All Along the Watchtower: Military Landholders and Serfdom Consolidation in Early Modern Russia*

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Abstract

We study the emergence of extractive institutions induced by external military threats. Using the case of early modern Russia, we explore the consolidation of serfdom under the pressure of landholding military elites who gained political influence due to the prolonged struggle with steppe nomads. To contain nomadic raids, the Russian state erected defense lines on the southern frontier, and granted lands in the area to soldiers in charge of its defense. The soldiers could not farm while on defensive duties, nor could they compete in the market for peasant labor because the lands had been selected for their defensive rather than agricultural value. The system was therefore only sustainable by gradually binding peasants to the land. Using newly digitized 17th century population data, we show a higher prevalence of serfs and military landholders in districts on the defense line. We also find a higher prevalence of small estates – up to 25 serf households – sufficient to support a warrior and his family. Placebo tests reveal that these patterns do not hold for non-serf peasants and in other, defensively non-optimal, locations. To ensure causality, we develop a novel algorithm that reconstructs the optimal invasion routes for nomads and pinpoints the optimal location of the defense line using topographic data. Our results suggest that military considerations – rather than the high land-labor ratio – were among the key factors of serfdom formation. This sheds new light on the possible mechanisms of institutional divergence between Eastern and Western Europe in the early modern period.

Keywords: serfdom, extractive institutions, factor markets, early modern Russia

JEL codes: N33, N43, N53, J47, O43

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1 Introduction

The persistence of extractive institutions has been a subject of extensive research in economics in recent decades.[1] However, less has been written about how extractive institutions emerge in the first place. One famous example of such an extractive institution is Russian serfdom. Consolidated at the turn of the 17th century, serfdom tied previously free peasants to the land, and persisted for more than 200 years, constraining economic output and casting a long shadow on contemporary development.[2] In this paper, we study the origins of this institution, and show that a transition from relatively free labor markets to serfdom appeared as a unique confluence of geographical factors, military technology, external threats, and political developments in early modern Russia.

We argue that serfdom resulted largely from the defense needs of the southern frontier against the longstanding threat of steppe nomads' raids. These nomads complemented their pastoral income with the "Harvest of the Steppe": periodic raids aimed at capturing Russian peasants and selling them through Crimean ports to the slave markets of the Ottoman Empire. To contain these raids, the Russian state erected continuous defensive lines on the frontier that required constant deployment of large numbers of soldiers for their defense. Given the limited fiscal capacity of the early Russian state, it was impossible to collect sufficient taxes centrally, and then transport them to the generally distant garrisons. Instead, Russia developed the *pomest'e* system – a variation on Western European feudalism that saw the allocation of frontier lands to high ranked soldiers in exchange for garrison service. This institutional device created an influential armed class whose economic survival depended on restricting the mobility of their agricultural labor force. These vested interests persisted even after the nomads' threat became less severe, and contributed to the institutionalization of serfdom in the mid-17th century.

To test this theory, we leverage newly digitized data from the 1678 households' census – the earliest available systematic records of the Russian population. Using various published sources, we compile a unified data set on 172 districts that includes male population numbers for six distinct types of peasants (private serfs, royal peasants, church peasants, etc.), the number of military landholders, landholders' estate location, and estate size in terms of number

[1] See Nunn (2020), Acemoglu et al. (2021) and Voth (2021) for recent reviews of the literature.

[2] See Dennison (2011) on the functioning of Russian serfdom, Markevich and Zhuravskaya (2018) on the economic effects of the abolition of serfdom, and Buggle and Nafziger (2021) on its long-term legacy.

of serf households. We supplement these data with the location of the defense line, nomads' invasion routes, and a number of geographic variables.

We find that districts on the defense line had a much higher proportion of serfs – about 40% of the population in contrast to 14% in the country as a whole. The difference of about 25 percentage points holds even after accounting for a battery of geographic and climatic variables, such as grain productivity, temperature seasonality, annual precipitation, terrain ruggedness, a river dummy, and distance to Moscow (see Figure 1). This pattern does not hold for peasants who were not property of the military – the defense line is negatively associated with the location of royal peasants, and insignificant in predicting the location of church- and free peasants. Hence, we find a strong association between the defense line, military landholders, and serfdom.

The location of the defense line could be correlated with unmeasurable non-military benefits, either by design or coincidence, which could have made locating serfs there more desirable. To rule out possible endogeneity, we construct an instrument for the actual defense line – an optimal defense line – using a novel algorithm for calculating the optimal invasion routes for nomads, and topographic data on forest and steppe ecological zones. The idea is that the optimal defense line should block the paths of most frequent attacks *and* be located close to the edge of the forest-steppe boundary, both because the overgrown forest diverted the nomads' attacks, and because timber was the cheapest construction material available for reinforcing the open areas.[3] Indeed, the intersection of the optimal invasion routes and the forest-steppe boundary predicts the location of the actual defense line. Using the interaction term as an instrument for the actual defense line location we confirm our OLS estimates.

In addition, we construct four placebo defense lines by moving the actual line in north-south and east-west directions. These defensively non-optimal lines are not correlated with the location of serfs and military landholders. Thus, the results confirm that the distribution of privately owned serfs was mainly determined by the local needs of frontier defense troops, rather than maximizing national income or even the extractive capacity of the landholders.

We further analyze the mechanism of enserfment using data on the size and location of landholding estates. If serfdom evolved to provision the military in the face of limited fiscal capac-

[3]The same principle applied to the Great Wall of China that also served as a protection against nomads on China's northern frontier. The wall was erected perpendicular to the most frequent angle of attack using locally available materials – stones over mountain ranges, and rammed earth in the plains (Waldron, 1990).

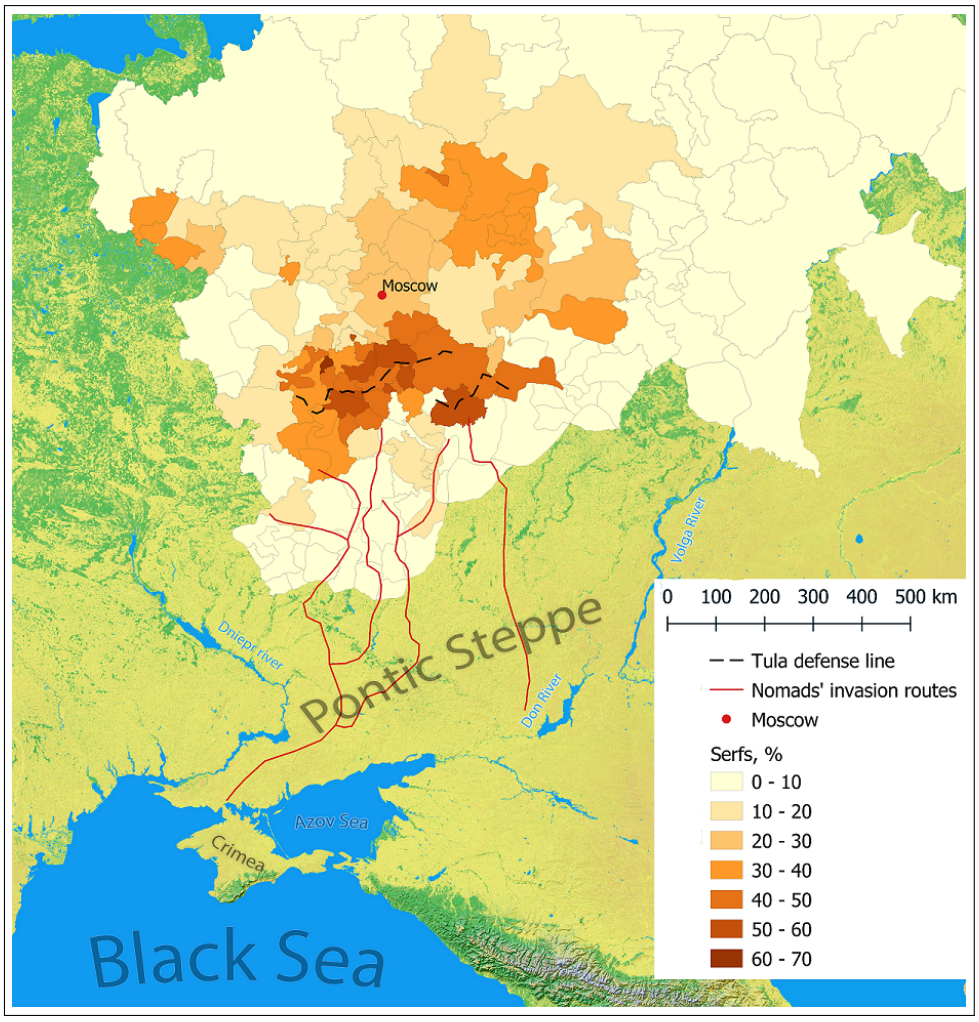

Figure 1: Invasion routes, defense line and serfdom

Notes: Moscow and Central Russia suffered from nomadic raids originating from the Black Sea and Pontic Steppe areas, mostly following well established *shlyakhs* (transportation/invasion routes). The Tula Defense Line was built to protect Moscow by blocking these routes, and this is also the area where we find the highest concentration of serfs.

ity, we would expect that defense line soldiers should be assigned relatively small parcels of land, with a correspondingly small number of serfs – sufficient only to provide a cavalryman with a horse, military equipment, as well as food and shelter for him and his family. In this way, the government would maximize the number of soldiers on the line, given the limited pool of forcible peasant labor. We find that the average estate area was, indeed, significantly smaller in the defense line districts, and that defense line estates were also smaller in terms of the number of serf households – very small (up to 5 households) and small estates (6-25 households) were disproportionately located in the defense line districts. In contrast, the location of middle sized and large estates, the properties of rich hereditary landowners expected to provide marketable surplus, was independent of the defense line.

We further explore the mechanisms of enserfment using textual analysis of the landholders' collective petitions and the 1649 Law Code. In 17th century Russia, collective petitions to the Tsar (*chelobitnye*) were the main way various groups communicated their interests and concerns to the government. We conduct a similarity analysis between the landholders' collective petitions and the Law Code of 1649 – a comprehensive legal document that formalized serfdom and served as a fundamental law code in Russia until the 19th century. We find that Chapter 11 of the Code, which explicitly prohibited peasants' mobility, was largely the government's response to the demands of military landholders, conveyed via collective petitions. In contrast, chapters on other topics (like townsmen's rights) do not display any textual similarity with soldiers' collective petitions. In addition, we show that the timing of petitions corresponds to the incidents of urban uprisings, when the government's vulnerability increased the bargaining power of the military class. Overall, the evidence suggests that the institutionalization of serfdom largely resulted from the political pressure of military landholders who took advantage of the government's dependency on their loyalty in times of political upheavals.

Finally, we document a strong persistence in the spatial distribution of serfs, up until their emancipation in the mid-19th century. Specifically, areas that were part of the defense line maintained the highest percentage of serfs in the 1719, 1795 and 1858 censuses. This relationship holds both if we restrict the analysis to provinces that were in the 1678 census, and if we consider the newly acquired areas of the Russian Empire.

Our paper contributes to several strands in the political economy and economic history literature. First, we demonstrate, empirically, the importance of *external* factors in the evolution of national *economic* institutions. A large literature on the link between warfare and institutions studies mainly the emergence of modern nation states. Starting from the classical argument of Tilly (1990), that "war made the state, and the state made war", empirical studies document that pre-modern warfare increased fiscal capacity, spurred urbanization and consolidation of parliaments.[4] Our paper, instead, focuses on the evolution of institutions that govern factor markets, since "the question why did economic performance differ is in fact a question about how pre-modern markets emerged" (Epstein, 2000, p. 9). We show that defense considerations lead to the formation of a coalition that benefited from extractive labor institutions. While these institutions constrained total output, they ensured that surplus

[4]See Gennaioli and Voth (2015); Dincecco and Onorato (2016, 2018); Becker et al. (2022) among others.

was available to support soldiers in economically secondary, but strategically crucial locations. The institutions then persisted, delaying the onset of modern economic growth (Markevich and Zhuravskaya, 2018) and shaping regional development patterns long after their demise (Buggle and Nafziger, 2021).

Second, we contribute to the large literature on the origins of extractive labor institutions. Starting from the seminal paper of Domar (1970), economic historians argue about the relative importance of geographic, demographic and political factors in the development of serfdom and slavery.[5] Acemoglu and Wolitzky (2011) summarize these debates in an elegant principal-agent model. Building on the assumption that coercion increases effort, they show that in the general equilibrium setting, coercive labor institutions will prevail when labor scarcity is combined with a lack of outside options for peasants. Our data allows us to test these ideas empirically. We do not find a positive correlation between labor scarcity and serfdom prevalence in a sample of 172 Russian districts, thus contradicting Domar's conjecture. Instead, we do confirm one of the central predictions of Acemoglu and Wolitzky (2011): serfdom dominates in areas with (exogenously) high coercion capacity and limited outside options for peasants.

