Serfs and the Market:
Second Serfdom and the East-West goods exchange, 1579-1857

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This version: June 2, 2019

Abstract

Using novel shipment-level data on maritime trade between 1579 and 1856, this paper documents the evolution in grain exports from from Western to Eastern Europe and the rise of unfree labor in the former. Hypotheses first formulated more than 60 years ago, that export opportunities spurred labor coercion, motivate the exploration of this relationship. A new dataset of key labor legislation dates in the Baltic area captures de-jure unfree labor (e.g. serfdom or mobility bans). We also capture *de-facto* variation in coercion using existing data on coercion proxies (land holdings, serf manumission and/or wages) in Denmark, Prussia and Scania and novel household-level corvée data in Estonia.

Our findings suggest that increases in grain prices and exports to the West happen, in many instances, concurrently with increases in de-jure and de-facto coercion in the East; thus, providing support for the hypothesis. Specifically, we observe that locations with better export potential see higher de-facto labor coercion; a finding that cannot be reconciled with existing models which predict *less* coercion in the proximity of cities due to outside options. We rationalize these findings in a new, open-economy labor coercion model that explains why foreign demand for grain is particularly likely to foster coercion. Our empirics may also be interpreted as evidence that Scania's opening of the land market to peasants allowed them to benefit from trade and reduced labor coercion even in the absence of any coercion-constraining labor policies. It is hoped that this research and the data it contributes provides new conceptual and empirical approaches to understanding past and present unfree labor that may also focus more closely on the broader political economy.

Keywords: coercion · Early-Modern Europe · primary exports · periphery regions · geo-spatial analysis

JEL: F1 · F5 · F61 · N33 · N73

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To my dad

"*Local dominance was complete, for, in the course of time, the Junker had become not only an exacting landlord, hereditary serf master, vigorous entrepreneur, assiduous estate manager, and nonprofessional trader, but also the local church patron, police chief, prosecutor, and judge. [. . .] Many of these experts in local tyranny were experienced in whipping the backs, hitting the faces and breaking the bones of 'disrespectful' and 'disobedient' peasant serfs.*"

German historian Hans Rosenberg commenting on Prussian
miniature autocracies as quoted in Clark (2006, p. 162)

"*From Martinmas, one thousand eight hundred and ten (1810) all serfdom shall cease throughout our whole realm. From Martinmas 1810 there shall be only free persons, as is already the case upon the royal domains in all our provinces, free persons, however, still subject, as a matter of course, to all obligations which bind them as free persons by reason of the possession of an estate or by virtue of a special contract.*"

Extract from Prussian October Edict of 1807.
Translation from Robinson (1902, p.27).

1. Introduction

Perceptions that trade is 'unfair' have risen in recent years. Developed economies fear the loss of lower-skilled jobs and the developing world is concerned with moving up the value chain and access to markets. The risk of trade wars and their effects loom all over the world. Academics have moved from solely considering the efficiency gains of trade to looking more closely at the winners and losers (e.g. Autor et al., 2013). The literature has emphasized wage-setting, after multinational's use of sweatshop production came under international scrutiny, (e.g. Harrison & Scorse, 2010) and how fair-trade labelling initiatives may lead to better terms for producers (e.g. Dragusanu et al., 2014). What is assumed in this literature, however, is that workers and producers *voluntarily* agree to the terms of employment.[2] This is in stark contrast to historical and present-day evidence that many labor transactions include the use or threat of *force*. In 2016, the International Labour Organization (2017) estimates that 25 million people

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[2] Dragusanu et al. (2014) state that "[i]n the case of plantations, [fair trade] certification requires workers' freedom of association, safe and equitable working conditions, the absence of forced or child labor, and salaries that are at least as high as the established minimum wage".

were forced laborers, many of them producing for international markets. Throughout the last decade, the coercion of more than 1 million Uzbekistanis in the country's cotton export industry made news (BBC, 2012).

The aim of this paper to advance our understanding of the relationship between coerced labor and international goods trade.[3] To explore this relationship, we study a prolonged period of history in Early-Modern Europe that saw the rise of unfree labor in the East, the so-called 'Second Serfdom', coinciding with a decline in the West, as well as a boom in East-West exports of grain.[4] Serfdom, the most severe form of labor coercion in our sample, lasted for many centuries. This is highlighted by the introductory quote from the Prussian October Edict of 1807, that marks the beginning of a lengthy abolition process that would last until 1848 in Prussia. Starting with Polish scholars in the 1950s and led by Marian Malowist (1958, 1959), a debate ensued among historians on whether this tightening of peasants' labor conditions was due to the rise in grain exports. While this debate is far from being settled (see Section 2.2), a review of accounts of the Second Serfdom shows grain exports are cited as one of its potential causes (e.g. Moon, 2001; Stanziani, 2009; Cerman, 2012; Eddie, 2013). Furthermore, Wallerstein's (2011), who developed the world-system theory, mentions Marian Malowist's accounts of Eastern Europe as one of his main inspirations for developing the concept of a periphery region whose role is defined by exporting primary products to a core region (e.g. Western Europe).

We add some first cliometric evidence to this debate by drawing on a new extensive dataset, the Danish Sound Toll records, that covers daily grain shipments leaving the Baltic Sea on ships over the course of 277 years (1579-1856).[5] These data not only allow us to quantify the volume and value of the East's maritime grain exports, but also uncover the origin and destination of shipments and who conducted the trade. Equipped with the Sound Toll records and data on unfree labor, we answer the following questions:

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[3] We do not consider the forced trade of labor itself (e.g. the slave trade), but the trade in commodities. Our case compares to the slave trade triangle to the extent that both consider the export of raw materials produced with forced labor.

[4] For the remainder of the paper, East will refer to the European East and West to the European West. Importantly, we do not use a contemporary definition of Eastern Europe, since we include all countries around the Baltic Sea, thus also Denmark and Sweden. We also restrict our analysis to those countries close to the Baltic Sea.

[5] The Sound Toll (Danish: Øresundstolden) was introduced in 1429, however, at the time of writing, the data transcribed by the Sound Toll Registers Online project only dates back to 1580, see www.soundtoll.nl. Also, the years 1582-3, 1594, 1612-13 and 1634 have only been partly transcribed, hence we drop them. The Sound Toll was abolished early in 1857, so that we also drop this year.

- On the country (macro) level,[6] do the East's grain export booms occur before and/or during *de-jure* reforms that limit peasant freedom?

- On the sub-national level, can a locality's *de-facto* extent of unfree labor be related to its potential to export grain to the West that is determined by its access to ports and ports' export volume?

On both the macro and the micro level we find support for Malowist's export hypothesis that grain trade booms were to the detriment of peasant freedom. We rationalize these findings in a theoretical model of unfree labor that focuses on an open economy, which – to the best of our knowledge - is a novelty in the literature. In particular, we show that relative to domestic grain demand shocks, foreign grain demand shocks are more likely to increase labor coercion. Foreign shocks tend to have a larger impact as they do not stem from local population growth, which can reduce coercion through changes in the land-labor ratio and improving outside options for peasants. At present, this research cannot make the claim that the relationship is causal, however, we believe that world prices and most of the studied demand shocks in the West are plausibly exogenous to the numerous countries and sub-national entities of the East. While we do believe that particularly de-facto improvements in peasant freedom also enhance long-term peasant welfare, we do not conduct sufficient analyses to back-up this claim and rely on the literature that shows that peasant's freedom may be related to lower welfare in the short-term; this is shown in Eddie's (2013) fittingly entitled "Freedom's price".

This research interacts with several strands of literature. Clearly, it adds to the literature on the drivers of unfree labor (see Section 2.1) that has rarely considered international trade, but also sheds some light on the consequences of unfree labor (e.g. Markevich & Zhuravskaya, 2018; Buggle & Nafziger, 2016). In assessing the role of distance to port on labor coercion, we also provide new perspectives on the 'blessing of bad geography' literature that suggests that hard to traverse geography may constrain foreign influences that carry 'negative' consequences (e.g. Nunn & Puga, 2012). A by-product of our empirical analysis are trade statistics that, due to the granularity of our data, are on the city level and can be extended to more commodities to complement the sparse evidence of Early-Modern Eastern Europe's and, more generally, peripheries' economic links to core regions. Putting more focus on trade volume than prices, our re-

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[6]We use the term country out of convenience to refer to jurisdictions that reformed peasant's rights. This includes actual countries, such as Denmark, but also colonies, such as Swedish Estonia, or the splinters of the Holy Roman Empire that did not fall under any defined nation.

search also presents a departure from the common, terms-of-trade based analysis of Early-Modern trade (Williamson, 2008; Pomeranz, 2009; Broadberry & Gupta, 2006). We also contribute to the understanding of the endogenous formation of institutions. Dippel et al.'s (2016) study of the effects of sugar trade and outside options on coercion in the British West Indies is perhaps the most closely related paper to ours, but much of those region's institutions were determined by the colonizer, unlike in our case. We also challenge the view that only high-value export crops (e.g. sugar and cotton in the Americas) were produced with unfree labor, while less valued export crops (e.g. wheat) were produced by freeholders (Engerman & Sokoloff, 1997) by showing that also the production of medium-priced grains (e.g. rye) involved substantial coercion.

In our opinion, the main contributions of our research is to test the export hypothesis, add to the understanding of open economy labor coercion and, more generally, provide trade observations and draw attention to (new) estate-level data. Commodity trade may play a decisive role in the tightening of peasants' labor conditions, but there is certainly more work required to understand the complex power relations between lords and peasants and the precise mechanisms through which trade may affect them. Proximity to cities may not always make coercion less pronounced by offering outside options, given that they may serve as export hubs to foreign markets and, thus, channel price-enhancing foreign demand that makes coercion profitable. This paper is organized as follows: Section 2 summarizes the literature discussing the drivers of unfree labor, including the export hypothesis; Section 3 presents our open-economy model of labor-coercion; Section 4 provides a historical background on Early-Modern institutions, unfree labor regimes and trade in Eastern Europe for all countries in our sample; Section 5 details the data sources and provides some descriptive statistics; Section 6 explains the methodology and shows our findings; finally, Section 7 concludes and we suggest some next steps in 8.

2. Literature on the Drivers of Unfree Labor

Labor-coercion institutions, such as serfdom or slavery, have received scholarly attention for many years. Generally, two questions are asked: "what causes labor-coercion institutions?" and "what consequences, for example, for economic growth, do they carry?". This research primarily addresses the first question based on historic evidence suggesting trade as the root cause (See Section 4 for the historical background). While this paper focuses on the impact of international markets on labor coercion, most

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theories concerning the emergence of unfree labor only require a closed economy. We will turn to those first, before discussing the open-economy export hypothesis.

2.1. Closed-economy Labor-Coercion Theory

Early attempts to rationalize labor-coercion institutions have focused on the *land-labor* ratio. The sparse population density in parts of the Americas and the European East have led Domar (1970) to conjecture that labor coercion exists in those regions because where labor is scarce relative to land, the cost of labor in a non-coerced labor market will be high. Hence, landowners, as employers, will have strong incentives to extract large amounts of coerced labor; this is to ensure their land is worked at a sufficiently low cost, and they will endeavour to maintain the institutional system that facilitates this coercion.[7] This theory has been criticized by, among others, North & Thomas (1973) and Brenner (1976) who argue that the fact that post-plague Western Europe experienced both an increase in the land-labor ratio and a decline in labor coercion goes against a theory that *only* considers the land-labor ratio. These authors highlight the role of local conditions, such as the 'weakness' of cities in providing employment and the strengths of landed elites that set the East of Europe apart from the West. These conflicting theories are reconciled by Acemoglu & Wolitzky (2011) in a theoretical model that shows that a rise in the land-labor ratio can have two countervailing effects. Firstly, it may increase the profitability of coercion and thus its extent (in accordance with Domar (1970)).[8] Contrarily, it may also increase the wage that peasants can earn in outside activities (that depend on local conditions, such as the proximity and size of cities), which decreases the productivity and, therefore, the extent of labor coercion. Other models consider the role of politics and bargaining power (governed by the ability to credibly commit) that see elites strategically relinquished coercive economic power in order to avert social unrest (Acemoglu & Robinson, 2000; Aidt & Franck, 2015). Yet others highlight the role of changing opinions on the morality of subjection Finley (1980) and its efficiency (Oudin-Bastide & Steiner, 2015).

2.2. Export hypothesis

The theories presented thus far have not explicitly incorporated changes in international market conditions, rather they have focused on domestic factors, such as land-labor ratio and outside options. In the

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[7] Domar (1970, p. 21) argues that, given the lack of governments or of landlords' organizations able to prevent competition for labor, the land-labor ratio would even give rise to a free peasantry, if transaction costs were not positive.

[8] Klein & Ogilvie (2017) show that this was the case in Bohemia in the middle of the 18th century.

1950s, Polish historian Marian Malowist is among those who pioneered relating labor coercion to international trade in the English-language literature (e.g. Malowist, 1958, 1959), which was later coined as the 'export hypothesis' (Cerman, 2012). Building on this, Topolski (2009, pp. 269) distinguishes 'autonomous' demesnes run by the gentry that produce a variety of goods for local markets and 'expansionist' demesnes that produce some specific crops for exports and that produced more with rising export opportunities. Using data on 500 Polish demesnes in 1564-5, Guzowski (2011) advances this argument by showing that 'expansionist' demesne were more frequently located on the Vistula river and its tributaries that provide easy access to Danzig than in locations with inferior access to international markets. While he estimates that only 5% of grain produced in those two years in Poland was exported[9], those exports generated about as much demesne income as the 25% sold on domestic market. This not only underlines the profit potential in international markets, but also shows that the majority of produced grain remained in the demesne for reseeding and consumption. Guzowski's (2011) analysis of grain types shows that high-priced rye was the dominant export crop - as was the case for most of the East's exports as we show in Appendix E.5 - while the cheaper wheat and barley were sold to domestic markets. This finding may support Engerman & Sokoloff's (1997) argument that only high-value crops are produced with coerced labor, but newly shows that also grains and not only sugar or tobacco can fall into this category.

Small shares of grain exports in production such as those reported in Guzowski (2011) are often used to argue that the role of international markets was limited and, thus, cannot explain labor coercion (e.g. Kula, 1970). In the absence of holistic grain production series, we are in no better position than those critics to assess the share of exports in production, but we argue that our new data (Section 5) show that grain exports were quantitatively large. Assuming 121kg per capita per annum of grain consumption (based on Allen et al.'s (2013) subsistence basket for Northern Europe), the exported grains could have fed more than 6.5 million people (or 2.1 times the Dutch population)[10] in the peak export year of 1847 and a quarter of that on average across the period (compare Appendix E.4). Around 1850, the population of the countries around the Baltic Sea equalled 22.5 million without European Russia and 92.5 with it.[11] We note that

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[9]Given that our trade data at the time of writing is not available for those years, we are unable to discern how much grain was exported by the rest of the East. However, we plot the number of shipments for all years that the Sound Toll records have been preserved in Appendix E.1 and note that in 1564-5 the number of shipments was not as large as, for example, during the 1590s, such that Poland's export share may have been higher later in the 1500s.

[10]Population estimate of 3.057.000 in 1840 is taken from the acclaimed Faber et al. (1965).

[11]Except for Prussia, this number is based on McEvedy & Jones (1978) who quote population figures in millions in 1850 as follows: Denmark (1.5), Finland (1.5), Poland (5), East Prussia (ca. 12 based on 1849 Prussian census (Becker et al., 2014)), Sweden (2.5) and

grain exports were concentrated in number of ports that were changing (see Figure 4) across time, thus, even in years when overall exports are small, we observe significant exports from particular ports, which presumably corresponds to a sizable share in the surrounding region's production.

Another critique of the export hypothesis deals with the fact that labor coercion existed also in the far inland and eastern regions that could have not plausibly exported grain on either maritime or land routes (Cerman, 2012). We note that our study of the sub-national distribution of de-facto labor coercion in Estonia and Prussia reveals that in both countries labor coercion increases with proximity to ports and, in accordance with Guzowski's (2011), also navigable rivers. A comprehensive comparison of sub-national data of other, more inland countries may help understand how far this gradient extents. Currently, the only evidence of far inland countries comes from Klein & Ogilvie's (2017) study of Bohemia in the middle of the 18th century that finds that land-labor ratios are positively correlated with coercion.

From the existing literature it remains unclear what the precise mechanism behind the export hypothesis are and when and where it applies. We address some aspects of the mechanism question in Section 3 where we construct a theoretical model. Furthermore, we investigate all countries around the Baltic Sea for an export hypothesis given that, outside agricultural crisis years, most of them were net grain exporters and a minimum extent of unfree labor (e.g. labor dues like corvée labor) applied to all of them (Cerman, 2012). There is evidence, however, for an export hypothesis in other periphery regions. Comparing *Argentina* and *Chile*, which both saw their wheat exports triple in the 1850 to 1870 period, Bauer (1975) observes that while labor demand surged in both countries, only Argentine agricultural wages rose. He relates the stagnation of Chilean wages to the relative labor scarcity in the country, which led to higher labor dues, suggesting an interaction between labor scarcity and foreign demand. Concerning the *American South*, Wright (1975) notes that the pace of economic expansion was principally governed by the rate of growth of world cotton demand. He posits that given that the demand for cotton collapsed and then stagnated between 1860 and 1900, the economic successes of slavery would not have persisted.

3. Modelling Open-economy Labor Coercion

How do the implications of the land-labor ratio and of outside options for unfree labor change once international markets are considered? To the best of our knowledge, the literature does not address this

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European Russia (70).

question and contributors to the export hypothesis do not specify the mechanisms of the relationship they hypothesize. Below we develop a simple model with two actors: landowners who can engage in costly coercion and peasants who are subject to the level of coercion chosen by the landlord unless they exploit outside options, such as running away. Our data (see Section 5) and the literature on the trade of Baltic Sea countries suggest that local and international grain prices were highly correlated. In the case of Scania, this correlation remained strong even after it only had exposure to international markets through grain imports after banning itself from exporting (Olsson, 2006).

Figure 1: Grain production in Denmark and Scania and local and "Western" prices, 1706-1856
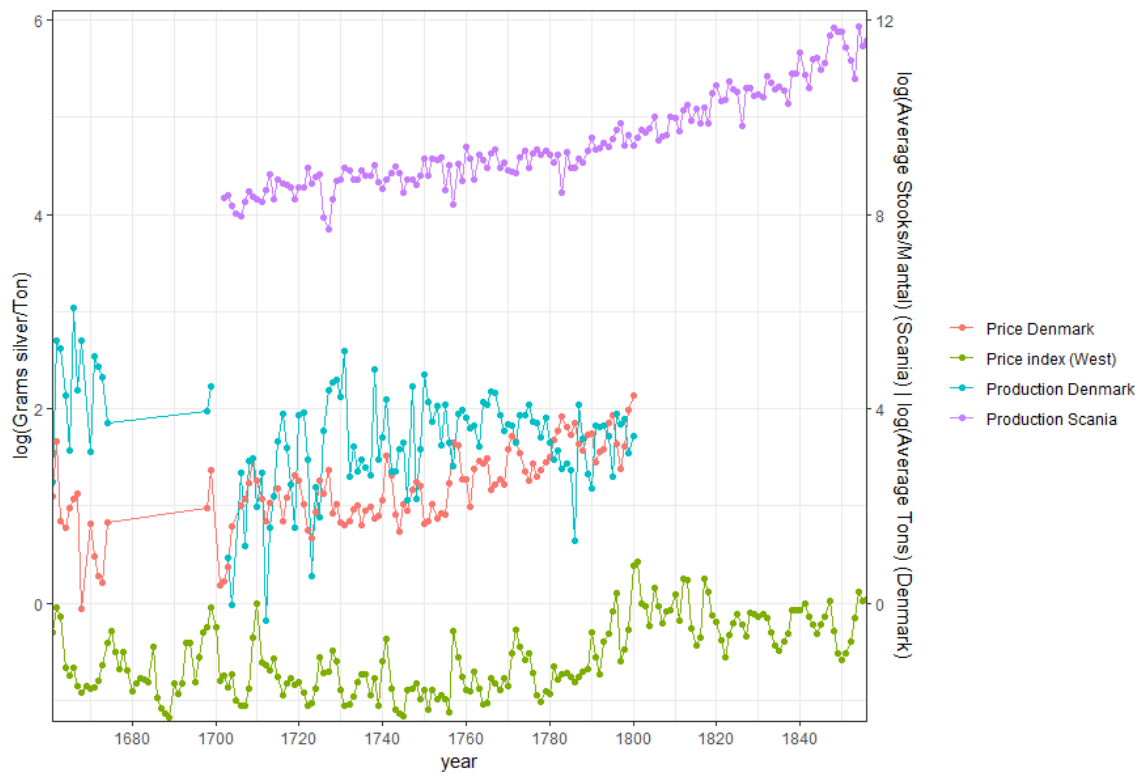
Notes: Figure plots grain prices and production, which appear to be highly correlated. Price index constructed from product of share of grain type in exports and their respective price (see Appendix E.6 for details and sources). Production aggregates all grain types. See Sections 5.3.1 and 5.3.4 for the Danish and Scanian sources, respectively.

This casts doubts on whether Acemoglu & Wolitzky's (2011) labor demand effect applies to our case; that is, whether "the price an employer faces for his output is determined endogenously by the production—and thus coercion and effort— decisions of all employers and affects the marginal product of labor and the return to coercion." (Acemoglu & Wolitzky, 2011, p. 558). To better fit our case, we develop a model

with domestic and foreign demand shocks that raise the price of grain and should raise peasant's wages (in the case of foreign demand through a Stolper-Samuelson effect) unless the landowner uses more coercion (in this case we refer to the wage as counterfactual). The landowner is, therefore, more likely to use coercion given that the cost of coercion – although fixed in absolute terms – will have fallen relative to the reward: not paying the higher counterfactual wage. This effect - the direct effect - resembles the labor demand effect in Acemoglu & Wolitzky (2011) that, however, stems from an increase in the land-labor ratio, see Figure 2.

Figure 2: Visualization of model that differentiates the effects of domestic and foreign demand shocks and contrast to model of Acemoglu & Wolitzky (2011)
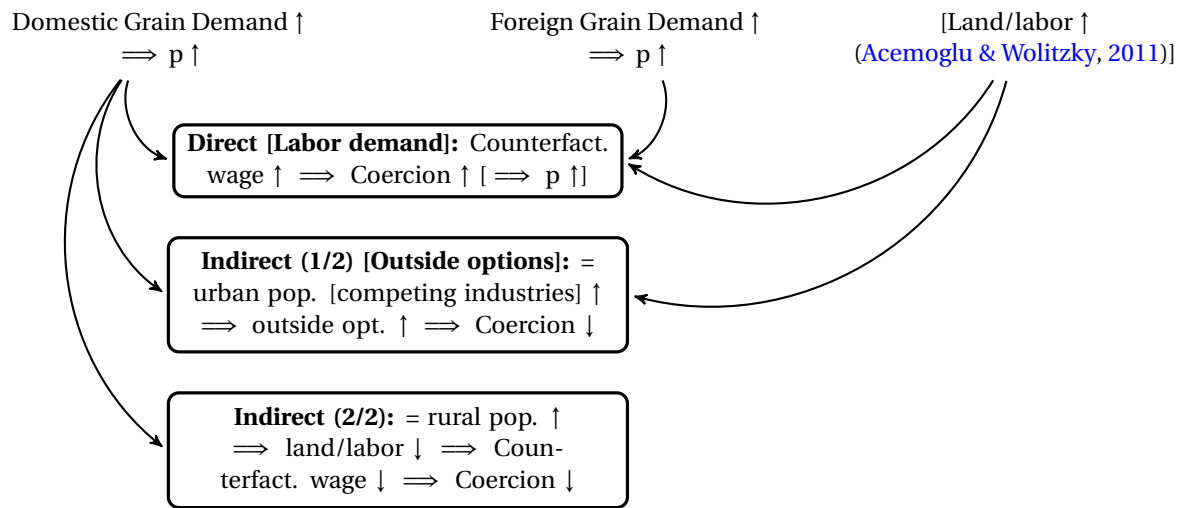
Notes: This Figure visualizes the key ideas in the model that we formalize later on in this section. In this model, domestic grain demand shock can be decomposed into urban and rural population growth. Given that grain is a staple good, we abstract from income effects and assume a fixed consumption per capita. Terms in square brackets include terminology or parts of the model from Acemoglu & Wolitzky (2011) if they deviate from ours.

In our model the direct effect is homogeneous for domestic and foreign shocks; however, as mentioned, our interpretation of historical evidence is that prices are determined internationally – outside years of acute crop failure or trade embargoes.[12] The cause of a domestic grain demand shock can be decomposed into urban and rural population growth. A rise in the urban population increases outside options while a rise in the rural population reduces the land-labor ratio. In accordance with Acemoglu & Wolitzky (2011) and Domar (1970), these more *indirect* effects reduce coercion in the face of a domestic

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[12]Using annual tree-ring growth data to proxy for weather shocks, we observe common year to year variation, but also a substantial asymmetric distribution of weather patterns in our sample within the same year. Observing in the same year good harvests in some localities and bad ones in others should imply active trade and an important role of international markets.

demand shock, which implies that the overall effect of domestic grain demand shocks on coercion is ambiguous. Foreign demand, however, does not stem from domestic population increases, and, therefore, unambiguously increases coercion in our model.

