UNTIL THE BITTER END?
The Diffusion of Surrender Across Battles

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Abstract

Why do armies sometimes surrender to the enemy and sometimes fight to the bitter end? Existing research has highlighted the importance of battlefield resolve for the onset, conduct and outcome of war, but has left these life-and-death decisions mostly unexplained. We know little about why battle-level surrender occurs, and why it stops. In this paper, we argue that surrender emerges from a collective action problem: success in battle requires that soldiers choose to fight as a unit rather than flee, but individual decisions to fight depend on whether soldiers expect their comrades to do the same. As a result, surrender becomes contagious across battles, as soldiers take cues from what other soldiers had done when they were in a similar position. Where no recent precedent exists, mass surrender is unlikely. We find empirical support for this claim using a new dataset of conventional battles in all interstate wars from 1939 to 2011. These findings advance our understanding of battlefield resolve, with broader implications for the design of political-military institutions and decisions to initiate, continue, and terminate war.

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Across a sequence of battles, surrender and desertion can cascade through an army, undermining unit resolve and hastening a military's disintegration.[1] During the Battle of Sailor's Creek in the U.S. Civil War, eight Confederate generals and 7,700 troops surrendered to the Union army, following a string of similar events in the Appomattox Campaign. Analogous episodes occurred during the Italian campaign of World War II, Israel's conquest of the Sinai Peninsula in 1967, and, recently, the fall of Ramadi, Fallujah and Mosul to the Islamic State in Iraq.

Decisions to raise the white flag of surrender have consequences far beyond the battlefield. Besides the obvious – loss of territory, shifts in the local balance of power – surrender reduces the costs of war for the opponent, making conquest easier and military action more attractive. It is difficult to signal resolve, deter aggression or compel the opponent to stop fighting if one's own troops will not fight. Surrender is also individually costly – many political authorities consider it high treason, and establish political-military institutions to prevent it. Given the gravity of such decisions, the choice to lay down one's arms is not a trivial one. Why do soldiers surrender en masse in some battles, but not others?

In this paper, we argue that battlefield surrender emerges from a collective action problem within military organizations. Battlefield success requires that soldiers fight as a unit rather than flee, but individual decisions to fight depend on whether soldiers expect their comrades to do the same. When they receive information about recent acts of surrender – within the same army, or in other armies fighting the same opponent – soldiers expect their own unit's resolve to be low, and become less likely to fight. These dynamics are not unlike those driving the diffusion of labor strikes, protests and insurgency: actors learn from the experience of others and update their beliefs about what others will do in similar situations. Where no recent precedent exists, surrender is unlikely to occur.

Using a new battle-level dataset of all conventional wars from 1939 to 2011, we show that surrender is indeed contagious across battles. Soldiers are much more likely to surrender to the enemy if other soldiers have done so recently. This effect holds after we account for alternative explanations of surrender, like military effectiveness and expectations of high losses. We also consider the role of principal-agent dynamics in this process, and show that low expectations of punishment by commanders make soldiers' collective action problem even worse.

This study advances our understanding of surrender in several ways. On a theoretical level, existing research has highlighted the importance of battlefield resolve for the onset, conduct and outcome of war, but has left these life-and-death decisions mostly unexplained. International conflict literature has traditionally

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[1] We define *resolve* as a unit's ability to continue fighting as an organized, cohesive force.

treated the military as a unitary actor, and a direct, cohesive extension of the state.[2] More direct examinations of battlefield surrender have studied this phenomenon largely in the context of war termination, investigating how surrender impacts higher-order political decisions, but not why surrender occurs in the first place (Ramsay, 2008; Weisiger, 2015). Other works have privileged macro-level state attributes (Reiter and Stam, 1997; Belkin et al., 2002; McLauchlin, 2010; Castillo, 2014; Lyall, 2014), attributing surrender to relatively static institutional features – like regime type, state-society relations and treaty membership – that cannot explain why units from the same military behave differently across battles.

Compounding these theoretical challenges is the reliance of most previous empirical research on highly aggregated, macro-level data, with entire conflicts – rather than individual battles – as units of analysis. This macro-level perspective has conflated the concept of battlefield surrender with war termination, limiting our understanding of how battle dynamics influence decisions to capitulate, and why battlefield surrender occurs in the first place. With a handful of exceptions (Reiter and Stam, 1997; Ramsay, 2008), political scientists have mostly avoided looking below the aggregate level of war, due in large part to the selection problems and limited scope of existing battle-level datasets.[3] Despite the recent proliferation of "micro-comparative" studies of civil war, similarly disaggregated data have been mostly absent from research on conventional war. As a result, quantitative scholars continue to treat wars as unitary black-box events, and qualitative approaches continue to dominate research on surrender.[4]

We build on this previous work by conceptualizing battlefield surrender as a collective action problem, and test the validity of this perspective with new battle-level data. Our core finding – that surrender can have a cascade effect – challenges macro-level explanations by showing that information about previous battles, rather than the attributes of states fighting them, drive decisions to surrender (Reiter and Stam, 1997; McLauchlin, 2010; Castillo, 2014). Our findings also open a new empirical frontier for research on intrawar bargaining (Filson and Werner, 2002; Slantchev, 2003; Powell, 2004), by treating resolve not as an exogenous cause

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[2] Research on militarized interstate disputes (MID) (Jones, Bremer and Singer, 1996), for example, frequently assumes that state leaders purposefully initiate all disputes, while the military faithfully carries out its orders. Even civil-military relations literature, which explicitly questions assumptions of a unitary state, often treats the military itself as a unified entity (Feaver, 2009).

[3] The most common existing battle-level dataset is the U.S. Army's CDB90, otherwise known as HERO (Dupuy, 1984; Helmbold and Kahn, 1986). While CDB90 provides a useful baseline for disaggregating wars into battles, its selection of battles is an ad hoc convenience sample: primarily Western front battles in WWII, the Arab-Israeli wars, and the Vietnam War.

[4] In a survey of over 100 academic articles on the topic published in leading political science and policy journals in the last 25 years, we found that 55 percent used only qualitative methods like process-tracing, 41 percent used quantitative or mixed methods, and 4 percent used formal models.

of war termination, but as an outcome of primary theoretical interest.

Surrender as a Collective Action Problem

From an individual standpoint, fighting is costly. These costs may be outweighed by the benefits of battlefield success, but success is impossible if many soldiers abandon the fight. Surrender, of course, is also not costless. Militaries harshly punish insubordination and desertion, and opponents often do not treat prisoners well. In deciding to fight or flee, soldiers consider what others are likely to do. If they expect others to flee, they will view success as less likely and opt to surrender rather than die fighting. As an American paratrooper in World War II recalled, "Once fear strikes, it spreads like an epidemic, faster than wildfire. Once the first man runs, others soon follow" (Burgett, 1999 cited in Hamner, 2011, p.79).

The choices soldiers make on the battlefield are part of a broader class of collective action problems that drive participation in conflict, violence and other contentious politics. In a typical threshold model of collective action, a group of individuals decide whether or not to participate in an activity (e.g., riot, strike, protest), depending on how many others are already participating (Granovetter, 1978; Kuran, 1991; Macy, 1991; Kim and Bearman, 1997). Most such models have explored the dynamics of initial mobilization, since groups involved in civil conflict and protest often lack extensive organizational structures initially. These 'start-up' challenges are less of a concern for military units in battle, where the state has already overcome initial mobilization problems, and is instead seeking to maintaining resolve in the face of outside pressure.

The pre-existence of an organizational structure settles the mobilization challenge, but also adds a layer of complexity highlighted by principal-agent models: the soldiers' collective action problem unfolds in a hierarchical context, where principals seek to maintain control over their agents' behavior. Yet when agents are part of an organized group and rely on each other's coordinated actions to improve their chances of success and survival, the principal-agent dynamic alone may not fully explain the agents' choices (Holmstrom, 1982). In addition to the threat of punishment from above, soldiers face a more proximate and variable danger on the battlefield, the scope of which depends on whether they expect others to fight or flee. Each choice implies a safety in numbers. A standard principal-agent framework overlooks these collective action dynamics.

Although many studies have considered how social movements expand and transform, questions of how and why groups decline have traditionally received less consideration in the literature (Koopmans, 2004).[5] Several recent efforts have used global games (Carlsson and Van Damme, 1993) to model the cohesiveness of a group's actions in the face of external coercion.[6] These models examine incentives to manipulate information to either prevent or enable an uprising (Edmond, 2013; Bueno de Mesquita, 2010), and the effect of information flows on coordination problems facing both dissidents and the regime (Casper and Tyson, 2014).

The central insight of the collective action literature – that information about past collective action drives future collective action – implies a diffusion process, where the occurrence of a new event in one context alters the probability of a similar event happening elsewhere (Simmons and Elkins, 2004; Brooks, 2007). In the context of decisions by commanders and troops in war, such processes typically involve the transfer of information from one battle to another, and the updating of prior beliefs about the wisdom of a given action. As armed actors consider the choices before them – the most basic of which is to continue fighting or surrender – they draw lessons from this previous experience. Initially uncertain about the appropriateness of a given action to their situation (i.e., surrender), soldiers examine how previous battles developed, and the decisions people fighting in them made. If surrender has been widespread, this uncertainty declines, as soldiers come to expect similar dynamics in the current case, and adjust their own behavior.

Despite an abundance of empirical research on conflict diffusion, no study has yet examined battlefield surrender as a dynamic, self-reinforcing process.[7] By analyzing these phenomena in a diffusion framework, we can potentially account for the endogenous dynamics of learning and updating of beliefs based on prior experience in battles, explain how such processes emerge, and predict if a given case of surrender is likely to spark a general breakdown of war-fighting resolve.

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[5] There are exceptions. Several studies have explored whether repression (Francisco, 2004; Siegel, 2011; Davenport, 2015), leadership decapitation (Cronin, 2006; Jordan, 2009; Johnston, 2012; Price, 2012), and some organizational features contribute to groups' decline (Edwards and Marullo, 1995).

[6] Carlsson and Van Damme (1993) introduce the global game formulation in a 2x2 one-shot setting, where players face a coordination problem with incomplete information and must choose a strategy based on a noisy signal. Other research extends this approach to a dynamic setting, with a large number of players interacting over multiple rounds (Angeletos, Hellwig and Pavan, 2007).

