The Cascading Dynamics of War Expansion

Kyle A. Joyce
Department of Political Science
University of California, Davis
kjoyce@ucdavis.edu

June 11, 2014

Abstract

Why do some international wars expand while others do not? And of those that do expand, why do some grow to include only a few additional states while others explode to include many states? I argue that the key mechanism that answers these two questions is the interdependent nature of third parties' decisions. I develop an agent-based model of war expansion, the central feature of which is the interdependence between a single third party's decision to join an ongoing war and all other third parties' decisions. In the model, this interdependence is captured by allowing each third party to forecast which other third parties are expected to join the war in the future, and on which side, and condition its contemporaneous joining decision on these expectations. Comparing the simulated wars to the historical record, the agent-based model accurately predicts both the percentage of actual wars that expanded and the percentage of states that joined in wars that expanded. Thus, in order to understand and explain war expansion we must account for the interdependence of third-parties' joining decisions.

Introduction

The war between Austria-Hungary and Serbia that began in July 1914 quickly expanded to include additional states. Only three months into the war, two states had joined on the side of Austria-Hungary and five on the side of Serbia. By the time the war ended in November 1918, thirteen additional states had joined; what had began as a war between two states had become World War I. As with most wars that expand (e.g., World War II, Korea, Vietnam), World War I was one of the deadliest conflicts in history, accounting for an astonishing 27% of the fatalities across all interstate wars between 1816 and 2007.

While the vast majority of interstate wars (73%) do not follow this deadly progression—they end without ever expanding to include third parties (i.e., states beyond the two or more initial belligerents)—those that do expand are often the deadliest in terms of fatalities. Indeed, among all interstate wars between 1816 and 2007, the 27% that expanded account for 87% of all fatalities (See Figure 1).[1] Certainly, states in the international system beyond the initial belligerents have an interest in the outcome of wars; interested parties might include allies, neighbors, or trade partners. But despite the interests that might encourage such states to join ongoing wars, war expansion is still a relatively rare phenomenon. In most cases—including many long, highly violent conflicts such as the eight-year war between Iran and Iraq (1980-1988)—a war will end with exactly the same states with which it began. *Why do some wars expand while others do not?*

Insert Figure 1 here.

Beyond the dramatic skew in whether or not wars expand, among wars that do expand the historical record indicates a dramatic skew in the number of states that join. Figure 1

[1]These calculations are based on the Correlates of War (COW) Inter-State War data set. The COW Project defines interstate war as one "in which a territorial state that qualifies as a member of the interstate system is engaged in a war with another system member" (Sarkees and Wayman 2010, 41). To qualify as an interstate war there must have been at least 1,000 battle-connected fatalities among all of the system members involved in the war. In order for a state to qualify as a war participant it must have either "a minimum of 100 fatalities or a minimum of 1,000 armed personnel engaged in active combat" (42).

shows the empirical distribution of the number of historical wars that expanded. The vast majority of wars do not expand to include any additional states (circles at 0 on the x-axis). Yet among the wars that expanded, a small number of important wars not only expanded but did so explosively, eventually engulfing 12 (Gulf War), 13 (World War I), 14 (Korean War), and even 23 (World War II) additional states. In general, the few wars that undergo dramatic expansion also claim a much higher number of fatalities (y-axis) than those wars that either do not expand or have low levels of expansion. Table 1 lists the wars between 1816 and 2007 that expanded to include at least one additional state. Of the wars that expanded during this time period (27% of the total), a little more than half had more than one third-party joiner. *Why do some wars expand to include a large number of additional states while others only expand to include only a few?*

Insert Table 1 here.

War, the state interaction that produces it, and the behavior of other states during it, are all complex phenomena. While most international conflict research focuses on the onset, duration, and outcome of wars—often ignoring the effect of third-party participation (i.e., expansion) on the war process—the absence or presence of third-party participation directly affects how a war unfolds. As a result of this relative deficit of attention in international conflict research on war expansion (especially the development of theoretical models), we know comparatively little about how third-party participation influences the participation decisions of other third parties; how individual third-party decisions to join a war produce the macro-level patterns of war expansion (i.e., whether or not a war expands and if a war expands how many other third parties join).

In order to fill this gap in the literature, I develop a model of war expansion to address two questions: 1) Why do some wars expand while others do not? 2) Why do some wars expand to include a large number of additional states while others only expand to include only a few? I argue that these questions can be answered by understanding two linked mechanisms related to third-parties' decisions about whether or not to join an ongoing conflict:

1) When each third-party state is deciding whether or not to join a war (and if so, on which side to join), it bases its decision not only on the war as it is currently being waged and its relationships with the initial belligerents in the war, but also on its expectations about which other third-party states will join (and on which side) and how the states expected to join would affect the balance of power and the ultimate outcome of the war. For example, the United States' decision to join the Korean War was undoubtedly related to its expectation that China would join the opposing side. Similarly, it stands to reason that the United States' decision *not* to intervene in the Six Day War in 1967 influenced the decisions of all other third parties, especially the Soviet Union.

2) Each third-party state *updates* its joining decision over time as the *dynamics of a war*—which I define as the shifting balance of power between the two sides—unfold. As a war evolves, the likelihood of victory for one side rises and falls with successes and failures on the battlefield. With each third party attuned to these changes, the dynamics of a war will affect which states, if any, join and at what point during the war. For example, Mongolia's entry on the side of the Allies only a few days before the end of World War II was likely informed by the impending Allied victory. In turn, third-party joining affects the dynamics of a war, since when a third party joins it affects the likelihood and timing of victory for both sides. For example, if the US had joined World War I earlier, the war would likely have followed a different course, with some states that joined the war instead remaining neutral and other states that remained neutral instead deciding to join.

In order to examine how these two linked mechanisms influence a third party's decision to join an ongoing war, I develop an agent-based computational model and run computer simulations in an artificial international state system populated by heterogeneous agents (i.e., states) that interact in an anarchic environment. In this model, following the onset of a "war," each third-party agent simultaneously decides whether or not to join. Each agent's decision is a function of its ability to influence the outcome of the war, the utility it would derive from each of the initial participants winning the war, and how costly it is to join the war. Furthermore, each agent's decision is endogenous to the expected joining decisions of all other agents. Before each agent decides whether or not to join, it forecasts which other agents are going to join in the next time point and uses this information to make their contemporaneous joining decision. Whereas most existing models of third-party joining make predictions about which third parties are likely to join ongoing wars and the side on which that joining is expected to occur, *none* allow the third parties themselves to use this information when deciding whether or not to join. Finally, the timing of a war's ending is endogenous to the war's dynamics; when the distribution of capabilities between the two coalitions of participants exceeds a victory threshold, the war has some probability of ending. As a result, the model simulates both expanding and non-expanding wars.

After conducting computational experiments in this artificial world (in the form of computer simulations) under varying initial conditions, I examine the emergent macro-level patterns of war expansion. These emergent patterns serve as theoretical predictions that should emerge in the real world under similar conditions. Here, I focus on two emergent macro-level patterns of war expansion: the percentage of simulated wars that did and did not expand and the percentage of agents in the artificial international system that joined the simulated wars. If the computational model I present is worth its salt, then it should produce simulated wars with the same rates of expansion and third-party joining as we observe in the historical record. And, indeed, it does. When the interdependent role of third-party joining is removed, the model performs very poorly. These findings suggest that when third parties decide whether or not to join ongoing wars their decisions are based, in part, on which other third parties are expected to join the war in the future.

In the next section, I discuss existing research on war expansion. Next, I present a process of war expansion and identify the most important components that should be included in a formal model of the expansion process. I then provide a brief explanation for why agent-based modeling is an appropriate tool for modeling the two linked mechanisms I argue underlie a third party's decision to join an ongoing war and to uncover the macro-level patterns of war expansion. Finally, I present an agent-based model of war expansion, the results of the computer simulations, and summarize the macro-level patterns that emerge from the computer simulations. I then compare these macro-level patterns to historical wars.