One could argue that facilitating foreign demand provides more employment in cities and, thus, improves outside options. However, the literature characterizes Eastern cities as stagnating in growth even during trade booms due to their institutional make-up, which only benefited a selected few (Lindberg, 2009, 2010). In particular, the landed elites are often reported to have bypassed local merchants in cities by trading directly with foreign merchants. Indeed, our trade data show that the vast majority of ship captain's resident cities are in the West, mainly in the Netherlands (see Appendix E.2). Additionally, we show that the population growth of coastal East-Elbian, German cities appear independent of their export trends (see Appendix C).

Like Acemoglu & Wolitzky (2011), our model still reconciles the rise of coercion in the European West and the fall in the East. We agree with Acemoglu & Wolitzky (2011) that outside options were relatively more limited in the East and that this enabled coercion. Both the West and the East experienced dramatic population losses due to the plague and subsequently population growth surged. Admittedly at this point in history, European grain markets were not very integrated (Jacks, 2004; Chilosi et al., 2013) and East-West shipping was confined to luxury and not bulk goods (Van Tielhof, 2002). Thus, the land-labor-ratio rather than trade-based models fit those early years. However, we argue that our model applies to later years, when Malthusian population cycles, rather than pandemics, determined local demand and trade surged leading to international prices becoming important in domestic markets. The fact that the West emerged with higher population density from the Middle Ages than the East (Bairoch et al., 1988) put it first in line to demand grains from elsewhere. Facing this foreign demand aggravated the scarcity of labor in the East, fostering unfree labor.

For the remainder of this section, we formalize some of the mechanics of our model. To this end, start by focusing on what sets our model in motion: exogenous changes in domestic (D_{domestic}) and foreign demand (D_{foreign}) that (through a function f) drive determine the price p at which grains sell both domestically and internationally:

$$p = f\left[D_{\text{domestic}} \underset{(+)}{\left(\underset{(+)}{Pop_{\text{rural}}}, \underset{(+)}{Pop_{\text{urban}}} \right)}, \underset{(+)}{D_{\text{foreign}}} \right] \tag{1}$$

D_{domestic} depends positively on rural (Pop_{rural}) and urban population (Pop_{urban}). Pop_{rural} can be used as labor (L) in grain production:

$$Pop_{\text{rural}} = L \tag{2}$$

The amount of available land is fixed and set equal to 1, such that the land-labor ratio equals $\frac{1}{L}$. The production function (g) determines the produced quantity q of grain solely depends on L:

$$q = g(L) = \alpha(L_f + L_c) \qquad \text{s.t.} \quad 0 < \alpha < 1, \tag{3}$$

$$L_f + L_c = L$$

Labor can either be free (L_f), in which case it is paid a wage w based on its marginal productivity, or coerced (L_c). L_f and L_c sum to L, the maximum amount of labor. L_f can be converted into L_c and vice-versa. Coerced labor is paid a small subsistence wage (σ) that does not depend on its marginal product. Coercion costs coercion effort χ per coerced unit of labor. Free and coerced labor are assumed to be equally productive contributing to output by a factor α. Note that the landowner's output is always the same as a result.[13] The landowner's profit (π) maximization writes as follows:

$$\max_{L_f, L_c} \quad \pi = p\alpha(L_f + L_c) - wL_f - (\sigma + \chi)L_c \tag{4}$$

$$\text{s.t.} \quad 0 < \sigma < 1,$$

$$0 < \chi < 1,$$

$$w = h(\underset{(-)}{L}, \underset{(+)}{p}) = h\left(\underset{(-)}{L}, f\left[D_{\text{domestic}}\left(\underset{(+)}{Pop_{\text{rural}}}, \underset{(+)}{Pop_{\text{urban}}}\right), \underset{(+)}{D_{\text{foreign}}}\right]\right)$$

The landowner can choose how much free and much coerced labor to employ, i.e. can convert free into coerced labor. Given $\frac{\partial w}{\partial p} > 0$, the landowner will employ more free labor as long as $w < \sigma + \chi$, but will employ more coerced labor as soon as $w > \sigma + \chi$ in order to avoid paying wages. This consequence of rise in the price (that stems from foreign and domestic demand surges) is the aforementioned *direct* effect.

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[13]Land is always tilled, either by free or coerced labor and grain "always sells". One could also introduce productivity differences between the labor types and also labor hording.

We now turn to the 2 indirect effects.

The first indirect effect focuses on outside options (proxied by by urban population in our model) that increase the cost of coercion (χ) according to a function i:

$$\chi = i(\underset{(+)}{Pop_{\text{urban}}}) \tag{5}$$

Thus, given that an increase in Pop_{urban} not only leads to an rise in w (through p), but also and increase in χ, its effects on the equilibrium condition for more coercion ($w > \sigma + \chi$) are ambiguous. A rise in coercion is made even more improbable by the second indirect effect, which dampens wage growth (given $w = h(\underset{(-)}{L}, \underset{(+)}{p})$) due to increased abundance of labor following an increase in Pop_{rural}. As mentioned before, in our model an increase in D_{foreign} only has a direct effect and, thus, unambiguously increases coercion.

4. Historical Background: Institutions, Unfree Labor, and Trade in Early-Modern Eastern Europe

As our paper covers 277 years, and deals with the diverse set of countries around the Baltic sea, writing a concise historical background can be complicated. Given this scope we cannot hope to cover all aspects and dynamics of the history of the Baltic Sea region, rather we outline the more relevant developments - a timeline is provided in Appendix A). Furthermore, in the areas where we will study de-facto labor coercion, more specific accounts of the institutional, trade, and unfree-labor developments will be provided: Denmark, Estonia, Prussia, and Scania (Sections 4.2-4.5). With these points in mind, it is impossible to cover all interactions between coercion and international trade in our sample, however, the selected case studies, and their underlying institutional diversity, provides illustrative insights.[14]

4.1. Three Broad Developments: The Price & Commercial Revolution, the Second Serfdom, and the Great & Little Divergence

This research interacts with three broad Early-Modern developments: the Price and Commercial Revolutions, the Second Serfdom, and the Great and the Little Divergence. The Price Revolution occurred

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[14]We note that we are not including Poland for which perhaps the export hypothesis was most intended for. We do include, however, the parts of Poland that fell to Prussia and point readers to, for example, Guzowski (2011), but we were not able to obtain county- or estate-level panel data. This certainly is a fruitful avenue for further research.

between c.1515 and c.1650 and entailed persistent inflation across Europe, although the exact causes are unknown historians have developed two main explanations. The first being that the influx of Spanish-American silver rose prices – although prices had been rising before though; and the second being that rising population and urbanization post-plague increased demand and, therefore prices – but this recover was slow and may only explain grain, rather than general, price trends (Munro, 2008). One consequences of the Price Revolution was a further boost to the Commercial Revolution that had begun in ca. 900 with trade networks in the European South and that had reached the Baltic at least after the rise of the Hanseatic League. We explore the implications of the decline of the League in a related paper that uses the same trade data source (Raster, 2018). Historians of the Netherlands commonly refer to the Baltic trade as 'the mother of all trades' (Van Tielhof, 2002) due to its early beginnings and role in feeding the rising population with grain.[15] Indeed, with the onset of the Price Revolution the trade shifted from luxury goods (like pelt) to include more bulk goods (grain, timber, and tallow). In return, countries in the East imported manufactured textiles, from places such as Antwerp and later England, and dried fish or simply coins to balance payments (Raster, 2018).

A second broad trend that is central to this paper is the Second Serfdom that refers to the general rise of unfree labor regimes in the European East and decline in the West. The term 'second' may be somewhat misleading since in some regions of the East no serfdom came before the Second Serfdom. For example, when the eastern-most extents of Prussia were conquered, most new settlers were allotted land as part of the *Ostsiedlung* and severe forms of unfree-labor emerged only later (Clark, 2006). Despite the absence of a 'First Serfdom' in some areas, peasant working conditions were restricted across virtually all of Eastern Europe; serfdom lasted until 1861, when Russia became the last country to abolish serfdom. Nonetheless, substantial temporal and spatial variation existed within Eastern Europe that involved not only serfdom, but an array of coercion regimes, such as mobility bans, or peasants having no rights to sue. Even when these 'unfreedoms' were called serfdom, what this could entail may differ starkly across regions (Cerman, 2012). For instance, serfdom in Denmark mostly affected the mobility of farmhands, while serfdom in Estonia governed virtually all aspects of peasant live. Also, the fact that European peasants were referred

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[15]Comparing the UK's or the Netherlands' grain imports from the Baltic to those from the rest of the world would be an interesting exercise. However, at the time of writing no such data is available to us. At least for the period 1771-1787 for which Amsterdam's shipping books have been analyzed, we know that Baltic grain imports made up the lion's share in cities grain trade (Scheltjens, 2012, Figure 19). This share declined from ca. 1700-25 as England was exporting a sizeable amount of grain to the Netherlands.

to as serfs rather than slaves may falsely suggest the absence of extremely harsh treatment of peasants. For example, the sale of individuals without land and, thus, the splitting up of families that is commonly considered a unique feature of slavery occurred during Denmark's spell of serfdom (Christensen et al., 1934). In this paper we make a first attempt to provide a holistic overview of the de-jure unfree labor reforms during the Second Serfdom (see Section 5.2).

A third and last trend we point to is the Great and Little Divergence, which describe the rise of Western Europe versus the rest of the world and versus Eastern and Southern Europe, respectively (Pomeranz, 2009; De Pleijt & Van Zanden, 2016). The Great Divergence has been related to relative and absolute real wage improvements mainly in Britain and the Low Countries that preceded the Industrial Revolution and were due to domestic (Allen, 2003) and international factors (O'Rourke & Williamson, 2005). Others view institutional changes, such as active parliaments, that may have resulted from Atlantic trade as drivers of the divergence (Acemoglu et al., 2005). Relative to Southern and particularly Western Europe, the East's agricultural productivity remained low from 1300 to 1800 (De Pleijt & Van Zanden, 2016).[16] It is, thus, possible that the East could only compete in prices with the West by slashing costs and increasing workers' effort through the use of servile labor. As De Pleijt & Van Zanden (2016) state, due to limitations in their data, they are unable to determine the effect of trade in the Little Divergence debate. The data we present as part of this research may be used by future research to fill this gap.

4.2. Denmark

Denmark was the last country in our in Europe to introduce serfdom country-wide. After experiments with serfdom that began on Denmark's eastern islands in the late 15th century ended in 1717, serfdom (*stavnsbåndet*) was introduced in all of Denmark's core territory[17] in 1733. Perhaps contrary to the export hypothesis, Denmark's reintroduction of serfdom did not coincide with an export boom, but a bust, that followed the Great Northern War (1700-21), and lead to declines in the international prices of Denmark's main agricultural exports – livestock and grains. Given this price shock production declined, which resulted in a sharp fall in labor demand in rural areas, these changes resulted in rapid urbanization. To counteract this loss of manpower for landed elites and the militia, serfdom – that mainly entailed mobility bans on farmlands, but not other workers – was introduced; this chimes well with Domar's (1970) thesis

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[16]See also Kirby (2014, p.21) who presents similar findings.
[17]Norway, Iceland, and Danish overseas colonies followed their own paths.

that high land-labor ratios foster coercion. Beginning in 1788 serfdom was gradually abolished, first for those under 14, then those over 36 or veterans, as prices and growth increased again.[18]

4.3. Estonia

Estonia is the only country among those discussed here that may qualify as a colony.[19] after a German elite settled it following the crusades of the 13th century (Kasekamp, 2017). Unlike in Prussia's easternmost regions, the German colonizers never attempted to assimilate the native population nor did they expel them. Instead, owning virtually all arable land, the Baltic Germans introduced a feudal system that gradually turned into serfdom during the 16th century, which, coincided with increasing Western demand for grain (Kasekamp, 2017, p. 38). Such developments were akin to Livonia (present-day Latvia) and Courland (present-day Lithuania), but their paths diverged when in 1560 Northern Estonia, the area we will focus on, fell to Sweden[20]. The Baltic Germans[21] retained three-quarters of all of Estonia. This was because the Swedish Crown – who took the remaining quarter – was unable to set up their own administrative apparatus, and, therefore, entrusted the Baltic Germans with those tasks. However, given that the peasantry in Sweden had never been enserfed (see Section 4.5), serfdom was abolished in 1687 (Kasekamp, 2017). To determine what tax burden could be imposed on Estonian peasants, the Swedish Crown tasked the Baltic Germans to compile detailed records, the *Wackenbücher*, on labor dues and farm wealth that we use in this research (Section 5.3.2).

Serfdom was reintroduced when Russia conquered Estonia in 1710 and peasant rights reached a low point as the Baltic Germans, who also under the Russians were acting as administrators, were no unconstrained in the dues they could impose (Raun, 2002, p.41). This 'low-point' can be seen in the Wackenbücher, which were continued in the Russian era, that show a large increase in dues. Serfdom was formally abolished in Estonia in 1816, making it the first among the Baltic governates (Courland: 1817, Livonia: 1819) and putting it significantly before the abolition of serfdom in the Russian heartlands in 1861. This earlier abolition in the Baltics, who had neither Russian elites or peasants, can be seen as an experiment by the Tsar; however, there is also evidence that it was a response to peasant demands, *and*

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[18]There were earlier unsuccessful attempts to, for example, reduce labor service due (which amounted to up to 250 days a year) to 144 days annually (Munck, 1990, p. 250).

[19]The others are the remainder of the Baltic governates (Livonia and Courland) and, perhaps, Swedish Ingria and Pommerania)

[20]The Ösel island fell to Denmark, but in 1645 also ceded to Sweden

[21]At this time the Baltic Germans only had loose ties to the German lands and were in disputes with Lübeck and the Hansa (Dollinger, 1970)

also the demands of the Baltic Germans, who pressed for more freedom to regulate their peasants' work. Similar to Prussia, the abolition of serfdom in Estonia implied that peasants lost their tenure rights. This is reported to have severely deteriorated peasants' material conditions, who frequently revolted. Potentially the Estonian experience discouraged the Russian crown from abolishing serfdom earlier in the rest of the country. The situation of Estonian peasant may have improved starting in 1848 when the buying of allotments was legalised, however, peasants' labor obligations remained unchanged (Moon, 2001, pp. 43).

This narrative speaks to several viewpoints on unfree labor. It shows that the abolition of serfdom may not immediately improve peasant welfare (Eddie, 2013) and may harm production as was the case in the post-abolition American South (Fogel, 1994). It also makes clear the contrast between those who argue that the de-jure abolition leads to de-facto 'changes' quickly (Markevich & Zhuravskaya, 2018) and those who argue for a delayed, longer response, which in Russia lasted until 1918 (Stanziani, 2010).

4.4. Prussia

Prussia's experience with unfree labor and its politics – and later that of all Germany's politics – are defined by the power of the Junkers, the noble landowners of the districts east of the Elbe river.[22] Derived from German *jung Herr* (young lord), Junkers were originally the second generation of German noblemen who had settled during the waves of German eastward expansion in the Middle Ages. Given that Junkers were granted eternal tax exemptions they had significant resources, which allowed them to restructure their lands in the 1400s – this left them with the most fertile lands. This, at a time when Prussian mostly had infertile land and was heavily dependent on agriculture, gave the Junkers significant power. Their position of power implied that the Junkers' influence extended to politics and law matters; this is especially clear when manipulating the deeply indebted state authority to permit their estates becoming integrated legal and political spaces: thus, giving them even more power over their peasants (Clark, 2006), see first introductory quote.

Concurrently to those developments was the gradual enserfment of peasants that occurred for several reasons: firstly, the lack of a tradition of peasant rights in these recently settled lands; secondly, the population losses during the long agrarian depression of the late Middle Ages; and lastly, the aforementioned

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[22]This section heavily draws from Clark (2006), who provides a very illustrative and multifacetted account of all of Prussia's history.

compliance of the state.[23] In 1518 the Junkers ruled that also their subjects' children would face the same obligations as their parents (*Gesindezwang*) and in 1536 they enacted a mobility ban. In 1572 two corvée days per week were declared customary, which served as a reference point until the liberation of peasants (*Bauernbefreiung*) that began in 1807 (Kaak, 2007, pp.76). Against this stood a substantial proportion of non-subject peasants on crown lands, who sometimes provided waged-labor for Junkers. While peasants on Junkers lands often enjoyed strong hereditary rights, perhaps the most significant right they lacked was the right to appeal to courts higher than those presided by their Junker.[24]. Junkers reduced the amount of corvée days somewhat following the devastation of the Thirty Years' War to outbid competing Junkers who also attempted to hire labor from incoming settlers (Clark, 2006). The right of peasants to remain footloose and negotiate better terms ended in 1653 when a universal movement ban was enacted. This 1653 recess also reinstated serfdom where it had previously applied (Eddie, 2013, pp. 90), which is indirect evidence that it had been introduced previously.[25] In general, the tenure of peasants on the lands of their Junker degraded as a result of the Thirty Years' War; in some localities east of the Elbe up to 60% of the population were lost, which led to a fall in grain demand and a drop in prices by 50% between 1625-1685.

Many of these unfree-labor reforms coincided with the decline of the Hanseatic League, and, therefore, the transfer of trade privileges from merchants to local rulers (Raster, 2018). There is little evidence of the quantities of Prussian exports in this period, aside that provided by the Sound Toll data. Naudé (1901) estimates annual exports of 130,000 hecto liters around 1740 that were mainly exported through the Elbe, but it remains unclear how this compares to total production. Cities, including trading ports, increasingly came under the Crown's influence, who introduced excise taxes that left them at a substantial disadvantage relative to Junkers who faced no such taxes even when exporting through those ports. In general, the urban sector was not very developed in Prussia at this time; for example, in 1700 only only two of the 30 German cities with populations of 10,000 or more were in Brandenburg-Prussia: Berlin and Königsberg (Bairoch et al., 1988). Beginning in 1770, export demand from England[26] rose leading to an increase in agricultural prices, which caused land prices to inflate.[27]

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[23] Earliest attempts to introduce mobility bans can be observed in Brandenburg in 1484 (Kaak, 2007, p.67)

[24] This practice was called *Gutsgerichtbarkeit*.

[25] Other evidence on the extent of serfdom before the Thirty Year's War is scarce.

[26] In fact, most grain exports went to non-German land in the West and to, for example, Hamburg or Bremen (Kopsidis, 2015).

[27] It remains unclear how peasant's rents and labor dues changed during this period; if they decreased or stayed constant this would constitute a significant transfer of wealth to peasants (Eddie, 2013, pp.114). Without de-facto unfree labor data in this period we cannot speak to this point.

By 1800 the power of Junkers was still unbroken and would remain so throughout the Age of Revolution, leading the German lands onto a special path of "incomplete" modernization (*Sonderweg*). It is estimated that around this time the Junkers held between 40-62% of cultivable land depending on how much land was held by the crown in each county, which is comparable to England, but significantly higher than French and Russian notabilities only held c. 20% and 14%, respectively. Starting in 1702, the crown had attempted to sell of parts of its land to raise money and gain the support of peasants. However, there was little demand among peasants who were discouraged by the unchanged rental obligations to the Crown despite owning the land and by fear of maintaining farms at their own cost; even after the offer was sweetened by removing upfront payments demand remained low (Eddie, 2013, pp. 108). The Junker's powers even remained intact as the Crown's administration gradually expanded its political influence, changed the legal code, and introduced a standing army. For once, the existence of larger crown domains – due to their failed attempts to sell them – meant the crown did not have to focus on expanding the tax base and, thus, did not interfere significantly with the Junkers. The Junkers who nonetheless complained saw most of their requests approved on the spot (Clark, 2006).

Following a defining defeat at the hands of Napoleon in 1807, Prussia lost large swathes of land; in response to this Prussia passed a long list of reforms to boost agrarian productivity: the October Edict, which started the reform era. It included three specific measures: firstly, noble land could be purchased without restrictions; secondly, anyone could pursue any occupation; thirdly, hereditary servitude came to an end. Due to the vague formulation formulation of the latter aspect of the October Edict that stated there would only be 'free men', compare second introductory quote, debates erupted as to whether labor dues were still to be paid; however, once word of the edict spread labor dues were almost impossible to enforce, but landowners viewed it as a carte blanche to evict peasants. Supplementary reforms in 1808, 1811, and 1816 clarified the matter to a certain degree: those with previously secure tenure rights would keep them, while those without could loose them with the permission of the state. Ultimately it was decided that most peasants were left with two options: they could outright buy the land having to pay off the seigneurial portion, or they could they could retain right of usage to between one and two thirds of the land. It is worth nothing that paying off seigneurial portions would take most peasants more than 50 years. In our analysis of de-facto unfree labor Prussia, we exploit the statistics of Meitzen (1869), who in 1848 took stock of the progress of serf emancipation, as well as landownership inequality that is documented

by censuses.

Unlike all other regions in the sample, serfdom was never legal in Scania, Sweden's southernmost province and grain granary, or in the rest of the country. Danish rule of Scania lasted until 1658, only being briefly reinstated from 1676-9 and 1711; hence, Danish rule of Scania pre-dated Denmark's late spell of Serfdom (1733-88). Despite Sweden's medieval traditions of peasant emancipation, Scania was characterized by large landed estates with high levels of ownership concentration and tilled by a large number of vassal farmers with unregulated corvée labor: a legacy of Danish rule. When ceded to Sweden, 54% of land was owned by the tax-exempt noble elite, 27% by the crown, 11% by the church and 8% by freeholders (Weibull, 1923, p.63). While tenants on crown lands were guaranteed inheritable tenure when rents were paid, tenants on noble land were only protected against eviction outside the annual general moving day (Olsson, 2006).

Scania's high land inequality is thought to have resulted from the commercial upswing that began in the early sixteenth century and saw large-scale grain and cattle exports to the West - primarily to the Netherlands. Olsson's (2006) detailed study of Scanian estates shows that the landed nobility profited from rising grain prices by converting their tenants' obligation from monetary payments to payments in grain. The trade boom ended when Scania was ceded to Sweden in 1658, which instated a ban on international grain exports to stabilize domestic grain supply. In order to finance the Great Northern War, a statues was issued in 1701 that allowed the sale of crown lands to peasants, in the following century data shows that landownership in Scania underwent drastic changes: by 1801 30% of Scania was owned by freeholders (Weibull, 1923, p.64). Since 1791 peasants were also allowed to buy manorial land; this decision, which reflects the Crown's search for peasant support, has been linked to the king's assassination by nobles in the following year (North, 2015, p.156).

This dramatic change in landownership, driven by a need for finance, resulted in an increase in property rights – provided peasants bought the land – and was accompanied with deregulation of the grain market in the 1820s. Scania gradually became a net grain exporter again, despite rapid population growth; this was made possible by a four-fold increase in agricultural productivity, which allowed Sweden to escape the Malthusian trap (Olsson & Svensson, 2010). It is worth noting that these changes took place despite unregulated corvée labor, that reached a European high with, on average, 314 days per tenant per

year in 1850 (Olsson, 2006, p.490).

With this economic growth came a rise in wealth inequality that pre-dated Sweden's industrialization. Bengtsson et al. (2018) find that while Sweden started off more egalitarian than the European average in 1750, it had comparable levels of wealth inequality by 1900. In rural areas, this increase in inequality was mainly due to the sales of crown lands to peasants that increased within-peasantry wealth inequality given that peasants on noble lands had more limited opportunities to purchase land. When peasant purchases of noble lands was later made legal, it was peasants that owned former crown lands that used their 'first-mover advantage' in wealth acquisition that bought those lands rather than the peasants that tilled those lands under the nobility.

5. Data and Descriptive Statistics

To answer our research questions, we use four types of data. We discuss the first three in turn: firstly, trade data; secondly, data on de-jure unfree labor; thirdly, data on de-facto unfree labor. It is worth noting that the data on trade, de-jure unfree labor, and the Estonian de-facto dataset are novel. The additional fourth type of data are controls for potential yield based on soil conditions and drought severity based on tree-ring growth that we discuss in Appendices M and N, respectively.

5.1. Trade between Baltic and North Sea: The Sound Toll

This paper is largely made possible by the availability of trade statistics recorded by Danish tax collectors who levied the so-called Sound Toll. Introduced by King Erik VII in 1429, the Sound Toll was a tax levied on ships passing through the Øresund: a sea narrow between modern-day Denmark and Sweden. Controlling both sides of the Sound at the time, a castle was erected at Elsinore (the setting of Shakespeare's Hamlet) that, by pointing canons, stopped ships passing through the Sound to collect taxes. Following pressure by an international alliance led by the United States, the Sound Toll was abolished in 1857.

Next to a flat fee, the toll was proportional to the value of the goods and the rate depend on their type, for example wheat or wine. This tax structure produced extensive records on the shipment level, where usually each combination of good type, origin, and destination is recorded as a shipment. A ship could carry several shipments and, hence, was recorded as going between two or more locations.

The record state the quantity and the tax levied, but not the value[28], per shipment, as well as the captain's domicile town.[29] The shipment value was determined through self-declaration by the captains; however, to prevent fraudulent declarations the tax-collectors themselves could purchase the goods at the value declared. This 'threat' mechanism strongly discouraged fraudulent declarations, which have been shown to be limited Degn (2018, pp.369). The Sound Toll´records also include Danish and other ships since these were also subject to taxes although they were lower.

