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Political institutions, resources, and war: *Theory and evidence from ancient Rome*☆

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ABSTRACT

How does a governing coalition's size affect the extent and type of violence in society? The model developed here predicts that larger coalitions are less likely to fight for private goods (e.g., plunder) than for public goods (e.g., defense), yet this substitution need not reduce the overall scale of fighting. That prediction is tested by investigating how Rome's transition from Republic to Empire affected military patterns. The raw data and three empirical tests suggest that the Republic engaged in more battles overall and that Republican battles had more of a public goods component. This study furthers our empirical knowledge about the ancient world while bringing data to bear on contemporary debates about the causes of peace and war.

> We have discovered war to be derived from causes which are…private as well as public.
>
> — Socrates, *Plato's Republic*

> It is surer and safer to quest for food with sword and buckler than with all the instruments of husbandry.
>
> — Socrates, *Xenophon's The Economist*

1. Introduction

When deciding on America's political regime, Hamilton asked: "Have republics in practice been less addicted to war than monarchies?" (Hamilton et al., 1787, No. 6). Appealing to the history of ancient republics, he argued "no". Yet a large literature has since claimed otherwise.[1] Many posit the reason democracies will be more peaceful is that they have larger governing coalitions that want more peace as a public good (Bueno de Mesquita et al., 1999; McGuire and Olson, 1996; Olson, 1993). However, many others argue that conflict results from different factors altogether (Hirshleifer, 1787; Tullock, 1974), and an insurgence has again cast doubt on whether monarchies are relatively more violent (Arena and Nicoletti, 2014; Caverley, 2014; Gartzke, 2007; Mousseau, 2013). Ancient Rome has been largely absent from the debate because the evidence does not fit neatly into data sets – despite having been

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[1] For example, Lake (1992, p. 24) says "autocracies will be more expansionist and, in turn, war-prone". See Hegre (2014) for a review.

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thoroughly studied by earlier scholars of governance (Hamilton et al., 1787; Machiavelli, 1517; Montesquieu, 1734; Smith, 1763; Smith, 1776). Therefore, this paper compiles a new database on battles in the ancient world to re-examine whether monarchies are more war-prone. It systematically analyzes how Rome's military patterns changed as the ruling coalition shrank from small to smaller after Julius Caesar crossed the Rubicon in 49 BCE to become "dictator for life".

Historians have argued that the Pax Romana occurred when Rome was ruled by an emperor while the military was often used for his personal gain (Bang and Turner, 2015; Beard, 2015; Goldsworthy, 2016; Harris, 2016). For example, Scheidel (2015, p. 168) argues that "the Empire had been rooted as the personal hunting ground of a smallish set of political, military, and religious leaders." The reason there was more peace, Harris (2016, p. 110) explains, is that "it was less and less obvious that the interests of the *princeps* were served" (original emphasis on the emperors' title of princeps). In contrast, the Republic – not a full-fledged democracy but sharing many democratic features – was more militant. A self-interested senate waged many wars and believed it was acting defensively (Beard, 2015; Eckstein, 2006; Harris, 1979; 2016).

This paper provides an in-depth empirical analysis of ancient Roman military patterns. The data show that the Roman Republic entered into more battles than did the Empire (contra the prediction that larger coalitions reduce violence along the extensive margins; Bueno de Mesquita et al., 1999), and three empirical tests suggest that Republican battles were more likely to be for defense than for personal gain. First, the Republic fought in battles that were more likely to improve defensive logistics by decreasing Rome's perimeter/area ratio. Second, in accord with scholars who argue for a relationship between defense and terrain ruggedness (Nunn and Puga, 2012; Winder et al., 2015), the Republic was more likely to fight for land used to support defensive colonies – as indicated not only by the raw data but also by regressions that control for other factors. Third, building on the work of ancient historians who observed a link between plunder and civil war, tests reveal that the Republic was associated with fewer internal conflicts. Each test relies on a different set of assumptions (concerning, respectively, spatial logistics, battles over defensive land, and the benefits of civil war), but all results point in the same direction.

To help explain these findings, this paper incorporates the arguments of leading ancient historians into a simple model that highlights two main theoretical differences between classical and contemporary theorists. First, both public and private goods (i.e., resp., defense and loot) were obtained from Roman military activity (Eckstein, 2006).[2] Second, ancient historians do not think democratic peace theory applies to the ancient world and some scholars have emphasized economic factors instead (Gat, 2006; 2017; Morris, 2014; Robinson, 2001). For example: Harris (2016, p. 41) argues that "economic motives predisposed them [Rome] to go constantly to war"; and Beard (2015, p. 162) describes the ancient Mediterranean as "a world where violence was endemic" and where "plunder was a significant revenue stream for everyone." These differences are captured in the ancient epigrams and make up the core of the model.

In the model, there is a governing coalition that allocates resources to military activity for private or public benefit. The *imperial coalition* refers to the emperor (who has a "desire to concentrate glory and victory in his own person"; Harris, 2016, p. 134) along with a close circle of advisors.[3] The *republican coalition* refers to the senate together with some other military men and wealthy clients (but not the general population, since this was not a "true" democracy). A comparison between larger republican coalitions and smaller imperial coalitions, where both senators and emperors have peripheral influence, reveals that larger coalitions fought more for public goods (such as defense) and less for private goods (such as plunder). These tendencies could lead either to more or to less fighting overall (depending on the magnitudes of the changes in both types of goods), but the profitability of war is unambiguously affected by demographic and technological factors. Hence, the theory explains why the effect of coalition size depends on (and is often confounded with) those demographic and technological factors. Although there is much more to the rich history of Rome, this simple model provides a starting point from which to organize the overarching military patterns.

The broader contribution of this paper is combining economic methods and qualitative historical evidence to broaden our understanding of the causes of peace and war. The econometric approach used here joins a growing trend of using geospatial information to piece together data from millennia past in order to lend empirical support to one side of a debate or a consensus narrative (as in Barjamovic et al., 2019). However, the approach adopted here does not supplant the detailed work of Roman historians and classicists; rather, it complements that work with a fresh perspective. It helps us better understand the ancient world and, in turn, uses ancient history to inform current debates about the role of various types of institutions in society. The processes and institutions of the ancient world yield many empirical insights because the evidence is not confounded with such modern factors as the Industrial Revolution. The model helps interpret the historical data and thus refines conventional thought in the field of political economy.

2. Theoretical model

This section develops a model based on the narratives and case studies provided by ancient historians. In the model, a governing coalition of a leading international power allocates military resources based on the benefits and costs to its members.[4] The governing

[2] According to Harris (1979, p. 92), for example, "economic gain, both public and private, was a normal concomitant of successful warfare and of the expansion of power"; likewise, "in order to understand the Roman political economy, we have to take into account the balance between public and private exactions" Hopkins (1980, p. 105). Kagan (2006, p. 362) notes that there were "limited military resources[,] so that the emperor could liberate sufficient combat power to act either offensively or defensively".

[3] The Empire has been referred to as a military dictatorship with one-man rule (Beard, 2015; Harris, 2016), but these and other scholars acknowledge additional influences. For example, the Praetorian prefect often had substantial sway and sometimes there were co-emperors.