Third, our results shed new light on the possible mechanisms of institutional divergence between Eastern and Western Europe in the early modern period. The dominant theories of divergence focus on the role of land property rights (North and Thomas, 1973), political institutions (Acemoglu et al., 2005), demographic regimes (Voigtländer and Voth, 2013a,b), ideas of the Enlightenment (Mokyr, 2016; McCloskey, 2016), and kinship systems (Henrich, 2020).[6] We highlight the importance of the military factor. While military revolution in Western Europe produced fiscally capable states with centrally organized armies of regular infantry, in Russia, the need to provide peripheral defense against nomads prolonged the existence of the feudal cavalry supported with land grants and serf labor. This delayed the consolidation of Weberian bureaucracy allowing for the persistence of a "garrison state" – a state whose institutions and social structure are largely shaped by the military considerations.[7]

[5] See North and Thomas (1971); Fogel and Engerman (1974); Brenner (1976); Sokoloff and Engerman (2000); Lagerlöf (2009); Dell (2010); Klein and Ogilvie (2017); Abad and Maurer (2019) among others.

[6] See Koyama and Rubin (2022) for the most up to date review of theories and empirical evidence.

[7] The term "garrison state" was coined by American sociologist Harold Lasswell, who defined it as a state dominated by the interests of the military-industrial complex (Lasswell, 1941). Writing in the midst of World War II, he expressed concerns that the future political elites in the West might be composed of "specialists on violence" who might subvert civil liberties and gear the economy towards military goals. In our study, we use the term in a broader sense.

Fourth, we contribute to the literature on "second-best institutions", pioneered by Rodrik (2008), which argues that choosing apparently inefficient institutions can in some cases improve outcomes, if there are other social or economic factors which cannot be altered. For example, the traditional historiography of the Mesta had argued that the vast privileges afforded to Spanish shepherds prevented the kind of agricultural progress which followed the Enclosure Acts in England. But Drelichman (2009) used archival data to demonstrate that the institution was necessary to unlock the potential of Spain's wool industry, and that the Crown was perfectly able to curtail enforcement of these privileges when it was expedient to do so. Fogli and Veldkamp (2021) argued that in countries with high disease load, the populations naturally converge on a partitioned social structure, which limits the spread of epidemics, but also of ideas. And Buonanno et al. (2020) showed that the large landed estates of Italy were likely a response to the high disease burden from malaria, which made individual farming risky. In all these papers, an apparently sub-optimal institution (as is serfdom in our case), is actually found to be optimal, once the external circumstances beyond the control of agents are considered.

The paper also makes a methodological contribution by applying geospatial methods to calculate high-resolution measures of the optimal attack route between two points. Currently, the standard tools used to measure potential exposure to military threats are terrain ruggedness (Nunn and Puga, 2012), and geographic distance from particular points. The approach used in this paper can provide high frequency variation in contexts where the existing methods would lack statistical power (flat areas, or those with only one threat origin, correlated with other variables). This algorithm can be used by other scholars who study modern or historical military conflicts using quantitative methods.

Finally, our work contributes to the growing body of empirical literature on Russian economic history. A recent comprehensive review by Zhuravskaya, Guriev and Markevich (2023) covers mostly Imperial and Soviet periods, since "new economic history research on Russia in the early modern period is to this day very limited" (p. 3). To the best of our knowledge, our paper is the first quantitative study of the pre-Imperial Russian economy, and the first that employs statistical analysis to explore the origins of one of the most durable, and lamentable, institutions in Russian economic history.

2 Historical background

2.1 The Eurasian steppe and the Russian state

The history of the Russian state is intimately bound with the history of its steppe neighbours.[8] The vast expanses of the Eurasian steppe begin about 200 kilometers south of Moscow, stretching from the Carpathians to Mongolia. These black earth soils are perfectly suited for settled agriculture but were mostly uninhabited by peasants up until the mid-17th century, because of the constant threat of nomads' raids.[9] The most durable threat came from the Crimean Khanate – a successor of the Golden Horde and the Mongol Empire, and a vassal state of the Ottomans from the late 15th century. The slave trade was one of the main income sources for the Crimean nobility, and an important economic support for the otherwise mostly pastoral population. Skilled Crimean horsemen "harvested the steppe" (Khodarkovsky, 1999) by capturing peasants on the Russian, Ukrainian and Polish frontiers, and brought them to the Crimean port of Caffa (modern Feodosia) for export to the slave markets in the Ottoman Empire.

Estimates of the number of captives show significant population losses. According to Fisher (1972) about three million people were captured from all the Slavic lands (Russia, Ukraine, Poland) in the 15th and 16th centuries. Novoselskiy (1948) estimates that about 200,000 people were abducted from Russia in the first half of the 17th century. To put these numbers in perspective, the total population of Russia at the time was only about 7 million people (Vodarskiy, 1973). Hellie (2003) argues that had the Russian state not taken countermeasures, most of the country's population would have been sold through the Crimea into the Middle Eastern slave markets.[10]

The steppes were a difficult area for the Russian army to campaign in due to logistical problems. Food could not be acquired from local peasants since they did not exist, nor could it be brought by river from populated areas, because the steppes are drained by rivers that flow into the Black Sea, while Central Muscovy is part of the Volga drainage basin, which empties into

[8] See Khodarkovsky (2002), Davies (2007) and Stevens (1995, 2007) for the major studies on the impact of the steppe frontier on the Russian state building, military reforms, imperial visions, and territorial expansion.

[9] The broad belt of southern steppes became safe enough to attract peasants only in the late 17th-early 18th centuries. By the mid-19th century the "wild field" had become an integral part of the Russian Empire – the most densely populated area, and the main region of agricultural production (Markevich and Mikhailova, 2013).

[10] In the early modern period, Russia, Ukraine and Poland were among the world's major "slave reservoirs", along with Africa (Hellie, 2003). The word "slave" comes from the Latin "sclavus", which, in turn, comes from the ethnonym "Slav" – Slavic people (Oxford English Dictionary, 1989).

the Caspian Sea. Any transportation across the two watersheds would necessarily include slow and expensive portaging across the divide. Furthermore, since Moscow was on the defensive, they had to deploy and feed the guard forces whether nomads attacked or not.

In contrast, the nomadic way of war was perfectly suited to the open and sparsely populated conditions of the frontier. From their winter pastures along the Black Sea coast, raiders would venture north as soon as the spring mud season receded. The scale of the raids could range from a few dozen members of the same extended family to tens of thousands of horsemen. Crucially, they brought with them extra horses to both milk and butcher as they went, which meant they could sustain themselves anywhere fresh pasture could be found. In addition, the raiders could decide when and where to attack, unlike the Russians who had to be constantly prepared for the defense of any part of the frontier. If a location was strongly defended, a band of nomads would seek to distract the Russian army, while others took captives undisturbed.

Russians alternated between trying to fight off the nomads and paying money to the Crimean nobility to keep them from invading. These payments amounted to one million rubles in total between 1613 and 1650, or 26,000 rubles annually, on average. For comparison, in 1640 the state allocated 13,500 rubles for construction of two frontier fort towns (Novoselskiy, 1948, p. 442). Hence, the payments to Crimean nobles were roughly equivalent to the construction costs of four frontier fort towns, every year.

In summary, whether in the form of slave raids or payments to avert them, the nomads presented the greatest continuous threat to the Russian state in the early modern period. In the following subsections, we show how a response to this threat – the construction of defense lines and land granting along the southern frontier – resulted in the rise of the landholding military class, which played a decisive role in the enserfment of the Russian peasantry.

2.2 Taming the "Wild Field": the construction of the defense lines

To contain the nomads, the Russian state organized the construction of a series of fortification lines along the southern frontier, starting from the mid-16th century. In their purpose, the lines were analogous to the Great Wall of China and the Roman Limes, marking the boundaries between settled agrarian societies and their stateless nomadic neighbors. The first line, known as the Bereg Line (Riverbank line), was composed of the Ugra and Oka rivers, which were the only significant water course that cut the entire invasion axis from West to East.

To avoid the possibility of a single point of failure allowing raiders access to the interior, and to expand the protected area, a new line was built some 50-100 km to the south. The Great Abatis Line (*Bol'shaya zasechnaya cherta*), also known as the Tula defense line (*Tul'skaya cherta*), was a chain of fortifications erected in the 1560-s, and centered on the town of Tula, about 180 kilometers south of Moscow. The line was built from felled trees laid in a row with the sharpened tops towards the enemy and augmented, where possible, by earth mounds, ditches and watchtowers. The line was a formidable obstacle since it deprived the nomads of their main tactical advantage – mobility. By 1630, the line consisted of about 40 fort towns and stretched for more than 500 kilometers in the east-west direction. This type of fortification could be quickly built in forest areas. Aside from being an obstacle for nomads and a natural shelter in case of unsuccessful defense, forest was the main source of construction material. This explains why the southern border of Muscovy did not advance past the forest-steppe boundary until the end of the 16th century.

Panel A in Table 1 shows the difference in mean values of geographical variables between districts located on the defense line and the rest of the districts in our sample (for data sources see Section 3). It appears that the defense line area did not differ from the rest of Muscovy in agricultural suitability, annual precipitation, seasonality or terrain ruggedness. The main distinctive feature of the defense line was that it was located on the forest-steppe boundary, and perpendicular to the most common routes of nomadic attacks, roughly the area between the Dnieper and the Don rivers. This location possessed the highest defense value – it was optimized for containing the raids using natural advantages of the forest area.[11] The arrival of gunpowder and improvements in firearms gradually shifted the balance of power towards settled societies, which allowed Russians to advance the southern frontier further into the steppe throughout the 17th century.[12]

2.3 The rise of the landholding military and the consolidation of serfdom

Any obstacle, no matter how imposing, is merely a traffic hazard if there is not a garrison to impose unacceptable casualties to an enemy trying to bypass it. The defense lines were

[11] We employ this fact in our identification strategy in Section 6.

[12] Notably, the first firearms plant was built in Tula, the largest town on the defense line, by Dutch entrepreneur Andries Winius in 1632. Together with his partner, an engineer Peter Marselis, he received a ten-year monopoly on iron and weapons production from the Russian tsar (Gamel', 1826). The water-driven Tula arms plant was one of the first industrial iron producers in Muscovy (Fuhrmann, 1972). Today the Tula plant is the oldest and one of the largest arms plants in Russia.

therefore only effective if guarded by large military forces permanently residing on the defense line, and patrolling the "wild field" for the advanced warning. Given the agrarian economy, primitive taxation technologies, and costly transportation, the state found it impossible to support the military from tax revenues alone. Hence, the government assigned lands on the southern frontier to high ranked soldiers in exchange for military service. The soldiers were expected to support themselves by means of peasant labor.[13] This institutional device, later called the *pomest'e* system, permitted the formation of large permanent cavalry despite the low fiscal capacity of the state.

The crucial element of this institution was that land could be owned only on condition of service in the military or state administration. The rule that determined Russian land tenure for several hundred years stated: "the land must not leave the service" (*zemlia ne dolzhna vykhodit' iz sluzhby*) (Rozhdestvenskiy, 1897, p. 59). This implied that one could not be a landowner without serving the Tsar, and one could not leave his service without losing one's land property (Pipes, 1994, p. 527).

Initially, the soldiers had to either hire free peasant labor or rent out their lands to free tenants. As they became more numerous and influential, they pressed the government to restrict peasants' freedom. The process began in the 1580s when the government introduced the so-called "forbidden years" (*zapovednye leta*) – a temporary prohibition for peasants to leave their masters. In 1597, the prohibition became permanent with a five-year period for searching for runaway peasants.

In the first half of the 17th century, the military landholders sent dozens of collective petitions (*chelobitniye*) to the Tsar lobbying to extend the period for the search of runaways. The government was in general responsive to these demands and extended the period first to ten years, and later to fifteen. The enserfment culminated with the Law Code of 1649 (*Sobornoe Ulozhenie*) that explicitly prohibited any movement of private peasants and made flight a criminal offense with an unlimited search time for runaways.

Panel B in Table 1 shows that private peasants were disproportionately concentrated in districts on the Tula defense line. The concentration is more pronounced for the serfs' subgroup – while they constituted about 14% of total population, they amounted for about 40% in districts

[13] In contrast, the low ranked soldiers (*strel'tsy, pushkari, sluzhilye kazaki*) lived off the government salaries and were denied the right to exploit serf labor. They were recruited mainly from poor townsmen and peasants.

on the Tula defense line. Similarly, Panel C in the same table shows that high ranked military landholders (*vybornye uezdnye dvoryane*) were also disproportionately concentrated in districts on the Tula defense line.

In summary, security considerations required the maintenance of a permanent army in strategically crucial but economically uncompetitive locations. The institutional arrangement devised by the Russian state to form these garrisons – land grants on the frontier in exchange for military service – created an armed class interested in restricting peasants' labor mobility. These vested interests persisted even after the nomads' threat was no longer existential, and contributed to the consolidation of serfdom in the mid-17th century.