It is important to note that, because the Sound toll was collected at the connection between the Baltic and the North seas, ships sailing solely within those seas or shipments offloaded before the ship's arrival at Elsinore are not recorded. While we are interested in trade with the West, this limits our ability to determine where the grain export was produced in the East. As Figure 4 makes clear, there are no inland ports (e.g. Torun down the Vistula river) that directly exported grain to the West; furthermore, the very large export tonnage of Danzig and other towns suggest that they receive significant, within Baltic Sea grain trade, which has also been suggested in the literature (e.g. Van Tielhof, 2002). In the absence of long within Baltic Sea export series, one cannot tackle this issue fully; that said, we can use the descriptions associated with a shipment to learn more about the origin of the grains.[30]

For the sub-national analysis of de-factor unfree labor, the focus is on studying the implications of proximity to a port – where each port has been weighted by the amount it produces – we also argue that this 're-exported' grain is not a concern. This is because we are not interested in the how much grain the sub-national entity actually delivered to the port (which we do not observe), but rather: how close the entity is to the port, and how well the port is connected to Western markets where re-exporting can be counted in.

Although elements of the Sound Toll data have been used in previous research (e.g. Scheltjens, 2012; Van Tielhof, 2002), it has never been used for such a long, continuous period, and for such a wide array of commodities – with all types of grain - or in the cliometric way used in this paper. The first extensive description of the Sound Toll records was published recently by Degn (2018); the early research relied

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[28]The value cannot easily be inferred since the tax rates are only loosely documented.

[29]Not all information is available for every shipment. For example, port of destination was recorded on an irregular basis for some years in the 1660s, but the first year for which the information is complete is 1669.

[30]We make use of the description of the grain that sometimes reveals more about the origin of the grains (e.g. foreign versus domestic or Prussian'). This only marginally changes our findings and we chose to report the results that do not make use of this additional information. This choice is motivated by the otherwise complicated assignment of grains that are labelled after their region of origin to specific export ports.

on the Sound Toll Tables, which Degn (2018, pp.9) has shown included serious mistakes.[31] These issues may have misinformed the literature's discussions on the export hypothesis. Launched in 2009, an ambitious and ongoing program in the Netherlands, the Sound Toll Registers Online project (www.soundtoll.nl) (henceforth: STRO), enables us to study all Sound Toll records on the shipment level starting 1579.[32] In particular, the STRO provides the literal transcription of the original Sound Toll records. For reference, one such original is shown in Figure 3: it contains place names, good descriptions (in Danish), units, and currencies. Currencies can be identified quite easily in the STRO's literal transcription. That said, it should be noted that in other cases spelling can vary considerably, and this is particularly true for port names. For example, we identify more than 500 spelling variants for Newcastle upon Tyne, many appear to have been influenced by the captain's own origin: for instance, a Dutch captain would refer to Newcastle as the composite of nieuw (Dutch: new) and kasteel (Dutch: castle). Such declarations were then noted down by a Danish tax collector, who may have altered the spelling further. After significant cleaning efforts[33] that benefited from the resources provided by the STRO (detailed in Appendix B), the vast majority of the remaining missing value stem from actual blanks rather than from unidentified strings (see Appendix D). This leaves us with more than 397,000 grain shipments and more than 5.2 million shipments of all commodities.[34]

We show a breakdown of grain trade by exporting cities in the East in Figure 4 before and after the beginning of the Thirty Years' War. Throughout both periods Danzig is clearly the export leader; however, ports in the Baltic governates and Russia had started to catch up: St. Petersburg, founded in 1703, was among the 20 largest exporters. It can also be observed that the number of ports that export grain to the West has grown throughout the periods shown below, which might be evidence for the decreasing importance of staple rights that, for example, the Hanseatic League had previously enforced.

We provide additional descriptive statistics and analyses in Appendix E that are briefly summarized, followed by the unfree labor data section.

- **Pre 1579 and share of grain in total trade**: The full Sound Toll data mentioned above is not avail-

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[31] The main mistake was to confuse a captain's domicile city with the origin or destination of the shipment.

[32] The project is ongoing and will add earlier years in the coming years.

[33] c. 2 years

[34] This number is large also because fishing vessels, passenger ships and war fleets are recorded in the data. Furthermore, there is a significant amount of local trade, for example, ships crossing between two ports in Denmark or Sweden. We exclude such regional trade in our study of grain exports.

Figure 3: Example of a ship and its shipments recorded in the Sound Toll records on 18.4.1711

Notes: Example of the entry of a ship on 18.4.1711 whose captain resides in Hoorn (the Netherlands). All shipments originate in Danzig and are bound for Amsterdam. The precise reason for the toll discount are unknown, but may be related to the captain's country of residence. A last is approximately equal to 1.8 tons. Source: Sonttolregisters-175_0238 (film), 632752 (record id).

able for the pre 1579 period, so instead we rely on the data from Degn (2018). These data, though, do not distinguishe grain exports or tonnage, but rather just the total number of passages. This data is shown in Appendix E.1. Using this data allows us to more clearly see the extent of the trade upswing that culminated in the 1590s: with almost half of all passages containing grain shipments. The number of passages during this peak was only surpassed two centuries later in the late 1700s – although the number of passages containing grain was never again surpassed; it is shown, though, that by 1820 the tonnage of grain surpassed the 1590s peak. This implies that, while grain-containing passages were fewer, their average tonnage was larger. We also show that more than half of the passages contained grain from the 1590s to the 1600, but that this share was much lower, c. 10%, during other periods.

- **Grain trade by domicile of captain:** Appendix E.2 breaks down the Baltic's grain exports by the captain's domicile city, which effectively show under which flag a ship sailed. Domicile cities are not to be equated with place of citizenship, since many captains reallocated to foreign regions. It becomes clear that most trade was conducted under the Dutch flag until the 1790s, when Prussian

Figure 4: Exporting ports for grain (in tons)
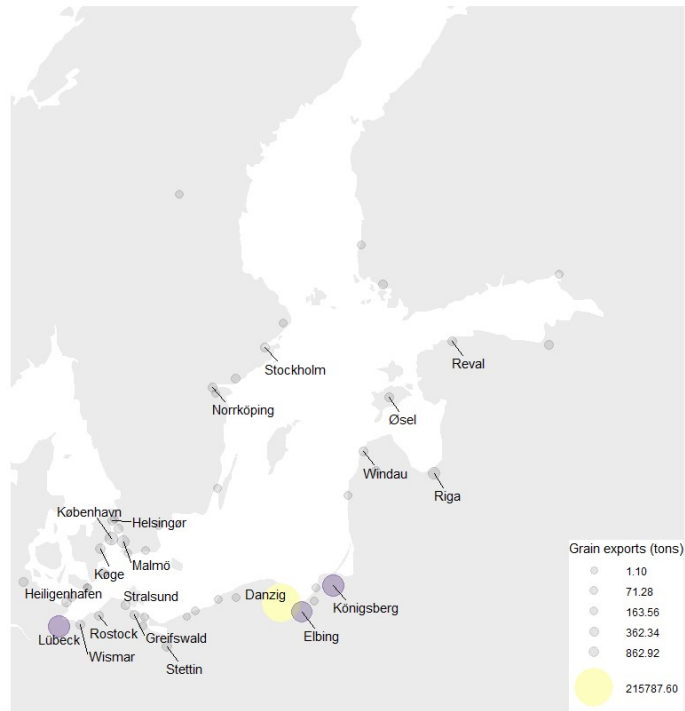
(a) Before Thirty Years' War (1584-1617)
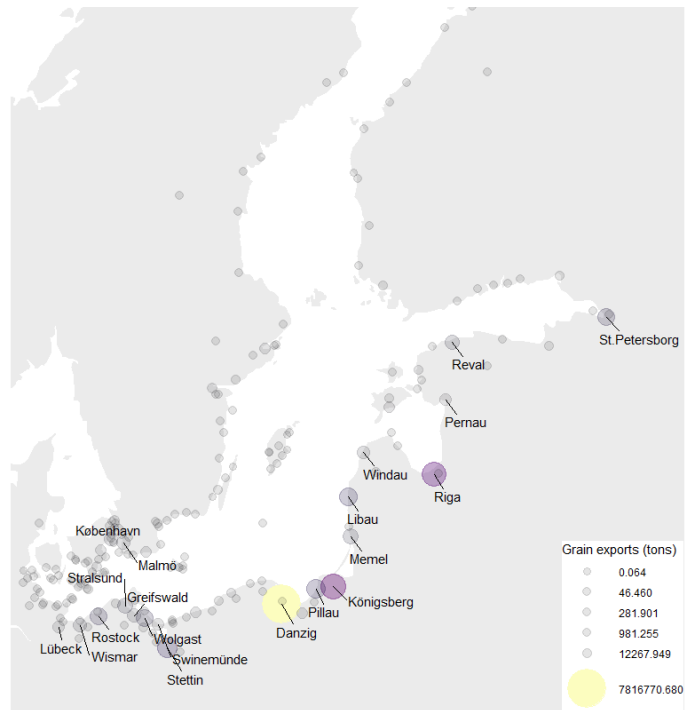
(b) During and after Thirty Years' War (1618-1856)

Notes: Author's calculations based on Sound Toll. 20 largest export ports with names in each panel. Each dot represents a port that exported grain. Inland dots refer to countries or regions that are in a few instances mentioned as origins in the Sound Toll instead of ports. Panel-specific dot size and coloring relative to respective sextile of grain exports.

flags began to dominate.

- **Grain trade by origin:** In Appendix E.3, we shows how the shipments of grains evolved by region of origin. Throughout the entire period, the German lands on Baltic shores from Schleswig to Memel in East Prussia are the export leaders. Starting in the 1780s, the Baltic governates start contributing c. a quarter of total exports. Sweden and Russia's grain exports rise to c. a fifth of the total starting in the 1820s.

- **Grain trade by destination:** In Appendix E.4, we offer a breakdown of the destination regions of Baltic grain exports. Prior to the Napoleonic wars, the Netherlands were the main destination, but after the British Isles became more as the Corn Law tariffs were phased out. Vast amounts of export tonnage bound for the British Isles are be observed in 1847 when the local economy was hit by crop failures and the Corn Laws had been completely abolished. Subsequently, they overtook the Netherlands as the prime destination, trading primarily with Prussia.

- **Grain trade by type of grain:** In Appendix E.5 we show the share of different types of grains, such as rye and wheat, in the Baltic's exports. Rye, used to make bread, was the most exported crop until the 1790s when it was overtaken by wheat that was mainly produced in Prussia. During peak export years, other grains such was barley, buckwheat, and oats were also exported, likely because those years coincided with grain price booms that made exporting other grains profitable, which were cheaper than rye and wheat.

- **Correlation of grain export tonnage and prices in the West:** In Appendix E.6 we use data on grain prices in the West and show that they are highly correlated with the amount of Baltic exports. This exercise explains the strong year-to-year variation in exports as prices were also very volatile.

- **Share of Baltic grain in French imports:** Appendix F uses French grain import data and shows that Baltic grain only made up a very small share. However, with most imports coming from Britain and the Netherlands, it is possible that the grains were re-exported and in fact originated in the Baltic. In fact, using Amsterdam's import due records in 1771-1787, Scheltjens (2012) shows that most of French imports from the Netherlands originated in the Baltic Sea area, making it likely that re-exported grains from the Netherlands originated in the Baltic Sea area. A systematic study of British grain imports by David Jacks that is currently underway, may further clarify the issue.

- **St. Petersburg's exports compared to Odessa's:** Using additional grain export data for Odessa, Appendix H shows that already by 1812 it had overtaken St Petersburg. Since we observe comparatively low shares of serfs both in the proximity of St Petersburg and Odessa, we argue that it is unlikely that the export hypothesis occurred in Russia's heartland, but we do argue that it existed in Estonia.

5.2. De-jure unfree labor

As mentioned, this research distinguishes between *de-jure* and *de-facto* unfree labor. As the historical background has made clear, the de-facto changes may not immediately follow de-jure reforms and may not go in the 'expected direction' in the short run, as the Estonian and the Prussian cases illustrate. We address this fact by also looking at de-facto unfree labor in our four case studies, but we argue that the exact timing of de-jure unfree labor reforms also deserves attention. The Prussian example in particular shows the role of special interest groups in shaping unfree labor legislation. Given Malowist's (1959) export hypothesis, we would expect the Junker's bargaining power to increase during export booms and, thus, de-jure coercion to rise.

To our surprise, we are not aware of any systematic listing of the beginning and end of any type of de-jure coercion. Blum (1978, p. 356) provides the initial decrees emancipation, however, only with regards to serfdom. Cerman (2012, p.23) provides a chronology of the introduction of movement bans, however, he does not include some of the bans introduced later and does not mention when they were lifted. Drawing on these, and many other secondary sources, we construct a dataset of the de-jure changes in the four types of coercion that we observe most frequently: laws forbidding peasants from suing their landlord (Gutsgerichtbarkeit); legality of expropriation (Bauernlegen); mobility bans (Schollenbindung); and serfdom. The specific dates the source material are shown in Appendix G. Absence of these types of de-jure coercion, however, should not be interpreted as peasants enjoying complete freedom, as labor dues existed in the entire Baltic Sea regions, including in Sweden and Finland where serfdom existed at no point. Moreover, the codification of some types of coercion did not occur in some regions, or it was not made explicit in the literature.

Figure 5 plots the de-jure data as timelines. This novel comparative view reveals that often mobility bans predated serfdom Overall there appears to be substantial temporal variation in the de-jure introduction and removal of types of coercion.

Figure 5: Types of de-jure coercion across time, 1579-1861
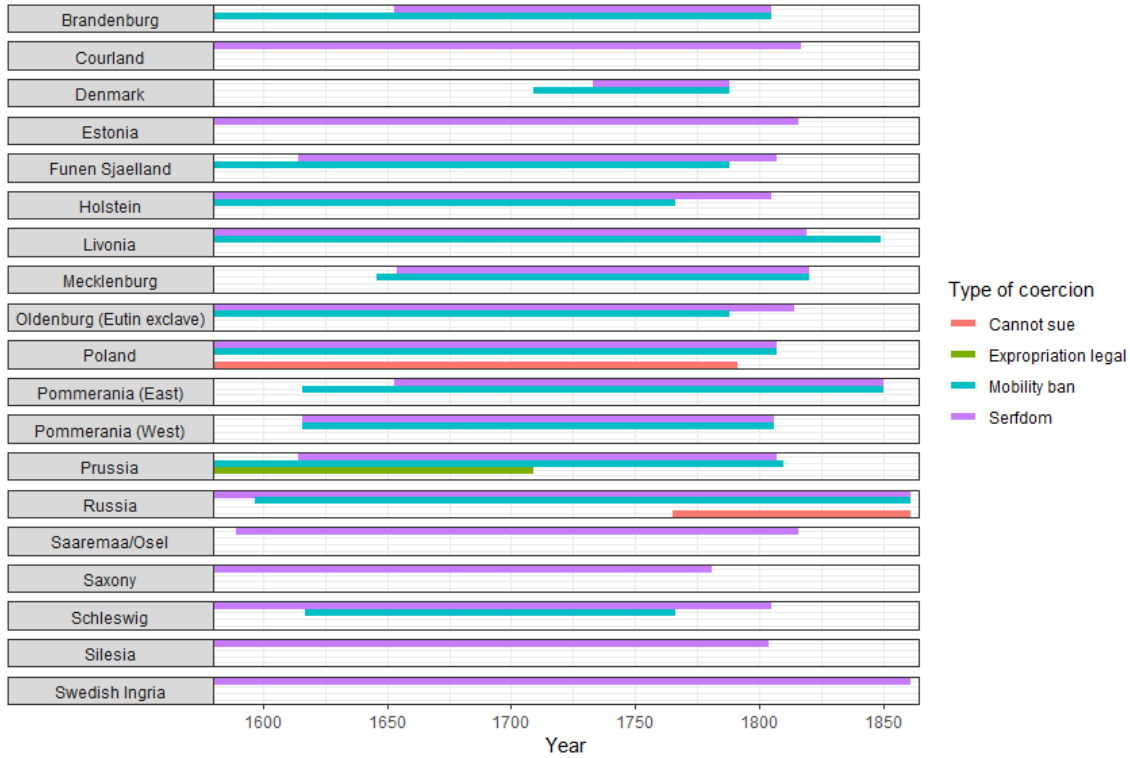
Notes: Compiled from various secondary sources that, together with the exact dates, are detailed in Appendix G. Bars show period of legality of the most common types of labor coercion in the sample (German terms in parentheses): bans to sue in any court other than the one presided by one's landowner (*Gutsgerichtbarkeit*), legality of expropriation (*Bauernlegen*), mobility bans (*Schollenbindung*), and serfdom (*Leibeigenschaft*). Bars extending to the left margin indicate that coercion type became legal prior to 1579. Despite extensive surveying of the literature, absence of 'bar(s)' may not always imply absence of coercion type, but rather unknown start and/or end dates. Scania and Finland are not shown since none of the considered coercion types were found to have been codified into law. In case a country ceased to exist (e.g. Swedish Ingria) we apply the end date of the country it had fallen to at that time (e.g. Russia).

5.3. De-facto unfree labor

In terms of de-facto unfree labor, this paper includes all existing, sub-national, panel data of unfree labor proxies that we are aware of (Danish estates, Prussian counties, and Scanian villages) and introduces a new cross-sectional, full-universe dataset of Estonian household's corvée days in 1732. Each of these data sets will be discussed in turn for the remainder of this section, before moving to methodology and results.

5.3.1. Danish estates

Data on individual hiring records of farmworkers and other laborers by estate is available for the period 1706-1801 as repeated cross-sections. The data were transcribed from original estate records by the

Danish Price History Project at the University of Copenhagen that lasted from 1939 to 2004.[35] After we cleaned the data and coded variables, each observation reveals the worker's wages, the task performed (such as assisting in harvesting or digging a trench); the worker's gender; level of expertise (master, apprentice, or helper); and whether the worker is an adult or a child. As Danish Serfdom only affected farm hands, we generated a dummy that indicated whether the work description falls into that category, following Jensen et al. (2018), the only other researchers to use these data.

Figure 6: Denmark estates and export ports, 1706-1801
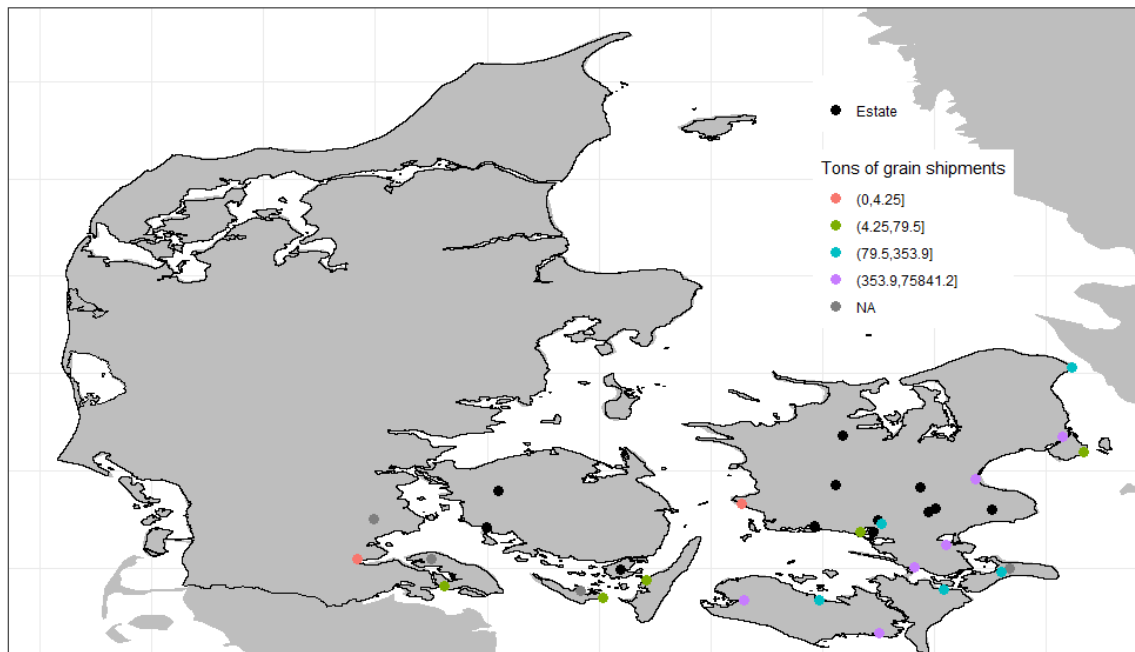
Notes: Figure shows the location of the 12 estates in the sample and the tons of grain shipped (sum of the 1705-1801 period in the Sound Toll) from ports in the surrounding. Missing port observations are ports that did not export grains in the considered period but at some earlier or later point.

Like Jensen et al. (2018), we document the wage gap between farm hands and other worker before and after the introduction of serfdom; however, we also consider the role of trade in our analysis, by assessing the location of the estate – and thereby the works – to export hubs. Additionally, we use data on each estate's grain purchase and sales, which we aggregate annually to proxy for an estate's participation in grain markets.[36] Figure 6 shows the locations of these 12 estates and of grain-exporting ports. We restrict

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[35]The actual files were kindly provided by Dan Andersen, who co-authored Andersen & Pedersen (2004), which summarizes the estate records.

[36]We convert the units to metric.

the data to these 12 estates on the Danish islands, thereby dropping four estates with available data in the north of the mainland, since they likely do not export through the Sound. Future research may focus also on livestock exports, which were also important to the Danish economy and are also recorded in the Sound Toll.[37]

In Figure 7 we provide some first evidence that trade was influenced by the introduction of serfdom in Denmark. In particularly it emerges that the introduction of serfdom coincided with a steep drop in the wage of farmhands, which is in contrast to the wage of non farm hands that does not appear to be affected. This is in line with difference-in-difference regression results of Jensen et al. (2018) that compare those two groups across time. The wages of those two groups of laborers appear to have followed similar trends before serfdom was introduced and again starting in 1740 when serfdom was still in effect. We add to the results of Jensen et al. (2018) our observation that shortly after serfdom was introduced, grain exports spiked to an all-period high. This was in part due to an increase in prices, but we argue that it also the drop in farm hand wages due to serfdom may have played a role; making Danish grain cheaper and, thus, more competitive internationally. In this sense, the agricultural planning board that convinced the Crown to introduce serfdom achieved their goal to of increasing output and, by removing farm hands' mobility, wage bidding severely declined.[38] It can also be observed in Figure 7 that the real wage of all workers fell during serfdom. Its strong positive correlation with export tonnage is partly due to closer relationship between prices and exports.

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[37]Additional data cleaning would be necessary to incorporate those products into our research.

[38]We do observe a rise in grain sales in this year.

Figure 7: Denmark wages (farm hand vs. rest) and exports, 1706-1801
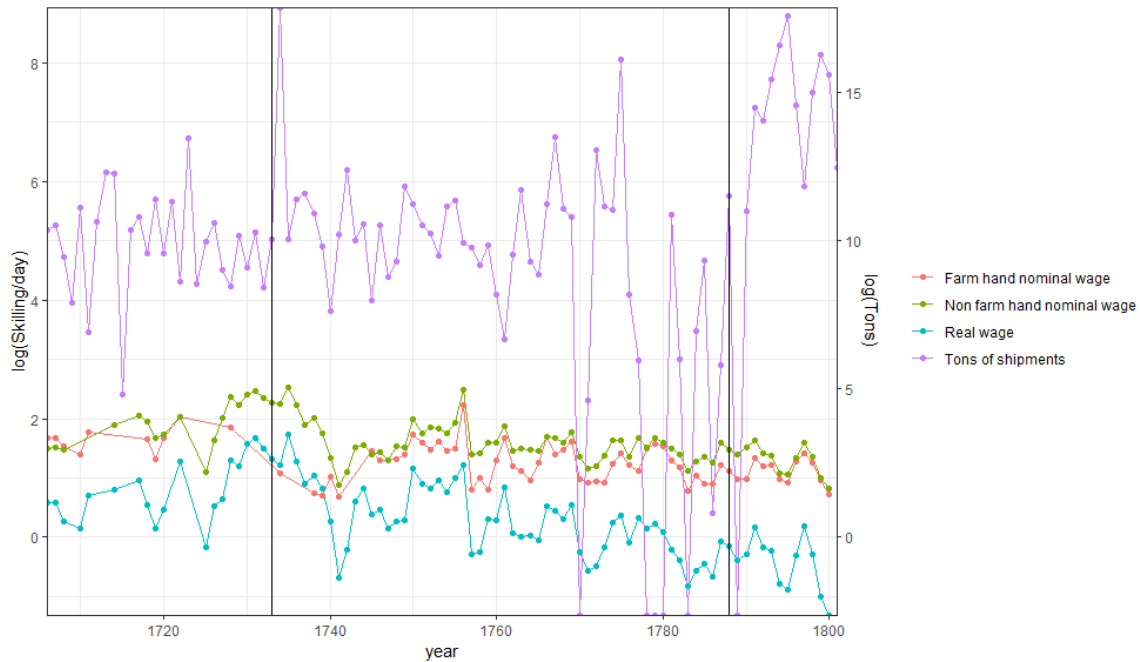
Notes: Vertical lines show introduction and abolition of serfdom. Tons of grain are aggregated from all ports shown in Figure 6. Real wage is nominal wage for both farm hands and other workers deflated using average grain prices of the grain sales of all estates.