[4] This setup unites models of conquering empires (Grossman and Mendoza, 2001), ruling military coalitions (North et al., 2009), and trade-offs among defense, offense, and production (Grossman, 1991; Grossman and Kim, 1995).

coalition chooses to spend military resources on providing either public or private benefits – respectively, fighting for the safety and security of the state or fighting to plunder and persecute political adversaries. Larger governing coalitions have more members that would benefit from public goods but also more members among which any acquired private goods must be divided. Since military resources are scarce, it follows that larger coalitions replace the pursuit of military-provided private goods with their public goods counterpart (as when troops are used to prevent attacks that harm many instead of to hunt personal rivals for private gain). Such substitution can lead to either more or less fighting overall depending on military efficiency, market productivity, population, and other factors. The model, therefore, suggests that the effect of coalition size on the overall level of violence is highly contingent on demographic and technological factors. The baseline model focuses on how the coalition *size* affects the level and type of conflict (although strategic decisions about troops' destinations are explicated in Appendix Section A.1).[5]

The economy consists of N laborers that produce $Z(N,t) = z(t)N$ total units of output, where t is a per-unit output tax. Output is either consumed or taxed, and tax revenues are allocated to military spending. Total tax revenues equal $tz(t)N$, which is first increasing and then decreasing in t; consumption $[1-t]z(t)N$ is strictly decreasing in t. The governing coalition produces private goods X and public goods Y by spending tax revenues on military activities. For these two purposes, the funds allocated (m_x and m_y, resp.) are transformed into returns according to the concave functions $X(m_x)$ and $Y(m_y)$, where $X' > 0$, $Y' > 0$ and $X'' < 0$, $Y'' < 0$. This technology implies the constraint

$$tz(t)N = m_x + m_y. \tag{1}$$

Subject to resource constraints, the governing coalition maximizes the well-being (utility U) of its coalition members. In a population of N individuals, there are N_c members of the governing coalition. Each coalition member i has identical preferences over the private good X_i received from military activities, the public good Y_i received from military activities, and the private good Z_i received from market (i.e., nonmilitary) activities:

$$U_i(X_i, Y_i, Z_i) = f(Z_i + X_i) + g(Y_i), \tag{2}$$

where f', $g' > 0$ and f'', $g'' < 0$

Each coalition member has an equal share in any private goods resulting from military expenditures: $X_i = X(m_x)/N_c$, whereas public goods are enjoyed by all coalition members: $Y_i = Y(m_y)$. Thus, larger coalitions have more members benefiting from public goods but also more members dividing private goods. Each individual also has an identical share of consumption: $Z_i = [1-t]z(t)$. After these return technologies are plugged into the utility function, Eq. (2) becomes $U_i = f\left([1-t]z(t) + X(m_x)/N_c\right) + g(Y(m_y))$. Then, since $\sum_i^{N_c} U_i = N_c U_i$, the coalition's goal is to solve the following problem:

$$\max_{m_x, m_y, t} N_c \left[f\left([1-t]z(t) + \frac{X(m_x)}{N_c} \right) + g(Y(m_y)) \right] \quad \text{s.t.} \quad tz(t) = \frac{m_x + m_y}{N}. \tag{3}$$

Let us assume the existence of an interior solution for military expenditures and taxation. Then, for a given tax, the marginal rate of substitution between types of military activity has three components: (i) marginal utilities, f'/g'; (ii) military efficiency, X'/Y'; and (iii) coalition size N_c. Formally,

$$\left(\frac{f'}{g'}\right)\left(\frac{X'}{Y'}\right) = N_c. \tag{4}$$

The marginal rate of substitution shows that coalition-size is effectively the price of using the military for public or private gain; increasing the coalition size entails a substitution away from private goods X and toward public goods Y. Thus, the model shows that, when $N_{\text{Republic}} > N_{\text{Empire}}$, emperors face different implicit prices. Although neither regime fights battles *only* for private or for public gain, the model predicts that there will be a larger proportion of battles for the emperor's private gain under the Empire and a larger proportion of battles for the public good under the Republic.[6]

There is an ambiguous relationship between the political regime and the total resources allocated to military activity. On the one hand, larger coalitions prefer more public returns and fewer private returns, so the *combined* military expenditure will depend on each effect's magnitude. On the other hand, the population level (N), military technology (X', Y'), productivity of industry (z), and economic cost of taxation (z') have unambiguous effects on the level of violence. The tax rate is chosen to equate the marginal costs of taxation and marginal benefits from fighting, so if taxes are more distortionary ($z'\uparrow$) then the cost of military activity increases and there will be less of it. Improvements in productive technology will result in fewer resources being allocated to plundering.[7] The effects of population size N are more nuanced because they are contingent on whether the coalition size N_c also changes. However, wars of

[5] Rome confronted a host of different opponents, from small tribes to large Mediterranean powers (and often various sorts of enemies at the same time). If opponents are stronger or weaker at different times and places then, as shown in Appendix Section A.1, this will affect "military efficiency" – that is, a larger number of more powerful contestants can reduce the amount of plunder returned. See Garfinkel and Skaperdas (2007) for a useful review of the strategic effects that can arise in contests.

[6] The model assumes that private goods (i.e., plunder) are consumed; however, an extension could incorporate plunder offsetting general taxation. In this case, governing coalitions would expend different amounts toward fighting for different goods but smaller coalitions would still fight more for private goods (even though some of the private returns are ultimately used to finance public goods).

[7] It follows that there are opposing effects of a wealthy population broadening the coalition to include lower-income individuals. There is a claimant effect, whereby sharing the spoils with more people *reduces* the incentive to plunder; there is also an income effect, which reflects that coalition members are now poorer on average and so *increases* the incentive to plunder.

all types are subsidized whenever the population grows without expanding the governing coalition. (See Appendix Section A.2 for other links between the model and aspects of Roman history as well as Appendix Section A.3 for discussion about the coevolution of political and military patterns.)

3. Data and empirics

This study begins in 494 BCE shortly after the birth of the Republic, and ends in 395 CE with the death of the last emperor who had unified rule. In addition to this long time-period period, the study covers a large geographic area, providing unique insights into the military patterns of a leading power. Moreover, this study exploits the most comprehensive record of violence in the ancient world: a database of 615 battles, where each account is the combined product of several scholars over multiple years. Individual battles were collected into encyclopedias edited by military historians: major battles were collected by Jaques (2007), while smaller battles were collected from Taylor (2016) and Taylor (2017). The records were digitized and integrated (smaller battles added as supplementary information for larger battles). After which, most battles were manually linked to a geographic location in the online Pleiades database (Bagnall et al., 2006), which is supported by the Ancient World Mapping Center (Moss et al., 2012). Much of the location data ultimately originate with the *Digital Atlas of the Roman Empire* (Åhlfeldt, 2015) and the *Digital Atlas of the Roman and Medieval Civilizations* (McCormick et al., 2010).

What follows is a battle excerpt from Jaques (2007) under each regime. The first excerpt matches the general description by Rosenstein (2007, p. 237) that, "when a choice between a peaceful and a bellicose resolution of a foreign conflict presented itself, many members of the senate could see much to incline them to choose the former." The last excerpt matches the general description by Goldsworthy (2016, p. 341) that "Septimius Severus' legions took Ctesiphon again, in a war fought as much for glory and to secure the loyalty of the eastern armies as to deal with any perceived Parthian threat." Both excerpts accord with the model; more specifically, the model predicts that the Empire would have more battles like Atra and that the Republic would have more battles like Noreia.[8] Moreover, both excerpts indicate that battles are not the result of small, day-to-day thinking.

> **Battle of Noreia, 113 BCE , Rome's Gallic Wars**
> *When Cimbri and Teuton tribesmen spread south to the Danube and threatened the Taurisci (allies of Rome), Consul Papirius Carbo marched north of the Alps into Corinthia and met them at Noreia, near the Magdalensberg in modern Austria. The invaders won a decisive victory, but ignored Italy.*

> **Battle of Atra, 194 CE , Wars of Emperor Severus**
> *Emperor Septimius Severus attacked the Parthian city of Atra (Al Hathr), famous for its wealthy sun temple, in the desert west of the Tigris.*

Battles are the best measure of conflict for this study, especially since (a) lists of wars can be binned and aggregated in a variety of subjective ways and (b) most of the more detailed information is unavailable or suspect. Many of the surviving source-records were written with political incentives in mind. For example, much information about the Gallic Wars ultimately comes from the *Commentarii de Bello Gallico* by Julius Caesar, and many imperial records were written under a sophisticated and encompassing system of propaganda.[9] Because such commentary is almost certainly self-serving (e.g., *The Deeds of the Divine Augustus* by Augustus), scholars are skeptical about the underlying motives for peace. For example, Wallace-Hadrill (2018, p. 24) says of Augustus' Rome that, "from different viewpoints, we may see this 'restoration' as a devious and cynical piece of political manipulation." Although there is little reason to doubt that a battle did occur when a caesar described one, there are reasons to doubt that such battles were fought precisely as recorded. So after first reviewing the basic trends, the empirical analysis presented here uses attributes about the battles to classify them into types.