3 Data sources

We digitized several published historical sources to construct a unified district-level data set of the Russian population in the late 17th century. The original data were collected by historical demographers from primary sources in the Russian State Archive of Old Documents (RGADA), and published in a series of books starting from the 1960s (Vodarskiy, 1966; Beskrovniy et al., 1972; Vodarskiy, 1977; Vodarskiy and Shvatchenko, 1989).

Peasants in 1678. Our main source of population data is the 1678 household census published and described in Vodarskiy (1977). The data contains male population numbers for six peasant groups in 172 districts (*uezd*) of Muscovy. The groups include private peasants, royal peasants, church peasants, free peasants (*chernososhnye krest'yane*), smallholders on the southern frontier (*odnodvortzy*), and non-Russian peasants in the (at the time recently annexed) Kazan region (*yasashnye ludi*). In addition, Beskrovniy et al. (1972) report data separately for subgroups of private peasants, like cotters (*bobyli*) and servitors (*dvorovye*), which differed in their legal status from other peasants (see Section 4 on the differences between various peasant groups). We merge these data and exploit the variation in legal status between private peasants, and across all groups, to explore the determinants of serfdom.

Citizens in 1678. The data on town dwellers (*posadskie ludi*) from the 1678 census were published in a separate paper by Vodarskiy (1966). The data contains male population numbers for 196 towns and forts. Towns' population consisted of merchants, artisans, and state officials, while forts were mostly populated by the military. We match the 196 towns and forts to the original 172 districts data.

Landholders and estates in 1678–1700. The 1678 census included only tax subject households (*tyaglye ludi*), but not landowning elites and clergy. Vodarskiy and Shvatchenko (1989) employed alternative archival sources, such as military lists, to construct a data set on the number of landholders (*uezdnye dvoryane*), number of estates, estate size in terms of number of serfs, and spatial distribution of estates across 125 districts. We merge these data with the household census to construct a unified database of the earliest available population and land holding records for Russia.

Defense lines. The location of defense lines is reconstructed in many historical studies. Yakovlev (1916) is the main study on the Tula defense line published in the Imperial period. A recent study by Burtzev, Deduk and Stolyarov (2020) draws on archaeological evidence to reconstruct, in detail, not only the line but also the location of fortresses and watchtowers. Maps of the nomads' invasion routes are from Novoselskiy (1948). More recent studies by Davies (2007) and Stevens (2007) served as a check for all geographical data on the location of defense lines and invasion routes.

Geography. Frolov and Golubinskiy (2017) is the source of the GIS shape file of districts in the late 17th century Russia.[14] Kessler and Markevich (2020) is the source of the GIS shape file of districts in the mid-19th century. Geographical controls are from well-known sources: agricultural suitability indices are from Galor and Özak (2016), temperature and precipitation are from Fick and Hijmans (2017), terrain ruggedness and land cover data are from Shaver et al. (2019). Soil types are from the FAO-GAEZ soil taxonomy database.

Table A1 in the on-line appendix presents summary statistics for all variables. Table A2 details the origins of each variable listing page numbers in the published sources.

[14]District (*uezd*) was the main administrative unit in Muscovy until the 1708 reform when Peter I introduced provinces (*gubernia*) as a higher level of administrative division. In our econometric analysis, we cluster standard errors within these later established provinces.

4 Population structure in 1678

Figure 2 shows the population structure of Muscovy according to the 1678 household census. The bulk of the population were peasants, divided by the census into six groups. All groups were obliged to pay taxes to the state, but differed in their legal status in relation to landholders. These differences largely determined the extent of personal freedom.

Private peasants constituted the majority of the peasant population and were owned by two types of landholders – hereditary landowners who inherited their land from noble ancestors (*boyare*), and high ranked soldiers who held the land on the condition of military service (*dvoryane*). Private peasants were subdivided into three groups:

1. villeins (*krest'yane*) who farmed the landlord's land with their own tools for three or four days a week, and their own land plots the rest of the time;
2. cotters (*bobyli*) – poor peasants without property who worked full time for their landlord in exchange for payments, usually in kind; they also had lower tax obligations;
3. servants (*dvorovye i zadvornye*) who also owned no property and lived on the landlord's estate or nearby, employed in housekeeping and other support of the landlord's family.

The latter two groups can be defined as serfs since they were totally dependent on their landlord, and could not keep the marginal product of any part of their labor. They constituted about 14% of the population in 1678. By the beginning of the 18^{th} century, these three groups gradually merged, and in 1723 Peter I transferred all private peasants into the common category of serfs.

The other groups of peasants recognized in the 1678 census, although also denied land property rights, at the time, possessed more personal freedom. Church peasants belonged to the clergy and farmed the lands of churches or monasteries, while royal peasants were the personal property of the Tsar and worked on his lands to supply the court. Both of these categories had greater personal freedom than private peasants, including greater ability to move within the monastic or royal lands respectively. Free peasants (*chernososhnye*) lived mostly on unproductive and remote lands in the North (e.g. Arkhangelsk) and were not the property of any class. Finally, small groups of non-Russian peasants (Tatars, Chuvash, etc.) occupied conquered areas of the former Kazan Khanate.

These differences in legal status, documented by the census, reflect a variation in the extent of peasants' dependency on landlords. In the following sections, we exploit this variation for empirical gain.

5 Defense line and serfdom

To quantify the effect of the defense line on the spatial distribution of the Russian peasantry, we estimate the following equation:

$$Serfs_i = \beta_0 + \beta_1 DefenseLine_i + \beta_2 GrainSuit_i + \mathbf{G}\beta_3 + \tau_j + \varepsilon_i, \quad (1)$$

where $Serfs_i$ is the share of serfs (or relevant subset of interest) in the total population of district i; $DefenseLine_i$ is a dummy variable which takes the value 1 for districts located on the Tula defense line ($n = 17$) and 0 otherwise. The coefficient of interest β_1 shows the difference in the average share of serfs between the districts on the Tula defense line and the rest of the country. $GrainSuit_i$ is the grain suitability index calculated as the arithmetic average index of three basic agricultural crops in Russia – wheat, rye, and oats [15]. **G** is the vector of geographic controls that includes temperature seasonality, annual precipitation, terrain ruggedness, a dummy for location on the Volga river, and distance to Moscow; τ_j are fixed effects for five large geographical areas: Center (n=49), Black Earth (n=57), East and South-East (n=30), North and North-East (n=22), West and North-West (n=14). These capture broad geographic, demographic, and climatic effects. In all specifications, we cluster standard errors within the provinces established after the 1708 administrative reform.[16]

Table 2 reports estimation results for Equation 1. Column (1) shows the unconditional relationship between defense line location and serf labor. As stated if the previous section, only the lower two classes of peasants are considered as serfs (*bobyli* and *dvorovye i zadvornye*). The relationship is highly significant both statistically and economically – defense line districts had, on average, 30 percentage points higher share of serfs than the rest of the country. In columns (2)-(5) we gradually add geographic controls to ensure that the relationship is not driven by the location's agricultural suitability for serf labor. While grain suitability, precipitation and terrain ruggedness are statistically significant in column (3), they are no longer significant after controlling for distance to Moscow and region fixed effects in columns (4) and

[15] The first two were the staple crops for humans, while the latter was primarily consumed by horses.
[16] Alternative clusterizations within 250 km or 500 km using Conley (1999) yield similar results.

(5). The coefficient on the defense line, however, remains remarkably stable – the districts had about 25 percentage points higher share of serfs accounting for the environmental conditions. This is in fact similar to the raw difference in means between districts on the line, where serfs were around 40% of the population, and districts elsewhere, where serfs were only 10% (see Table 1, panel B). This implies that the area around the defense line did not have any specific economic advantage, but the concentration of serf labor served some other purpose.

In column (6), we substitute the share of serfs variable with the share of villeins (private non-serf peasants). Again, we find a significantly higher concentration in districts on the defense line, but the magnitude of the effect is only half that of serfs. Notably, geographic factors are also significant – private non-serf peasants resided closer to Moscow, and in districts with higher seasonality. This confirms that villeins were bonded not only to high ranked soldiers on the defense line but also to the hereditary landowners (*boyare*) with estates in the geographic core of the country around Moscow.

Our theory would be invalidated if non-private peasants also resided in districts on the defense line. We conduct a placebo exercise in Table 3, where we regress the shares of non-private peasants on the same set of explanatory variables. These peasants were not the property of military landholders, but rather of landowners who had no military obligations towards the state. Hence, we do not expect a positive correlation between their location and the defense line. We find that the defense line is negatively associated with the location of royal peasants and insignificant in predicting the location of church peasants, free peasants and non-Russian peasants. We conclude, only peasants with the least personal freedoms were located on the defense line. This supports the decisive role of military considerations in the enserfment of the Russian peasantry.

6 Optimal location of the defense line

It is possible that defense line districts possessed other non-military value that made labor coercion profitable. To rule out this possibility we conduct an IV estimation with the newly constructed instrumental variable – optimal defense line – which is a dummy variable for districts located on the intersection of the optimal invasion routes and the forest-steppe boundary.

The idea rests on the fact that successful defense against nomads imposes two requirements on the fortifications' location: 1) block the routes of most frequent nomads' attacks; 2) be in proximity to a forest, because timber was a much cheaper construction material than stones or bricks. Moreover, the forest served as a natural shelter from nomads in case of unsuccessful defense.[17] Thus, deciding on the defense line location, the Russian military strove for a continuous fortification blocking most frequent invasion routes as far south as possible (to maximize the defended area), but within the forest zone. We construct the optimal defense line dummy in two steps: 1) we calculate optimal invasion routes for nomads; 2) we identify districts on the forest-steppe boundary. The resulting variable takes the value 1 if a district is located on the *intersection* of the optimal invasion routes and the forest-steppe boundary, and 0 otherwise. In the following subsections, we describe each step in detail.

6.1 Optimal invasion routes

The first step is calculation of the optimal invasion routes for nomads. A naive view would be that nomads would always take the shortest path, but in this case, the Russians could fight off any raid concentrating their forces along that single path. To avoid this scenario, nomads actually played the mixed strategy equilibrium attacking along different paths in different years or conducting several simultaneous feints along previously not used paths to mask their true intentions. However, given the short warm season in Russia, the nomads still had to keep a somewhat direct route towards Moscow, or risk being caught by winter before having reached their objectives. Hence, they followed three major routes – Muravsky trail, Izyum trail, and Kalmius trail – that minimized natural barriers on the way from Crimea to Moscow (Davies, 2007, p. 18).

To calculate the optimal invasion routes, we employ the following algorithm:

1. We calculate a cost raster, approximating the cost of nomadic raiding, given the natural topography of the terrain. To do this, we took the flow accumulation value for each cell.[18]

2. The raster has extremely high right skewness due to the way river networks naturally

[17] Indeed, some parts of the 500 km defense line were just thick unbroken forest left overgrown to impede the nomads. Nearby peasants were prohibited to cut the forest for their own needs (Burtzev et al., 2020).

[18] The flow accumulation value is the size of the basin drained through a particular cell, and is proportional to the amount of water that would flow through a particular cell, if all cells received the same amount of rainfall, and there were no evaporation or subsurface water flow.

branch – most cells have very low values, while few cells have extremely high values (the terminal part of large rivers). We took the square root of the flow accumulation to correct for this skewness. This will also be roughly proportional to the width of the river, assuming the ratio of width to depth remains roughly constant.

3. We then calculate the lowest cost path between Perekop (Crimea) and Moscow, using the cost map resulting from step 2.

4. Starting from the cost map calculated in step 2, we added a penalty of 200 to all cells that were within 15 km of the optimal path calculated at step 3.

Steps 3-4 were repeated a further three times, obtaining the four fastest land paths between Crimea and Moscow. As shown in Figure 3, there is excellent agreement between the first three paths resulting from our algorithm and the three main historical invasion routes used by nomads. We then assign value 1 to the districts that lie on these three best routes – namely districts that fall between 35 and 42 degrees of longitude (see Figure A1a in Online Appendix).

6.2 Forest-steppe boundary

The second step is to construct a measure of forest cover for each district and identify those that lie on the boundary of the forest-steppe zones. The data on forest cover in the 17th century or earlier is non-existent. We cannot proceed with modern land cover data either, because contemporary forest cover is endogenous to population patterns and agricultural practices in the past. Instead, we rely on a well-established fact in environmental science that certain vegetation is to be found on certain soil types. For instance, alfisols are a soil type typically found under a hardwood forest cover. In Eastern Europe, they dominate in the Baltic and Central Russia regions. In contrast, mollisols typically form under a grassland cover and are most commonly present in the steppes of southern Russia and Ukraine.[19] We use FAO-GAEZ soil taxonomy data to proxy for historical land cover. Figure 4 shows the defense line and invasion routes superimposed on the soil map. It is apparent that the Tula defense line was located exactly on the boundary between alfisols and mollisols, namely the boundary between the forest and the steppe zones.[20]

[19] In other regions, the same pattern holds. For example, mollisols are also dominant in the American Great Plains and Argentinian Pampas. See USDA global soil map and FAO-GAEZ soil taxonomy documentation.