[7] The study of diffusion has a long tradition in conflict research. Since the pioneering work of Most and Starr (1980), theoretical and empirical models of diffusion have produced new insights about the onset of interstate and ethnic conflict (Hammarström, 1994; Bas and Coe, 2012; Weidmann, 2015), the spread of innovations and military technologies (Goldman and Andres, 1999; Horowitz, 2010*a*), the proliferation of tactics like suicide terrorist attacks (Horowitz, 2010*b*), and the effect of coercion on the spread of insurgent violence (Toft and Zhukov, 2012).

THEORETICAL EXPECTATIONS

We now outline the basic intuition behind the collective action model of surrender, using the theoretical framework of global games (Carlsson and Van Damme, 1993; Angeletos, Hellwig and Pavan, 2007). We describe our logic qualitatively below, and provide formal derivations in the appendix.

We assume that a military unit's resolve in battle depends on its ability to fight effectively as a team toward some pre-defined objective. Soldiers within the unit can choose either to *fight* (i.e., contribute an individual effort to the battle and support other soldiers), or *abandon* (i.e., surrender, desert or defect).[8] Each battle can result in one of two states: *success*, in which a critical mass of soldiers fights and the military maintains its organizational resolve and effectiveness, or *failure*, where organizational resolve breaks down and a critical mass of soldiers choose to abandon.[9] In this sense, 'success' and 'failure' are conceptually distinct from military 'victory' and 'defeat,' but are not completely orthogonal.[10] Crucially, if enough battles end in 'failure' because a critical mass of soldiers abandoned, then political leaders may need to negotiate an end to hostilities on unfavorable terms.

The payoffs to fighting and abandoning are different under the two states. If a soldier chooses to fight when a sufficiently large proportion of others also fight ('success' state), the soldier pays some personal cost for fighting, but also receives a positive benefit for maintaining resolve and contributing to the effort. If instead he chooses to fight and most others abandon ('failure' state), he receives no positive benefit, but still pays the cost of fighting. If the soldier abandons, in either state, he receives no positive benefit, and pays a different kind of cost, which may include punishment by commanders, harsh treatment as a prisoner of war, or both.

In deciding to fight or abandon, soldiers make inferences about the battle's likely state, using surrender rates in past battles as a noisy signal about their own unit's resolve. If soldiers see that many of their comrades surrendered in recent battles, they will reason that a 'failure' state is likely in the current battle, and that payoffs from fighting under these circumstances are likely to be worse than if one abandoned. If past surrender rates were low, soldiers will instead expect a

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[8] Although the relative payoffs between surrendering, deserting, or defecting are likely different in many battles, we argue that the basic process is not. To reduce the argument to its core components, we focus on a binary choice set rather than a multinomial one.

[9] Formally, *resolve* is the maximum level of abandonment a unit can withstand while still being able to effectively fight.

[10] For 'success,' the actual battle outcome could be victory, stalemate, or defeat. Consequently, a regime may be forced to negotiate an end to hostilities given a series of 'success' outcomes if these battles did not fully achieve their strategic objectives, such as gaining territory. However, due to sustained organizational resolve, the terms of ceasefire should be more favorable to the regime in this case. In the 'failure' case, however, the actual battle outcome does result in a defeat.

‘success’ state, where payoffs to fighting are considerably higher. As more battles occur, soldiers receive more information, update their priors and converge in their beliefs. Thus, we can establish the following testable hypothesis:

> *Hypothesis*: Battlefield surrender is increasing in the amount of information soldiers receive about high rates of surrender in previous battles.

ALTERNATIVE EXPLANATIONS

While past surrender may influence battlefield decisions, soldiers may also look to other types of information to assess whether their comrades will fight or flee. We now survey ten explanations advanced by past research on combat motivation, and consider their implications for our theoretical model and empirical analysis. These explanations range from small-group dynamics within individual units, to macro-level, national institutions. As independent causes of surrender, many of these explanations compete with each other. As we argue, however, nearly all of these explanations are consistent with the collective action framework, either in influencing expectations of resolve or in shaping individual incentives in battle.

Alternative explanation 1: Mutual surveillance

Expectations of battlefield resolve depend on the observability of battlefield behavior – the ability of commanders to monitor and direct their troops, and of soldiers to monitor each other (Hamner, 2011). For this purpose, in part, soldiers have historically fought in tightly-grouped, closed tactical formations (Keegan, 1976). Besides an increased volume of fire, tight formations make abandonment more costly and more visible, compared to dispersed formations, where soldiers are more isolated and unable to observe each others’ actions (Hamner, 2011). Although combat tactics have evolved away from tight formations, the mechanism at play – mutual surveillance between soldiers – has imperfect counterparts on the modern, dispersed battlefield.[11] The development of two-way radios and modern communications equipment in the twentieth century, for instance, has allowed isolated groups on the battlefield to coordinate and share information, while giving commanders greater visibility over their actions. Depending on the direction and pace of this technological diffusion – and its consequences for communications capabilities in battle – we may expect different baseline rates of surrender for different combatants, in different wars.

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[11] The benefits of tight formations typically exceeded their cost in pre-modern warfare, but changes in the accuracy and destructiveness of weaponry have since turned tightly-grouped troops into clear targets for enemy fire. To increase soldiers’ survival chances, modern tactics have evolved toward increased dispersion.

In the context of the collective action model, mutual surveillance affects soldiers' coordination problems. Increased surveillance lowers information uncertainty and improves coordination, but the effect of this coordination on surrender could conceivably be in either direction. For example, while tight formations can provide visual assurances that others will fight, direct observation of troops abandoning the battlefield could swiftly lead to organizational breakdown. Similarly, increased communication among dispersed soldiers could make it easier to coordinate both fighting and surrendering as a group.

Alternative explanation 2: Training and discipline

Some military scholars attribute surrender to general problems of military discipline and training. Here, expectations of battlefield resolve stem not from operational experience, but organization-wide standards and procedures. Where military training and discipline are rigorous, "prowess and personal courage all but disappear beneath an armor-plated routine" (McNeill, 1982, p.130). Where these qualities are lacking, surrender becomes pervasive.

Historically, the emphasis on training and discipline emerged out of efforts to improve battle outcomes. Drawing inspiration from Roman tactics, Maurice of Nassau introduced a series of reforms to Dutch military training in the late sixteenth century, emphasizing smaller units, constant drills, and a clear operational chain of command. These reforms enhanced control over soldiers' actions in battle, decreasing uncertainty over decisions to fight or flee. Whereas medieval "crowd" armies relied on mass and individual talents to win battles (Keegan, 1976), Maurice showed that a smaller, more professional army could consistently defeat a much larger force. Other armies soon took notice and adopted similar tactics and procedures, which they passed on to their institutional successors.[12]

One limitation of military discipline as a cause of battlefield surrender is that discipline tends to vary mostly at the national or organizational level, and – due to the time needed to implement new training standards – it changes relatively slowly. While discipline may explain variation in surrender across combatants and across wars, it may be too static to explain variation across individual battles.

Alternative explanation 3: Social cohesion

Following World War II, leading social science explanations of combat motivation attributed battlefield resolve to the strength of within-unit social bonds (Shils and

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[12] Sustainable improvement in discipline is a perennial challenge for military organizations, due to personnel turnover and the individual incentives that compete with organizational purposes.

Janowitz, 1948; Marshall, 1954). According to this view, soldiers are less likely to flee if strong bonds of mutual trust and loyalty exist between them and their comrades, and more likely to flee if they are socially isolated.[13] As in the collective action model, mutual expectations about what others will do in battle are central to the social cohesion story. Where the approaches diverge is on the origins of these expectations: within-group social structures drive expectations in the social cohesion school, not information on recent behavior by other units and groups.

While this literature speaks mainly to the internal dynamics of small units, one empirical implication is that recruitment methods matter: surrender should be less likely where units consist of volunteers rather than conscripts (McLauchlin, 2015). In volunteer armies, interpersonal relationships are generally less conflictive, and within-unit social integration is greater (MacCoun, Kier and Belkin, 2006; Siebold, 2007). In armies staffed by long-service professionals, soldiers may therefore expect a higher baseline of resolve.

Alternative explanation 4: Ideological cohesion

One challenge to the social cohesion perspective is that unit composition can change dynamically through combat and attrition, yet soldiers often continue to fight – even after initial unit social structures collapse. Drawing on the experience of World War II, Bartov (1992) advances an alternative explanation for combat motivation, attributing surrender not to mutual expectations of battlefield behavior, but to the ideology instilled within soldiers by political authorities. Where this indoctrination is more extreme and uncompromising (e.g., German troops opposing the Soviet army on the Eastern Front of WWII), soldiers should expect higher resolve in their army, and will therefore be more reluctant to surrender.

The empirical implication of the ideological cohesion school is straightforward: surrender rates should increase as ideological cohesion breaks down. The problem is that, in war, state ideology tends to change slowly, if at all. While ideological differences may help explain variation between countries and between wars, changes in political ideology may not occur frequently enough to explain organizational breakdown within war. For example, there was no coinciding shift in the Nazi regime's ideology when Wehrmacht troops began surrendering en masse in 1945.

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[13] More recent research on unit cohesion has shifted away from social structures, and toward units' commitment to specific combat missions and tasks (MacCoun, 1993). This view holds that trust among soldiers stems not from social bonds, but from soldiers' performing their jobs in order to accomplish their common mission (Hamner, 2011, p.180). In many ways, task cohesion in an army is closely related to military training and discipline, outlined in alternative explanation 2.

Alternative explanation 5: Aggregate military power

While we may group several of the previous explanations under the general rubric of 'troop quality,' rates of surrender may also depend on aggregate preponderance in capabilities, and more general perceptions of the balance of power. At the macro level, bargaining models of war – both the "costly lottery" (Fearon, 1995; Powell, 1996) and "costly process" variants (Slantchev, 2003; Smith and Stam, 2004) – assume that the probability of military victory follows the dyadic balance of power. A lopsided balance should therefore increase resolve expectations in the more powerful army. Conversely, soldiers in weaker armies should anticipate that more of their comrades will lay down their arms, rather than fight a hopeless battle.

