

Technology and the Era of the Mass Army¹

Massimiliano Onorato

IMT Lucca

Kenneth Scheve

Yale University

David Stasavage

NYU and Sciences-Po

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Abstract

We provide the first systematic examination of the determinants of military mobilization over the very long run. Focusing on a sample of thirteen great powers between 1600 and 2000 we argue that changes in transport and communications technology were the single most important factor in both ushering in the era of the mass army and in leading to its eventual demise. During the nineteenth century the development of the railroad made it possible for the first time to mobilize and feed armies numbering in the millions. During the late twentieth century further advances in transport and communications technology made it possible to deliver explosive force from a distance and with precision. This development has made mass armies less relevant. We find strong support for our technological interpretation using a new data set that measures army size, population mobilization, and methods of recruitment from the beginning of the seventeenth century. In so doing we also consider several other plausible determinants of military mobilization. Contrary to what is so often suggested by political scientists, we find little evidence that the French Revolution and the invention of the concept of “the nation in arms” was associated with a substantial increase in levels of mobilization across nations. Even for the French case alone, the magnitude of what is sometimes referred to as the “Napoleonic watershed” was smaller than what is often believed.

1 Introduction

Well known authors as diverse as Hinsley (1963), Finer (1975), Levy (1983), and Tilly (1990) present a pattern whereby competition between the great powers over the last few centuries was associated with wars that became less frequent over time but which also increased dramatically in their scope and intensity. Yet we know little about the exact factors that governed this evolution and which ultimately led to the era of the mass army, culminating in the two world wars. This is important to understand both for its own sake and because recent work has emphasized how the development of mass mobilization led to political pressures for countries to adopt steeply progressive tax systems.¹ Different authors have pointed to a range of developments that led to societies mobilizing larger and larger armies, but these explanations have, for the most part, not been systematically tested. Nationalism, and in particular the invention during the French Revolution of the concept of “the nation in arms,” may be the single factor most heavily emphasized by political scientists who seek to explain the increased intensity of warfare over time.² In this paper we take a different tack. We argue first that the French Revolution was less of a watershed for military mobilization than is often suggested. We then argue that changes in communications and transport technology, and in particular the invention of the railroad, constituted the most important factor in ushering in an era of mass warfare where armies numbered in the millions. Subsequently, further changes in communications and transport technologies that made it possible to remotely deliver explosive force have made it less necessary and less desirable to mobilize a mass army. The implication then is that the era of the mass army was a bounded period dependent on a specific state of technological development.

In terms of technology, some political scientists have previously emphasized the importance of railroads for military mobilization, but in doing so they have focused above all on

¹See Scheve and Stasavage (2010, 2012).

²Political scientists who emphasize this fact include Posen (1993), Snyder (2000), Cederman, Sornette, and Warren (2011), Fearon (1997), Van Evera (1998), and Walt (1992). Specialists in military affairs who emphasize this point include Cohen (1996), Mahnken (2011), Liddell Hart (1954), Krepinivich (2002), and of course Clausewitz (1832).

the effect of rail transport on the offense-defense balance.³ These same scholars have made less effort to see whether and why rail transport proved to be a watershed in the scale of military mobilization. This contrasts strongly with work by military historians that has shown precisely why railroads made it possible to mobilize forces on a scale previously thought unimaginable.⁴ Prior to the invention of the railroad, large armies faced a fundamental problem of logistics. While soldiers could transport themselves, their supplies had to be carried. The long-standing alternative to this was for armies to forage, but this then meant that the size of an army was constrained by the agricultural productivity of the land across which it marched. The use of horses changed this equation but only slightly. Horses could pull wagons carrying supplies, but horses also needed to be fed, and they ate in prodigious quantities. The adoption of the railroad by militaries changed this situation completely as it was now possible to transport men, munitions, and food in such quantities and with such speed that armies numbering in the millions could become a reality. The parallel development of the telegraph made it possible to command operations on this scale. Armies representing ten percent or more of a society's total population suddenly became feasible, and to find such numbers of individuals, states were obliged to recruit not only from the ranks of the poor but also from the middle and upper classes.

While descriptions of military mobilization over the long run generally refer to a secular trend towards increasing army size, by now any satisfactory explanation ought to also be able to account for the more recent trend away from mass armies. There are no doubt multiple plausible explanations here. Without dismissing these accounts, in what follows we suggest that even in the absence of these factors, developments in communications and transport technology may have greatly reduced incentives for states to mobilize mass armies. The inventions of the industrial revolution made it possible to move men and their supplies with unprecedented speed. More recent developments in communications and transport technologies involving the gyroscope, the laser, radar, the computer, and satellites have made

³See in particular Fearon (1997), Sagan (1986), Shimshoni (1990), van Evera (1984), Snyder (1984), and Jervis (1978).

⁴See in particular Pratt (1915), van Creveld (1977, 1989), Westwood (1980), Wolmar (2010), McNeill (1984) p.223, Fischer (1925), Fuller (1998), and Ropp (1959 p.161).

it possible to deliver explosive force remotely with unprecedented effectiveness. It would be hard to argue that the invention of nuclear weapons did not also play a role in ending the era of the mass army, but it should be remembered that as early as 1946, Bernard Brodie observed that in the nuclear age the development of missile and guidance technology would be critical.⁵

To test our argument as well as several alternatives we have compiled a new data set that records army sizes, levels of military mobilization (army size/total population), and recruitment methods for thirteen great powers over the period from 1600 to 2000. We adopt the classification of great powers first proposed by Jack Levy (1983). Our army size data derives from the Correlates of War data set for the period since 1815. For the period between 1600 and 1815 we have constructed measures of army size by referring to a wide range of historical sources, all of which are listed in the appendix to this paper. When combined with available estimates of population, these also allow us to construct mobilization levels for this period.

In order to test our hypothesis about the impact of shifts in communications and transport technology, we first propose an indirect test and then a more direct test. Using a pooled regression that includes country fixed effects, we regress either military size or military mobilization on an indicator variable that takes a value of 1 beginning in 1859, the first year that railways were used in a major way in combat, as well as on an indicator variable that takes a value of 1 beginning in 1970, a threshold year in the development of cruise missile technology. Finally, the regressions also include an indicator variable that takes a value of 1 beginning in 1789. This tests the alternative hypothesis that the invention of the idea of “the nation in arms” led to an increase in army size and mobilization levels.

When we use either military size or military mobilization as a dependent variable, we observe, consistent with our core hypothesis, that the year 1859 was associated with a large and statistically significant shift upward in both of these dependent variables, whereas the year 1970 was associated with a shift downward in both of these variables. In strong contrast,

⁵Brodie (1946).

there is no evidence in our pooled regressions that the year 1789 was associated with a statistically significant shift upward in either army sizes or levels of mobilization.

Given the results of the indirect test of our transport and communications hypothesis, we also propose a more direct test. To do so we augment the previously described regressions by including a variable measuring the number of kilometers of railway existing in a given country in a given year. Two variants of this variable are used, alternatively using the number of kilometers, or the number of kilometers relative to country size. We also add control variables for population, GDP per capita, state institutions, and political regime and model unobserved time effects through a quadratic time trend. We find in these estimates that the extent of a country's railway network is significantly correlated with the magnitude of military mobilization. Importantly, we also observe that when this variable is introduced into the regression, our indicator variable for post-1859 years is no longer statistically significant, and its coefficient drops substantially in magnitude. This is strong evidence for the importance of the railroad in ushering in the era of the mass army. We adopt a very similar approach to directly investigate the correlates of the introduction of precision weapons. Once we include a dummy variable in our regressions that takes a value of 1 for all years in which a country had obtained cruise missiles, then we observe that the coefficient on this variable is negative and generally statistically significant, and the coefficient on the post-1970 indicator is no longer statistically significant, and it is much smaller in magnitude. Finally, consistent with our earlier results, in none of these further tests do we find that the year 1789 was associated with a significant shift upwards in either army sizes or mobilization levels.

We refrain from suggesting that our regressions are definitive evidence of the precise causal mechanism that we have in mind. One alternative possibility would involve one of reverse causality if rail networks are extended in anticipation of mass war. To investigate this possibility we also report results of a series of instrumental variables regressions in which we instrument for the size of a country's railway network by using the size of the network in neighboring countries that were not great powers at the time. All of the substantive conclusions from our OLS estimates remain robust when instrumenting for great power rail

networks in this way.

A second source of bias could involve the possibility that railway networks made it physically possible to mobilize mass armies, but they also changed societies in a number of other very significant ways. By binding people from different communities more closely together, railways undoubtedly contributed to a greater sense of national identity which may in turn have favored mass mobilization for war. Even if this was the case, however, it would be simply be another reason to suggest that technology played a critical role in ushering in the era of the mass army, and therefore the French Revolution may have been a less important watershed than is so often suggested.

In addition to this pooled analysis, we also discuss the history of French mobilization in greater depth. We focus on France because it is the case that has most informed the thinking of political scientists about the evolution of mass armies and their emphasis on nationalism. Our discussion of France suggests that even in this case, it is clear that the magnitude of the influence of the French Revolution and Napoleonic era on army size and mobilization was relatively small and the era of the mass army was a late 19th and 20th century phenomena, which coincided with and depended on the technological innovations of the industrial revolution.

Finally, we also consider the methods through which armies were recruited in the period between 1600 and 2000. It is common to see universal conscription as an invention that made the mass army possible. We will argue below that the evidence on military recruitment actually fits more closely with our alternative, technology based interpretation. The causal chain may actually lead from technological change, to universal conscription, to the emergence of mass armies. More recent technological change may have had the exact opposite development. Our regression results are consistent with the former claim, though the evidence for the latter is somewhat weaker.

In the remainder of this paper, we proceed as follows. Section 2 outlines our argument that changes in communications and transport technology, and in particular the invention of the railroad, constituted the most important factor in ushering in an era of mass warfare. In

Section 3 we consider alternative explanations. In Section 4, we present a new comparative data set on the size of the military in thirteen great power countries from 1600 to 2000, and we also consider the methods by which these armies were recruited. Section 5 then presents our empirical evaluation of our argument and Section 6 considers the French case in greater detail. Section 7 concludes.

2 Technology and the Mass Army

The core question we ask in this paper is what factors have determined the size of armies that great powers have mobilized over time and the fraction of their citizens that are in the armed forces. Since we are examining a long stretch of history, there are undoubtedly multiple factors that have been at play, and below we will discuss those that have been most heavily emphasized in previous scholarship. Before doing so, however, we will emphasize a further argument that has long been appreciated by military historians but which has received scant attention from political scientists and economists. We will argue that changes in technologies for transport and communications have governed the size of armies that it has been feasible and desirable to mobilize.

In the first instance, fielding a mass army depends on the ability of a state to recruit a sufficiently large set of individuals. It also depends on two further factors. First, a state must have the ability to actually deploy troops and to keep them supplied. Second, a state that has the ability to recruit a mass army must also prefer this format of military force to one in which a more limited number of individuals serve. In what follows we will argue that prior to the invention of the railroad, it was physically impossible for states to field armies numbering in the millions. Even had it been possible to raise, transport, and support an army of this size, before the invention of the telegraph and telephone, it would have been extremely difficult to exercise command. It was thus the application of the inventions of the industrial revolution that allowed a broad set of states for the first time to field armies representing up to 10% of their total population. We will then argue that over recent decades, further developments in transport and communications technology have pushed in the opposite direction. As was

recognized (and feared) by Soviet military planners as early as the 1970s, in an environment where weapons can be targeted remotely and with increased precision, a mass army may be increasingly obsolete.

2.1 A First Revolution - Transporting Men by Railway

Prior to the adoption of the railway for military purposes, it was possible in theory for a state to recruit a mass army, but fielding it faced several very significant obstacles.⁶ While the soldiers of a mass army could transport themselves by marching to the field of battle, once there they needed to be commanded by some means. In addition, any munitions required for the army needed to be transported. Finally, a mass army—men and horses—needed to be fed. Since antiquity, armies had most often met this last requirement by foraging. But this strategy depended upon the carrying capacity of the land in question. By the eighteenth century the widespread adoption of the potato in Europe had increased the number of calories that could be extracted from a typical plot of agricultural land, but there remained serious limitations on the ability of a very large army, numbering in the hundreds of thousands, to feed itself via either feeding off the land or bringing supplies from the rear via wagon. Napoleon's armies built a reputation for moving quickly. One of the reasons they had to move quickly was that otherwise they would have starved after exhausting all nearby resources.⁷ Prior to the invention of the railway, an army numbering in the millions would have starved in short order.

The first modern railway was made feasible by the merging of an old technology – the concept of moving goods on rails – together with the principal invention of the industrial revolution – the steam engine. First envisioned at the outset of the nineteenth century, it was not until several decades later that trains capable of carrying passengers were first developed, and several decades after that before railways could carry large number of passengers and freight.⁸ Although railways were used in the Crimean war, the authoritative account by

⁶This section draws on the studies by Pratt (1915), van Creveld (1977, 1989), Westwood (1980), Fischer (1925), Fuller (1998), and Wolmar (2010).

⁷See van Creveld (1977) on this point.

⁸See Mokyr (1990) for a discussion of some of these innovations and the obstacles faced.

