis of Crosscutting between Political Cleavages," Comparative Politics, Vol. 1, No. 4 (Jul., 1969), pp. 534-547.

9 Easton, David, "An Approach to the Analysis of Political Systems," World Politics, Vol. 9, No. 3, (Apr. 1957), pp. 383-400.

10 Linz, Juan J., The Breakdown of Democratic Regimes: Crisis, Breakdown, and Reequilibration (Baltimore: The Johns Hopkins University Press, 1978) pp. 27-38.

11 For a detailed discussion of the theories and operationalizations of the DPH, see Lustick et al. "From Theory to Simulation: The Dynamic Political Hierarchy in Country Virtualization Models", Prepared for presentation at the American Political Science Association, Washington, D.C., September 2-5, 2010.

12 The threshold for meeting the supermajority requirement in this model is 70%, a decision made by the modeling team that has proven plausible across a distribution of seven politically distinct countries in Southeast Asia: Thailand, the Philippines, Indonesia, Vietnam, Bangladesh, Sri Lanka and Malaysia.

13 Linz, 1978, pp. 27-38.

14 Finifter, Ada, "Dimensions of Political Alienation," The American Political Science Review, Vol. 64, No. 2 (Jun., 1970), pp. 389-410.

15 The cartogram is built using the Gastner and Newman technique: Gastner, M.T. and Newman, M. (2004). Diffusion-based method for producing density equalizing maps. In Proceedings of the National Academy of Sciences of the United States of America, 101(20): 7499-7504.

16 The normal level of influence for VirThai is 2487. This number is constant because the effect of lobby, protest, and violence is not taken into account.

17 For a more thorough explanation of the experimental process see Lustick et al. "From Theory to Simulation: The Dynamic Political Hierarchy in Country Virtualization Models", Prepared for presentation at the American Political Science Association, Washington, D.C., September 2-5, 2010.

18 It should be noted that the values for protest and attack do not directly translate to the real world because they are an artifact of the number of agents in the VirThai model, among other things. For our purposes, these numbers are used as relative comparisons, highlighting low, medium, and high levels of protests and attacks under different conditions.

19 Coser, Lewis A. The Functions of Social Conflict (New York: The Free Press, 1956), Simmel, Georg Conflict and the Web of Group Affiliations (New York: the Free Press, 1955)

20 By being highly reinforced, we mean that, for example, a large percentage of incumbent agents not only have an incumbent identity in their repertoire but have all, or nearly all, incumbent identities in their repertoire.

21 An indirect connection exists by virtue of their being at least one regime identity that shares connections with both the Dominant/Incumbent levels and the System/Non-System levels of the DPH; the greater the number of Regime identities for which this is true, the greater the indirect connection between the two poles.