Existing Explanations for War Expansion

Existing research on war expansion has primarily focused on how the characteristics and relationships between a third party and the initial belligerents influence the third party's likelihood of joining an ongoing war. Some of the more widely examined characteristics include a given third-party's material capability, contiguity, alliances, and regime type. As described below, studies have examined how these characteristics influence the likelihood of a third-party joining, which side (typically, initiator or target) a third party is likely to join, and when a third party is likely to join.[2]

One of the most widely explored factors that influences a third party's decision to join is how its capability contribution will influence the conflict's eventual outcome. Stoll asserts that "findings across a variety of studies are consistent with the premise that states are motivated by basic realpolitik considerations when they decide to join or abstain from a war" (1995, 136). A third party is likely to consider the threat posed to its external security by an ongoing conflict when making its joining decision (Haldi 2003). In general, research shows that third parties with higher levels of material capability, relative to the initial belligerents, are more likely to join an ongoing conflict (Altfeld and Bueno de Mesquita 1979, Bremer

[2]Third parties' joining decisions are, of course, also shaped by the identity of the initial belligerents and the existing balance of power. In turn, expectations of third-party joining affects the behavior of initial belligerents (Smith 1995, 1996) who may adjust their demands to dissuade a third party from joining (Werner 2000).

1980, Huth 1988).[3]

A second widely examined factor is geographic proximity. A third party's geographic proximity to the initial belligerents has been shown to influence the likelihood that a conflict will expand (Most, Schrodt, Siverson, and Starr 1990, Siverson and Starr 1991, Raknerud and Hegre 1997), with contiguous third parties more likely to join ongoing conflicts than non-contiguous third parties. However, Joyce and Braithwaite (2013) show that the likelihood of contiguous third parties joining an ongoing conflict decreases as their distance from the actual location of a conflict increases.

The importance of alliances as a primary reason for conflict expansion has also been widely examined (Altfeld and Bueno de Mesquita 1979, Kim 1991, Levy 1982, Sabrosky 1980, Siverson and King 1979, Siverson and Starr 1991, Smith 1996, Werner and Lemke 1997). Potential joiners are likely to consider the costs of maintaining their alliance commitments during an ongoing conflict. There is some evidence that states tend to honor their alliance commitments (Corbetta 2010, Leeds 2003*a*, Leeds 2003*b*, Smith 1996). Leeds (2003*a*) finds that 80 percent of allied states fulfilled their alliance obligation when the conditions of the alliance were invoked by war. An interesting exception to this finding is a study by Gartzke and Gleditsch (2004), who show that democracies are less likely to come to their allies' assistance than non-democracies.[4]

Previous research also demonstrates that third parties are more likely to join states with similar domestic political regimes (Corbetta 2010, Huth 1998, Raknerud and Hegre 1997,

[3]However, initiators are more likely to target weak states (Gartner and Siverson 1996, Huth 1998), who they believe will not receive third-party support, and so the distribution of military capability is likely to favor the initiator. Werner and Lemke (1997) find that as the initiator of a dispute becomes more powerful, third parties are more likely to join on its side but as the target becomes more powerful, third parties are less likely to join on its side and argue that this finding lends support to the revisionist realists (e.g., Schweller 1994). Reiter and Stam (2002) find no support for a weaker target receiving third-party assistance.

[4]While many states might honor their commitments, there is little support for the notion that alliances result in extended deterrence success (Bueno de Mesquita 1981, Huth 1988, Werner 2000). If a challenger knows that a target has an alliance and is still willing to take militarized action, this idea suggests that the challenger does not believe the alliance is reliable. A state is more likely to issue a challenge if it believes that the target's ally will not come to its assistance (Smith 1995).

Reiter and Stam 2002, Werner and Lemke 1997). For example, Werner and Lemke (1997) find that institutional similarities are important in a state's decision to join and that there is little merit to the argument that 'opposites attract.' Democracies tend to join ongoing conflicts more frequently than autocracies (Raknerud and Hegre 1997).[5] Werner and Lemke (1997) find that autocracies also consider regime similarity and differences in their alignment decisions and find that autocracies are more prone to honor their alliance commitments. Corbetta (2010) finds that autocracies join other autocracies.Raknerud and Hegre (1997) also find that autocracies join fellow autocracies but to a lesser extent than democracies join with other democracies.

In contrast to the research described above, which focuses on a single third party's characteristics and relationships with the initial belligerents, very little research has examined how a third party's decision to join an ongoing war is influenced by other third parties' decisions. The research that has examined this mechanism has focused on how the prior participation of a major power influences other third parties' decisions (Joyce, Ghosn, and Bayer 2014, Kim 1991, Yamamoto and Bremer 1980). Yamamoto and Bremer (1980) argue that the joining decisions of major powers are highly dependent on the participation of other major powers (see also Kim 1991). However, a major power's decision of whether or not to pin influences the decisions not only of other *major* powers, but all other potential joiners as well. Additionally, although past research has examined how a third party's decision is influenced by other third parties' decisions at a given point in time, it has not examined how a third party's decision is influenced by its *expectations* regarding future participation of other third parties.

In sum, existing research has identified several factors that influence the likelihood of

[5]Reiter and Stam (2002) find that there is no evidence that democracies are more likely to join democratic targets (see also Melin and Koch 2010). As initiators are more likely to target weak states and as democracies are more likely to initiate conflicts that they expect to win (Bueno de Mesquita, Morrow, Siverson, and Smith 1999, Reiter and Stam 2002), democracies might resist joining a democratic target but may not have the same reservations about joining a democratic initiator.

third-party joining, providing a solid foundation for future studies. However, past research has primarily focused on factors that influence a single third party's decision to join an ongoing conflict at a single point in time, thereby ignoring the likely interdependence of third-party joining decisions and, thus, the macro-level patterns of war expansion that might result.

The Process of War Expansion

War expansion—defined as the military intervention of one or more third parties into an ongoing interstate war—consists of three interconnected relationships, namely those between: 1) the initial belligerents (I_A and I_B, where A and $B \in \mathbf{N}$, and $\mathbf{N}$ is the set of all states 1, 2, ..., N), 2) the initial belligerents and a third party considering joining the war (O_i, where $i \in N$), and 3) each third party (O_i) and all other third parties (e.g., O_j, where $j \in N$ and $j \neq i$). A third party's (O_i) decision whether or not to join an ongoing war is based, in part, on the strategic interaction between the initial belligerents (I_A and I_B)—specifically, the current conditions of the war (i.e., which side is winning, which is losing, and by how much)—and on O_i's belief about how the war would evolve both with and without its participation. A third party (O_i) will assess whether its entry into the war will increase the prospects of victory for the side it joins or whether that side is likely to lose even if it participates.[6] For example, if O_i is considering joining I_A, who is currently winning on the battlefield and is likely to win the war without O_i's participation, then O_i is only likely to participate if the expected spoils of the war (i.e., the benefits of joining) are greater than the expected costs of fighting. If not, the expected costs of joining the war are likely to convince O_i to refrain from participating. By contrast, if O_i is considering joining I_B, who

[6] A third party can increase the probability of victory for the side it joins by contributing troops to battle, providing new locations for combat, forcing an opponent to relocate forces, or compelling an opponent to revise its military strategy.

is currently losing on the battlefield and is expected to lose the war, and O_i can increase the prospects of I_B's victory, then its participation is more likely. However, if I_B is likely to lose even with the participation of O_i, then O_i is unlikely to join because the expected costs of joining are likely to outweigh the expected benefits.[7] In this way, potential joiners anticipate their effect on the dynamics of the war and base their joining decision, in part, on the expected dynamics following their participation.

However, a third party's joining decision is complicated by the third party's expectations regarding other states' participation. For example, if O_i is considering joining I_A but expects O_j to join I_B, then O_i's decision is more intricate, particularly if the participation of O_j is likely to impede O_i's ability to increase the prospects of victory for I_A. The expectation that O_j will join I_B, giving I_B an advantage that O_i cannot counteract by joining I_A, makes O_i unlikely to join unless O_i expects one or more additional third parties (e.g., O_k, where $k \in N$ and $k \neq i, j$) to also join I_A. In this case a third party might not join and instead implicitly subsidize the intervention out to other third parties because it is less costly to do so, or might join if doing so would put the third party in good favor with fellow victorious states. Thus, O_i's decision to join the war is informed by its *expectations* regarding every other O_j, where O_j might decrease the probability of joining the ongoing war but O_k might increase the probability of joining. In sum, each third party's decision of whether or not to join influences every other third party's decision.