Pratt (1915) suggests that the first time they were used in a significant manner was by France during the Italian campaign of 1859. Subsequently, railways played a crucial role in both the American Civil War and the Franco-Prussian War.

We do recognize that the substantial increase in army size during the second half of the 19th century was made possible by railroads but also made substantially more desirable by the development of the telegraph and widespread use of breach-loading rifles. Further, the invention of the internal combustion engine radically changed how the wars of the first half of the 20th century were fought. However, in many ways, this innovation, as important as it was, largely amplified the effects of the railroad. Moving and supplying large armies became even more feasible and more desirable. Thus, our focus on railroads and technologies for remote delivery seeks to highlight what are in our view the two most important technological innovations influencing the use of mass armies, but our larger argument emphasizes the general importance of technological change in understanding long run trends in the format of military force.

2.2 A Second Revolution: Remote Delivery of Explosive Force

Though late nineteenth century advances in transport and communications technologies removed the obstacles to fielding a mass army, there is no reason to necessarily believe that each new advance in this area has led to, or will lead to, the mobilization of ever greater numbers of individuals. The key reason is that if improvements in transport can make it easier to move soldiers to the field of battle, they can also make it easier to deliver and target explosive force from areas withdrawn from the actual field of battle. A wide variety of new technologies have emerged that can allow remote delivery of explosive force and often with great precision. These include the gyroscope, the radar, the laser, and the satellite.⁹ What are the implications of remote delivery of explosive for levels of mobilization? To quote Major Leonard Litton of the US Air Force, in this era of new weaponry

It is no longer required to bring forces into the same geographical area to bring

⁹See the contributions by Krepinevich (2002) and Murray and Knox (2001) for discussions of how precision weapons can alter incentives to mobilize mass armies.

their effects to bear on the same target and, in fact, on the modern battlefield it may be dangerous as well (Litton 2000, 3).

In other words, there may be a straightforward technological explanation suggesting why the era of the mass army is now over. Interestingly, while certain US military planners have advocated the idea that new technologies allow for maintaining the same defensive capability with far fewer men, it was actually Soviet military planners who first highlighted this possibility. Evidence shows that from the late 1970s Soviet planners grew fearful that US advances in the area of precision weapons would render inoperable the principal Soviet war plan which involved quickly pushing a mass army westwards across the European continent.¹⁰

2.3 Predicted Effects of The Two Revolutions

We have laid out an argument suggesting that advances in communications and transport technology, a result of the industrial revolution, helped allow states to mobilize mass armies on a scale not previously possible. We then suggested how subsequent advances in communications and transport technology have pushed states in the opposite direction by facilitating the remote delivery of explosive force. The implication then is that after a century long period during which technology favored the development of mass armies, the major powers in more recent decades have begun to mobilize smaller armies that in size bear more resemblance to those of the pre-industrial era. There are three observable implications of this argument.

First, in absolute terms we should expect to observe that armies grew larger in size as countries developed railroad networks to transport both men and the materials to keep them supplied. We should likewise expect that as countries gained access to new technologies allowing them to deliver explosive force at a distance and with precision, then armies shrank in size.

Second, we should also expect to observe that as railroad networks expanded, countries were able to mobilize a larger fraction of their overall population. Likewise, the arrival of

¹⁰See Murray and Knox (2001) on this point.

precision weapons should lead to lower levels of mobilization.

Finally, we should also expect technological change to influence the way in which states recruit their armies. Since the time of Sidgwick (1883) and more recently by Ross (1994), it has been suggested that very large armies will need to be recruited by conscription, which is equivalent to a tax in kind. The reason is that paying each member of a very large army a market wage would require a level of taxation so high as to impose major deadweight costs on the economy. If this is the case, then we should expect the arrival of the railroad to be associated with a shift to recruitment by conscription and the arrival of precision weapons to increase the likelihood of states reestablishing a professional army. A key feature of this argument is that it applies to conscription regimes in general and not exclusively to regimes of universal conscription. Sidgwick actually believed that social welfare would be maximized with a conscription regime in which those who could earn high incomes in the market economy should be exempted from service.

An alternative prediction regarding recruitment developed by Scheve and Stasavage (2012b) suggests that the two technological revolutions to which we have referred had their most noticeable impact on the tendency of states to adopt *universal* conscription, and not necessarily conscription of any form. According to this account, facing the need to recruit a small army, a state can maintain a system of conscription that exempts the middle and upper classes and which targets the poorer members of society who have less to lose in the case that they are selected and must therefore forego their market wage. Compliance with this system of conscription can be maintained through coercion alone. But when a state desires to raise a much larger army that must by necessity include members of the middle and upper classes, then it can face an incentive to make conscription universal. For the reasons identified by Levi (1997), if individuals are more likely to contribute to a collective project when they believe that all will contribute, then a system of universal conscription is the optimal method for raising a very large army. For this reason we should expect the arrival of the railroad to be associated with a shift to universal conscription and the arrival of precision weapons to be associated with a shift away from this system of recruitment.

3 Alternative and Complementary Explanations

3.1 State Capacity

The need to raise revenues, which depends on administrative capacity to raise them, is a constraint that has without a doubt influenced the size of armies that states can mobilize. Recruiting volunteer soldiers is easier the better they are paid. Compliance with conscription is also improved with better pay and conditions for soldiers. And, of course, the use of foreign mercenaries depends almost entirely on having revenues available to pay them. Finally, for states to be able to raise large armies, they also have to have revenue to arm and supply them. The effectiveness of countries in raising revenue is primarily determined by their wealth and by the transactions costs that rulers face in raising revenue. The importance of national income and wealth for raising revenues and for sovereign borrowing is obvious. Economic resources, however, do not automatically make themselves available to the state. In the first instance raising resources depends on the development of effective bureaucratic institutions of the sort described by James Tracy (1986) for the Netherlands in the sixteenth century and by John Brewer (1988) for the United Kingdom in the eighteenth century. It is difficult to measure the effectiveness of bureaucratic institutions of this sort on a comparative basis and particularly over such a long time period. One option, which we will pursue, is to simply assume that state capacity is correlated with per capita income, a point made abundantly clear by Besley and Persson (2011). A second option, which we will also pursue, is to use the established ability of a state to conduct a national census as a proxy for bureaucratic capacity.

3.2 Political Rights

Another alternative hypothesis involves the role of political rights and their association with both the willingness of citizens to fight and the ability of a state to finance a war.

Historically, mobilization of a significant share of a country's population for war has often occurred in a context where those who fight are granted new rights that place them on an

equal footing with other groups in society.¹¹ At the most basic level this would involve being considered a citizen, and at a further level sharing the same rights for voting, representation, and political expression as others. However, mobilization of all does not necessarily have to be associated with a democratic form of government. What it instead implies is that all enjoy the same rights of citizenship and political participation, however extensive or restricted they may be.

At first glance, the equalization of rights has seemed to be a powerful force in enabling states to raise large armies and mobilize a significant share of their populations to fight. In France in the 1790s those who fought were operating in an environment in which privileges long held by nobles had recently been abolished. Similarly, a handful of countries adopted universal suffrage in the context of World War I. Even China provides an example, as in the 1940s those who fought for the Peoples Liberation Army were operating in a context in which privileges of a landlord class had been abolished via extensive land reform.¹² In our empirical analysis we focus on examining the impact of the extension of voting rights and competitive elections on army size, rates of citizen mobilization, and methods of recruitment.

In addition to focusing on the relationship between universal suffrage and mass mobilization, we can also focus on an earlier set of political rights which many have suggested were associated with the ability to raise revenues and loans for wars. Before the advent of universal suffrage, it was common for European states to have representative assemblies in which a more limited set of citizens could exert influence over policy. At a basic level, a representative assembly could serve as a venue in which a ruler sought citizen consent for taxation, a mechanism that Levi (1988) and previously Sidgwick (1903) suggest allowed for raising more revenue than if a ruler simply tried to levy taxes without seeking consent. At a second level, a representative assembly could also be given prerogatives over the management of spending, a feature that might make citizens more willing to consent to taxation, as well as

¹¹This is in fact a very old argument. The earliest known exposition of this claim is in the Pseudo-Xenophon's text "The Constitution of the Athenians", presumed to date from the 5th Century B.C. See Levi (1997) for a discussion of the link between citizenship and conscription in modern times.

¹²See Gittings (1967).

more willing to lend if they anticipated that this increased a state's creditworthiness.¹³ We can investigate both of these possibilities using the variables coded and collected by Stasavage (2011, 2010) and extended to several other cases.

3.3 Nationalism

Finally, there is little doubt that nationalism has been a potent force for states seeking to mobilize their citizens for war. The key question is how important nationalism has been relative to the other factors that have influenced army sizes and the intensity of mobilization. Those who emphasize the importance of nationalism refer to the French Revolution as a key watershed. By inventing the idea of the nation in arms, the French revolutionaries, it is said, ushered in an era where conflict took on a new intensity and scale. In the words of Jack Snyder,

The wars of the French Revolution (1792-1802) and the Napoleonic Wars (1803-1815) revealed for the first time in history the full potential of belligerent mass nationalism (2000 p.154).

Among political scientists, Cederman, Sornette, and Warren (2011) present the most recent argument in this vein. They emphasize nationalism as an essentially exogenous force. Posen (1993) in contrast suggests that nationalism emerged endogenously as states in competition needed to motivate their populations. However, he shares the same emphasis on the French Revolution as a break point. According to this account, the critical turning point occurred during 1793 when the French revolutionaries first declared a *levée en masse*, applying the idea that anyone could be obliged to serve in order to defend France against encroaching armies. What is less often recognized by political scientists, is that the *levée en masse* was actually a one off policy adopted during a period of particularly acute danger from invasion. Moreover, while it is clear that revolutionaries in Paris spoke of the importance of the nation in their public speeches, those careful studies that exist of the *levée en masse* at the local

¹³An idea most directly associated with North and Weingast (1989).

level do not reflect the same degree of patriotic fervor.¹⁴ Finally, contrary to what is often presumed, Napoleon actually abandoned the *levée en masse* as a method of recruitment. He instead used a more traditional system of conscription in which the wealthy could purchase a replacement.¹⁵

The idea that the French Revolution was a structural break provides one feasible way of examining the nationalism hypothesis. We can do so first of all by looking at all of the powers in our sample and examining whether both army sizes and levels of mobilization noticeably increased after 1789, and if so by how much. The idea here would be that while France pioneered the use of nationalism, other European powers were soon obliged to follow suit. For example, Linda Colley (1994) has argued that the wars of the revolutionary and Napoleonic period saw a new sense of nation appear in Great Britain. McNeil (1982), among others, argues that nationalistic fervor played an important role in Prussia's rearmament in 1813-1814. A second way in which we can examine the nationalism hypothesis is to look at a time series for France alone to examine to what extent the French Revolution appears as a structural break in the data on army sizes and mobilization ratios.

If we fail to find evidence that 1789 constituted a major break in army sizes or mobilization ratios, we might still want to consider the possibility of an interaction effect between the nationalism hypothesis and our own. It may have been the case that nationalism constituted a powerful force for motivating citizens, but until the invention of the railroad there was a technologically imposed ceiling on the size of an army that could actually be fielded and supplied. It may have been the case, as suggested by J.F.C. Fuller (1998) with reference to the railroad's inventor

"Thus it came about that the genius of George Stephenson (1781-1848) gave life to the Clausewitzian theory of the nation in arms."

¹⁴See Gagnage (1996) for an excellent example.

¹⁵Pigeard (2003) provides the most authoritative recent study on conscription during the Napoleonic era.

4 War Mobilization in Great Power States, 1600-2000

4.1 Army Size and Mobilization Levels

To assess what factors determine the scale of warfare and the extent of citizen participation in war, we have constructed a data set recording the size of the military and the extent of population mobilization for great power states from 1600 to 2000. We adopt Levy's (1983) definition of a great power as "a state that plays a major role in international politics with respect to security-related issues" (p. 16), and we adopt his coding of great powers. Levy identifies thirteen states that were great powers during some portion of the 1600 to 2000 period.

The key variable in the data set is *Military Size* which is defined as troops under the command of the national government and intended for use against foreign adversaries. It is measured in thousands. This definition does not include reserve troops, colonial troops, civil defense units, and domestic police forces. A common problem with statistics on the size of the military is that states have an incentive to inflate them. We made efforts to use numbers that reflect "actual" or "effective" forces rather than "paper" forces wherever possible. The appendix of this paper provides a complete discussion of the sources that we used to construct our data.

Military Size measures the absolute magnitude of great power forces. We are also interested in the extent to which citizens in these countries are mobilized for war, and so we have constructed the variable *Military Mobilization*, equal to military size divided by total population, to measure citizen participation. In addition to the distinction between "actual" and "paper" forces, it is important to keep in mind variation over time and across countries in the extent of the use of foreign troops. Ideally, our data for this measure would clearly separate domestic and foreign troops. While we have a good deal of information about the recruitment patterns of each state and will discuss these in the next subsection, it is not possible to separate out foreign troops for the full data set. Instead, we will be careful throughout the paper to consider how the presence of foreign troops may influence our interpretation of the main

factors determining variation in the size of military forces and the extent of mobilization.