Two figures summarize the distribution of external battles over space and time. (To exclude internal conflicts, battles were manually coded to indicate whether or not they were between Romans.) Fig. 1 plots the number of battles in each exclusive 49-year bin (although the first and last bins each contain only 44 years each). This figure documents that the Republic was violent before the Empire ruled over a relatively peaceful period known as the Pax Romana. Observe also that the peak number of battles occurred in the time bin *before* 200 BCE (which includes the Second Punic War against the republic of Carthage and its allies). It was two republics – not two dictatorships – that were responsible for some of the largest conflicts to have taken place in the ancient world, which is inconsistent with democratic models of peace. Fig. 2 shows the number of battles at each location under each regime and documents that Rome fought over a vast area and variety of landscapes, which I will use to test the specific predictions of the theoretical model developed in Section 2. The first two empirical tests exclude internal battles, but the third one analyzes them explicitly.

The database also contains naval battles (30 external conflicts that could be located and geocoded to the nearest land location). These naval battles are often a complementary part of a land battle and occur very close to a land location, which reflects that "ship-to-ship combat was neither the primary purpose of ancient war fleets, nor the typical manifestation of ancient naval warfare"

[8] Some historians have noted that emperors provided goods that were desirable to the public (e.g., the grain dole), which are often termed "public" goods but do not match the nonrival, non-excludable sense of public goods used in this paper. So even though, for instance, Augustus says it was a public gift when he gave war spoils to colonies of his soldiers, this is actually – in the economic sense – a payment of private goods.

[9] There were also condemnations of emperors (e.g., *The Life of Caligula* by Suetonius under the reign of Hadrian). Famous denunciations (e.g., the Philippicae of Cicero condemning Mark Antony) and praise (e.g., the Panegyrici Latini corpus of praise for Roman emperors) have lent their names to our words "philippic" and "panegyric".

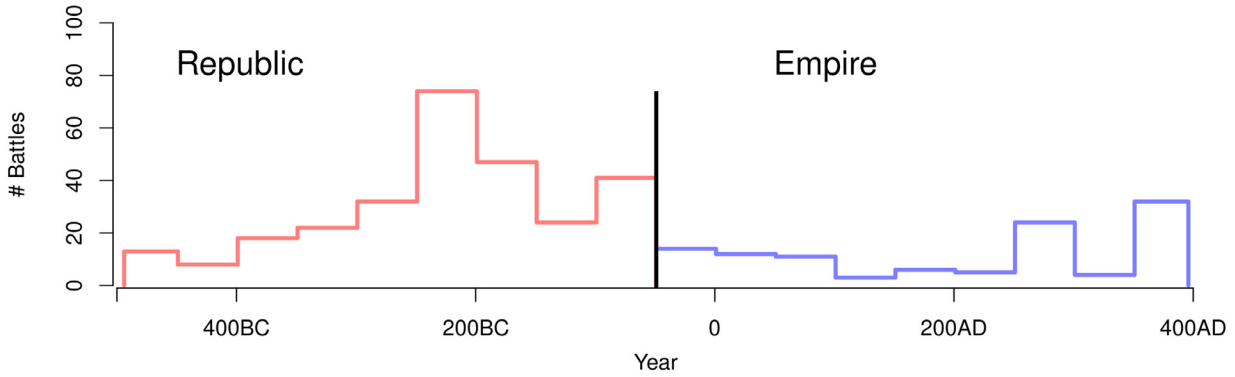

Fig. 1. Number of battles over time by political regime. Time-series histogram showing the number of battles within each exclusive 49-year bin (the first and last bin each include only 44 years).

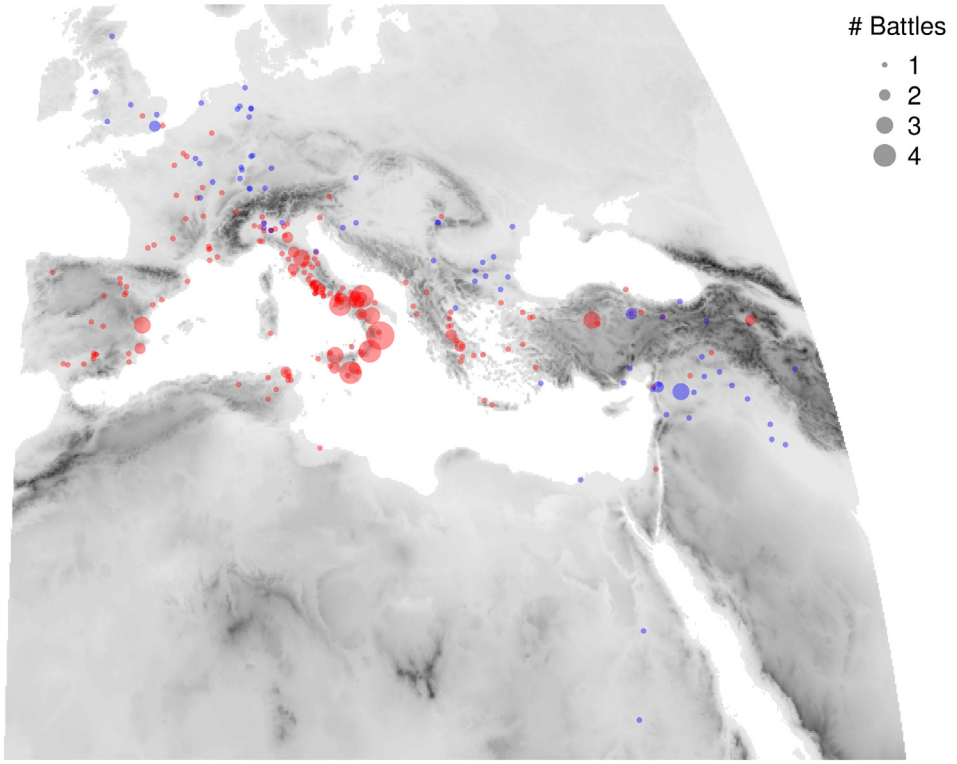

Fig. 2. Number of battles over space by political regime. Map of battle locations: red for Republic, blue for Empire; background grayscale indicates elevation.

(de Souza, 2013). Although land was the main dimension of Roman warfare, many general descriptions of naval activity also match the model. For instance, Taylor (2017, p. 17) says that "maritime activity in the early Republic was largely confined to protection of coastal communities and colonies against piracy" but that "the changed nature of the navy's role in imperial defence led to an inability to properly respond to major strategic threats to the security of the Empire" (Taylor, 2016, p. 22). Naval battles are excluded from Figs. 1 and 2 and also from the empirical test concerning defensive land.

3.1. Battles and perimeter logistics of rome

The first test of how the nature of battle changed is to establish whether battles consolidated extant lines of defense or reached less cohesively into the periphery. Battles that reduce the perimeter relative to the area of Rome make it easier to defend, and battles that

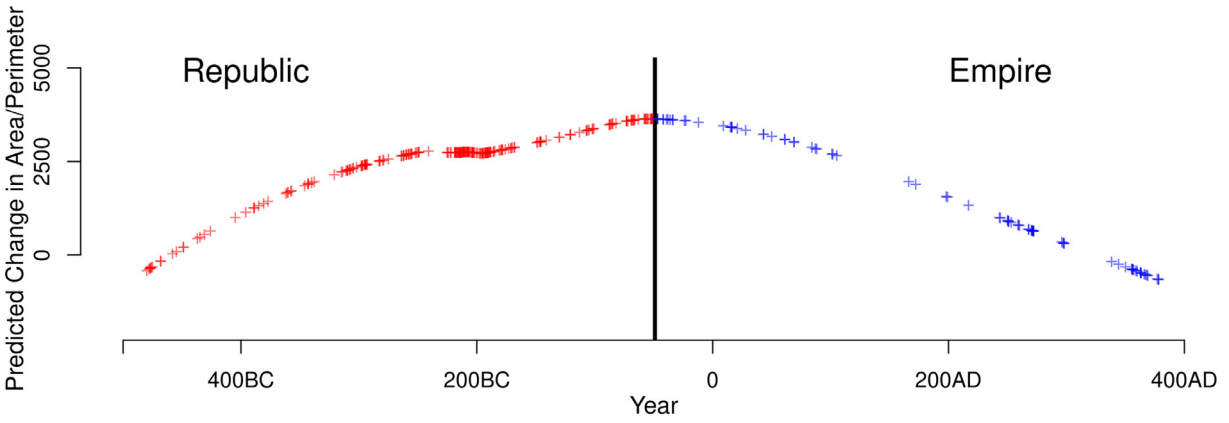

Fig. 3. Evolution in shape of military activity. Each mark represents the prediction of a LOESS smoother for how a battle changed the perimeter/area ratio of the convex hull of all prior battles.

extend the perimeter unharmoniously were more likely to be for plunder or glory.[10] First, the change in Rome's perimeter/area ratio is measured by how each battle changed the *convex hull* of all previous battles. (A battle that did not expand the frontier was coded as causing 0 change in the perimeter/area ratio.) Then a nonparametric algorithm (locally estimated scatterplot smoothing, LOESS) is used to estimate how much each battle affects that ratio. Fig. 3 shows that battles in the Republican era were more likely than those in the Empire era to increase the perimeter/area ratio. Although the smoother does not allow for discontinuities, this figure shows different trends before and after Caeser's coup; the implication is that the Empire's battles were less focused on improving defenses.

