CONTAGIOUS COERCION: THE EFFECT OF PLAGUES ON SERFDOM IN THE BALTICS

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WORKING PAPER N°2023/23

NOVEMBER 2023

WORLD INEQUALITY LAB

Contagious coercion: The effect of plagues on serfdom in the Baltics

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October 9, 2023

Abstract

Labor scarcity is the main hypothesized determinant of labor coercion (Domar, 1970), however, its effects are theoretically ambiguous and remain empirically untested. This paper provides the first causal estimate of the effect of labor scarcity on labor coercion. I obtain quasi-exogenous variation in labor scarcity from immense spatial dispersion in deaths from three plagues in the Baltics (1605-6, 1657, 1710-2), which I show is uncorrelated to a host of local, pre-plague characteristics. To measure the intensity of labor coercion, I hand-collect thousands of serf labor contracts in Estonia, which capture the work obligations of serfs. I find that labor scarcity substantially increases coercion à la Domar (1970). Investigating mechanisms, I find that this effect is enhanced by the lack of outside options and increased labor monopsony power, in line with theoretical models. Investigating the consequences of (labor-scarcity instrumented) coercion, I find negative effects on education and increased migration. Taken together, these findings highlight the conditions under which labor scarcity raises coercion and provide suggestive evidence of why it does not in other cases (e.g., in Western Europe following the Black Death).

Keywords: labor coercion, pandemics, plague, Domar, outside options

*I am very grateful to my advisor, Thomas Piketty, and committee members, Sheilagh Ogilvie and Katia Zhuravskaya. I also thank Ed Glaeser, Kersti Lust, Andrejs Plakans, Marten Seppel, and seminar participants at Harvard, LSE, Princeton, and PSE. I am indebted to the staff at the National Archives of Estonia for answering my numerous queries.

1 Introduction

Many employment relationships, past and present, are shaped by coercion. As of 2021, at least 27.6 million people are in forced labor, a number that rose by 2.7 million from 2016 (ILO, 2022).[1] Theories of forced labor view the marginal product of labor (MPL) as the main determinant of the levels of coercion. In this literature, labor scarcity is the most commonly mentioned driver of the MPL[2] and, thus, coercion:

> "A major question in the economics of coercion, both from a historical perspective and for understanding the continued prevalence of forced labor today, is the effect of labor scarcity on coercion." – Acemoglu and Wolitzky (2011, p. 587)

This hypothesized role of labor scarcity can be traced back to Domar's (1970) famous thesis that the population losses of the Black Death (1346-53) were responsible for the subsequent intensification of serfdom, the so-called Second Serfdom, in eastern Europe. His theory was criticized by Brenner (1976), who noted that for a comparable share of plague deaths, post-Black Death western Europe experienced a decline in labor coercion. This suggests that the effects of labor scarcity on coercion are ambiguous. Acemoglu and Wolitzky (2011) reconcile these differential responses of coercion to labor scarcity in a theoretical model by introducing outside options in an urban sector. When an urban sector provides significant outside options, rural landlords face competition following labor shortages and need to decrease the levels of coercion. This is argued to have occurred in post-plague Western Europe with its larger and more 'free' cities. On the contrary, such offsetting forces were less pronounced in Eastern Europe, where cities were fewer and smaller, resulting in an increase in coercion.

This paper provides the first causal evidence of the effect of labor scarcity on the intensity of coercion, also focusing on channels, including outside options. To this end, I hand-collect thousands of archival documents on the coercion intensity of serfs in Estonia for a panel of manors from 1590 to 1884 and leverage three plagues (1605-6, 1657, 1710-2) which create highly spatially varied labor scarcity. I demonstrate that, based on a

[1] This estimate should be understood as a lower bound. The actual number is likely to be significantly higher (ILO, 2022).

[2] Trades, specifically the prices of exports are another determinant of the MPL and coercion (see e.g. Saleh, 2022).

host of covariates, plague deaths are quasi-random at the local level.[3] As a result, plagues, through their impact on labor scarcity, allow me to elicit the causal effects of labor scarcity on coercion. This exogenous variation in the levels of coercion induced by plague also allows me to study the causal effects of coercion on a number of outcomes, before and after the abolition of serfdom in 1816-19.

Estonia is an ideal (and understudied) setting, given its unparalleled and reliable documentation of both plagues and serfdom. Many of the data collection practices also remained in place after the abolition of serfdom, given that the ruling, Baltic-German, elite remained powerful. Additionally, plague deaths exhibit immense spatial heterogeneity in an otherwise fairly homogeneous territory that has common institutions.

Related literature. This paper relates to three main strands of literature.

First, it contributes to the literature on the causes of coercion. As mentioned, this literature usually considers factors that influence the MPL, such as labor scarcity (Domar, 1970; Klein and Ogilvie, 2019) but also trade (Saleh, 2022). Outside options, i.e., sectors competing with the coercive sector, are important in that they dampen or even reverse the influence of labor scarcity (Acemoglu and Wolitzky, 2011; Brenner, 1976; Dippel et al., 2020).[4] To the best of my knowledge, this paper is the first to causally test the effect of labor scarcity on forced labor. I also contribute by studying the intensive margin of coercion and by highlighting the channels through which this relationship arises.[5]

Second, with my focus on plagues as shifters of labor scarcity, I contribute to the growing literature on the effects of plagues and pandemics (for a recent summary, see Alfani, 2022; Jedwab et al., 2022).[6] While there is no clear consensus, most studies point toward the positive effects of pandemics on a variety of outcomes. This paper introduces coercion as a consequence of pandemics and, by also documenting the adverse effects of coercion on a number of outcomes, contributes to a less optimistic view of the effects of pandemics. This finding is also important for unified growth models (Galor, 2011), which

[3] This is consistent with the fact that "there are no natural foci of the plague in the territory of Estonia" (Jõgiste et al., 2004, p.467), which would otherwise drive spatial clustering. Likely, there was an "extra-European reservoir [that was] feeding plague into Western Europe in multiple waves" (Guellil et al., 2020, p.28328).

[4] A recent literature in labor economics (Caldwell and Harmon, 2019; Jäger et al., 2022; Schubert et al., 2021) shows that outside options also today are important determinants of employee wages.

[5] Most closely related is the work by Klein and Ogilvie (2019) showing that there is a strong association between the land-labor ratio and coercion in a cross section of Bohemian villages.

[6] The effects of labor scarcity have also been applied to non-European contexts, e.g., Sellars and Alix-Garcia (2018) finds that disease-induced population losses result in higher land concentration.

usually assume that wages *rise* following pandemics. In these models, these temporary surpluses for workers are important for growth. In contrast, my findings suggest a rise in coercion, i.e., a decline in wages, in Eastern Europe after pandemics, which may explain why its growth fell behind that of Western Europe.

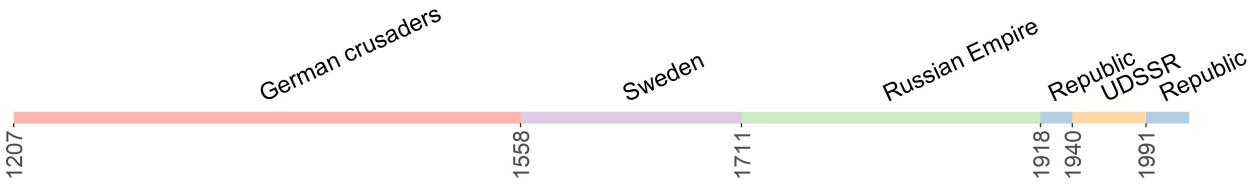
Third, this paper contributes to the literature on the consequences of forced labor. This literature largely finds negative effects of forced labor on education, wealth, health, infrastructure, and industrialization (Ashraf et al., 2022; Bobonis and Morrow, 2014; Buggle and Nafziger, 2021; Dell, 2010; Lowes and Montero, 2021; Markevich and Zhuravskaya, 2018; Nunn, 2008; Nunn and Wantchekon, 2011).[7] My findings highlight the negative effects of serfdom intensity on education and trust and provide a detailed analysis of channels, including migration that was strictly banned under serfdom and legalized with its abolition. Migration is a channel that has previously been overlooked in the literature (Carpio and Guerrero, 2021). When considering the post-abolition short-run, I document a worsening of conditions after abolition, echoing, for example, the US after the Jim Crow laws (Althoff and Reichardt, 2022).

Outline. This paper proceeds as follows. Section 2 provides background information on serfdom in the Baltics. Section 3 details the numerous archival data that were collected for this research. Section 4 provides the empirical strategy, which also establishes the locally quasi-exogenous nature of the plagues. Section 5 presents the findings. Section 6 concludes.

[7] A few studies also report positive long-run developmental outcomes resulting from historical forced labor regimes. This can be the case when the product produced by coercion requires upgrading of infrastructure (Dell and Olken, 2020) or when coercers face competition (Méndez and Van Patten, 2022)

2 Historical background: serfdom & plagues

Figure 1: Rulers of Estonia, 1207-today



Notes: Baltic Germans, the descendants of German crusaders, concentrated most power and wealth in Estonia despite changing rulers. During the first Estonian Republic in 1919, Baltic Germans were largely expropriated and in 1945 all Baltic Germans were expelled.

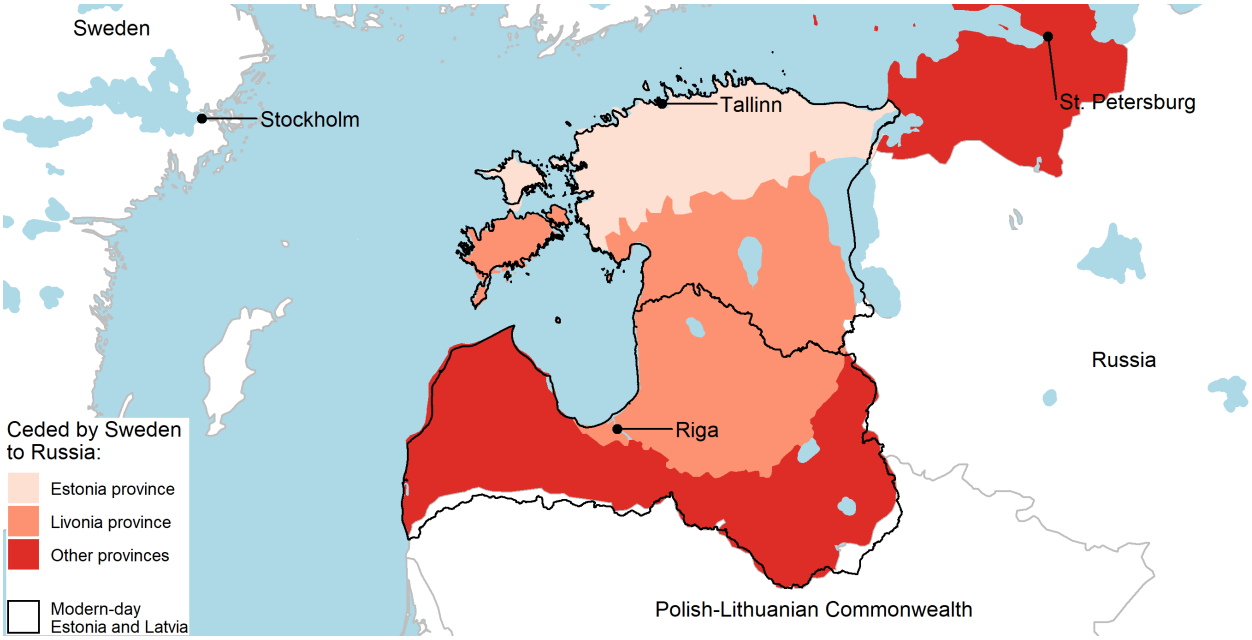
Estonians, a Finnic ethnic group, have inhabited present-day Estonia and surrounding areas for thousands of years. Starting with the conquest of crusaders from Denmark and the Holy Roman Empire between 1208 and 1227, Estonia was ruled by a series of foreign powers (Figure 1). The Danish possessions were sold to the Teutonic Order in 1346, which was made up of the successors of the German crusaders (who referred to themselves as *Baltic Germans*). In 1558, the north of present-day Estonia, then called the province of Estonia, fell to Sweden, following an unsuccessful Russian invasion. The south of present-day Estonia fell to Poland.[8] In 1625 and 1645, Sweden annexed all of modern-day Estonia as well as northern modern-day Latvia. In 1710, Russia's ambition to conquer the Baltics was ultimately successful following its victory in the Great North War. The aforementioned division into provinces (Estonia and Livonia), now called governorates, was maintained (Figure 2).

Throughout these changing rulers, the Baltic Germans remained the de-facto administrators and dominant landholders for more than 700 years until their partial expropriation in 1919 due to a land reform and ultimate complete expulsion in 1945 (Raun, 2002). They retained this powerful position despite weakening ties to the German lands and their small numbers: In the late 17th century, they made up only 3 to 4% of the population and were heavily concentrated in towns (forming 40 to 60% of the urban population).[9] By contrast, Estonians comprised 90% of the population and 95 to 99% in rural areas. Among

[8]The south then formed the northern part of the province of Livonia (see Figure 2). In 1559, Saaremaa, the largest island in Estonia, was sold to Denmark.

[9]The number of other nationalities was small in Estonia, about 2% were Swedish and 0.5% Russian. Baltic Germans made up almost all the nobility and clergy, which amounted to 1.5% of the total population (Palli, 1993).

Figure 2: The Baltics following the Great Northern War (1700-21)



Notes: I focus on the territory of present-day Estonia, which, until 1918, was divided in the province of Estonia and the northern part of the province of Livonia. Present-day Estonia, Latvia, and the surroundings of St. Petersburg were ceded by Sweden to Russia following its defeat in the Great Northern War (1700-21).

the Estonian peasantry, 75% were farmers and their families, 20% were farmhands, and 5% manor staff (Palli, 1993). In related work (Raster, 2023), I show how this resulted in an extreme concentration of wealth among Baltic German individuals and families that persisted even after the abolition of serfdom.

2.1 Serfdom

Estonians did not surrender unconditionally during the 12th century crusades; initially, they made contracts with the crusaders and kept their right of free movement and the ownership of their land, including the right to hand it down to their offspring (Wittram, 1954). Estonians had to work a moderate number of corvée days, about 2 days a week per serf household, and they had to pay tithe and taxes. In-kind dues consistent mainly of grain, which already during those years was an important export product. In contrast to the German colonization of other parts of Eastern Europe, only German clergy and nobility migrated to Estonia. The absence of a German peasantry prevented assim-

ilation with native Estonians.[10] Baltic Germans established a stark delineation between themselves and the native Estonians and discriminated against them in numerous ways (Zimmermann-Schulze, 2004).

Conditions for Estonians worsened in the 14th and 15th centuries as part of a general 'crisis of free movement' across Eastern Europe. Estonians were stripped of their right to own land and to freely move. Weekly average corvée days increased to multiple days a week. On the manor, the lord could not only set labor and other dues, but would also act as the judge in local courts. To summarize, "serfdom began in the second half of the fourteenth century, grew markedly in the fifteenth, reached near completion in the sixteenth century, and received juridical confirmation in the seventeenth century" (Raun, 2002, p.20).[11]

Estonian serfs fought back on multiple occasions in response to the high number of corvée days. In 1558, when the Teutonic Order had collapsed following a Russian invasion, a rebellion was launched on the grounds that the Baltic Germans had not provided protection against the invaders. This rebellion, like others before and after it, was unsuccessful. More so, the new Swedish overlords, who had pushed back the Russians and annexed Estonia, confirmed the privileges of the Baltic German nobility. Specifically, Baltic Germans maintained the right to their Protestant faith, to their land laws, their use of German as the official language, and to self-administration. Therefore, the conditions of the serfs did not improve. However, in need of money after the war, the Swedish Crown expropriated a large number of manors, transferring their ownership from Baltic German to Swedish nobility between 1641 and the 1680s.[12] In practice, many of those expropriated manors were still administered by Baltic Germans, and the conditions of serfs did not improve. The Swedish crown had a profound distaste for serfdom, which did not exist in Sweden proper, and was appalled by the conditions of Estonian serfs, but Baltic Germans successfully resisted the attempts of the Swedish Crown to abolish serfdom. When planning to abolish serfdom, Swedish administrators mandated precise documentation of land allotment and serfs' dues, creating an invaluable resource, the so-called *Wacken-*

[10]The reasons for why German peasants did not migrate to Estonia include the large distance that included crossing the Baltic Sea, poor soils, harsh climate, and a lack of cleared woodland. In contrast, Prussia, another German colony at the time, had much more favorable conditions.

[11]The reformation that began in the 1520s did not challenge the relationship between Estonians and Baltic Germans and Estonians had to follow their lords in converting to the new religion. The reformation did, however, lead to the first publications in Estonians and a slow expansion of the school system.

[12]In total, half of the manors were expropriated in the Province of Estonia, a quarter on the island of Saaremaa, and 84% in the Province of Livonia.

bücher, that makes this research possible. In 1696, 1025 manors were mentioned on the territory of present-day Estonia.

When Russia conquered Estonia and neighboring areas during the Great Northern War (1700-21), the expropriation of Baltic Germans was reversed entirely. Unlike in Sweden, serfdom was very common in the Russian Empire. The Baltic Germans obtained provincial self-governing rights. The Russian conquest was accompanied by an extremely deadly plague wave that decimated the population of the Baltics (see the next Section 2.2). Serfdom intensified under the Russian ruler. Labor days are said to have increased further, leaving serfs with too little time (and energy) to work in their own fields, which they relied on for subsistence farming.