Figures 1 and 2 present our data for *Military Size* and *Military Mobilization* for each of the thirteen sample countries during the years for which they were great powers. For each country, the plot with filled-in circles records the overall size of the military in thousands (left y-axis) and the plot with hollowed diamonds records mobilization levels (right y-axis). In interpreting these graphs, it is important to keep in mind a few basic patterns in the data. First, annual data is generally available only for observations after the resolution of the Napoleonic Wars in 1815. Secondly, the incidence of war is greater in earlier periods than later periods.¹⁶ Third, these two facts interact in that data on war mobilization in the 17th and 18th centuries are more likely to be observed in war years. Given these patterns, as well as our substantive interest in war mobilization, as opposed to the size of peacetime armies in our statistical tests, we will focus our attention on the patterns of military size and mobilization during years in which these states are engaged in conflicts.

Table 1 reports descriptive statistics for *Military Size* and *Military Mobilization* for war years by century. The table along with Figures 1 and 2 highlights the most striking feature of our data: mass mobilized warfare reached an entirely new scale in the first half of the 20th century. The average for military size almost doubles from the 17th to the 18th century, it almost triples from the 18th to the 19th century, and then increases by a factor of 5.7 from the 19th to the 20th century. The averages for *Military Mobilization* are perhaps even more striking in highlighting the uniqueness of the 20th century. The 17th, 18th, and 19th century average mobilization levels are not that different from each other but average mobilization doubles from 0.017 in the 19th century to 0.034 in the 20th century. Figures 1 and 2 suggest that unsurprisingly these patterns are primarily driven by World War I and World War II. Although one might be worried that these averages are driven by differences across centuries in the propensity to fight wars and do not reflect the main events of international politics, for military size, the maximum values of the variable increase at quite similar rates as the averages (increasing by a factor of 2.02, 2.72, and 6.25 across each century).

¹⁶Using data primarily from Levy (1983) and the Correlates of War (2010), we found that 65%, 60%, 25%, and 23% of great power years involve wars in the 17th, 18th, 19th, and 20th century respectively.

Mobilization in Great Powers, 1600-2000

Military Size and Mobilization Rates

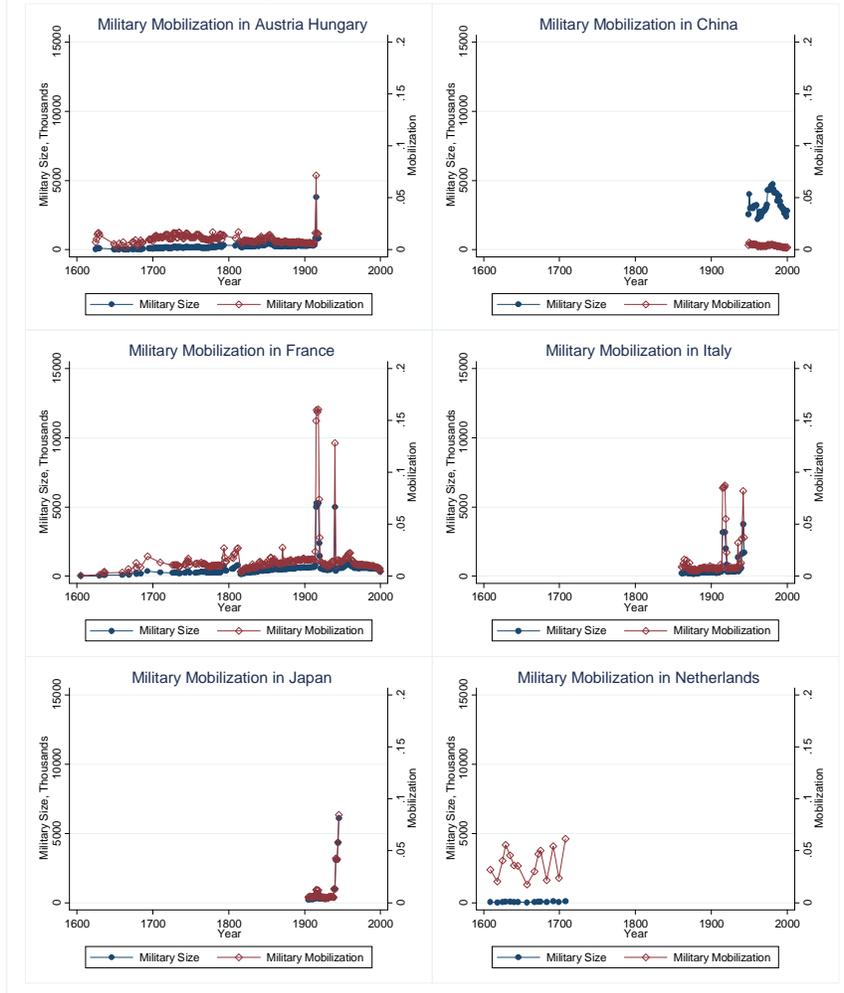


Figure 1: Mobilization in Great Powers, 1600-2000, Panel A.

Mobilization in Great Powers, 1600-2000

Military Size and Mobilization Rates

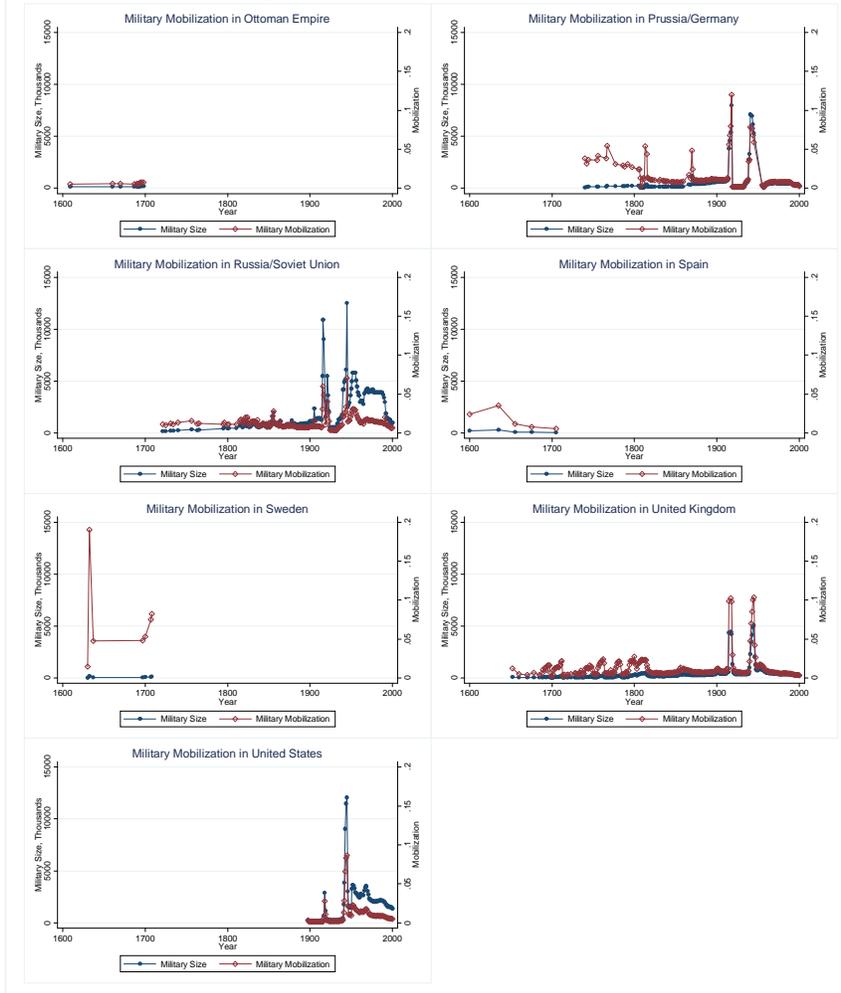


Figure 2: Mobilization in Great Powers, 1600-2000, Panel B.

	Observations	Mean	Standard Deviation	Minimum	Maximum
17th Century					
<i>Military Size</i>	69	95.370	62.225	13.000	362.000
<i>Military Mobilization</i>	69	0.018	0.025	0.002	0.190
18th Century					
<i>Military Size</i>	152	179.559	102.351	12.725	732.474
<i>Military Mobilization</i>	152	0.016	0.011	0.002	0.082
19th Century					
<i>Military Size</i>	80	481.516	324.011	11.134	2000.000
<i>Military Mobilization</i>	80	0.017	0.009	0.002	0.054
20th Century					
<i>Military Size</i>	142	2762.583	2546.014	125.923	12500.000
<i>Military Mobilization</i>	142	0.034	0.036	0.002	0.161

Table 1: *Military Size and Mobilization by Century*. This table reports descriptive statistics for *Military Size* and *Military Mobilization* for each in year in which a great power in our sample is at war.

At first glance, the maximum values for military mobilization rates appear to follow a different pattern but this is not very informative because the key figure that is out of place is the maximum of 0.19 for *Military Mobilization* in the 17th century. This is the value for Sweden in 1632 and it is a true outlier for the century (the next closest value is 0.056). Further, as we discuss below, this value is inflated by the heavy use of foreign troops. That said, there is a clear pattern of high mobilization rates with relatively small armies for small states like Sweden and Netherlands in 17th century and even somewhat larger states such as Prussia in the middle of the 18th century. Nevertheless, in the data set overall, Sweden 1632 is the only point in the top twenty mobilization rates that is not from the twentieth century. This descriptive evidence is suggestive of a clear break in the size of military forces and the extent of citizen participation in the twentieth century, a pattern we will probe in much greater detail below.

4.2 Recruitment Methods

In order to better understand changes in the format of military force over time, it also makes sense to consider how armies were recruited. We argued above that the invention of the railroad helped lead to a shift towards universal conscription in which members of the middle classes would be expected to serve in great numbers. This is a hypothesis that we will test formally below, but first it is worth presenting the evidence in more descriptive fashion.

Using a variety of different sources, we have been able to provide a sketch of the evolution of recruitment practices over time across the thirteen great powers. Each country is considered only for the period in which it was classified as a great power following the classification by Levy (1983). The results of this exercise are presented in Table 2. In this table we code a country as having had a system of conscription if there was a system by which central authorities determined how many individuals would be obliged to serve, how many from each region or locality, and if central authorities also established a rule (most commonly a lottery) through which individuals would be chosen. Situations where central authorities implicitly or explicitly sanctioned the use of force by local recruiters but did not establish a procedure for selection do not count as conscription according to this rule. In Table 2 we also identify the date at which a system of conscription became universal. Since no system of conscription is ever truly universal, it is also worth detailing how we arrived at this classification. By universal here we are referring to a system in which there are no explicit exemptions for those owning property and no possibilities for purchasing a replacement. However, according to the definition we have adopted a system of universal conscription might still have exemptions for age and educational deferments.

What conclusions can we draw from the evidence in Table 2? A first observation is that conscription of the non-universal variant developed quite early in a number of states, and in fact well before the French Revolution. At an earliest stage of development, recruitment tended to be decentralized and ad hoc, potentially reflecting weak central state capacity. Central authorities would give either army captains or local authorities the responsibility for recruiting a set number of individuals within a specific region. Army captains or local

	Great power?	Conscription?	Universal?	Foreign $\geq 50\%$?	Sources
Austria	1600-1918	1771-1918	1868	no	Duffy (1977) Coxe (1820) Rothenburg (1982)
China	1949-2000	1953-2000	1953	no	Gittings (1967) Cheng (2007)
France	1600-2000	1636-2000 ¹⁷	1793-4, 1905	no	Lynn (1997) Forrest (1989) Crépin (2009)
Italy	1861-1943	1861-1943	1907	no	Prasad and Smythe (1968)
Japan	1905-1945	1905-1945	1873	no	Ogawa (1921) Hunter (1984)
Netherlands	1609-1713	no	never	yes	van Nimwegen (2009)
Ottoman Empire	1600-1699	1600-1666	never	no	Aksan (1999, 2007) Murphey (1999)
Prussia	1740-2000	1740-2000 ¹⁸	1813	no	Wilson (2000) Walter (2009)
Russia	1721-2000	1721-2000	1874	no	Duffy (1981) Wildman (1980)
Spain	1600-1808	1630-1645, 1704-1776	never	no	Mackay (1999) Parker (1972) Black (2007)
Sweden	1617-1721	1617-1682	never	yes before 1660	Aberg (1973) Roberts (1979) Villstrand (2000)
United Kingdom	1600-2000	1916-1918, 1939-1960	1916	no	Clode (1869) Mccranie (2009) Gates (1996)
United States	1898-2000	1917-18, 1940-73	1917	no	Prasad and Smythe (1968)

Table 2: *Military Recruitment.*

Conscription was practiced somewhat irregularly in France during the 17th century and it was interrupted in France during a few later periods including 1715-1725 and 1814-1817.

Conscription was interrupted for Germany between 1919 and 1935, as well as between 1945 and 1959.

authorities then had considerable discretion in deciding what types of individuals would be recruited and what conditions would be offered in exchange for service. Over time, a number of states shifted toward a system of conscription in which a set number of individuals from each region had an obligation to serve, and central authorities specified the rule according to which individuals would be chosen. This was the case with the French system of militia recruitment from a very early date.