Alternative explanation 6: Offensive advantages

One criticism of macro-level preponderance is that a smaller force can concentrate its strength at the weak point of the adversary, creating local superiority despite aggregate disadvantage. As a result, macro-level perceptions of the balance of power may have little bearing on battle-level outcomes. This insight lies at the core of literature on offensive advantages (Van Evera, 1998) and the '3:1 rule' (Mearsheimer, 1989). Within wars, attackers generally begin battles with numerical superiority, to offset the challenges of fighting defenders in prepared positions. Due to local preponderance – and other first-mover advantages like speed, initiative and surprise – expectations of resolve may be higher among attacking troops.

Alternative explanation 7: Principal-agent problems

From the standpoint of military leadership, battlefield surrender represents a principal-agent problem (Gates and Nordås, 2016): commanders delegate direct orders to lower-ranking personnel, but cannot perfectly observe the latter's performance. To prevent surrender, commanders often institute harsh punishment for insubordination and desertion. During World War II, for instance, Stalin's Order No. 270 stated that Soviet personnel "who surrender to the enemy shall be considered malicious deserters, whose families are liable to be arrested" (Zolotarev, 1997, 58-60). Georgy K. Zhukov, the Soviet general, had a reputation for publicly executing deserting troops to deter others from fleeing. The implication for the collective action framework is that where monitoring is less effective and punishment is less severe, soldiers' incentives to surrender may be higher.

The ability of commanders to monitor and punish subordinates depends on many things, including institutional factors like discipline and training, and tactical considerations like mutual surveillance. Empirically, one circumstance where principal-agent problems are arguably most acute is that of a breakdown in leadership: a commander who surrenders in battle is one who cannot effectively monitor or punish surrendering troops. To the extent that such principal-agent dynamics may help solve soldiers' collective action problem, we should expect higher troop surrender rates in armies where senior officers had surrendered in recent battles.

Alternative explanation 8: International law

The expected costs of surrender depend not only on internal dynamics within one's own military, but also on the likely treatment of detainees by the opponent. All else equal, soldiers are more likely to surrender if they believe the opponent will treat prisoners well (Morrow, 2014). One potentially informative signal of humane treatment is the ratification of treaties stipulating basic rights for wartime prisoners, like the Geneva Conventions (Reiter and Stam, 2002; Grauer, 2014). Where the opponent has made such commitments under international law, soldiers may expect the cost of surrendering to be lower than the cost of fighting, and therefore anticipate that more of their comrades will abandon the fight. Like other macro-level factors, however, treaty ratification is a relatively static variable, better suited for explaining cross-national variation than battle-level outcomes.

Alternative explanation 9: Political regime type

Another national-level signal of humane treatment is political regime type (Reiter and Stam, 1997; McLauchlin, 2010). Due to autocracies' comparative lack of transparency, repressive institutions and weaker records on human rights, soldiers may doubt these regimes' commitments to protecting prisoners from abuse. For this reason, soldiers fighting against more democratic armies may expect more of their comrades to surrender, while those fighting against more repressive regimes may expect surrender to be rare. Yet regime type is another macro-level variable, which typically remains constant over the course of a war. While it may explain why troops in some armies have different incentives for fighting than troops in other armies, it is less informative of why troops from the same country, fighting the same opponent, are more likely to surrender in some battles than others.

Alternative explanation 10: Military effectiveness

Finally, because troops often surrender, at least in part, because they are either losing or expect to lose, information about past surrender may simply be a proxy for broader conceptions of military effectiveness: whether one's army 'won' or 'lost' a battle, and how well others had fared against the same opponent. Because definitions of 'winning' and 'losing' tend to be subjective and battle-specific (Biddle and Long, 2004), quantitative measures of military effectiveness have tended to focus on relative casualties inflicted by each side. One example is the loss-exchange ratio (LER), or the number of enemy troops killed divided by the number of friendly troops killed (Biddle, 2004; Cochran and Long, 2016). In this case, if troops enter a battle knowing that others in their position had suffered significant casualties while inflicting little damage on the opponent, they may see success as unlikely. This expectation alone may be enough to make them lay down their arms.

The above explanations highlight the extensive scholarly debate on the determinants of battlefield resolve. At their root is an inherent tension between a soldier's individual motivation to survive, and the physical danger of taking or defending some political objective through force. The question is why soldiers are sometimes able to overcome their survival instincts and other times not. Most of these approaches agree that the answer depends on what soldiers expect their comrades to do in battle: fight if they expect others to fight, flee if they expect others to flee.

The first nine explanations are not inconsistent with a collective action framework. Mutual surveillance helps alleviate coordination problems in battle. Discipline, social cohesion, ideology, aggregate power, and attacker advantages all impact expectations of resolve. Principal-agent problems, international law, and political regime type shape individual incentives in various ways.

Despite this overlap, the collective action perspective diverges from existing accounts in two important respects. First, unlike ideology, military discipline, regime type and international law – which assume a relatively static set of expectations in an army over the course of a war – our model allows these expectations to either remain firm or change as soldiers receive more information about what others have done. Second, unlike unit cohesion and mutual surveillance – where surrender is primarily an intra-unit and intra-battle phenomenon – we allow these dynamics to extend across units and battles, with past surrender in one unit affecting future surrender in other units and even other countries' armies.

In sum, the collective action framework conceptualizes surrender as a process that unfolds endogenously across battles, depending on the dynamic flow of information. Competing with this approach, however, is the view that surrender is a by-product of military effectiveness: since soldiers observe information not just about surrender, but also about their military's general performance in battle, expectations of relative casualties could be driving decisions to surrender.

In the remainder of the paper, we consider the empirical validity of the collective action model, and our main hypothesis in particular. We also examine how well this hypothesis fares compared to the other perspectives we outlined above. To do so, we employ a new battle-level dataset of surrender.

DATA

To enable the empirical study of surrender, we developed a new battle-level dataset of conventional wars, comprising every major battle in interstate conflicts from 1939 to 2011. To overcome the selection problems present in CDB90/HERO and other previous battle datasets, we opted to collect data for the full population of interstate conflicts since and including World War II, using Correlates of War (Singer, 1979) to enumerate the population of cases for which battle data were to be collected. For each interstate conflict, we assembled a chronological list of battles from the encyclopedias of Clodfelter (2008) and Showalter (2013).

Since wars are hierarchical enterprises conducted by hierarchical organizations, their disaggregation requires some non-trivial decisions about what constitutes an individual battle. For our purposes, we define a battle as a major engagement involving at least two opponents fighting over some clearly defined overarching military objective. This definition does not require disaggregation down to every skirmish between small units, since such actions are typically part of larger efforts. Rather, we collected data for discrete campaigns, disaggregating them further if they entailed multiple distinct operational objectives and are detailed as such in historical records. For example, we coded the Normandy D-Day landings by Allied forces on June 6, 1944 as a single battle, rather than dividing it into sub-objectives like the Gold, Juno, Sword, Omaha, and Utah Beaches. However, we include separate battles for Caen and St. Lô, since these D-Day objectives saw subsequent fighting distinct from the Normandy landings.[14]

In all, our data include 597 battles from 82 conflicts, covering 83 percent of interstate conflicts in Correlates of War between 1939 and 2011.[15] We collected data for each battle participant, including each coalition member fighting on the attacking and defending sides, yielding a total sample size of 1,720 battle-dyads.[16]

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[14] In this sense, some battles enter the dataset as distinct events because of how military efforts unfolded over time, rather than because they were independently planned objectives. Since we are focused on battle outcomes, rather than causes, this inclusion criterion is appropriate for our needs.

[15] Interstate wars for which we do not currently have data include: Franco-Thai War of 1940-1941, Offshore Islands War of 1954, Ifni War of 1957-1959, Taiwan Straits War of 1958, War of Attrition of 1969-1970, Sino-Vietnamese Border War of 1987, Kargil War of 1999.

[16] The dyads here are directed. For example, the USSR-Germany dyad for Stalingrad enters the data more than once – first with Germany as the focal combatant (attacker vs. defender), once with the USSR (defender vs. attacker), and with additional observations for Italy and other Axis members fighting the USSR in the battle.

We collected location data for each battle from historical maps and military atlases, recording the geographic coordinates for the towns or geographic features where fighting took place. We used the distribution of these locations to construct convex hull polygons encompassing the largest extent of area over which forces were engaged.[17] Figure 1 illustrates the spatio-temporal distribution of battles in our dataset. We used these data to calculate deployment distances to each battle, as well as the geographic size of the front, and the temporal sequence of events.

We used Clodfelter (2008) as the primary source for data on battle participants, troop numbers and casualty statistics, including killed (KIA), wounded (WIA), missing in action (MIA), prisoners of war (POWs), defections, and desertions.[18] To capture military commanders' influence on subsequent events, we coded separate binary variables as 1 if a flag officer (i.e., those ranked in the General or Admiral grade or equivalent) surrendered, defected, or was captured or killed in battle.[19] In addition to raw counts of casualties and prisoners, we calculated the loss-exchange ratio (LER) for each battle participant (i.e., enemy casualties divided by friendly casualties) – a standard measure of relative attrition. To account for relative differences in personnel surrendering from smaller and larger formations, we created an ordinal measure of battle size.[20]

To test alternative hypotheses proposed in past literature and control for other potential confounders, we supplemented this battle-level information with country-year-level variables from other sources. To account for political regime type, we used a modified version of the Polity index (Marshall, Gurr and Jaggers, 2014).[21] To account for perceptions of the overall balance of power, we measured rela-

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[17] For naval battles, we used approximate geographic coordinates to encompass areas of water in which ships were attacked or sunk.

[18] This source provides a relatively comprehensive account of force strength and losses, but organizes this information primarily in narrative form, rather than as tables of statistics.

[19] We rely on Clodfelter's narratives to indicate whether a flag officer surrendered, defected, or was captured or killed in battle. Since these events are high-profile and are typically prominently highlighted in historical records, we assume that Clodfelter captured most of these events in his narratives.

[20] The levels, based on the size of the largest force participating in the battle, are (1) 0-5,000 troops, (2) 5,001-20,000, (3) 20,001-100,000, (4) 100,001-400,000, (5) 400,001-1,000,000, (6) 1,000,001-10,000,000. These correspond, roughly, to (1) brigade and below, (2) division, (3) corps, (4) army, (5) army group, (6) theater. We do not use per capita surrender rates for two reasons. First, the number of personnel directly engaged in combat can vary greatly over the course of a battle. Second, per-capita surrender rates can be inherently misleading: the forces engaged in large battles are often only a small proportion of the total force size present, whereas those engaged in smaller battles are more likely to include a larger proportion of the total force present.