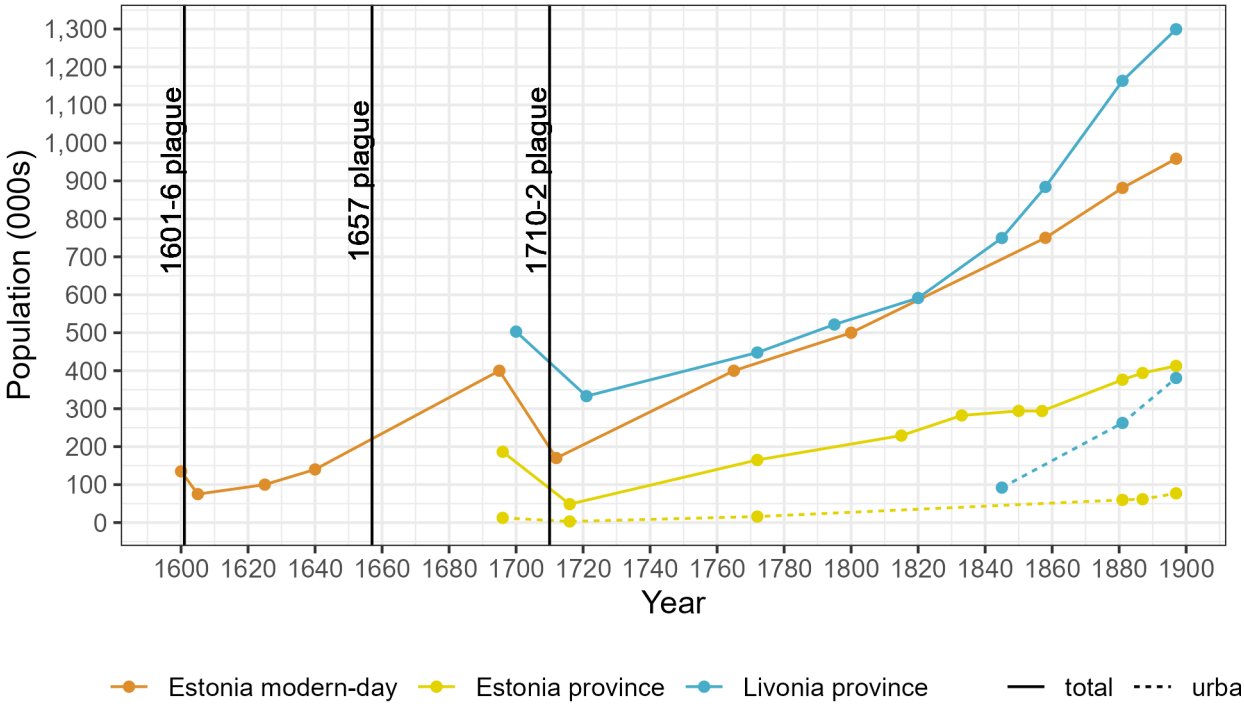
In the latter half of the 18th century, some Baltic Germans changed their views of serfdom and their treatment of native Estonians. Enlightenment ideas were spreading with the immigration of young scholars from the German lands. These young scholars worked with Estonians as pastors and learned Estonian. A long struggle ensued with the Baltic German manor lords. Reforms were passed in the *Landtag*, the Baltic German parliament that had existed since medieval times. Ultimately, serfdom was abolished in 1816 in the governorate of Estonia and in 1819 in the governorate of Livonia in one of the rare abolitions that were led by the landowner elites. The abolition of serfdom in the Baltic was the first abolition in the Russian Empire and the only one before the general abolition in 1861. One should, however, be skeptical of altruistic motives among the Baltic German *Landtag*'s decision to abolish serfdom. Serf revolts preceded reforms and abolition, and it was generally agreed that agricultural reforms were needed. The post-abolition experience is perhaps the best testament to the ulterior motives of Baltic German elites for the abolition of serfdom. It is generally noted that the decades following abolition were marked by a decline in the living standards of the former serfs. This can be explained by the fact that the abolition did not outlaw the much-despised labor dues. It only legalized internal migration (requiring registration with the police) and the ownership of land for Estonians. In practice, manor lords evicted many peasants, and, due to a lack of money, the landownership among Estonians only rose extremely slowly (see Appendix Figure D.2). Labor dues were finally outlawed in 1849 in Livonia and in 1856 in Estonia.

Given this description of serfdom in Estonia, what are the predicted effects of labor scarcity on its intensity? In Acemoglu and Wolitzky's (2011) framework, this depends on the availability of outside options. In Estonia under serfdom and even in the aftermath of its abolition, many factors severely restrict outside options. As mentioned, Baltic

Germans established a strict ethnic and linguistic divide between them and Estonians, making it easier to discern serfs from non-serfs. Baltic Germans also heavily controlled access to cities and collaborated in returning runaway serfs. As a result, labor scarcity can be expected to, on average,*increase* coercion intensity in Estonia in line with Domar (1970). Qualitative evidence supports this hypothesis. Bērziņš (1935, p.167) notes that the plague led to an increase in the intensity of serfdom or even "a situation that can be called de facto slavery". Sievers (1970) relates the intensification of post-1710-2 plague serfdom to manor lords' desire to compensate for the revenue lost due to plague deaths among serfs.

2.2 Plagues

Figure 3: Population of Estonia, 1696-1900



Sources: Hupel (1777); Jordan (1886, 1889); Palli (2004); Pankratov et al. (2020); Plakans (2011); `demoscope.ru`. For individual town population trajectories and sources, see Appendix Figure D.1.
Notes: Vertical lines denote plagues. Following the 1601-6 plague, the Estonian population (modern-day territory) decreased by 44% from 135,000 to 75,000. After the 1710-2 plague, it decreased by 57% from 400,000 to 170,000.

Deadly epidemics were commonplace in medieval and early-modern societies (Voigtländer and Voth, 2013), including the plague which was caused by the bacteria *Yersinia pestis*. In contrast to medieval and even earlier times when isolated large plague waves occurred, notably the Black Death (1346-53), by the 17th and 18th centuries the plague had become endemic across Europe.[13] In Estonia, major outbreaks of the plague occurred in 1211-12, 1532, 1549-53, 1565-80, 1601-6, 1657, and 1710-2 (Frandsen, 2010; Jõgiste et al., 2004; Oja, 1996; Winkler, 1907).[14] Given that data on the coercion intensity of serfs is available from 1624 onwards, I focus on the last three of these plague outbreaks (1605-6, 1657, and 1710-2). No plague occurred after 1712 (Frandsen, 2010). Each of the three plagues accompanied a war. The 1601-6 plague occurred during the Polish–Swedish War (1600–1611) over control of Livonia and Estonia. The 1657 plague accompanied the Second Northern War (1655-60) between Sweden and the allied Polish-Lithuanian Commonwealth and Russia (Winkler, 1907). The extremely deadly 1710-2 plague was initially spread in the Baltics by troops of the Great Northern War (1700-21), in which an alliance led by Sweden fought a coalition headed by Russia.

The impact of the plagues is clearly visible in Estonia's aggregate population figures. Figure 3 shows that the 1605-6 plague was associated with a 44% drop. No estimates of the total population are available in the immediate aftermath of the 1657 plague, but my estimates of population changes on manor and qualitative sources (Winkler, 1907) suggest many deaths. The 1710-2 plague was by far the deadliest, killing an estimated 57% of the population. In the province of Estonia, roughly the northern half of modern-day Estonia, mortality was even higher at 74%. Such high mortality rates are "outnumbering even those of the Black Death" (Keller et al., 2022, p.1). The deadliness of Estonia's 1710-2 plague can likely be explained by human-to-human (pneumonic) transmission that took place in addition to the more common transmission through the rat flea (Schofield, 2016).[15] Important for serfs' outside options, Estonian towns were hit to a comparable extent as rural areas (see Appendix Figure D.1). Overall, it took more than 60 years, until 1772, before the total population recovered to pre-1710-2 plague levels.[16] The three separate plague outbreaks I study (1605-6, 1657, 1710-2) differ in their aggregate mortality rates. This allows me to test Domar's (1970) thesis for a plague that has

[13] As mentioned, there likely was an extra-European reservoir that fed the plague into Europe (Guellil et al., 2020).

[14] It is unclear whether the 6th century Justinian Plague and the Black Death reached Estonia (Jõgiste et al., 2004).

[15] This would be an indication for a pneumonic plague that is even more deadly than the bubonic plague.

[16] Birth rates increased following plagues (Palli, 1983).

mortality rates comparable to those of the Black Death, such as the 1710-2 plague, and for plagues with lower mortality rates (1605-6, 1657). Additionally, the wars that raged during those plagues also differed, with the Great Northern War (1700-2) that caused the initial spread of the 1710-2 plague resulting in Russian rule over Estonia. As I will show, all plagues increase coercion consistent with Domar (1970), although to different degrees.

How did the population respond to such frequent plagues? The only theoretically effective measure against plagues was the passing of plague ordinances (*Pestordnungen*), which mandated quarantine for the sick, lockdowns, border and market closures, among other measures (Hormuth, 2018). However, such measures were hardly effective in the case of Estonia (Winkler, 1907). Due to low compliance with quarantining measures and the immense speed at which plagues spread (the speed of a horse rider), the spread of the plagues was unmitigated (Jordan, 1880). Contemporary witnesses were baffled by the great degree of variation in deaths that were recognizable even between neighboring manors (Bērziņš, 1935).[17] I confirm this local quasi-randomness in my empirical strategy (Section 4) by showing that none of the numerous covariates systematically explain plague deaths at the manor level.

3 Data

I digitize and transcribe a wealth of primary data from archives in Estonia, Latvia, Sweden, and Russia. Additionally, I collected and synthesized (statistical) information from a large number of secondary sources. Figure 4 gives a schematic overview of the collected data. The precise sources are listed in Appendix Table F.1. In the following, I discuss the data on coercion (Section 3.1), plague deaths (Section 3.2), several consequences of coercion (Section 3.3), and additional data (Section 3.4).

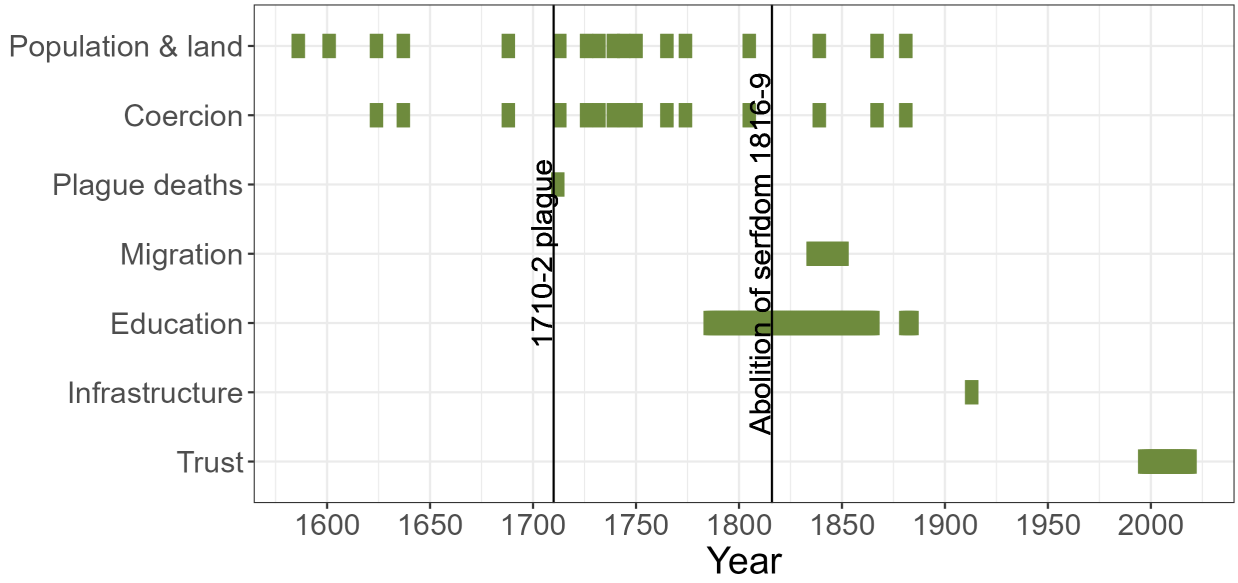
3.1 Coercion intensity – the *Wackenbücher*

Labor coercion is the main outcome variable in this paper. Crucially, I am able to capture the intensive margin of coercion rather than the share of serfs in the population.[18] This is

[17] Other papers have argued that the degree to which towns in the Holy Roman Empire were hit by plagues is also quasi-random (e.g. Gingerich and Vogler, 2021).

[18] The vast majority of the non-German population of the Baltics were serfs, leaving little variation on the extensive margin. Focusing on the intensive margin of labor coercion is a departure from the existing

Figure 4: Data overview



Sources: for detailed sources, see Appendix Table F.1.

made possible by an extraordinary tradition in the Baltics to draft legal contracts between serf households and lords (*Wackenbücher*) that quantify labor, in-kind, and monetary dues. First drafted in 1564 at the beginning of the Swedish rule over Estonia (Tarkiainen, 2013), the *Wackenbücher* also include extensive information on the demographic composition and farm wealth of each serf household.

Importantly, the dues set in the *Wackenbücher* are binding for both the serfs and lords and were updated in so-called revisions approximately every 15 years. This was mandated first under Swedish rule in order to prevent conflicts and, if they arise, settle them more efficiently. An additional goal of the Swedish Crown, which had a distaste for serfdom and never permitted in Sweden proper (Seppel, 2020b)[19], was to document the extent of serfdom in order to inform its decision on how to reform or even abolish it in the Baltics. However, these plans never came to fruition as plans to abolish serfdom were interrupted by Russia's annexation of the Baltics in 1710 following the Great Northern War. Several manors were nationalized by the Swedish Crown, which I explore in the analysis. Crucially, the Swedish Crown, like the later Russian rulers, never restricted or sanctioned the intensity of coercion (Seppel, 2005).

literature (e.g. Dell, 2010; Markevich and Zhuravskaya, 2018).

[19]Corveé labor, however, existed in Sweden proper (Olsson, 2006).

I transcribe numerous waves of *Wackenbücher*, prioritizing those just before and just after plagues.[20] This choice is also due to the fact that the *Wackenbücher* contain the population estimates used to measure labor scarcity and proxies for 1605-6 and 1657 plague deaths (see next Section 3.2). In total, I transcribe coercion data from *Wackenbücher* scans or reproductions of their information in secondary sources for 1637 (after the 1605-6 plague), 1688 (after the 1657 plague), 1732 (after the 1710-2 plague), and 1839.

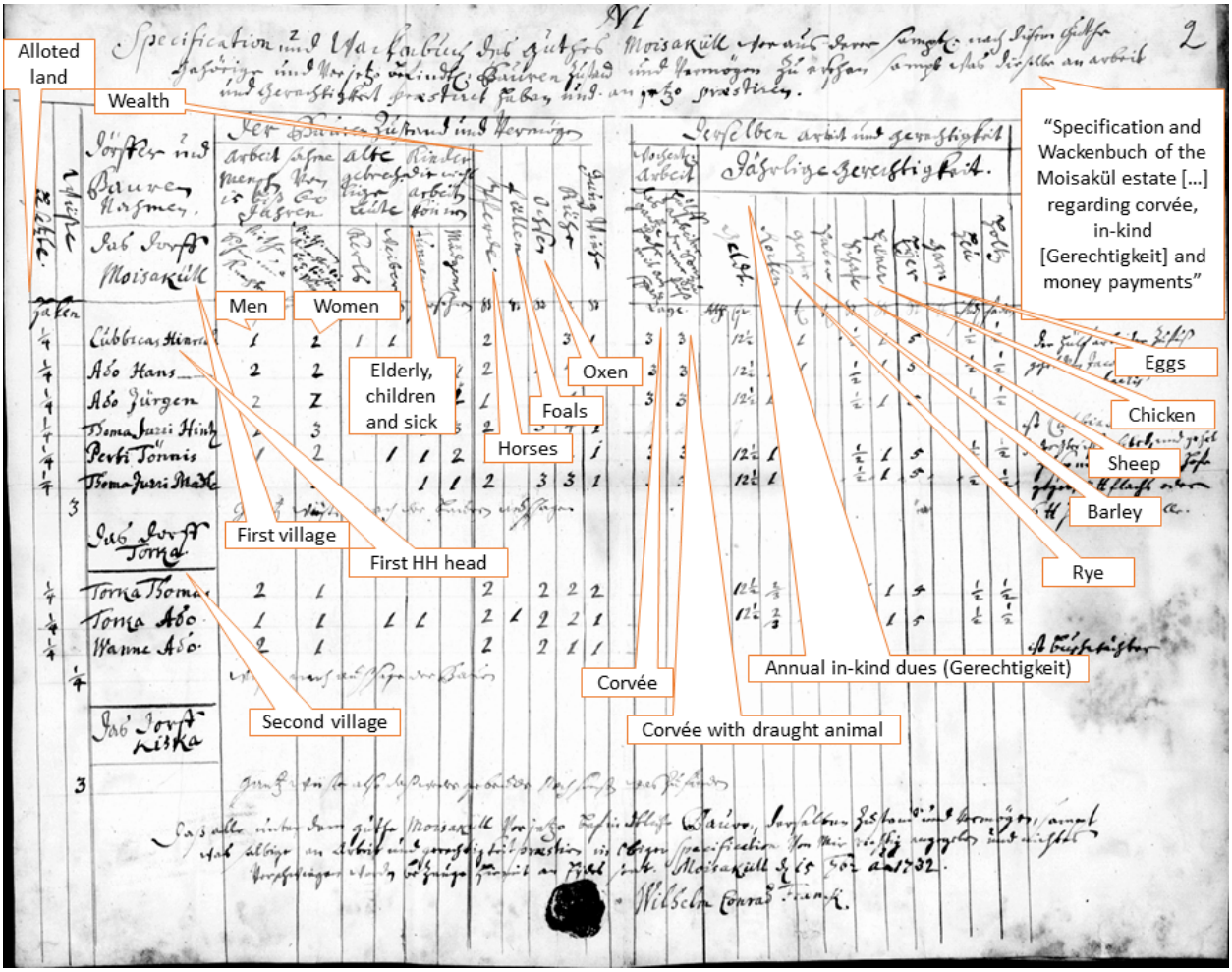
Figure 5 gives an example page of a 1732 *Wackenbuch*. Each row reports on a household of serfs. To measure the intensity of coercion, I calculate the ratio of corvée days per land unit (*Haken*). A *Haken* is a combined measure of land area and quality used in the Baltics. It approximately equaled 6 hectares of suitable land (Tarvel, 1983). each serf household between $\frac{1}{8}$ and 1 *Haken* (i.e., $\frac{3}{4}$ to 6 hectares) depending on the size of their household, with a median of $\frac{1}{2}$ or 3 hectares. Corvée days are reported at the household level in columns 15 and 16 of Figure 5. They represent the number of days per week a serf household needs to work on the Baltic-German manor owner's fields. There are two types of corvée days: those where only a worker needed to be sent (German: *Fußtage*, Column 15) and those where, in addition to the worker, a draft animal needed to be sent (German: *Spanntage*, Column 16). Although all types of corvée meant hard and coercive work, corvee days where serfs had to bring their own farm animal were viewed as more coercive. In other manors and other years, an additional, even more coercive category of corvée days existed, the so-called help days (German: *Hilfstage*). On help days, the manor lords forced serfs to harvest the lord's fields, depriving them of the opportunity to harvest their own fields. In all seasons except winter, the lord mandated that corvée days be used mainly for agricultural activities: the production of grain and flax. In winter, they were mainly used for logging, transporting goods, and making brandy (see Appendix Figure K.2 for a schematic overview)

Corvée days were proportional to the amount of land a serf household was allotted by the local Baltic-German manor lord. On their allotted land, the serfs cultivated crops for consumption and sale. The allotted land is quoted in *Haken* in Column 1 in Figure 5.