5.3.2. Estonian households

As mentioned in Section 4.3, a German-speaking elite held much of the land in Estonia throughout the entire period of our study. As part of their role as administrators, the Swedish overlords required the Baltic Germans to record the land allotments, farm wealth, household members, and labor dues of all peasants households in the so-called *Wackenbücher*; a practice that was upheld also by the later Russian rulers (Moon, 2001, p. 43). The purpose of the *Wackenbücher* was to capture the carrying capacity of peasants before imposing taxes. Updated often more than once per decade and organized by estate, village[39] and household, the *Wackenbücher* provide unique insights in the labor dues of native Estonians, but have so far only been used in genealogical research (they give the name of the household head). We make use of the newly released literal transcription of all *Wackenbücher* in 1732 for Estonia's 4 northern counties (Harju, Järva, Lääne, and Viru) that was recently completed by the Estonian National Archives. In Figure 8 we given an example of a full *Wackenbuch*. After cleaning these data, we have more than

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[39] Frequently multiple villages could belong to one estate.

24,000 households that, based on the number of mentioned family members per household, represent more than 79,000 individuals. This amounts to almost half of the population of Estonia at the time (Raun, 2002, p.12) and likely nearly all peasants in the considered parishes. The labor dues reported in the *Wackenbücher* may be deemed reliable since once Estonia fell to Russia, the authority of the Baltic Germans - that had been limited under the Swedish - was unrestricted, leading some to refer to the previous regime as the 'good old Swedish times'. As a result, German elites were unlikely to misreport labor dues since they could impose them arbitrarily in the first place under Russian rule. Moreover, discrepancies can expected to be limited given that the *Wackenbücher* were compiled by changing enumerators that were send by the central Estonian administration (*Landtag*). These enumerators also had access on the previous *Wackenbücher* and, thus, could spot inconsistencies. We complement these data with information on the estates, like whether they were owned by knights or by the church, and geo-reference each estate's location.

Figure 9 shows the location of all estates in the counties with parishes colored according to the number of weekly corvée days per 'work fit' adult household member.[40] We aggregate days were one was required to only bring oneself (and tools) and those where a draught animal was also required. When the number of weekly corvée days exceeds 7 (8.36 is the maximum), it may imply that also children or unfit workers were called to work for the estate owner, or that the peasant needs to hire labor to meet the corvée requirements.[41] Figure 9 also gives the location of grain export ports and how many tons they exported in the last decade. The vast majority of exports appear to be concentrated in Tallinn in the North and not in the other port cities of Pärnau to the south, or Narva in the far north-east. As part of the Russian Empire at the time, there is the possibility that Estonia exported grains via St. Petersburg – which may be particularly relevant for North-Eastern areas – however, foreign trade statistics for the Russian Empire only began in 1802 and, hence, we cannot assess this.[42] We note that Russia was a net exporter - to the West - during this period as the Sound data show and, based on historical evidence (Attman, 1981), Estonian grain exports to Russia went through Tallinn and not through other ports. Thus, our estimates for Tallinn's grain exports should be understood as a lower bound, but we do not believe that we misrepresent its importance relative to other ports.

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[40]The *Wackenbücher* distinguish sick and old men and women from 'work fit' adults and children.

[41]Given the heavy corvée requirements on all peasants, it is unlikely that much labor was available from peasants with land allotments who had to till their land during non-corvée days.

[42]See this project for a collection of those statistics: www.hist.msu.ru/Dynamics/foreign$_t rade_e n.htm$

Figure 8: Example of a Wackenbuch in 1732

Notes: Figure shows a full Wackenbuch of Moisakül estate. The book shows for each household the name of the head, a breakdown of its members, the allotted land and other wealth. On the rights the dues are detailed, including corvée, in-kind, and monetary payments. Source: EAA.854.7.101

5.3.3. Prussian counties

We use the Prussian censuses[43] of 1816, 1849, and 1858 that are often lauded for their detail and consistent methodology and that have been used in most research on Prussia (Kopsidis & Wolf, 2012; Cinnirella & Hornung, 2016; Ashraf et al., 2018, e.g.). While this census provides a wide array of information on demographics and the Prussian economy, it falls surprisingly short in directly documenting unfree labor. For example, unlike the Russian censuses we use in Section H, it does not record the number of share of serfs explicitly, nor does it record corvée days.

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[43]The data is obtained from the iPEHD project (Becker et al., 2014), see www.cesifo-group.de/ifoHome/facts/iPEHD-Ifo-Prussian-Economic-History-Database.html.

Figure 9: Estonia estates, average corvée days per parish per perions, and export ports, 1732
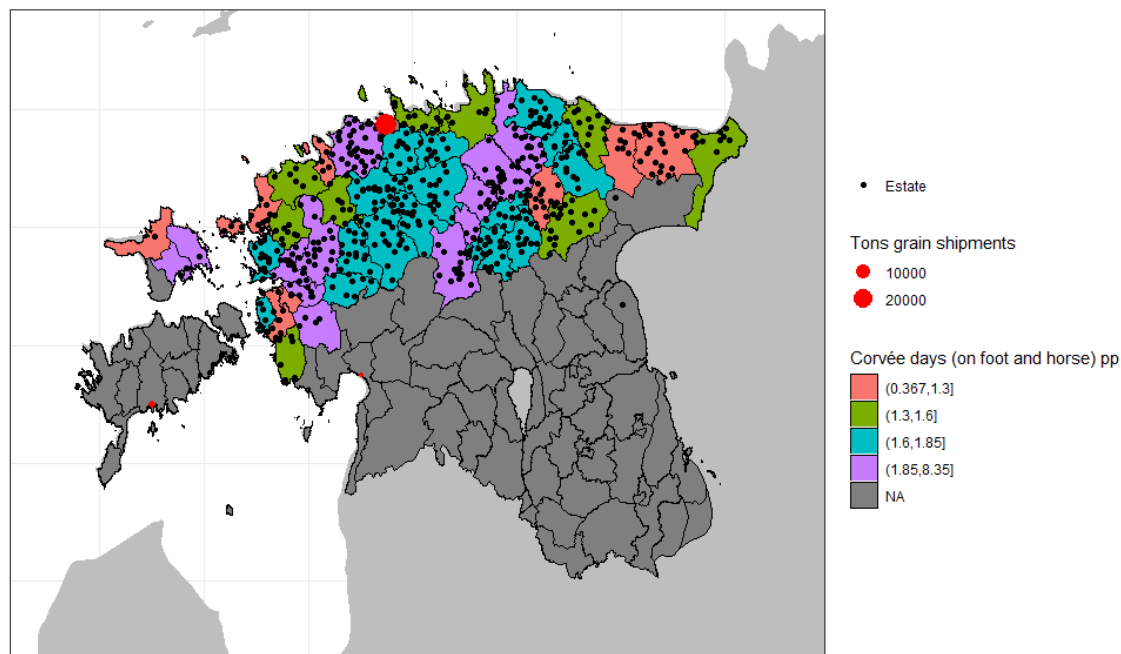
Notes: Figures shows the location of estates and in which quantile of weekly corvée days per person (summing days with and without own draught animal) by parish. Missing observations are parishes in Estonia, but outside of those in sample. The location of grain export ports and how many tons they exported to the West during the last 10 years is also shown. The vast majority of exports appear to be concentrated in Tallinn in the north and not in the other port cities of Pärnau more south or Narva in the very north-east at the border with the Russian heartland.

Therefore, we use two county-level proxies for labor coercion: firstly, we use the share of large estates as a proxy for how much land was tilled with coerced labor and not owned by free holders. This is based on the historical background and related research (Cinnirella & Hornung, 2016) that highlight that very large estates were almost exclusively owned by Junkers. Censuses classify estates in sometimes varying categories based on their size. The category larger than 50 hectare or 300 Prussian Morgen is the largest estate size category that is observed in all three land-holding censuses that fall in the period of our study and, thus, serves as our proxy. Another advantage of this proxy is that we are able to construct a comparable measure in Scania that also corresponds to the 3% largest estates. 3% is the average share of large estates in the total number of estates, see Figure 10.

Secondly, we use a cross-section of the share of manumitted serfs in the rural population that is captured in Meitzen (1869) for 1848. Tasked by the Prussian Crown, Meitzen (1869) takes stock of the progress of the peasants' redemption of dues that would free them from servitude . This was made possible by the 1821 ordinance. Following Ashraf et al. (2018), we divide the cumulative stock of emancipation cases

Figure 10: Share of large estates averaged across all East-Elbian counties, 1816, 1849, 1858, 1886, 1896
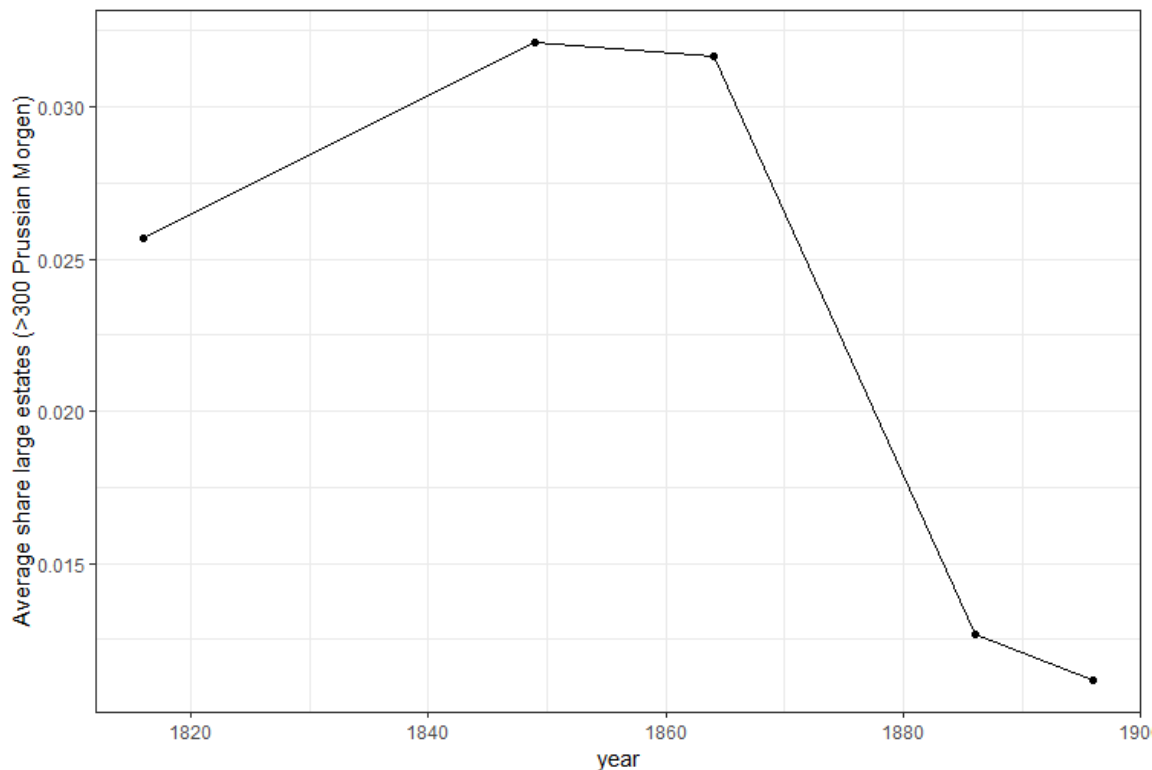
Notes: We show the share of large estates averaged across all East-Elbian counties for the 3 census years we use in our analysis and also for 1886 and 1896 (Becker et al., 2014).

settled between 1821 and 1848 by the fraction of the county's rural population that is eligible for manumission. Before 1850, only tenants who had previously had fairly secure tenure were eligible for manumission.[44]

Figure 11 plots both proxies in 1848-49. They appear to be inverses of each other: where there are more large estates, fewer serfs are manumitted. Proximity to export hubs, whose annual grain export tonnage is also shown in Figure 11, appears to be positively related to the share of large estates and negatively to the share of manumitted serfs. We take this as first visual evidence for an export hypothesis in Prussia and note that these sharp county-level differences are striking in country with a unified legal system. Figure 10 shows that the average share of large estates was low across all counties, which makes those counties with

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[44]We show the distribution of eligible peasants in Appendix K. Interestingly, more peasants close to the coast appear to have had fairly secure tenure rights, which may be interpreted as evidence for *Konservation*; that peasants accept to pay/serve more dues in return for an insurance against risks.

large shares, up to 15%, around the coasts distinct. In Appendix K we show the share of large estates for the other years (1816 and 1856) that data is available. In our analysis we exclude counties West of the Elbe river, the second from the left in Figure 11, based on the aforementioned settlement history that limits the influence of Junkers in those areas. A fruitful avenue for future research would be to also consider information recorded by the *Landschaften*, credit institutions for Junkers first founded in 1770, that may reveal more on land holdings and profits.

Figure 11: Share of large estates and emancipated peasants in Prussia, 1848-49
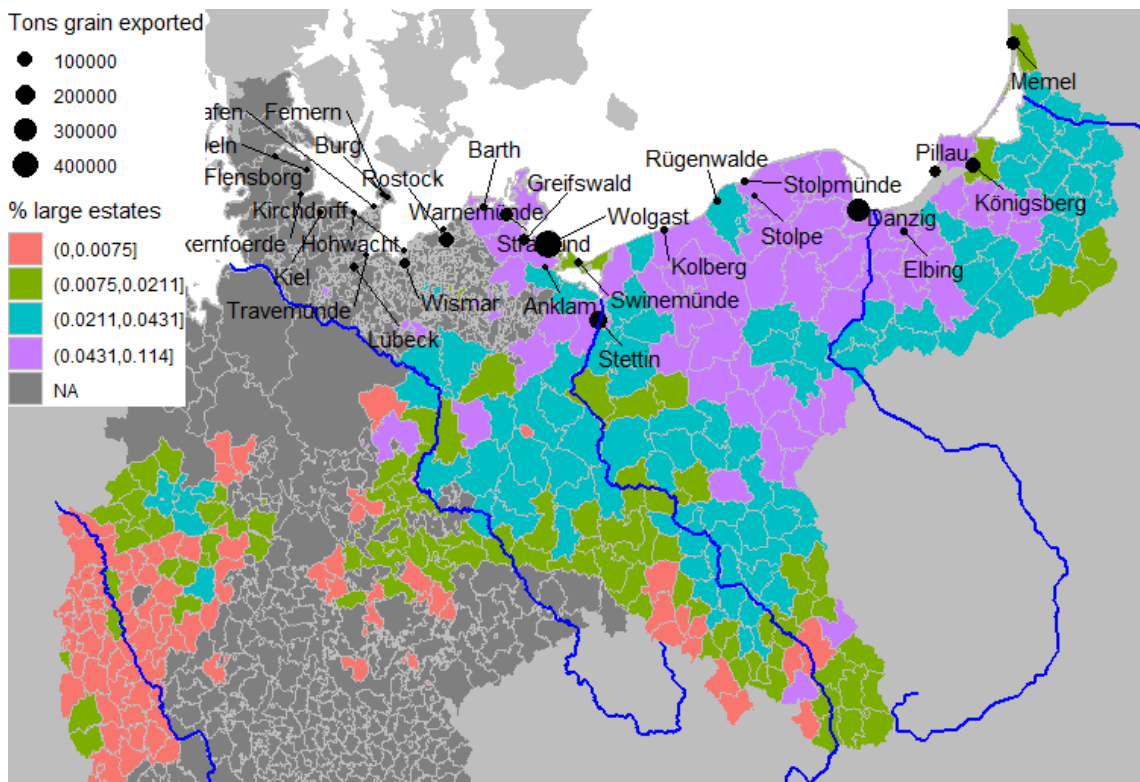
(a) Share of large estates in 1849.
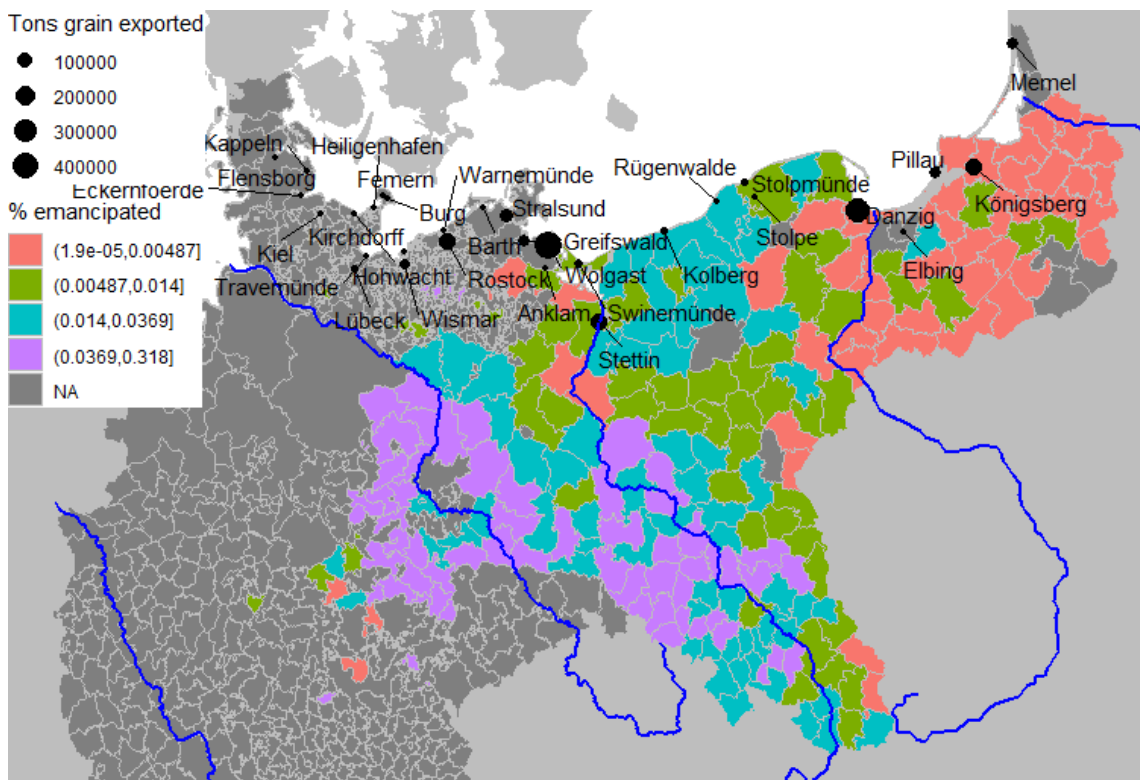
(b) Share of emancipated peasants in 1848.

Notes: Landownership based on Prussia census (Becker et al., 2014). Manumissions compiled from Meitzen (1869). Numerator is number settled emancipation cases of those who previously had lifetime duties and from the Dissolution Ordinance of 1821 to 1848 has redeemed them (*Dienst- und Agabenpflichtige, welche abgelöst haben*). Denominator is population eligible for such emissions, i.e. the rural population, recorded in the 1849 census, that had strong enough tenure rights *(spannfähige bäuerliche Nahrungen)* (Meitzen, 1869, p.307). Sound Toll trade during 5 prior years.

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5.3.4. Scanian villages

Scanian panel data at the land plot level is available from the Historical Database of Scanian Agriculture in the period 1702-1856 (Olsson et al., 2017).[45] The data is based on the church's surveys of all land types of land - crown, manorial, and peasant -, which were used to determine the tithe[46]; the church tax all peasants had to pay and that was proportional to the value of the land they tilled, even when they did not own it. We aggregate the data first by cultivator, thus summing all land plots that are tilled by the same peasant within one village. Note that this does not imply that the peasant owned the land, which is information that we will exploit at a later stage when we distinguish crown, manorial, and freehold lands. We do not observe the same cultivator names in two or more adjacent villages, thus, peasants did not till land in more than one village, which is consistent with the historical evidence. Since we only have the name of the cultivator, we do, however, not observe the actual owner of the land unless it is classified as freehold land, in which case the cultivator is the owner. This means that we do not observe whether one individual holds land in more than one village or even parish, which was the case since manors stretched across village and parish boundaries. What we capture is land inequality within one village and its ownership structure, which means that our observed top wealth shares will be low compared to a hypothetical analysis in which we have information on the individual owners of the land.

Also note that each plot is not recorded in a measure that solely represents its surface area, but rather a measure, the so-called mantal, that combines information on surface area *and* land quality. Plots with more hectar in infertile areas may, thus, have the same mantal as a smaller plot in a more fertile region. Notably, a plot of land always has the same mantal and so also the village's total mantal is constant, since, once determined by the church's commission, land quality is fixed. If a plot of land gets divided, its pre-division mantal is proportional assigned to each share. In that sense, we are repeatedly observe a 'pie' of the same size that is determined by the villages total mantal, but with a distribution of how much land is tilled by each cultivator that may change from year to year. From the share of mantal per cultivator in a village, we construct the the share of large land holdings within a village, which resembles the dependent variable used in the Prussia regressions. Large land holdings are defined as those with a 'mantal' value of 0.75. We pick this threshold since the share of land plots larger than 0.75 mantal in Scanian villages, about

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[45]See www.ekh.lu.se/en/research/economic-history-data/HDSA-1702-1881
[46]The name tithe is derived from tenth, since most often the tax rate was about 10%.

3% across the entire period (see Figure 13), is similar to the share of estates in Prussian counties that are larger than 300 Prussian Morgen. As mentioned, the methodology of the Prussian census confines us to use this threshold.

Figure 12: Scania villages and export port location, 1702-1856
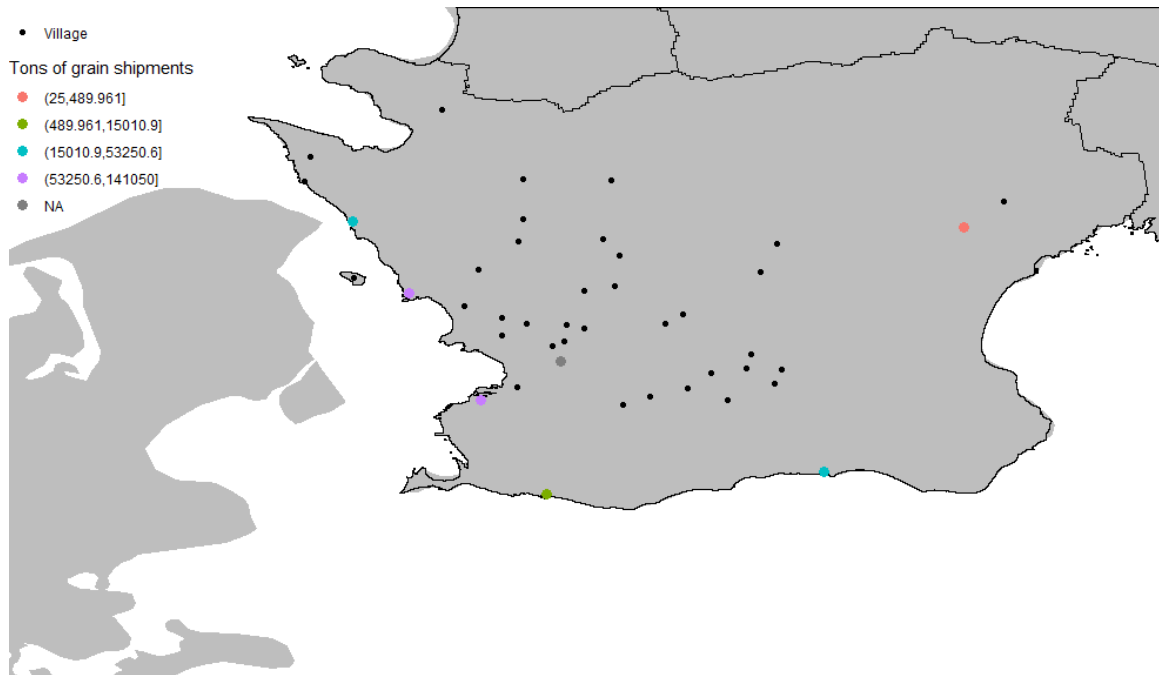
Notes: Figures shows the villages in Scania and the location of export ports and how much they exported across the entire period. Grey shaded dots represent ports that exported prior to 1702, but not in 1702-1856

The resulting panel includes 47 villages that are located all over Scania and, thus, should send their grain to different ports, such as Helsingborg, Landskrona, Malmö, and Ystad, see Figure 12. Indeed there is also some temporal variation in how much is exported from these ports. Figure L.3 shows how the total mantal were distributed across types of ownership: crown, manorial land sold to peasants, manorial (where the manor is located either within or outside the parish), the similar manorial demesnes, and peasant-owned. Throughout the entire period the share of cultivators who own their land almost quadrupled from 12 to 47%, while the share of crown and manorial land decreased. Figure L.3 also plots the grain export tonnage of all ports that were previously shown in Figure 12. It is apparent that Scania adhered to it self-imposed grain export ban since we only observe grain exports after its removal in the 1770s. As trade began, we observe for the first time that manorial land was sold to peasants. A surge in peasant owned land that begun in 1835 again coincided with a trade boom. For the 154 years that we have data, our panel

Figure 13: Distribution of mantals by cultivators across all years, 1702-1856
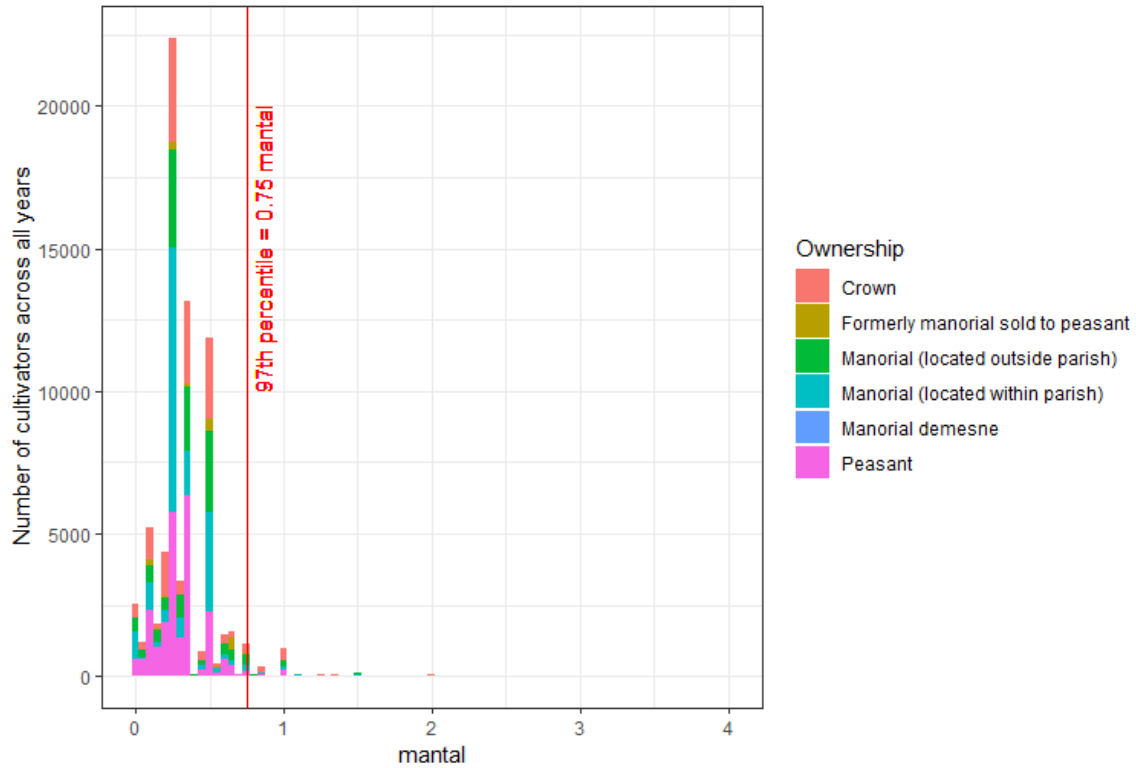
Notes: Figures shows the distribution of mantals by cultivators. Note that only peasant land and former manorial land is actually owner by the cultivator. The red vertical lines the thresholds that defines large estates.

is not balanced: on average, we observe each village 77 times. In Appendix L we show that we can draw similar conclusions when making the sample more balanced by restricting it to the 20 most frequently observed villages. We also show the distributions by the number of cultivators rather than mantal, which leads similar results.