Exploiting the convex hull is a purely empirical approach to estimating the extent of military activity, and it captures significant military activity that extended beyond official perimeters (to the extent that borders existed in the way we now think of them). However, Beard (2015, p. 484) argues that "modern maps that claim to plot the edges of the empire in a simple line can be more misleading than helpful." So, a spatial kernel density estimate of battles that allows for "fuzzy" borders is calculated for each 49-year time bin. The spatial distribution of battles for each century (using the same kernel density calculations) is shown in Fig. A.7 (see the Appendix). The average change in the perimeter/area ratio – based on 75% contours – is over twice as large for the Republic as compared to the Empire. In sum, both the micro-level time series of battles and the macro-level contour averages suggest that the Empire was less focused than was the Republic on improving defenses.

3.2. Battles for defensive land

The second empirical test examines the type of land being fought for. Most conflict theories model the amount of fighting at a location as a function of the benefits individuals expect to receive, and in modern data, there is much empirical support for a link between conflict and land values. The following analysis builds on these insights to help explore conflict in ancient Rome, where – as is evident in the database – land battles were the main dimension of military activity. Moreover, the different location patterns of battles provide systematic information about the ancient world that is exogenous to violence, politics, and polemical record keepers.

When battles are fought for land that will probably be used to create defensive colonies, the implication is that the government is acting on behalf of the public good to provide defense. In contrast, battles fought on random terrains might be initiated for a variety of reasons. According to Goldsworthy (2016, p. 287), for example, "the greatest landowner of all was the emperor, for the imperial estates were immense, with property all over the empire, acquired during initial conquest or through confiscation from disgraced senators and other wealthy men." These were instances of fighting for locations *other* than those used to establish a defensive colony. Yet Smith (1776) argued that the first benefit of colonies is "in the military force which they furnish for its defense", and Roselaar (2017b) says of colonization in the Republic that "most important was the stabilization of newly conquered territory in order to discourage hostile peoples from warring against the Romans."[11] Using information from Bagnall et al. (2006), the Republican colonies from Roselaar (2010) are digitized and geocoded as defensive colonies. The data on terrain ruggedness are then used to identify land that is optimal for defensive colonies, which in turn is used to construct a *Defensive Land* value for each location.

Defensive Land is calculated by dividing the geographic space into non-overlapping geocells that are about a hundred square kilometers (100 km^2) in surface area. Then, for each geocell g, the *terrain ruggedness index* is calculated as $\text{TRI}_g = \sqrt{\sum_{g'} (E_g - E_{g'})^2}$, which is the average difference in elevation over eight directions (see Fig. 4(a)). Note that the Mollweide projection was used to

[10] While certain landmarks play a role in boundary determination, most examples are more "metes and bounds" than "inherent cage". Thus the Alps did not keep Romans on the peninsula, the Pyrenees did not keep them out of Spain, and the English Channel did not prevent them from entering Britain.

[11] This differs from the Empire, where colonies "became the most important way for generals to reward their veteran soldiers" (Roselaar, 2017a).

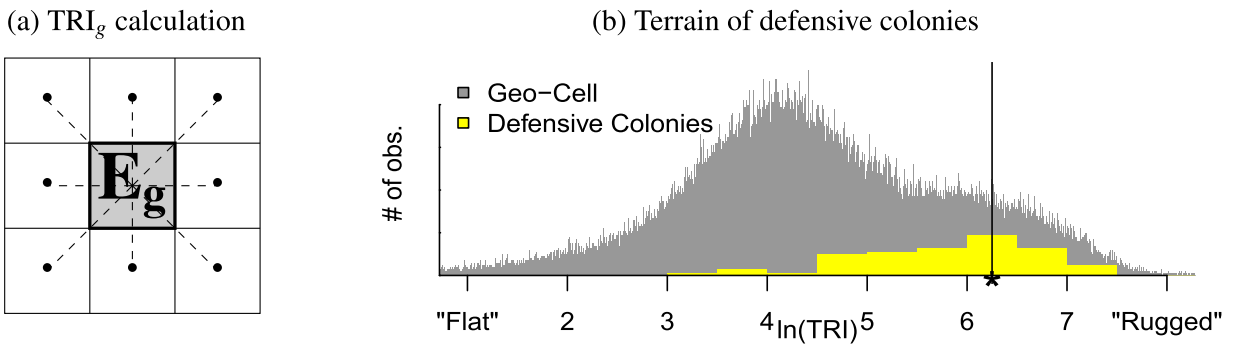

Fig. 4. Calculation of defensive land. (a) shows how land ruggedness is calculated; (b) illustrates the extent of ruggedness that is optimal for defensive colonies.

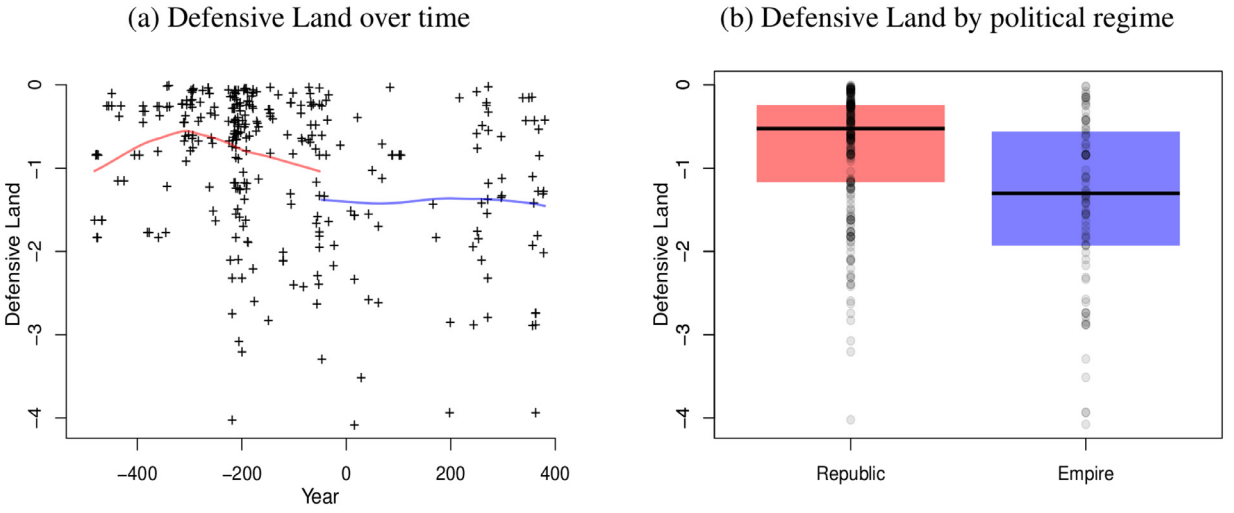

Fig. 5. Defensive land of battles. Each mark represents an individual battle. (a) provides a scatterplot and LOESS estimate of the Defensive Land of battles over time within each regime; (b) plots the corresponding averages (solid horizontal lines) and interquartile ranges (shaded boxes).