Finally, a third party's (O_i) decision whether or not to join an ongoing war affects the strategic interaction between I_A and I_B as well as the strategic interactions between O_j and O_k. Moreover, each of these relationships affects and is affected by the dynamics of war, since the probabilities of each side winning change with events on the battlefield. As a war evolves, battlefield events and outcomes alter each state's decision calculus. Thus, war

[7] This conceptualization ignores other strategic considerations by O_i, who might, for example, join I_B in a losing cause because it is allied with I_B and wants to send a costly signal to its other alliance partners and the rest of the international system that it fulfills its alliance obligations.

dynamics influence whether I_A or I_B will continue fighting, as well as whether O_i will join I_A or I_B, conditional on all other O_js' joining decisions. In turn, each O_i's joining decision alters the war dynamics, the joining decisions of other O_js, and the decisions of I_A and I_B to continue fighting.

A detailed understanding of war expansion based on these theoretical principles is significant in its own right, but it becomes even more important in the context of understanding war onset more broadly. The *expected* dynamics of a war influence the war's initial onset. States contemplating fighting a war base their decisions, in part, on their beliefs about the *expected* dynamics of the war and whether they are likely to win or lose. States also develop expectations about the role of third parties, specifically whether they expect third parties to join on their behalf or on the behalf of their opponent(s). For example, if I_A believes it can win in a war against I_B but expects O_i to join I_B, and I_A cannot win in a war against I_B and O_i, then I_A may decide not to fight in the first place and seek a peaceful resolution of the issues in dispute prior to the onset of a war. On the other hand, if I_A believes that O_i will align itself with I_A, then I_A may be more willing to fight against I_B. In other words, since potential joiners can alter the course of war and influence the eventual settlement, they can therefore alter the probability that a war will occur between I_A and I_B in the first place. Thus, the expected dynamics of a war, based in part on the potential participation of third parties, play a significant role in the initial onset of the war. As Altfeld and Bueno de Mesquita (1979) note: "If decision makers could forecast the behavior of other states, they might be more cautious about undertaking policies that might lead to war, especially if their calculations revealed a high probability that their intended foe would receive significant aid from other states" (87-88). In short, war expansion is a complex process, requiring a theoretical model capable of capturing the varied strategic interactions between states as well as the shifting dynamics of the war itself.

Modeling War Expansion

The primary mechanism that I argue influences a third party's decision to join an ongoing war—its belief about which other third parties are going to join and on which side—is located at the micro-level. While at the micro-level each third party simply decides what is in its best interest at each time point in the war, at the macro-level, behavioral patterns of war expansion emerge from these individual decisions. Agent-based modeling is particularly well-suited to examining these emergent patterns.

"Agent-based modeling is a computational methodology that allows the analyst to create, analyze, and experiment with artificial worlds populated by agents that interact in non-trivial ways and that constitute their own environment" (Cederman 2001, 16). In general, a computational model, of which agent-based modeling is one type, is a formal representation of a theory as a set of algorithms in a computer program. The contents of the model are defined by the researcher, and the behavior of the model is produced by conducting "runs" or computer simulations of the computer program. The output from the runs are then analyzed to provide insight into the dynamics of the aggregate system that emerges from the behavior of the agents.

Agent-based models are typically composed of a set of diverse agents (e.g., states) that interact with each other using decision-making rules, adapting their behavior based on their own past behavior and/or that of other agents. Computer simulations run using these models can thus uncover the patterns that emerge at the macro-level based on the micro-level decisions made by individual agents. The strengths of this approach include the ability to examine the behavior of a large number of diverse agents and the ability to model agent behavior in a dynamic environment.

An Agent-Based Model of War Expansion

Below I present the main parts of an agent-based model of war expansion, specifically: 1) the agents' characteristics, 2) the execution of the model, 3) the agents' decision rule for joining the war, 4) the war termination rule, and 5) the simulation loop.[8]

The Agents' Characteristics

The construction of the model begins with the creation of an artificial international system populated by 100 heterogeneous agents (i.e., states) that interact in an anarchic environment. From the initial set of agents, two are exogenously chosen to be designated as the initial belligerents in a "war," drawn randomly from the set of all agents.[9] Each agent has an equal probability of being selected as an initial belligerent.

Each agent has two characteristics: 1) material capability and 2) the utility it would derive from each of the initial belligerents winning the war. Each agent is assigned numbers to represent these characteristics, which are drawn from distributions that approximate the empirical distributions of these same characteristics in actual international relations data sets.[10] Thus, this artificial international system approximates the real world international system. Constructing the artificial international system in this way lends realism to the model (i.e., helps with external validity) and lays the groundwork for evaluating the macro-level patterns generated by computer simulations of the model when compared with empirical data from historical wars.

[8] The agent-based model was programmed in Java using the Recursive Porous Agent Simulation Toolkit (Repast) (North, Collier, and Vos 2006).

[9] In the COW Inter-State War Data Set (Sarkees and Wayman 2010), 80% of wars began between two states, 19% between a state and a coalition of states, and 1% between two coalitions of states. Of the wars that expanded, 73% began between two states, 23% between a state and a coalition of states, and 4% between two coalitions of states. Thus, while only two agents are selected as the initial belligerents in the simulated wars this reflects the number of initial belligerents in most historical wars.

[10] The precise procedures used to create the agent distributions can be found in the web appendix.

Material Capability

The first characteristic each agent has is material capability, which is used to calculate its ability to influence the outcome of the war. One commonly used measure of state capability is the Correlates of War (COW) Composite Index of National Capability (CINC) (Singer, Bremer, and Stucky 1972).[11] In order to assign each agent a value to represent their material capability, I first examined the empirical distribution of CINC scores from 1816-2007. Next, I selected a distribution from which to draw agent capability values that closely resembled the empirical CINC distribution with specific parameter settings. Each agent was randomly assigned a value (P_i), drawn from the agent capability distribution, to represent their capability. As in the real international system, in this artificial international system the modal agent has little capability, a few have a moderate level of capability, and even fewer have high capability. After assigning capability values, the stronger initial belligerent was denoted I_A and the weaker initial belligerent I_B, with capability values P_A and P_B, respectively.

Utility for Initial War Belligerents Winning the War

The second characteristic each agent has is a utility for each of the initial belligerents winning the war. One way to measure a third party's utility from an initial belligerent winning the war is to compare the similarity in foreign policy commitments between a third party and an initial belligerent, which can be measured empirically using Kendall's τ_b (Bueno de Mesquita 1975, 1981).[12]

[11] The CINC index is comprised of three dimensions: military, demographic, and industrial. Each dimension has two components: military personnel and military expenditures for the military dimension; total population and urban population for the demographic dimension; and iron/steel production and energy consumption for the industrial dimension. In order to create the index each state's proportion of the total system capabilities for each of the six indicators is calculated. Each state's average across all of the indicators is then calculated, and this average represents its CINC score.

[12] Kendall's τ_b produces a value for the correlation between the two states' foreign policy commitments that ranges from -1 to 1. If a third party has exactly the same foreign policy commitments with an initial participant, including a mutual defense pact, it receives a correlation value of 1. If it has no common foreign policy commitments, it receives a correlation value of zero. If it has completely dissimilar foreign policy commitments, it receives a correlation value of -1. Thus, negative values represent dissimilarity in

In order to assign each agent a value to represent its similarity in foreign policy commitments with each initial belligerent, I first examined the empirical distribution of τ_b scores from 1816 to 2000. Next, I selected a distribution from which to draw τ_b values that closely resembled the empirical distribution of τ_b scores with specific parameter settings. Each agent was randomly assigned two values (α_i^A and α_i^B) from the agent distribution; the first one representing its utility from I_A winning the war, the second representing its utility from I_B winning the war.

Model Execution

The execution of the model is the sequence in which agents are called upon to execute their decision rule (i.e., joining decision), which will be described below. The historical record reveals that in some wars multiple third parties joined on the same date and also that some third parties exited wars before they ended.[13] For example, in World War II, four states joined on September 3, 1939: Australia, France, New Zealand, and the United Kingdom. Also, in World War II, numerous states joined the war and then exited before the war ended, including Greece (April 23, 1941) and Finland (September 19, 1944) among many others. In order to capture these empirical facts in the model, agent decisions are made in parallel (Duffy 1992, Cederman 1997); at each time point all agents simultaneously decide whether or not to join the ongoing war. Agents who joined in $t-1$ have to decide whether they want to remain in the war at the next time point (t) or exit the war. Agents who did not join at t still have the opportunity to join at $t+1$, $t+2$, ..., T. In this way, multiple agents can join at each time point during the war, agents who previously joined can exit the war at any

foreign policy commitments, a value of zero represents no similarity, and positive values represent similarity. Signorino and Ritter (1999) provide several important criticisms of τ_b and propose another measure (S). These criticisms, while important, are not directly relevant for the current model, except that the distribution of S scores is quite different from the distribution of τ_b scores.