[20] Despite the endogeneity caveats mentioned above, in practice, using modern forest cover data from Shaver et al. (2019) yields similar estimations. It appears that modern forest cover is at least roughly proportional to historical forest cover. The results are available upon request.

Our final step is to assign the value 1 to districts that lay on the boundary between alfisols and mollisols and 0 to the rest of the districts (see Figure A1b in Online Appendix). We call this dummy variable "forest-steppe boundary" and use it in the first stage of the IV estimation.

6.3 IV estimates

The first stage regression is the linear probability model in the following form:

$$DefenseLine_i = \alpha_0 + \alpha_1 Inv_i + \alpha_2 ForestSteppe_i + \alpha_3 Inv_i \times ForestSteppe_i + \mathbf{G}\alpha_4 + \tau_j + \epsilon_i, \quad (2)$$

where Inv_i denotes districts on the invasion trail and $ForestSteppe_i$ – districts on the forest-steppe boundary. The rest of the covariates are as in Equation 1.

Table 4 reports the results. Column (1) shows that the defense line was more likely to be located on the invasion trail, and column (2) shows that the defense line was also more likely to be located on the forest-steppe boundary. However, once we include both factors simultaneously with their interaction in column (3), only the interaction term is significant (with a much higher coefficient) in predicting the actual defense line location. In column (4), we add a standard set of geographic variables, in column (5) the regional dummies. The coefficient on the interaction remains stable and statistically significant.

Table 5 shows the results of the second stage with serfdom as a dependent variable and the interaction between the invasion trail and forest-steppe boundary as an instrument for the defense line. We confirm our previous results – defense line is the best predictor of the location of serfs and private peasants across 172 districts. The coefficients are slightly higher than in our OLS estimations, but very stable and statistically significant.

6.4 Placebo defense lines (non-optimal location)

To ensure that we are not just capturing some generalized north-south gradient, we construct four placebo defense lines by moving the actual line to the north, south, east, and west, and rerun the analysis each time. In this way, we leave only one out of two factors that determine the optimal location of the line. For example, moving the line 150 km south, we no longer locate on the forest-steppe boundary while staying on the invasion routes. Moving the line to the east, we stay on the forest-steppe boundary but depart from the main invasion routes. In the western direction, we do not have enough districts on the forest-steppe boundary. Hence, we assign all west-border districts to the western placebo line. Figure 5 shows the location of

the placebo lines districts relative to the actual line. Table 6 reports estimations of Equation (1) with placebo lines instead of the actual defense line as independent variables. We find no positive association between the defensively non-optimal lines and the location of serfs and other private peasants.

7 Mechanisms

7.1 Land grants on the southern frontier

As described in Subsection 2.3, the government assigned lands on the southern frontier to high ranked soldiers in exchange for military service, while binding private peasants to the land to ensure these soldiers could support themselves, and any retinue. The land plots and the number of peasants assigned to an average cavalryman were usually small, only sufficient to provide food and shelter for him and his family, as well as a small surplus to obtain a horse and some primitive military equipment. In this way, the government maximized the number of soldiers available for defense on the line, given the constraint on the pool of potential serfs and limited fiscal capacity of the state. At the same time, the small number of peasants assigned meant that the cavalryman was able to supervise them directly.

Crucially, the Russian state only needed to verify that the soldier had indeed reported for duty at the appointed time and place. In an alternative centralized system, the state would have had to regularly assess each citizen for tax paying ability, collect amounts due each year, and then recruit, train, equip, pay and feed each soldier. This would have been a monumental bureaucratic undertaking, far beyond the capabilities of the Russian state at the time.

If, indeed, serfdom was introduced to supply the army independently of centralized state capacity, we would expect to observe a concentration of small estates in areas around the defense line. The data on Russian landowners, compiled by Vodarskiy and Shvatchenko (1989), allows for testing this mechanism. Figure 6 shows the distribution of estate size by the number of peasant households in late 17^{th} century Russia. About half of the landholders owned less than 5 peasant households, and another 38% owned from 6 to 25 peasant households. Owning more than 25 households placed a landholder into the top 10% of wealth distribution, measured by the number of private peasants. The data allows us to explore the variation of this distribution across districts. Hence, we estimate Equation (1) with a new dependent variable

– the number of estates in each size bracket per district area – and the same set of explanatory variables on the right hand side. Table 7 presents the results.

Column (1) shows that districts on the defense line had, on average, 3.2 more estates per 100 square kilometers than districts in the rest of the country. This is a huge effect, given that the average number of estates across all Russian districts was about 2.3 per 100 sq. km.[21] These figures imply that the average estate area was significantly smaller on the defense line. Columns (2)-(3) show that defense line estates were also smaller in terms of the numbers of peasant households – very small (up to 5 peasant households) and small estates (6-25 peasant households) were disproportionately located in the defense line districts. The location of middle sized and large estates was independent of the defense line (columns 5 and 6). Thus, we observe a very consistent pattern – smaller estates, both in terms of acreage and the number of serfs, were more likely to be located on the defense line.[22]

Altogether, these exercises demonstrate the mechanism of the enserfment at work – small estates in a location, most suitable for the defense against nomad raids, were granted to the high ranked soldiers to render military service.

7.2 Political pressure via collective petitions

Serfdom was institutionalized in the Law Code of 1649 (*Sobornoe Ulozhenie*) that explicitly prohibited peasants' mobility and made flight a criminal offense. Chapter 11 of the Code regulated peasants' status and obligations. The evidence below suggests that this chapter was, in large part, the government's response to the demands of military landholders conveyed via collective petitions.

In the 17th century Muscovy, collective petitions to the Tsar (*chelobitnye*) were the main way the military class communicated their interests and concerns to the government.[23] We conduct a textual analysis of similarities between a collective petition written in 1637 and Chapter 11

[21] This includes northern districts with free peasants and no landholding estates. In regions with non-zero estates, the average number was 4.1 per 100 sq. km.

[22] Placebo regressions in Table A3 in the Online Appendix further solidify this conclusion – we find no positive association between estate size and placebo defense lines.

[23] Historians widely agree that collective petitions are a representative historical source that attest for landholders' corporate solidarity and self-awareness about their common interests (Andreev, 2000). For example, one of the earliest surviving petitions of 1611, signed by military representatives from 25 towns, pressured the government to grant land estates on an equal basis with hereditary landowners (Cherepnin, 1978, p. 173-177).

of the Law Code of 1649.[24] We employ an algorithm that calculates the most common bigrams (a pair of consecutive words) in the petition and in the chapter. We found a close similarity between the two texts – the top five most common bigrams are essentially the same in both. They are: "runaway peasants", "commoner peasants", "census books" (linking peasants to estates), "search years" (term limit for runaways' search) , and "tsar's decree". The correlation coefficient between the top twenty bigrams in two texts is 0.7 (see Figure 7). In contrast, there is no correlation between the petition and other chapters, which legislate non-peasantry matters (Figure A2 in the on-line Appendix). Hence, textual analysis confirms the influence of collective petitions on the formalization of serfdom.[25]

Next, we quantitatively analyze a corpus of 96 collective petitions written between 1608 and 1698. Most of these writings did not survive. However, Vysotskiy (1988) gathered the data on the year they were written and on the main topic of the petition. Figure 8 plots the data over time. On average, landholders petitioned once a year. The distribution, however, was very uneven – in 1648, landholders signed 9 collective petitions, and in 1682 they signed 13. These peaks correspond to the two largest civil uprisings in Moscow. The 1648 uprising, also known as the "Salt Riot", was triggered by the government's attempt to impose a new salt tax on merchants and townsmen. The rioters burst into the Kremlin, executed several officials and burned down thousands of houses in Moscow. Members of the military landholding class did not join in the rioters but neither did they take arms to defend the government. Rather they took advantage of the regime's moment of weakness to advance their interests via collective petitions. In the months following the uprising, the government undertook large redistribution of land and peasants from rich hereditary elites to poor cavalrymen, and initiated a nationwide assembly for new legislation that resulted in the Law Code in 1649 (Kivelson, 1993).[26]

Vysotskiy (1988) also classified the 96 petitions into six groups by their main topic: 1) on land holding rights; 2) on the extension of search time for runaway peasants; 3) on military service conditions; 4) on equal rights with hereditary landowners; 5) on demands to organize runaways' search by government means; and 6) others. Figure 9 shows the distribution of

[24]The text of the 1637 collective petition is one of the few that fully survived to this day. It was retrieved from the archive and published by Smirnov (1915). The Law Code was published in Tikhomirov and Epifanov (1961).

[25]See also Man'kov (1980) and Andreev (1983, 2000) for qualitative evidence in support of this conclusion.

[26]The next peak in petitioning activity in 1682 corresponds to the musketeers' revolt that was triggered by the power struggle between noble families after the death of young Tsar Fedor without leaving a heir. These petitions pressured the government for legalizing harsher punishments for runaway peasants (including torture) and eventually lead to new decrees in 1683-85 (Man'kov, 1962).

petitions by topic, before and after the institutionalization of serfdom in the Law Code. It is apparent that collective petitions before 1649 were roughly equally divided between the first four topics – soldiers lobbied for larger estates, for the extension of search time of runaway peasants, against powerful hereditary landholders who competed with them for peasantry, and for better conditions of military service.

In contrast, after the institutionalization of serfdom the landholders' main concern was to organize the search of runaway peasants by government means. Since most soldiers owned only a few serfs, even one runaway presented a significant loss of wealth and ability to render military service. Individual searches for runaways were costly, since it took soldiers' time away from their other duties. Hence, soldiers pressured for a government level solution to the problem of runaways.[27] Note that the share of petitions on land rights did not change after 1649 since the government continued to assign and reassign frontier lands to the soldiers. The other three concerns, however, were subsumed by the soldiers' lobbying efforts for a new "public good" – government's assistance in search of runaways.

Overall, the evidence suggests that military landholders employed their political influence in moments of government's vulnerability, channeling the lawmaking in the direction of institutionalization of serfdom in the 1649 Law Code, and strengthening their grip on peasants in additional decrees thereafter.

8 Persistence of serfdom

Our results can be questioned if the spatial distribution of serfs is not stable over time. By definition, serfs were tied to the land and unable to relocate without the consent of their landlords. Hence, we should observe persistence in the spatial distribution of serfs even with the territorial expansion of the Russian state. We test this prediction using three poll tax censuses conducted after the enserfment, and before the emancipation of serfs, namely in 1719, 1795 and 1858. Table 8 reports the results of the estimation of Equation 1 where the dependent variable is the share of serfs according to each of these censuses.

The results show that districts located on the defense line had a disproportionately higher density of private serfs in each of the subsequent periods. It is important to note that by

[27] These efforts eventually succeeded when in the 1650-60s the government introduced an institution of detectives and imposed substantial fines for hiding runaway peasants (Man'kov, 1962).

the mid-19th century the line had played no role in the state defense system for more than a century – areas south of the line became an integral part of the Empire. In column (4), we restrict the sample to districts that were part of Muscovy in the second half of the 17th century and exclude areas of the Poland-Lithuanian Commonwealth annexed in the second half of the 18th century. The results do not change – three years before emancipation, the spatial distribution of serfs was similar to what it had been 200 years before, at the time of serfdom's consolidation. Hence, the results reflect the persistence of the serfdom institution, far beyond the set of incentives that had led to its creation.

9 Conclusion

We study the evolution of labor institutions induced by external military threats, exploring the case of Russian serfdom. We document that the need for defense of the southern frontier, coupled with the limited fiscal capacity of the state, required farm labor to be allocated close to the defensive lines so that a soldier/landholder could simultaneously oversee the production necessary for his support, and discharge his military duties. This spatial distribution of the population was incompatible with competitive labor markets: if peasants were free to move, they would have simply moved to areas that offered better living conditions. To prevent this, the Russian state, responding to the demands of military landholders, restricted peasants' freedom, subordinating them to the military class, which, from then on, had a continuing vested interest in preserving the institution of serfdom.

While we make no claim that this was the only reason for enacting serfdom in Russia, the findings open a new set of interpretations on one of the most durable economic institutions. In particular, the empirical analysis supports the assertion of Hellie (1971) on the importance of the southern frontier and military class in the enserfment of Russian peasantry. On the contrary, we find no support for Domar's hypothesis on the primary role of the land-labor ratio (Domar, 1970). In fact, areas with a higher population density within Russia had a higher proportion of serfs.[28] Hence, the results imply a decisive role of political and military elites in the evolution of economic institutions that govern land and labor markets.