In addition to their unparalleled representation of labor dues, the *Wackenbücher* also contain other crucial information. At the beginning of a manor's entry, a short survey of the manor's general economic conditions was provided in the form of the number of mills

[20]Transcriptions of the 1732 *Wackenbücher* for the province of Estonia were kindly provided by the Estonian National Archives. This motivated the transcription of the Livonian *Wackenbücher* in 1732, in favor of a from-scratch transcription of the 1726 *Wackenbücher* of both provinces.

Figure 5: Example page from a *Wackenbuch*, 1732



Source: EAA.854.7.101 with own annotations.

Notes: The book shows for each household the name of the head, a breakdown of its members, the allotted land, and other wealth. On the right, the dues are detailed, including corvée, in-kind, and monetary payments. *Wackenbücher* were first mandated by the Swedish Crown, which was opposed to serfdom, but did not regulate it. They continued to be drafted by judges and formed basis for disputes.

and ponds and the available farm equipment. On the household level, the *Wackenbücher* recorded important demographic information: the number of adult men and women, the number of male and female elderly, and the number of farm hands and maids. Also, nonlabor dues, such as those paid in-kind or with money, were recorded. In Figure 5 these dues are reported under the heading *jährliche Gerechtigkeit*, German for annual entitlement (of the lord), in the 11 right columns. They comprise money, live animals (sheep and chicken), eggs, thread, hay, and wood. My analysis mainly focuses on labor dues given evidence that this is the margin on which coercion was increased.[21]

The corvée days per haken ratio can be understood as a coercive rent for the land that a serf household is allotted. It is identical for all serfs in a manor, reflecting the collective bargaining and contracting in the *Wackenbücher*. However, there are substantial differences between manors in the ratio of corvée days and *Haken*.

Historians have made essential contributions to our understanding of the *Wackenbücher* related sources, and Estonian serfdom (Lust, 2020; Palli, 2004; Plakans and Wetherell, 1992; Seppel, 2005, 2009; Zimmermann-Schulze, 2004). For example, Plakans and Wetherell (1992) show how serfs without land allotments were hired by those with land allotments to complete their corvée days. However, the main focus of this literature has been to follow a small number of manors over many years (Plakans and Wetherell, 1992). With this paper, I contribute a panel data set that includes the universe of documented manors and many periods.[22]

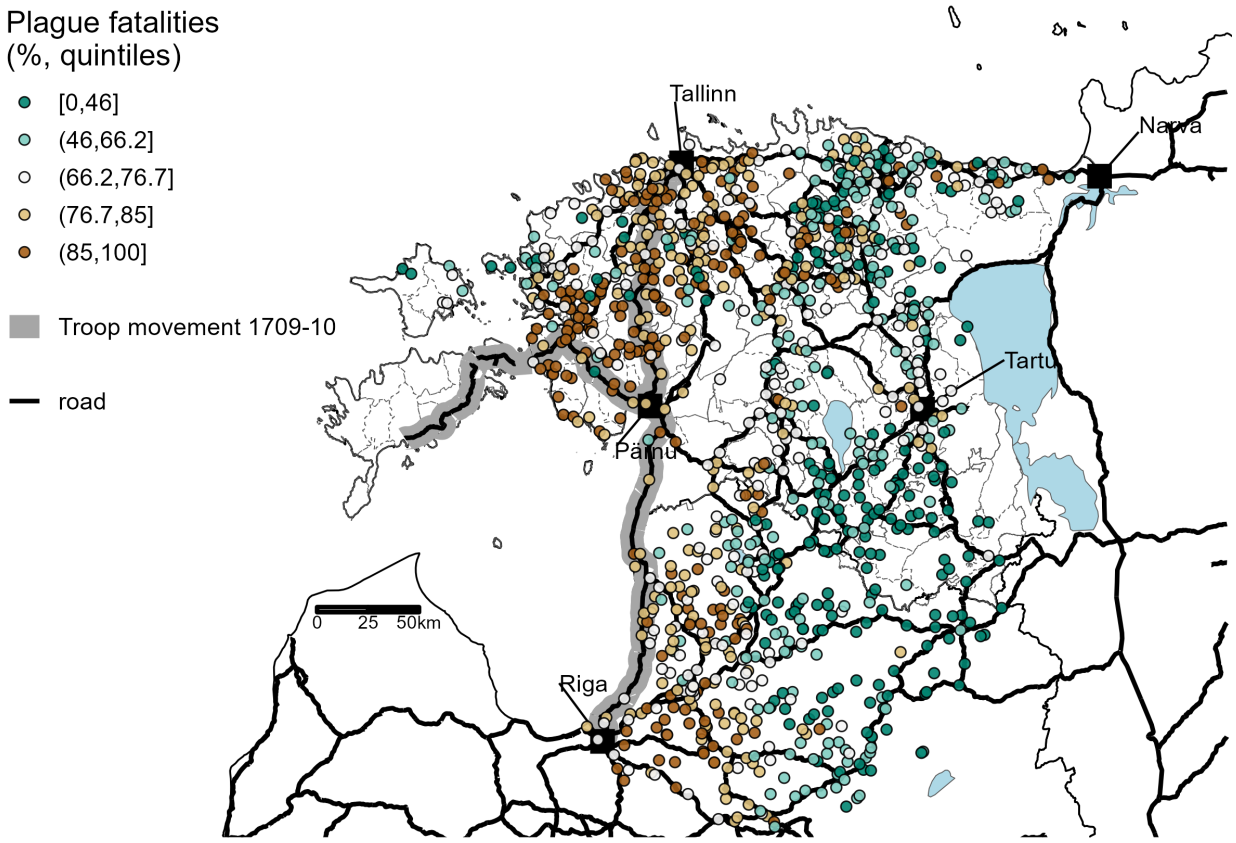
3.2 Plague deaths

Plagues are used in this research as locally-varied drivers of labor scarcity. For the three plagues considered in this research (1605-6, 1657, 1710-2), plague deaths are directly reported only for the 1710-2 plague deaths. For the first two plagues, I proxy plague deaths with the change in a manor's population as recorded in the *Wackenbücher*. In the regressions that relate coercion to the 1710-2 plague, I instrument the change in a manor population with plague deaths. For the other two plagues, I use simple OLS regressions

[21] Kahk (1999) defines the timing of the transition from manorialism to estate ownership (which included directed own production by the lord) as the moment when the amount of grain produced on the lord's fields with corvée labor exceeded the grain that was collected through in-kind dues.

[22] Coercion data has also been studied for different geographies (Dribe et al., 2012), for example corvée data in Sweden (Olsson, 2002, 2006), and serf data in Russia proper (Dennison, 2005; Nafziger, 2019; Stanziani, 2009), and Bohemia (Klein and Ogilvie, 2019).

Figure 6: Plague deaths, 1710-2



Sources: plague deaths based on hand-collected archival plague reports (see example page in Appendix Figure F.1) and secondary sources (Bērziņš, 1935; Konks, 1961); troop movement (Fainstein, 1960); roads (Holterman et al., 2022).
Notes: at manor level. Modern-day borders of Estonia and Latvia. The spread of the plague initially accompanied the movement of troops in the Great Northern War.

with the (uninstrumented) change in manor population as the main explanatory variable.

For 1710-2 plague deaths among serfs, I mainly rely on a 1712 survey of plague deaths[23] that was drafted to inform the Russian Czar about the extent to which the newly conquered territories were ravaged (Jordan, 1880). I transcribe this household-level survey from archival scans (see example page in Appendix Figure F.1). I supplement this data with additional sources (Bērziņš, 1935; Kõpp, 1929; Oja, 1996). Figure 6 maps plague deaths in Estonia and northern Latvia at the manor level. What is striking is the wide

[23] A supplement drafted in 1716 is used in some cases (see Ungern-Sternberg, 1912).

range of plague mortality rates. Some manors did not experience any plague deaths, while in others every serf died from the plague. It is apparent that there are more plague deaths in the proximity of the 1709-10 troop movement from Riga to Tallinn and from Riga across the ice to the island of Saaremaa. This troop movement represented the final stage of the Great Northern War in Estonia and culminated in the capture of Tallinn. Little actual fighting took place since the troops, both Swedish defenders and Russian attackers, themselves experienced numerous plague deaths (Kroll and Krüger, 2006).[24] In the empirical strategy (Section 4), I demonstrate that while the distance to troop movements mattered on a large scale for plague deaths, it cannot explain deaths at the local (parish) level. Similarly, revolts during the war (Fainstein, 1960) did not affect plague deaths.

Did the plague affect certain demographic groups more than others? In Appendix Figure F.2, I investigate differences in mortality based on sex, age, and whether serfs were allotted land. None of the groups experiences significantly different rates of mortality. This implies that the 1710-2 plague, unlike other plagues and pandemics, was an 'indiscriminate killer', which is consistent with qualitative evidence in Estonia (von Bruiningk, 1914) and elsewhere (Frandsen, 2010). For the purposes of this research, this implies that plagues drive overall labor scarcity, without changing the composition of the population.

3.3 Data on the consequences of coercion

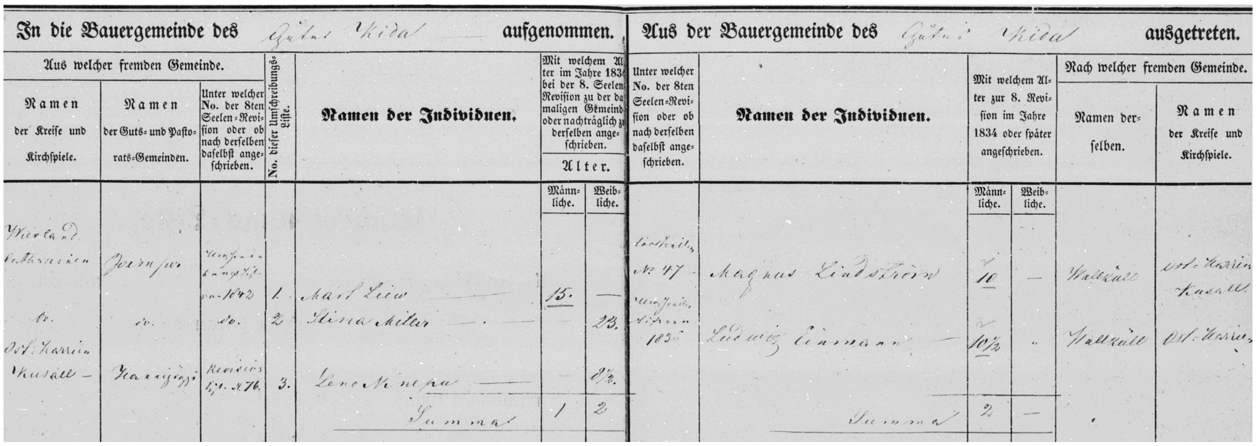
The second part of this paper is concerned with studying the effects of coercion on various developmental outcomes. To this end, I collect the following data:

- *Education* (birth cohorts: 1776-1855): data on literacy at the manor level is available starting with the birth cohort of 1776-95, which corresponds to the schooling cohort of 1786 to 1805. The data come from the Russian army, which recruited random young men among the population of the manor. The original military records were synthesized in Aarma (1990)
- *Migration* (1836-51): Internal migration was legalized with the abolition of serfdom (1816-9), however, former serfs who wanted to migrate had to register their move, both origin and destination, with the police; see the example below in Figure 7 and Appendix Table F.1. Therefore, "unlike all but a very few peasantries elsewhere, the Estonian population continued to be precisely enumerated by state authorities even

[24] The Russian troops faced no resistance in Pärnu as most Swedish soldiers had perished from the plague.

after the abolition of serfdom in 1816-1819" (Palli, 1983, p.290). I transcribe these records and obtain migration matrices between manors.

Figure 7: Migration data example, 1836


In die Bauergemeinde des ... aufgenommen. | Aus der Bauergemeinde des ... ausgetreten.

Aus welcher fremden Gemeinde.											Nach welcher fremden Gemeinde.	
Namen der Kreise und Kirchspiele.	Namen der Guts- und Pastorats-Gemeinden.	Unter welcher No. der 8ten Seelen-Revision oder ob nach derselben daselbst angeschrieben.	No. dieser Umschreibungs-Liste.	Namen der Individuen.	Mit welchem Alter im Jahre 1834 bei der 8. Seelen-Revision zu der damaligen Gemeinde oder nachträglich zu derselben angeschrieben. Alter. Männliche.	Weibliche.	Unter welcher No. der 8ten Seelen-Revision oder ob nach derselben daselbst angeschrieben.	Namen der Individuen.	Mit welchem Alter zur 8. Revision im Jahre 1834 oder später angeschrieben. Männliche.	Weibliche.	Namen derselben.	Namen der Kreise und Kirchspiele.

Source: EAA.1864.2.VIII-76.
Notes: left: 3 incoming migrants are recorded, right: 2 outgoing migrants.

- *Industry* and *infrastructure* (1909-13): Estonia experienced an industrial boom, mainly in distilling, towards the end of the 18th century and with the opening of the first railroad in 1870 (Pönicke, 1973). Conventional industrial surveys in the Russian Empire only capture the few (mainly heavy and mainly urban) industries in Estonia. As a remedy, I rely on a detailed set of address books (Richter, 1909, 1913). These books contain detailed information on the economic activities of each manor, ranging from beekeeping to distilling spirits to iron smelting. For all manors, it is reported whether they use windmills, watermills, or steam engines. The address books also report on the distance of the manor to infrastructure, such as doctors and shops.
- *Trust* (2013): Forced labor regimes have been associated with present-day trust (Nunn and Wantchekon, 2011). I provide the first evidence of the effect of serfdom on trust. I obtain access to the 2013 Estonian Social Survey (ESS, Statistics Estonia, 2019), which, as part of the EU-SILC, asks respondents how much they trust others, the political and the legal system. The data is provided with geographic identifiers at the extremely fine-grained area code level (N = 4,713); see Appendix Figure L.1. This allows for a very clean mapping from the historical manor level, at which plague deaths and coercion intensity were recorded.

3.4 Additional data

I collect numerous additional data that is used in heterogeneity analyzes and as controls.

- *Manor ownership*: Manors were owned by either nobles, the state, or the church. I code which noble family member owned a manor at a given point in time or whether it was owned by the state or the church from a variety of primary and secondary sources, see Table F.1. I also collect information on which manors were nationalized by the Swedish Crown and when they were re-privatized. The ownership data also allows me to investigate variations in serfs' outside options, which decrease when the same noble family owns multiple adjacent manors.
- *Plague deaths among manor owners*: The death of manor owners during plagues provides important insights into the effects of plagues. I match the name of the manor, collected in the above-mentioned manor ownership data, to their profiles on crowdsourced genealogy websites (mainly `geni.com`). These profiles contain the individual's vital events and death location. Due to a great interest in Baltic-German genealogy, the match rates are very high, exceeding 95%. I code owners as having died from the plague when the plague is mentioned as their cause of death of if they died within the Baltics during plague years. Plotting death years of noble owners in Appendix Figure H.1, it is clear that there were pronounced mortality peaks in plague years.

4 Empirical strategy

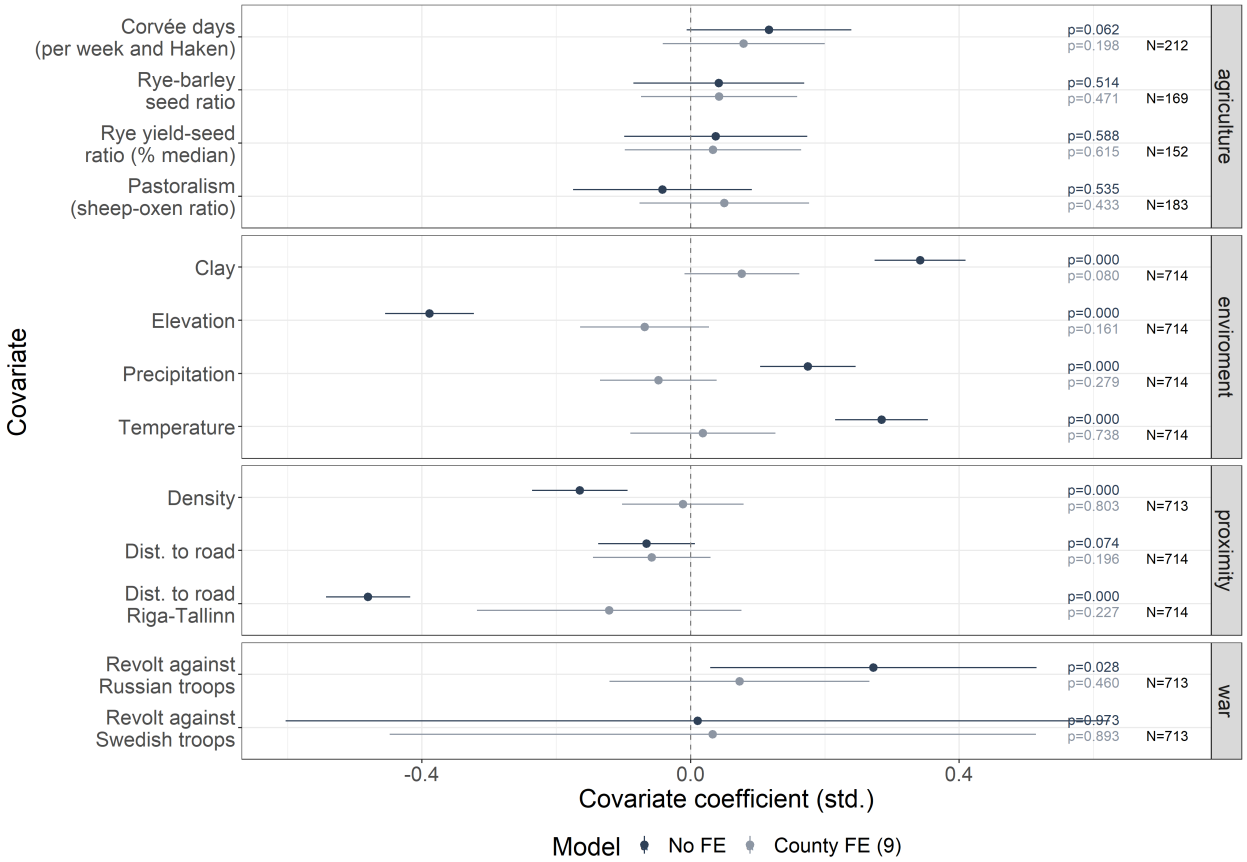
The empirical strategy relates coercion as an outcome Y to labor scarcity S and a vector of controls C for manor i in year t in an OLS specification:

$$Y_{it} = \beta_0 + \beta_1 S_{it} + \theta C'_{ict} + \epsilon_{it} \tag{1}$$

I define labor scarcity S as the negative of the growth rate of a manor's population P between periods:

$$S = -\left(\frac{P_{it} - P_{it-1}}{P_{it}}\right) \tag{2}$$

Figure 8: 1710-2 plague deaths and 1680s covariates



Sources: corvée and agriculture estimates based on 1680s *Wackenbücher*. For environmental variables, see Appendix E. Revolts based on Fainstein (1960).
Notes: Covariates are hypothesized drivers of the spread of the plague the plague (e.g. Benedictow, 2004). Most covariates appear to be balanced in the county (and municipality) FE specification. Haken≈ 6ha, avg. HH .25-.5 haken.