[13] In the COW Inter-State War Data Set (Sarkees and Wayman 2010), 35% of the wars that expanded had multiple third parties join on the same date and in 23% of the wars that expanded third parties that joined exited before the war ended.

time, and agents who joined the war and then exited can later re-join.

Agents' Decision Rule for Joining the War

Based on the two characteristics described above—1) each agent's material capability and 2) the utility it would derive from each of the initial belligerents winning the war—each agent initially calculates its "naive utility" for joining the war (without considering what all other agents will do).

If $\alpha_i^A > \alpha_i^B$, then agent O_i prefers I_A to win and would join the war if and only if:

$$\left[\frac{\mathrm{P}_A + \mathrm{P}_i}{\mathrm{P}_A + \mathrm{P}_B + \mathrm{P}_i} - \frac{\mathrm{P}_A}{\mathrm{P}_A + \mathrm{P}_B}\right] \times (\alpha_i^A - \alpha_i^B) > c_{it} \tag{1}$$

where c_{it} represents the cost each agent expects to pay for joining the war (the cost term is described more fully below). In words, the left side of the inequality in (1) represents the difference in the probability that I_A wins if O_i joins I_A and the probability that I_A wins if O_i does not join (i.e., remains neutral) multiplied by the difference in utility O_i would derive from I_A and I_B winning the war, respectively. If the left side of the inequality is greater than the expected cost of joining, then O_i would join the war on side I_A.

If $\alpha_i^A < \alpha_i^B$, then O_i prefers I_B to win and would join the war if and only if:

$$\left[\frac{\mathrm{P}_A}{\mathrm{P}_A + \mathrm{P}_B + \mathrm{P}_i} - \frac{\mathrm{P}_A}{\mathrm{P}_A + \mathrm{P}_B}\right] \times (\alpha_i^A - \alpha_i^B) > c_{it}. \tag{2}$$

The only difference between (1) and (2) is that the first term in brackets represents the probability that I_A wins if O_i joins I_B. If the left side of the inequality in (2) is greater than the expected cost of joining, then O_i would join the war on side I_B.[14]

Finally, if $\alpha_i^A = \alpha_i^B$, then O_i does not have a preference for whether I_A or I_B wins and will

[14]Note that the left side of the inequality in (2) is positive since $\frac{\mathrm{P}_A}{\mathrm{P}_A+\mathrm{P}_B+\mathrm{P}_i} - \frac{\mathrm{P}_A}{\mathrm{P}_A+\mathrm{P}_B} < 0$ (a negative number) and $(\alpha_i^A - \alpha_i^B) < 0$ (also a negative number), so the product is positive.

not join. However, since α_i^A and α_i^B are drawn from continuous distributions the probability that $\alpha_i^A = \alpha_i^B$ is zero. The agents that will not join are those for whom $\alpha_i^A > \alpha_i^B$ but for whom the left side of the inequality in (1) is less than or equal to c_{it} or $\alpha_i^A < \alpha_i^B$ and for whom the left side of the inequality in (2) is less than or equal to c_{it}. In both cases, O_i will not join because the expected costs of joining are too high.

Thus, we have three groups of states: 1) those that could potentially join I_A (F^A), 2) those that could potentially join I_B (F^B), and 3) those that would not join because the expected cost of joining is too high.

Forecasting

Each third party's decision is informed by its ability to influence the war as well as by the difference between, on the one hand, the utilities the third party would derive from each initial belligerent winning and, on the other hand, the expected cost of joining. In addition, each third party's decision is complicated by the many other third parties that could potentially join the war, since a third party's ability to influence a war in each time point is determined by the distribution of capabilities between the two coalitions of participants, which is calculated from the combined capabilities not only of the initial belligerents but *of all the third parties that could join each side* as well. Third parties are therefore likely to use information about other third parties' joining decisions when deciding whether or not to join by forecasting the future joining behavior of other states. As Kim notes "much of third party decision making rests on what third nations think other third nations will do" (1991, 664). While most theoretical and empirical research examining third party joining in ongoing wars make predictions about which third parties are likely to join ongoing wars and the side on which that joining is expected to occur, no existing studies allow the third parties themselves to use this information when deciding whether or not to join. In contrast, in this model, each third-party agent forecasts which other third parties will join in the next time point and incorporates this forecast into its contemporaneous joining decision. Since my interest is in defining the conditions under which a given state will and will not join an ongoing war, building a forecasting ability into the model is a crucial step.

In the model, the forecasting rule is based on each agent's "naive utility" for joining as defined by the inequalities in (1) and (2). At the beginning of each time point in the war, each agent knows its own naive utility, the naive utilities of all of the other agents, and the expected cost of joining the war. Before each agent makes its joining decision, it uses this information to forecast which other agents could potentially join the war in the next time point.

The forecasting rule is implemented as follows: if an agent's naive utility for joining is positive and $\alpha_i^A > \alpha_i^B$, the agent is forecasted to join I_A; if an agent's naive utility for joining is positive and $\alpha_i^A < \alpha_i^B$, the agent is forecasted to join I_B; and if an agent's naive utility for joining is negative, the agent is forecasted to remain neutral. Thus, the agents that are forecasted to remain neutral are those for whom the expected costs of joining are too high.[15]

For all of the agents that are forecasted to join I_A or I_B in the next time point, their capability values are summed (denoted $\sum\limits_{j \in F^A} \mathrm{P}_j$ and $\sum\limits_{k \in F^B} \mathrm{P}_k$, respectively). Next, each agent calculates the probabilities of I_A and I_B winning the war based on which agents are forecasted to join each side. The probability of I_A winning if all of the states forecasted to join I_A and I_B actually do so is:

$$p_i^A = \frac{\mathrm{P}_A + \sum\limits_{j \in F^A} \mathrm{P}_j}{\mathrm{P}_A + \mathrm{P}_B + \sum\limits_{j \in F^A} \mathrm{P}_j + \sum\limits_{k \in F^B} \mathrm{P}_k} \tag{3}$$

The probability of I_B winning is: $p_i^B = 1 - p_i^A$, or:

[15]As mentioned above, since α_i^A and α_i^B are drawn from continuous distributions the probability that $\alpha_i^A = \alpha_i^B$ is zero. Agents are forecasted to remain neutral only when the expected costs of joining are too high and not when the utilities they would derive from each initial belligerent winning are equal.

$$p_i^B = \frac{\mathrm{P}_B + \sum\limits_{k \in F^B} \mathrm{P}_k}{\mathrm{P}_A + \mathrm{P}_B + \sum\limits_{j \in F^A} \mathrm{P}_j + \sum\limits_{k \in F^B} \mathrm{P}_k} \tag{4}$$

In words, for all of the agents that are forecasted to join I_A or I_B in the next time point, their capability values are summed and then added to the combined capability values of the initial belligerents. Thus, the probabilities of I_A and I_B winning are based not only on the capabilities of I_A and I_B but also on the capabilities of all of the agents that are forecasted to join each side.

Each agent then calculates its expected utility for joining the war:

$$\mathrm{EU}_i(\mathrm{J}) = \alpha_i^A p_i^A + \alpha_i^B (1 - p_i^A) - c_{it} \tag{5}$$

where p_i^A is calculated as above.