[28]The correlation coefficient between population density and the share of serfs is 0.38. Regressing the serfs share on population density with a standard set of geographic controls yields a positive and 10% level statistically significant coefficient.

Our approach also hints at one possible cause for the divergence. Due to the near universal adoption of firearms in Western Europe, any invading army would need protected lines of communication to their sources of gunpowder. The best way to blunt such an invasion was by making cities as siege-proof as possible, in the knowledge that the invader wouldn't dare to bypass them for fear of being cut off from supplies. In practice, this meant that Western European sovereigns were, in general, happy to let peasants relocate to cities, the linchpins of the defense of the realm. In contrast, in Eastern Europe the nomadic raiders preferred mobility to firepower, and consequently were able to easily infiltrate between strongholds wherever they could find a gap. This required soldiers in a continuous line through remote areas, which, in turn, could only be consistently supplied by a captive labor force. While this cruel solution may have been initially necessary, due to the entrenched power of the soldier-landholders, this second-best institution outlasted its actual usefulness by two centuries.

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Tables

Table 1: Balance tests

	(1) Districts on the defense line $n = 17$	(2) The rest of the sample $n = 155$	(3) Difference (1)-(2)	(4) p-value
Panel A: *Geography*				
Grain suitability index (wheat, rye, oats)	5 629	5 109	520	0.101
Average annual temperature, Celsius	4.9	4.1	0.8**	0.042
Temperature seasonality, Celsius	10.2	10.4	-0.2	0.151
Precipitation (annual), mm	596.8	590.5	6.3	0.596
Precipitation seasonality, mm	31.8	31.5	0.3	0.747
Terrain ruggedness index	34.7	31.4	3.3	0.257
Volga river	0.0	0.14	-0.14*	0.097
Invasion trail	1.0	0.48	0.52***	0.000
Forest-steppe boundary	0.59	0.11	0.48***	0.000
Panel B: *Peasants in 1678*				
Serfs, %	40.2	10.3	29.9***	0.000
Villeins (other private peasants), %	38.8	21.7	17.1***	0.000
Royal peasants, %	4.1	12.7	-8.6	0.150
Church peasants, %	6.5	10.6	-4.1	0.230
Free peasants, %	0.0	9.2	-9.2	0.154
Non-Russian peasants, %	0.0	7.2	-7.2	0.147
Panel C: *Estates and landholders in 1678*				
Estates, number per 100 sq. km	6.5	1.8	4.7***	0.000
Military landholders, %	0.13	0.05	0.08**	0.023
Observations	17	155		

Notes: Column (1) presents mean values of respected variables for districts located on the Tula defense line ($n = 17$); column (2) – mean values for the rest of the sample ($n = 155$). Column (3) presents a difference in means, and column (4) presents p-values for the difference in means t-test under the null hypothesis of no difference. For more detailed summary statistics see Table A1; for data sources see Table A2.
* p<0.10, ** p<0.05, *** p<0.01.

Table 2: Defense line and serfdom (OLS regressions)

	(1)	(2)	(3)	(4)	(5)	(6)
	Serfs in 1678, % of population					Villeins, %
Defense line	29.89***	28.82***	27.95***	24.91***	24.65***	12.98***
	(3.53)	(3.69)	(2.27)	(3.12)	(4.14)	(3.00)
Grain suitability (wheat, rye, oat)		0.21*	0.17**	-0.10	-0.43	-0.47
		(0.09)	(0.07)	(0.19)	(0.39)	(0.32)
Temperature seasonality			-3.77	-2.37	0.08	7.34**
			(2.42)	(2.83)	(2.97)	(2.90)
Precipitation			0.08*	0.08*	0.09	0.08
			(0.04)	(0.04)	(0.06)	(0.08)
Terrain ruggedness			-0.15*	0.00	-0.00	0.27*
			(0.07)	(0.12)	(0.11)	(0.14)
District on Volga river				2.99	1.34	2.58
				(3.00)	(3.31)	(8.64)
Distance to Moscow				-0.02	-0.01	-0.04***
				(0.01)	(0.02)	(0.01)
Region fixed effects					✓	✓
R^2	0.28	0.30	0.46	0.49	0.52	0.44
Observations	172	172	172	172	172	172

Notes: The dependent variable in columns (1)-(5) is the share of serfs in total population; in column (6) the share of other private peasants. The unit of observation is district (*uezd*). Region fixed effects are dummies for large geographical areas: Center (n=49), Black Earth (n=57), East and South-East (n=30), North and North-East (n=22), West and North-West (n=14). Constants are estimated but not reported. Robust standard errors are clustered within provinces delineated after the 1708 administrative reform, and reported in parentheses.
* p<0.10, ** p<0.05, *** p<0.01.

Table 3: Defense line and other types of peasants (OLS regressions)

	(1) Royal peasants, %	(2) Church peasants, %	(3) Free peasants, %	(4) Non-Russian, peasants, %
Defense line	-8.36***	-4.14	-0.42	3.17
	(2.23)	(3.02)	(0.77)	(1.83)
Grain suitability (wheat, rye, oat)	-0.22	-0.28	-1.17***	-0.04
	(0.17)	(0.20)	(0.19)	(0.15)
Temperature seasonality	3.63	-2.23	2.09	1.21
	(3.04)	(1.93)	(3.52)	(2.88)
Precipitation	-0.03	-0.00	0.05	0.07*
	(0.07)	(0.02)	(0.05)	(0.03)
Terrain ruggedness	-0.52**	-0.10	-0.01	-0.05
	(0.20)	(0.05)	(0.05)	(0.10)
District on Volga river	-2.18	-1.41	-2.80**	4.91
	(8.10)	(2.97)	(1.02)	(4.56)
Distance to Moscow	-0.01	-0.01	0.01*	0.02
	(0.01)	(0.01)	(0.01)	(0.01)
Region fixed effects	✓	✓	✓	✓
R^2	0.12	0.28	0.81	0.57
Observations	172	172	172	172

Notes: The dependent variables are the shares of royal, church, free (*chernososhnye*), and non-Russian (*yasashnye*) peasants in total population in 1678. The unit of observation is district (*uezd*). Region fixed effects are dummies for large geographical areas: Center (n=49), Black Earth (n=57), East and South-East (n=30), North and North-East (n=22), West and North-West (n=14). Constants are estimated but not reported. Robust standard errors are clustered within provinces delineated after the 1708 administrative reform, and reported in parentheses.
* p<0.10, ** p<0.05, *** p<0.01.

Table 4: Location of the defense line (LPM regressions)

	(1)	(2)	(3)	(4)	(5)
			Defense line		
Invasion trail	0.18**		0.09	0.02	0.00
	(0.06)		(0.05)	(0.02)	(0.03)
Forest-steppe boundary		0.32*	0.00	-0.00	0.00
		(0.15)	(0.00)	(0.02)	(0.02)
Invasion trail × Forest-steppe boundary			0.62**	0.61**	0.58**
			(0.19)	(0.18)	(0.18)
Grain suitability (wheat, rye, oat)				-0.00**	-0.00
				(0.00)	(0.00)
Temperature seasonality				-0.02	-0.01
				(0.05)	(0.05)
Precipitation				-0.00	-0.00
				(0.00)	(0.00)
Terrain ruggedness				0.00	0.00
				(0.00)	(0.00)
District on Volga river				-0.04	-0.02
				(0.02)	(0.02)
Distance to Moscow				-0.00**	-0.00
				(0.00)	(0.00)
Region fixed effects					✓
R^2	0.10	0.15	0.40	0.43	0.43
Observations	172	172	172	172	172

Notes: The dependent variable equals one if a district is located on Tula defense line and zero otherwise (n=17). Invasion trail is dummy for district's location on nomads' invasion routes (n=92). Forest-steppe boundary is dummy for district's location on the boundary between forest and steppe zones (n=27). Region fixed effects are dummies for large geographical areas: Center (n=49), Black Earth (n=57), East and South-East (n=30), North and North-East (n=22), West and North-West (n=14). Constants are estimated but not reported. Robust standard errors are clustered within provinces delineated after the 1708 administrative reform, and reported in parentheses.
* p<0.10, ** p<0.05, *** p<0.01.

Table 5: Defense line and serfdom (second stage of 2SLS regressions)

	(1)	(2)	(3)	(4)	(5)	(6)
	Serfs in 1678, % of population					Villeins, %
Defense line	38.67*	36.93*	37.27**	35.51**	38.03**	35.45***
	(16.74)	(17.12)	(13.46)	(12.53)	(13.09)	(8.43)
Grain suitability (wheat, rye, oat)		0.18	0.14	-0.05	-0.27	-0.21
		(0.11)	(0.08)	(0.14)	(0.26)	(0.34)
Temperature seasonality			-3.15	-2.32	-0.34	6.62*
			(2.80)	(2.87)	(2.72)	(3.28)
Precipitation			0.09*	0.08*	0.09	0.07
			(0.04)	(0.04)	(0.06)	(0.08)
Terrain ruggedness			-0.17*	-0.06	-0.06	0.16
			(0.09)	(0.09)	(0.09)	(0.16)
District on Volga river				3.89	1.20	2.34
				(3.50)	(3.56)	(8.29)
Distance to Moscow				-0.01*	-0.00	-0.02*
				(0.01)	(0.01)	(0.01)
Region fixed effects					✓	✓
First stage F-statistics	102.79	51.42	21.11	17.55	11.05	11.05
Second stage R^2	0.25	0.28	0.43	0.46	0.47	0.37
Observations	172	172	172	172	172	172

Notes: The dependent variable in columns (1)-(5) is the share of serfs in total population; in column (6) the share of other private peasants. The unit of observation is district (*uezd*). Region fixed effects are dummies for large geographical areas: Center (n=49), Black Earth (n=57), East and South-East (n=30), North and North-East (n=22), West and North-West (n=14). Constants are estimated but not reported. Robust standard errors are clustered within provinces delineated after the 1708 administrative reform, and reported in parentheses.
* p<0.10, ** p<0.05, *** p<0.01.

Table 6: Placebo defense lines and serfdom (OLS regressions)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Serfs in 1678, %				Villeins, %			
Placebo defense line, North	-16.82***				-14.49**			
	(3.10)				(5.52)			
Placebo defense line, South		-8.76				-7.36		
		(5.78)				(6.01)		
Placebo defense line, East			0.08				17.15	
			(1.73)				(10.07)	
Placebo defense line, West				11.24				10.70
				(9.97)				(7.49)
Full set of controls	✓	✓	✓	✓	✓	✓	✓	✓
Region fixed effects	✓	✓	✓	✓	✓	✓	✓	✓
R^2	0.42	0.39	0.37	0.39	0.44	0.43	0.45	0.43
Observations	172	172	172	172	172	172	172	172

Notes: The dependent variable in columns (1)-(4) is the share of serfs in total population in 1678; in columns (5)-(8) the share of other private peasants. The unit of observation is district (*uezd*). Full set of controls include the same variables as in Table 2. Region fixed effects are dummies for large geographical areas: Center (n=49), Black Earth (n=57), East and South-East (n=30), North and North-East (n=22), West and North-West (n=14). Constant is estimated but not reported. Robust standard errors are clustered within provinces delineated after the 1708 administrative reform, and reported in parentheses.
* p<0.10, ** p<0.05, *** p<0.01.

Table 7: Mechanism: estate size on the defense line (OLS regressions)

	(1)	(2)	(3)	(4)	(5)	(6)
	Number of estates per 100 sq. km,					
	total	1-5 peasant households	6-25 peasant households	26-125 peasant households	126-250 peasant households	251-500 peasant households
Defense line	3.17***	1.59***	1.41***	0.19*	-0.02	-0.00
	(0.71)	(0.42)	(0.18)	(0.10)	(0.03)	(0.00)
Grain suitability (wheat, rye, oat)	-0.08**	-0.05*	-0.03**	-0.00	-0.00	-0.00*
	(0.03)	(0.02)	(0.01)	(0.00)	(0.00)	(0.00)
Temperature seasonality	0.33	0.11	0.16	0.06	-0.00	0.00***
	(0.27)	(0.17)	(0.14)	(0.04)	(0.01)	(0.00)
Precipitation	0.01	0.00	0.00	-0.00	-0.00	-0.00
	(0.01)	(0.01)	(0.00)	(0.00)	(0.00)	(0.00)
Terrain ruggedness	0.10*	0.06*	0.03*	0.00	0.00	0.00
	(0.05)	(0.03)	(0.02)	(0.00)	(0.00)	(0.00)
District on Volga river	0.76	0.33	0.30	0.12	0.00	-0.00*
	(1.35)	(0.59)	(0.56)	(0.19)	(0.02)	(0.00)
Distance to Moscow	-0.01**	-0.00**	-0.00**	-0.00*	-0.00	-0.00**
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Region fixed effects	✓	✓	✓	✓	✓	✓
R^2	0.42	0.43	0.43	0.27	0.08	0.15
Observations	170	170	170	170	170	170

Notes: The dependent variable in column (1) is the absolute number of landholding estates in a district; in columns (2)-(6) the absolute number of landholding estates of a particular size in terms of peasant households. The unit of observation is district (*uezd*). Region fixed effects are dummies for large geographical areas: Center (n=49), Black Earth (n=57), East and South-East (n=30), North and North-East (n=22), West and North-West (n=14). Constants are estimated but not reported. Robust standard errors are clustered within provinces delineated after the 1708 administrative reform, and reported in parentheses.
* p<0.10, ** p<0.05, *** p<0.01.