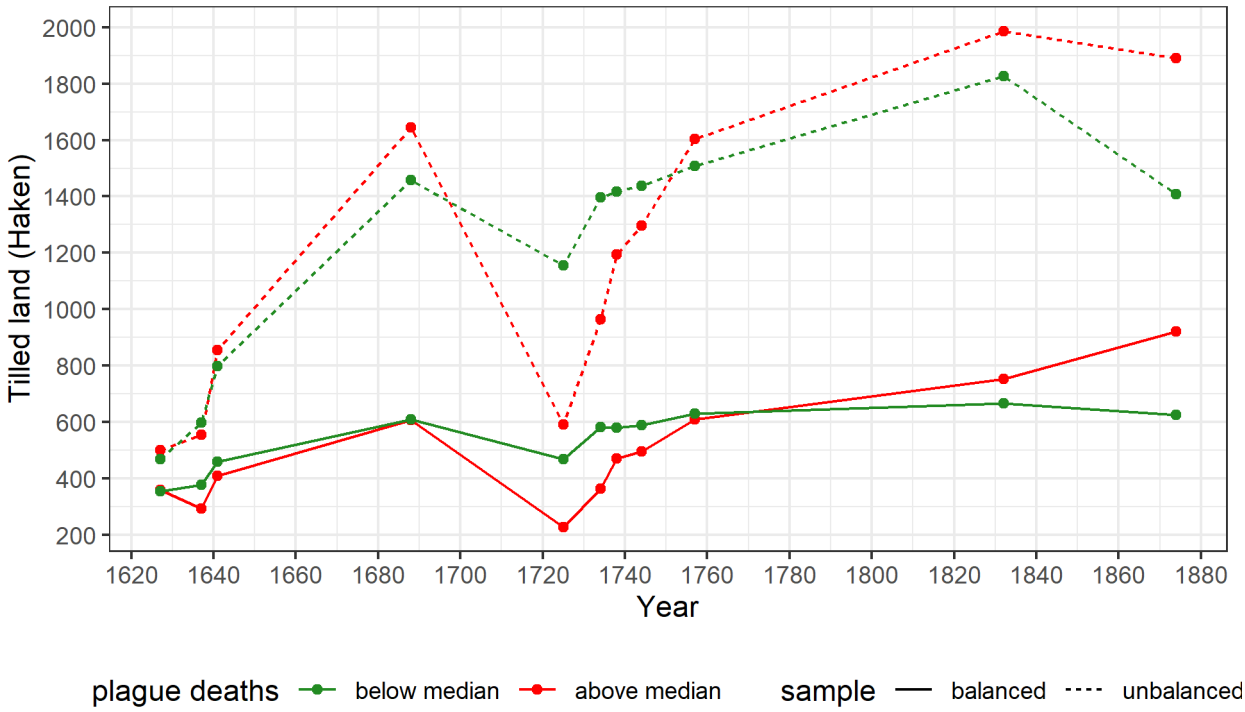
In most specifications, S is calculated for $t-1$ as the latest available data wave before a plague and t as the most immediate wave after a plague.[25] For the 1710-2 plague, I observe plague deaths directly. In this case, I instrument S with plague deaths and substitute $\widehat{S}$ in Equation 1, which then becomes the second stage.

To allow for a causal interpretation of my estimates, plague deaths ought to be quasi-exogenous at the local (county) level. This claim is supported by qualitative evidence that notes the apparent randomness of plague outbreaks (Bērziņš, 1935). I also test for the quasi-randomness of plague by correlating it to a large number of covariates. These

[25] I also consider a version of S where it is simply calculated between adjacent data waves in the absence of plagues.

covariates cover all the hypothesized drivers of the spread of the plague (Benedictow, 2004), such as density, distance to the roads, and the presence of animals. I hand collected rich information on the manor and its serfs as reported in the 1680s *Wackenbücher*. I add data on revolts during the war (Fainstein, 1960) as well as rich environmental data on soil conditions and climate (see Appendix E). I find that none of these covariates can predict the share of plague deaths at manors when applying county fixed effects; see Figure 8.

Figure 9: Tilled land, Northern Livonia, 1627-1881



Sources: Johansen (1933); von Stryk (1877, 1885).
Notes: As for population, plague leads to substantial drops in tilled land. Manors with below-median plague deaths follow very parallel pre-plague trends compared to those above.

In addition to the above evidence on local plague exogeneity, I also show evidence of parallel pre-trends in the amount of tilled land of manors before the outbreak of the 1710-12 plague (Figure 9). To this end, I split the sample into manors above and below the median of plague deaths (53%). While they followed similar trajectories before the 1710-2 plague, afterwards manors with above-median plague deaths experienced a notably more pronounced and lasting decline in tilled land.

5 Findings

I first focus on labor scarcity as a cause of the intensity of labor coercion (Section 5.1). Second, I study the consequences of serfdom on several short- and long-term outcomes (Section 5.2).

5.1 Testing Domar (1970): plagues, labor scarcity, and coercion

Table 1: Effect of labor scarcity on coercion

	Corvee days/haken/week			
	1638	1688	1732	1732 IV
Δ% pop reduction 1601-6 plague	0.068***			
	(0.023)			
Δ% pop reduction 1657 plague		0.384**		
		(0.184)		
Δ% pop reduction 1710-2 plague			4.307***	9.390**
			(0.455)	(4.543)
N	99	240	460	391
Adj R^2	−0.060	0.000	0.050	0.060
Mean dep var.	7.086	24.102	27.495	26.855
SD dep var.	4.409	12.335	9.253	8.045
Mean exp. var	−0.235	−0.758	0.354	0.345
SD exp var	3.354	1.422	0.514	0.565
F-stat 1st stage				11.44

Notes: At manor level. Clustered standard error and fixed effects at the parish level. IV: reduction in land is instrumented by 1710-2 plague deaths. Haken≈ 6ha, avg. HH .25-.5 haken. $^{***}p < 0.01$; $^{**}p < 0.05$; $^{*}p < 0.1$

To study the effects of labor scarcity on the intensity of coercion, I estimate Equation 1. Table 1 shows the results. The outcome variable is the number of corvée days per *Haken* per week, which represents the coercive rent serfs had to pay for their allotted land. The corvée days had to be worked on the fields of the manor lord. The explanatory variable is the *negative* population growth (Equation 2) between the pre- and post- plague period. Columns 1 to 3 in Table 1 represent separate regressions for the population decline

during different plagues (1601-6, 1657, 1710-2), with the intensity of coercion taken from *Wackenbücher* in 1638, 1688, and 1732, respectively.

As hypothesized by Domar (1970), plague-induced labor scarcity is associated with a significant increase in coercion. The magnitudes of the coefficients are quite different across the different plagues. In Column 4, I instrument the negative growth rate of population with recorded plague deaths. Relative to the OLS estimate (Column 3), the estimate more than doubles in magnitude. This could be due to post-plague in-migration that partially offset the change in population.[26]

5.2 Consequences of coercion

I now turn to the consequences of coercion under Estonian serfdom. I focus on migration (after abolition), education (before and after abolition), and trust (in 2013). To obtain causal identification, I use the exogenous variation in coercion created by the 1710-1 plague (column 4 in Table 1).

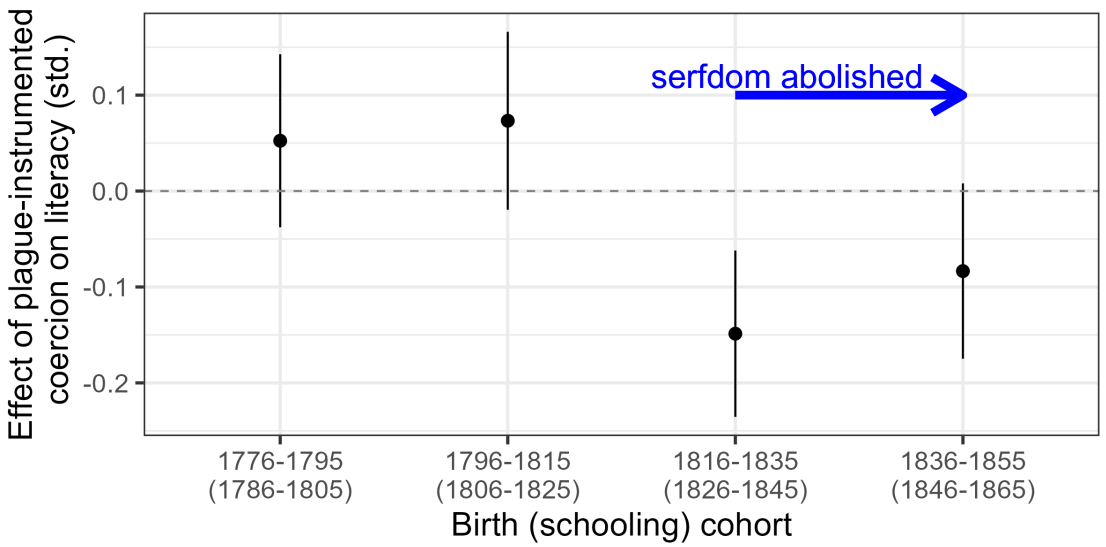
I construct migration moves based on police registrations. Post-abolition, migration was legal, but registration (with the origin and destination manor) was an absolute necessity. Crucially, the abolition did not ban the corvée days, which were coercive and much disliked by the (former) serfs.

I find that corvée days are important for migration. On average, former serfs move to manors with, on average, 2.28 *fewer* corvée days per *Haken* per week than in their manor of origin. Viewed differently, migrants are motivated by cheaper (less coercive) land rents.

These migration patterns are important in rationalizing the effect of instrumented coercion on education. I show that higher instrumented coercion leads to lower literacy (Figure 10) only *after* the abolition of serfdom. I argue that this can be explained by the above finding that higher coercion leads to more outmigration after abolition. As migrants tend to be more literate relative to non-migrants, this can explain the lower literacy rates post-abolition.

[26]Migration of serfs was strictly banned without the lord's consent. However, there is evidence of migration following plagues. Furthermore, in Estonia, serfs were also sold and traded by manor lords. However, this occurred to a more limited degree than under slavery.

Figure 10: Effect of plague-instrumented coercion on literacy of recruits born 1776-1855, Estonia



Source: based on military recruit data collected by Aarma (1990). Recruits are randomly drawn from the draft-eligible population.
Notes: Plague-instrumented coercion has a negative effect on literacy only after the end of serfdom.

Table 2: Effect of instrumented coercion on trust in 2013

	Trust in (std.)		
	Others	Political system	Legal system
Coercion (std).	-0.08^{***}	-0.04	-0.06^{**}
	(0.03)	(0.03)	(0.03)
Male (0/1)	-0.14^{***}	-0.16^{***}	-0.15^{***}
	(0.05)	(0.04)	(0.05)
Age (years)	-0.00^{***}	-0.01^{***}	-0.01^{***}
	(0.00)	(0.00)	(0.00)
Russian speak. (0/1)	-0.56^{**}	-0.80^{***}	-0.46^{*}
	(0.26)	(0.21)	(0.25)
County FE	Y	Y	Y
Education	Y	Y	Y
Income	Y	Y	Y
Adj. R^2	0.04	0.10	0.08
N	1822	1761	1727

Notes: IV regressions on the individual level based on Estonian Social Survey 2013. IV: coercion in 1732 is instrumented by 1710-2 plague deaths. Outcomes are 0-10 indexes that have been standardized. Standard errors clustered by county. *p<0.1; **p<0.05; ***p<0.01

The last finding is the effect of instrumented coercion on trust in 2013. I draw on the 2013 Estonian Social Survey, which is part of EU-SILC. This survey provides very detailed geographic information on the domicile of the respondents that allows me to map it to historic manors.

I follow the same strategy as above and use plague-instrumented coercion as the explanatory variable. The outcome variables are the respondent's trust in others, the political system, and the legal system on a 0 to 10 scale, which I standardize. The findings are reported in Table 2. Trust in others and in the legal system is significantly reduced, while the effect on trust in the political system is also negative and similar in magnitude, but statistically insignificant. Note that this magnitude (0.08 and 0.06 of a standard deviation) is comparable to the effects of exposure to the slave trade reported in (Nunn and Wantchekon, 2011). The results regarding trust in the legal system may stem from the long legacy that Baltic Germans had in controlling the courts and law-making.

6 Conclusion

A fundamental notion in economics is that when a factor of production becomes scarcer, its rewards should increase. It is commonly thought that the holder of this factor will reap these higher rewards. Therefore, a worker shortage should lead to higher wages. However, in the presence of coercion, this basic relationship can break down. Instead of paying a higher wage, employers force employees to work for a below-market wage and reap the rewards.

Focusing on labor shortages after plagues in Estonia, I provide the first causal evidence of this mechanism. Coercion, as measured by the number of serf labor days, increased substantially following each of the three studied plague waves (1605-6, 1657, 1710-2). These findings support the influential hypothesis of Evsey Domar (1970). Domar (1970) argued that the increase in the land-labor ratio following the Black Death (1346-53) led to the intensification of serfdom (the so-called Second Serfdom) in Eastern Europe. I argue that the limited availability of outside options in Estonia that was created and maintained by an oppressive Baltic German elite can explain this response. In other settings, e.g., Western Europe, the average response might be different (Acemoglu and Wolitzky, 2011; Brenner, 1976).

To the extent that similar mechanisms are present today, authorities should particu-

larly investigate contexts where outside options are limited (like they were under Estonian serfdom). A recent literature in labor economics (e.g. Caldwell and Harmon, 2019; Jäger et al., 2022; Schubert et al., 2021) shows that also today employee wages are low when outside options are limited. However, employers may also use coercion in these contexts to keep wages even lower, particularly following worker shortages. The institutional framework is key when analyzing coercion and its response to shocks.

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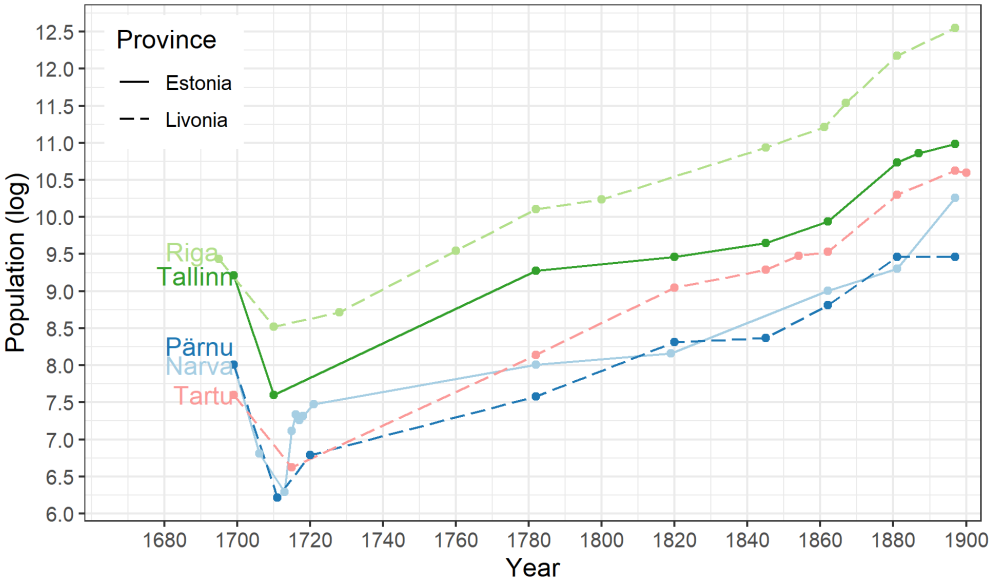
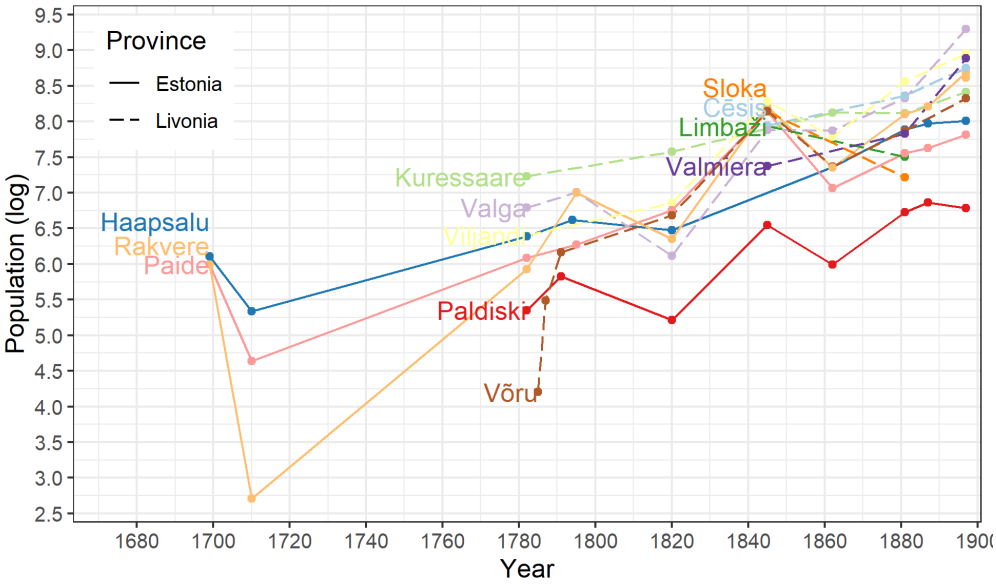
D Additional Figures

Figure D.1: Population of towns, Estonia and Livonia, 1696-1922

(a) Large towns



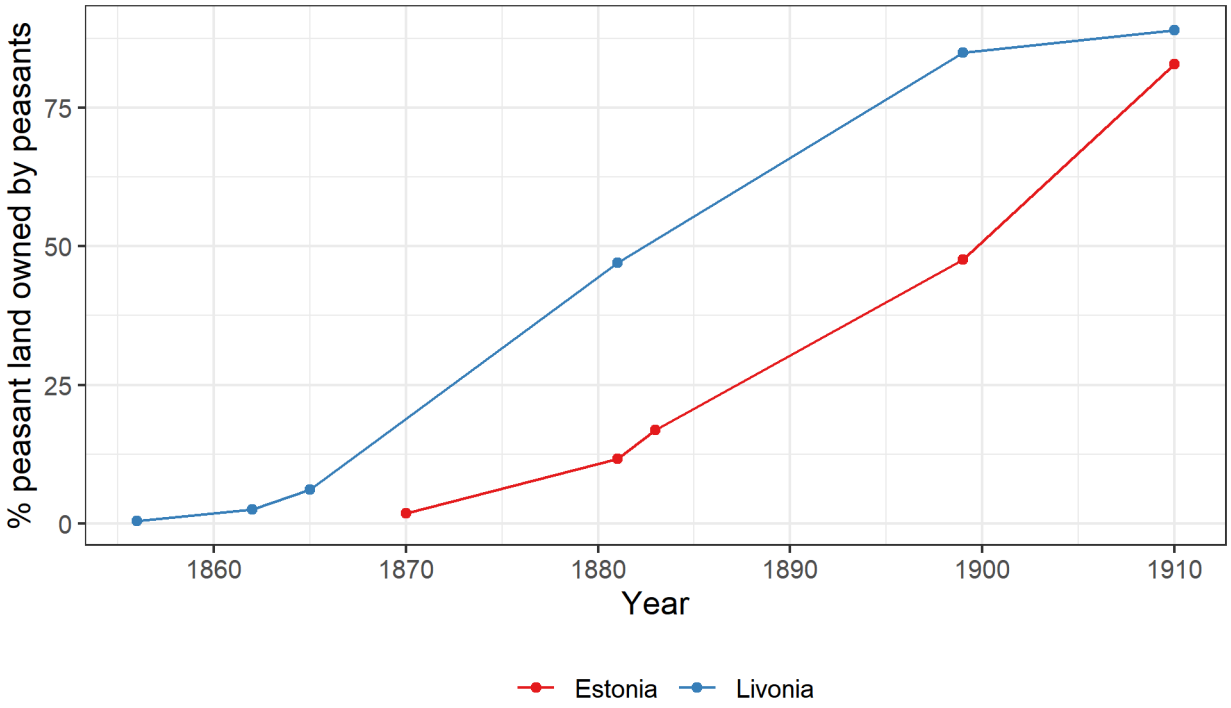
(b) Small towns



Sources: Hueck (1845); Jordan (1886, 1889); Kant (1935); Plakans (2011); Pullat (1992, 1997); Russian Census 1897 (1897); von Jung-Stilling and Anders (1885) and `ome-lexikon.uni-oldenburg.de`.