A second observation is that with the notable exception of Prussia, it was not until late into the nineteenth century, a period corresponding to the first military uses of the railroad, that one can begin to speak of the emergence of truly universal conscription in Europe. It is generally known that European powers initially adopted conscription systems that provided the middle classes and the rich with substantial opportunities to escape service thanks to exemptions, opt-outs, or possibilities for purchasing a replacement. Even in those European cases that are sometimes offered as early examples of "universal" systems of conscription, actual practice until well into the nineteenth century involved substantial opportunities for the middle classes and the wealthy to avoid service. In France the *levée en masse* of 1793 was indeed an instance where those with wealth had few opportunities to avoid service.¹⁹ However, this was also a very brief episode. After Thermidor and Napoleon's subsequent assumption of power, France returned to a system of conscription in which those with wealth could avoid service by purchasing replacements.²⁰ During the course of the nineteenth century the legal opportunities for avoiding service evolved continuously, and as documented by Crépin (2009), as late as 1905 conscription laws in France continued to offer certain social groups the opportunity of avoiding service. Prussia is often offered as another case of an early shift to universal conscription beginning in 1813, and we have used this date in Table 2.²¹

In addition to drawing conclusions about how soldiers were recruited, the sources listed

¹⁹See Gagnage (1996) as well as Berthaud (1988).

²⁰The most authoritative account of the system of replacement in France can be found in Schnapper (1968). This practice was abolished in 1872.

²¹With this said, it should be noted that Walter (2009) concludes that even after this date there remained very substantial opportunities for middle and upper income groups to avoid service.

in Table 2 also provide us with useful information addressing the second question referred to above - who was recruited? It seems fair to say that it was not until the late nineteenth century that one can speak of the development of mass armies in which members of the middle and even upper classes served alongside peasants and the urban poor. During the era of voluntary and decentralized recruitment regimes, the most common pattern was for recruiting agents to focus on individuals who were in sufficiently difficult economic circumstances that even a very poorly paid position in the army might be voluntarily chosen. Subsequent compliance was then ensured by implementing extremely severe punishments for shirking or desertion. Another key feature of this era was that several states made extensive use of foreigners serving in their army. This was the case for Spain's Army of Flanders during its long campaign against the Dutch Republic.²² It was also the case for the army of the Dutch Republic during this period as well as for Sweden's army during the Thirty Years War.²³ In fact, provided that they had access to the necessary finance, recruitment of foreigners provided states that had small populations, such as Sweden and the Netherlands, with a means of recruiting armies of the same size as those fielded by states with much larger populations.

The evidence in Table 2 supports the core argument of this paper. Rather than the invention of the idea of universal conscription and "the nation in arms" directly leading to the development of mass armies, the evidence in Table 2 is more consistent with our alternative interpretation. It was not until the invention and perfection of railroad transport that it became feasible and desirable to mobilize a truly mass army. Once this technologically driven transformation occurred, states faced incentives to develop systems of universal military conscription.

²²See the detailed evidence provided by Parker (1972).

²³van Nimwegen (2009) cites evidence suggesting that half of Dutch forces were foreigners. Roberts (1979) estimates that in several key battles toward the end of the Thirty Years War, over four fifths of the forces under Swedish command were foreign.

5 Evaluating Explanations for Patterns of War Mobilization

The data presented in Section 4 on military size and mobilization indicate significant variation in the format of military force adopted by great power states. In this section, we propose a series of empirical investigations using this data in order to evaluate our argument that the introduction of new transport and communication technologies has been the major factor determining the use of mass armies. We also discuss the evidence in light of the main alternative explanations emphasized in the literature.

5.1 Army Size and Mobilization - OLS Estimates

We start our investigation of the pooled data by examining whether key dates associated with various arguments are correlated with changes in levels of military size and the extent of mobilization, recognizing of course that other factors may have changed at the same time.

First, we investigate whether two key dates associated with innovations in transport and communication technology are significantly correlated with changes in observed levels of mobilization. For railways, we set the date at 1859, the year proposed by Pratt (1915) in which railways were first used in a significant way in military conflict. This date corresponds quite closely with the introduction of the Pullman sleeping car, which occurred in 1857. While troops at this time certainly traveled in considerably less luxurious conditions than Pullman sleepers, this is nonetheless a good indication that railway technology was undergoing a very rapid advance. There are a number of plausible alternative dates for innovations which dramatically improved the remote delivery of explosive force. One possibility is to focus on the role of precision-guided weapons. For this innovation, we set the date at 1970 to correspond to the development of modern cruise missiles. Although the United States developed an early version of a cruise missile in 1954 and the USSR did so in 1956,²⁴ it was not until the late 1960s that fully operational and effective cruise missiles were a viable option to military planners.²⁵ We also considered focusing on the role of intercontinental ballistic missiles

²⁴An early U.S. cruise missile was the TM-61 Matador (Huisken 1981, p.167) and an early USSR cruise missile was the SSC-2 Kennel (Huisken 1981, p.98).

²⁵See Werrell (1985 ch.5) for a discussion of advances in cruise missile guidance systems and the plausibility

(ICBM) in expanding the remote delivery of explosive force. The first operational ICBM was in 1957, and the results discussed below are quite similar using this date rather than 1970.

As a second test, we look for evidence that the French Revolution was a structural break consistent with the nationalism hypothesis by examining whether army size and levels of mobilization noticeably increased after 1789, and if so by how much.

To test for these hypothesized breaks, we constructed three indicator variables, *D1789*, *D1859*, and *D1970*, equal to 0 for all years before the year indicated and equal to 1 thereafter. The sample is all 443 country years for which we have data on military size and a great power country is at war. In evaluating these break points, it is essential that we take into account fixed unobserved factors for each state. Great powers differ in important ways that may influence their propensity to raise a large army or to mobilize a significant proportion of their population. Some of these differences are relatively fixed, having to do with the historical origins of the state's formation or its salient geographic features. To control for these determinants, we include country fixed effects. Note further that our analysis conditions on countries being in the sample of great powers. We are investigating the correlates of military size and mobilization given that a country is a great power. To the extent that great power status is determined by unobservables correlated with these break points or other variables of interest, the results will not give good estimates of the correlates of military size and mobilization for all types of countries. That said, some of our analyses will control for the most obvious measures determining great power status such as size and wealth. Moreover, we are primarily interested in the question of the size of the military for the central states of the international system. Our initial evaluation of the role of these potential structural breaks is simply fixed effects regressions with *Military Size* and *Military Mobilization* as the dependent variables and the three indicator variables as the only independent variables.

The results for these regressions are reported in column 1 of Tables 3 and 4. Table 3 provides the estimates for *Military Size* and Table 4 reports results for *Military Mobilization*. Starting with Table 3, the coefficient estimate for *D1789* is -23.930 with a standard error,

 of 1970 as a break date. It is also worth noting that this date corresponds quite closely to the first operational use of a laser guided bomb, which was by the United States in 1968.

adjusted for clustering by country, of 138.442. This indicates that there is no substantively or statistically significant difference between the size of armies in war time before and after 1789. The estimate for $D1789$ in Table 4 with *Military Mobilization* as the dependent variable is also small and statistically insignificant. There is little evidence associated with a structural break in the adoption of larger armies at the time of the French Revolution or Napoleonic Wars. This may be inconsistent with the nationalism hypothesis and reflect the fact that European powers had already mobilized relatively large armies for major conflicts such as the War of Austrian Succession throughout the 18th century. Alternatively, it may indicate that only France was able to successfully construct a nationalist ideology conducive to raising significantly larger armies than in previous periods. We evaluate the French case in greater detail in the next section.

Turning to the potential break point for the influence of railroads, the coefficient estimate in column 1 of Table 3 for $D1859$ is 2,031 with a standard error of 545. This estimate suggests that the great powers fielded armies which were on average 2 million men larger after 1859. Similarly the estimate in column 1 of Table 4 for $D1859$ is 0.021 with a standard error of 0.004. This indicates that population mobilization was a full two percentage points higher on average during this period. To put this in context, Table 1 indicates that the average mobilization level for the 18th century was 0.016 and so a 0.021 difference is a more than doubling of mobilization rates. These estimates clearly suggest an important structural break in military size and mobilization, the timing of which coincides with major expansion of the railroads and the adoption of rail transport for moving troops and military supplies.

Finally, the coefficient estimates for $D1970$ in column 1 of both Table 3 and Table 4 are negative and substantively and statistically significant. The estimate in the *Military Mobilization* regression is comparable in magnitude to that for $D1859$ and the estimate for *Military Size* is also quite large. This suggests that the extent of mobilization after 1970 returned to levels that looked quite similar to those before 1859. This is consistent with the hypothesized negative effect of precision weapons. This evidence, however, should be interpreted cautiously because in addition to it being simply based on the timing of

mobilization changes, there are a limited number of wars involving great powers after 1970. Nevertheless, the descriptive evidence for both *Military Size* and *Military Mobilization* is broadly consistent with our argument that the most substantial innovations in the use of mass warfare were made possible by critical changes in transport and communications technology.

The evidence that we have presented so far is essentially indirect. To more directly test the importance of transport technology, we constructed the variable *Railroad Track* equal to the length of railroad track available to the public in each country and the variable *Railroad Track Area* equal to this measure divided by the country's area measured in square kilometers.²⁶ Ideally we would have a measure available that indicates in a precise manner how each extension of a nation's railway network increased the maximum army size that could be sustained, by facilitating movement of men as well as the goods to keep them supplied. Since this is clearly beyond our means, we use these two measures as the best available proxies. To more directly test the importance of the expansion of the remote delivery of explosive force, we constructed the variable *Cruise Missile* which is equal to the 0 for each year before a country acquires a cruise missile and 1 for each year after acquisition. We also find qualitatively similar results using a measure indicating the acquisition of nuclear weapons and an estimated count of nuclear warheads.

Column 2 of Tables 3 and 4, reports the results for fixed effects regressions which are the exact same specification discussed for column 1 with the addition of the variables *Railroad Track* and *Cruise Missile*. Starting with Table 3, the coefficient estimate for *Railroad Track* is equal to 43,707 with a standard error of 11,831 which indicates that if a country increases its rail network by a thousand kilometers, it would on average increase the size of its army during war time by about forty-four thousand troops. The standard deviation of *Railroad Track* is about 71 thousand kilometers and so a standard deviation increase in the length of track is associated with an increase in troop size of over 3 million troops. This estimate is consistent with our claim that railroads played a decisive role in the transition to truly

²⁶The original railroad track data is measured in kilometers but for *Railroad Track* we have divided this variable by one million—thus the units are millions of kilometers—so that the coefficients for both *Military Size* and *Military Mobilization* could be easily read. The sources for the railroad track data were Mitchell (2007a, 2007b, 2007c).

	Military Size								
	OLS Estimates				IV Estimates				
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
<i>D1789</i>	-23.930 (138.442)	96.674 (83.746)	-101.669 (143.132)			170.483 (196.083)	-175.284 (205.480)		
	0.866	0.271	0.491			0.385	0.394		
<i>D1859</i>	2030.983 (545.037)	219.159 (477.470)	1156.257 (1079.888)			-886.100 (612.724)	312.763 (419.761)		
	0.003	0.654	0.305			0.148	0.456		
<i>D1970</i>	-1166.186 (448.374)	353.256 (339.786)	-786.047 (618.139)			1069.057 (748.257)	-749.353 (684.678)		
	0.023	0.319	0.228			0.153	0.274		
<i>Railroad Track</i>		43707.090 (11831.450)		41367.250 (4790.590)		70273.410 (13882.910)		75083.15 (23225.440)	
		0.003		0.000		0.000		0.001	
<i>Railroad Track Area</i>			10921.660 (9841.452)		7088.894 (5084.943)		21373.050 (4459.857)		17895.090 (5709.142)
			0.289		0.189		0.000		0.002
<i>Cruise Missile</i>		-427.278 (271.825)	-288.236 (619.330)	-3917.180 (577.057)	-4167.457 (716.414)	-446.074 (581.101)	-184.753 (615.284)	-3364.214 (704.369)	-3514.752 (701.659)
		0.142	0.650	0.000	0.000	0.443	0.764	0.000	0.000
<i>Population</i>				0.014	0.019		0.010	0.010	0.019
				(0.003)	(0.005)		(0.004)	(0.004)	(0.003)
				0.000	0.002		0.013	0.013	0.000
<i>GDP per capita</i>				0.411	0.180		0.597	0.597	0.174
				(0.151)	(0.098)		(0.143)	(0.143)	(0.066)
				0.018	0.090		0.000	0.000	0.009
<i>Democracy</i>				-479.686 (494.499)	-548.206 (646.459)		-529.056 (314.021)	-529.056 (314.021)	-744.995 (338.338)
				0.351	0.413		0.092	0.092	0.028
First-stage F-stat						59.908	281.568	25.604	149.328
First-stage p-value						0.000	0.000	0.000	0.000
Country Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year & Year Sq. Trends	No	No	No	Yes	Yes	No	No	Yes	Yes
Number of Observations	443	443	443	443	443	443	443	443	443

Table 3: *Military Size in Great Power Wars, 1600-2000*. The table reports the results of pooled-time-series-cross-sectional OLS and IV regressions for the variable *Military Size*. IV estimates employ *Regional Railroad Track Area* as an instrument for either *Railroad Track* or *Railroad Track Area* depending on specification. See appendix for full first stage results.