Table 8: Persistence of serfdom (OLS regressions)

	(1)	(2)	(3)	(4)
	Serfs, %, in			
	1719	1795	1858	1858
Defense line	34.02***	15.12***	10.90***	9.81***
	(8.59)	(4.95)	(3.32)	(3.03)
Grain suitability (wheat, rye, oat)	-1.01	0.08**	0.10**	0.09***
	(0.64)	(0.04)	(0.05)	(0.04)
Temperature seasonality	8.45*	1.15	2.56	2.01
	(4.39)	(2.93)	(3.91)	(3.39)
Precipitation	0.23	0.25	0.19	0.31
	(0.14)	(0.16)	(0.17)	(0.25)
Terrain ruggedness	0.38*	0.45	0.52	0.41
	(0.20)	(0.21)	(0.35)	(0.38)
District on Volga river	3.97	2.02	3.05	1.15
	(5.20)	(4.20)	(2.95)	(2.1)
Distance to Moscow	-0.06**	-0.08***	-0.15***	-0.12***
	(0.02)	(0.02)	(0.03)	(0.03)
Region fixed effects	✓	✓	✓	✓
R^2	0.53	0.41	0.43	0.38
Observations	172	502	502	273

Notes: The dependent variables are the share of serfs (*pomeshich'i krest'yane*) in total population of a district in 1719, 1795 and 1858. In column (4) the 1858 sample is restricted to districts that were part of the area of Muscovy in 1678. Region fixed effects are dummies for large geographical areas: Center, Black Earth, East and South-East, North and North-East, West and North-West. Constants are estimated but not reported. Robust standard errors are reported in parenthesis.
* p<0.10, ** p<0.05, *** p<0.01.

Figures

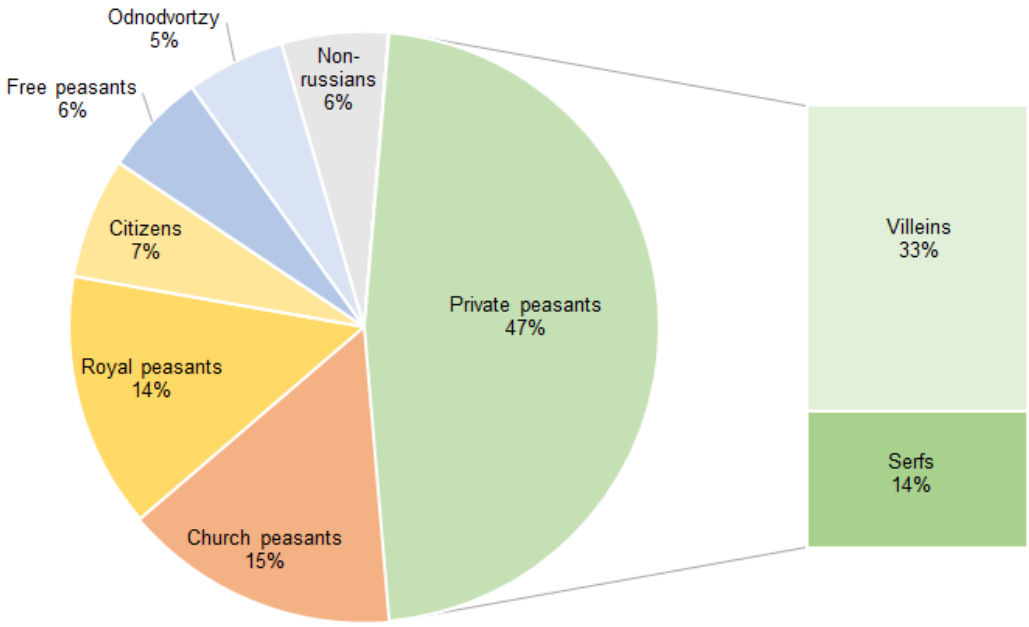


Figure 2: Population structure in 1678, % of total population

Notes: Legal status of each group described in Section 4. For data sources see Table A2.

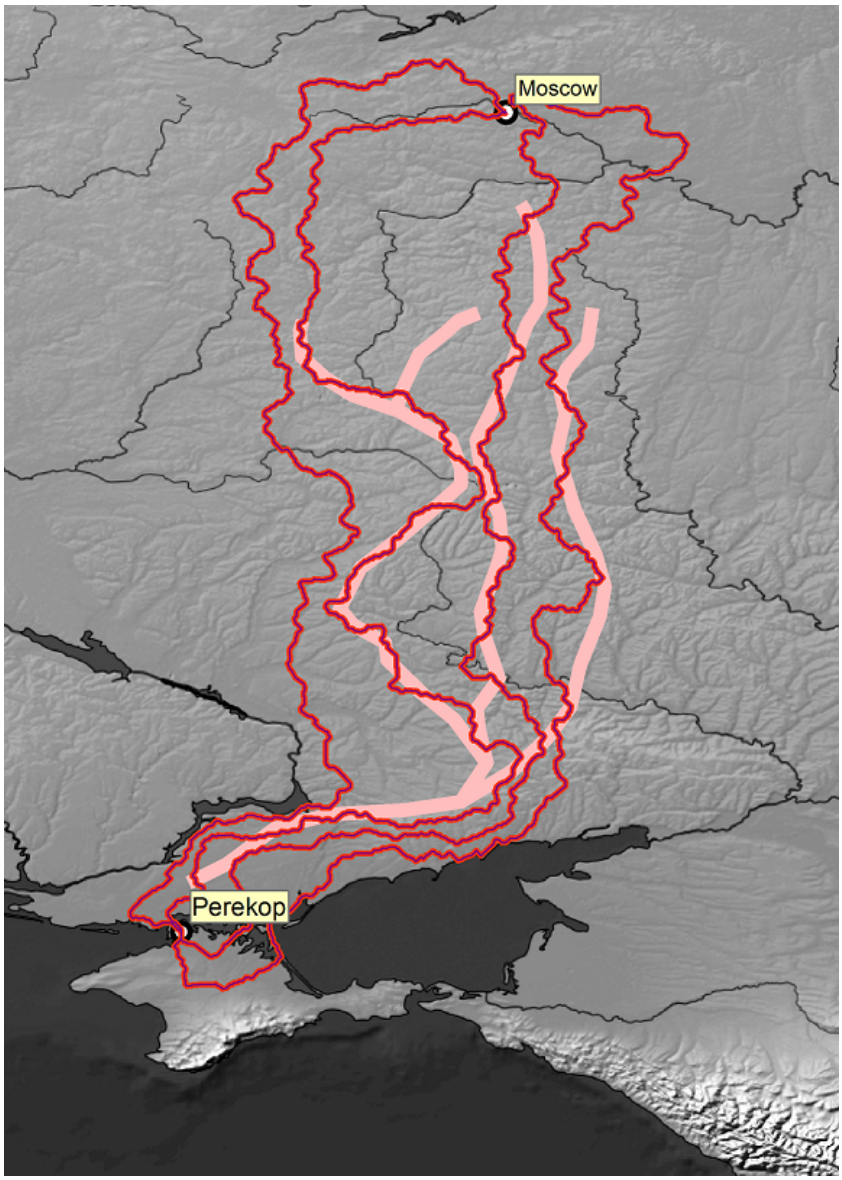


Figure 3: Optimal and actual invasion routes

Notes: Red lines: calculated optimal invasion routes. Pink thick lines: the actual historical invasion routes. For maps of the actual invasion routes see Khodarkovsky (2002), Stevens (1995) and Davies (2007).

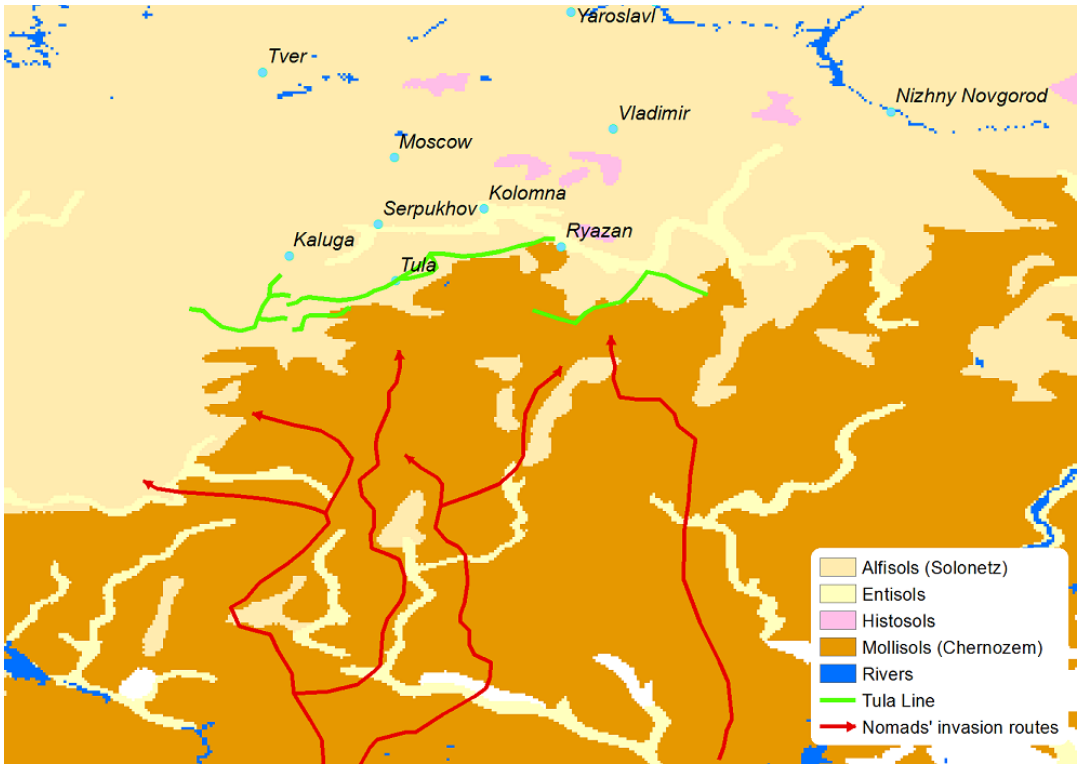


Figure 4: Soil types, invasion routes and defense line

Notes: Light brown are alfisols soils typically found under a hardwood forest cover. Dark brown are mollisols soils typically found under grassland ecosystems. Red arrows are the nomads' invasion routes, green lines represent Tula defense line. Soils data are from USDA global soil map and data description from FAO-GAEZ soil taxonomy documentation.

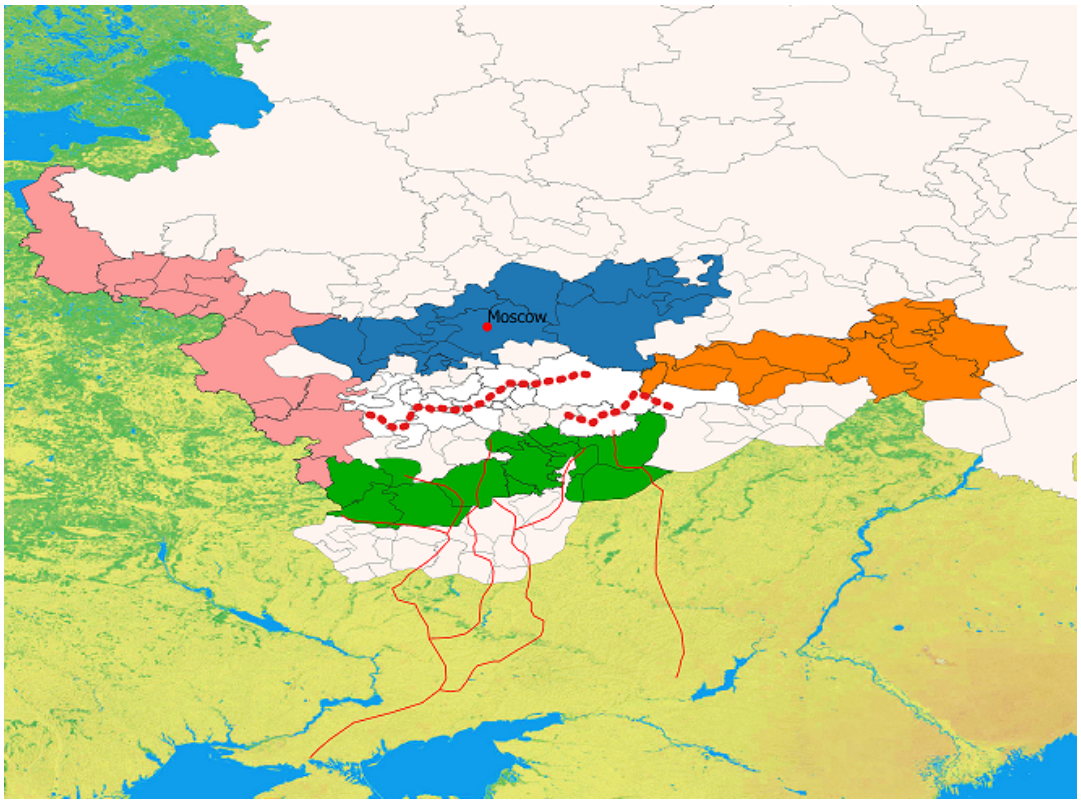


Figure 5: Placebo lines districts

Notes: Red dashed lines represent the actual defense lines. Blue – northern placebo line districts; green – southern placebo line districts; orange – eastern placebo line districts; rose – western placebo line districts. Thin red lines represent the nomads' invasion routes.

