An agent-based model of military mechanization

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May 5, 2018

1 Introduction

This paper presents an agent-based model of military mechanization. First, it provides a theoretical discussion of military mechanization, states the research hypothesis, and explains why agent-based modeling is an appropriate research strategy. Then, it details an original agent-based model; presents results; and discusses their implications for the academic debate on military mechanization.

In summary, the orthodox view of military mechanization is that it is a reflexive process: states choose their mechanization posture largely based on that neighbors and enemies. This paper argues that this view—based on traditional longitudinal data analysis—is ripe for agentization:

2 Background

2.1 Military mechanization

States differ in the composition of their military ground forces.[1] One notable axis of comparison is *mechanization*: the degree to which an army consists of infantry vs. combat vehicles. Treating mechanization as a continuous variable, one extreme is an army consisting exclusively of dismounted, small arms-wielding infantry units; the other extreme is an army consisting solely of tank units, armored personnel carriers, artillery, and the like. Clearly, no modern state embodies either extreme, but the 1970s-era Vietcong are a good example of a low-mechanization army and the 1980s-era Israeli army of high mechanization.

The consequences of choices regarding mechanization are large. There is academic consensus that defense policy—including but not limited to mechanization—conditions battlefield effectiveness. Lyall and Wilson 2009 finds that highly mechanized militaries are less effective at counterinsurgency, while Biddle 2004 argues that mechanization-enabled mobility aids conventional warfighting. It thus pays to have an army that is designed to win the kinds of conflicts that a state is likely to face. Lacking a crystal ball, however, leaders cannot always

[1] States may have multiple organizations that conduct ground combat operations: e.g., the United States operates both an Army and a Marine Corps as independent services. Henceforth, this paper uses the terms "army" and "ground forces" interchangeably.

forecast conflict, and armies are large, complex organizations that typically are held to change only infrequently and slowly at that, even if there is a pressing need (Murray and Millett 1998, Locher 2004, Zegart 2000). A state suddenly faced with a war for which its mechanization posture is ill-suited can either concede or pay a cost in blood and treasure; what it cannot do is quickly overcome the constraints imposed by past mechanization decisions. A quote from then-Secretary of Defense Donald Rumsfeld—made in 2004, when the U.S. military was confronted in Iraq with the consequences of past choices regarding mechanization—emphasizes the point: "you go to war with the army you have" (Schmitt 2004).

The causes of military mechanization are disputed. *Realists* believe that mechanization choices are driven by security environment. States choose mechanization policies that they believe will allow them to prevail against potential adversaries, or to send a signal of deterrence, or to learn from the perceived mistakes of the last war (Mearsheimer 1983; Huth 1988; Murray 2011). The other school of thought is more diverse and so harder to name, but may be termed *institutionalists*. They believe that factors other than strategic calculation determine military mechanization. Domestic political institutions—e.g., democracy vs. autocracy, politically stable vs. coup-prone, the state of civil-military relations, and so on—may influence force structure (Reiter and Stam 2002; Quinlivan 1999; Talmadge 2015; Brooks 2008). Economic factor endowments may play a role: e.g., capital-rich states may mechanize more than labor-rich states (Gartzke 2001). Lastly, ideology (Van Evera 1984) and culture (e.g., Pollack 2004) are hard-to-measure but perhaps influential. Consider Ireland: between the 1920s and 1940s, it expended a large portion of its defense budget on building a small number of tanks. They were wholly insufficient to repel a British invasion (their ostensible purpose), and Ireland would have been better-served to pursue a low-mechanization guerrilla defense strategy, but tanks were seen as a prestigious signifier of a "real" professional military, an important factor for the young Irish state (Farrell 1998; Farrell 2001).

Sechser and Saunders 2010 is the landmark study on military mechanization. They assemble a longitudinal dataset at the country-year level of the mechanization of all states between 1979 and 2001, and conduct regression analysis to identify the effect of covariates on mechanization. They conclude that "choices about mechanization are strongly associated with a state's security environment." The more mechanized a state's geographic neighbors and enemies, the higher the state's own mechanization; also, states learn from defeat in insurgency by subsequently decreasing their mechanization.

2.2 The case for agent-based modeling

The findings of Sechser and Saunders 2010 are ripe for agentization. The conclusions drawn implicitly claim that states are autonomous agents; that they have cognition regarding how to perceive the outside world in terms of mechanization and how to adjust their own mechanization to it; that spatiality and neighborhood matter; that inter-agent relationships (e.g. whether you are my enemy or

not) matter; and that agents learn from experience. Agent-based modeling is uniquely well-suited to represent such phenomena (Gilbert and Troitzsch 2005; Miller and Page 2009).

Importantly, if the findings of Sechser and Saunders 2010 are correct and states largely determine their own mechanization levels on the basis of what other states are doing, a positive feedback loop exists. State A has high mechanization, causing enemy State B to raise their mechanization, causing State A to raise their mechanization... and so on. This feedback loop—often called the "security dilemma"—has been extensively studied, including by Thomas Schelling, one of the pioneers of agent-based modeling (Schelling 1960; Schelling 2006).

2.3 Research question and strategy

I hypothesize that the arguments of Sechser and Saunders 2010 are incomplete and that some omitted variable or set of variables acts as a "brake" on military mechanization.[2] An agent-based model is used to test this hypothesis. In broad terms, agents (states) are defined to have the cognitive and learning behavior implicitly claimed by Sechser and Saunders 2010. The model is initialized with real-world data from 1979 and allowed to run until 2001. The micro- and macro-outcomes are then validated against real-world 2001 data. If Sechser and Saunders 2010 are correct, the model's 2001 outcomes should match real-world 2001 outcomes. If the model mechanization levels in 2001 are much higher, then their claimed behavioral rules are incomplete and fail to include some "brake" on mechanization, matching my hypothesis. Proving exactly what that missing variable or set of variables is is outside the scope of this model and paper, though it is discussed.

3 Model

This section of the paper describes the model. It does not use the ODD protocol of Grimm et al. 2006 but covers many of the same points.

3.1 Agents

There is one agent type: states. Agents exist at a fixed location and do not move. The composition of agents changes throughout the

3.2 Environment

Agents exist in a spatial environment. Spatiality is represented by neighbor relationships rather than a raster or vector GIS map. Two states are defined as being neighbors if they share a contiguous land border or a stretch of water less

[2] By "omitted", I mean that they conclude that the variable is not very important for mechanization, not that they do not address the variable at all.

than 400 miles. Every agent has an attribute `neighbor_list`, a list in which it stores the names of neighboring agents for that time-step.

3.3 Initialization and Time

3.4 Dynamics and Interactions

4 Results

5 Discussion

6 References

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