[21] Because Polity often assigns scores of -66 (foreign interruption), -77 (interregnum), or -88 (transition) for country-years at war, we converted these missing values to the regime's most recent Polity score prior to its -66/-77/-88 value.

tive military capacity, using the Composite Index of National Capabilities (CINC) (Singer, Bremer and Stuckey, 1972).[22] Because national-level measures of relative power potentially mask significant local imbalances, we included an indicator of which side is on the offensive, as well as a measure of the local force ratio at the start of the battle. We also created a dummy variable for a state's primary means of recruitment (from Toronto 2005) – coded 1 if a state relied only on volunteers and 0 if it also relied on conscripts. Finally, we considered whether each side had ratified the Geneva Conventions (ICRC, 2016).[23]

Table 1 lists the descriptive statistics for battle-level and country-level variables.

DATA ANALYSIS

We model the determinants of battlefield surrender as follows:

$$y_{ijk} = \rho W(y) + \gamma Z_k + \beta X_{ij} + \alpha_i + \zeta_m + \theta_{\tau(k)} + u_{ijk} \tag{1}$$

Our unit of analysis is the battle-dyad, where m indexes the war (e.g., WWII), k indexes the battle (e.g., Stalingrad), i indexes the focal combatant (e.g., USSR) and j indexes the opponent (e.g., Germany). The dependent variable y_{ijk} is the logged number of soldiers from combatant i who surrendered to opponent j in battle k.

The parameter of primary theoretical interest is ρ, which captures the influence of past surrender rates on surrender in the current battle. We specify the set of combatants and past battles that influence i's decision to surrender with an information flow network, $W(y)$. We consider two types of information: instances of past surrender by combatant i to all opponents in war m ('same combatant'), and past surrender by all other combatants to opponent j during war m ('same opponent'). Following Zhukov and Stewart (2013), we estimate the ρ coefficient in separate models for each diffusion measure.[24]

We assume that soldiers place greater weight on more recent and geographically proximate cases of surrender. We specify the *temporally-weighted* diffusion term as

$$W(y)^{[\text{same combatant}]} = \sum_{t}^{\tau(k)} \frac{y_{i.t}}{(1+r)^{\tau(k)-t}} \tag{2}$$

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[22] CINC captures states' combined population, military personnel and expenditures, iron and steel production and energy consumption as a proportion of the world total.

[23] Prior to 1950, when the first state ratified the 1949 Geneva Conventions, we coded the variable based on the 1929 version of the treaty.

[24] Including multiple, partially-overlapping networks in a single model can yield biased estimates of autoregressive parameters (Zhukov and Stewart, 2013).

$$W(y)^{[\text{same opponent}]} = \sum_{t}^{\tau(k)} \frac{y_{.jt}}{(1+r)^{\tau(k)-t}} \tag{3}$$

where $\tau(k)$ is the start date of battle k, and t indexes the start dates of previous battles in war m, involving either the same combatant (Eq. 2) or other combatants fighting opponent j (Eq. 3).[25] $r \in (0,1)$ is the temporal discount rate, with higher values placing a greater weight on more recent battles, and $r = 0$ placing equal weight on all past battles in war m. Because we do not have a strong prior on r, our empirical models automatically select values that minimize the Akaike Information Criterion (AIC). We also provide sensitivity analyses for all $r \in (0,1)$.

We specify the *geographically-weighted* diffusion term as

$$W(y)^{[\text{same combatant}]} = \sum_{t}^{\tau(k)} y_{i.t} \frac{d_k^{-r}}{\sum_t^{\tau(k)} d_k^{-r}} \tag{4}$$

$$W(y)^{[\text{same opponent}]} = \sum_{t}^{\tau(k)} y_{.jt} \frac{d_k^{-r}}{\sum_t^{\tau(k)} d_k^{-r}} \tag{5}$$

where d_k is the geographic distance, in kilometers, between battle k and all previous battles in war m, involving either combatant i (Eq. 4) or other combatants fighting opponent j (Eq. 5). $r \in (0,1)$ is a spatial discount rate, selected by AIC, with higher values assigning greater influence to past battles closer to k.

To illustrate the structure of information flow implied by these diffusion terms, Figure 2 shows a subset of the resulting diffusion network, with the Second World War as an example. We display this network in three dimensions, with geographic locations of battles on the x and y axes (east-west, north-south – same as in Figure 1), and time on the z axis (earlier battles on bottom, later battles on top). The red lines represent temporally-weighted information flows from past battles involving – in this case – the same focal combatant (Eq. 2).

In addition to the information flow network, our model includes a set of battle-level (Z_k) and dyad-level covariates (X_{ij}). These include essential control variables like battle size, and variables needed to account for additional explanations of surrender, like recruitment (i.e., whether i has a professional army), regime type (i.e., whether i has a higher Polity2 score than j), and treatment of prisoners (i.e., whether j has ratified the Geneva Conventions), as well as controls for relative power (i.e., difference in CINC scores between i and j; local force ratio between i and j), offensive and defensive battles, logistics (i.e., i's deployment distance) and

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[25] In wars with only two combatants, the 'same combatant' and 'same opponent' measures should converge to the same value.

time (i.e., year in which the battle began). We also include fixed effects for each combatant (α_i), war (ζ_m), and season of the year ($\theta_{\tau(k)}$), and an i.i.d. error term (u_{kij}). These fixed effects help us account for relatively static, macro-level drivers of surrender, like ideology, discipline, and technological change from war to war.

RESULTS

Tables 2 and 3 report the empirical determinants of surrender, with temporally and geographically-weighted diffusion terms, respectively. The first two models in each table estimate the effect of information on past surrender by the same combatant (Model 1) and other combatants fighting the same opponent (Model 2). The remaining models incorporate battle-level and combatant-level covariates. Because parameter estimates are sensitive to scales of measurement, we report standardized coefficients – representing estimated standard deviation (SD) changes in the outcome following a standard deviation increase in the explanatory variable.

Surrender is contagious across battles

The analysis reveals strong evidence for our hypothesis: surrender is more intense following other recent cases of surrender. According to Model 1 in Table 2, a standard deviation increase in recently-surrendered troops from the same army increases the logged number of troops surrendering in the current battle by .27 SD (95% confidence interval: .21, .32). This figure is slightly smaller, .24 SD (95% CI: .18, .31), for surrender from other armies fighting the same opponent (Model 2).

Parameter estimates are of similar relative magnitude for the geographically-weighted diffusion measures in Table 3, which represent the influence of past surrender in nearby battles. A standard deviation increase in surrendering troops in spatially-proximate battles produces a .23 SD rise (95% CI: .16, .30) in logged POWs if the surrendering troops were from the same army (Model 1), and a .19 SD increase (95% CI: .12, .26) if they were from armies fighting the same opponent.

Figure 3 shows a graphical representation of this relationship, through simulations based on Models 1 and 2 in Table 2 (temporal weights), with fixed effects for Russia/USSR fighting an average summer battle in WWII. Following a hypothetical increase from zero to 300,000 recent POWs from the same combatant – roughly equivalent to Soviet POW rates during the 1941 Battle of Smolensk – the expected number of surrendering troops rises by 330 percent per battle, on average (95% CI: 245, 560), from 68,880 to 296,556.[26] The rise is a smaller, but still formidable 139

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[26] Predictions based on Model 1 in Table 2.

percent (95% CI: 119, 182), from 92,768 to 222,161 per battle, following an identical increase in POWs among other armies fighting the same opponent.[27]

A greater sensitivity of troops toward past surrender rates in their own army is not surprising. From a theoretical standpoint, signals soldiers receive through the 'same combatant' network should be less noisy than those from the 'same opponent' network. Due to pre-existing social networks, communication channels and rumor mills, troops are likely to be better informed about the conduct of units within their own military, than other countries' armed forces – even if the latter are part of the same coalition. Troops may also see previous surrender within their army as a more indicative signal of how their own comrades will behave.

Contagion effect is stronger if soldiers think opponent treats prisoners well

Are soldiers more likely to surrender to opponents who have signed treaties on the humane treatment of prisoners of war? The evidence here is more mixed. Tables 2 and 3 suggest that – if such an effect does exist – it cannot explain battle-level variation on its own. The coefficient for the opponent's ratification of the Geneva Conventions is statistically insignificant in Models 3-4.

There is, however, tentative evidence for an interactive relationship between Geneva ratification and past surrender. As Table 4 shows, the contagion effect is significantly stronger if the opponent has ratified the Geneva Conventions. Here, a standard deviation increase in past surrender within the same army yields an increase of between .22 (Model 3) and .31 SD (Model 1). Where the opponent had not ratified (about 30 percent of cases), past surrender has no discernible effect.

This apparent heterogeneity is not surprising, given the logic of collective action. Where the opponent has ratified the Conventions, soldiers can reasonably expect the costs of surrender – narrowly defined as the probability of harm or death in captivity – to be relatively low. Where opponents have not ratified, soldiers are more uncertain about these costs, and are more hesitant to pay them. As a result, ratification of the Geneva Conventions can amplify the contagion effect of surrender.

Troops are more likely to surrender if senior officers recently surrendered

Can some actions by military leaders potentially accelerate the tide of surrender? The role of principal-agent problems is difficult to empirically establish without battle-level data on monitoring and punishment of deserting troops. To the extent

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[27] Predictions based on Model 2 in Table 2.

that more autocratic governments can institute more draconian forms of punishment than democracies (Castillo, 2014), we could assume that the costs of surrendering are higher in the armies of more repressive regimes. Yet the negative and insignificant coefficients on 'More democratic' in Tables 2 and 3 are not what we would expect to find if such regimes succeeded in deterring troops from surrendering. Moreover, while regime type changes relatively slowly, commanders' treatment of subordinates can vary greatly over the course of a war.

By way of an indirect test, we examined the impact of past *surrender by commanders* on surrender by rank-and-file troops in subsequent battles. Our reasoning here is that, when a commander has previously abandoned the battlefield, subordinates are likely to significantly discount the leadership's monitoring and punishment capacity. As a result, future commanders' threats to punish insubordination, surrender and desertion lose credibility. If surrender is indeed less likely where monitoring and punishment capacity is high, then we should expect it to be more likely where commanders have themselves recently surrendered.