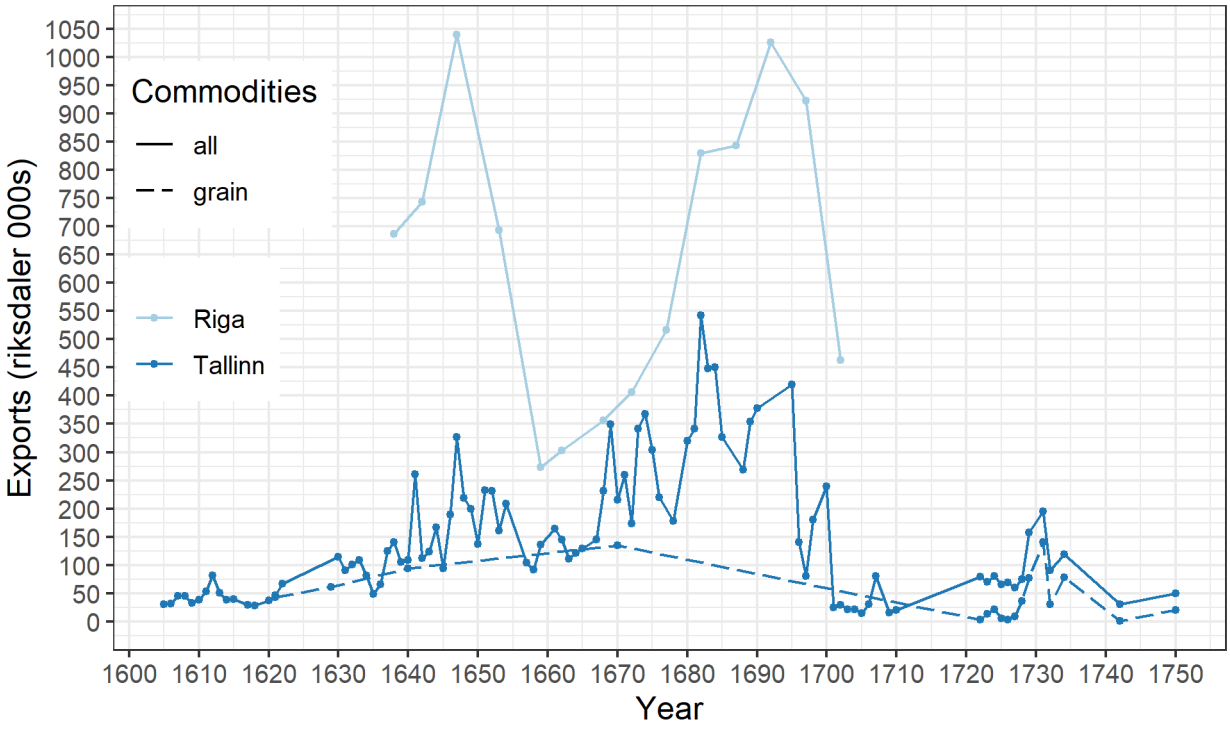
Notes: The 1710-2 plague led to a substantial drop in both large and small town populations, which were still catching up to pre-plague levels in the 1780s. Population losses were similar to those of the countryside.

Figure D.2: Peasant landownership, Estonia and Livonia, 1856-1910



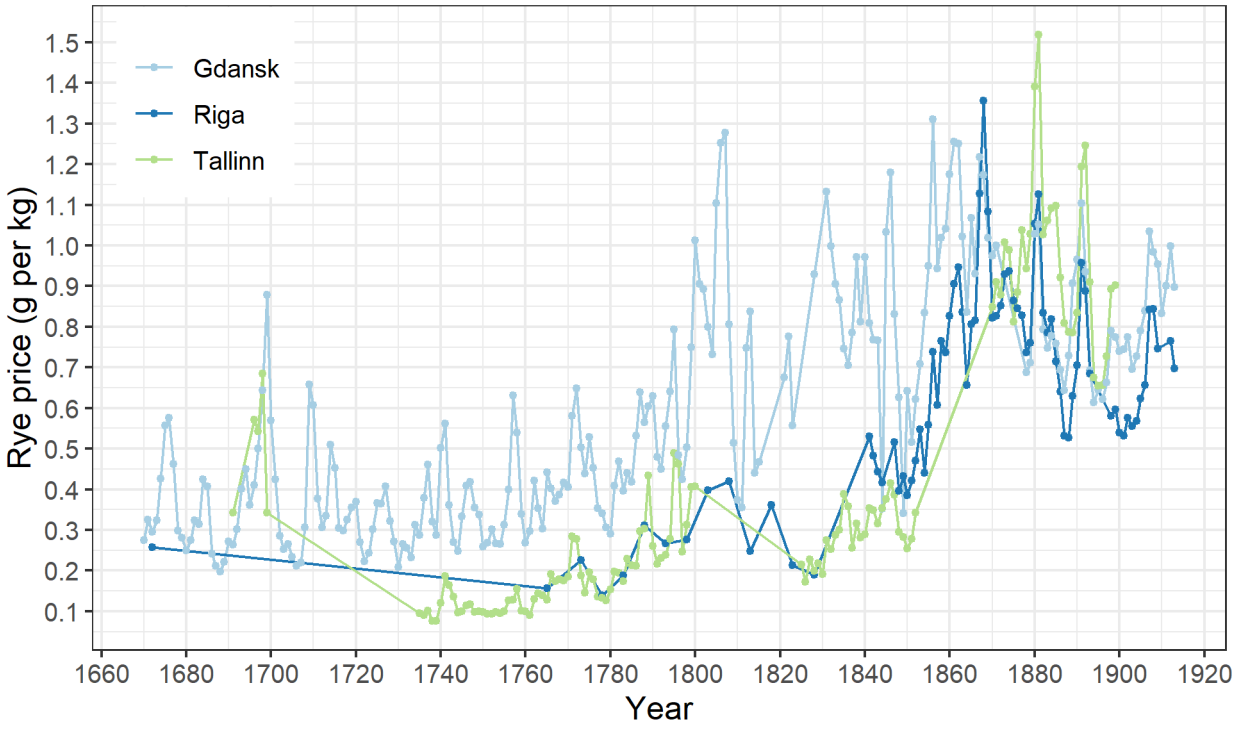
Source: Zimmermann-Schulze (2004).
Notes: The purchase of land by peasants progressed very slowly in both provinces, even many years after the abolition.

Figure D.3: Exports Tallinn and Riga, 1605-



Sources: Doroschenko (1985); Küng (2019).
Notes: Trade is not affected by plagues (1605-6, 1657, 1710-2).

Figure D.4: Rye prices, Gdansk, Tallinn and Riga, 1660s-1910s



Sources: Seppel (2015); Vinnal (2013).
Notes: Rye prices spike during the famine 1695-7.

E Key historical events

1207 Baltic German crusaders settle and gradually enserf natives:

- strict mobility ban
- prohibit landownership
- dues (corvée days, in-kind, money) as rent for allotted land, determined by inter-generational tit-for-tat + shocks

1558 Territory falls to Sweden, but Baltic Germans remain powerful

1711 Russia invades during Great Northern War, plague kills $> 56\%$

1816-9 Abolition of serfdom initiated by Baltic Germans

1858 Estonian peasant revolts convince Alexander II to implement more 'peasant-friendly' abolition in Russia proper

1919 Baltic Germans expropriated; 1940 UDSSR collectivization

F Data construction

A Main sources overview

Table F.1 provides an overview of the main archival and secondary sources used in this research.

Table F.1: Sources

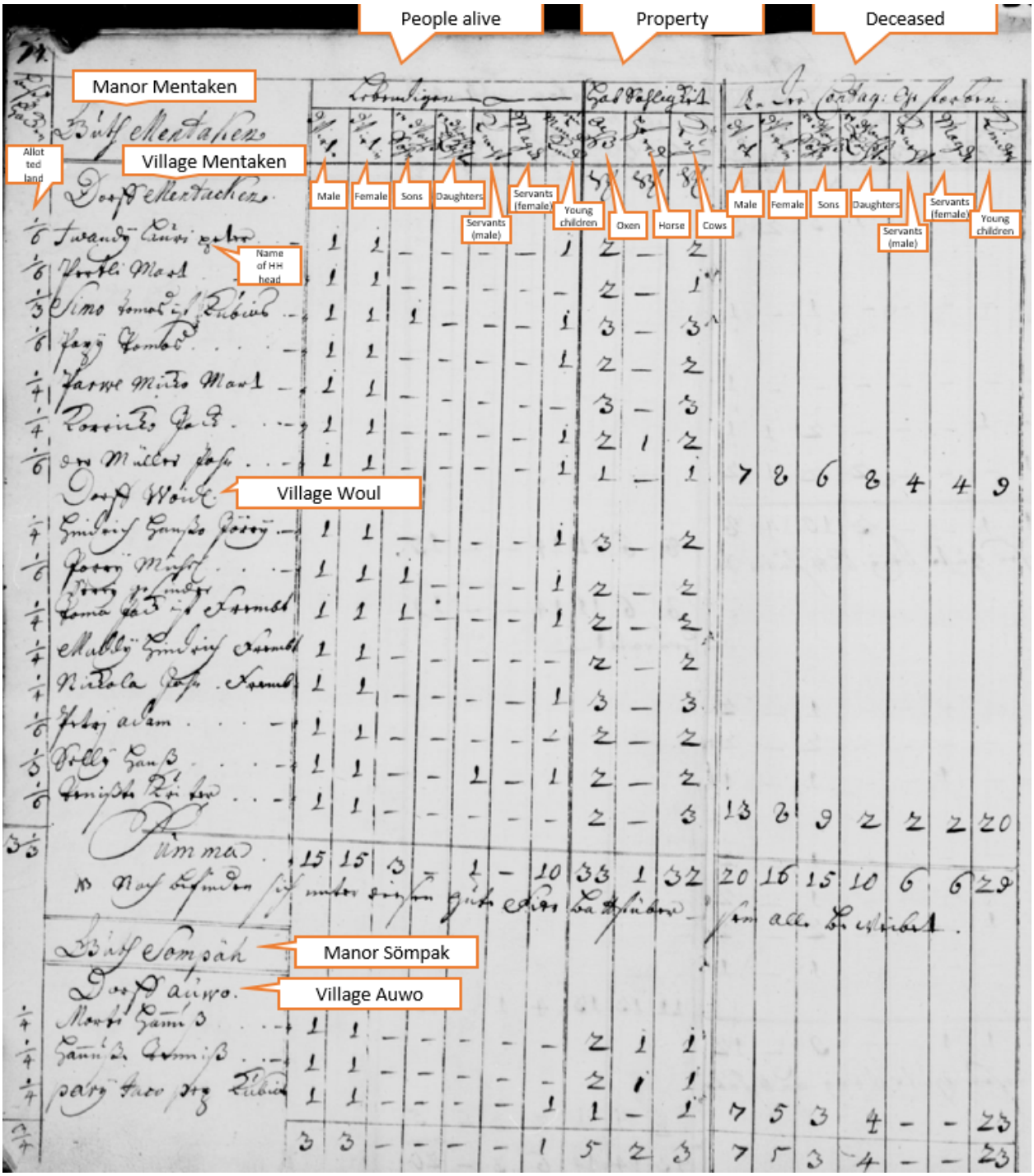
Year(s)	Province/region	Sources	coercion	pop.	plague	manor owner
1586	Estonia	Koit (1975)		1		
1601	Livonia	Roslavlev (1967)		1		1
1624/37	Livonia	Roslavlev (1965a,b)	1	1		1
1627, 1637, 1641, 1688, 1725, 1734, 1738, 1744, 1757, 1832, 1874	Livonia	von Stryk (1877)		1		
1637	Jerwen	Johansen (1933)		1		
1638	Livonia	Rebane (1941); Roslavlev (1969)	1	1		1
1640	Estonia	EAA.854.2.1619, LVVA.7349.1.217	1	1		
1688	Estonia	RGADA.274.1.1614, RGADA.274.1.1614/1, RGADA.274.1.1614/3-11, EAA.1.2.940-2				
1688	Livonia	SRA 55410/35-39				
1688, 1750, 1765	Livonia	Hupel (1782)		1		
1688, 1765, 1774	Estonia	Hupel (1782)		1		
1690	Saaremaa	AM.20.1.26		1		
1710-2	Estonia	EAA.3.1.445, EAA.3.1.448			1	
1731	Saaremaa	EAA.311.1.89				

1731, 1756 (all), 1645, 1726, 1766, 1845 (private)	Saaremaa	von Buxhöwden (1851)		1	
1782	Saaremaa	Hupel (1782)		1	
1816, 1834, 1852	Estonia	Uexüll (1853)		1	
1839	Estonia	EAA.854.1.1291-1308	1	1	
1842	Saaremaa	von Hagemeister (1843)		1	
1881	Estonia	Jordan (1884)			
continious	Livonia	von Stryk (1877)			1
continious	Järva	Schilling (1970)			1
continious	Harju, Viru	Paucker (1847)			1
continious	Lääne				1
continious	Coastal Estonia	Russwurm (1855)			1
continious	Saaremaa	von Buxhöwden (1851)			1
1721, 1726, 1853	Estonia	Uexüll (1853)			1

Notes: The archives acronyms are as follows: AM = Estonian History Museum, EAA = National Archives of Estonia, LVVA = Latvian State Historical Archives, RGADA = Russian State Archive of Ancient Documents, SRA = Swedish Military Archives

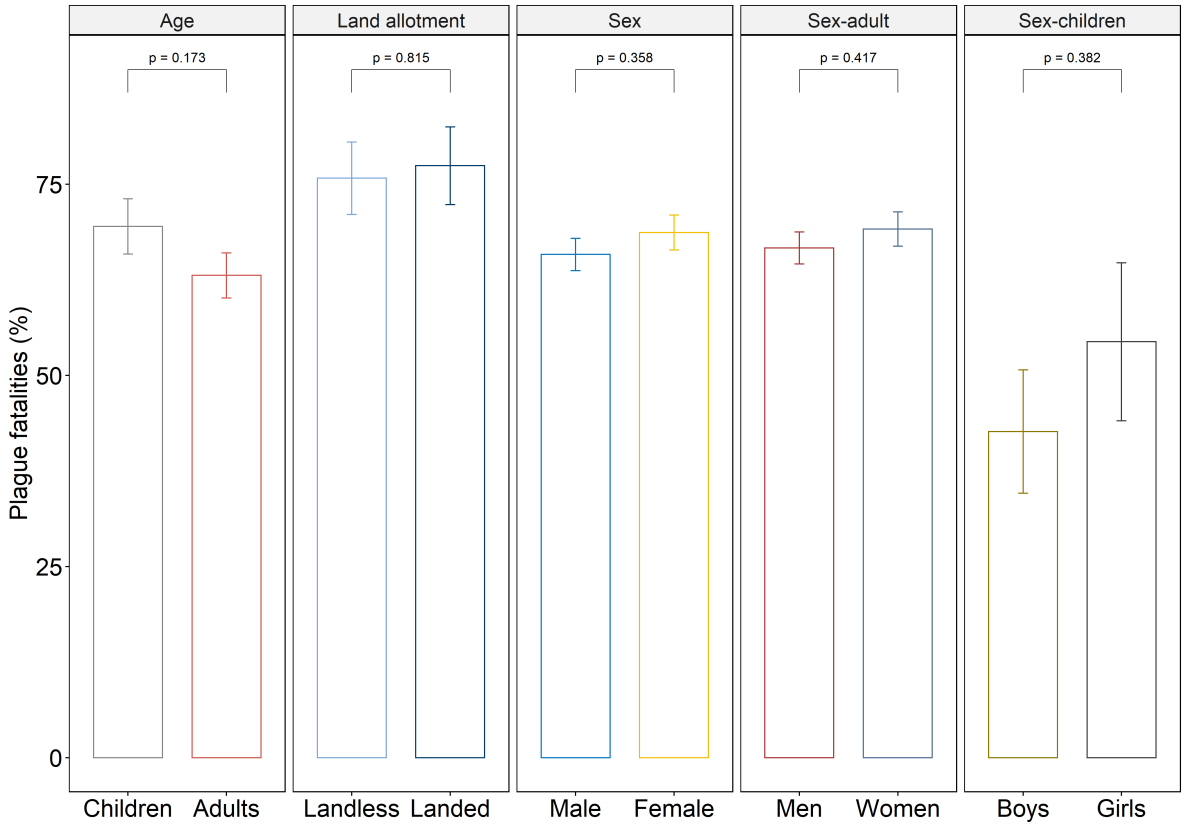
B Plague data and further descriptive statistics

Figure F.1: Example of plague record



Source: EAA.3.1.448, annotation by author.
Notes: Age, sex and relationship to household head of people alive and those who died of plague. Farm wealth and land holding information is also provided.