Figure 14: landownership by mantal and grain exports, 1702-1856
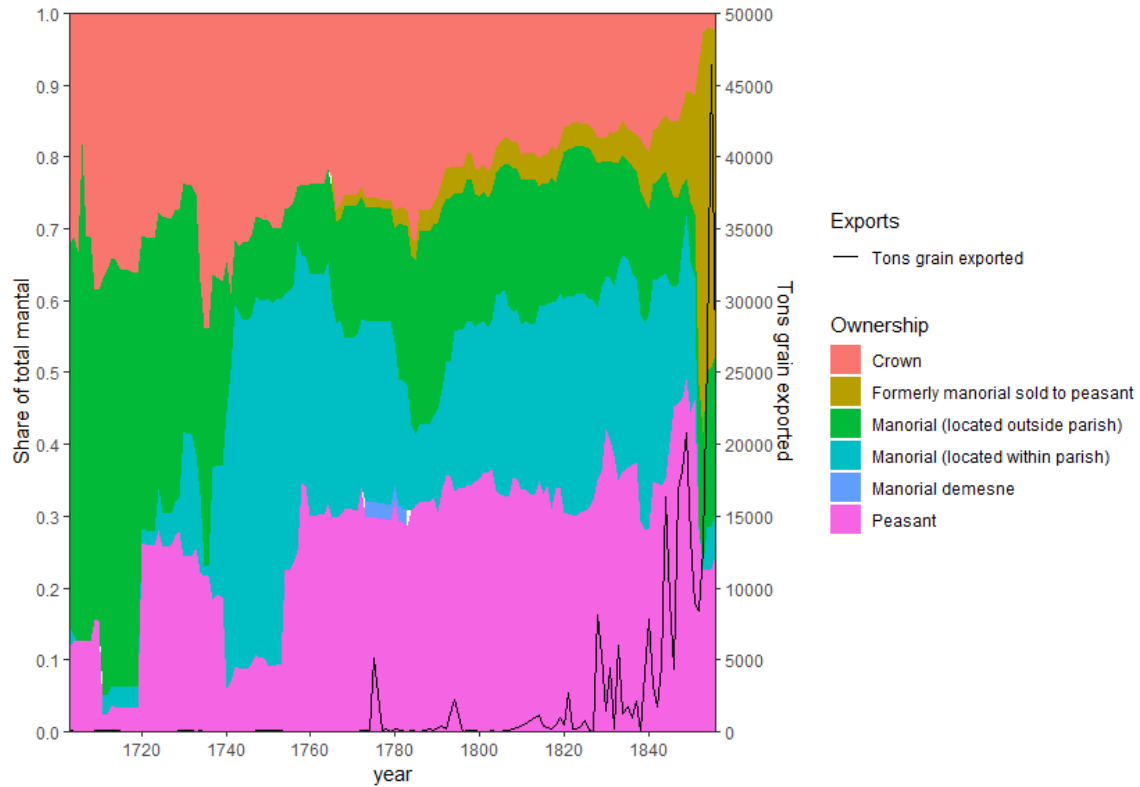
We also construct mantal wealth shares, which we plot in Figure 15. It emerges that the share of the top 10% most wealthy mantal holders decreased rapidly from 40% in the 1770s when the trade boom was lifted to c. 25% in 1856. The spike in the wealth share in the 1750s is due to our sample becoming much more balanced from those years onward. The top 1%'s share stayed roughly the same across the entire period at around 5%, which confirms the findings of Bengtsson et al. (2019) that the wealth levels of the very wealthy aristocracy only slightly changed in this period. Also, overall inequality increased despite a smaller share of wealth held by the top 10%, as can be observed in Figure 15 for the overall Gini and the village and parish Gini averages. As mentioned in the historical background, these developments were due to the fact that peasants on crown lands were sooner allowed to purchase their land than peasants on manorial land, who were, thus at a disadvantage. Also, division of land by inheritors was made legal in this period, which increased the number of land plots.

The fact that literature on Scania is very developed also allows us to look at other statistics, such as

Figure 15: landownership and grain exports, 1702-1856
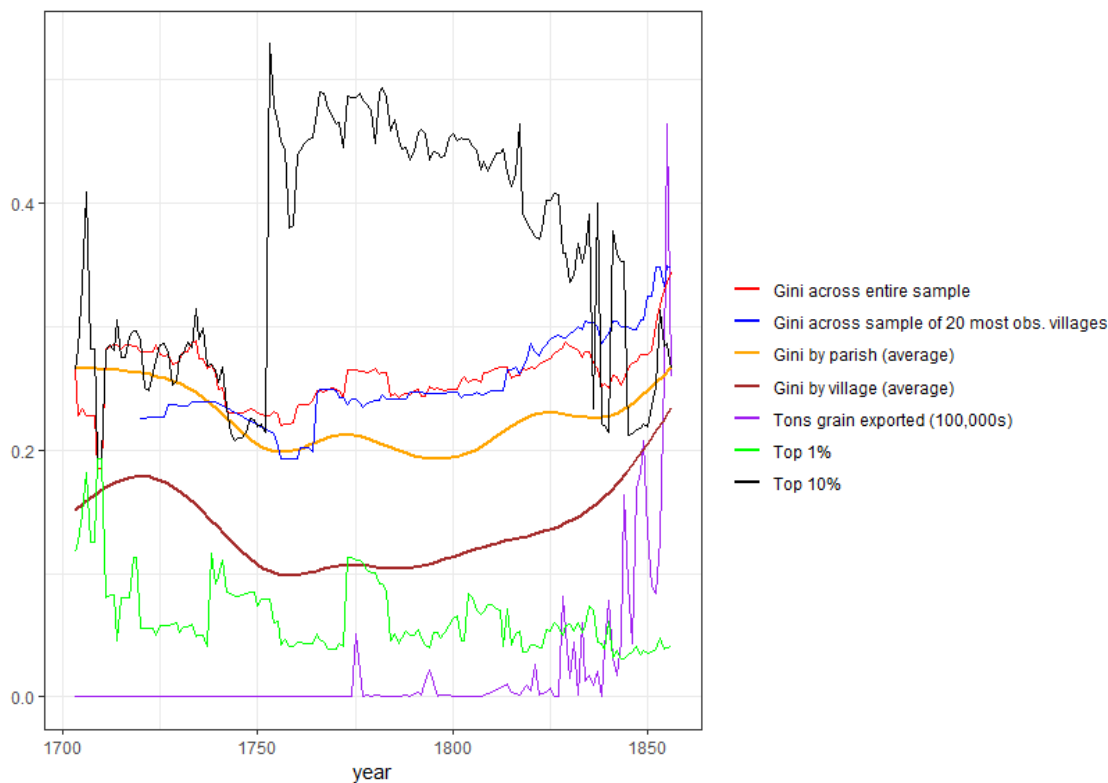
Notes: Constructed from the Historical Database of Scanian Agriculture (Olsson et al., 2017) and the Sound Toll. Note that the used data specifically refers to Scania rather than the whole of Sweden.

nominal and real wages, grain production, population and even GDP per capita that we plot in Figure 16. It appears that the log of Scanian grain export volume (in tons) is correlated with grain production and nominal wages. However, the price increases that appear to coincide with production and export booms appear to undo these nominal wage gains, leading to a flat real wage. Throughout the last 100 years of the period of study (1750-1850), population roughly doubled and GDP per capita of Scania caught up from 67% of the Swedish average to 83% (Enflo & Missiaia, 2018). Note that the data used in Figure 16 specifically refers to Scania rather than the entirety of Sweden. As our discussion has demonstrated, the literature on Scania is very developed, however, we note that the role of trade has not been taken into account before.

In closing this section on Scania, we plot grain exports and the share of estate income that comes from coerced labor, that is unpaid corvée labor, versus wage labor in Figure 17. The latter data is based on the 9 estates in Olsson (2002) for which detailed accounts are provided, however, data on all estates will be

Figure 16: Scania (1703-1856): Trade, wages, harvest, GDP, and population
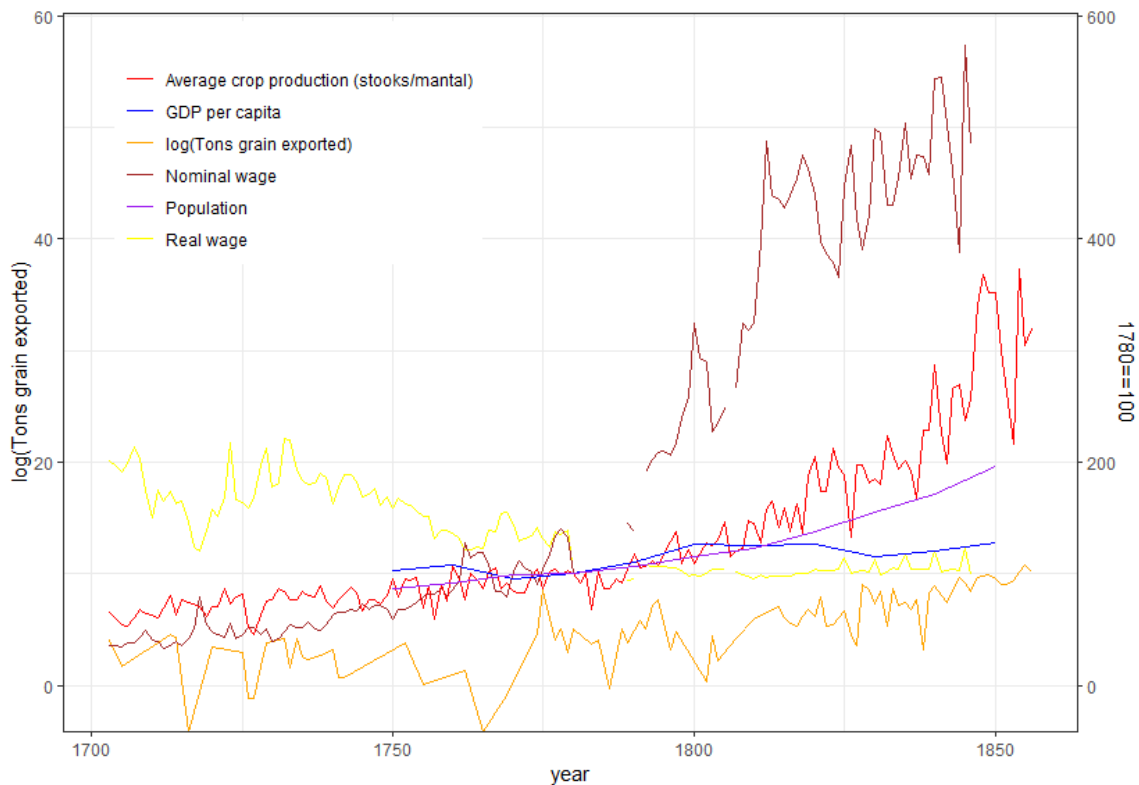
Notes: Figure plots macro stastics specific for Scania to assess the economy-wide effects of trade liberalization and/or land markets. Real and nominal wage data for rural, male, annual workers in Scania taken from Gary (2018) who uses a respectability basket for Malmö to deflate. Production per mantal calculated from our usual Scania data. Population and GDP calculated from Enflo & Missiaia (2018) using the Kristianstads and Malmöhus districts.

incorporated in a future version of this research. This will allow us to assess whether estates with more export potential differed in their use of corvée labor. It becomes clear that throughout of the period, the revenues of estates of selling goods - mainly grain - that were produced with coerced labor rose from 50% to almost 100%. This is evidence that the manorial economy intensified even as manorial lands became smaller and, thus, as shown by Olsson (2002, 2006), manor revenues dropped. Notably, there were no legal boundaries to the extent that manor owners could coerce their subjects in Scania. In the absence of legal changes, we interpret these findings as evidence that manor owners found it harder to attract wage laborers as the number of freeholder increased and, hence, had to resort to imposing more corvée labor on their remaining subjects, which should lead to sharp income differences between freehold and subject peasants.

Figure 17: Share of estates' income from coerced labor versus wage labor and grain exports, 1680-1856
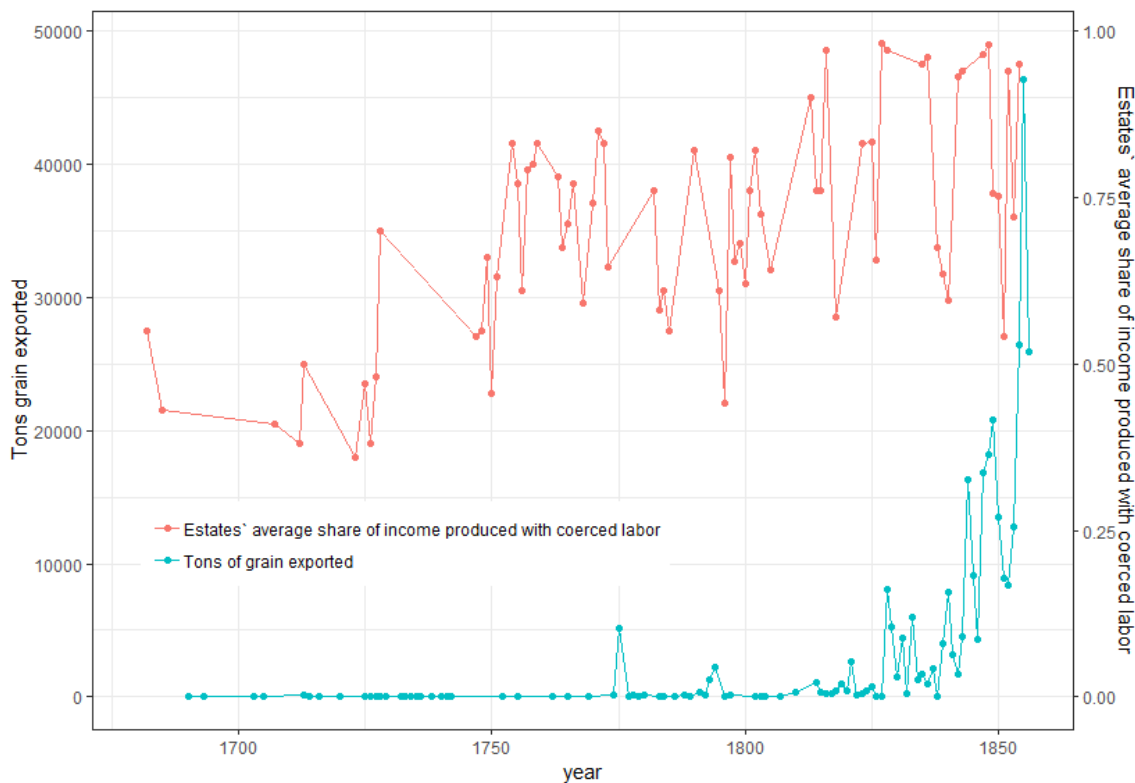
Notes: This figure shows the share of income that a manor declares as having been generated by coerced, that is unpaid, corvée labor. Based on the 9 estates for which this information is provided disaggregated in Olsson (2002). More data will be provided by Mats Olsson in the future that will allow us to assess whether these trends are affected by export potential.

6. Methodology and Results

We first discuss the implications of grain exports on de-jure and then on de-facto unfree labor. For more analysis and descriptive statistics, see Appendices I, J and K.

6.1. De-jure Unfree Labor

Using the dataset we constructed on the reform dates, introduction and removal, of de-jure type of labor coercion, we investigate how grain prices and exports evolve prior, during and after those reforms. In this analysis, distinguishing between cause and consequence is difficult: did rising prices and export lead to more de-jure coercion, or did more de-jure coercion lead to more exports? Acknowledging this difficulty does not mean it is insurmountable, given that these reforms were spatially and temporally diverse – shown in our data – there is a strong argument for plausible exogeneity. That is, that prices

were likely exogenous to de-jure reforms given that there was no waves of reforms across regions – rather they were localized – there is unlikely any general grain supply effects caused by de-jure reforms and influencing prices in the West.

This of course does not rule out other underlying factor that drive both unfree labor reforms and exports, such as the Napoleonic Wars in the case of Prussia. While we indicate those years in which such conflicts occurred in this section's Figures, we cannot control for other concurrent developments, such as shortfall in the Crown's treasury that weakened its bargaining position vis-a-vis Junkers. These lack of controls and the inapplicability of fixed effects to regions where, across long time periods, little remains 'fixed' leads us to use visual evidence rather than regressions.[47] Our aim is, thus, to answer to the question: What grain price and export developments surrounded de-jure changes in unfree labor? The question why some reforms occurred during a certain, but not during other price and export booms or busts is left for future research.

To is end, we first focus on prices. Figure 18 plots an index of grain prices in the West that uses weights based on the share of different grain types in the Baltic's exports, see Appendix E.6. The sources of those price observations in the West are not related to the Sound Toll. On this price plot, we place vertical lines that represent the introduction or removal of de-jure coercion. This analysis shows that changes in de-jure coercion predominantly occurs at the end of price depressions. This mirrors the Danish experience that saw more coercion after a drop in prices provoked a rural exodus, but it also speaks to the concept of *Konservation* highlighted by Eddie (2013); the concept describes peasants increased willingness to accept more coercion in times when they valued the insurances provided by their landlord more. It is worth noting, however, that the timing of those reforms - just before a rise in prices - may also be linked to Junkers correctly expecting that prices would rise again. Based on those expecations, the lobby for more de-jure coercion in the wake of higher profitability, which would correspond more closely to Malowist's (1958) export hypothesis.

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[47] With the emergence of more data, regressions might become more feasible in the future.

Figure 18: Index of grain prices in the West and de-jure unfree labor reforms, 1579-1856
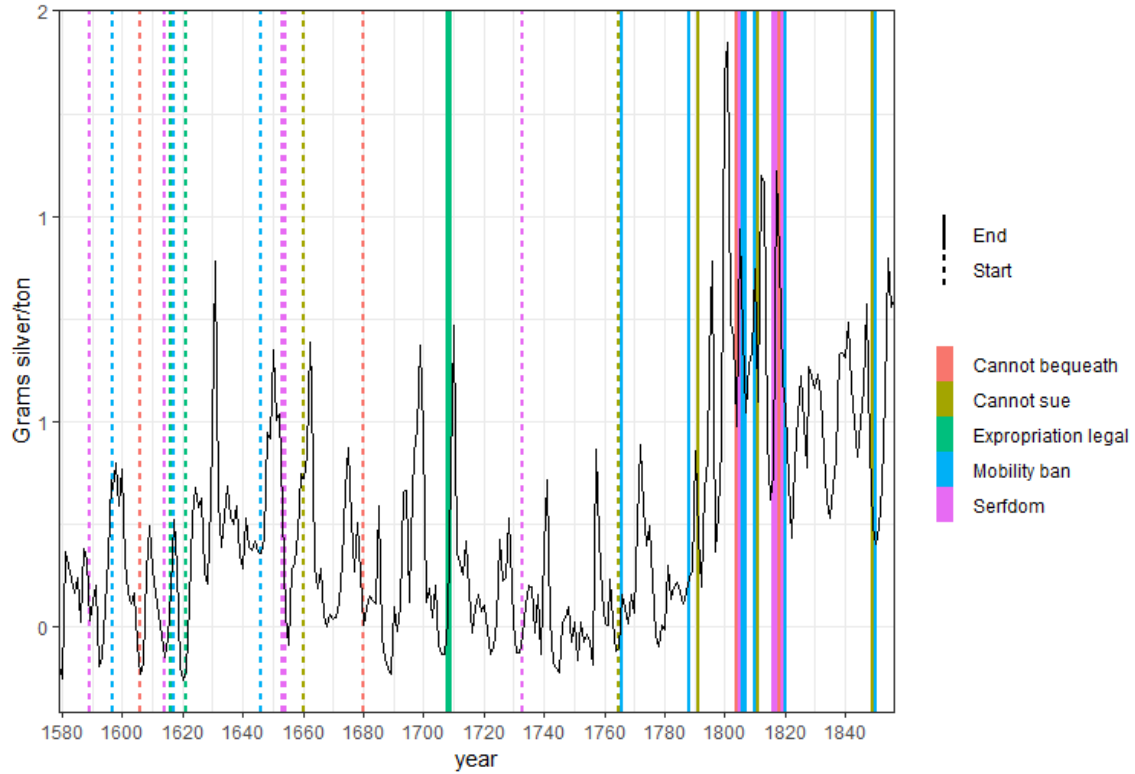
Notes: This figure combines the price index of grains we construct and de-jure unfree labor reform data for all countries and investigates their relationship. The index is constructed from prices of different types of grains in the West based on long-run series. The prices of grain types contribute to the index based on the grain type's share in Baltic grain exports. Thus, multiplying it by the export tonnage leads the total value of Baltic exports (in grams of silver).

Figure 19 complements these findings by showing that, following export busts, de-jure coercion was introduced as exports began to pick up again. Given the close relationship between prices and export that we have pointed out before, this similarity between our findings for prices and exports is not surprising.