Table 5 reports the results of these additional analyses, with Models 1-4 estimating the impact of past surrender by commanders on surrender in the current battle by rank-and-file troops. These results confirm that soldiers are significantly more likely to surrender if commanders had recently done the same. A standard deviation increase in surrender by commanders within the same army yields an increase in the logged number of surrendering troops of between .13 (95% CI: 0.04, 0.2) and .25 SD (95% CI: 0.2, 0.3). Unsurprisingly, the actions of commanders in the soldiers' own army has a more substantial impact than commanders surrendering from other armies fighting the same opponent.

If surrender by commanders helps drive surrender by their troops, a natural question arises: why do commanders surrender? Our data suggest that the collective action problems facing soldiers may be part of a broader problem in military organizations, which reaches across ranks. As Models 5-8 in Table 5 show, commanders are more likely to surrender if other commanders had recently surrendered. In making this choice, furthermore, commanders take cues not only from their own colleagues, but also from other armies fighting the same opponent.

Macro-level state characteristics are poor predictors of surrender

While these results provide tentative evidence that surrender is contagious across battles, past surrender rates are, of course, not the only potential drivers of soldiers' decisions. Unsurprisingly, surrender rates are higher in larger battles, where more troops are potentially at risk.[28] Surrender rates are also lower for attacking

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[28] We are grateful to an anonymous reviewer for raising this point.

troops – potentially due to offensive advantages in numbers, speed, and surprise.

Yet perhaps the most surprising results are about what does not matter. Macro-level national and dyadic variables – like national power, regime type, and conscription – explain virtually none of the battle-level variation in surrender. The direction of these estimated effects is consistent with what we might expect from past literature. Fewer troops surrender from more materially-capable armies. Armies staffed by long-service professionals are less likely to see higher rates of surrender than conscript armies. Troops are less likely to surrender if the opponent is less democratic than their home state. Once we account for battle-level factors like past surrender and battle size, however, these effects disappear.

SENSITIVITY ANALYSIS

The evidence so far has been supportive of the collective action model: troops are more likely to surrender if – based on recent battlefield experience – they expect others to do the same. We now consider how robust these findings are.

How sensitive are our results to soldiers' discount rates (r in Eq. 2-5)? In the preceding analyses, we used values of r that optimized AIC. As we show in Figure 4, these values were relatively low for temporal discount rates ($r^* = .005, .007$ in Models 1,2 of Table 2) and intermediate for geographic discount rates ($r^* = .581, .197$ for Models 1,2 of Table 3). These choices have implications for the scope of our findings: Table 2 assumes that soldiers weighed recent and past battles about equally, while Table 3 assumes they focused on battles that occurred nearby.

To ensure that our findings hold under a broader set of time and geographic horizons, we replicated Models 1-2 in Tables 2-3 with values of r between 0 and 1. As Figure 4 shows, estimates for $\hat{\rho}$ gradually decrease and level off as r increases in the temporal weights models, while remaining steady in the geographic ones. Overall, however, the value of r does not fundamentally change our results. The impact of past surrender remains positive and significant in all four sets of models, irrespective of how heavily one discounts long-ago events, or far-away battles.

Another potential objection to our analysis is that dynamics of surrender are different for ground battles than air and sea battles, but our dataset pools these events together. Because modern sailors and airmen typically surrender after the destruction of their ship or aircraft, past surrender is less salient to their decisions.

To address this concern, we re-ran the models in Tables 2-3 with a restricted data sample that includes only land warfare. The results – which we omit here for space – are consistent with those we reported above. In the geographically-weighted network, the contagion effect even increases, to .24 SD (95% CI: .17, 32) for the same combatant, and to .23 SD (95% CI: .16, .30) for other combatants fighting the same opponent. This increase makes intuitive sense: since it is more difficult for airmen and sailors to surrender mid-battle, keeping these battles in the sample should attenuate the estimated effect of past surrender.

PREVIOUS SURRENDER OR MILITARY EFFECTIVENESS?

Could more general expectations of military success be driving the contagion of surrender? So far, we have seen little evidence that troops surrender at lower rates to militarily weaker opponents. As Models 3 and 4 show, combatants with higher CINC scores than their opponents ("more powerful") have few discernible advantages in this area. Yet because aggregate national capabilities do not vary across individual battles in a given year, they are a poor proxy for military effectiveness. Local numerical preponderance, meanwhile, has no apparent effect (Models 5, 6).

To more directly account for perceptions of battlefield success and failure, we reran our models with several 'placebo' diffusion terms, capturing information about total dead and wounded in previous battles, and previous loss exchange ratios (i.e., enemy dead and wounded divided by friendly dead and wounded). Higher loss exchange ratios (LER) indicate superior military effectiveness, in the narrow sense of being able to inflict heavy losses on the opponent with minimal casualties of one's own. If coefficient estimates on these placebo terms are positive, then the tendency to surrender may simply reflect expectations of higher losses, rather than any precedent set by previous surrendering troops.

To illustrate this possibility, Figure 5 shows Japan's average monthly LER in WWII (logged), along with Japan's monthly surrender rates (logged). The plots suggest an inverse relationship. Early in the war, Japan's military effectiveness was high and surrender rates were low. Beginning in late 1943, LER dropped below parity (red line), and surrender rates grew. From this picture, one may conclude that Japanese troops became more likely to surrender not due to cases of past surrender, but due to an increasingly untenable military situation.

Table 6 reports the results of our placebo tests. In each specification, the confidence interval on the diffusion coefficient covers zero. The high uncertainty around these placebo effects provides further evidence in favor of our preferred interpretation of the 'past surrender' result. Surrender is neither more nor less likely in battles that – based on past experience – soldiers should expect to lose. Nor is the expectation of death by itself predictive of surrender. If political authorities wish to maintain the resolve of their armies in battle, these results indicate that they should worry less about how dangerous a combat environment is likely to be, and more about recent precedents for mass surrender.

CONCLUSION

Our results offer several contributions to research on interstate conflict. We demonstrate that battlefield surrender can be contagious, due to a collective action problem within military organizations. Success in battle requires that soldiers fight as a cohesive unit, but individual decisions to fight depend on whether soldiers expect their comrades to do the same. As troops learn of past decisions to surrender within their own army, they lose confidence in their unit's resolve, and decide to flee rather than fight. This pattern is particularly acute if the expected costs of surrender are also low – either because troops believe the opponent will treat prisoners well, or because senior officers have recently surrendered, shaking the credibility of threats to punish desertion and surrender by the rank and file.

In addition to diffusion, we examined several alternative explanations of surrender. We found tentative, if mixed, support for a few factors that might affect the parameters of the collective action model – like international law, principal-agent problems, and offensive advantages. However, we found no evidence that surrender depends on political regime type, recruitment methods, or relative national power. Although data limitations prevent us from directly testing several other explanations – mutual surveillance, discipline, and ideology – we sought to at least account for them econometrically, through combatant and war fixed effects. We also demonstrated that it is information specifically on past surrender – rather than military effectiveness generally – that drives soldiers' decisions.

The determinants of surrender are theoretically important because these life-and-death choices tend to resonate well beyond individual battles. Although previous research suggests that combatants acquire information about war-fighting resolve through battle outcomes, scholars often treat resolve as an exogenous cause of war termination. In our approach, by contrast, battlefield resolve is of primary theoretical interest. If wars are a continuation of political bargaining, reconciling informational asymmetries through the use of force, then understanding the mechanisms and processes influencing battlefield resolve is crucial for explaining and predicting bargaining outcomes. Our results illustrate that wartime resolve does not depend solely on political leaders' assessment of probabilistic battlefield outcomes. Instead, military officers and their troops are the primary actors mutually influencing each other's behavior. Because soldiers' choices in future battles depend on precedents set by others in the past, it is these cascading battlefield decisions that ultimately shape and constrain leaders' choices.

Our study opens several future avenues of research. For example, although we have demonstrated that surrender can have a contagion effect across battles, we do not analyze how this process begins within battles, and what critical events must occur to jump-start surrender and its subsequent diffusion. While our focus has been on inter-battle dynamics, a more explicit focus on intra-battle behavior is needed to understand the conditions leading to initial organizational breakdown.

Further research is also needed to understand how different political-military institutions affect whether the diffusion process occurs, or whether it can be reversed. We know little about why some military organizations can absorb losses and adapt to changing circumstances, while others are unable to recover from battles in which soldiers surrendered en masse. By disaggregating wars into battles and stepping away from the classical approach of treating the military as a unitary actor, we can better understand how collective action dynamics affect battlefield outcomes and, ultimately, decisions to initiate, continue or terminate war.

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THEORETICAL APPENDIX

This section formalizes the collective action model of surrender, which we described qualitatively above. We develop a basic theoretical framework for a global game using the structure in Angeletos, Hellwig and Pavan (2007) and apply it to the domain of battlefield surrender. In the model, survival-oriented soldiers choose either to fight, thus increasing their unit's chances of success, or abandon. Soldiers' decisions depend on what they expect others to do, based on private information and observation of previous battles. We begin by specifying a baseline static model, and discuss the dynamic version separately below.

The game unfolds as a series of battles in discrete time, indexed by $t \in \{1, 2, ..., T\}$.[29] At t, each soldier $i \in \{1, 2, ..., N\}$ in an army simultaneously chooses to *Fight* ($a_{it} = 0$) or *Abandon* ($a_{it} = 1$). We denote the proportion of soldiers abandoning at time t as $A_t \in [0, 1]$.[30] The payoffs associated with fighting and abandoning depend on the resultant battle's state: *success* or *failure*. The state depends on whether the proportion of soldiers abandoning exceeds the army's level of organizational resolve, $\theta \in \mathbb{R}$. We can interpret θ as the maximum level of abandonment an army can withstand while still being able to fight as a cohesive force.

If the abandonment rate is low ($A_t < \theta$), the battle will end in a success state, and each soldier who fights will receive payoff B. If, instead, abandonment rates are high ($A_t > \theta$), a failure state will occur, and each soldier who fights will receive a lower payoff η. A soldier who abandons will receive payoff z in the success state and v in the failure state. Payoffs z and v depend on both the level of punishment abandoning troops receive from their own army – which is particularly salient in the success state payoff, z – and the opponent's treatment of prisoners of war.

In a success state, soldiers prefer fighting to abandoning ($z < B$). In a failure state, they prefer abandoning to fighting ($\eta < v$). Soldiers also prefer successful fighting over abandoning in failure ($v < B$) and, by transitivity, prefer fighting in a success state to fighting in a failure state ($\eta < B$). The value of z relative to v can vary, based on expected punishment with one's own army and expected treatment by the opponent.