Figure F.2: Plague mortality by age, land allotment, and sex, Estonia 1710-2

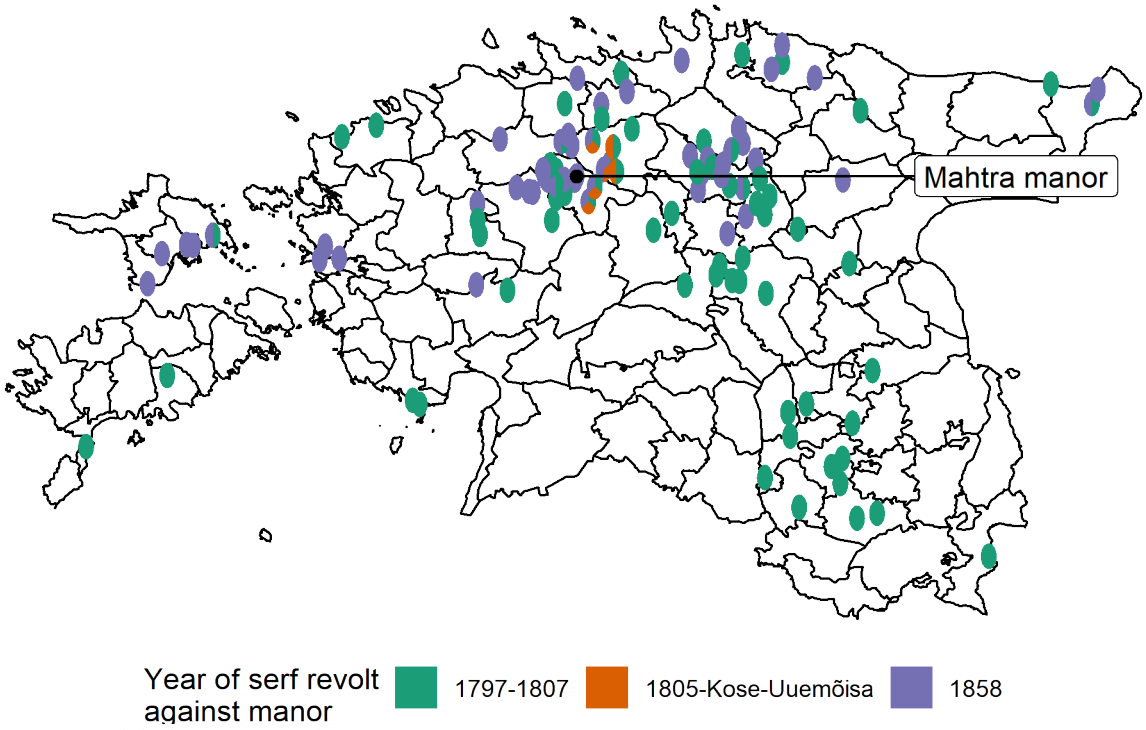


Sources: author, based on primary sources at Estonian National Archives.
Notes: Plague mortality does not differ significantly by age, land allocation, or sex. Differences between facets are partly due to data availability.

C Outcome variables

population change from before and after abolition.

Figure F.3: Serf revolts, Estonia and Northern Livonia, 1797-1858



Sources: Kahk (1958, 1961).
Notes: Manors where revolts occured in multiple years are those with multi-colored dots. In 1858, only revolts in Estonia province are recorded. In this year, revolts broke out at Mahtra manor. Revolts during the Great Northern War are shown in Figure G.1.

D Manor spellings and location

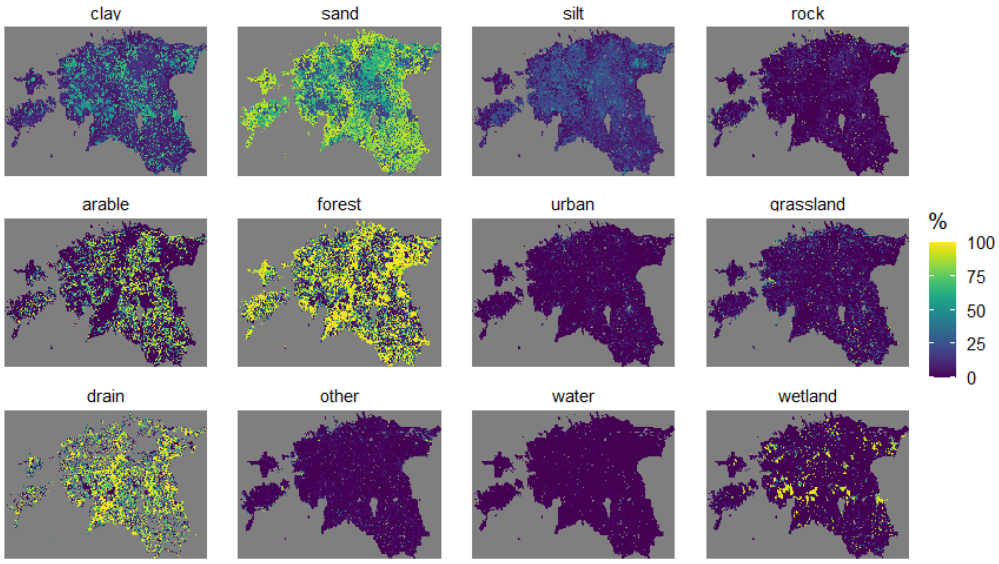
I compile a dataset of the location of all Estonian manors and villages. To this end, I draw on the Place Names Database KNAB (KNAB) (www.eki.ee/knab), and Feldmann et al.'s (1985) encyclopedia of Baltic places. In a few cases, I supplement missing coordinates or spelling variants by drawing on online sources. For Latvia, I draw on online sources[27]

The dataset provides numerous spellings of locations and has very complete coverage, also for geolocations. In total, it covers more than 2,600 manors and more than 19,000 villages. Most manors and villages in the primary and secondary sources can be matched to this database, given that they often specify the parish and given the near complete coverage of spelling variants in the dataset.

[27]Particularly http://manasvietas.blogspot.com/p/pilis-un-mui.html.

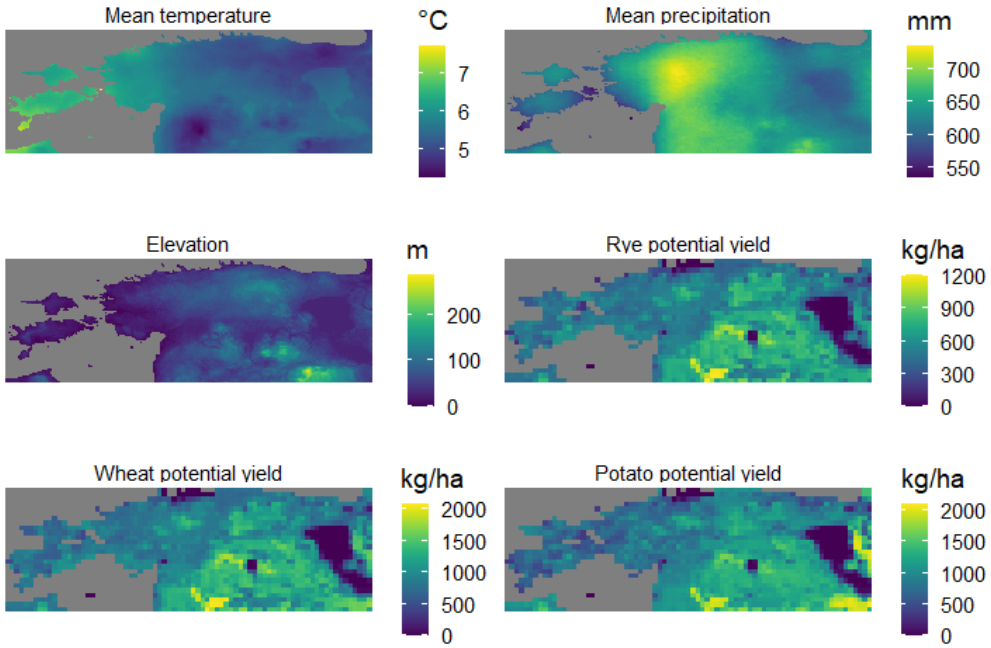
E Environmental variables

Figure F.4: Eco-hydrological variables



Notes: based on Kmoch et al.'s (2021) extrapolation of soil samples.

Figure F.5: Temperature, precipitation, elevation and crop yields



Notes: Based on Fick and Hijmans (2017) and FAO and IIASA (2023, low input, rain-fed, historical climate).

G Plague exogeneity

A Recruitment

Prior to the Great Northern War, the Swedish Crown, despite a de-jure draft, relied primarily on voluntary mobilization, given the low need for troops. This changed when the Great Northern War broke out and Sweden was forced to fight on two fronts: Russia to the East, and Saxony to the West. In 1700, when Charles XI successfully defended Narva in Estonia's far east, he continued on to the Polish–Lithuanian Commonwealth via Riga, leaving only about 5,400 troops were left in the provinces. As a consequence, an additional 6,600 men were drafted in the same year and 600 more in 1701. In these two years, manor tenants were obliged to provide three dragoons, mounted infantry, per *haken*, with the aim that over the coming years to raise 10 conscripts per *haken*. Each pastor and wealthy burgher had to raise one dragoon (Kroon, 2018). Combined with earlier recruitment, in total about 10 to 15% of the male population was mobilized in the 2 provinces (Kroon, 2018). Soldiers who survived the war had to return to the manor they belonged to before.

one recruit with clothes per 1.5 haken (Kelch, 1875, p.246)

For the purposes of this paper, it is important that recruitment, which is the only permitted form of mobility, does not systematically differ across localities. Otherwise, for example, villages with more dues may send more recruits, who, when returning after the war, can increase plague deaths. This would, thus, provide a positive relationship between dues and plague deaths, while I argue that the latter are exogenous to the former. To ascertain that this is not the case, I collect extensive data on recruitment, which is recorded in muster rolls (Kroon, 2018). Table G.1

Table G.1: Pre-war manor characteristics and war involvement

Recruits (%)	Draft evaders (%)	Deserters (%)	Wounded (%)	Died (%)
pre-1700		1700-10		

Notes: Outcomes are expressed as shares of the male population (Columns 1-2) or of recruits (Columns 3-6).

Table G.2 how a manor's war involvement, i.e. the outcome variables of Table G.1,

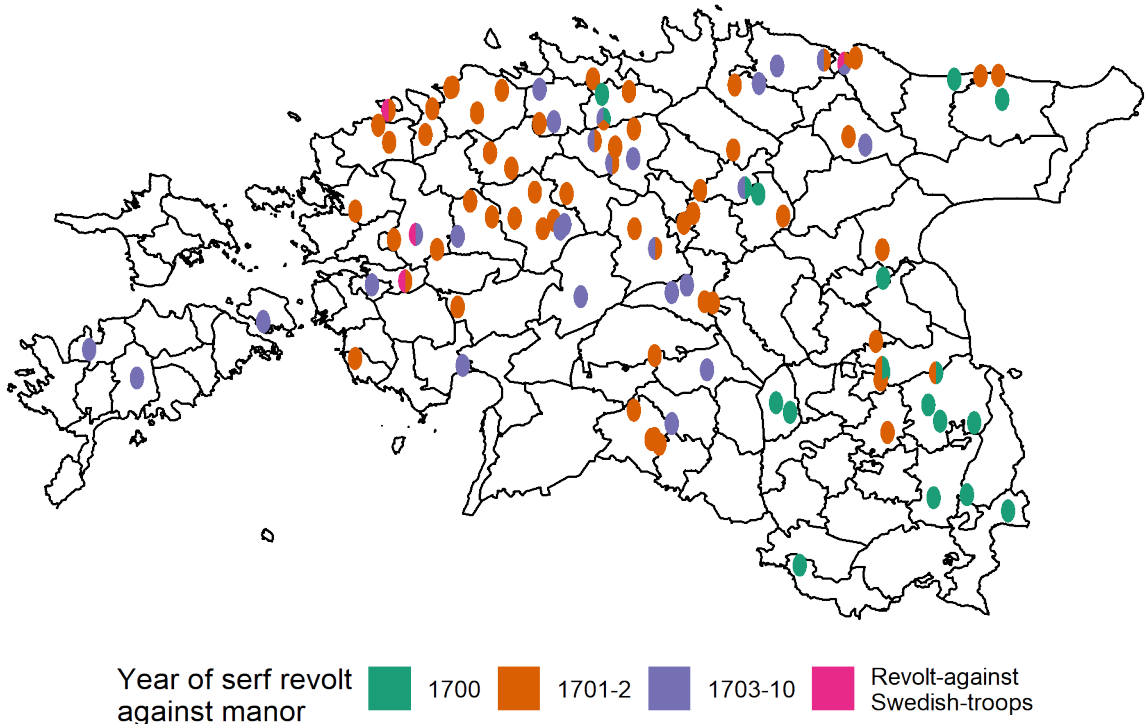
relate to 1700-10 plague deaths.

Table G.2: War involvement and plague deaths

Plague deaths (%)

Notes: Explanatory variables defined as in Table G.1

Figure G.1: Serf revolts during Great Northern War, Estonia and Northern Livonia, 1700-10

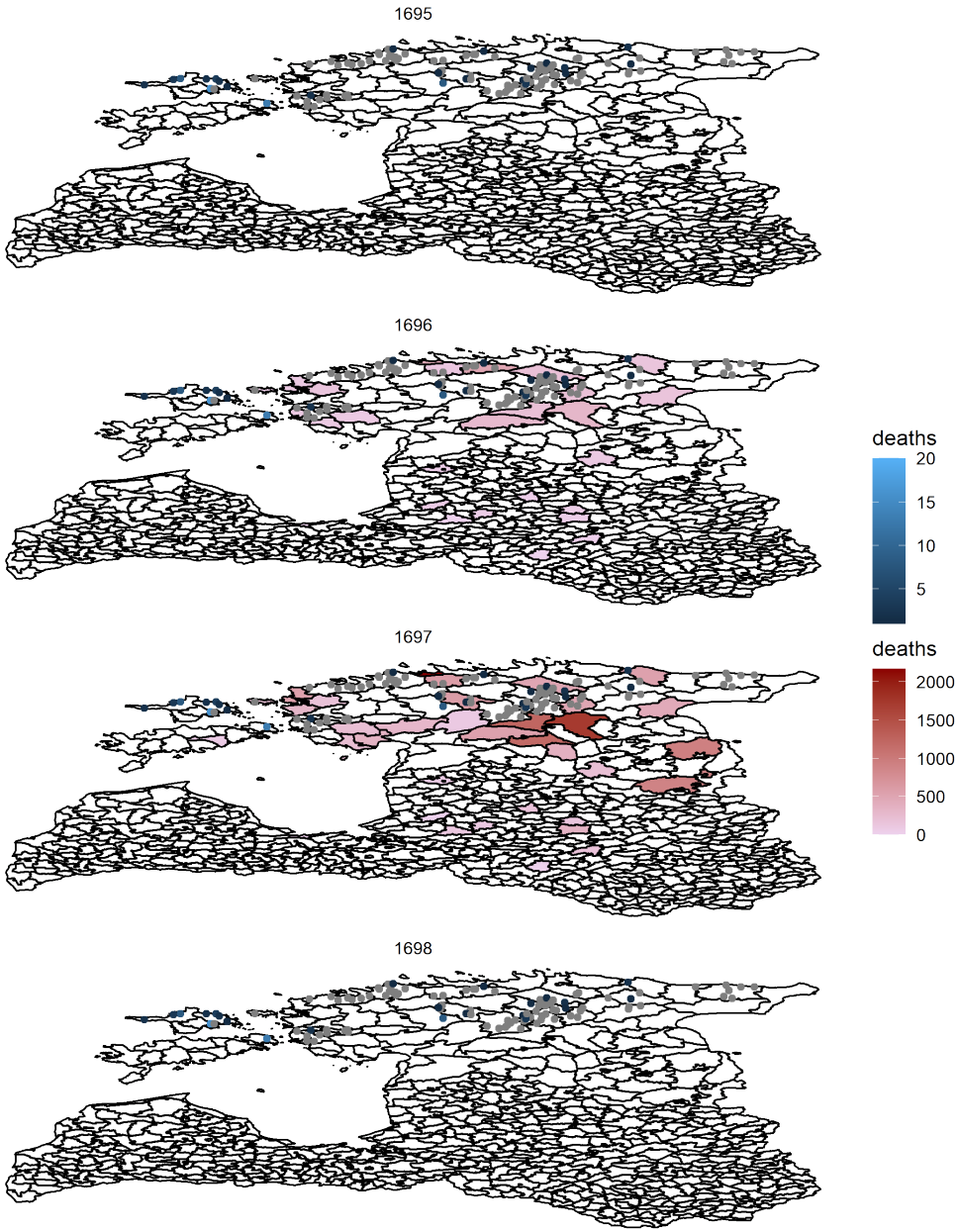


Source: Fainstein (1960).

Notes: Manors where revolts occured in multiple years are those with multi-colored dots.