Figure 19: Grain exports and de-jure unfree labor changes
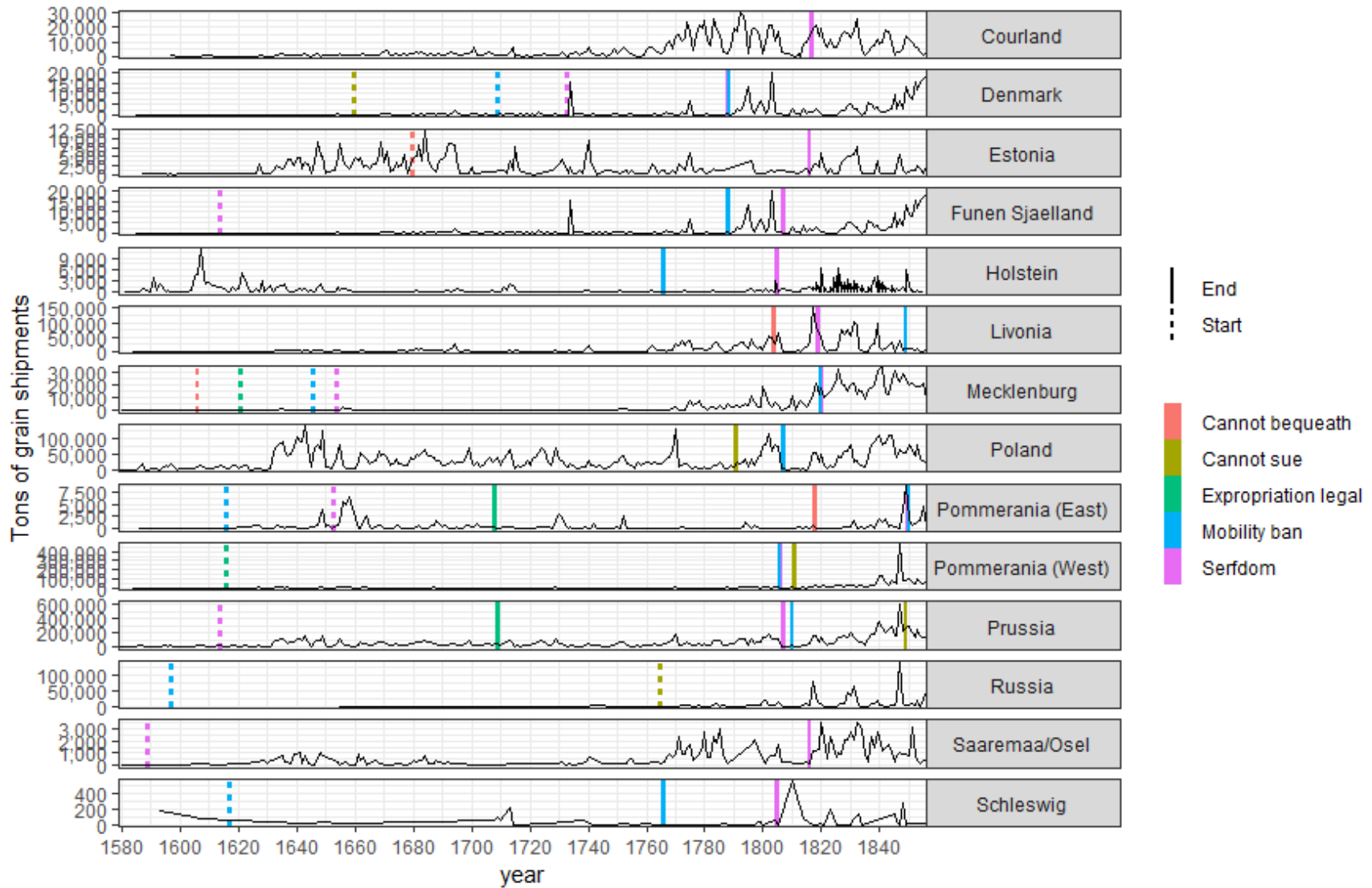
Notes: This figure combines our trade and de-jure unfree labor reform data and investigates their relationship. Ports assigned to each region are based on constant boarders. In most cases there were no important border changes, except for Russia, for which we only use St. Petersburg that was founded in 1703 and for Poland we only use Danzig at the mouth of the Vistula river. For Prussia we use all ports from Lübeck to East Prussia.

We provide more details on the specific case of Mecklenburg, for which we have well-documented evidence on five types of labor coercion (Klußmann, 2003) that all occured in peace time. Combining the price and export series, Figure 20 shows that the introduction of inheritance, suing, and moving bans, as well as the loss of protection against expropriation occurred during at then end of price slumps. In each case, exports rose concurrently and subsequently. The simultaneous abolition of all de-jure unfreedoms occured during a price and export slump.

Figure 20: Grain exports and unfree labor in Mecklenburg, 1579-1856
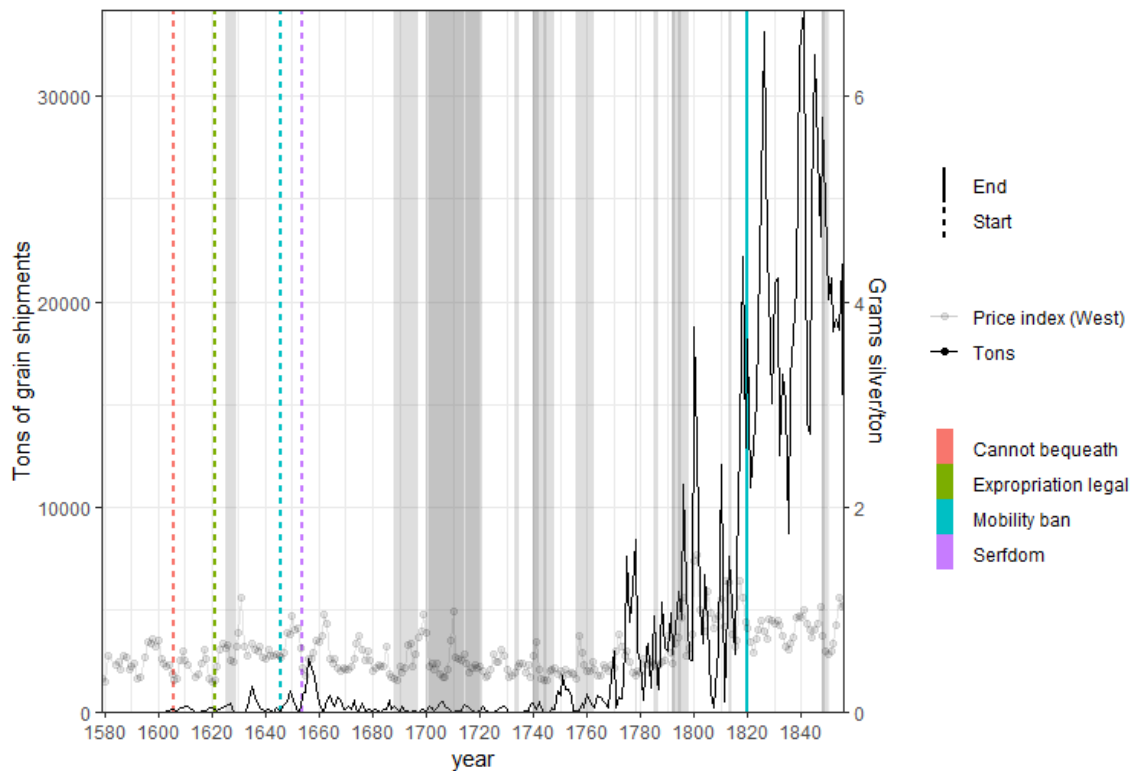
Notes: This figure presents the specific example for Mecklenburg, for which unfree labor reforms are well documented. Figure is based on Sound Toll (exports), our de-jure reform data, and the price index we construct. Dark shaded years are those with wars involving Mecklenburg based on Brecke (1999), which could be potential omitted variables, but they do not coincide with de-jure reforms. Ports with grain exports attributed to Mecklenburg include: Kirchdorff, Mecklenburg, Rostock, Schwerin, Warnemünde, Wismar.

6.2. De-facto Unfree Labor

We now turn to discussing the four applications of de-facto unfree labor data: Danish estates, Estonian households, Prussian counties, and Scanian villages. We conduct an additional analysis for Russia's heartland that we present in Appendix H. This analysis confirms that it is unlikely that the export hypothe-

sis applied to Russia, but rather that internal migration and domestic markets determined labor coercion, as suggested in the literature (e.g. Stanziani, 2010).[48]

Before moving to the results in each region, we discuss the methodology, which is the same in all applications. As mentioned, the proponents of the export hypothesis see "export opportunities" as the driver of labor coercion (e.g. Malowist, 1958). In our interpretation, this implies that between two comparable estates, the one with better access to international markets should see more labor coercion. We test this in all four regions using different proxies: corvée days (Estonia), wages (Denmark), manumissions (Prussia), and the demesne share in estate income (Scania).[49] A second interpretation is that estates should be larger in the proximity to export hubs, assuming that they expropriate peasants, which was called *Bauernlegen* in Prussia, and bar them from purchasing land; this hypothesis is tested in Prussia and Scania. The concentration of land at the top also proxies for the share of land that was tilled using forced labor, since the use of forced labor primarily occurred on large estates.[50]

In all the data we use it is not revealed how much grain the sub-national entity sent to ports to be exported.[51] Instead, our data show total grain production, except in Prussia where we have no such information. Therefore, we need to take an indirect approach by focusing on the 'export potential' of a sub-national, rather than their actual exports. We define export potential as a sub-national entity's distance to export ports weighted by how active those ports are in exporting grains to the West. Focusing on potential rather than actual export also limits our concerns regarding reverse causality, because it is unlikely that a single entity, particularly a single estate, can create an export hub by itself.[52] Furthermore, distance is of course immutable.[53]

An entities export potential is explicitly defined below, to do this we create an index for which we cre-

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[48]We do think that future research should look at Russia more carefully using more proxies for de-facto coercion than the share of serfs that we use. Also, carefully documenting the role of domestic markets would be necessary to assess the applicability of our theoretical model.

[49]Mats Olsson agreed to share data on corvée dues in Scania, however, these data were not received in time for the current version of this research.

[50]This is not to say that no wage labor was used on large estates, but they uses coerced labor more than smaller estates or freeholders.

[51]We came across receipts of grain sales for exports in Estonia recently, but could not clean and work with the data in time for this version of our research.

[52]There could of course be collective action, but in general Junkers did not exert much influence on cities.

[53]Distance can of course be bridged more cheaply with better infrastructure. At this stage, we only consider straight line distances due to the lack of information on roads in some regions. Our impression is that there were many roads and that those were of comparable quality, but certainly measurement error could be introduced by calculating distance on roads. Other relevant transport cost shifters are access to rivers, which we control for, and railroads, which only Prussia constructed prior to the final year of the Sound Toll. Future research may use, for example, the straight line instrument and the quasi-exogenous local rail access that has been used for Prussia by Hornung (2015). Those railroads also connected to port cities and, thus, may have been relevant for exports.

ate an index for each period (t) and sub-national entity (c). Sub-national entities differ between the three regions we study due to differences in the data sources: households, estates, villages, or counties. This index is inspired by Kopsidis & Wolf (2012), who divide town population by distance to towns for a cross-section of Prussian counties in 1865 and show agricultural productivity was driven by urban demand.[54] Instead of towns population, we use the total tons of grains that a port p exported over the past τ years before year t: $\sum_{t-\tau}^{t} GrainExportsTons_{pt}$. With this we aim to capture the extent to which a port was connected to grain markets in the West at a given time. Throughout this research, we experiment with different τ. In the results we show, we use $\tau = 0$ when we have annual data (Denmark and Scania) and $\tau = 5$ for Prussia, where observations are less frequent. However, our findings are robust to small changes in τ. The grain export tonnage is calculated from the granular Sound Toll data that we now use disaggregated at the port level. As we noted before, there is substantial year-to-year variation in a port's share in total exports. We divide this number by the straight-line distance of the sub-national entity to the port to proxy for the transport costs encountered by a sub-national entity that transports grains to the port: $Distance_{cp}$. We sum this ratio across all ports P to obtain the index:

$$ExportPotential_{ct} = \sum_{p}^{P} \frac{\sum_{t-\tau}^{t} GrainExportsTons_{pt}}{Distance_{cp}} \tag{6}$$

Hence, this index varies across years because of the changing grain export tonnage of ports. It varies by sub-national entity because of their individual distance to different ports. An intuitive way to think about our index is to put it in the context of a gravity model. That is, it captures the 'gravitational pull' of a port that is proportional to how much it exports and the intensity of this pull differs by entity, thus, predicting the extent of trade between the entity and the port and, hence, international markets.

One advantage of creating an index that summarizes the information of all ports per year is that, when used in a regression, this leaves us with only one coefficient of interest. We standardize the index to mean 0 and standard deviation 1 to improve the ease with which the regression coefficients can be interpreted.

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[54] Kopsidis & Wolf (2012) do not address unfree labor, which only played a limited role in 1865. They do not to distinguish the role of port and inland towns. It would be an interesting addition to replicate their approach under the lens and in the period of our research and to distinguish the role of port and inland towns. We control for general proximity to cities by using urbanization rates.

OLS regressions in all our four applications use a specification comparable to the one shown below:

$$\text{De Facto Unfree Labor}_{ct} = \beta_0 + \beta_1 ExportPotential_{ct} + \beta_2' \mathbf{X}_{ct} + \alpha_t + \sigma_c + \epsilon_{ct} \tag{7}$$

We regress our de-facto unfree labor proxy for each sub-national entity in each year on a constant, the export potential index, and on a vector of controls $\mathbf{X}$; ϵ_{ct} denotes the error term. In all applications, except for Estonia, we have panel data and, therefore, include time and entity fixed effects: α_t, σ_c. These fixed effects strongly improve the robustness of our specification by controlling for all time-invariant characteristics of a sub-national entity. This addresses concerns of simultaneity bias; for instance, that counties in Eastern or Western Prussia are different due to cultural or historical difference rather than differences in export potential, even after using controls. Equipped with this methodology, we now turn to our four applications.

6.2.1. Denmark, 1726-1801

We start by reporting the methodology and results for Denmark for which we are required to explain some more methodology, given that our first step is to replicate the approach of Jensen et al. (2018). Theses authors, using the same data, study the difference between laborers who are tied to the estate under serfdom - farm hands - and those who can still move freely - non farm hand. They study this difference before, during, and after Denmark's spell of serfdom. In this difference-in-difference approach they interact a dummy that equals 1 in the years (t) that serfdom existed (*Serfdom*) with dummy that equals 1 if the worker (i) was a farm hand (*Farmhand*). Jensen et al. (2018) are, thus, interested in β_3, the coefficient of this interaction in the following regression:

$$log(DailyWage)_{iet} = \beta_0 + \beta_1 Serfdom_t + \beta_2 Farmhand_{iet} + \beta_3 (Serfdom_t \times Farmhand_{iet}) +$$
$$\beta_4 ExportPotential_{et} + \beta_5 (ExportPotential_{et} \times Serfdom_t) +$$
$$\beta_6 (ExportPotential_{et} \times Farmhand_{iet}) +$$
$$\beta_7 (ExportPotential_{et} \times Farmhand_{iet} \times Serfdom_t) + \beta_8' \mathbf{X}_{iet} + \sigma_e + \epsilon_{iet}$$

Our contribution is to assess whether the effects of serfdom were *heterogenous* based on the export potential of the estate *e* that employs the worker. To this end, we include our *ExportPotential* index

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and interact it with *Serfdom*, *Farmhand*, and their interaction. Among these interaction terms, we are interested in the three-way interaction of *Serfdom*, *Farmhand*, and *ExportPotential* to which β_7 applies in the above regression. Thus, we study whether the wage gap between farm hands and other workers in years with serfdom relative to years without is different based on the estate's export potential. Put differently: does the mobility ban imposed by serfdom on farm hands affect their wage differently in estates with more export potential vis-a-vis those who are not affected by serfdom? Given that we do not observe the same worker more than once, we apply fixed effects (σ_e) at the estate instead of the individual level.

Table 1 shows the results of this approach. Columns with odd numbers have no estate fixed effects, in Columns with even numbers we include them. Column 1 replicates Jensen et al.'s (2018) difference-in-difference approach,[55] showing that serfdom significantly reduced the wages of those who it affected, which corresponds to Figure 7 shown earlier. These results are robust to including estate fixed effects (Column 2). Throughout all specifications we control for the worker's gender, seniority (master, regular worker, or helper), whether the worker is a child, in which season the worker is employed, and the worker's job category based on the HISCO system. We also control for how many tons of grain the manor sold in a given year net of purchases and include a grain price index based on the prices of the estate's grain sales. Thus, we deflate the wages with respect to grain prices.[56] We note that our results are robust to excluding one or two of those controls at a time. When adding our export potential index in Columns 3-4 it enters with a negative sign and is statistically significant. In the last two Columns (5-6) we include the mentioned interactions with *ExportPotential*. Our coefficient of interest, the three-way interaction is, however, insignificant. Instead, the interaction between *ExportPotential* and *FarmWorker* is significant at the 1% level, positive, and large in magnitude. In particular, it implies an 11.2% increase of farm hand wages for a 1 standard deviation increase in export potential vis-a-vis non farm hands. These findings are robust to not including the three-way and other interactions (not shown).

We interpret this findings as evidence that grain export booms benefit the grain-price-adjusted wage of farm hands and that they close parts of the wage gap between farm workers and non-farm workers. This

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[55] Our results differ slightly from Jensen et al.'s (2018) since we drop estates on the Danish mainland. Also, we clean the data in a similar, in an approach that is similar to Jensen et al.'s (2018), but independent.

[56] We observe also other goods that estates buy and sell and would, thus, also be able to create a more holistic CPI. This would be an interesting extension.

makes intuitive sense in a Stolper-Samuelson framework where those workers employed in the exporting industry see their wages rise. Notably, serfdom does not appear to significantly influence this relationship, which implies that our regressions do not pick up the brief, post-introduction of serfdom divergence in farm hand and other workers' wages shown in Figure 7. We two possible explanations for this specific findings. Firstly, serfdom the export-potential-based wage setting of farm hands was indeed not affected by serfdom. Secondly we may have only incomplete information on the relationship between farm-hands and manor owners, since we only capture wage labor and not corvée and other dues. In times of rising grain prices, manor owner may find it more profitable to pay subjects in money that deflates in value and impose corvée dues on them at the same time.[57]

Table 1: Results Denmark, 1726-1801

| | Individual's log(Daily Wage in Skilling) | | | | | |
| | Jensen et al.'s (2018) approach | | Including ExportPotential | | Including 3-way interaction | |
	(1)	(2)	(3)	(4)	(5)	(6)
Serfdom	−0.116***	−0.051***	−0.142***	−0.076***	−0.144***	−0.080***
	(0.012)	(0.012)	(0.013)	(0.013)	(0.013)	(0.013)
FarmWorker	−0.099***	−0.062***	−0.107***	−0.036	−0.145***	−0.083***
	(0.023)	(0.021)	(0.025)	(0.023)	(0.028)	(0.026)
Serfdom× FarmWorker	−0.069**	−0.061**	−0.062**	−0.087***	0.012	−0.002
	(0.028)	(0.026)	(0.030)	(0.027)	(0.040)	(0.036)
ExportPotential			−0.029***	−0.027***	−0.033***	−0.030***
			(0.005)	(0.005)	(0.006)	(0.005)
Serfdom×ExportPotential					0.005	0.002
					(0.011)	(0.011)
FarmWorker×ExportPotential					0.112***	0.141***
					(0.037)	(0.033)
Serfdom×FarmWorker×ExportPotential					0.026	0.008
					(0.099)	(0.089)
GrainSales (tons)	0.0001	0.0001	0.00003	−0.0001	0.00003	−0.00004
	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)
Constant	1.625***	1.807***	1.640***	1.835***	1.647***	1.844***
	(0.042)	(0.045)	(0.046)	(0.046)	(0.046)	(0.046)
Observations	8,595	8,595	8,595	8,595	8,595	8,595
Number of estates	12	12	12	12	12	12
Adjusted R^2	0.342	0.467	0.343	0.470	0.344	0.472
Estate FE	N	Y	N	Y	N	Y

Notes: Repeated cross-section of individuals hired by estates to do farm or other work (Andersen & Pedersen, 2004). We control for the worker's gender, seniority (master, regular worker, or helper), whether the worker is a child, in which season the worker is employed, and the worker's job category based on the HISCO system. We also control for the island the manor is located on, how many tons of grain the manor sold in a given year net of purchases and a grain price index. Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

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[57]While we do not have data on corvée or grain-based dues in Denmark, we do observe this for Prussian serf manumissions and Estonian households. At this stage we do not yet exploit this information, but instead 'control' for it in our regressions.

6.2.2. Estonia, 1732

Estonia is distinct from the other cases as we only have data for one year, 1732. However, the data may be extended to a many periods due to the abundance of digitized sources in the Rahvusarhiiv in Estonia. With only one period, we only use the denominator of our export potential index, distance to port, because we cannot exploit year-to-year variation in export tonnage. Table 2 shows the results of regressing the a household's weekly corveé days without a draught animal (Columns 1-2), with one (Columns 3-4), and their sum (Columns 5-6) on the distance to Tallinn and controls. Tallinn was by far Estonia's largest port for exporting grains to the West as we have shown in Figure 9. Among the controls used is the distance to Pärnau, which we add as a falsification test given that, while it was a port city, it exported negligible amounts of grain. Our findings suggest that the export hypothesis applied to Estonia: according to Column 1, manors located 1 kilometer closer to Tallinn, on average, require a peasant household to work 1.5% of a day, or 21 minutes[58], more per week all, ceteris paribus. With manors spread all over Estonia and the furthest almost 200 kilometers away from Tallinn, this distance effect[59] is large in magnitude and is also highly statistically significant. Distance to Pärnau in contrast has the opposite effect; it increases corvée days. We take this as evidence that grain exporting ports are those that see more coercion in their proximity. We also run these regressions without controlling for distance to Pärnau and/or controlling for distance to other ports and find similar coeffcients for distance to Tallin, see Appendix J. These robustness checks are motivated by the fact that Pärnau and Tallinn are too some degree on the North-South axis and their coefficients are similar in absolute magnitude, which would suggest that we simply capture the effect of a manor being located more north.

All results are obtained controlling for peasant land, both used and unused, the number of all household members, and horses. Those controls have the signs we expect: more allotted land, more manpower in the household and more horses are associated with higher corvée dues. In Columns 2, 4, and 6 we additionally include the allotted forested land, which appears to increase the importance of distance to Tallinn, but itself enters with changing signs and significance depending on the outcome of interest. We additionally control for the type of manor - most manors are owned by knights and only few by the state or the church-, various other farm animals that proxy for wealth, other dues, both in kind and monetary,

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[58]Multiply our coefficients by the total number of minutes per day (1440) to convert them to minutes.

[59]A peasant family at a manor in Tallinn would need to work three times more days per week than a peasant at a manor that is 200 kilometer away from Tallinn.

the potential yield, and the drought intensity average across in the past five years. One alternative interpretation of our findings would be that distance to Tallinn proxies for the amount of oversight exerted by landowners who reside there and, thus, could coerce labor more cheaply. However, landed Baltic Germans built and lived in lavish houses on their estates and not in Tallinn or Pärnau, hence this alternative explanation is valid.

Table 2: Estonia findings, 1732

| | HH's corveé days per week | | | | | |
| | Without draught animal | | With draught animal | | With and without draught animal | |
	(1)	(2)	(3)	(4)	(5)	(6)
Distance to Tallinn (in km)	-0.015^{***}	-0.032^{***}	-0.005^{***}	-0.007^{***}	-0.012^{***}	-0.033^{***}
	(0.001)	(0.003)	(0.0004)	(0.001)	(0.001)	(0.003)
Distance to Pärnau (in km)	0.011^{***}	0.024^{***}	0.008^{***}	0.008^{***}	0.011^{***}	0.027^{***}
	(0.001)	(0.002)	(0.0003)	(0.001)	(0.001)	(0.002)
Used land (in 12,5 ha)	3.291^{***}	4.084^{***}	2.689^{***}	2.919^{***}	5.357^{***}	6.222^{***}
	(0.325)	(0.824)	(0.104)	(0.192)	(0.335)	(0.873)
Unused land (in 12,5 ha)	-0.049	-0.532	0.088	-0.160	0.362^{*}	-0.282
	(0.196)	(0.413)	(0.065)	(0.099)	(0.213)	(0.447)
# HH member	0.158^{***}	0.119^{*}	0.115^{***}	0.117^{***}	0.302^{***}	0.337^{***}
	(0.029)	(0.066)	(0.009)	(0.016)	(0.031)	(0.071)
# horses	0.339^{***}	0.747^{***}	0.064^{***}	0.060^{*}	0.413^{***}	0.842^{***}
	(0.061)	(0.137)	(0.020)	(0.033)	(0.064)	(0.147)
Forested land (in 12,5 ha)		-0.233^{***}		0.050^{***}		-0.099
		(0.064)		(0.015)		(0.067)
Constant	-1.141^{***}	-0.658	0.929^{***}	0.239	-0.689^{**}	-2.554^{**}
	(0.287)	(2.147)	(0.091)	(0.220)	(0.287)	(1.005)
Observations	4,955	1,868	6,154	2,179	6,265	2,206
Adjusted R^2	0.248	0.388	0.473	0.464	0.280	0.320
Additional controls:						
Type of manor	Y	Y	Y	Y	Y	Y
Farm animals	Y	Y	Y	Y	Y	Y
Other dues	Y	Y	Y	Y	Y	Y
Potential yield	Y	Y	Y	Y	Y	Y
Drought intensity	Y	Y	Y	Y	Y	Y

Notes: Cross-section of Northern Estonian households as recorded in the *Wackenbuch* of their manor. Type of manor distinguishes between church, knight and state manors. Multiply the coefficients by 1440, the number of minutes per day, to convert them to the change in corvée minutes per household per week. Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

6.2.3. Prussia, 1816, 1849, 1858

Columns 1-4 of Table 3 show the results of regressing a county's share of large estates on our export potential index. In Columns 5-6 we change the dependent variable to the share of emancipated serfs. Both outcomes and our main explanatory variable, $ExportPotential$, are standardized to make interpretation straight-forward. We find the coefficient of $ExportPotential$ to be positive for the share of large estates, and negative for the share of emancipated serfs. This confirms the evidence of our earlier

descriptive statistics. Export potential is significant at the 1% level in Columns 1-5, and at the 10% level in Column 6. In our strictest specification that uses both county and year fixed effects, a one standard deviation increase of export potential is associated with a 0.147 standard deviation increase in the share of large estates. For our cross-section of serf emancipation, the same increase in export potential decreases the share of emancipated serfs by 9% of a standard deviation (Column 6). We show that the results for the share of large estates are similar when using no fixed effects and no control (Column 1), year fixed effects (Column 2), both types of fixed effects (Column 3), and to additionally including time-variant controls. In particular, we control for the the period-specific *Grundsteuerreinertrag* - a proxy for agricultural productivity - and the shares of protestants, urban dwellers, industrial workers, and those with a first language other than German. We also control for population and school density as well as the child dependency ratio. All these controls are taken from the Prussian censuses and are common in the literature (e.g. Kopsidis & Wolf, 2012; Cinnirella & Hornung, 2016; Ashraf et al., 2018). We add an additional control for drought intensity. It is important to note when we use a restrictive specification with both county and year fixed effects, we control for every potential effect that is constant within each county over the years. this could be something like geographic location, or is constant across all counties within each year, such as any Prussia-wide changes in legislation. The results for the share of serf emancipation are less robust to the inclusion of time-variant and invariant controls, such as soil conditions, but remain significant at the 10% level. We take these results as evidence that an export hypothesis applied to Prussia as was already suggested by the maps we showed before.