Next, each agent calculates its expected utility for the status quo (i.e., its expected utility for remaining neutral):

$$\mathrm{EU}_i(\mathrm{SQ}) = \alpha_i^A p_{\sim i}^A + \alpha_i^B (1 - p_{\sim i}^A) \tag{6}$$

where

$$p_{\sim i}^A = \frac{\mathrm{P}_A + \sum\limits_{j \in F^A, j \neq i} \mathrm{P}_j}{\mathrm{P}_A + \mathrm{P}_B + \sum\limits_{j \in F^A, j \neq i} \mathrm{P}_j + \sum\limits_{k \in F^B, k \neq i} \mathrm{P}_k} \tag{7}$$

$$1 - p_{\sim i}^A = \frac{\mathrm{P}_B + \sum\limits_{k \in F^B, k \neq i} \mathrm{P}_k}{\mathrm{P}_A + \mathrm{P}_B + \sum\limits_{j \in F^A, j \neq i} \mathrm{P}_j + \sum\limits_{k \in F^B, k \neq i} \mathrm{P}_k} \tag{8}$$

where $p_{\sim i}^A$ represents the probability that I_A wins if all of the agents forecasted to join I_A and I_B actually do so but if O_i does not join and $p_{\sim i}^B$ (or $1 - p_{\sim i}^A$) represents the probability that I_B wins if all of the agents forecasted to join I_A and I_B actually do so but if O_i does not join. If O_i was forecasted to remain neutral then $p_i^A = p_{\sim i}^A$. If $\text{EU}_i(\text{J}) > \text{EU}_i(\text{SQ})$, then O_i joins I_A or I_B depending on whether $\alpha_i^A > \alpha_i^B$ or $\alpha_i^A < \alpha_i^B$, and receives a payoff equivalent to $\text{EU}_i(\text{J})$. If $\text{EU}_i(\text{J}) \leq \text{EU}_i(\text{SQ})$, then O_i does not join (i.e., remains neutral), and receives a payoff equivalent to $\text{EU}_i(\text{SQ})$.[16]

One implication of this setup is that some agents are forecasted to join the war based on their naive utility but will not do so after forecasting which other agents will join and accounting for those agents' capability contributions and their expected costs of joining. In short, as in reality, not all agents forecasted to join in the next time point in the war actually do so.[17] However, because agents can enter and exit the war over time, an agent may remain neutral for some time points but join the war in other time points.

Cost of Joining the War

The cost that an agent pays for joining an ongoing war contains both a fixed and stochastic component and is heterogeneous across agents. Specifically, $c_{it} = \dfrac{\kappa_i + \kappa_{it}}{2}$, where $\kappa_i \sim U[0.00001, 0.0001]$ is unique to each agent and does not vary with t, and $\kappa_{it} \sim U[0.01, 0.1]$ is unique to each agent but does very with t. The basic idea is that an agent's cost for joining reflects the importance of the war (κ_i), which should not change (at least much) over time, as well as the actual loss of resources, which does change over time (κ_{it}). When each agent calculates its naive utility (the inequalities in Equations 1 or 2), it estimates the cost of joining based on c_{it} but it does not pay the cost of joining unless it actually joins the war. If an agent joins the war then the cost of joining is subtracted from its capability (P_i). Thus, if an agent joins an ongoing war, the cost of joining decreases that agent's

[16] Note that $\text{EU}_i(\text{SQ}) \neq 0$.

[17] In the model each agent's joining decision is only first-order strategically consistent. This setup is different from having each agent calculate every possible joining scenario. For example, suppose there are three agents forecasted to join: x, y, and z. In this case, the probability that I_A wins is p_{xyz}^A, where x, y, $z \in \{0, 1\}$ and 0 represents an agent not joining and 1 represents an agent joining. In this case x, y, z could each calculate $(p_{111}^A - p_{011}^A)(\alpha_i^A - \alpha_i^B)$, $(p_{110}^A - p_{010}^A)(\alpha_i^A - \alpha_i^B)$, $(p_{101}^A - p_{001}^A)(\alpha_i^A - \alpha_i^B)$, and $(p_{100}^A - p_{000}^A)(\alpha_i^A - \alpha_i^B)$.

capability, in turn reducing its ability to influence the outcome of the war. As a result, agents that are relatively more powerful have the potential to participate longer in a war than agents with relatively less power. Since an agent's capability influences its naive utility, its capability affects whether or not the agent is forecasted to join in the next time point as well as its expected utility for joining the war ($\text{EU}_i(\text{J})$), influencing in turn whether or not $\text{EU}_i(\text{J}) > \text{EU}_i(\text{SQ})$. As a result, agents that joined the war may later exit the war if the cost of remaining in the war is too high.

War Termination

The historical record shows considerable variance in the duration of wars. For example, the Six Day War in 1967 lasted, as its name implies, only six days while the war between Iraq and Iran lasted for 2,890 days (1980-88). In order to generate simulated wars of various lengths, the model contains a war termination rule. This rule endogenizes the timing of a war's termination to the war's dynamics (the probability of each side winning over time). Since third-party joining affects a war's dynamics, the war termination rule links third-party joining with a war's termination. Furthermore, this rule generates simulated wars that do not expand in addition to generating wars that do expand.[18]

The war termination rule is based, in part, on the point in a war when one side obtains a preponderance of capability (Cederman 1997). The war termination rule is comprised of two criteria: 1) when the distribution of capabilities between the two coalitions of belligerents (including the initial belligerents and any third parties that joined) exceeds the victory threshold, *and* 2) when a random number drawn from $U[0, 1]$ exceeds the victory threshold. When these two criteria are met, the war terminates. The second criterion allows a war to end probabilistically at each time point; that is, even if the distribution of capabilities

[18]However, since the dynamics of war are produced by third-party joining, if no third parties join, there are no dynamics; that is, the probability of each initial belligerent winning is constant throughout the entire war.

exceeds the victory threshold, there is some probability that the war will continue for at least one additional time point. This implementation does not allow wars in which the distribution of capabilities never exceeds the victory threshold to terminate. When the distribution of capabilities is less than the victory threshold, the war always continues until it surpasses the victory threshold (at which point the war has some probability of ending) or the war terminates exogenously at the 50th time point.[19] In the simulation results presented below the victory threshold was set at 0.67.

Simulation Loop

The computer simulation proceeds as follows:

1. Create 100 agents.
2. Randomly assign each agent a value representing its capability (P_i).
3. Randomly select two agents to be designated as the initial belligerents in a war with capabilities P_A and P_B, respectively.
4. Randomly assign each of the remaining agents two values representing the utility each agent would derive from each of the initial belligerents winning the war (α_i^A and α_i^B, respectively).
5. Each agent calculates its naive utility for joining.
6. Each agent forecasts which other agents are going to join the war in the next time point and then calculates its expected utility for joining ($\mathrm{EU}_i(\mathrm{J})$) and its expected utility for the status quo ($\mathrm{EU}_i(\mathrm{SQ})$).

[19] It is important to note that wars that ended at the 50th time point would have continued but ended because of this exogenously specified rule. However, the 50th time point was chosen because the dynamics of war change little after this point in time.

7. All agents simultaneously decide whether or not to join the war depending on whether $\text{EU}_i(\text{J}) > \text{EU}_i(\text{SQ})$ and, if so, which side to join depending on whether $\alpha_i^A > \alpha_i^B$ or $\alpha_i^A < \alpha_i^B$.

8. For each agent that joins the war, subtract the cost of joining (c_{it}) from its capability (P_i).

9. Repeat steps 5, 6, 7, and 8 until the war endogenously terminates or the 50th time point is reached.

Computer Simulations

One advantage of agent-based modeling is that it allows for perfectly controlled experiments, thus permitting the exploration of how agents' behaviors vary when the model's parameters are altered. I begin by varying one parameter: the forecasting rule. When the forecasting rule is 'on,' each agent makes its joining decision by comparing their expected utility for joining to their expected utility for the status quo after forecasting which other agents are expected to join in the next time point (see Equations 5 and 6). When the forecasting rule is 'off,' each agent makes its joining decision using their naive utility, which does not account for which other agents are expected to join in the next time point (see Equations 1 and 2). By varying this parameter I can turn third parties' strategic behavior on and off, which allows me to explore how the macro-level patterns of war expansion change when agent's are strategic and when they are not.

I conducted 1,000 simulations with and without the forecasting rule, with each simulation using a different random number seed. This number of simulations ensures that the initial conditions vary for each simulation and that the macro-level patterns that emerge are not contingent on the system's initial conditions. The macro-level patterns of interest in these simulated wars are: 1) the percentage of simulated wars that did and did not expand, and 2) the percentage of agents in the artificial international system that joined in simulated wars that expanded. These two macro-level patterns were chosen because they address the two questions of interest posed at the outset of the paper: 1) why do some wars expand while others do not, and 2) why do some wars expand to include a large number of additional states while others only expand to include a few.