	Military Mobilization								
	OLS Estimates				IV Estimates				
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
<i>D1789</i>	0.003 (0.002)	0.003 (0.002)	0.002 (0.002)			0.007 (0.004)	0.000 (0.003)		
<i>D1859</i>	0.263 (0.021)	0.135 (0.012)	0.455 (0.007)			0.085 (-0.034)	0.995 (-0.012)		
<i>D1970</i>	0.000 (-0.020)	0.012 (-0.003)	0.040 (-0.008)			0.004 (0.015)	0.073 (-0.007)		
<i>Railroad Track</i>	0.006 (0.006)	0.546 (0.004)	0.127 (0.005)	0.249 (0.068)		0.062 (0.269)	0.487 (0.011)	1.800 (0.500)	
<i>Railroad Track Area</i>		0.056 (0.106)	0.179 (0.025)	0.003	0.136 (0.033)	0.000	0.404 (0.069)	0.000	0.429 (0.100)
<i>Cruise Missile</i>		-0.013 (0.003)	-0.011 (0.004)	-0.032 (0.011)	-0.028 (0.012)	-0.014 (0.011)	-0.009 (0.010)	-0.007 (0.015)	-0.010 (0.012)
<i>Population, Billions</i>		0.000 (0.000)	0.011 (0.011)	0.011 (0.043)	0.045 (0.073)	0.212 (0.043)	0.337 (0.046)	0.658 (-0.152)	0.385 (0.072)
<i>GDP per capita, Thousands</i>				0.386 (0.002)	0.116 (0.000)		0.073 (0.003)	0.010 (0.001)	0.122 (0.000)
<i>Democracy</i>				0.451 (0.004)	0.870 (0.005)		0.001 (0.007)	0.012 (0.007)	0.883 (0.006)
First-stage F-stat				0.004	0.028	59.908	281.568	25.604	149.328
First-stage p-value						0.000	0.000	0.000	0.000
Country Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year & Year Sq. Trend	No	No	No	Yes	Yes	No	No	Yes	Yes
Number of Observations	443	443	443	443	443	443	443	443	443

Table 4: *Military Mobilization in Great Power Wars, 1600-2000*. The table reports the results of pooled-time-series-cross-sectional OLS and IV regressions for the variable *Military Mobilization*. IV estimates employ *Regional Railroad Track Area* as an instrument for either *Railroad Track* or *Railroad Track Area* depending on specification. See appendix for full first stage results.

mass armies that numbered in the millions. Importantly, once *Railroad Track* is included in the regression, the estimate for *D1859* is much smaller and no longer statistically significant. This is consistent with the idea that the likely reason for the structural break in the series for 1859 was the increasing use of railroads in warfare. The estimates in column 2 of Table 4 indicate a qualitatively similar story for *Military Mobilization*.

The coefficient estimates for *Cruise Missile* are negative in column 2 of Tables 3 and 4 which is consistent with the hypothesis that the capacity to deliver explosive force remotely made large armies less desirable. Importantly, it is also the case that the estimate for *D1970* is substantially attenuated and no longer statistically significant for either dependent variable. The coefficient estimate for *Cruise Missile* is only marginally statistically significant for *Military Size*, but the estimate for *Military Mobilization* is equal to -0.013 with a standard error of 0.003. This result suggests that great powers mobilized over one percent less of their populations after developing cruise missiles. Obviously, it is not likely that this full difference is solely attributable to the impact of cruise missiles as these states were developing a wide range of weapons that expanded their ability to deliver force at a distance—including nuclear weapons. Nonetheless, it is clear that the timing of these innovations with associated with a significant reduction in army size and mobilization.

The results reported in column 3 repeat this specification but use the variable *Railroad Track Area* to measure the expansion of the capacity to move and supply soldiers by rail. The results for this variable are weaker in the Table 3 estimates for *Military Size* but substantially stronger for the Table 4 estimates for *Military Mobilization*.

The estimates in columns 4 and 5 in Tables 3 and 4 explore the robustness of these estimates by adding additional control variables to the specifications in columns 2 and 3. Our discussion of alternative arguments about the determinants of army size and the extent of population mobilization emphasized two factors in addition to nationalism.

First, countries with greater fiscal capacity in terms of wealth and efficient institutions for taxation, are, all else equal, more likely to field large armies. We constructed the variable

GDP per capita as one proxy for a state's fiscal capacity.²⁷ In unreported specifications, we also used a dummy variable *Census* recording whether a state had carried out a national census to more directly proxy for administrative capacity.²⁸

Second, states may find it easier to raise large armies if they have extended substantial political rights to citizens. To explore this argument we first constructed the variable *Democracy*, set equal to one if the legislature is elected in free multi-party elections, if the executive is directly or indirectly elected in popular elections and is responsible either directly to voters or to a legislature elected according to the first condition, and finally if at least 50 percent of adult males have the right to vote.²⁹ In unreported specifications we also included two variables concerning prerogatives of representative assemblies. The dummy variable *Taxes* takes a value of 1 if a state has a representative assembly that has the authority to consent to or refuse new taxation. The dummy variable *Spending* takes a value of 1 if a state has a representative assembly with the authority to exert control over expenditure decisions.³⁰ Finally, in addition to all of the above controls, we also add a control for the size of a country's total population.

The results reported in columns 4 and 5 of Table 3 show that the addition of control variables results in relatively little change in our estimates of the coefficients for *Railroad Track* and *Railroad Track Area*. In strong contrast, the addition of controls does result in a very substantial change in the estimated coefficients for our *Cruise Missile* variable. In both columns 4 and 5 the coefficient on *Cruise Missile* is now statistically significant, negative,

²⁷The source for this variable for all countries except the Ottoman Empire was Maddison (2003). The data were accessed online at <http://www.ggd.net/MADDISON/oriindex.htm>. For the Ottoman Empire, we used estimates from personal communication with Sevet Pamuk (see also Pamuk 2009). Missing data was linearly interpolated for this variable. The variable used in Table 3 is in 1990 international G-K dollars. The variable is rescaled to thousands of 1990 international G-K dollars in Table 4.

²⁸The sources for this variable are as follows. Austria-Hungary (Encyclopedia Britannica 1911 edition), China (Orleans, 1957), France (Insee, "Le recensement de la population dans l'histoire", Italy (Encyclopedia Britannica 1911 Edition), Japan (Eng and Smith, 1976), Netherlands (Oomens and den Bakker, 1997), Ottoman Empire (Karpas, 1978), Prussia, Russia, Spain (Encyclopedia Britannica 1911 Edition), Sweden (Hendricks, 1861), UK (Taylor, 1951), United States (US Bureau of the Census). We report the results using *GDP per capita* to measure state capacity simply because the results for the census measure were generally quite weak. The use of the census measure did not affect any of our main results.

²⁹This follows the definition used by Boix and Rosato (2001), which is a modification of the definition used by Przeworski et al. (2000) to a context where the suffrage may be restricted.

³⁰The principal source for both of these variables is Stasavage (2011, 2010).

and also much larger than in the specifications without the controls. We drew very similar conclusions about our key variables of interest in our unreported specifications that added the *Census*, *Taxes*, and *Spending* variables to the specification.

The results reported in columns 4 and 5 of Table 4, which reflect the addition of control variables to our mobilization regressions, show a very similar pattern to that observed in the previous table. The addition of the control variables has very little impact on our coefficient estimates for either *Railroad Track* or *Railroad Track Area*. However, the addition of the control variables results in a substantially larger negative coefficient for our *Cruise Missile* variable. Once again, we drew very similar conclusions about our key variables of interest in our unreported specifications that added the *Census*, *Taxes*, and *Spending* variables to the specification.

5.2 Army Size and Mobilization - IV Estimates

There are a number of reasons why we might be incorrect in inferring that our OLS estimates in Tables 3 and 4 reflect a causal effect of the railroad on the scale of military mobilization. Prominent among these is the possibility of reverse causality - states intending to go to war, and in particular intending to increase the size of their armies, might have spurred investment in railroad networks prior to the outbreak of an actual conflict. To address this concern, we propose to use the process of technology diffusion in the development of railway infrastructures to identify exogenous variation in railroad networks in our great power states. A number of scholars have emphasized the importance of technology diffusion in the spread of transport infrastructures including railways (see e.g. Grubler 1990). The idea is that the technologies that made rail travel and transport economically beneficial spread across different areas of the world at different rates. To measure the extent to which each great power state was exposed to this diffusion of technology, we measure the growth of rail networks in states in the same region but were not great power states planning for large-scale military conflict and employ this measure as an instrumental variable.

For each state in our great power sample we constructed a variable *Regional Railroad*

Track Area as follows. We use the length in kilometers of open railroad lines in countries which were not a great power and were, at the same time, neighbors of a great power in the relevant period of our analysis (19th or 20th century). We construct four different sets of neighbor countries for the European great powers and Russia/Soviet Union, for the U.S., for Japan and for China, respectively. In the case of the European great powers (Austria-Hungary, France, Italy, Prussia/Germany, United Kingdom) and Russia/Soviet Union, the neighbor countries we use are: Belgium, Denmark, the Netherlands, Norway, Spain, Sweden, and Switzerland. According to the 1850 boundaries, each of these countries shared at least one border with one of the European great powers or with Russia. For Russia we consider only European neighbor countries. It is worth noting that none of the countries included in this set has been a great power from 1850 onwards. For the U.S., we use Canada and Mexico. The natural candidate to construct the instrument for Japan would have been Korea. This country though was under Japanese occupation for almost all the time Japan is coded as a great power (1905-1945). We, therefore, use as instrument for Japan the following countries: Australia, India and Indochina. Finally, for China the list of neighbor countries comprises Burma, India, Japan, and South Korea. We include also Japan since it loses its status of great power when China acquired this status (1949-2000). The kilometers of open railroad lines used to construct the instrument are normalized according to each country's area. The instrument for each of the great powers is then computed as a weighted average of the normalized railroad kilometers of its neighbor countries, where weights are given by the inverse of the distance between each great power's capital city and its neighbor countries' capitals. By doing so, we give more weight to neighbor countries closer to each of our great powers.

We can use *Regional Railroad Track Area* as an instrumental variable for either *Railroad Track* or *Railroad Track Area* as long as the standard assumptions for an instrumental variable are satisfied. *Regional Railroad Track Area* has to be a good predictor of each of the two other variables. As we will show, this is very much the case. In addition, to satisfy the exclusion restriction, it must also be the case that the size of the rail network in a neighboring

non-great powers would have no direct effect on mobilization levels in great powers, nor can it be correlated with any other factors that would have such an effect. One way in which this exclusion restriction might be violated is if expansion of rail networks in non-powers made it easier to ship more supplies at lower cost to great powers during time of war. While this is certainly a possibility—for example Sweden’s rail network made it possible to ship raw materials to ports and to belligerent nations during World War I—we do not think that this is generally a factor of substantial importance in determining the size of the army that a state can supply.

In Tables 3 and 4 columns six through nine report the results of instrumental variables (2SLS) estimates where we instrument alternatively for *Railroad Track* or *Railroad Track Area* using *Regional Railroad Track Area*. We do not propose an instrument for the *Cruise Missile* variable. At the bottom of each estimate we report the F-statistic from the first stage regression for the coefficient on *Regional Railroad Track Area*. Full first stage results are presented in the appendix. As can be seen, in all cases the F-statistic is large, and in most cases very large. So our estimates will clearly not suffer from a weak instruments problem. Also, remember that if there is a small violation of the exclusion restriction for *Regional Railroad Track Area*, then any bias introduced by this violation will be decreasing in the value of this F-statistic. So this should further increase confidence in our estimates.

In columns six through nine of Table 3 we report the instrumental variables results for *Military Size*. The estimated coefficient on *Railroad Track* continues to be statistically significant and is now substantially larger in magnitude than in the OLS estimates, although given the magnitude of the confidence intervals we should not overplay this difference.³¹ In addition, the coefficient on *Railroad Track Area* is also larger in magnitude and statistically significant. In columns six through nine of Table 4 we see a similar pattern. The coefficients on each of the two railroad track variables are statistically significant and in all cases substantially larger than in the OLS estimates. Overall, these instrumental variables estimates provide a strong indication that our inference about the impact of the railroad is not biased

³¹The increased magnitude of the estimated coefficient in the IV specifications may suggest that the OLS estimates suffer from some attenuation bias due to measurement error.

by a form of reverse causality in which the development of the railroad is only a consequence of great powers preparing for mass mobilized wars.