The relative cost of fighting for each soldier is $c = \frac{v-\eta}{B-z+v-\eta} \in (0, 1)$.[31] This cost is increasing in the payoffs to surrendering, v and z. In line with previous research,

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[29] The game ends at an undetermined time T, which we assume is determined by political leaders. We do not directly analyze the decision to terminate war here.

[30] We assume that N is relatively large, such that an individual soldier's contribution is negligible as a proportion of the entire effort.

[31] Because a soldier finds it optimal to fight if and only if he expects success, we can interpret c as the probability of a failure state, in which the proportion of soldiers abandoning is above the threshold value of organizational resolve ($A_t \geq \theta$).

we should expect v (and c) to be higher when opponents have ratified treaties on the humane treatment of prisoners. Armies who increase their opponents' v therefore increase the relative cost of fighting against them, which makes abandoning more attractive. Similarly, we should expect z (and c) to be lower when an army can effectively punish its own surrendering troops. Consequently, armies who decrease z reduce the cost of fighting (since soldiers then avoid punishment), making fighting more attractive. Table 7 summarizes the payoff structure, with soldiers' choices in the rows and the battle's state in the columns.[32]

STATIC EQUILIBRIUM ANALYSIS

Following Angeletos, Hellwig and Pavan (2007), when θ is perfectly known by all soldiers, there are two pure strategy equilibria for $\theta \in (0, 1]$: all soldiers fight ($A_t = 0 < \theta$) or all soldiers abandon ($A_t = 1 \geq \theta$).[33] When θ is imperfectly known and there exists heterogeneous information about organizational resolve, the decision to fight or abandon depends on signals that each soldier receives. In this case, Nature draws an initial common prior, $\theta \sim N(\omega, \frac{1}{\alpha})$, where α indicates the common prior's precision. Each soldier receives a private signal:

$$x_i = \theta + \epsilon_i$$

where $\epsilon_i \sim N(0, 1/\beta)$ indicates noise, i.i.d. across soldiers and independent of θ, and β describes the signal's precision.

Let $\hat{x} \in \mathbb{R}$ be a threshold, such that a soldier abandons when $x_i \leq \hat{x}$. Given this threshold, the proportion of soldiers who abandon is decreasing in θ:

$$A(\theta) = Pr(x \leq \hat{x}) = \Phi(\sqrt{\beta}(\hat{x} - \theta))$$

where Φ is the CDF of the standard Normal distribution. This observation dovetails with previous research: the proportion of soldiers abandoning is decreasing in the level of organizational resolve, which is related to factors such as attacker advantages.

Organizational failure occurs when $\theta \leq \hat{\theta}$, where $\hat{\theta}$ solves $\theta = A(\hat{\theta})$: $\hat{\theta} = \Phi(\sqrt{\beta}(\hat{x} - \hat{\theta}))$. The posterior of θ given x is distributed $N\left(\frac{\beta}{\beta+\alpha}x + \frac{\alpha}{\beta+\alpha}\omega, 1/(\beta + \alpha)\right)$.

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[32] To simplify notation, we express the payoffs by their differences and normalize them between zero and one. We thank Scott Tyson for suggesting this simplification.

[33] If $\theta \leq 0$ or $\theta > 1$, there is one pure strategy equilibrium: all abandon or all fight, respectively.

The resulting probability of failure is

$$Pr(\theta \leq \hat{\theta}|x) = 1 - \Phi(\sqrt{\beta+\alpha}(\frac{\beta}{\beta+\alpha}x + \frac{\alpha}{\beta+\alpha}\omega - \hat{\theta}))$$

This probability is decreasing in x. Consequently, a soldier will find it optimal to abandon when $x \leq \hat{x}$, where $\hat{x}$ solves $Pr(\theta \leq \hat{\theta}|\hat{x}) = c$

$$1 - \Phi(\sqrt{\beta+\alpha}(\frac{\beta}{\beta+\alpha}\hat{x} + \frac{\alpha}{\beta+\alpha}\omega - \hat{\theta})) = c$$

A monotone equilibrium $(\hat{x}, \hat{\theta})$ exists for all ω iff $\beta \geq \frac{\alpha^2}{2\pi}$.

Given a particular α, when β is smaller (i.e., private information is less precise), there are dominance regions where subsets of soldiers prefer one action over the other, depending on their individual value for x. However, as $\beta \to \infty$, the threshold $\hat{\theta}$ converges to $\theta_\infty \equiv 1 - c$. When this occurs, the proportion of soldiers abandoning converges to 1 for all $\theta < \theta_\infty$ and to 0 for all $\theta > \theta_\infty$.

While this analysis only describes the static, one-shot version of the game, the same basic mechanisms operate in the dynamic model, which we describe below.[34]

Dynamic model

In each period $t \geq 1$, each soldier receives a private and public signal about organizational resolve, θ. Furthermore, in $t \geq 2$, each soldier also receives a public and private signal about soldiers abandoning in previous battles, A_{t-1}. In the dynamic game, private information evolves over time, as soldiers receive more information and update their beliefs. We specify these signals as follows:

Private, θ: $x_{it} = \theta + \epsilon_{it}$
Public, θ: $z_t = \theta + \xi_t$
Private, A_{t-1}: $X_{it} = S(A_{t-1}, v_{it})$
Public, A_{t-1}: $Z_t = S(A_{t-1}, \zeta_t)$

where ϵ_{it} and v_{it} are idiosyncratic noise terms, ξ_t and ζ_t are common noise terms, and $S : [0,1] \times \mathbb{R} \to \mathbb{R}$. Each of the noise terms is distributed normally with mean zero and variance specified as follows, independent of θ, serially uncorrelated,

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[34] For a full proof of the dynamic game, see Angeletos, Hellwig and Pavan (2007, sec. 5.1, 5.2).

and i.i.d. across all *i* for private noise terms (Angeletos, Hellwig and Pavan, 2007):

$$\begin{aligned} \epsilon_{it} &\sim N(0, 1/\eta_t^x) \\ \xi_t &\sim N(0, 1/\eta_t^z) \\ \upsilon_{it} &\sim N(0, 1/\gamma_t^x) \\ \zeta_t &\sim N(0, 1/\gamma_t^z) \end{aligned}$$

The past period's signals condition posterior beliefs similarly to the static game.

Two cases illustrate the novelty of modeling the information structure in this way. First, consider a case where soldiers observe public and private signals only about the value for θ, but not the precise size of past levels of abandonment, A_t. If a soldier observes that abandonment has occurred (without knowing the size), and sees that it did not lead to organizational failure, she will update her beliefs *upward* about the value for θ. In other words, by recognizing that the organization was able to sustain some unknown level of abandonment without total failure, the soldier comes to see that the army may be *more* resolved than previously believed, making future abandonment less likely. Consequently, when expected resolve is high, an army becomes more resilient against individual bouts of surrender.

In a second case, where soldiers also observe past levels of abandonment, A_{t-1}, the dynamic changes. Here, separate signals about the proportion of soldiers abandoning in previous battles may counter the effect of knowing that the organization did not fail – based on the public signal about θ. When this happens, the likelihood that soldiers will abandon in the next battle can rise, potentially leading to a cascade effect across battles. These dynamics establish the micro-foundations of the diffusion process posited by our main hypothesis: the flow of information from previous outcomes affects soldiers' decisions in battle, and future surrender increases with information about past surrender.

Figure 1: Spatio-temporal distribution of battles in data.

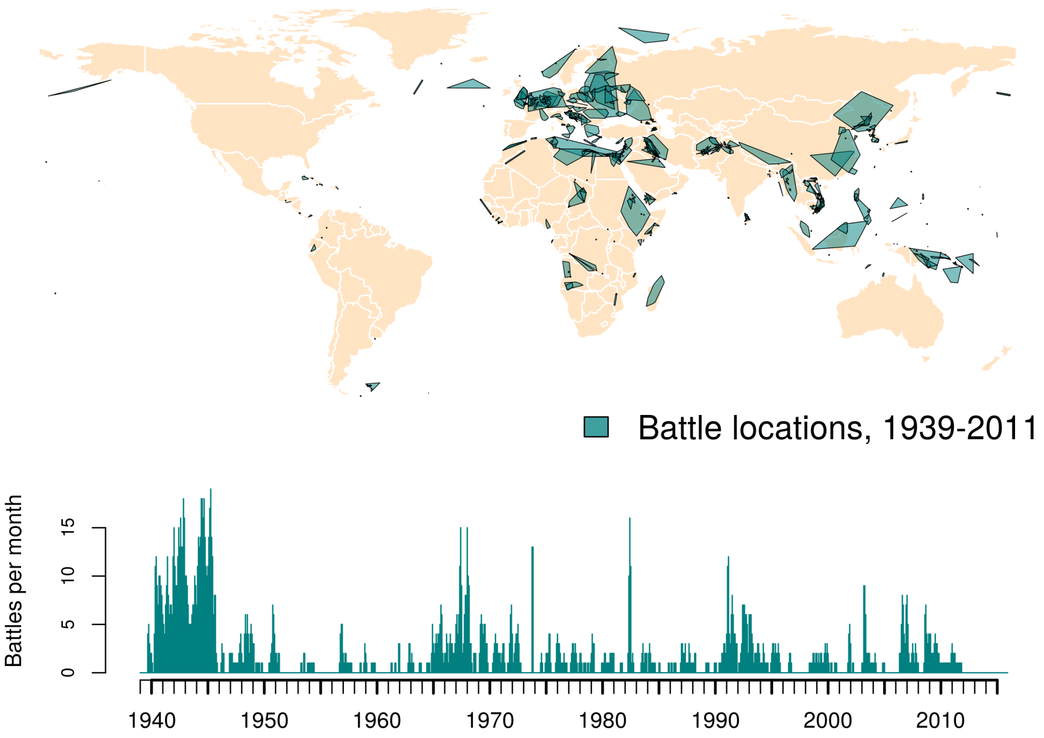

Figure 2: Flow of information about surrender across battles (WWII). Network: same combatant, $r = .01$.