B 1695-7 Famine

Figure G.2: Famine deaths, 1696-7



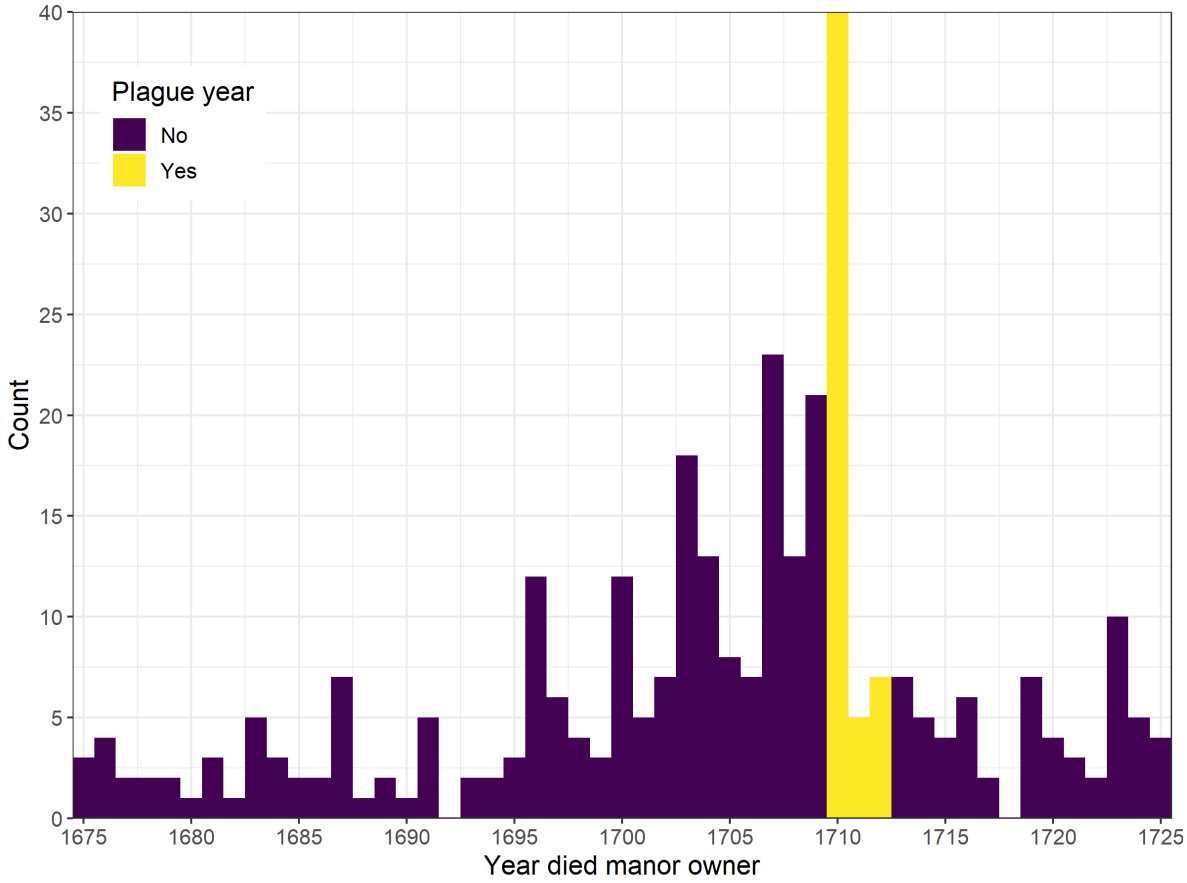
Sources: parish-level: Liiv (1938), manor-level: Seppel (2020a)

Figure G.3: Correlation hunger and plague deaths

Sources: hunger deaths: Seppel (2020a), plague deaths: Estonian National Archives
Notes: Similar to population, also tilled land recovers to pre-plague only c. 1757, i.e. almost 50 years later. The after the plague (1720s), a level is observed that matches that of 80 years earlier (1640s).

H Mechanisms

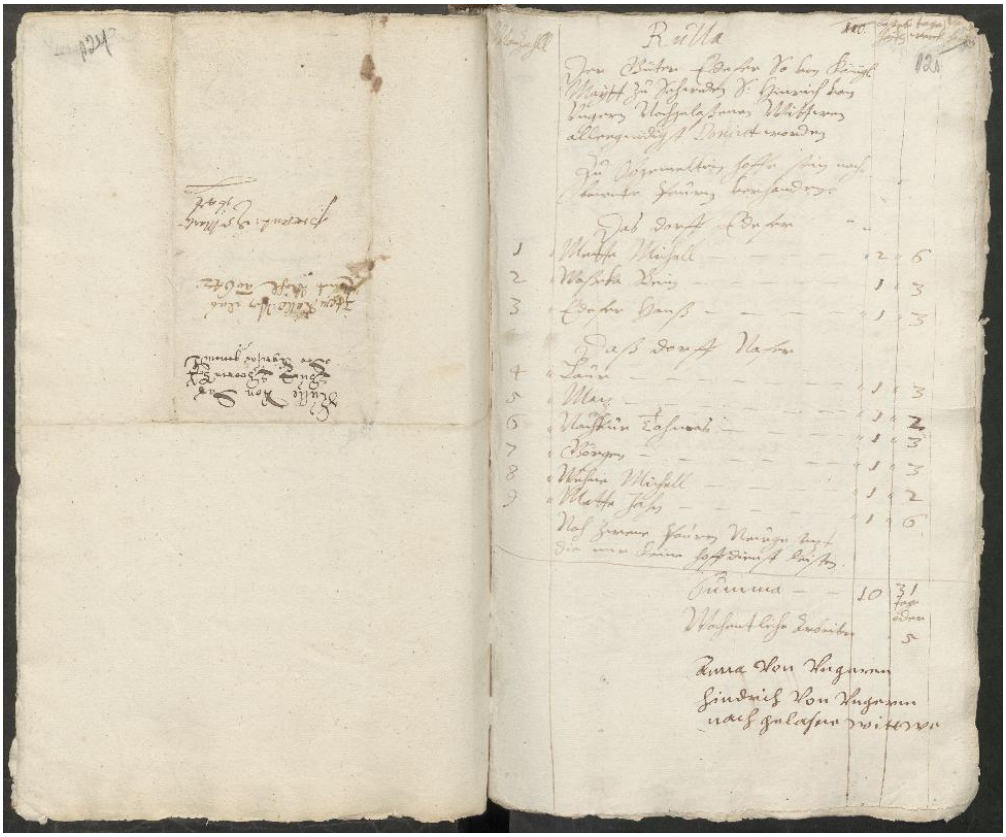
Figure H.1: Plague mortality of manor owners



Sources: names of manor owners matched to online genealogy websites.

I Coercion measurement

Figure I.1: Coercion data: example of a Wackenbuch in 1638



Source: LVA7349.1.217

The total extent of dues, i.e. labor coercion, is expressed as the rubles aggregate of its components: labor dues (corvée), in-kind dues, and money payments. Head and post taxes are also added in case the manor does not cover them.

I also construct price indexes, using the same price series with which I convert in-kind dues to rubles. The ruble total of dues is then deflated by the index to allow for comparison across periods.

1839 – All dues are recorded. Additionally, the wages of farm hands are stated, who are all paid in clothing[28] and, in most cases, also in grain. A few farm hands also receive money. When the type of grain is not mentioned, an equal split between the 3 most

[28]The clothing provided by the lords is assumed to be the same across manors and is priced at 10 loof rye (Hueck, 1845, p.192). I do not consider maids since they are predominantly paid in (more varied) clothing items, which complicates quantifying their wage.

common types (rye, barley, oats) is assumed, as this is the case when it is specified.

A Prices

To calculate the total amount of dues, I price in-kind and labor dues, before adding monetary dues. Prices are taken from various primary and secondary sources (Andersson and Ljungberg, 2015; Jacks, 2004; Vinnal, 2013; von Hagemeister, 1836). Among these, local sources, particularly sales receipts, give the most accurate valuation.

I convert volume measures to kilograms using the FAO/INFOODS's (2012) density database. All monetary amounts are first expressed in silver rubles, with conversions from banco rubles and other currencies based on Denzel (2017), before converting them to their grams of fine silver equivalent.[29]

Pricing corvée days is difficult, but a number of sources have dealt with this challenge. Various sources suggest that a human corvée day is counted as half of an animal corvée day (Blagoveshchenskii, 1861). In 1804, **?**, p.91 estimates that a animal and human corvée day are worth 0.176 and 0.08 ruble, respectively, which also indicates , a view that is also shared by Blagoveshchenskii (1861).[30] I count extra human corvée days during summer, i.e. during harvest, as 1.5 times a regular weekly

$$\begin{aligned} \text{1 animal corvée day} &= \text{1.5 irregular human corvée days in summer} \\ &= \text{2 irregular human corvée days in winter} \\ &= \text{2 human corvée days} \end{aligned}$$

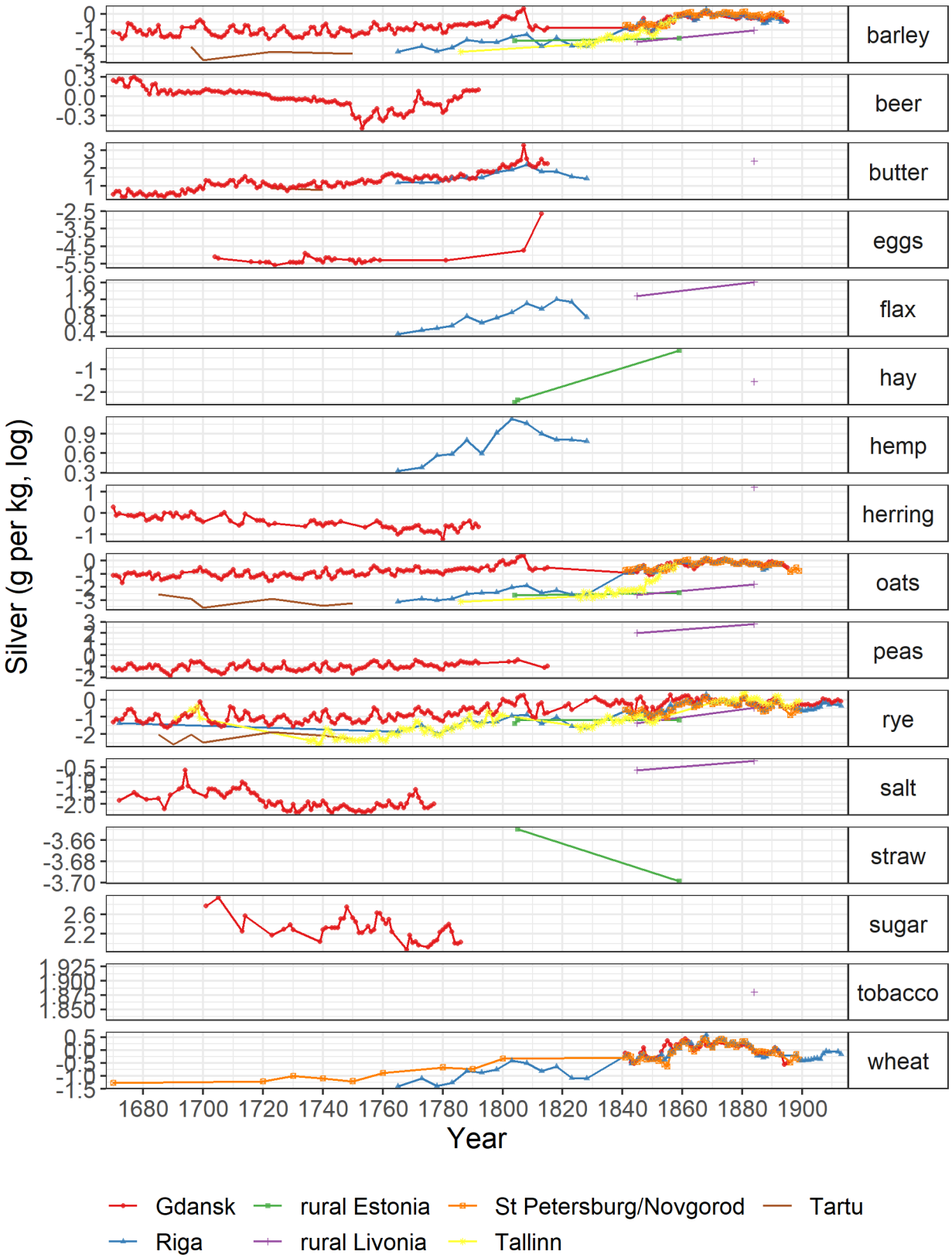
Table I.1: Conversion to metric system

Notes:

[29] The silver content of the ruble is taken from http://gpih.ucdavis.edu/files/Russia_Ag_content_ruble_1535-1913.xls

[30] Blagoveshchenskii (1861, p.98) puts animal days, summer human days, and winter human days at 21, 15, and 9 pounds rye, respectively.

Figure I.2: Goods prices, 1670-1914



Sources: Andersson and Ljungberg (2015); Edvinsson and Söderberg (2010); Fremdling and Hohorst (1979); Jacks (2004); Vinnal (2013); von Bodisco (1902); von Hagemeister (1836); von Richter (1858); **?** and GPIH.
Notes: Prices across towns are mostly comparable across towns in overlapping periods.

B Consumption basket and cost of living index

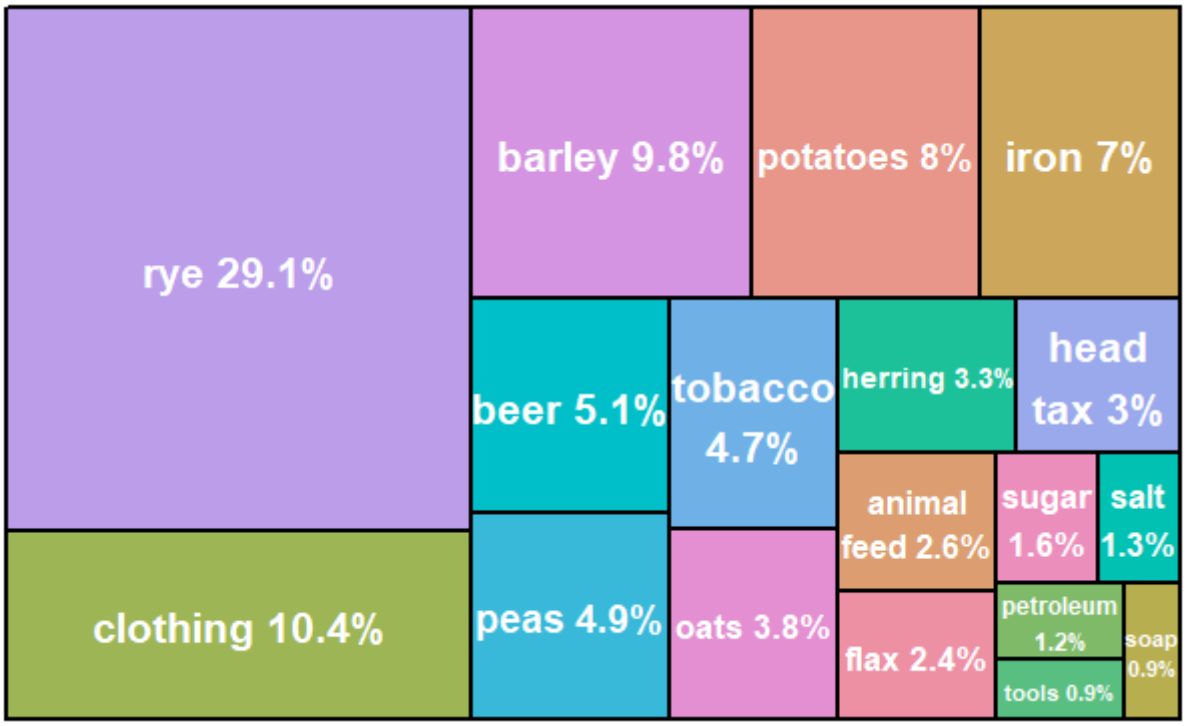
I use a CPI to set peasant dues in relation to their cost of living in a given period. To this end, I use the average across parishes of the consumption basket provided by Livländisches Landraths-Collegium (1885) for the year 1884. As shown in Table I.2, this basket consists of food and beverages, lighting, clothing, and animal feed, which is used in a household's own production of milk, butter, and meat. Also absent are costs of housing and heating, as this is provided by the manor lord.

Table I.2: Consumption basket

item	unit	quantity
animal feed	lof	5.67
barley	lof	9.38
beer	bottle	138.30
clothing	rubles	22.50
flax	lpfd	2.25
head tax	rubles	6.43
herring	lpfd	4.54
iron	rubles	15.00
oats	lof	5.50
peas	lof	3.56
petroleum	stof	12.83
potatoes	lof	26.19
rye	lof	21.47
salt	lpfd	7.61
soap	pfund	17.06
sugar	pfund	20.00
tobacco	lpfd	3.35
tools	rubles	2.00

Source: Livländisches Landraths-Collegium (1885).
Notes: Annual consumption quantities of a farm hand, his wife and children, mean of 11 parishes in Southern Livonia in 1884.

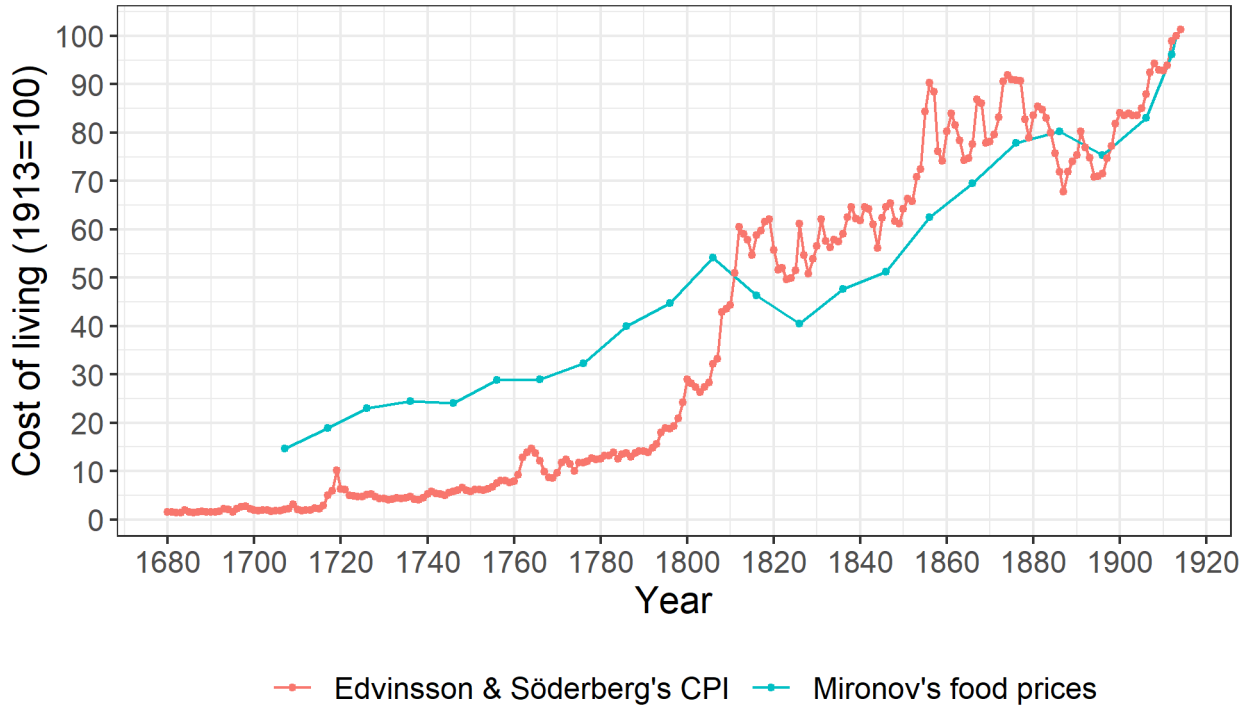
Figure I.3: Composition of cost of living, 1884



Source: Livländisches Landraths-Collegium (1885).
Notes: Basket quantities from Table I.2 are multiplied by prices specified by Livländisches Landraths-Collegium (1885). Total cost of living is 215.5 rubles.