create a two-dimensional grid with equal-area geocells; the motivation for this procedure was to eliminate any bias that would result from observables (e.g., battle counts, TRI) being correlated with unobservables for reasons of "data shaping" only. (Otherwise, larger cells would observe larger counts and probabilities of extremes from completely random processes.) Fig. 4(b) plots the distribution of geographic cells and defensive colonies as a function of terrain ruggedness. We can see that the defensive colonies are often located on more rugged landscapes, which suggests that such locations are more desirable for defense. Observe also that there is a "sweet spot" for defensive colonies – namely, the mode $\ln(\text{TRI})^* \approx 6.25$. The Defensive Land variable, shown in Eq. (5), measures the proximity of a geocell's ruggedness to that sweet spot. Two checks confirm that battles fought for Defensive Land were more for the public good: the Battle of Atra has a lower value than the Battle of Noreia (see the descriptions in Section 3); and civil war battles have lower average values than do external battles:

$$\text{Defensive Land}_g = -|\ln(\text{TRI})_g - \ln(\text{TRI})^*|. \tag{5}$$

The effect of political regime on Defensive Land is evident in the raw data. Fig. 5(a) plots the Defensive Land value of battles over time and fits a nonparametric smoother for each regime (I use a LOESS, which weights the surrounding points to construct a moving estimate). There is a discontinuity around the time of the coup, offering some evidence that the transition to Empire is immediately associated with different behavior. Yet many of the effects of a regime change are gradual, and it may take decades or even centuries for marginal changes to manifest widely. The pattern recognition analysis of Fig. A.8 (in the Appendix) shows that the battle data seem to be completely random when one looks at small areas over short periods, but not as one "zooms out", and this observation suggests that the larger scope is more appropriate. Fig. 5(b) shows the mean and interquartile range of Defensive Land values for battles within each regime's period *without* conditioning on any covariates. This large-scale analysis reveals that, although neither regime is fighting purely for Defensive Land, the Republic is consistently closer to that ideal. A similar result is found for Rome's finer, but less distinct, political periods (see Appendix Section A.4).

One concern is that Defensive Land might simply be an artefact of monotonic expansion or other factors. This concern is addressed by way of a regression analysis that controls for distance and other factors, as well as by inspecting the raw data on distance patterns.

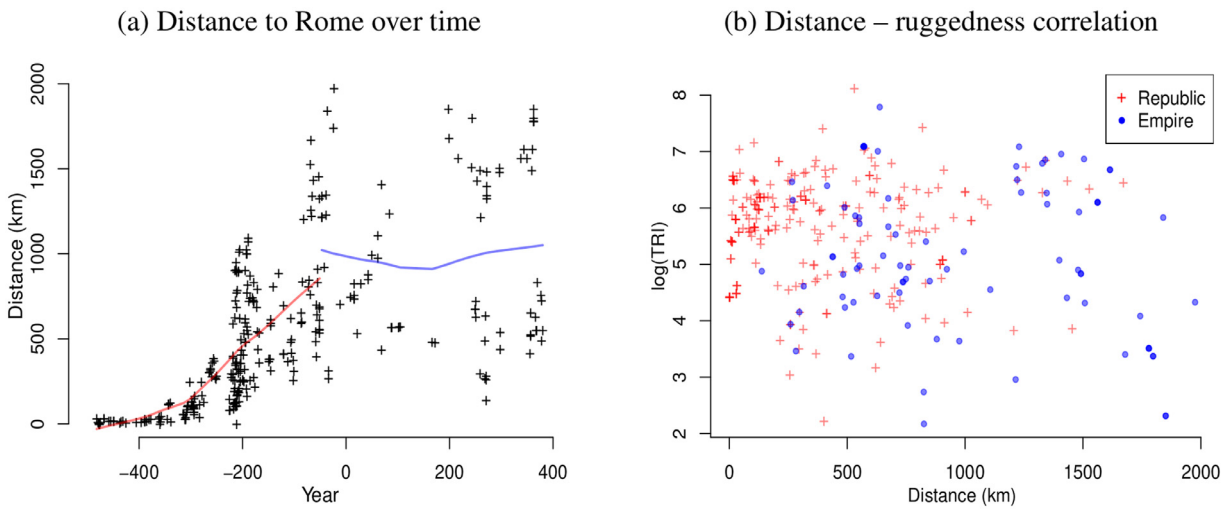

Fig. 6. Distance between battle location and Rome. Each mark represents an individual battle. (a) Provides a scatterplot and LOESS estimate, for each regime, of the distance to Rome of battles over time; (b) shows, for each regime, a scatterplot of the correlation between ruggedness and distance to Rome.

Fig. 6(a) shows the distance of the battle location from Rome (using the same procedure as in Fig. 5(a)). The battles steadily increase in that distance under the Republic - but fluctuate wildly under the Empire (yet maintain a similar average over time). Although there could be other changes in the battlefronts, this pattern complements the findings of Section 3.1: battles fought somewhere far away (as far away as Napata in modern Sudan), then somewhere close, then somewhere else far away are suggestive of a haphazard defensive policy. Thus Fig. 6(a) complements Fig. 3, which indicates that military resources under the Empire were being used to penetrate areas that were *less* likely to help defend Rome.

Fig. 6 (b) plots the terrain and distance from Rome for each battle and exhibits a qualitatively different pattern from that illustrated by Fig. 6(a). Moreover, the terrain is uncorrelated with the distance in both periods ($p > .1$), which implies that the Defensive Land differences under each regime are not mere statistical artefacts of the distance from Rome. On the contrary, the raw data suggest that regime change caused significant changes in the locations over which Rome fought.

The regression analysis controls for many factors other than distance to Rome. The average global lead emissions within each period (based on data from McConnell et al., 2018) proxies for production.[12] A region fixed effect for modern 21st-century countries (with data from Weidmann and Gleditsch, 2010) and for 3rd-century Roman provinces (with data from the Ancient World Mapping Center; Moss et al., 2012) controls for opponents that differ by region.[13] A time trend controls for changes in Rome's opponents over time. A space-time lag of battles (number of the previous period's battles within a radius of about 100 km) and the lag of the Empire's area (the convex hull of battles up to the previous period) help account for the dynamic spatial patterns of conflict.

Table 1 reports the results of ordinary least-squares (OLS) regressions with different sets of controls. The unit of observation is a geocell (as described in the TRI calculation) over an exclusive period (as described in the time series of battles). The number of battles is the dependant variable, and the main independant variables are: Defensive Land, as defined by Eq. (5); Empire, set equal to 1 only if the regime was an Empire during that period; and Defensive Land × Empire, which tests for whether the marginal effect of Defensive Land is weaker for Empire than for the Republic. Neither regime is predicted to have a greater disposition for war, but the coefficient for Defensive Land × Empire is predicted to be negative. All models give the same qualitative results: the Empire was less likely to fight for Defensive Land. Furthermore, Table A.4 (in the Appendix) also shows that this finding is robust to analyzing larger spatial units and to bootstrapping. Thus the regression analysis suggests that, ceteris paribus, the Empire directed military resources *away* from fighting for Defensive Land.

3.3. *Internal and external battles*

The third empirical test examines internal conflicts as an alternative way to identify wars fought for personal gain. Both in ancient Rome (LeBohec, 2015) and in the modern era (Collier and Hoeffler, 1999), civil wars have been linked with plunder. For example, Goldsworthy (2016, p. 203) argues that "the disruption caused by civil war or revolt created opportunities for enrichment, and it is striking that plunder featured in all of the incidents we have discussed". Consistent with the main hypothesis, Table 2 shows that there were more internal conflicts during the Empire.

[12] In particular, lead pollution is a byproduct of silver production (and of minting silver coins).
[13] Geocells that fall outside the region are coded as a separate region and are still included in the regressions.

Table 1
Imperial battles for defensive land (controlling for other factors).