5.3 Evidence on Conscription Regimes - OLS and IV Estimates

The bulk of the evidence that we consider in this paper concerns the scale of military mobilization, either in absolute numbers, or relative to the size of a country's population. However, above we also suggested that there are reasons to believe that states seeking to raise very large armies will be more likely to resort to conscription. There are actually two different variants of this argument. According to the first variant, as required army size increases, the deadweight costs of taxation necessary to fund a volunteer army increase, and therefore beyond a certain point it is optimal to shift to recruitment by conscription, which can be thought of as a tax in kind. This idea was first suggested by Sidgwick (1883) and first formalized by Ross (1994). As noted above, this argument applies to all types of conscription regimes, and not exclusively to universal conscription. According to the second variant, proposed by Scheve and Stasavage (2012b) we should expect that a regime of conscription with exemptions may be employed even to raise a relatively small army. However, for larger armies there will be an incentive to recruit via a system of universal conscription.

If we consider each of the above arguments in light of our claims about technology, then they imply the following causal chain. The state of technology will determine the size of the army that a state will seek to mobilize. This will in turn influence the preferred method of recruitment. To test each of the above two arguments we adopt the following strategy. We repeat the specifications we have employed for *Military Size* and *Military Mobilization* while substituting one of two new variables as the dependent variable in the regression. The first variable, *Conscription*, is a dummy indicator that takes a value of one if a state employs conscription of any form and zero otherwise. We have already presented our operational definition of conscription in the sub-section on recruitment methods. The second variable, *Universal Conscription* take a value of 1 in cases where universal conscription (as we have previously defined it) is present and zero if there is either non-universal conscription or

recruitment without conscription.

Table 5 reports results of both OLS and instrumental variables (2SLS) estimates where we use alternatively *Conscription* and *Universal Conscription* as the dependent variable. The results for the *Railroad Track* variable suggest that the expansion of railroad networks was associated with a shift to universal conscription in particular, but not with the adoption of conscription of all forms. This fits with the descriptive evidence presented in section 4.2. The results when using the *Railroad Track Area* variable are a bit more mixed. There continues to be no evidence of a correlation between the expansion of rail networks and the adoption of conscription in general. However, when using *Universal Conscription* as dependent variable the coefficient on *Railroad Track Area* is only statistically significant in the instrumental variables estimate and not in the OLS estimate.

We might also expect that our *Cruise Missile* variable should be correlated with the type of recruitment regime in place. The availability of cruise missiles might, according to the two alternative theories, be associated with either a shift away from any type of conscription or a shift away from universal conscription in particular. However, in Table 5 the coefficient on the *Cruise Missile* variable is generally not statistically significant, the exceptions being the instrumental variables estimates in columns five and seven where we find that the availability of cruise missiles is associated with a shift away from any form of conscription.

5.4 Summary

Overall, the results of our analyses in Tables 3, 4, and 5 provide firm support for our core argument; one revolution in technology, the railroad, made the era of the mass army possible while a second revolution involving remote delivery of explosive force helped bring this era to a close. The results for the railroad are particularly strong and robust to consideration of a wide variety of factors that might bias our inference.

	Conscription and Universal Conscription							
	OLS Estimates				IV Estimates			
	Conscription	Universal	Conscription	Universal	Conscription	Universal	Conscription	Universal
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	
<i>Railroad Track</i>	-5.329 (6.076)	4.831 (0.952)			-9.217 (3.181)	17.327 (1.659)		
<i>Railroad Track Area</i>	0.398	0.000	0.761 (1.795)	0.905 (0.920)	0.004	0.000	-3.437 (1.215)	6.462 (0.616)
<i>Cruise Missile</i>	-0.524 (0.418)	-0.423 (0.254)	0.679 (0.349)	0.345 (0.254)	-0.628 (0.175)	-0.090 (0.091)	0.005 (0.182)	0.000 (0.092)
<i>Population, Billions</i>	0.234	0.121	0.372	0.082	0.000	0.324	0.000	0.547
	2.853 (1.735)	2.055 (0.835)	1.851 (1.620)	2.985 (0.690)	3.591 (0.876)	-0.320 (0.457)	1.792 (0.649)	3.063 (0.329)
<i>GDP per capita, Thousands</i>	0.126	0.030	0.275	0.001	0.000	0.484	0.006	0.000
	0.011	0.023	0.027	0.001	-0.004	0.069	0.046	-0.024
	0.052 (0.839)	0.013 (0.101)	0.034 (0.433)	0.013 (0.857)	0.020 (0.870)	0.010 (0.000)	0.017 (0.007)	0.009 (0.006)
<i>Democracy</i>	0.156 (0.190)	0.060 (0.085)	0.123 (0.208)	0.058 (0.095)	0.168 (0.075)	0.018 (0.039)	0.204 (0.079)	-0.048 (0.040)
	0.430	0.497	0.563	0.563	0.025	0.639	0.010	0.230
First-stage F-stat					214.037	214.037	419.021	419.021
First-stage p-value					0.000	0.000	0.000	0.000
Country Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year & Year Sq. Trend	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Number of Observations	1046	1046	1046	1046	1046	1046	1046	1046

Table 5: *Conscription in Great Power Wars, 1600-2000*. The table reports the results of pooled-time-series-cross-sectional OLS and IV regressions for the variable *Military Mobilization*. IV estimates employ *Regional Railroad Track Area* as an instrument for either *Railroad Track* or *Railroad Track Area* depending on specification. See appendix for full first stage results.

6 Military Mobilization in France

Our pooled analysis explored the plausibility of our argument emphasizing the importance of technological change in accounting for the scale of warfare. Although there is much to be learned by a closer look at each of our cases, here we focus on France because it is the case that has most informed the thinking of political scientists about the evolution of mass armies. Our discussion of France emphasizes that even in this case, the era of the mass army was largely a late 19th and 20th century phenomena, that coincided with and depended on the technological innovations of the industrial revolution.

Figure 3 presents our variables *Military Size* and *Military Mobilization* for France and highlights the peak mobilization years for many of its most important conflicts over the last four centuries. The first thing to notice about the graph is that the 17th century is a time of dramatic growth in the size of the French army and the extent of mobilization. In our data, the French army reached 362,000 men during the Nine Years' War with a mobilization rate of almost 2 percent. As Lynn (1980, p. 568) puts it, "Henri IV felt it necessary to assemble no more than 55,000 troops in preparation for his still-born campaign of 1610, [while] his grandson Louis XIV required a force of nearly 400,000 during the Nine Years' War (1689-1698)." Lynn, Parker (1976), and others have noted this roughly eight-fold increase in the size of the French army during 17th century wars. While the determinants of this increase are varied, it is interesting to note that Parker emphasizes, among other factors, the role of transportation. "It was not possible to move large concentrations of troops at speed before the seventeenth century because there were no roads outside Italy which were capable of carrying a large army, its supply train, and its artillery" (1976, pp 209-210).³² Although this is not the transportation revolution that we emphasize in this paper, it clearly resonates with our emphasis on how the requirements necessary to move and supply armies placed important limits on the size of army it was desirable to raise.

The size of the French military varied throughout the many conflicts of the 18th century

³²Parker also emphasizes the importance of changes in military technology (the effectiveness of pikemen reducing the relative use of cavalry), innovations in public finance, and improvements in bureaucratic administration.

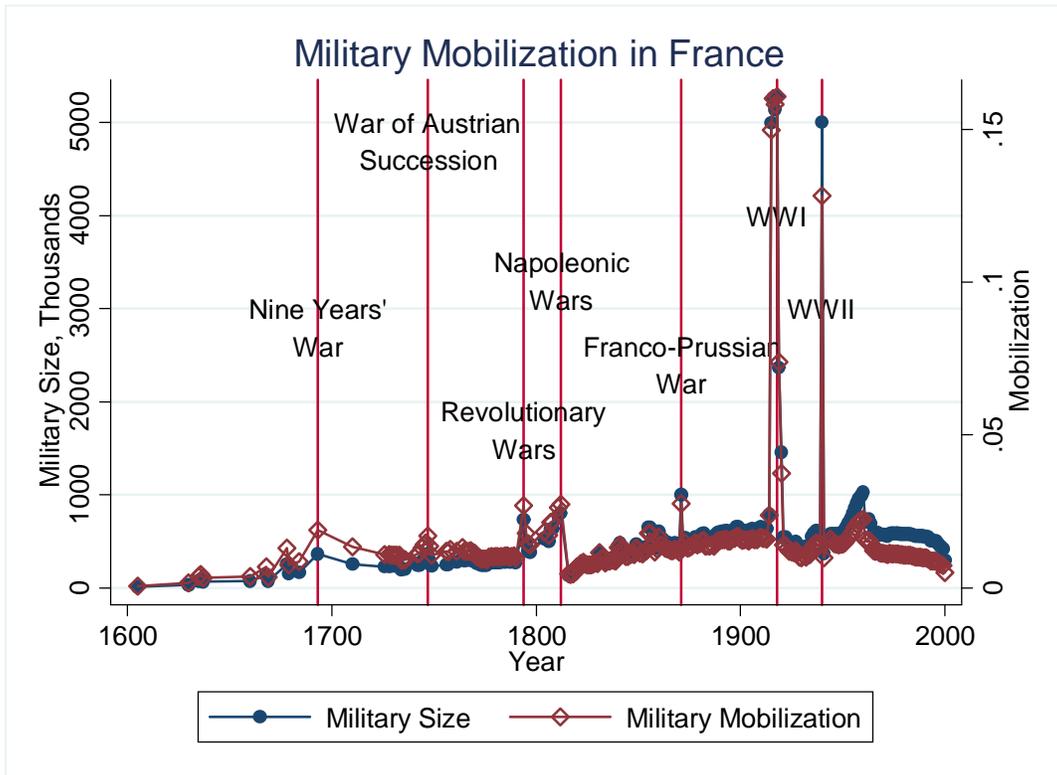


Figure 3: Military Mobilization in France, 1600-2000. Plot of *Military Size* and *Military Mobilization* in France. See appendix for sources. Lines indicate peak mobilization years for labeled conflicts.

but prior to the French Revolution it did not significantly surpass the scale reached at the end of 17th century. Nonetheless, it is important to note that throughout the 18th century France fielded armies that regularly were over two hundred thousand in number and when needed well in excess of three hundred thousand. The high point for 18th century army size in our data is 364,086 during the War of Austrian Succession.

This 18th century experience provides the context for interpreting the changes in military size associated with the French Revolution and Napoleonic Wars. As Figure 3 indicates, army size and mobilization did increase with the French Revolution. Our data suggest that France's revolutionary army included 732,474 soldiers in 1794 which constituted 0.027 of the population. In our data, this increase represents almost precisely a doubling of army size from the previous high point of 1747. Given the substantial population growth during this

period, the increase in mobilization was a more modest 60%. It is worth noting that in subsequent years during the revolutionary period, mobilization rates returned to lower levels that were not at all unusual in the 18th century (0.017 in 1795, 0.015 in 1796, and 0.014 in 1797). Although our data are not complete for the Napoleonic period, here larger armies and higher mobilization rates were sustained over several years. Army size in our data ranged from 504,220 in 1806 to 800,000 in 1812 with mobilization rates exceeding two percent in four of the six years for which we have estimates, with a peak of 0.027 in 1812. But again, the magnitude of these increases are more modest than is commonly assumed in political science discussions. They were also modest in comparison to the increases that France experienced in the 17th century and would experience in later periods. Peak Napoleonic army size was 2.2 times larger than 1747 and peak Napoleonic mobilization was 1.6 times larger than 1747. Our results regarding the magnitude of the revolutionary and Napoleonic mobilizations may seem surprising in light of received wisdom among political scientists. In fact, our conclusions fall very much in line with recent French historical work regarding the *levée en masse* in particular. Annie Crepin (2009 pp.106-107) suggests that the *levée en masse* produced an army that was larger but in the end not that different in scale from the armies raised by Louis XIV toward the end of his reign.

With that said, there was clearly an increase in army size and mobilization associated with the Revolutionary and Napoleonic Wars in France. The most common factor attributed in producing this change is the impact of the revolution in mass politics on mobilization. Mass politics influenced mobilization in at least two ways. First, as discussed above, the revolution is a classic example of a radical change toward more equal citizenship. This, and especially the initial move toward universal conscription, may have made a much broader and more representative set of the population available and willing to serve. This factor seems clearly important but most likely incomplete as an account given that mobilization was if anything higher in the Napoleonic period than the revolutionary period, that some of the advances in citizen rights had been lost, and that conscription had reverted to a more traditional form in which the rich and middle class could avoid service. Second, central to the revolution in mass

politics was the development of nationalism, specifically the idea of the “nation in arms.” This ideology was clearly related to actual changes in citizen rights but also constituted a change in the connection between individual identity and national service that may have increased France’s ability to mobilize and command large armies. One might ask why these historic changes did not result in a greater increase in army size and mobilization. Van Creveld’s (1977, Chapter 2) account of the challenges of supplying Napoleon’s armies strongly suggests that the existing technology of transport and communication limited the size of the armies that France could effectively raise, command, and support.

What happened after the Napoleonic era? While there was debate on the subject, we dispose of clear evidence showing that from a very early date some astute French observers recognized that the military use of the railroad would transform the nature of warfare. For two examples of this belief see Chevalier (1841) and Renouard de Sainte-Croix (1837). We also have clear evidence that after the defeat suffered in the Franco-Prussian war, French observers suggested that Prussia’s superior rail system had allowed for the Prussian army to mobilize more quickly and in substantially greater numbers than was the case for the French. For examples of this view see both Jacquemin (1872) and Tomyar (1882).