To test the contribution of the model I have presented, I look simply at whether the macro-level patterns exhibited by the simulated wars match those observed in the historical record of actual wars. Specifically, the proposed model accounts for two mechanisms of war expansion not yet addressed in the conflict literature: 1) third-party states base their joining decisions, in part, on the anticipated joining decisions of other third parties, and 2) third-party states update their joining decisions across the course of a war. If these mechanisms produce the same macro-level patterns of conflict expansion that we observe historically, then these findings support the need to incorporate the dynamic interdependence of third-party joining decisions into our models—both computational and statistical—not only of war expansion but also of war in general.

Simulation Results

Simulated Wars that Expanded and Did Not Expand

The first macro-level pattern of interest is the percentage of simulated wars that expanded compared to those that did not. If third parties base their decision to join an ongoing war, in part, on which other third parties are expected to join the war, then the percentage of simulated wars that expand when third parties anticipate the joining decisions of other third parties should better reflect the historical record than the percentage of simulated wars that expand without the forecasting rule in place. Recall that, in the historical record, 27% of the interstate wars between 1816 and 2007 expanded to include additional states while 73% did not (i.e., the wars began and ended with the same initial belligerents).

Insert Figure 2 here.

Figure 2 shows the distribution of the number of simulated wars that expanded across the percentage of agents that joined in those wars when the forecasting rule is "off" (left panel) and when the forecasting rule is "on" (right panel). When agents made their joining decisions without considering which other agents were expected to join in the next time point, 99.5% expanded while 0.5% did not expand. In contrast, in the simulated wars where agents made their joining decisions strategically, 30% of the simulated wars expanded to included additional agents while 70% did not expand. Thus, when agents do not make their joining decisions strategically the percentage of simulated wars that expanded is not close to the percentage of historical wars that expanded between 1816 and 2007. In contrast, when agent's make their joining decisions using the decision-making process described by the model, the percentage of simulated wars that expanded is not only empirically plausible but very close to the percentage that expanded in the historical record. This result provides some confirmation that when third parties are considering joining in actual wars they base their decisions, in part, on which other states are likely to join in the future.

Percentage of Agents that Joined in the Simulated Wars

Now that I have shown that the forecasting rule can produce simulated wars that are close to wars in the historical record, the next step is to see if the percentage of agents in the artificial international system that joined in those simulated wars is close to the percentage of third parties that joined in historical wars. The percentage of agents that joined in the simulated wars without the forecasting rule are not empirically plausible. A large number of those simulated wars expanded to include a large percentage of the international system including some that expanded to include every state in the international system. The largest war that expanded in the historical record (World War II) expanded to include 35% of the states in the international system. In the simulated wars that expanded without the forecasting rule, 33% of those simulated exceeded this percentage. In general, the simulated wars without the forecasting rule involve more joining than occurred in historical wars that expanded. As a result, I do not examine the percentage of agents that joined in the simulated wars that expanded without the forecasting rule.

Insert Figure 3 here.

In contrast to the simulated wars without the forecasting rule, when agents behave strategically most of the simulated wars that expand only include a few additional agents. Figure 3 shows the distribution of the number of wars that expanded across the percentage of agents that joined. The left panel shows the distribution for the simulated wars with the forecasting rule while the right panel shows the distribution for historical wars between 1816 and 2007.

Of the simulated wars that expanded with the forecasting rule, 98% expanded to include only one or two additional agents (1% or 2% of the artificial international system). However, there are a few simulated wars that expanded to include between 10 and 31 additional agents (10% to 32% of the system) but these large wars only account for 0.5% of the simulated wars. As in the historical record, most simulated wars expanded to include only a few additional agents but a few expanded to include a large number of additional agents. In sum, the percentage of agents the artificial international system that joined in the simulated wars when the forecasting rule was operative is comparable to the percentage of third parties that joined in historical wars that expanded between 1816 and 2007.

While at the micro-level, each agent simply decides what is in its best strategic interest at each time point in a war (i.e., join a side or remain neutral), at the macro-level there is a clear divide between the outcomes of no expansion (the majority of historical cases) and explosive expansion (e.g., World Wars I and II); as suggested by history, war expansion behaves like an "all or nothing" phenomenon. These aggregate patterns are especially interesting because in the model they are in no way driven by individual agents intending to produce a grand avalanche of expansion.

Conclusion

Why do some wars expand while others do not? Why do some wars expand to include a large number of additional states while others only expand to include a few states? In this paper, I argued that one mechanism that could provide an answer to these two questions is the interdependent nature of third parties' joining decisions. Specifically, when third parties decide whether or not to join ongoing wars they base their decisions on which other third parties are expected to join the war in the future. This mechanism was encoded in an agent-based model, where the central feature is the decisional dependence between a single third party's decision to join an ongoing war and all other third parties' joining decisions. In the model, this decisional dependence was implemented by allowing a third party to estimate which other third parties were expected to join the war in the future and condition its contemporaneous joining decision on this expectation. Simulations of the agent-based model produced the macro-level patterns of war expansion. In this paper I focused on two macro-level patterns: 1) the percentage of simulated wars that expanded and 2) the percentage of agents in the artificial international system that joined in those wars. These two macro-level patterns produced by the agent-based model are consistent with the macro-level patterns of war expansion observed in the historical record.

The next step in this project is to examine an additional macro-level pattern, specifically the dynamics of war. This macro-level pattern is how the probability of each coalition of participants winning changes over the course of a war. By examining this pattern I will be able to examine a key debate in the International Relations literature: balancing versus bandwagoning. When third parties join ongoing wars do they balance against the stronger side by joining the weaker side or do they join to bandwagon with the stronger side? When during an ongoing war is balancing or bandwagoning more prevalent? Do third parties join to balance early in a war but join to bandwagon late in a war once it becomes clear which side will win? These are important questions and they can be answered using the agent-based model developed in this paper.

As with any model there are a variety of components that have been left out. For example, an alternative way to implement the forecasting rule would be to allow agents to forecast farther into the future. Before third parties decide whether or not to join in real wars it is quite plausible that they forecast much farther ahead than a single time point. In a future iteration of this model, I plan to allow each agent to forecast farther into the future and incorporate not only which agents are expected to join in the next time point but also which agents are expected to join in future time points. As another example, third parties could also derive utility from a coalition of states winning a war as opposed to a single initial belligerent winning the war. One way to capture this utility would be to calculate a third party's similarity in foreign policy commitments with all of the states currently participating in the war on each side. In a future extension of the model, I plan to incorporate this feature. Finally, this model treats the onset of a war as exogenously determined. In a future extension of this model, I plan to allow the agents to decide whether or not to initiate a war and whom to target. In that model, one of the factors considered by the agents when deciding whether or not to initiate a war will be an expectation about which other agents are likely to join on their behalf and on behalf of their target. This extension will allow me to examine how the anticipated participation of third parties influences war onset.

References

Altfeld, Michael F., and Bruce Bueno de Mesquita. 1979. “Choosing Sides in Wars.” *International Studies Quarterly* 23(1): 87–112.

Bremer, Stuart A. 1980. “National Capabilities and War Proneness.” In *The Correlates of War II: Testing Some Realpolitik Models*, ed. J. David Singer. New York, NY: The Free Press pp. 57–82.

Bueno de Mesquita, Bruce. 1975. “Measuring Systemic Polarity.” *Journal of Conflict Resolution* 19(2): 187–216.

Bueno de Mesquita, Bruce. 1981. *The War Trap.* New Haven, CT: Yale University Press.

Bueno de Mesquita, Bruce, James D. Morrow, Randolph M. Siverson, and Alastair Smith. 1999. “An Institutional Explanation of the Democratic Peace.” *American Political Science Review* 93(4): 791–807.

Cederman, Lars-Erik. 1997. *Emergent Actors in World Politics: How States and Nations Develop and Dissolve.* Princeton, NJ: Princeton University Press.

Cederman, Lars-Erik. 2001. “Agent-Based Modeling in Political Science.” *The Political Methodologist* 10(1): 16–22.

Corbetta, Renato. 2010. “Determinants of Third Parties’ Intervention and Alignment Choices in Ongoing Conflicts, 1946-2001.” *Foreign Policy Analysis* 6(1): 61–85.

Duffy, Gavan. 1992. “Concurrent Interstate Conflict Simulations: Testing the Effects of the Serial Assumption.” *Mathematical and Computer Modelling* 16(8/9): 241–70.