	Battles	Battles	Battles	Battles
Defensive Land	5.60	5.36	7.29	8.25
	(1.96)***	(1.91)***	(1.90)***	(2.14)***
Defensive Land × Empire	−6.36	−8.98	−8.74	−7.85
	(2.26)***	(2.66)***	(2.21)***	(2.20)***
Empire	−13.76	−35.29		
	(8.30)*	(9.85)***		
Controls	Yes	Yes	Yes	Yes
Space–time lags	Yes	No	No	No
Fixed effects	None	Province+country	Province · empire	Country · empire

Notes: The unit of observation is a geocell-period; there are 194,161 geocells and 18 periods. The dependent variable is the number of battles, and the main independant variables are Empire (indicator set to 1 only for the Empire period), Defensive Land (defined by Eq. (5)), and Defensive Land × Empire. Control variables include distance to Rome, lead emissions, and period (a time trend). Fixed effects are for a 200 CE Roman province or for the modern country (c. 2000). Space–time lags count not only the previous period's number of battles within a radius of about 100 km but also the area of the convex hull of battles during that period. Standard errors are clustered at the geocell and period level; within each period, they are corrected heteroskedasticity and spatial autocorrelation (up to about 100 km). Values are multiplied by 100,000 for ease of reporting.

Table 2
Summary of internal and external battles.

	Total	External	Internal	External/total	Internal/total	Internal/external
Republic	390	311	79	0.80	0.20	0.25
Empire	225	113	112	0.50	0.50	0.99

Notes: Fractions rounded to hundredths for reporting.

Moreover, Table 2 includes 445 years for both regimes. This means the different battle counts under each regime are not an artifact of regime length and their ratio suggests the average frequency of internal conflicts in the Empire is roughly 1.4 times higher than in the Republic. However, also note that this relative frequency varies in different subperiods and depends on the exact dating of the transition from Republic to Empire. In particular, most internal Republican battles were near or part of the transition to Empire – seeming more like "the year of the four emperors" (a century later) than like "the subduing of Illyrians" (a century earlier).

Table 2 also paints a more complete picture of historical conflict by incorporating both internal and external conflicts. The difference in scale becomes *less* pronounced: the ratio of Republican to Imperial battle becomes smaller, while the difference in type-mix becomes *more* pronounced: the internal share of battles more than doubled under the Empire and the ratio of internal to external battles nearly quadrupled.[14] Many historical descriptions also illustrate the different nature of battle under the Empire. For example, the Battle of Baduhennawood in 28 CE was a tribal revolt driven by heavy Imperial taxation with little gained in return (Taylor, 2016). Another example is the Battle of Lake Benacus in 268 CE, where this account – "During a disputed succession in Rome (resolved at Mediolanum) Alemanni tribesmen crossed the Alps into northern Italy" (Jaques, 2007, p. 562) – represents the many 'external' conflicts under Empire that do not originate from a defensive inclination. Moreover, the substitution of military resources was central to these broader changes. As summarized by Goldsworthy (2016, p. 403), "provinces were stripped of their garrisons to muster the armies needed to make a man emperor". (see also Beard, 2015; Harris, 2016) These results and descriptions further suggest that Imperial battles were more for private gain than for the public good.

The simple baseline model helps explain why, as the ruling coalition became increasingly smaller, military resources were allocated to purposes other than public defense. Future work would do well to further explore to what extent providing fewer public goods encouraged revolt, how concentrating more private goods into fewer hands incentivized infighting, and how both effects interacted.

4. Conclusion

One of this paper's most important contributions is to develop a methodology that brings the Roman world (and perhaps other ancient societies) into current debates about various types of institutions in society. Presented here is a model created to help explain some of ancient Rome's military patterns and to relate these insights to contemporary social scientists. Of course, additional models would further our understanding of many aspects of Ancient Rome. Thus, future theories could further elucidate the extent to which wars were offensive or defensive in different subperiods and versus specific opponents (e.g., by incorporating details about how military traditions and equipment affected strategic interactions). This paper also delivers much new empirical information that other empirical studies could incorporate. In particular, information about Rome's institutional development might help advance

[14] To control for other factors, a geocell regression analysis was also performed (using the same unit of observation and controls used in the first data column of Table 1, plus an interaction term between Empire and the Area of Rome). The results show that, for both the number of internal conflicts and the *share* of internal conflicts, internal conflicts were more frequent under the Empire. (The results also show having a larger area leads to more internal conflict, although a negative interaction term suggests that area was less of a factor within the Imperial years.)

research on market activity in ancient Rome (Arruñada, 2018; Erdkamp, 2016; Hopkins, 2002; Temin, 2006). Scholars are beginning to uncover the large-scale building projects of the Republic (Bernard, 2018), so it may soon be possible to compare the long-run effects of the Republic's "golden age of Roman road-building" (Crawford, 2001, p. 42) with the emperors' expenditures. Overall, then, this paper is an early step in integrating modern political economy with ancient Roman history – furthering an interdisciplinary exchange on the topics of political institutions, resources, and war.

Appendix A

A.1. Location-strategic roman colonels

This section considers the strategic aspect of conflicts when players compete over a grid of locations. The ruling coalition is led by a colonel who acts on their behalf (i.e., who maximizes the net expected gains over all locations) and interacts with an arbitrary number of other colonels at other locations. Each location $\ell = 1, \dots, L$ yields private returns, public returns, or both. Without loss of generality, consider private returns: at each location, each colonel j expends military resources $m^{\ell}_{j,x}$ to obtain X^{ℓ}. Thus a colonel invests military resources according to the per-unit costs c^{ℓ}_{j} and expected gains $P(m^{\ell}_{j,x}, m^{\ell}_{1,x}, \dots, m^{\ell}_{o,x})X^{\ell}$, where $m^{\ell}_{-j,x}$ denotes the military resources for each opposing colonel $-j = 1, \dots, o$ and $P(\cdot)$ is the *contest success* function. Note that this contestsuccess function can specify the Heaveside step function (the assumption in standard Colonel Blotto games), the Tullock function (often used in two-player contests), or many other functional forms. Just as in a Colonel Blotto game, the colonel allocates military resources across all locations with the objective to solve the following maximization problem:

$$\max_{\{m^{\ell}_{j,x}\}_{\ell}} \sum_{\ell}^{L} P(m^{\ell}_{j,x}, m^{\ell}_{1,x}, \dots, m^{\ell}_{o,x})X^{\ell} \quad \text{s.t.} \quad \sum_{\ell} c^{\ell}_{j} m^{\ell}_{j,x} \leq m_{j,x}.$$

To compute optimal expenditures at each location, $\{m^{\ell *}_{j,x}\}_{\ell}$, and thus the overall expected gains, $X^{*}_{j} = \sum_{\ell}^{L} P(m^{\ell *}_{j,x}, m^{\ell *}_{1,x}, \dots, m^{\ell *}_{o,x})X^{\ell}$, would require knowing the exact form of the contest success function. If we can characterize an equilibrium, then we can often derive useful mathematical relationships (see e.g. Roberson, 2006). Although many factors – for instance, the number of other contestants, their relative strengths, and so forth – that affect equilibrium allocations, the one common theme in these games is that there will be more expenditures at more valuable locations. Hence there is a direct link between the value of the land and the amount of fighting at that location. Moreover, even without knowing the exact probability of success in war (what Keynes argued is the canonical case of unknowable probabilities), we can still be confident that the gains from conflict over all locations depends on the size of the colonel's budget; $X^{*}_{j}(m_{x,j})$. A colonel can always choose not to exhaust his budget, and will generate at least as many gains when there are more resources at his disposal: $X^{*}_{j}(m_{x,j} + \varepsilon) \geq X^{*}_{j}(m_{x,j})$ for $\varepsilon > 0$. This inequality implies that $[X^{*}_{j}(m_{x,j} + \varepsilon) - X^{*}_{j}(m_{x,j})]/\varepsilon \geq 0$, which is the relationship assumed in the main text. Thus the strategic aspects of conflict that other scholars have emphasized are implicitly included in the model's definition of military effectiveness.

A.2. Other aspects of rome related to the model

The model developed here does not rule out ordinary citizens also benefiting from warfare under either regime: "bread and circuses" under the Empire and plunder and temples under the Republic. But there are good reasons to suppose that the imperial coalition was not truly acting as a representative of the citizens. For example, the Dominate period is so named because the emperor's title was *dominus*—indicating that the relationship between citizens and emperor was one of slave and master rather than principal and agent. Earlier emperors behaved in an "inclusive" manner in order to avoid another Ides of March; Augustus, as *princeps* of the Principate, even "distributed bribes to make elections feel authentic" (Harris, 2016, p. 101). Yet one can hardly conclude that the regular population was included in the ruling coalition. Thus Beard (2015) contrasts Augustus, who "exercised such influence over elections that the popular democratic process withered" (p. 354), with the Republic, in which "the votes of the poor mattered and were eagerly canvassed" (p. 190).