By 1914, with an extensive rail system France was in a position to mobilize a much larger fraction of its population than ever before. The most striking feature of Figure 3 is the size of the military and levels of mobilization during World War I and more briefly during World War II. Although these mobilizations, which involved over five million soldiers and over 15 percent of the population, were foreshadowed by France’s substantial mobilization in the Franco-Prussian War, the scale of the world wars set them apart from France’s previous mobilizations including those during the revolutionary and Napoleonic period. In our data, military size in 1918 was 6.6 times larger than in 1812, the peak year of the revolutionary and Napoleonic period. The same multiple for mobilization was 6.0. Even in the French case, it is the late 19th and early 20th century that brings mass warfare involving millions of soldiers to the fore. While the Revolution probably facilitated the ability of the French state to recruit a large army, it was only once the railroads and other innovations in transportation

and communication were present that mass warfare became a reality.

Finally, Figure 3 also shows the decrease in army size and mobilization in the late 20th century. This is certainly consistent with our argument that innovations in precision weapons made raising mass armies less desirable but other factors could explain the data just as well. Importantly, France never faced the sort of conflict that would necessitate a large army even if one was both possible and desirable to raise.

7 Conclusion

We know surprisingly little about the factors that have governed changes in the scale of military mobilization over time. There is no shortage of plausible theories, from those focusing on the emergence of nationalism, changes in political regime, or finally technological change. But systematic tests of these arguments have been lacking, and the primary reason for this is that the data constraints for considering changes in military force over the long run are very considerable. In this paper we have attempted a systematic examination of the factors that produced the era of the mass army and which have subsequently led to its demise. This question is important both as a topic in itself, as well as for those interested in understanding the evolution of progressive taxation over time, because when the masses were conscripted, in many cases they demanded an equivalent conscription of wealth.

Political scientists, not surprisingly, tend to focus on the importance of political factors when seeking to explain the arrival of the era of the mass army. Nationalism, it is said, provided the motivation necessary for the masses to fight, and the extension of citizenship and democratic rights had a similar effect. But if having soldiers that are motivated is a necessary condition to fielding a mass army, it is certainly not a sufficient one. Fielding a mass army also depends on having the ability to keep it adequately supplied. In addition, governments must actually want to field a mass army as opposed to opting for some other format of military force. We have argued that over the last two centuries these factors depended on the evolution of transportation and communications technology. The railroad and the telegraph made it possible for the first time to field and command armies numbering

in the millions. Today, governments could keep a mass army supplied if they wanted to, but further advances in transport and communications technologies have given them less incentive to field one in the first place.

We have tested our argument regarding communications and transport technology using a new data set that provides a more extensive view of army sizes, mobilization levels, and recruitment methods among major powers than has previously been possible. While our conclusions are certainly preliminary, our results regarding the importance of the railroad are quite strong and robust to a number of different types of observable and unobservable confounding factors. In strong contrast, we have found little to no evidence that the invention of the concept of “the nation in arms” in 1789 was associated with a generalized shift towards larger armies. Even in the case of France, where we would most expect to see a shift, the “Napoleonic watershed” existed but was relatively small compared to the increase in mobilization associated with the railroad.

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A Appendix: Data on Military Mobilization

We have constructed a new data set on military mobilization for great powers from 1600 to 2000. We adopt Levy's (1983) definition of a great power as "a state that plays a major role in international politics with respect to security-related issues" (p. 16) and adopt his operationalization of the definition. This creates a sample of thirteen states which were great powers during some portion of the 1600 to 2000 period. At this point in our research, we have been unable to collect data for the Ottoman Empire which Levy codes as a great power until 1699, and thus our data includes twelve states.

The key variable in the data set is *Military Size* which is defined as troops under the command of the national government and intended for use against foreign adversaries. This definition does not include reserve troops, colonial troops, civil defense units, and domestic police forces. A common problem with statistics on the size of the military is that states have an incentive to inflate them. We made efforts to use numbers that reflected "actual" or "effective" forces rather than "paper" forces wherever possible. This included reading historiographies that discussed potential differences between reported army sizes and actual troops raised. However, for some cases, the only information we have is on the reported size of the army by the government and these numbers may exaggerate the size of the military, particularly in earlier periods. The data discussion for each case provides notes on this issue.

Austria-Hungary 1600-1918

Our data for Austria-Hungary's military for the 17th century is somewhat limited and of uneven quality. Our initial data are for 1625-1630 and are from Wilson (2009, p. 395, Table 3). For each year, we report his estimates of the probable effective size of the imperial army in the Thirty Years War. We do not include any other estimates for the size Austria-Hungary's forces during the Thirty Years War. Wilson (2009), however, suggests that these forces were not larger than during this early period. For the years 1649, 1650, 1655, 1656, 1661, 1664, 1668, 1673, 1675, 1677, 1679, 1681, 1683, 1684, 1685, and 1687, we have estimates from Hochedlinger (2003, p. 104, Table 3). These numbers are primarily estimates of effective strength except for 1664, 1679, 1684, and 1685. For the years 1695 to 1794, Dickson (1987b, p343-352) provides data on official infantry and cavalry sizes for the Empire. These official numbers, therefore, reflect an upper bound of the size of Austrian-Hungarian forces. We identified estimates of Austrian-Hungarian forces for 1809 and 1813 in Rothenberg (1973). The later number indicates the high point of Austrian-Hungarian mobilization during the Napoleonic Wars and should also be treated as an official, possibly inflated estimate. Finally, for 1816 to 1918, we used Correlates of War, National Material Capabilities, Version 4.0 (2010) numbers for the size of Austria-Hungary's military forces.

Population data for Austria-Hungary are also from several sources. For 1600 and 1650, we used data reported in Wilson (2009, p. 788, Table 8). For 1740, 1754, 1762, 1768, and 1787, the data are from Dickson (1987a, p. 36, Table 2.5) and refer to the central lands of the Habsburg monarchy. Finally, for 1816 through 1918, the data are from the Correlates of War Project (2010). Missing years for population were interpolated.

China 1949-2000

We used military personnel and population data from *Correlates of War* (2010) for China. These data should be interpreted cautiously as they may inflate the actual size of Chinese forces. We note further that for the period just prior to China's great power status, Gittings (1967 pp. 303-305) provides an informative account of the People's Liberation Army from the beginning of the Japanese war in 1937 through 1958. Since these figures are only for the PLA and not the KMT army during the anti-Japanese war and subsequent civil war, total Chinese mobilization during this period will be understated. Gittings (p. 1) also provides partial details on the size of the KMT army. He suggests 1.5 million troops in 1945 and 1.5 million again in 1947. Gittings also suggests that official figures for the KMT army were substantially higher (upwards of 5 million) raising again the issue of inflated official numbers.

France 1600-2000

Data on the French army during the 17th century are from three sources: David Parrott (2001), John Lynn (1997) and John Lynn (2006). Our first figure is from Parrott (2001, p. 183). It represents the peacetime establishment of the army in the first decade of the 17th century. We use this number for the year 1605. The figure for 1630 is also from Parrott (2001, p. 187). Parrott (2001, p. 194) mentions that "some 65,000 infantry and 9,000 - 9,500 cavalry were briefly operational" at the beginning of the 1635 campaign. We use the number of 74,250 for this year. According to Parrott (2001, p. 199), for a short period in 1636, France probably reached the highest number of men under arms ("70,000 - 80,000 infantry and 10,000 - 15,000 cavalry") during the time of Richelieu and Mazarin. We use for this year the number of 87,500 given by the sum of mid-point estimates for the size of both the infantry and the cavalry. On the basis of Parrott (2001, p. 202) who writes that probably "some 60,000 - 70,000 infantry and cavalry were either in existence or levied during the first months of 1637", we use the figure of 65,000 for this year. The figure for 1660 is from Lynn (1997, p. 45 and Table 2.1, p.55; 2006, p. 53) and gives the official peacetime strength of the army. Additional figures provide estimates of the size of the army during the wars that France fought in the second half of the 17th century. According to Lynn (1997, p. 46 and Table 2.1, p. 55; 2006, p. 54), the strength of the army in 1668 (during the War of Devolution) was on paper 134,000 men. Data for the years 1678 (Lynn, 1997, p. 46, p. 51 and Table 2.1, p. 55; Lynn, 2006, p. 54) and 1693 (Lynn, 2006, p.57) are estimates of the effective size of the army during the Dutch War and the Nine Years' War, respectively. Further data refer to the official strength of the army in years of peace in the second half of the 17th century. The first one (year 1669) is provided by Lynn (1997, p. 46; 2006, p. 53). The second one is for the year 1679 (Lynn, 1997, p. 46; Lynn, 2006, p.53); the third one refers to the year 1684 (Lynn, 1997, p. 47; Lynn, 2006, p.53).

Our first data for the 18th century (year 1710) is from Lynn (1997, p. 48 and p.55; 2006, p. 54 and p. 58) and it gives an estimate of the actual strength of the army during the War of Spanish Succession. Data for the period 1720-1790 are from two sources: Sturgill (1991) and Gebelin (1881). The former provides figures about the strength of the army. Before 1763, this source includes the militia only if it was on active service (see Sturgill, 1991, p. 129). Sturgill's figures, therefore, do not comprise the militia for the years of peace and of war demobilization before 1763. Prior to that year, militia figures are not included in the

army's strength also for some of the years of war preparation (1720, 1726-27, 1756) and are missing for some of the years of war (1757-63). When Stugill's figures on the army's strength do not incorporate the militia, we add to them the number of effectives of the provincial militias (soldiers and officers) provided by Gebelin (1881, p. 285). Finally, for the years from 1720 to 1763 in which figures on the militia are not available either from Sturgill or from Gebelin, we assign a missing value to our series. By adopting these coding criteria, we are able to compute figures on the strength of the army including the militia for the following years: 1726, 1728-1736, 1742-1749, 1756-1758, and 1761. Starting from 1764, figures on the strength of the army provided by Sturgill include militia and miscellaneous units, so we use these data for the years from 1764 to 1790. These figures should be considered as an upper bound estimate of the French army, since, as Sturgill (1991, p. 131) points out, militia troops were not likely to be ready immediately in the case of a mobilization for war. Data for the years 1794-97 are troop estimates reported to the Assembly. They are provided by Bertaud (1988, p. 272).

As it concerns the Napoleonic period, the figures for the years 1804, 1806-8, and 1811-12 are taken from Delmas (1992, p. 317). They represent the paper strength of the Imperial Army. Finally, the figures on the size of the military forces for the period 1816-2000 are from Correlates of War, National Material Capabilities, Version 4.0 (2010).

Data for our time series of the French population are taken from several sources. Figures for the years 1600, 1650 and 1700 are from De Vries (2007, p. 36, Table 3.6). We use the estimates of the French population provided by Mathias and O' Brien (1976, p. 604, Table 1) for the years 1715, 1725, 1730, 1735, 1740, 1745, 1750, 1755, 1765, 1770, 1775, 1780, 1785, and 1790. We take the data for the years 1801 – 1945 from Institut National de la Statistique et des Études Économiques (1966, p. 66-73, Tables 1 A - 1 D); for the years 1946 – 1984 from Institut National de la Statistique et des Études Économiques (1990, p. 26, Table 1); for the years 1985-1994 from Institut National de la Statistique et des Études Économiques (1997, p. 49, Table B.01-1); for the years 1995-99 from Institut National de la Statistique et des Études Économiques (2002, p. 49, Table B.01-1); for the year 2000 from Institut National de la Statistique et des Études Économiques (2007, p. 41, Table B.01-1). Missing data in our time series of the population have been interpolated.

Italy 1861-1943

We used military personnel from the Correlates of War (2010) for Italy. The population data come from Istituto Centrale di Statistica (1976), *Sommario di Statistiche Storiche dell'Italia 1861-1975*, Table 10 Popolazione residente calcolata a fine anno dal 1861 al 1975, p.16, Roma.

Japan 1905-1945

We used military personnel from Correlates of War (2010) for Japan. The population data come from Ministry of Internal Affairs and Communications, Statistics Bureau, *Historical Statistics of Japan*, Chapter 2 Population and Household, Population by Sex, Population Increase and Decrease, Population Density (1872–2009) (Accessed at: <http://www.stat.go.jp/english/data/chouki/02.htm>).

Netherlands 1609-1713

We used two principal sources for estimating Dutch army strength. Most historians use the *Staatsche Leger*, an early twentieth century source that although it sounds archival was not. These numbers should be treated as nominal or paper strength. Van Nimwegen (2006) presents a more contemporary set of estimates of effective strength. We use van Nimwegen wherever possible, but use the *Staatsche Leger* when we have no other estimates. To summarize, we use van Nimwegen for 1609 (this actually van Nimwegen's number for 1608 but is the closest number we have for the start of the period), 1629, 1640, and 1672 and the *Staatsche Leger* for 1618, 1625, 1635, 1645, 1657, 1667, 1675, 1683, 1692, 1699, and 1708. The population data is from Maddison (2003) and is linearly interpolated.