Table 3: Results Prussia, 1816, 1849, 1858

	% large estates (standardized)				% emancipated serfs (standardized)	
	(1)	(2)	(3)	(4)	(5)	(6)
ExportPotential (standardized)	0.175***	0.169***	0.166***	0.147**	-0.215***	-0.0909*
	(0.0455)	(0.0508)	(0.0609)	(0.0636)	(0.0582)	(0.0523)
Primary school enrollment				-0.661		2.749***
				(0.411)		(0.579)
Constant	0.484***	0.468***	0.467***	-0.111	0.0158	-0.967
	(0.0780)	(0.0894)	(0.0533)	(1.674)	(0.0589)	(1.191)
Observations	453	453	453	453	143	143
# counties	151	151	151	151	143	143
R-squared			0.037	0.180	0.088	0.446
Controls	N	N	N	Y	N	Y
Year FE	N	Y	Y	Y	NA	NA
County FE	N	N	Y	Y	NA	NA

Notes: Panel of East-Elbian Prussian counties (1800 constant borders) in 1816, 1849 and, 1858 (Columns 1-4) and cross-section of share of manumitted serfs (Column 5). *Grundsteuerreinertrag* proxies for agricultural productivity. Further controls include % protestant, % urban, % industrial, % agricultural, child dependency ratio, population density, school density, % first language not German. Time invariant controls include soil conditions. Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

6.2.4. Scania, 1702-1856

As mentioned, we use the share of large estates in Scanian villages, which we define based on a threshold, 0.75 mantal, that corresponds to the 3% largest estates. Hence, our dependent variable for Scania is comparable to Prussia's, where about 3% of estates are larger than 300 Prussian Morgen. Table 4 shows the results, which are statistically significant at the 1% level, but go in the opposite direction compared to Prussia. That is, export potential is associated with a lower share of large estates. These results remain robust to including year fixed effects (Column 2) and, additionally, village fixed effects (Column 3). Once year fixed effects are included, the coefficient on the amount of grain a village produces turns positive and becomes statistically significant. The increase in precision makes intuitive sense given that we now control for year effects that are common to all villages, thus, for the year-to-year average, Scania-wide agricultural conditions. We take this as evidence that peasants in villages producing more grain are more able to purchase due to the income from grain sales. We also control for the number of land plots in a village to account for the partitioning of inherited land that was made legal in this period. The coefficient is negative and significant at the 10% level in our stricter specifications (Columns 2-3), meaning that land partitioning reduces the share of large estates. This, in turn, implies that predominantly large estates were partitioned, which speaks to our earlier observation that the share of Crown and manorial land, which tended to be large, declined. Excluding the grain production and number of land plot controls only

slightly changes the coefficient of export potential.

Table 4: Results Scania share of large estates, 1702-1856

	Village's share of large estates		
	(1)	(2)	(3)
ExportPotential	-0.000848***	-0.000438**	-0.000533***
	(0.000146)	(0.000175)	(0.000174)
Grain production (in stooks)	-1.77e-05	0.000200***	0.000192***
	(5.45e-05)	(5.82e-05)	(5.77e-05)
# plots of land	-0.000484**	-0.000458*	-0.000457*
	(0.000231)	(0.000241)	(0.000247)
Constant	0.0428***	0.250***	0.253***
	(0.00930)	(0.0468)	(0.0458)
Observations	3,617	3,617	3,617
Number of villages	47	47	47
R-squared	0.1086	0.1223	0.121
Village FE	N	N	Y
Year FE	N	Y	Y

Notes: Mean and s.d. of ExportPotential are 1.3 and 5.9, respectively. Panel of Scanian villages observed, at most, annually from 1702 to 1856. Dependent variable is the share of large land plots in a village. Crown lands are excluded. Grain production include amount of grains produced (rye, barley, oats, wheat, buckwheat, and mixed) in stooks. # plots of land gives the number of land plots in a village, which would increase if existing plots were partitioned. Robust standard errors in parentheses. *** $p<0.01$, ** $p<0.05$, * $p<0.1$.

Table 5 provides more explicit evidence that peasants bought land following increased export potential. We now use the data at its lowest level of aggregation, the land-plot level, where our dependent variable now is a dummy that indicates whether the peasant owns the land, or whether it is part of a manor. We, thus, drop Crown land from the sample and focus on comparing the most coercive lands, manors, to those of potential former and future subjects, peasants. We find that in linear (Columns 1-4) and in a probit models (Column 5), export potential significantly increases the likelihood that peasants own the land they till, rather than tilling manorial land. These results are robust to including land plot and year fixed effects, as well as the land plot's grain production[60]. We also include dummies (Column 4-5) whether the cultivator changed as the land changed and whether the cultivator is widowed, which are all the cultivator characteristics that are available in the data. Combined, Tables 4 and 5 provide strong evidence *against* an export hypothesis in Scania and are, in stark contrast to the results for Prussia. We see those results as being driven by the opening of land markets to peasants, who, unlike in Prussia, avail of this opportunity. We give a more detailed explanation of the implication of those findings in the context of our other case

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[60]This is indeed observed for each land plot due to the incredible granularity of the data.

Table 5: Results Scania landowner by peasant, 1702-1856

| | Peasant owns land? [0/1] | | | | |
| | (1) | (2) | (3) | (4) | (5) |
	OLS	OLS	OLS	OLS	Probit/mfx
ExportPotential	0.00120**	0.00122**	0.00122**	0.00122**	0.302***
	(0.000590)	(0.000578)	(0.000584)	(0.000583)	(0.0564)
Grain produced (in stooks)			-0.000630	-0.000622	1.520***
			(0.000529)	(0.000519)	(0.348)
Cultivator changed? [0/1]				-0.00102	-0.391
				(0.00128)	(0.366)
Cultivator widowed? [0/1]				0.0103	2.454***
				(0.00755)	(0.350)
Constant	0.461***	0.420***	0.422***	0.422***	
	(0.0364)	(0.0112)	(0.0117)	(0.0116)	
Observations	59,716	59,716	59,716	59,716	59,716
Number of plots	1,963	1,963	1,963	1,963	
Land plot FE	N	N	Y	Y	Y
Year FE	N	Y	Y	Y	N
R-squared	0.000	0.034	0.034	0.035	

Notes: Mean and s.d. of ExportPotential are 1.5 and 5.6, respectively. Panel of Scanian land plots observed, at most, annually from 1702 to 1856. Dependent variable is binary indicator whether peasant owns land (*skatte*), or whether land is manorial. Crown lands are excluded. Grain produced include amount of grains produced (rye, barley, oats, wheat, buckwheat, and mixed) in stooks. Note that since we use land plot fixed effects, probit results are not bound by 0 and 1. Village-level cluster robust standard errors in parentheses. *** $p<0.01$, ** $p<0.05$, * $p<0.1$.

studies in the conclusion.

7. Conclusion

This paper studies the relationship between international trade and unfree labor, which is novel in the literature. We have focused on the period and region for which there is the most qualitative evidence that trade opportunities incentivized landowners to coerce labor: the Second Serfdom, Early-Modern Eastern Europe's long spell of a variety of unfree labor types that set it apart from the West. Our novel trade data enables us to produce cliometric evidence on this relationship for most of the Second Serfdom, specifically from 1579 to 1856. Among historic trade data, the Danish Sound Toll records that we use, are unrivalled in many aspects. They cover an extensive time period, 277 years, have granular and detailed information by recording trade between cities. This Toll data shows the number, weight and product type of individual shipments that crossed on ships between the Baltic and North Seas. After intensive cleaning efforts, these

data allow us to capture virtually all grain export from the Baltic Sea region to the European West.[61] This expansive grain trade raised the profitability of labor coercion - and thereby its extent - on grain producing estates owned by the nobility, the Junkers[62], according to the export hypothesis that was first formulated by Polish historians more than 60 years ago (e.g. Malowist, 1958). This hypothesis has informed popular accounts (e.g. Wallerstein, 2011; Pomeranz, 2009) on the forced division of labor between core and periphery regions, such as Western and Eastern Europe, but has not been tested empirically before.

In order to test the export hypothesis, we also require data on unfree labor. To this end, we undertook an extensive survey on unfree labor literature and created a new dataset that records de-jure reforms for different types of labor coercion that commonly existed in Baltic Sea region: serfdom, mobility bans, legality of expropriation, and inability to sue in a court. We supplement the de-jure measures of unfree labor with de-facto proxies from existing panel data for Denmark, Prussia, Russia and Scania, Sweden's southernmost province. We use proxies including wages and the share of (manumitted) serfs, large estates, and demesne income. We also use a new, full universe cross-section of Estonian households in 1732 and their corvée labor to estate owners.

Equipped with these data sources, we find that most introductions of de-jure coercion measures in our diverse Baltic Sea region sample occured at the end of grain price depressions in the West just as prices began to rise again. Our data show that at this time also grain exports start to rise. We argue that a single grain exporting region in the East was a price taker due to the high market integration and export volume; reaching up to 800,000 tons per year. Thus, plausibly exogenous market conditions - prices and exports- appear to drive changes in de-jure labor coercion, which is echoed also in many of the historic accounts from individual regions. Note that this only a general description of the conditions surrounding a de-jure coercion change; we leave it to future research to explore why reforms occur during some upswings and not others.[63] We interpret our findings as suggestive evidence that the nobility, the Junkers, shaped labor institutions to reduce labor costs at times where the price of output and, hence, the rewards to unpaid labor are highest and their bargaining power is larger; this is especially true given that they owned the most fertile lands for agricultural production.

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[61] Using these data on actual trade also presents a departure from using terms of trade as a proxy of the integration of markets.

[62] Junker was the term used to refer to the Prussian nobility, who were heavily involved in de-jure labor coercion, while coercing labor on their estates. Due to their similarities to notabilities in other regions, we use the term Junker to refer to them as well.

[63] We show that wars do not appear to influence many de-jure coercion changes; Prussia's peasant emancipation process that started after a defeat at the hands of Napoleon being a notable exception.

We further test this theory using the mentioned de-facto proxies for unfree labor in Denmark, Estonia, Prussia, Russia, and Scania that all had various types of labor coercion, eventhough Scania is set apart by having had no serfdom at any time. In Estonia and Prussia we show that more labor coercion existed and that - in Prussia - it disappeared more slowly in those manors or counties that had better 'export potential'. We proxy for export potential by a sub-national entity's distance to different ports, weighted by how much grain those ports exported to the West in a given year. These findings remain robust to the inclusion of a variety of controls and, for Prussia, also when using county and year fixed effects. For Denmark, our findings suggest that a Stolper-Samuelson mechanism that increases farm hands' real wages during export booms also works during serfdom. However, we do not observe peasants' labor and in-kind dues, that may well undo those wage gains. For Russian[64] we do not find that grain export to the West led to a change in coercion, which is also echoed in the literature that emphasizes other factors, such as internal migration (e.g. Stanziani, 2010).[65] We argue that the Estonian and Prussian evidence cannot be explained by existing models of land-labor ratios (e.g. Domar, 1970) and outside options (e.g. Acemoglu & Wolitzky, 2011) as those would predict less coercion in the proximity of cities due to the outside options they provide by offering runaway serfs employment in urban industries. In contrast, we observe *more* coercion in the vicinity of grain-exporting ports. To explain these finding, we propose a new open-economy model that treats prices as determined by international markets, rather than determined by a local coercive process as in Acemoglu & Wolitzky (2011). In our model, higher grain prices increase peasant wages, however, landowners counteract this by applying more coercion. We argue that this mechanism can explain the higher coercion in coastal areas, as estates there are more integrated with international markets; this integration provides them with more demand and higher prices, but also increased wage demands from peasants – these outcomes make coercion more profitable.[66] Another reason why foreign demand is more likely to foster coercion, relative to domestic demand in our model, is that the latter stems from domestic urban and rural population increases, that, respectively, provide more outside options and lower the land-labor ratios, which makes coercion less likely. In contrast, foreign demand has no such mitigating

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[64]We mean the Russian heartland since we exclude Estonia and the other Baltic governates, which were part of the Russian Empire in 1732.

[65]We do, however, think that the role of export should be considered and studied more closely in the Russian case, for example, using the more disaggregated, estate-level data that has informed recent approaches, such as Nafziger's (2019) study of serf manumission.

[66]We show that cities in the East do not appear grow during (grain) trade booms, see Appendix C.

effects on coercion.

We find the opposite effects for the proximity the grain-export-tonnage-weighted distance to ports in Scania, where peasants in villages with better export potential are more likely to become landowners and, thus, can escape manorial dues, such as corvée. This case, particularly in comparison with Prussia, illustrates the conditions under which peasants trade can improve peasant freedom: Scania's grain trade - beginning as it lifted its grain export ban - coincided with opening the market for land to peasants that was actively used. In contrast, the Prussian Crown's attempt to sell land to peasants was met with negligible interest among peasants against the background of weak property rights and centuries of unregulated, Junker-led trade. It is worth noting that in both Prussia and Scania labor dues were unregulated throughout these developments and that labor dues and estates' incomes from coerced labor were high, even relative to the rest of Eastern Europe.[67] Hence, in the case of Scania, more peasant freedom was achieved by *wealth* rather than by labor market policies.

This novel angle on the interaction of labor coercion with international trade and wealth policies may also inform research on such issues in the present-day world. As mentioned, nowadays 25 million individuals are estimated to be in coerced labor without the option to quit, often without pay, and often producing for international markets (International Labour Organization, 2017). The Danish Crown introduced serfdom in 1733 to ban peasants from migrating to cities following a collapse in international agricultural prices. Such mobility bans are also frequently observed today: guest workers in Qatar who have their passports confiscated by their employer; China's Hukou system that limits internal migration, and the recent European migrant crisis. In many of these cases, historically and presently, the role of trade remains to be assessed.

However, we do not argue that unfree labor developments can solely be explained by trade or by economic factors more generally. Perceptions of the rightfulness of unfree labor evolved in Early-Modern times and also evolve today. Even today it remains unclear how members of local communities are influenced by contact with foreign traders, with whom interaction across multiple periods is not as certain as that of their neighbours.

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[67]This speaks to the point that significant labor coercion also existed in regions such as Scania that never had serfdom.

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8. Next steps

We briefly outline some potential refinements and extensions to our current research (there are many others that we have mentioned in footnotes throughout):

- **Estonian *Wackenbuch* data:** These data can be extended to a full-universe panel for the 1700s based on digital archives at the Estonian Rahvusarhiiv. More information in those books can also be exploited to obtain a better understanding of a manor's economy as a labor-coercing firm: conversion of dues between corvée, in-kind, and money dues, runaway serfs (also recorded in the *Wackenbücher*), response to weather and other economic shocks to better understand the insurance (*Konservation*) that is provided by manor owners.

- **Exogenous transport-cost shifters:** Given that Prussia constructed its first railroads in 1838 in fairly straight lines between major cities this provides plausibly exogenous variation (Hornung, 2015) in transport costs of counties to ports and, thus, in their export potential.

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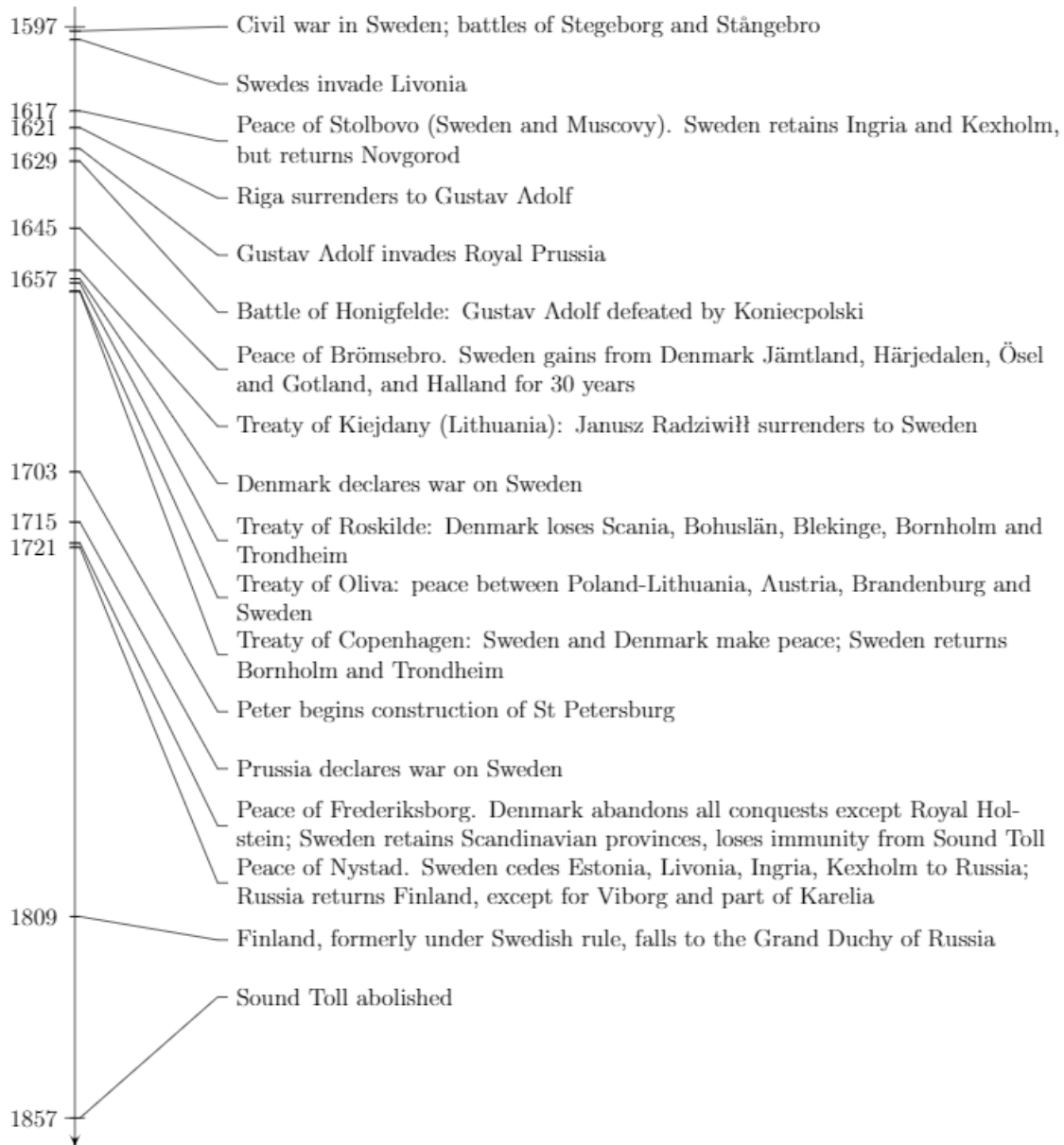
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Appendices

A. Historical Events Overview

Figure A.1: Timeline of key historical events in the Baltic Sea Region, 1597-1857

1597	Civil war in Sweden; battles of Stegeborg and Stångebro
	Swedes invade Livonia
1617	
1621	Peace of Stolbovo (Sweden and Muscovy). Sweden retains Ingria and Kexholm, but returns Novgorod
1629	Riga surrenders to Gustav Adolf
1645	Gustav Adolf invades Royal Prussia
1657	Battle of Honigfelde: Gustav Adolf defeated by Koniecpolski
	Peace of Brömsebro. Sweden gains from Denmark Jämtland, Härjedalen, Ösel and Gotland, and Halland for 30 years
	Treaty of Kiejdany (Lithuania): Janusz Radziwiłł surrenders to Sweden
1703	Denmark declares war on Sweden
1715	Treaty of Roskilde: Denmark loses Scania, Bohuslän, Blekinge, Bornholm and Trondheim
1721	Treaty of Oliva: peace between Poland-Lithuania, Austria, Brandenburg and Sweden
	Treaty of Copenhagen: Sweden and Denmark make peace; Sweden returns Bornholm and Trondheim
	Peter begins construction of St Petersburg
	Prussia declares war on Sweden
	Peace of Frederiksborg. Denmark abandons all conquests except Royal Holstein; Sweden retains Scandinavian provinces, loses immunity from Sound Toll
	Peace of Nystad. Sweden cedes Estonia, Livonia, Ingria, Kexholm to Russia; Russia returns Finland, except for Viborg and part of Karelia
1809	Finland, formerly under Swedish rule, falls to the Grand Duchy of Russia
	Sound Toll abolished
1857	

Notes: Compiled from North (2015).

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B. Sound Toll: Data Cleaning Steps

All variables in the Sound Toll data require intensive cleaning since the transcription done by the Sound Toll Online Project (STO) provides the literal text from the Sound Toll books, i.e. uses non-standardized spelling of place names and grain types and a variety of units and currencies. We received the data in 2 parts from the STO: a file with passages (i.e. at the passage/ship level) and a file with cargoes (i.e. at the shipment level). The passage and cargoes files were merged using a unique passage identifier. We detail the cleaning steps below:

- *Place names*, that is shipment origin and destination cities and captain's domicile city, have mostly been identified by the STO. We used their crosswalk from unstandardized to standardized spelling and supplement it with about 20% of total spelling variants and geo-referenced all places. The usual way Sound Toll collectors defined shipments was that each unique origin-destination-product-type combination makes one shipment. Some few shipments, are however, not recorded as having more than 1 origin or/and destination city or product type. For origin and destination city, we choose the first in the list (they do not appear to be in alphabetical order), assuming that it is the most important. When multiple product types are mentioned (e.g. wine and grain) in the same shipment, we do not consider the shipment as a grain shipment unless all types are grain (e.g. wheat and rye), see next bullet for details.

- We manually match all variants of *grain type* spellings. Products in the Sound Toll are generally described in Danish. The description can be quite detailed, e.g. for wine, but for grain the description mostly refers to the grain type (barley, buckwheat, mixed, oat, rye, and wheat), which we codify in our data. When the shipment is just described as grain, we classify it as mixed. We do not distinguish between processed grain (e.g. flour) and unprocessed grain. The latter makes up the vast majority of grain shipments. In this research, we focus on grain shipments, however, all types of products are captured in the Sound Toll data. When we refer to all shipments or passages (not only grain), we exclude those of that do not carry any goods, e.g. war fleets or empty, outgoing fishing trawlers.

- To convert the various weight and volume measures of our grain shipments into *metric units*, we first standardize the spelling of all non-metric units and the convert volume measures and non-

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metric weight units to kilogram using conversion that are commonly used in research on Early-Modern Europe (e.g. Thestrup, 1991; Gyllenbok, 2018; Treese, 2018).

- We convert the various *currencies* in the Sound Toll to their time-specific silver content using Degn (2018). For gold coins, we first derive their time-specific gold content and then convert it to the silver equivalent. This conversion is based on the gold price in British Pounds (based on the commonly-used www.measuringworth.com) and the Pound's own time-specific silver content based on Edvinsson et al. (2010).

As mentioned before, the Sound Toll data provides daily trade observations, which we aggregate per year. We choose to do so in order to obtain trading periods of comparable length. In particular, at the beginning and the end of the year, there are very few passages since the Sound is difficult to navigate in winters (Degn, 2018) and there are supposedly no harvests during those times. As a result, we deem the period change at the 31st of December as suitable, since it is unlikely that we group some grain shipments that are only days apart in this year, and some in the next year (since there are none at this time).

C. Trade and City Growth

Figure C.1: Grain exports and growth of selected, German cities, 1200-1856
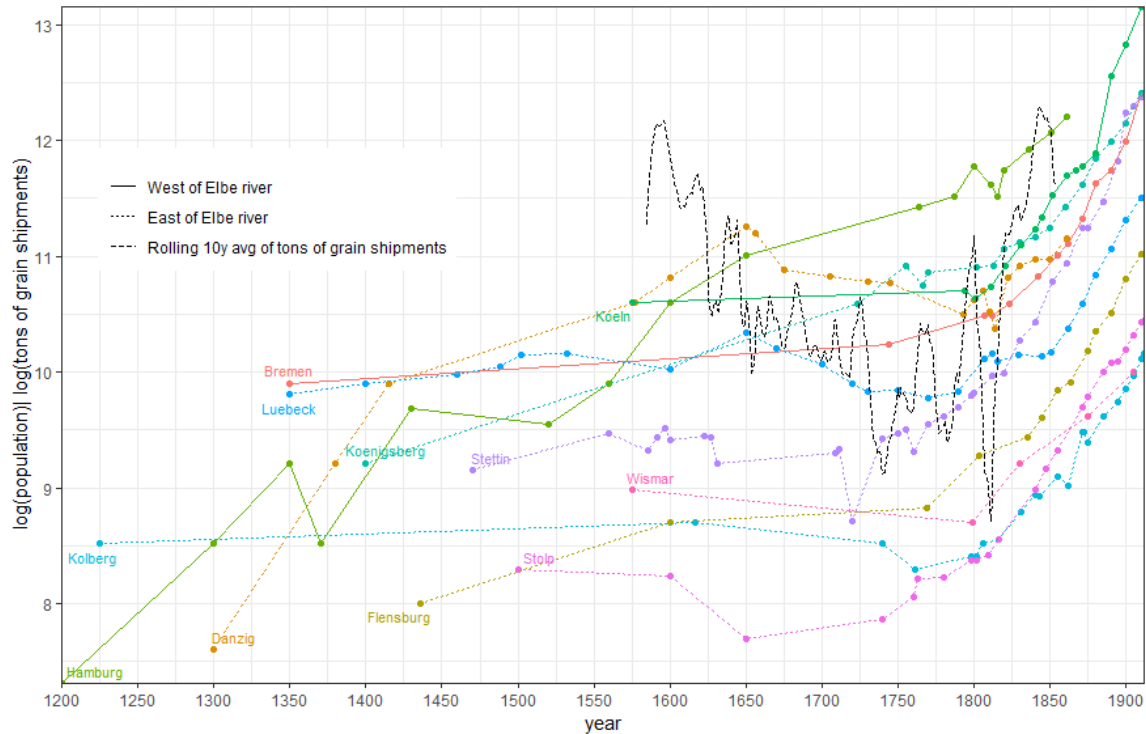

Notes: Figure shows the population across time of selected cities and the aggregated grain exports of East-Elbian, German cities. We observe a break in population growth for Danzig and Lübeck (and other East-Elbian cities) that is in stark contrast to that of Hamburg (and other West-Elbian cities). Lindberg (2009) relates this to the continued awarding of special privileges to a merchant elite in the East, while particularly Hamburg adopted a more laissez-faire approach to trading priviledges. Population data transcribed from the commonly-used German city books (Städtebücher) (Kayser, 1939, 1941, 1952, 1954, 1956; Stoob et al., 1995; Engel et al., 2000).