Gartner, Scott Sigmund, and Randolph M. Siverson. 1996. “War Expansion and War Outcome.” *Journal of Conflict Resolution* 40(1): 4–15.

Gartzke, Erik, and Kristian Skrede Gleditsch. 2004. "Why Democracies May Actually Be Less Reliable Allies." *American Journal of Political Science* 48(4): 775–795.

Haldi, Stacy. 2003. *Why Wars Widen: A Theory of Predation and Balancing.* Portland, OR: Frank Cass.

Huth, Paul K. 1988. *Extended Deterrence and the Prevention of War.* New Haven, CT: Yale University Press.

Huth, Paul K. 1998. "Major Power Intervention in International Crises, 1918-1988." *Journal of Conflict Resolution* 42(6): 744–770.

Joyce, Kyle A., and Alex Braithwaite. 2013. "Geographic Proximity and Third Party Joiners in Militarized Interstate Disputes." *Journal of Peace Research* 50(5): 595–608.

Joyce, Kyle A., Faten Ghosn, and Reşat Bayer. 2014. "When and Whom to Join: The Expansion of Ongoing Violent Interstate Conflicts." *British Journal of Political Science* 44(1): 205–238.

Kim, Chae-Han. 1991. "Third-Party Participation in Wars." *Journal of Conflict Resolution* 35(4): 659–677.

Leeds, Brett Ashley. 2003*a*. "Alliance Reliability in Times of War: Explaining State Decisions to Violate Treaties." *International Organization* 57(4): 801–827.

Leeds, Brett Ashley. 2003*b*. "Do Alliances Deter Aggression? The Influence of Military Alliances on the Initiation of Militarized Interstate Disputes." *American Journal of Political Science* 47(3): 427–439.

Levy, Jack S. 1982. "The Contagion of Great Power War Behavior, 1495-1975." *American Journal of Political Science* 26(3): 562–584.

Melin, Molly M., and Michael T. Koch. 2010. "Jumping into the Fray: Alliances, Power, Institutions, and the Timing of Conflict Expansion." *International Interactions* 36(1): 1–27.

Most, Benjamin, Philip Schrodt, Randolph Siverson, and Harvey Starr. 1990. "Borders and Alliance Effects in the Diffusion of Major Power Conflict, 1816-1965." In *Prisoners of War?: Nation-States in the Modern Era*, ed. Charles S. Gochman, and Alan Ned Sabrosky. Lexington, MA: Lexington Books pp. 209–229.

North, Michael J., Nicholson T. Collier, and Jerry R. Vos. 2006. "Experiences Creating Three Implementations of the Repast Agent Modeling Toolkit." *ACM Transactions on Modeling and Computer Simulation* 16(1): 1–25.

Raknerud, Arvid, and Håvard Hegre. 1997. "The Hazard of War: Reassessing the Evidence for the Democratic Peace." *Journal of Peace Research* 34(4): 385–404.

Reiter, Dan, and Allan C. Stam. 2002. *Democracies at War*. Princeton, NJ: Princeton University Press.

Sabrosky, Alan Ned. 1980. "Interstate Alliances: Their Reliability and the Expansion of War." In *The Correlates of War II: Testing Some Realpolitik Models*, ed. J. David Singer. New York, NY: The Free Press pp. 161–198.

Sarkees, Meredith Reid, and Frank W. Wayman. 2010. *Resort to War: 1816-2007*. Washington D.C.: CQ Press.

Schweller, Randall L. 1994. "Bandwagoning for Profit: Bringing the Revisionist State Back In." *International Security* 19(1): 72–107.

Signorino, Curtis S., and Jeffrey M. Ritter. 1999. "Tau-b or Not Tau-b: Measuring the Similarity of Foreign Policy Positions." *International Studies Quarterly* 43(March): 115–144.

Singer, J. David, Stuart Bremer, and John Stucky. 1972. "Capability Distribution, Uncertainty, and Major Power War, 1820-1965." In *Peace, War, and Numbers*, ed. Bruce M. Russett. Beverly Hills, CA: Sage Publications pp. 19–48.

Siverson, Randolph M., and Harvey Starr. 1991. *The Diffusion of War: A Study of Opportunity and Willingness.* Ann Arbor, MI: University of Michigan Press.

Siverson, Randolph M., and Joel King. 1979. "Alliances and the Expansion of War, 1815-1965." In *To Augur Well: Early Warning Indicators in World Politics*, ed. J. David Singer, and Michael Wallace. Beverly Hills, CA: Sage Publications pp. 37–49.

Smith, Alastair. 1995. "Alliance Formation and War." *International Studies Quarterly* 39(4): 405–425.

Smith, Alastair. 1996. "To Intervene or Not to Intervene: A Biased Decision." *Journal of Conflict Resolution* 40(1): 16–40.

Stoll, Ric. 1995. "The Evolution of War." In *The Process of War: Advancing the Scientific Study of War*, ed. Stuart A. Bremer, and Thomas R. Cusack. Amsterdam: Gordon and Breach Publishers pp. 129–160.

Werner, Suzanne. 2000. "Deterring Intervention: The Stakes of War and Third-Party Involvement." *American Journal of Political Science* 44(4): 720–732.

Werner, Suzanne, and Douglas Lemke. 1997. "Opposites Do Not Attract: The Impact of Domestic Institutions, Power, and Prior Commitments on Alignment Choices." *International Studies Quarterly* 41(3): 529–546.

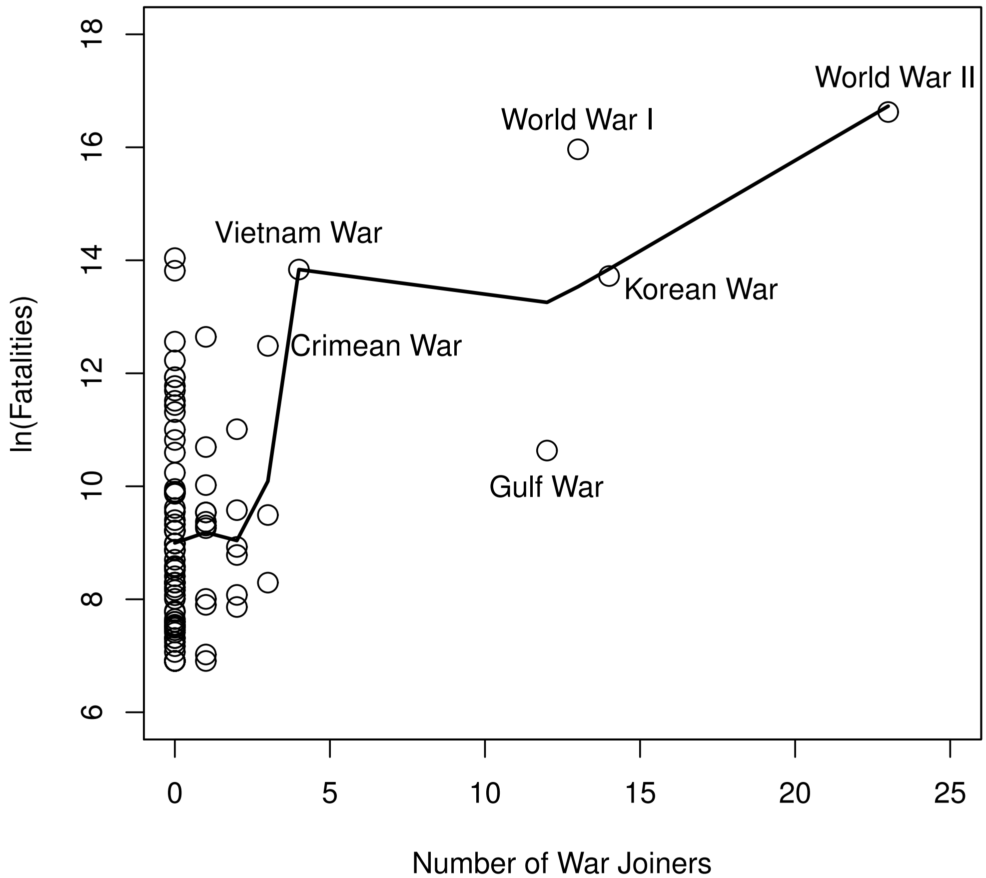
Yamamoto, Yoshinobu, and Stuart A. Bremer. 1980. "Wider Wars and Restless Nights: Major Power Intervention in Ongoing War." In *The Correlates of War II: Testing Some Realpolitik Models*, ed. J. David Singer. New York, NY: The Free Press pp. 199–229.