Ottoman Empire 1600-1699

The Ottoman army during the 17th century was comprised primarily of two groups. The first group is the sultan's permanent, standing army made of infantry (Janissaries), cavalry, and the artillery corps. We have estimates for this total for eleven years during the 17th century. The second group is the seasonally-mobilized, provincial cavalry. For 1609, our estimate of the standing army is from Murphey (1999). For 1660, we used Agoston (1999) and Murphey (1999) for the infantry estimate and Agoston (2005) for the artillery corps estimate. We used Murphey's (1999) estimate for the standing cavalry in 1670 to estimate the size of the cavalry in 1660. For 1670, we used Murphey (1999). For 1687, 1690-94, 1996, and 1698, we used Tabakoglu (1985) for our estimate of the total standing army. We relied on the discussion in Murphey (1999) and Aksan (2007) to arrive at a single estimate of 70,000 for the effective size of the provincial cavalry. This number is added to the total standing army for the eleven years that we have data for the 17th century to compute our total estimate for each year.

The population data is from McEvedy and Jones (1978) for 1600 and 1700 and is linearly interpolated. See Braudel (1972), Barkan (2000), and Quataert (2000) for additional estimates and discussion.

Prussia/Germany/West Germany 1740-2000

For Prussia, data on military strength is available from a number of sources including Craig (1955), Wilson (1998), Jany (1914), Correlates of War (2010), and the European State Finance Database. From 1740 to 1870, we rely primarily on Jany because his numbers are the most complete time series and are very close to the numbers in the other sources. In all cases, every effort was made to report either actual troop numbers or estimates adjusted to reflect actual troop strength. From 1871 to 2000, we use Correlates of War (2010) numbers. The data for 1955 to 1989 are for West Germany only.

Population data for Prussia for 1740 to 1865 are from Dincecco (2009) and for 1866 to 1870 are from Mauersberg (1988). We use Correlates of War population data for the remaining years of the series and again the data for 1955 to 1989 are for West Germany only.

Russia/Soviet Union 1721-2000

Our data for Russia's military in the eighteenth and early nineteenth century are collected from a number of sources. The value for 1721 comes from a 1720 budget approved by Peter

the Great (Keep 1985, p. 137); as such, the number most likely reflects an upper bound on the actual army size. Values for 1725, 1731, 1734, 1740, 1756, 1763, 1765, 1795, 1796 all come from Pintner (1984; estimates for 1740 and 1756 come from p. 233, and the rest are from p. 253, Table 5). For the table, Pintner cites two sources: von Stein (1859, pp. 92, 100, 151, 359) and Beskrovny (1959, pp. 58, 330). The data points for 1801, 1811, and 1815 are estimates of the Russian State Military Archives (RGVIA) as reported by Beskrovny (1973, pp. 12, 15). For all reported estimates, we attempted to validate all numbers with estimates from other sources for the same time period. From 1816 onwards, we take for the size of Russia's military forces from Correlates of War (2010).

We take estimates of Russia's population before 1816 from Kabuzan (1963, p. 164, Table 18). These data comes from a series of revisions to an unpublished 1702 government census: 1719, 1744, 1762, 1728, 1795, 1811, 1815. From 1816-2007, we use population estimates from Correlates of War (2010). Missing years for population were interpolated. Note: the first data point for population in the series (1721) is the number reported in the 1719 revision to the census.

Spain 1600-1808

For Spain, we currently have limited information about the size of the military. For 1600, we use Parker's (1976, p. 206, Table 1) estimate for the 1590s. Similarly, we use Parker (1976) for estimates for 1635, 1655, 1675, and 1705. Unfortunately, we have no further estimates on the overall size of the Spanish military for the remainder of the 18th century and into the 19th century when they were a great power. Parker (1972) provides additional detailed information on the Army of Flanders but again this data is for the 17th century. Population data is from Maddison (2003) and is linearly interpolated.

Sweden 1617-1721

For Swedish military forces, we have several high quality sources including Roberts (1968), Roberts (1979), Aberg (1973), and Nordmann (1972). These sources, however, provide numbers for only six years during the period that Sweden was a major power. We use Nordmann (1972, p. 135) for 1630. For 1632, we use Roberts (1979, p. 44). Nordman cites a lower figure for this year but this is derived from earlier work by Roberts. We again use Nordmann for 1637 (p. 137), 1697 (p. 141), 1700 (p. 143), and 1707 (p. 144). Finally, Roberts (1979, p. 45) provides a number for 1708. Population data is from Maddison (2003) and is linearly interpolated.

United Kingdom 1600-2000

The first two data on the size of the army in the 17th century refer to the years 1652 and 1660. They are provided by Firth (1902, p. 35). We use figures on the strength of the army from Childs (1996, p. 47) for the years 1670 and 1678. For the year 1685 (December), we report the data on the number of soldiers in England under James II provided by Childs (1980, p. 2). Two additional figures refer to the official strength of the army at the end of October 1688 (Childs, 1980, p. 3) and in April 1689 (Childs, 1987, p. 102). It is worth noting that the last number does not include the Dutch troops stationing in England in that year (on this point, see Childs, 1987, p. 102 and French, 1990, p. 8). The main source for our data on the British

military forces for the years from 1691 to 1815 is Floud, Wachter, and Gregory (1990). For the period 1691-1714 we use their data on the establishment of the army (Floud, Wachter, and Gregory, 1990, p. 44, Table 2.1). The official strength of the British military forces for the years 1715, 1718-19, 1723, and 1728-55 is given by the sum of the establishment of the army (Floud, Wachter, and Gregory, 1990, pp. 44-45, Table 2.1) and of the navy (Floud, Wachter, and Gregory, 1990, p. 68, Table 2.6). For the period 1756-1773 we add up the figures for the establishment of the army (Floud, Wachter, and Gregory, 1990, p. 45, Table 2.1), of the navy and of the marines which are reported in Floud, Wachter, and Gregory, 1990, pp. 68-69, Table 2.6. For the period going from the year 1774 to the year 1815, we are able to provide estimates of the actual strength of the British military forces. In specific, for the years 1774-83 and 1785-1815 we use data on the effective size of the army provided by Floud, Wachter, and Gregory, 1990, pp. 45-46, Table 2.1. We add to these numbers the figures about the “Seamen (including Officers), Boys, and Marines (...) actually Borne” in the naval service for the years 1774-83 and 1785-1815. The source for these last data is the House of Commons Parliamentary Paper, 1860 (168). For the years 1816-2000 we use the data on the military forces provided by Correlates of War (2010).

The time series of the total population is constructed in the following manner. For the years from 1600 to 1706 we take the population of England and Wales. We add the population of Scotland to that of England and Wales for the period 1707 – 1800. For the years going from 1801 to 1921 we sum the population of Ireland to that of England, Wales and Scotland. Finally, for the years from 1922 to 2000 the total population corresponds to the sum of the population of England & Wales, Scotland and Northern Ireland.

The source for the total population of England and Wales in the years 1650 and 1700 is De Vries (2007, p. 36, Table 3.6). Missing data are interpolated. We take the estimates of the Welsh population in 1701, 1751, 1781, and 1801 from Deane and Cole, 1967, p. 103, Table 24. Missing values are interpolated. We use these data as an estimate of the population of Wales for the years 1701 to 1800. The source for the population of England (which does not include Monmouthshire) for the years 1701 – 1800 is Mitchell (1988, pp. 7-8). Mitchell (1988, pp. 11-14) provides data on the overall population of England & Wales for the years 1801 to 1980. We turn to Deane and Cole (1967, p. 6, Table 2) for estimates of the population of Scotland in 1701, 1751, 1791, and 1801. We interpolate missing data and use this series for the years 1707 – 1800. We take data on the Scottish population for 1801 – 1980 from Mitchell (1988, pp. 11-14). Figures on the population of Ireland for 1801-1921 are taken from Mitchell (1988, pp. 11-13). The population of Northern Ireland for the years 1922 – 1980 are provided by Mitchell (1988, pp. 13-14). Finally, the data on the population of the United Kingdom for the years 1981 – 2000 are taken from the Office of National Statistics, Population estimates for UK, England and Wales, Scotland and Northern Ireland – current datasets. Data are available at: <http://www.statistics.gov.uk/statbase/Product.asp?vlnk=15106>.

United States 1898-2000

The military personnel data for 1898 to 1995 are active duty personnel from all branches excluding the Coast Guard. The source for these data is the *Historical Statistics of the United States, vol. 5*, Table Ed26-47, Military personnel on active duty, by branch of service and sex: 1789-1995, p. 5-353-359. The data for 1996 to 2000 are from Correlates of War (2010). The population data for the United States for 1898 to 1929 are from the *Historical Statistics of the*

United States, vol. 1, Table Aa9-14, National population and the demographic components of change: 1790-2000, p. 1-30-33. From 1930 to 1949, we used *Historical Statistics of the United States*, vol. 1, Table Aa6-8, Population 1790-2000, p. 1-28-29. And from 1950 to 2000, the population data are from U.S. Census Bureau, National Estimates and Projections, Table 2, Population, accessed from <http://www.census.gov/compendia/statab/cats/population.html>.

B Appendix: First-Stage Instrumental Variable Estimates

	Military Size – First-Stage IV Estimates			
	Railroad Track		Railroad Track Area	
	Model (6)	Model (8)	Model (7)	Model (9)
<i>Regional Railroad Track Area</i>	0.378 (0.049)	0.296 (0.059)	1.244 (0.074)	1.244 (0.102)
	0.000	0.000	0.000	0.000
<i>Cruise Missile</i>	0.001 (0.005)	-0.009 (0.005)	-0.010 (0.008)	-0.031 (0.009)
	0.911	0.073	0.213	0.001
<i>Population</i>		0.000 (0.000)		0.000 (0.000)
		0.000		0.702
<i>GDP per capita</i>		-0.000 (0.000)		0.000 (0.000)
		0.000		0.000
<i>Democracy</i>		-0.005 (0.003)		-0.010 (0.005)
		0.078		0.055
First-stage F-stat	59.908	25.604	281.568	149.328
First-stage p-value	0.000	0.000	0.000	0.000
Country Fixed Effects	Yes	Yes	Yes	Yes
D1798, D1859, D1970	Yes	No	Yes	No
Year & Year Sq. Trends	No	Yes	No	Yes
Number of Observations	443	443	443	443

Table A-1: *Military Size in Great Power Wars, 1600-2000*. The table reports the first-stage regressions for Models (6)-(9) in Table 3. The endogenous variables are either *Railroad Track* or *Railroad Track Area* depending on specification. The excluded instrument in all specifications is *Regional Railroad Track Area*.

Military Mobilization – First-Stage IV Estimates				
	Railroad Track		Railroad Track Area	
	Model (6)	Model (8)	Model (7)	Model (9)
<i>Regional Railroad Track Area</i>	0.378 (0.049)	0.296 (0.059)	1.244 (0.074)	1.244 (0.102)
	0.000	0.000	0.000	0.000
<i>Cruise Missile</i>	0.001 (0.005)	-0.009 (0.005)	-0.010 (0.008)	-0.031 (0.009)
	0.911	0.073	0.213	0.001
<i>Population, Billions</i>		0.121 (0.023)		-0.015 (0.039)
		0.000		0.702
<i>GDP per capita, Thousands</i>		-0.005 (0.001)		0.004 (0.001)
		0.000		0.000
<i>Democracy</i>		-0.005 (0.003)		-0.010 (0.005)
		0.078		0.055
First-stage F-stat	59.908	25.604	281.568	149.328
First-stage p-value	0.000	0.000	0.000	0.000
Country Fixed Effects	Yes	Yes	Yes	Yes
D1789, D1859, D1970	Yes	No	Yes	No
Year & Year Sq. Trends	No	Yes	No	Yes
Number of Observations	443	443	443	443

Table A-2: *Military Mobilization in Great Power Wars, 1600-2000*. The table reports the first-stage regressions for Models (6)-(9) in Table 4. The endogenous variables are either *Railroad Track* or *Railroad Track Area* depending on specification. The excluded instrument in all specifications is *Regional Railroad Track Area*.

Conscription and Universal Conscription – First-Stage IV Estimates		
	Railroad Track	Railroad Track Area
	Models (5) & (6)	Models (7) & (8)
<i>Regional Railroad Track Area</i>	0.434 (0.030)	1.163 (0.057)
	0.000	0.000
<i>Cruise Missile</i>	-0.012 (0.003)	-0.037 (0.007)
	0.001	0.000
<i>Population, Billions</i>	0.169 (0.014)	-0.070 (0.026)
	0.000	0.008
<i>GDP per capita, Thousands</i>	-0.003 (0.000)	0.005 (0.001)
	0.000	0.000
<i>Democracy</i>	-0.007 (0.002)	-0.008 (0.003)
	0.000	0.021
First-stage F-stat	214.037	419.021
First-stage p-value	0.000	0.000
Country Fixed Effects	Yes	Yes
Year & Year Sq. Trends	Yes	Yes
Number of Observations	1046	1046

Table A-3: *Conscription in Great Power Wars, 1600-2000*. The table reports the first-stage regressions for Models (5)-(8) in Table 5. The endogenous variables are either *Railroad Track* or *Railroad Track Area* depending on specification. The excluded instrument in all specifications is *Regional Railroad Track Area*.