Neither does the model rule out military or strategic factors; instead, it simply focuses on how political developments in Rome affected military patterns. This approach builds on those of ancient historians who argued that many of the largest changes in the military were driven by politics. For instance, Harris (2016) traces the major changes in auxiliary troops and recruitment practices to Augustus, and Goldsworthy (2019, p. 191) discusses another emperor's creation of field troops used for personal security as "one of the most significant changes in the structure of the later army." It is noteworthy that, according to Trundle (2013), foreign troops were often added by caesars to help win civil conflicts, which makes it unlikely that changing troop compositions is an exogenous factor. To the extent that adding foreigners was harmful (which it might not have been, as some say they were useful ever since the early Republic; Goldsworthy, 2019; Trundle, 2013), the makeup of the army appears to be a symptom rather than the cause of changes to the military during this period. Most arguments about how the army's "barbarization" led to war refer to the Dominate or later periods, and this factor does little to explain variation in the number battles or in the other time trends described here for the perimeter/area ratio, distance to Rome, Defensive Land, and the plunder of internal wars.

Another prediction of the theoretical model is that resource availability would affect the level of violence. In that case, if the Empire had expanded until there was no good land left, then the emperors who came later would fight less. This "no good land left" account could also affect battle types, but it is consistent neither with the bulk of the empirical evidence presented here nor with historical narratives that underscore how different political regimes affect the type of conflict. Empirically, the regressions already

Table A.3
Important dates for this study.

509 BCE	Foundation of the Republic
264–241 BCE, 218–201 BCE, 148–146 BCE	Punic Wars
58–49 BCE	Caesar's command in Gaul
49 BCE	Caesar becomes dictator
31 BCE–284 CE	Principate period
284–395 CE	Dominate period

control for distance to Rome (which means that comparisons involve plots of land that are each far from the capital) and Defensive Land need not be "good land" (whatever that may be). Historically, the "no good land left" story cannot explain why the Empire added *imaginifers* (standard-bearers who carried an image of the emperor) to the army and had "all recruits taking an oath (the sacrementum) of allegience to the princeps rather than [to] the Senate and People of Rome" (Goldsworthy, 2019, p. 126). Moreover, there are many other aspects that would remain unexplained even if there were, in fact, no good land left. One such aspect is that "as the level of Roman wealth rose by comparison with that of other peoples, so some Roman aristocrats must have come to regard the proceeds of plunder as negligible" (Harris, 1979, p. 76).

A.3. Political and military evolution

The years addressed by this study include the two distinct periods of Republic and Empire, which are broad classifications of major trends and events during Rome's evolution. Throughout the Empire, emperors controlled the military. The later *Dominate* is a period of undisguised monarchy that is traditionally dated to 284 CE, when Diocletian (known to some economists for his Edict on Maximum Prices) officially adopted the title *dominus*. In the earlier *Principate*, emperors concealed their totalitarian ambitions and proclaimed to rule for the common Roman. The Principate is usually dated to 31 BCE, after Octavian (Augustus) defeated Mark Antony and commandeered Rome along with the title of *princeps*. The transition to Empire was not necessarily simple or always in one direction but, before then, Rome was a republic and the senate decided military matters.

The Republic was founded in 509 BCE, with the overthrow of the ruling monarchy. Initially, the government was composed of patrician elites, but plebeians were gradually incorporated into the political system, and a *Patrician and Plebian* subperiod is sometimes demarcated for the years 367-133 BCE. (In the middle of the Republic, the Punic Wars against Carthage produced some of the largest military engagements in the ancient Mediterranean, and the conclusion of Third Punic War in 146 BCE is sometimes used as an alternative demarcation date.) There is some debate over whether the Republic was truly defensive (Harris, 1979) and, by the *End of the Republic*, the battles began to reflect the narrow interests of individual generals. According to Beard (2015, p. 274), for example, "Pompey has a good claim to be called the first Roman Emperor". He fought with Julius Ceasar who commanded the Roman legions in Gaul and eventually took control of Rome. Despite Caesar's propaganda (and the claims of his heir, Augustus, to 'restore the Republic'), Loewenstein details the concentration of political power and clarifies that "the dictatorship for life obviously was nothing but the legalization – as legalization goes – of absolute power, monocratic rule" (1973, p. 86).

Table A.3 lists the events central to the evolution of Roman battles within this paper. For further discussion of Rome's political and military patterns over time, along with detailed lists of key events related to Rome's military, see Goldsworthy (2019, p. xv) and Harris (2016, p. xvi). For a detailed description of Rome's political institutions throughout its history, see Loewenstein (1973). And, for a general history of Rome with discussion about political and military patterns, see Beard (2015).

Fig. A.7, which plots battles over space for each century, includes all types of battles. Because some battles are close together and are therefore difficult to distinguish at this macro scale, Fig. 1 should be consulted for more precise counts over time. As an accurate illustration of fighting's spatial extent, Fig. A.7 also plots a spatial kernel density estimate for all previous battles (i.e., it displays the cumulative extent of conflict). This nonparametric density estimate views observed battles as realizations of an underlying distribution, and the graph uses the colors yellow, red, and black to represent (respectively) higher, lower, and no probability densities. Hence this figure does not assume battle-free locations to be without any military presence; rather, it estimates a lower-level military presence at locations that are more distant from other military activity.

A.4. Alternative units of space and time

Fig. A.8 uses Ripley's K-Statistic, $K(u, v)$, to compare the clustering of battles (over space intervals u and time intervals v) with complete Poisson randomness ($\pi u^2 v$). When one analyzes small space and time windows, the patterns look completely random. But this result is overturned when zooming out, which suggests that a "big picture" analysis of political change and violence is the appropriate choice.

Larger geocells are used to address empirical concerns about the scale of analysis (e.g., inaccuracies in battle locations and spatial autocorrelation). The baseline analysis uses geocells of about 10 km × 10 km (roughly the size of Bronx County, New York), but the results are robust to grouping geocells into larger units up to eight times (with geocells about the size of Rhode Island). A confidence interval for Defensive Land × Empire is estimated using the m out of n bootstrap (using 300 bootstrap samples, where $m = n^{0.9} < n$ for extreme events). All regressions include the baseline control variables (distance to Rome, lead emissions, and time trend) for each level of aggregation. Table A.4 reveals that the sign of the coefficient remains the same for much larger aggregations, from which