Table 1: Number of War Joiners, 1816-2007

Name of War	Number of War Joiners
Austro-Sardinian (1848-49)	2
Roman Republic (1849)	2
Crimean (1853-56)	3
Italian Unification (1859)	1
Lopez (1864-70)	1
Naval War (1865-66)	1
Seven Weeks (1866)	1
War of the Pacific (1879-1883)	1
Second Balkan (1913)	2
World War I (1914-18)	13
Estonian Liberation (1918-1920)	1
Latvian Liberation (1918-1920)	3
Hungarian Adversaries (1919)	1
World War II (1939-1945)	23
Korean (1950-53)	14
Sinai (1956)	2
Ifni (1957-1959)	1
Vietnam (1965-75)	4
Second Laotian (1968-1973)	1
Communist Coalition (1970-1971)	2
Yom Kippur (1973)	2
War over Angola (1975-1976)	1
Second Ogaden (1977-1979)	1
Ugandan-Tanzanian (1978-1979)	1
Gulf War (1990-91)	12
Invasion of Afghanistan (2001)	3

Source: Correlates of War Project Inter-State War Data, 1816-2007 (Sarkees and Wayman 2010).

Figure 1: War Joining and Fatalities in Interstate Wars, 1816-2007



Note: Each circle represents one war and the line is a local linear regression of the natural log of battle-connected fatalities on the number of war joiners. Source: Correlates of War Project Inter-State War Data, 1816-2007 (Sarkees and Wayman 2010).

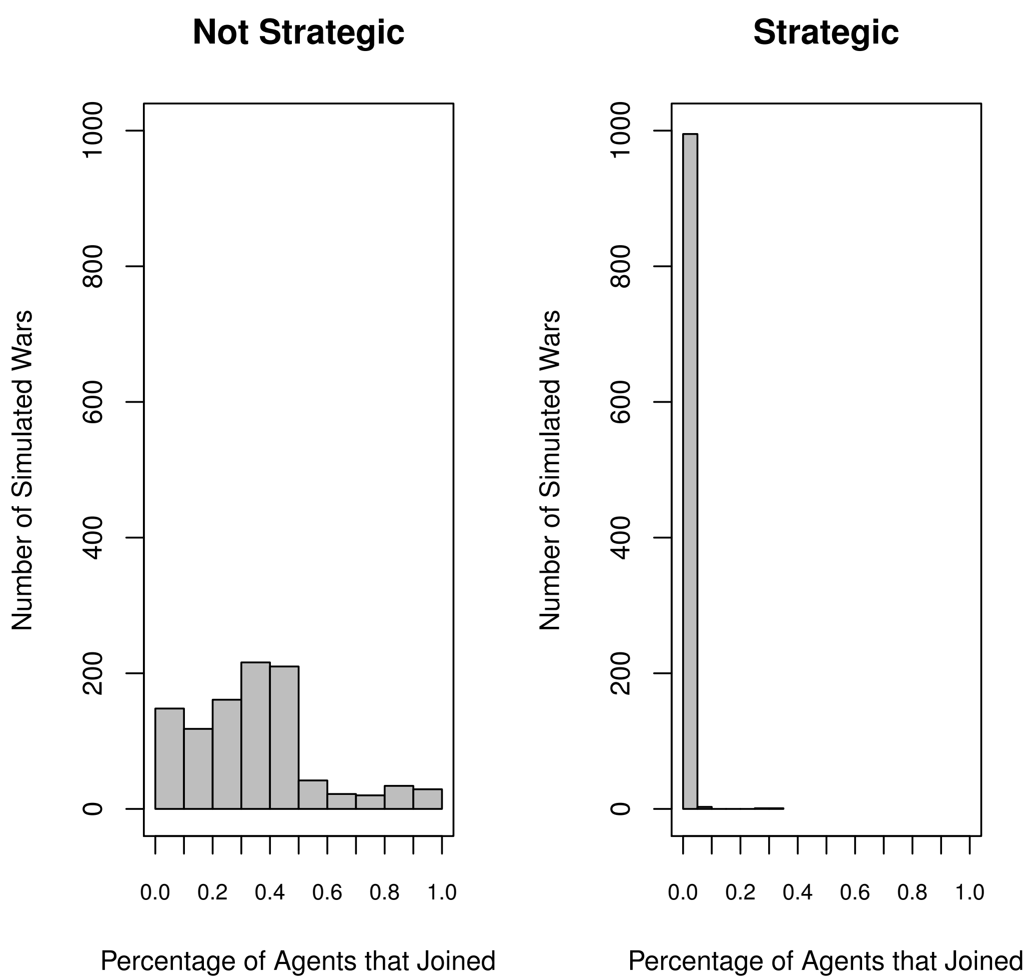


Figure 2: Percentage of Agents that Joined in Simulated Expanded Wars.

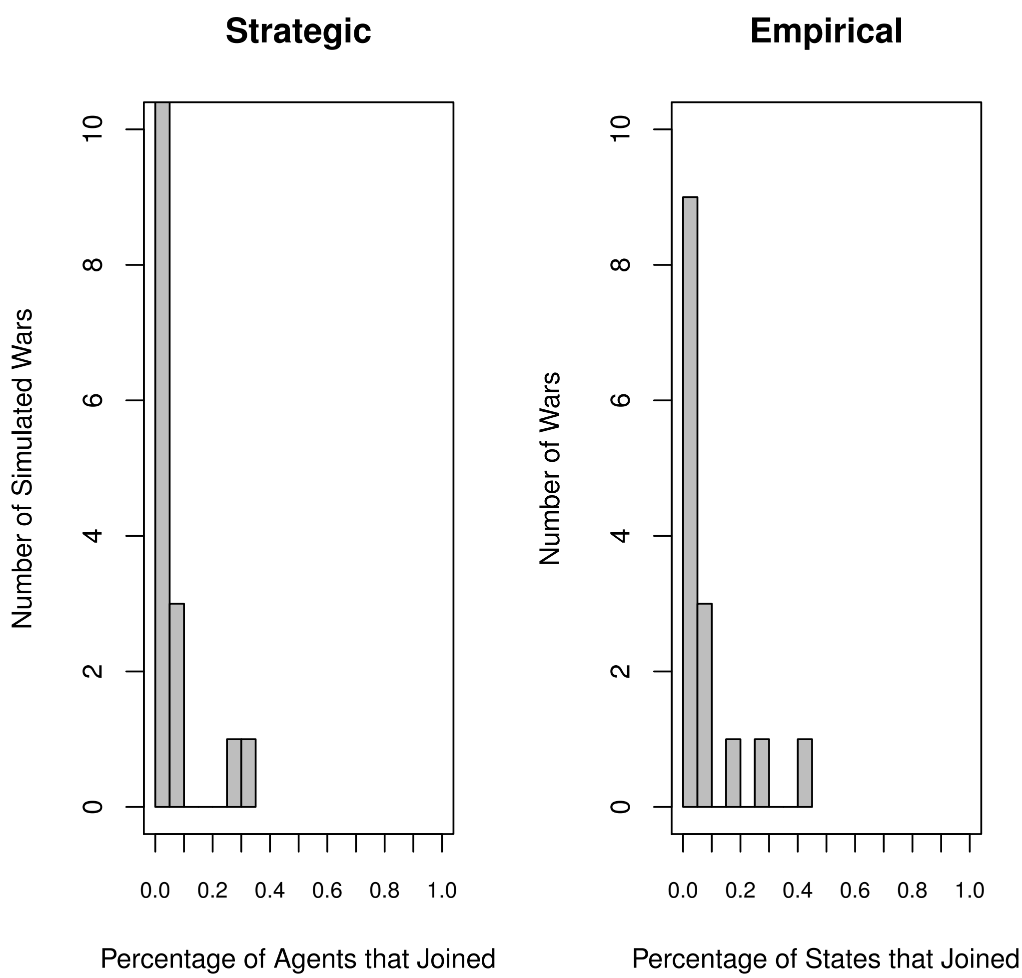


Figure 3: Percentage of Agents that Joined in Simulated Expanded Wars and in Historical Wars (1816-2007).