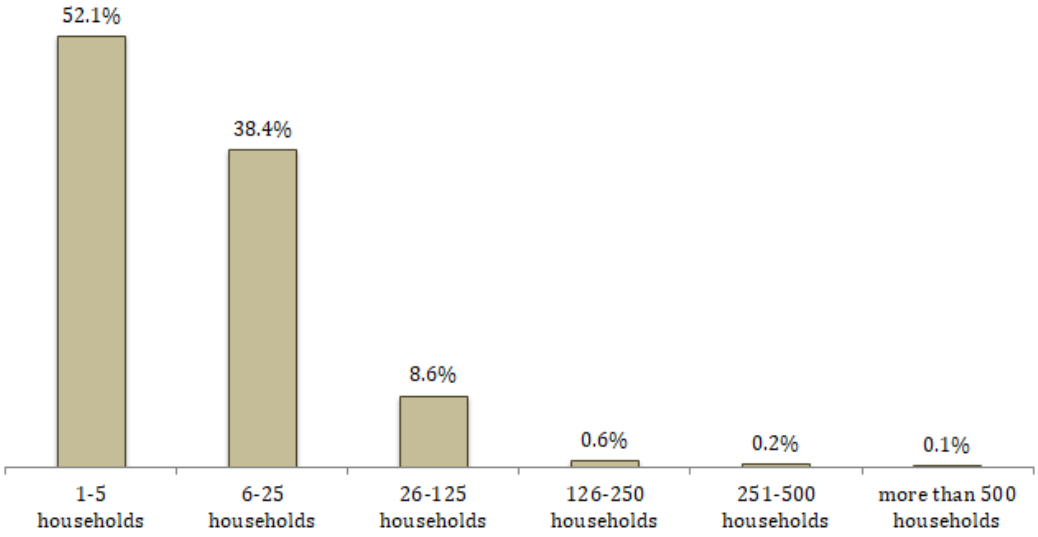


Figure 6: Estate size distribution by the number of private peasant households

Notes: Data from Vodarskiy and Shvatchenko (1989), Table 5.

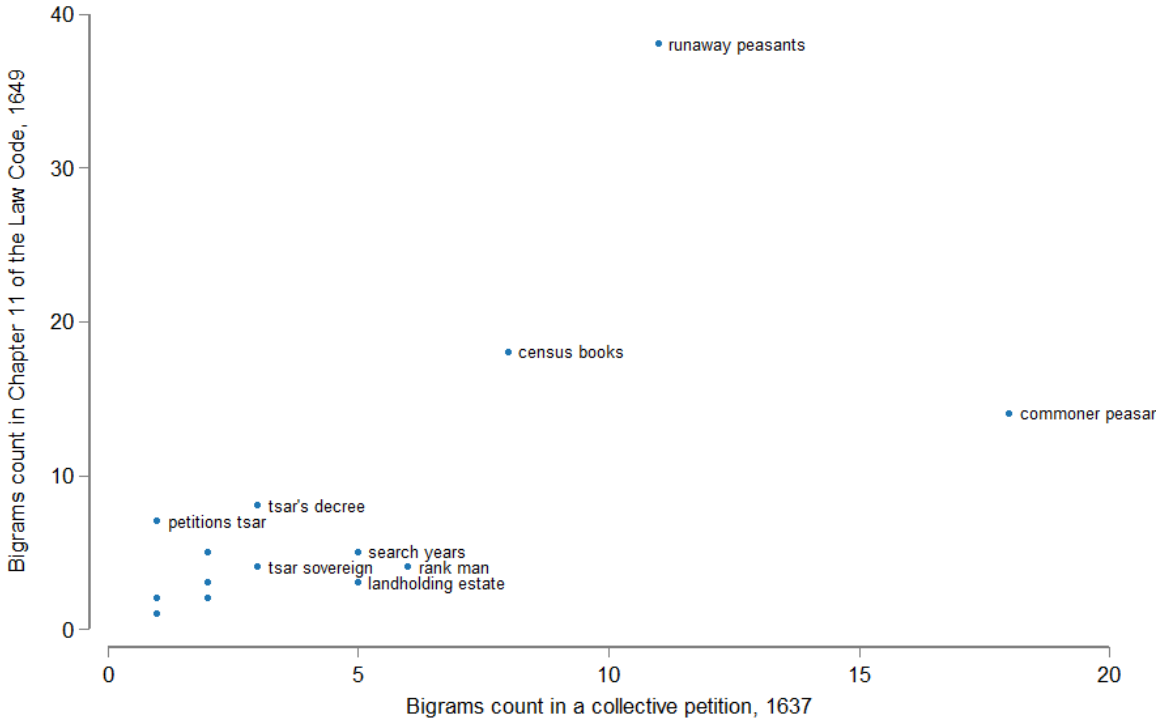


Figure 7: Bigrams count in the 1637 petition and Chapter 11 of the Law Code of 1649

Notes: Chapter 11 of the Code regulated peasants' status and obligations. The top 5 bigrams in the petition and the Law Code chapter are "runway peasants", "commoner peasants", "census books" (linking peasants to estates), "search years" (term limit for runaways' search) , and "tsar's decree". The collective petition was retrieved from the archive and published by Smirnov (1915); the Law Code was published in Tikhomirov and Epifanov (1961). See also Man'kov (1980) for qualitative evidence on textual similarities between collective petitions and the Law Code's Chapter 11.

Figure 8: Number of collective petitions per year, 1608-1698

Notes: Data from Vysotskiy (1988), Appendix 2, p. 209-230.

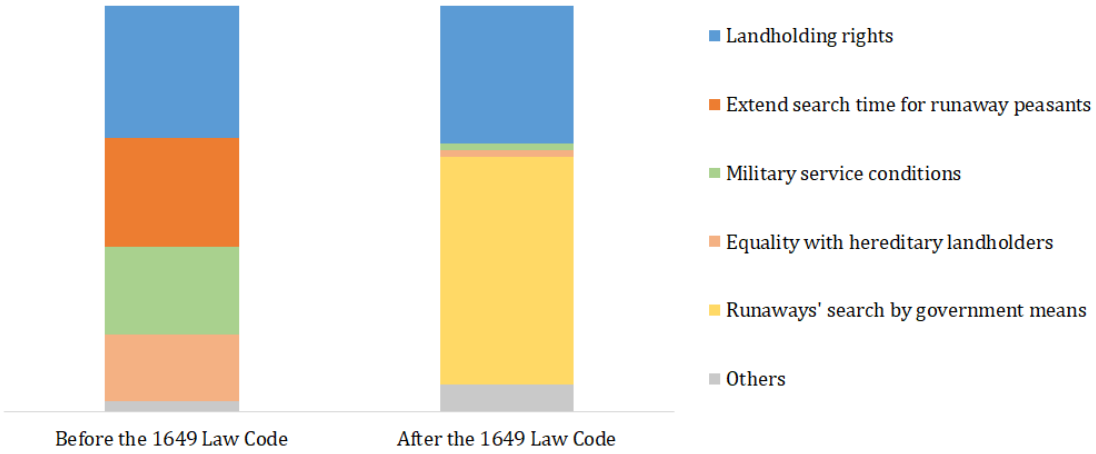


Figure 9: Collective petitions by topic (% of all petitions), 1608-1698

Notes: Data from Vysotskiy (1988), Appendix 2, p. 209-230.

On-line Appendix

A Tables and Figures

Table A1: Summary statistics

	Mean	SD	Min.	Max.	N
Panel A: *Population in 1678*					
Private peasants (total), %	36.6	33.8	0	95.6	172
Villeins, %	23.4	22.4	0	92.5	172
Serfs, %	13.2	17.0	0	61.5	172
Church peasants, %	10.2	13.4	0	100	172
Royal peasants, %	11.9	23.3	0	100	172
Free peasants, %	8.3	25.1	0	100	172
Odnodvortzy, %	14.6	29.4	0	100	172
Non-Russian peasants, %	6.5	19.3	0	92.9	172
Military landholders, %	0.06	0.13	0	1.1	172
Panel B: *Estates in 1678–1700*					
Estates, number per 100 sq. km	2.29	3.44	0	24.50	170
1-5 peasant households	1.28	1.92	0	14.99	170
6-25 peasant households	0.83	1.28	0	9.16	170
26-125 peasant households	0.16	0.30	0	2.46	170
126-250 peasant households	0.02	0.09	0	1.25	170
251-500 peasant households	0.003	0.008	0	0.054	170
Panel C: *Serfs in 1719, 1795 and 1858*					
Serfs (private peasants) in 1719, %	42.4	34.1	0	98.4	172
Serfs (private peasants) in 1795, %	39.1	28.5	0	88.1	502
Serfs (private peasants) in 1858, %	37.7	25.3	0	85.2	502
Panel D: *Geography*					
Defense line	0.10	0.30	0	1	172
Grain suitability index (wheat, rye, oats)	5 160	1 243	0	6 492	172
Average annual temperature, Celsius	4.2	1.6	-3.8	6.8	172
Temperature seasonality, Celsius	10.4	0.8	8.8	12.6	172
Precipitation (annual), mm	591.1	46.4	478.7	703.7	172
Precipitation seasonality, mm	31.5	3.3	21.3	38.6	172
Terrain ruggedness index	31.8	11.5	9.8	71.7	172
Volga river	0.13	0.33	0	1	172
Distance to Moscow, km	437.3	273.6	14.6	1571.6	172

Notes: The unit of observation is district (*uezd*). For data sources see Table A2.