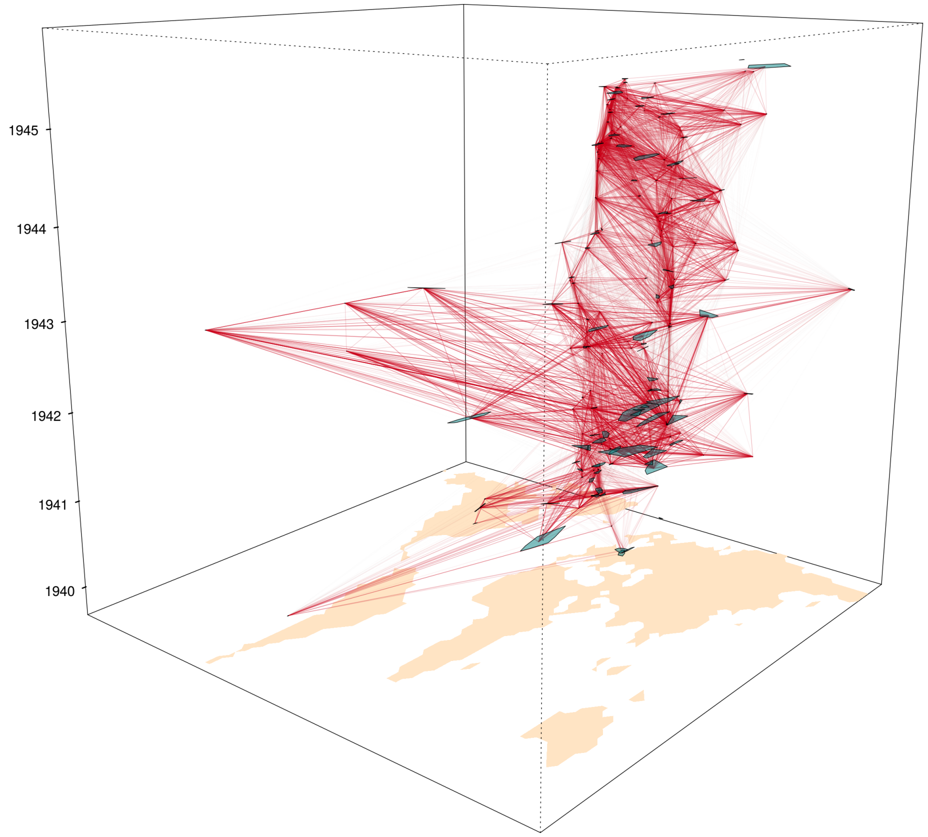

Figure 3: IMPACT OF PAST SURRENDER ON SURRENDER IN THE CURRENT BATTLE. Simulations based on Models 3 and 4 in Table 2. Fixed effects: ζ_m = WWII, α_i = Russia/USSR, $\theta_{\tau(k)}$ = summer.

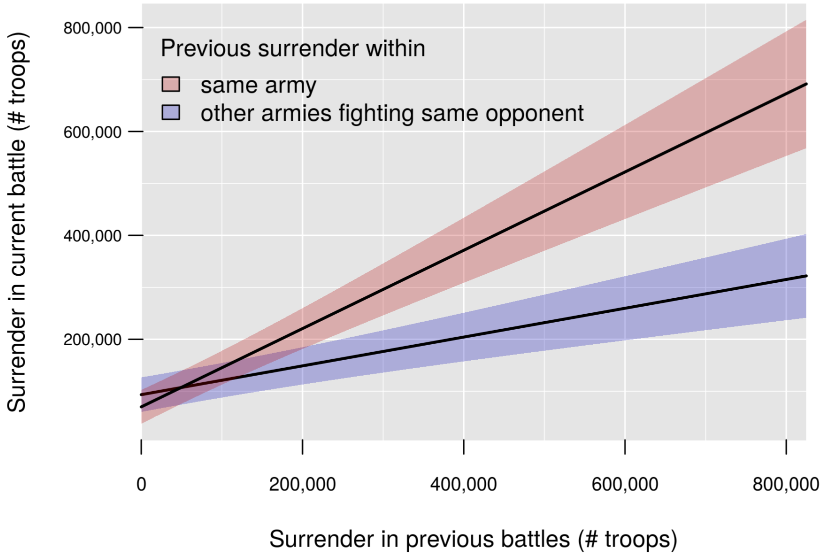

Figure 4: How discount rate affects the contagion of surrender. Values shown are estimates of $\hat{\rho}$ (effect of surrender in past battles) at different levels of r (discount rate). Top row replicates Models 1 and 2 from Table 2, bottom row replicates Models 1 and 2 from Table 3. r^* are values of r used in original models.

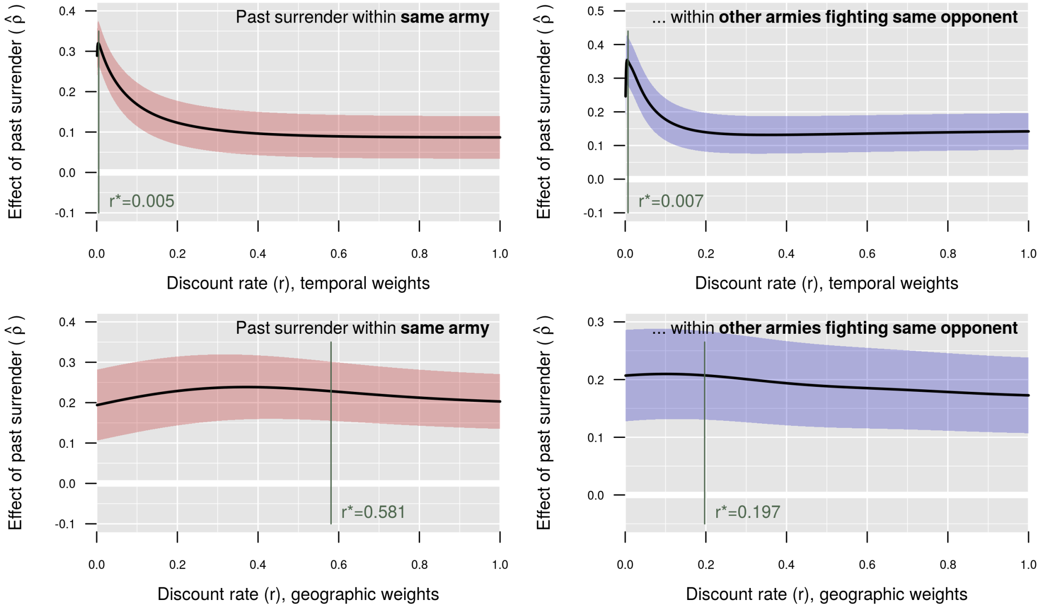

Figure 5: Japan’s military effectiveness and surrender rates against U.S. Values shown are monthly averages of the logged loss-exchange ratio (top pane) and average logged surrender rates (bottom pane)

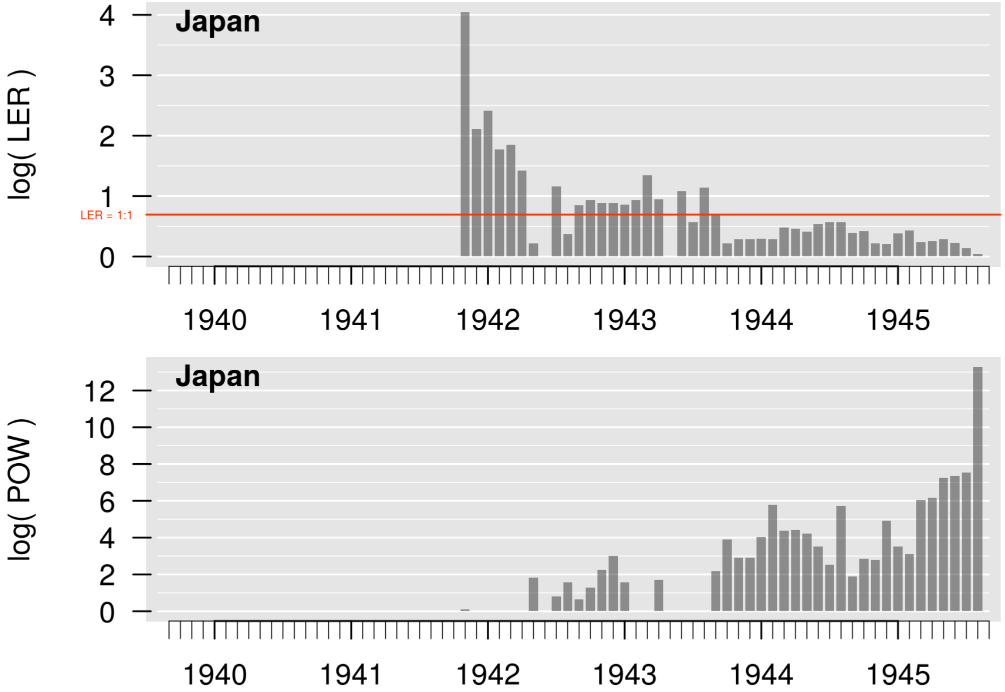

Table 1: Descriptive Statistics: Battle-Combatant Variables. $N = 1720$.

Variable	Mean	SD	Min	Max	# Missing
Start Year	1966.27	23.63	1939	2011	0
KIA (# personnel)	6,557.61	31,845.47	0	458,080	932
WIA (# personnel)	10,900.44	83,661.08	0	1,855,605	1,077
MIA (# personnel)	360.63	2,916.20	0	60,000	1,005
POW (# personnel)	13,829.11	80,023.16	0	1,200,000	876
Battle size (ordinal)	2.42	1.27	1	6	387
Polity Index	3.31	7.77	-10	10	498
CINC	0.077	0.099	0.00001	0.38	385
LER Side A	1,747.91	6,463.96	0	26,000	1,069
LER Side B	16,202.99	51,305.89	0	179,000	911
Leader Surrendered	0.03	0.16	0	1	2
Volunteers	0.17	0.38	0	1	452
Geneva Ratifiers	0.71	0.45	0	1	0
Distance from Capital	5,959.38	7,595.41	0	35,279.91	329
Battle Initiator	0.56	0.50	0	1	2

Table 2: Determinants of battlefield surrender (temporal weights).