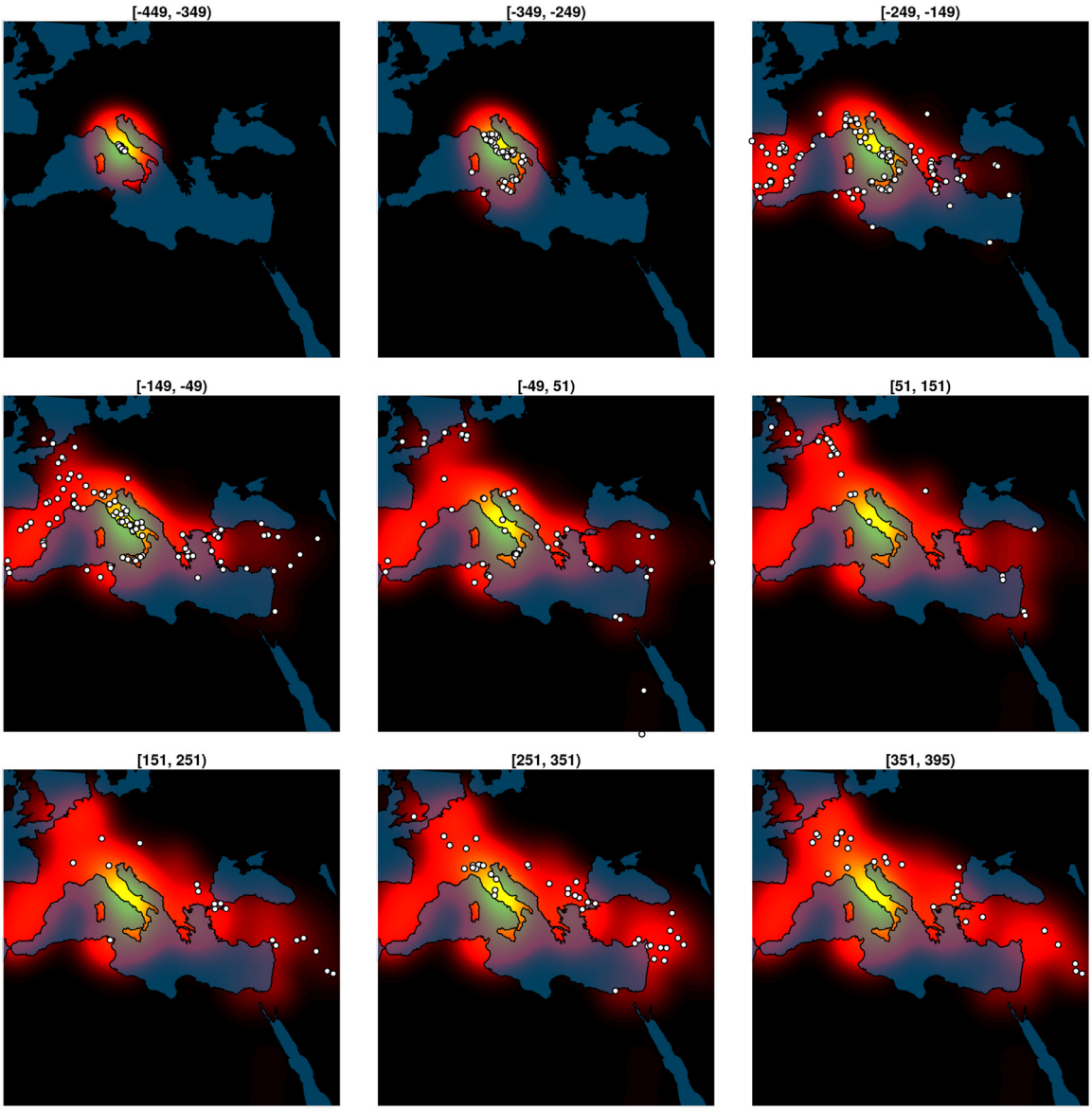

Fig. A.7. Battles over space by century. Time panel of maps of battles, where individual battles within each time period are shown as points (the white discs). Kernel density estimates of all battles prior to (and including) each focal time period are in color: yellow and red for, respectively, higher and lower estimates.

Table A.4
Defensive Land × Empire (bootstrap confidence intervals by spatial aggregation factor).

Confidence interval	Aggregation factor						
	2	3	4	5	6	7	8
2.5%	−5	−11	−21	−29	−40	−52	−63
97.5%	−2	−4	−8	−12	−15	−21	−19

Notes: The unit of observation is a geocell-period and the dependent variable is the number of battles. Control variables include Empire, Defensive Land, distance to Rome, lead emissions, and period (a time trend). The table reports 95% confidence intervals derived from estimating an OLS model for 300 bootstrap samples at different levels of spatial aggregation. The baseline analysis uses an aggregation factor of 1 with geocells of about 10 × 10 km. An aggregation factor of a means that each group of a geocells were grouped and averaged (in which case the area of each geocell is about $a10 \times a10$ km). Each column header shows the aggregation factor used. Values are multiplied by 10,000 for reporting purposes.

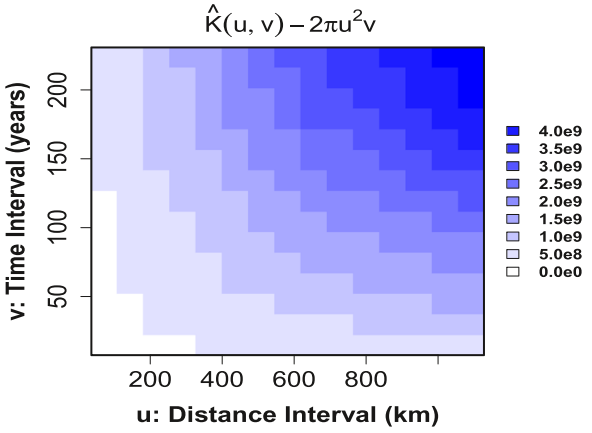

Fig. A.8. Pattern recognition via space-time scale. Difference between Ripley's *K*-Statistic of observed clustering and simulated Poisson random clustering; darker shading corresponds to greater differences.

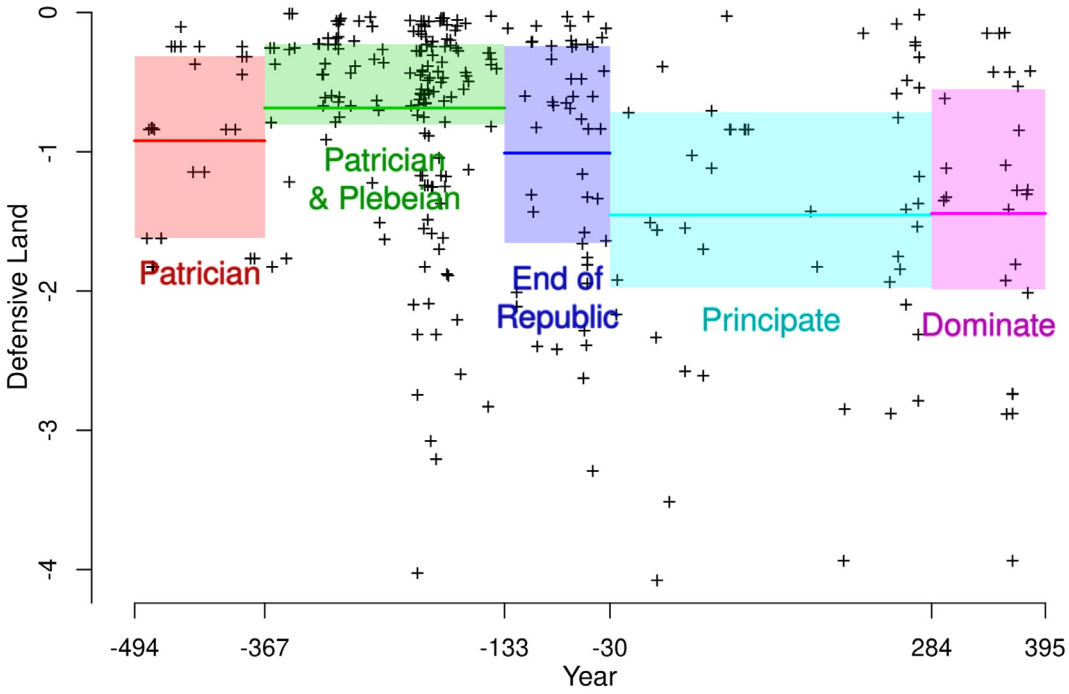

Fig. A.9. Battles for defensive land by alternative historical eras. Each mark represents an individual battle; averages and interquartile ranges are shown as (respectively) solid horizontal lines and shaded boxes.

one can conclude that the results are not driven either by the scale at which the data were organized, imprecisely located battles, or by omitted variables that are correlated over space. These findings suggest also the empirics do in fact capture the large-scale plans of a ruling body – that is, rather than the contingent strategies of a colonel.

Distinguishing between the Republic and the Empire is the best method available for identifying the size of the ruling coalition during this period. When using data collapsed over time, the coefficient for Defensive Land × Empire remains negative in a geocell regression that includes Distance to Rome and an intercept. (Moreover, correcting for coefficient-stability based on the Oster method leads to a more negative coefficient which suggests that unobservables are not responsible for the main empirical patterns.) Nonetheless, the model's predictions can also be applied to Rome's smaller but less distinct regimes (overviewed in Section A.3). In analogy to Figs. 5 and A.9 shows the Defensive Land values of battle locations over time along with the average value and interquartile range for each regime. This less granular depiction of Rome's political variations confirms that battle locations were more defensive in periods for which it is reasonable to suppose that the coalition size was larger. The data and code used in this article are available at Adamson (2019).

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