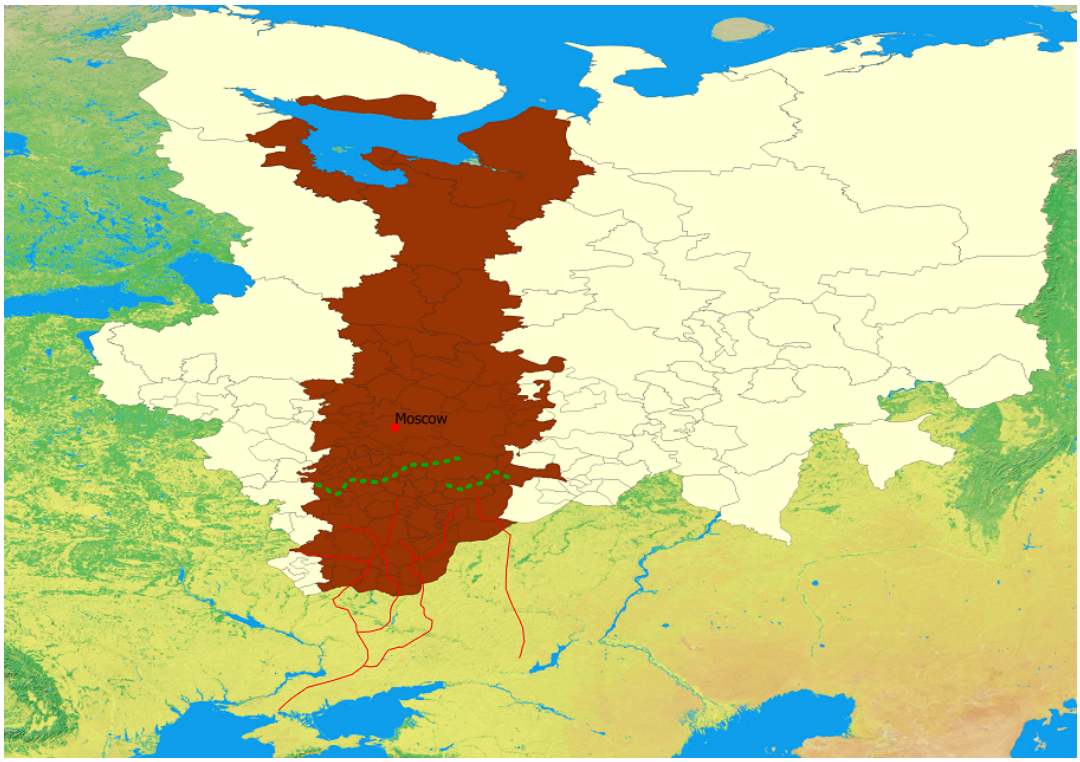
Table A2: Data sources

Variable	Source
	Panel A: *Population in 1678*
Private peasants	Vodarskiy (1977), Appendices 5–9, pages 221–231, row 2
Serfs and other private peasant types	Beskrovniy, Vodarskiy and Kabuzan (1972), Volume 1, pages 60–80
Church peasants	Vodarskiy (1977), Appendices 5–9, pages 221–231, row 5
Royal peasants	Vodarskiy (1977), Appendices 5–9, pages 221–231, row 8
Free peasants	Vodarskiy (1977), Appendix 9, pages 230–231, row 14
Odnodvortzy	Vodarskiy (1977), Table 19, pages 105–107, column 3
Non-Russian peasants	Vodarskiy (1977), Table 20, page 110, column 3
Merchants and artisans	Vodarskiy (1966), Appendix, pages 282–290, column 9
State officials	Vodarskiy (1966), Appendix, pages 282–290, column 11
Other citizens	Vodarskiy (1966), Appendix, pages 282–290, column 13
Other groups (raznochintzy, etc.)	Beskrovniy, Vodarskiy and Kabuzan (1972), Volume 1, pages 60–80
	Panel B: *Estates and landholders in 1678–1700*
Number of estates (total)	Vodarskiy and Shvatchenko (1989), Table 5, pages 96–103, column 2
Number of estates by peasant households	Vodarskiy and Shvatchenko (1989), Table 5, pages 96–103, columns 4, 6, 8, 10, 12
Number of military landholders	Vodarskiy and Shvatchenko (1989), Appendix, Table 2, pages 123–126, column 5
	Panel C: *Serfs in 1719, 1795 and 1858*
Serfs (private peasants) in 1719	Vodarskiy (1977), Appendices 5–9, pages 221–231, row 3
Serfs (private peasants) in 1795	Beskrovniy, Vodarskiy and Kabuzan (1972), Volume 5
Serfs (private peasants) in 1858	Buggle and Nafziger (2021)
	Panel D: *Geography*
GIS map of districts in 1678	Frolov and Golubinskiy (2017) with checks from Vodarskiy (1977)
GIS map of districts in 1858	Kessler and Markevich (2020)
Temperature and precipitation	Fick and Hijmans (2017)
Agricultural suitability indexes	Galor and Özak (2016)
Terrain ruggedness and land cover	Shaver, Carter and Shawa (2019)

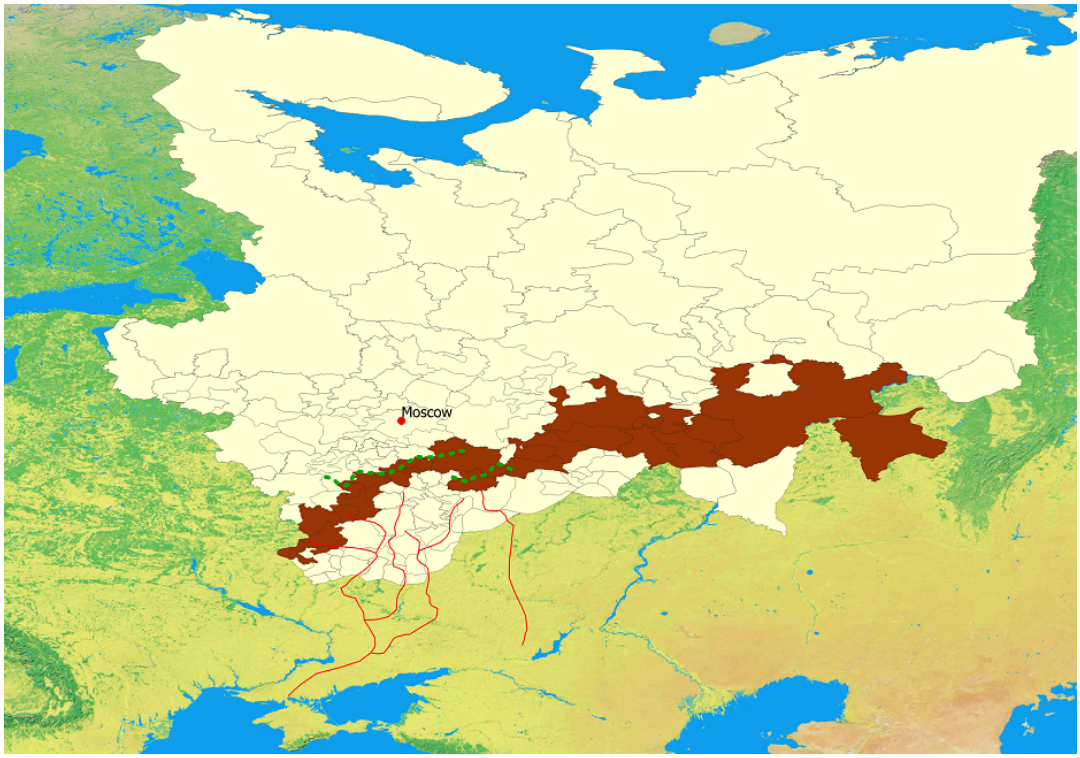
Table A3: Estate size on placebo defense lines (OLS regressions)

	(1)	(2)	(3)	(4)	(5)	(6)
	Number of estates per 100 sq. km,					
	total	1-5 peasant households	6-25 peasant households	26-125 peasant households	126-250 peasant households	251-500 peasant households
Placebo line, North	-0.17	-0.15	-0.15	0.04	0.08***	0.00*
	(0.34)	(0.18)	(0.18)	(0.03)	(0.01)	(0.00)
R^2	0.36	0.38	0.35	0.24	0.11	0.19
Placebo line, South	-1.87**	-1.03***	-0.70*	-0.14**	-0.00	-0.00
	(0.60)	(0.28)	(0.30)	(0.05)	(0.02)	(0.00)
R^2	0.38	0.40	0.36	0.25	0.07	0.18
Placebo line, East	0.11	0.03	0.04	0.04	-0.00	0.00
	(0.84)	(0.46)	(0.31)	(0.10)	(0.02)	(0.00)
R^2	0.36	0.38	0.35	0.24	0.07	0.19
Placebo line, West	0.68	0.30	0.34	0.05	0.00	-0.00
	(0.62)	(0.33)	(0.24)	(0.08)	(0.01)	(0.00)
R^2	0.36	0.38	0.35	0.24	0.07	0.18
Full set of controls	✓	✓	✓	✓	✓	✓
Region fixed effects	✓	✓	✓	✓	✓	✓
Observations	170	170	170	170	170	170

Notes: The dependent variable in column (1) is the absolute number of landholding estates (*pomest'e*) in a district; in columns (2)-(6) the absolute number of landholding estates of a particular size in terms of peasant households. The unit of observation is district (*uezd*). Full set of controls include the same variables as in Table 2. Region fixed effects are dummies for large geographical areas: Center (n=49), Black Earth (n=57), East and South-East (n=30), North and North-East (n=22), West and North-West (n=14). Constants are estimated but not reported. Robust standard errors are clustered within provinces delineated after the 1708 administrative reform, and reported in parentheses.
* p<0.10, ** p<0.05, *** p<0.01.



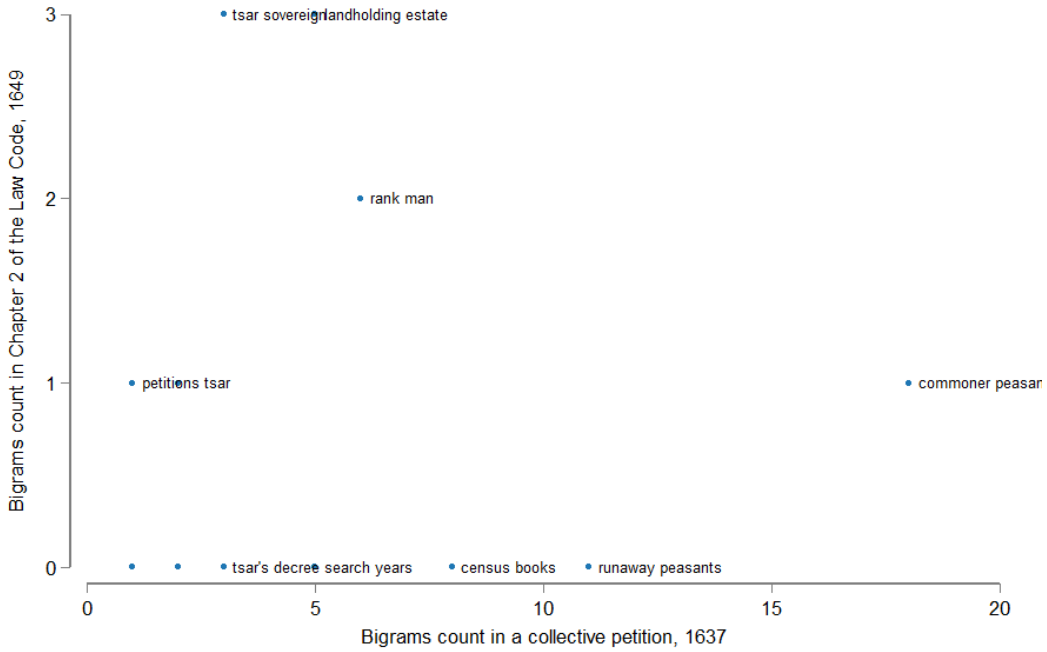
(a) Invasion trail districts



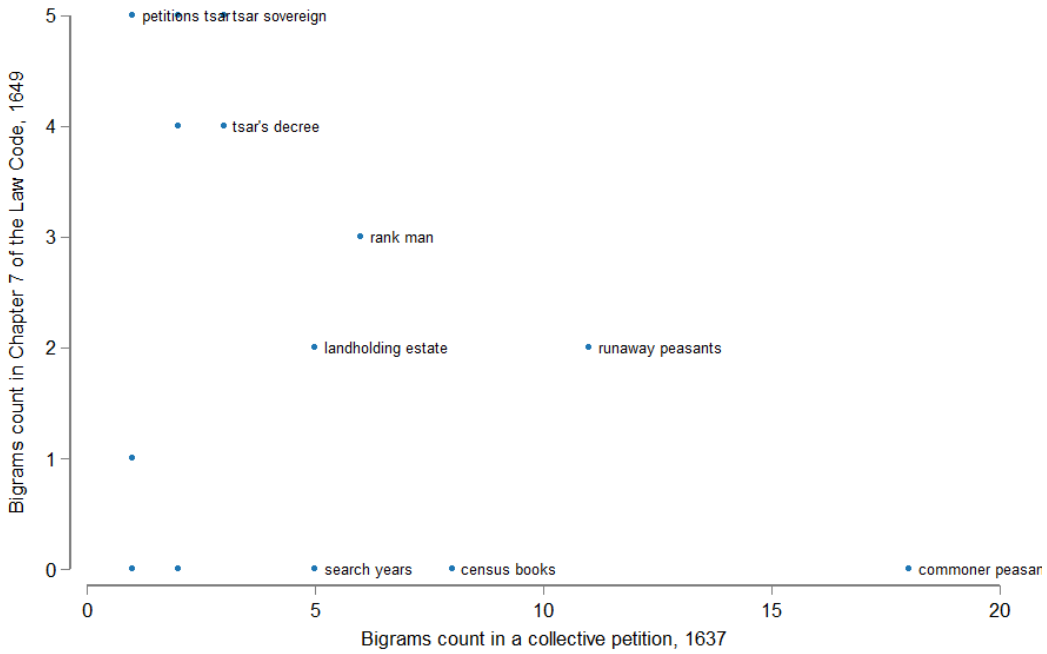
(b) Forest-steppe boundary districts

Figure A1: Invasion trail and forest-steppe boundary

Notes: Dark districts are (a) the invasion trail and (b) forest-steppe boundary. Green dashed lines represent the Tula defense line. Red lines are the nomads' invasion routes.



(a) Chapter 2. "The Sovereign's honor, and how to safeguard His Royal Well-being"



(b) Chapter 7. "Service of various military personnel of Muscovy"

Figure A2: Bigrams count in the 1637 petition and chapters of the Law Code of 1649

Notes: Chapter 2 of the Code titled "The Sovereign's honor, and how to safeguard His Royal Well-being". Chapter 7 of the Code regulated the rights of military servicemen. The collective petition was retrieved from the archive and published by Smirnov (1915); the Law Code was published in Tikhomirov and Epifanov (1961). See also Man'kov (1980) for qualitative evidence in support of the same conclusion.