	Dependent variable:					
	log(POWs)					
	(1)	(2)	(3)	(4)	(5)	(6)
Surrender in previous battles $W(y)$						
W(same combatant)	0.27*** (0.21, 0.32)		0.21*** (0.13, 0.29)		0.21*** (0.12, 0.29)	
W(same opponent)		0.24*** (0.18, 0.31)		0.12* (0.02, 0.23)		0.13* (0.03, 0.24)
Battle level covariates Z_k						
Battle size			0.27*** (0.17, 0.37)	0.28*** (0.18, 0.38)	0.27*** (0.17, 0.37)	0.28*** (0.17, 0.38)
log(Force ratio)					−0.03 (−0.08, 0.03)	−0.02 (−0.07, 0.04)
Deployment distance			−0.01 (−0.20, 0.19)	−0.05 (−0.25, 0.15)	0.11 (−0.10, 0.31)	0.08 (−0.13, 0.29)
Initiator			−0.63*** (−0.81, −0.45)	−0.69*** (−0.87, −0.51)	−0.61*** (−0.80, −0.43)	−0.67*** (−0.86, −0.49)
Start year			−0.02 (−0.09, 0.05)	0.04 (−0.02, 0.11)	−0.01 (−0.08, 0.06)	0.06 (−0.01, 0.12)
Dyad and national-level covariates X_{ij}						
More powerful			−0.06 (−0.20, 0.09)	−0.10 (−0.26, 0.06)	−0.06 (−0.22, 0.09)	−0.10 (−0.26, 0.06)
Professional army			−0.02 (−0.78, 0.73)	−0.21 (−0.98, 0.56)	−0.31 (−1.22, 0.61)	−0.56 (−1.49, 0.37)
More democratic			−0.31 (−1.33, 0.70)	−0.26 (−1.30, 0.78)	−0.10 (−1.18, 0.98)	−0.07 (−1.18, 1.04)
Geneva (opponent)			0.78 (−0.09, 1.64)	0.48 (−0.40, 1.36)	0.74 (−0.13, 1.60)	0.43 (−0.45, 1.32)
Seasonal fixed effects	✓	✓	✓	✓	✓	✓
War fixed effects	✓	✓	✓	✓	✓	✓
Combatant fixed effects	✓	✓	✓	✓	✓	✓
Observations	844	844	426	426	411	411
Adjusted R^2	0.34	0.30	0.49	0.47	0.50	0.48
Log Likelihood	−1,092.13	−1,119.79	−518.64	−529.29	−498.13	−507.58
UBRE	0.81	0.87	0.69	0.73	0.68	0.72
RMSE	0.73	0.75	0.68	0.69	0.67	0.69
AIC	2184.25	2239.59	1037.27	1058.59	996.26	1015.16

Note: Standardized coefficients. 95% confidence intervals in parentheses.
$^{\prime}$p<0.1; *p<0.05; **p<0.01; ***p<0.001

Table 3: DETERMINANTS OF BATTLEFIELD SURRENDER (geographic weights).

	Dependent variable:					
	log(POWs)					
	(1)	(2)	(3)	(4)	(5)	(6)
SURRENDER IN PREVIOUS BATTLES $W(y)$						
W(same combatant)	0.23***		0.13**		0.09′	
	(0.16, 0.30)		(0.04, 0.22)		(0.0000, 0.18)	
W(same opponent)		0.19***		0.10*		0.08*
		(0.12, 0.26)		(0.02, 0.18)		(0.001, 0.16)
BATTLE LEVEL COVARIATES Z_k						
Battle size			0.29***	0.29***	0.29***	0.29***
			(0.19, 0.39)	(0.19, 0.39)	(0.18, 0.39)	(0.18, 0.39)
log(Force ratio)					−0.02	−0.02
					(−0.08, 0.03)	(−0.08, 0.03)
Deployment distance			−0.04	−0.02	0.06	0.08
			(−0.24, 0.16)	(−0.22, 0.18)	(−0.15, 0.27)	(−0.13, 0.30)
Initiator			−0.72***	−0.72***	−0.71***	−0.71***
			(−0.90, −0.54)	(−0.90, −0.54)	(−0.90, −0.53)	(−0.89, −0.53)
Start year			0.06	0.07*	0.07*	0.08**
			(−0.01, 0.12)	(0.01, 0.14)	(0.01, 0.13)	(0.02, 0.15)
DYAD AND NATIONAL-LEVEL COVARIATES X_{ij}						
More powerful			−0.15*	−0.16*	−0.17*	−0.17*
			(−0.30, −0.01)	(−0.30, −0.01)	(−0.31, −0.02)	(−0.32, −0.02)
Professional army			−0.30	−0.29	−0.52	−0.55
			(−1.07, 0.46)	(−1.06, 0.48)	(−1.46, 0.41)	(−1.48, 0.39)
More democratic			−0.39	−0.36	−0.17	−0.15
			(−1.43, 0.65)	(−1.40, 0.68)	(−1.29, 0.94)	(−1.26, 0.97)
Geneva (opponent)			0.54	0.47	0.50	0.44
			(−0.34, 1.42)	(−0.42, 1.35)	(−0.39, 1.38)	(−0.45, 1.32)
Seasonal fixed effects	✓	✓	✓	✓	✓	✓
War fixed effects	✓	✓	✓	✓	✓	✓
Combatant fixed effects	✓	✓	✓	✓	✓	✓
Observations	844	844	426	426	411	411
Adjusted R^2	0.29	0.28	0.47	0.47	0.47	0.47
Log Likelihood	−1,126.69	−1,132.90	−528.07	−529.16	−509.22	−509.14
UBRE	0.88	0.89	0.72	0.73	0.72	0.72
RMSE	0.76	0.76	0.69	0.69	0.69	0.69
AIC	2253.38	2265.79	1056.13	1058.32	1018.43	1018.28

Note: Standardized coefficients. 95% confidence intervals in parentheses.
′p<0.1; *p<0.05; **p<0.01; ***p<0.001

Table 4: INTERACTION BETWEEN PAST SURRENDER AND OPPONENT'S RATIFICATION OF GENEVA CONVENTIONS.

	Dependent variable:			
	log(POWs)			
	(1)	(2)	(3)	(4)
INTERACTION $W(y) \times X_{ij}$				
Interaction (same combatant)	0.58*** (0.30, 0.86)		0.45* (0.02, 0.87)	
Interaction (same opponent)		0.25 (−0.30, 0.80)		0.15 (−0.54, 0.83)
SURRENDER IN PREVIOUS BATTLES $W(y)$				
W(same combatant)	−0.27* (−0.54, −0.01)		−0.23 (−0.64, 0.17)	
W(same opponent)		0.07 (−0.47, 0.60)		−0.03 (−0.70, 0.64)
GENEVA CONVENTIONS X_{ij}				
Geneva (opponent)	0.02 (−0.35, 0.39)	0.07 (−0.34, 0.48)	0.36 (−0.61, 1.32)	0.50 (−0.39, 1.39)
Battle level covariates			✓	✓
Dyad level covariates			✓	✓
Seasonal fixed effects	✓	✓	✓	✓
War fixed effects	✓	✓	✓	✓
Combatant fixed effects	✓	✓	✓	✓
Observations	844	844	426	426
Adjusted R^2	0.36	0.32	0.49	0.46
Log Likelihood	−1,083.61	−1,108.69	−518.16	−530.51
UBRE	0.79	0.84	0.69	0.73
RMSE	0.72	0.74	0.67	0.69
AIC	2167.22	2217.38	1036.31	1061.03

Note: Standardized coefficients reported, 95% CI in parentheses.
$^{*}p<0.05$; $^{**}p<0.01$; $^{***}p<0.001$

Table 5: The impact of past surrender by commanders.

	Dependent variable:							
	log(POWs) *GLM link: identity*				Commander surrenders *GLM link: logistic*			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Surrender by commanders in previous battles $W(x)$								
W(same combatant)	0.25^{***} (0.2, 0.3)		0.17^{***} (0.1, 0.3)		2.11^{***} (1.2, 3.0)		1.03^{**} (0.3, 1.8)	
W(same opponent)		0.17^{***} (0.1, 0.2)		0.05 (−0.02, 0.1)		2.59^{***} (1.6, 3.6)		1.88^{**} (0.8, 3.0)
Battle level covariates			✓	✓			✓	✓
Dyad level covariates			✓	✓			✓	✓
Seasonal fixed effects	✓	✓	✓	✓	✓	✓	✓	✓
War fixed effects	✓	✓	✓	✓	✓	✓	✓	✓
Combatant fixed effects	✓	✓	✓	✓	✓	✓	✓	✓
Observations	844	844	426	426	1,718	1,718	813	813
Adjusted R^2	0.31	0.27	0.48	0.46	0.13	0.10	0.32	0.35
Log Likelihood	−1,111	−1,135	−524	−532	−374	−373	−184	−182
UBRE	0.85	0.90	0.71	0.74	−0.56	−0.57	−0.55	−0.55
RMSE	0.75	0.77	0.69	0.70	0.14	0.14	0.17	0.16
AIC	2223	2271	1049	1063	748	746	369	364

Note: Standardized coefficients reported, 95% CI in parentheses.
$^{*}p<0.05$; $^{**}p<0.01$; $^{***}p<0.001$

Table 6: Placebo tests: determinants of surrender.

	Dependent variable:			
	log(POWs)			
	(1)	(2)	(3)	(4)
Casualties in previous battles $W(KIA + WIA)$				
W(same combatant)	0.06 (−0.01, 0.13)			
W(same opponent)		0.04 (−0.04, 0.12)		
Loss-exchange ratios in previous battles $W(LER)$				
W(same combatant)			0.10 (−0.03, 0.22)	
W(same opponent)				0.01 (−0.12, 0.14)
Battle level covariates	✓	✓	✓	✓
Dyad level covariates	✓	✓	✓	✓
Seasonal fixed effects	✓	✓	✓	✓
War fixed effects	✓	✓	✓	✓
Combatant fixed effects	✓	✓	✓	✓
Observations	371	371	371	371
Adjusted R^2	0.49	0.48	0.49	0.48
Log Likelihood	−444.65	−445.88	−445.08	−446.49
UBRE	0.67	0.67	0.67	0.68
RMSE	0.66	0.66	0.66	0.66
AIC	889.31	891.76	890.16	892.98

Note: Standardized coefficients reported, 95% CI in parentheses. *p<0.05; **p<0.01; ***p<0.001

Table 7: Payoff Structure.

	$A < \theta$ Success	$A \geq \theta$ Failure
Fight ($a_{it} = 0$)	$1 - c$	$-c$
Abandon ($a_{it} = 1$)	0	0