I then use this basket to calculate a CPI as the product of quantity and price for all relevant years. Specifically, I assume that the quantity consumed of the individual goods remains the same across years as it was in (Livländisches Landraths-Collegium, 1885). What changes is their price, meaning that the CPI, calculated as quantity times price, changes only due to prices. The result is plotted in Figure I.4.

Figure I.4: Author's cost of living index compared to others, 1690-1914



Source: author, Mironov's (2010) St. Petersburg food price index, and Edvinsson and Söderberg (2010) Swedish CPI.
Notes: Author's index constructed by multiplying quantities of consumption basket (Table I.2) with period-specific prices (Figure I.2). Missing prices are imputed through the .

J Trade

Trade can lead to increased labor coercion (Dippel et al., 2020; Malowist, 1957; **?**). Specifically for the Baltic context, Malowist (1957) has argued that the vast grain exports to the European West tightened serfdom in the East, where lord were producing grains on their estates.

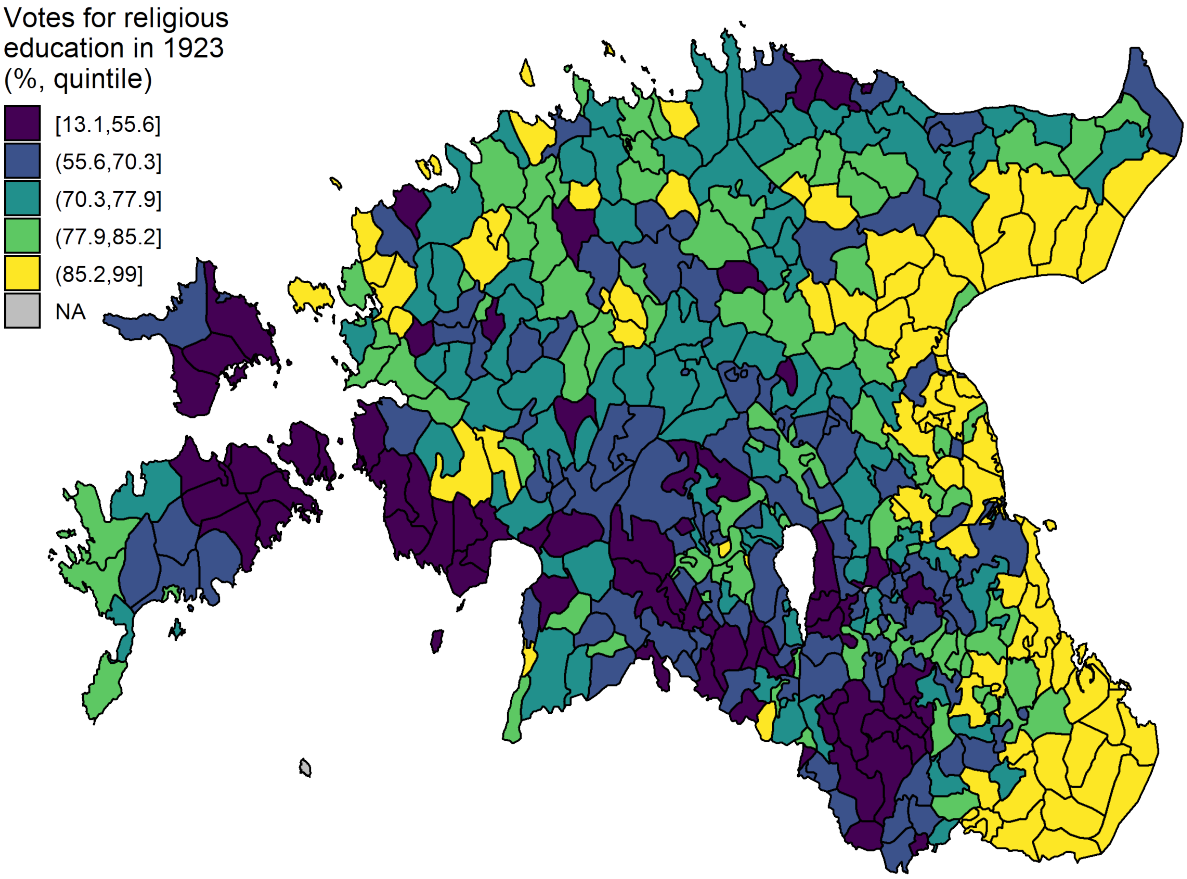
K Potential other effects of plague

A Fertility

B Religiosity

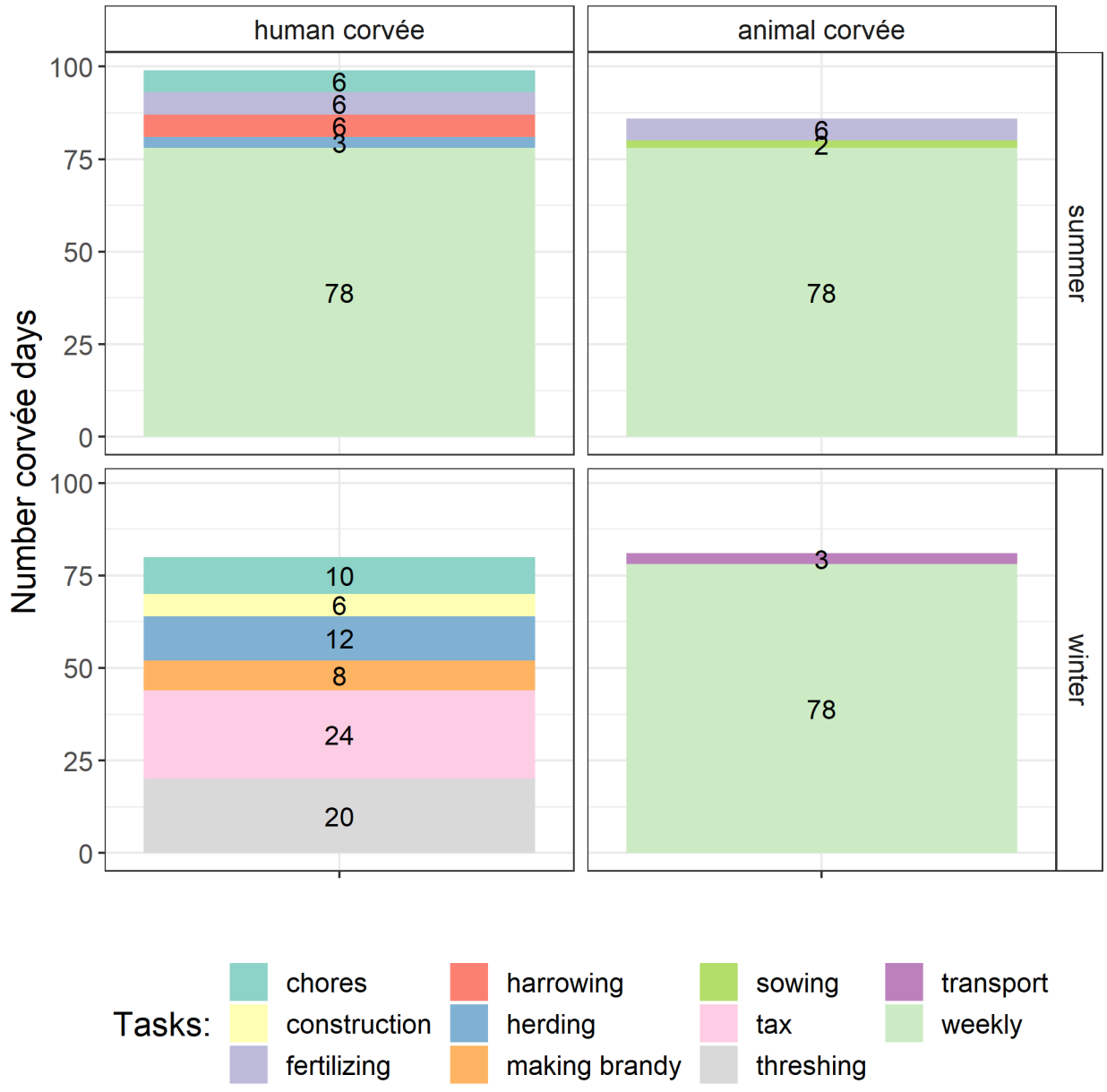
Estonia, which today is the least religious country in the world, held a referendum in 1932 on whether state-founded religious education should be part of the school curriculum. The referendum surprisingly passed with 71.9% of voters in favor and a turnout of 66.2% (Eesti Statistika, 1923). I digitize the parish-level results of this referendum (Figure K.1). Regressing them on 1710-2 plague deaths and controlling for (Table XX) shows that there is no significant association, limiting concerns that the plague influenced religiosity.

Figure K.1: Votes on religious education, 1923



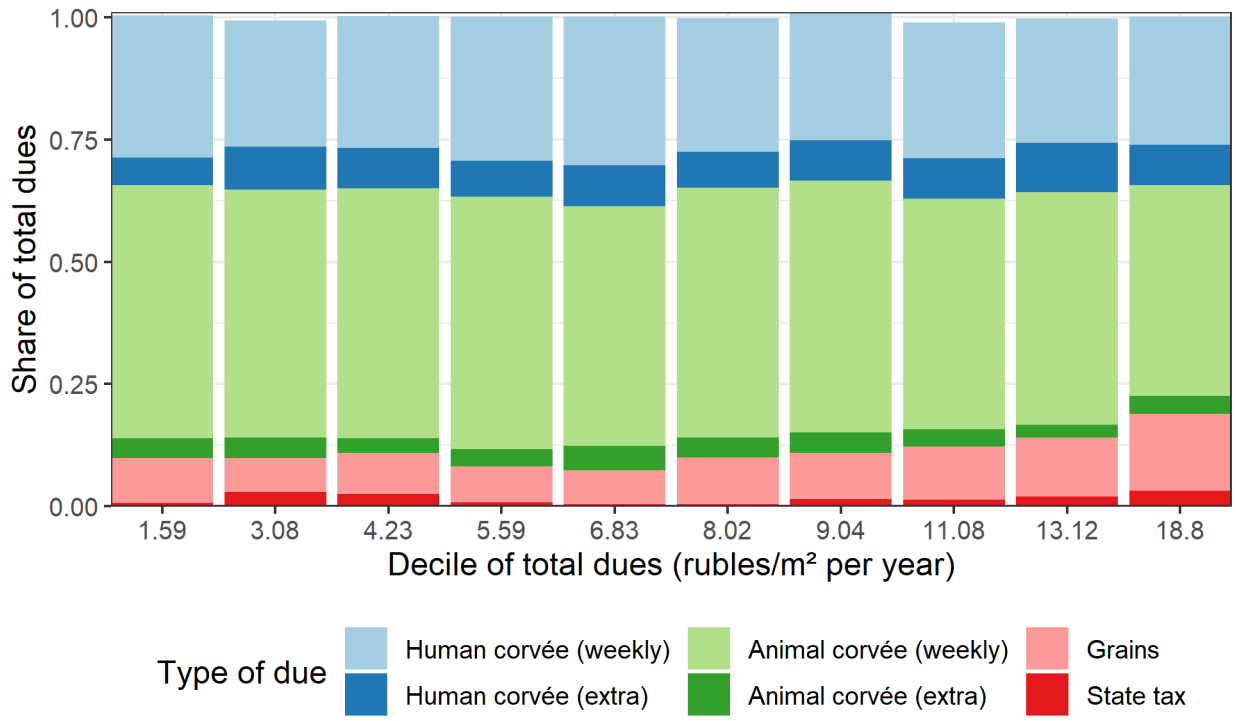
Sources: Eesti Statistika (1923)
Notes: Marked geographic variation in the vote in favor for state-funded religious education that is positively correlated to the share of Lutherans.

Figure K.2: Distribution of a serf household's annual 346 corvée days across tasks, Estonia c. 1845



Source: Hueck's (1845, p.160) representative serf household. Numbers represent days.
Notes: Weekly corvée primarily consists of general field work in summer (c. 23. April - 29. September) and logging in winter. Remainder are days that are requested irregularly, e.g. during harvest. This serf household pays taxes in corvée to manor which pays state, rather than a direct, in-kind or money payment to state.

Figure K.3: Composition of dues by decile, 1839



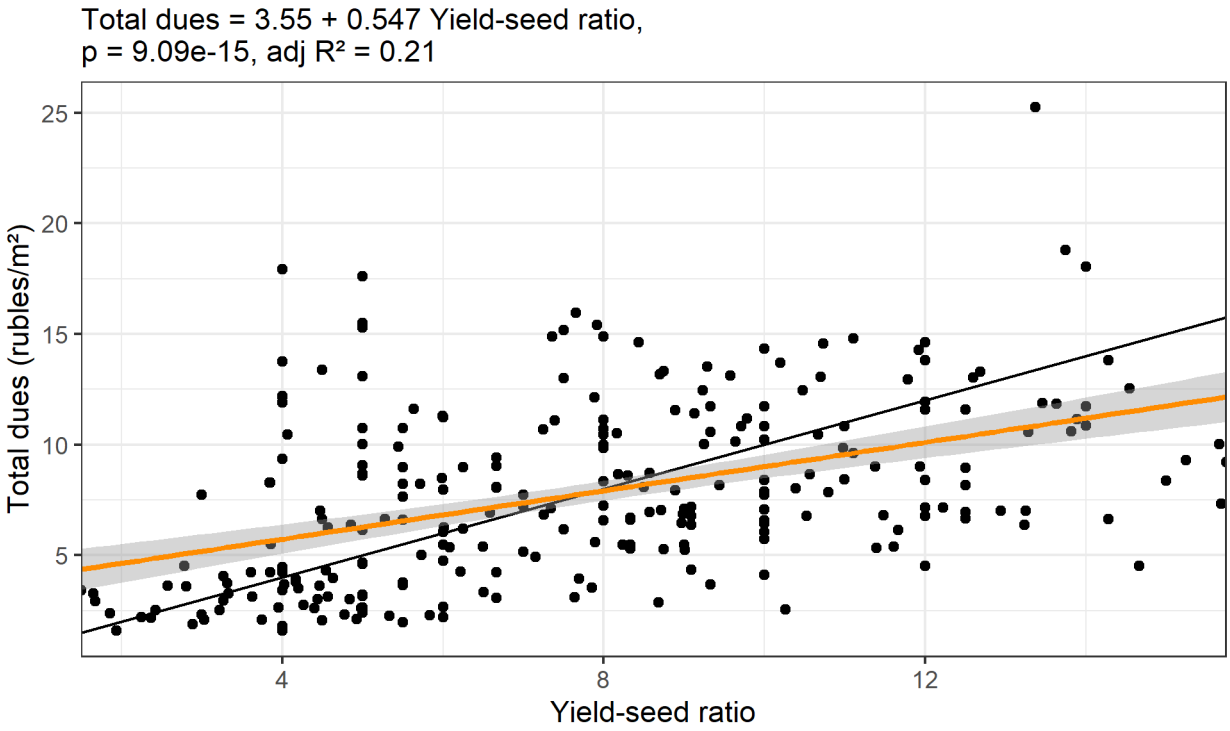
Source: National Archives of Estonia. See Section A for pricing of corvée and in-kind dues.
Notes: As dues increase, the share of grains increases slightly. Variation in tax is due to some manors lords covering it for peasants.

There is abundant qualitative evidence that corvée was the most despised part of the dues shown in Figure K.3.

31

[31] Figure K.2 shows the tasks that serfs have to complete during these irregular corvée days.

Figure K.4: Relationship between dues and yields, Estonia 1839

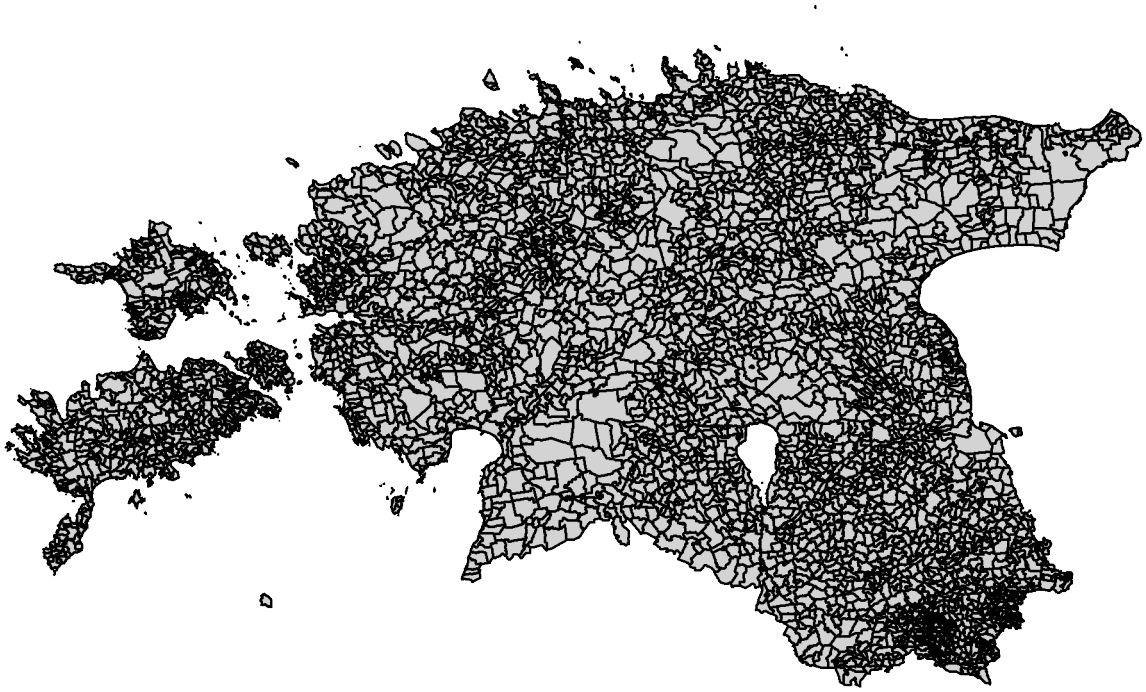


Source: 1839 land survey.
Notes: ss

L Modern-day outcomes

Access to fine-grained modern-day data is purchased from Statistics Estonia.

Figure L.1: Estonian area codes



Source: Estonian Social Survey (Statistics Estonia, 2019)
Notes: 4,713 Area codes across 79 municipalities.