D. Sound Toll: missing values

Despite these cleaning efforts, missing values remain in the Sound Toll data. There are 2 sources of missing values: values that are missing because we were unable to make sense of the text in the Sound Toll transcription and values that are missing because they were left blank in the original Sound Toll record. For metric conversion, the number of both types of missing values is low with 2.254% of observations. This number is comparably low for matching place names and identifying goods (because the variety of grains is limited). Figure D.1 shows the share of missing tonnage observations in total number of grain shipments. Comparing this Figure to the tonnage that we observe, we note that those missing values occur during peak export years where traffic through the Sound apparently influenced the record keeping.

Thus, our estimates should be understood as lower bounds. Acknowledging this missing value structure, we show both the number of shipments and their tonnage in Appendices E.2, E.3, and E.4. Also in these Appendices we shows the distribution of missing place names.

Figure D.1: Share missing tonnage observations in total number of grain shipments
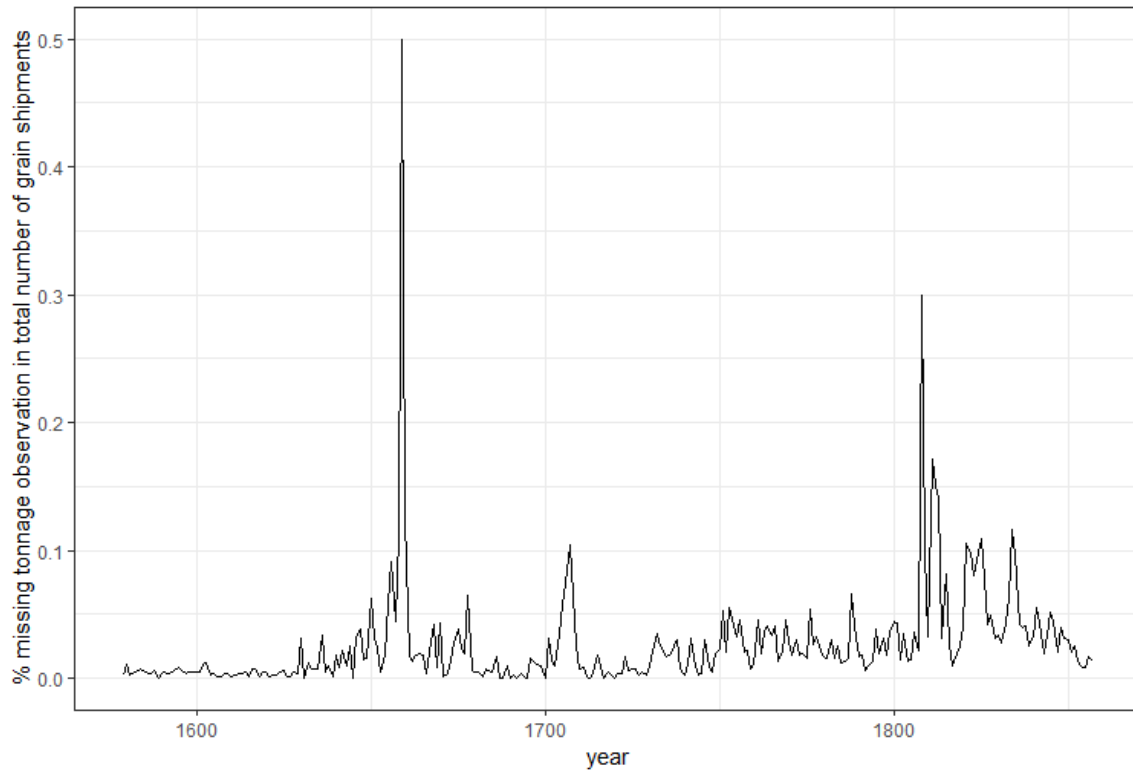
## E. Sound Toll: Further Descriptive Statistics

E.1. *Entire period Sound Toll records are preserved: 1497-1856*

In this Appendix we show the number of passages for all years that the Sound Toll records have been preserved (hence also pre 1579)[68] and for not only those passages with grain shipments. Now the trade upswing that culminated in the 1590s and that saw almost half of the ship passages carrying grain becomes more apparent. The number of all passages during this peak was only surpassed in the late 1700s, but the number of grain passages was never again surpassed. However the *tonnage* of shipments did surpass the 1590s grain trade booms starting in the 1820. This implies that, while grain-containing passages

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[68]We take these numbers not from the STRO but from Degn (2018).

were fewer, their average tonnage was larger.

**Figure E.1:** Passages for entire period Sound Toll records are preserved, 1497-1856
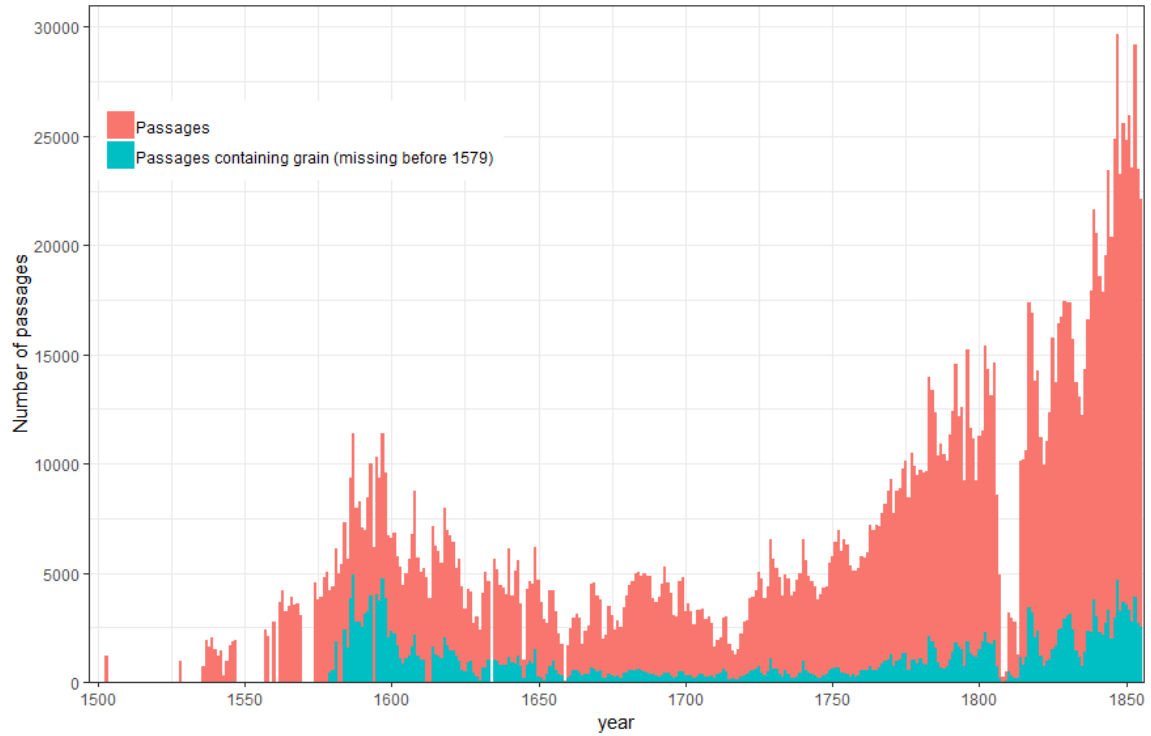
Notes: Figure shows the number of passages through the Sound throughout the entire period that the Sound Toll records are preserved. For the years that predate our sample (1497-1578), this number is taken from Degn (2018, pp.181) and we do not observe whether passages contain grain shipments. We take this as evidence for a grain export boom as early as the 1580s. The effects of the Napoleonic Wars are apparent in the beginning of the 19th century.

E.2. Grain trade by domicile of captain

Here we distinguish the domicile region of the captains that were consistently recorded in the Sound Toll since they, in part, determined the tax rate. That is, they were akin to the modern principle of 'sailing under a flag'. Domiciles do not always correspond to the region that the captain was likely born in. For example, there is a large number of captains with Dutch names with domicile cities in the East. This is evidence that Dutch talent was in high demand in the East. When captains declared their domicile in the Netherlands, often times the named places were small islands, which are known to have produced excellent skippers.
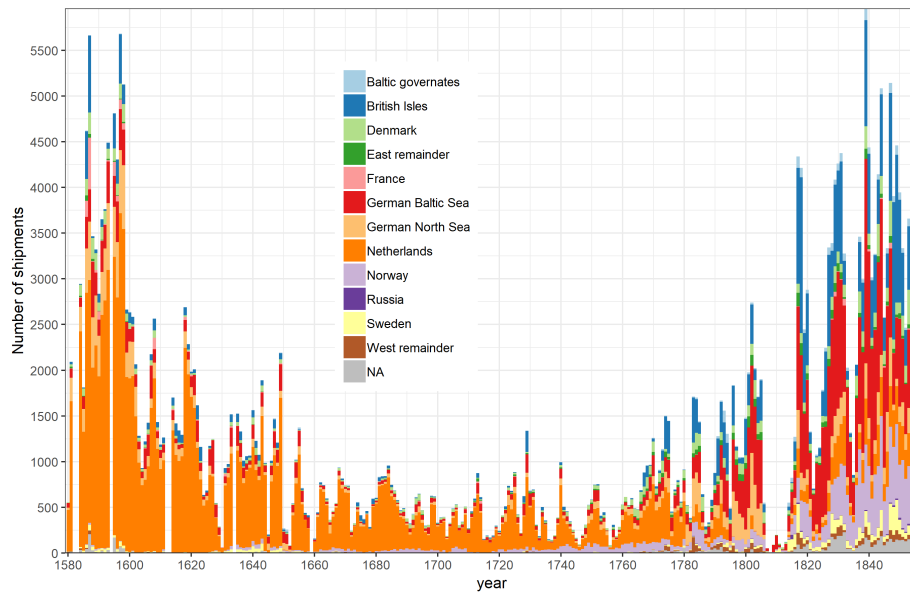
(a) Number of shipments
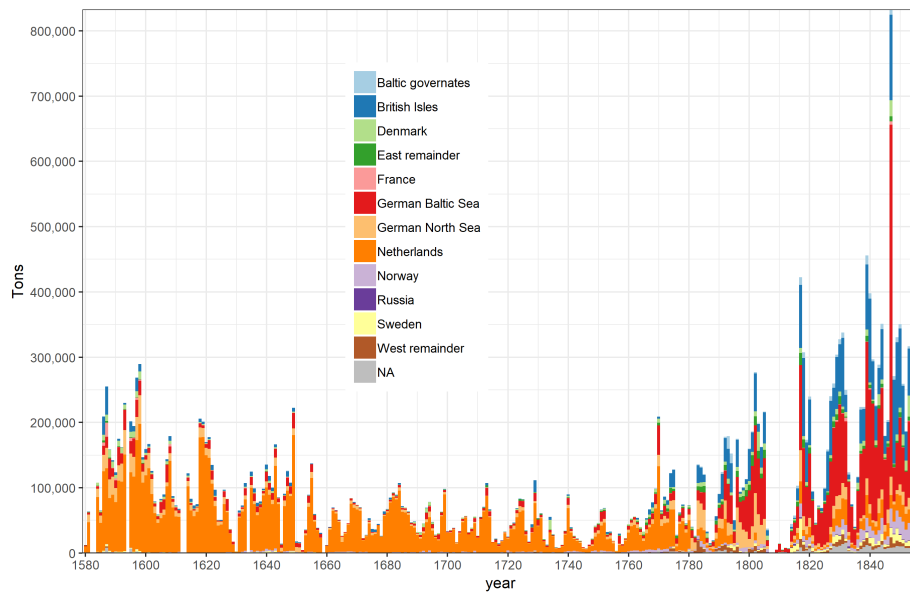
(b) Tons

Notes: Figure shows domicile region of captain based on domicile city reported in Sound Toll. We use 'remainder' categories for both the East and the West such that all captain domicile cities are assigned a category. Thus, missing values are actual blanks.
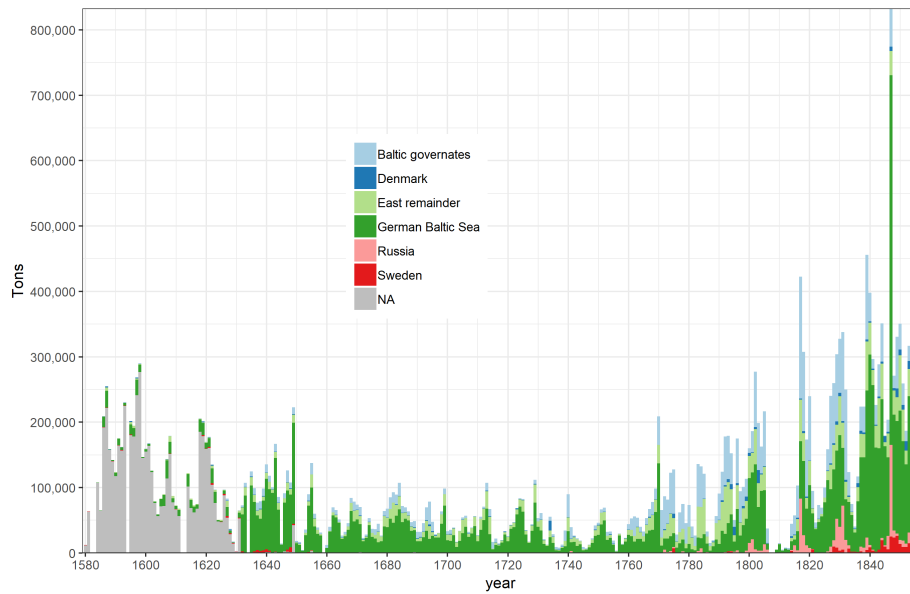
E.3. Grain trade by origin

This section shows the origin of grain shipments by regions, which reveals that prior to 1633 most information on the origins of shipments are missing, see Figure E.3 below, which is due to different reporting requirements at the Sound during those years (Degn, 2018). We impute most of those missing values with the rich information on the origin of grains that is contained in their description, for example "Prussian wheat" or "Riga rye". Those descriptions are detailed, but do not always reveal the city, which leaves our data at the still granual region level for those years. However, this is not concerning given that we only focus on regions pre 1633 since our de-facto unfree labor applications are all in later periods.

Figure E.3: Grain trade by origin, 1579-1857
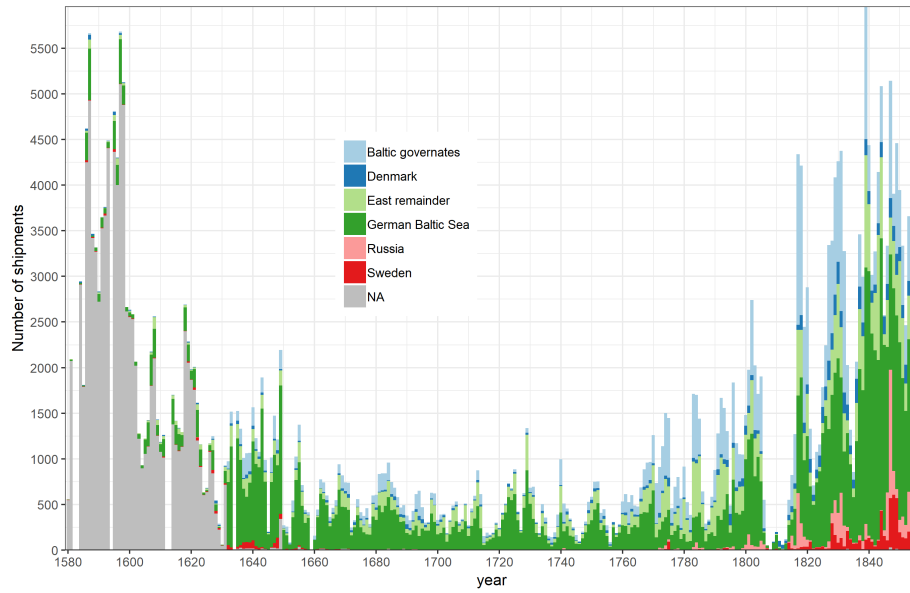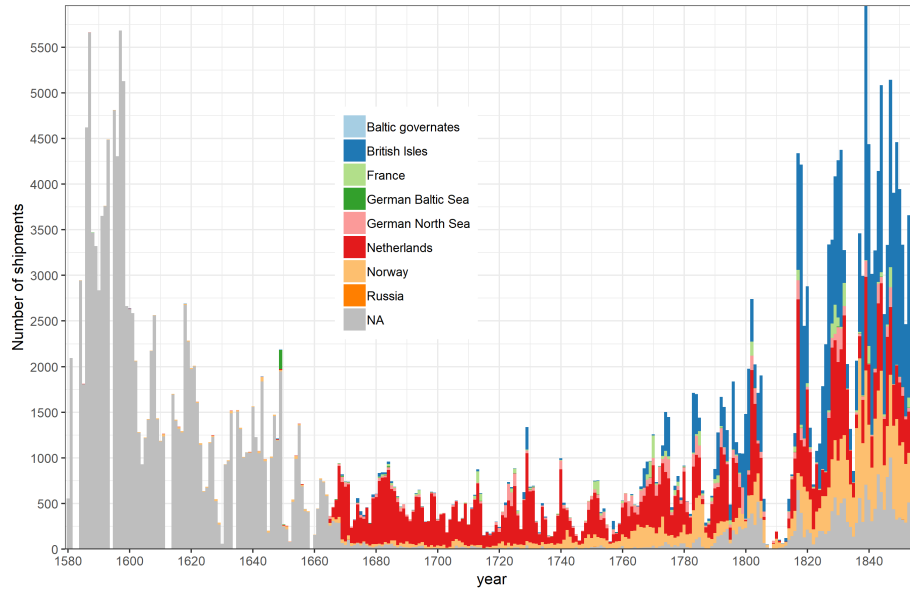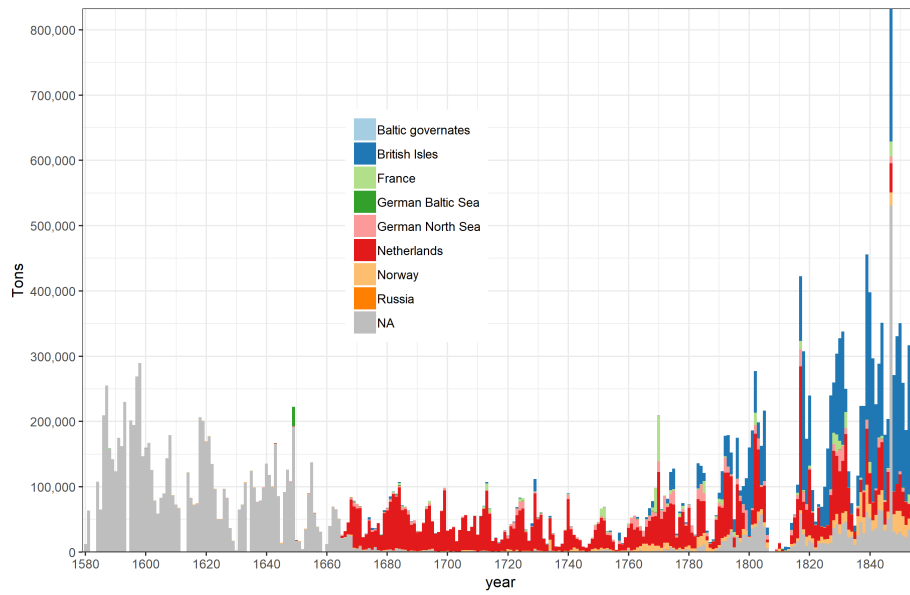

(a) Number of shipments

(b) Tons

Notes: Figure shows origin region of shipment based on origin city reported in Sound Toll. We use 'remainder' categories for other destinations. Thus, missing values are actual blanks.

Figure E.4: Grain trade by destination, 1579-1857
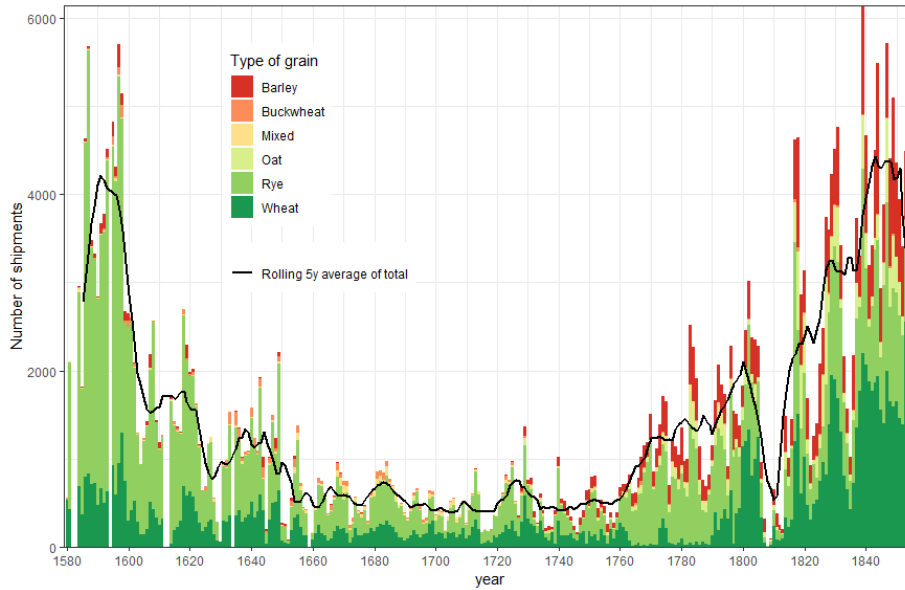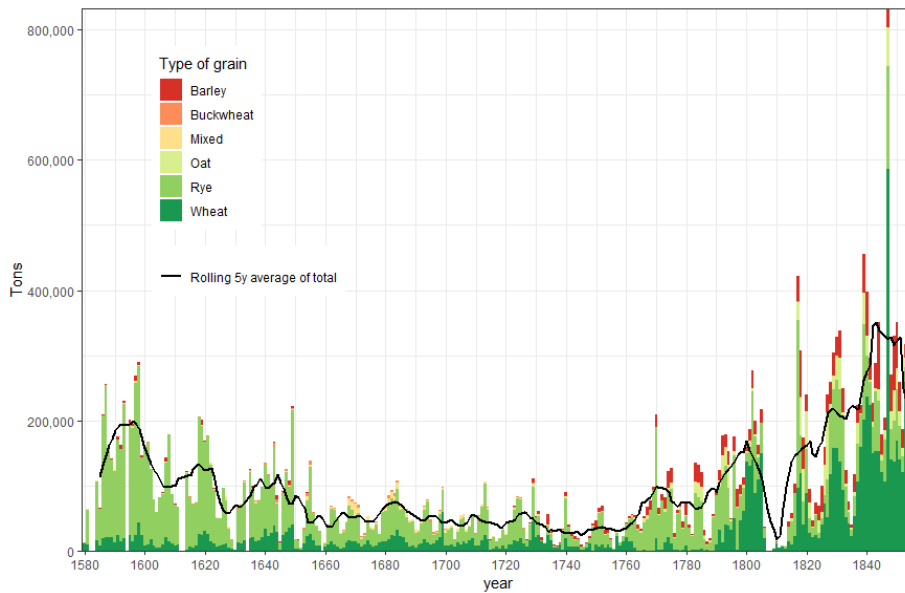

(a) Number of shipments

(b) Tons

Notes: Figure shows destination region of shipment based on destination city reported in Sound Toll. We use 'remainder' categories for other destinations. Thus, missing values are actual blanks.

E.5. Breakdown of exports by grain type

Figure E.5: Breakdown of exports by grain type, 1579-1856


(a) Number of shipments

(b) Tons

Notes: Figure shows the number and tonnage of grain shipments broken down by grain types. Most shipments appear to contain rye, followed by wheat. Starting in the 1790s, the share of wheat increases. In years with many grain shipments, exports appear to be topped of with grain types that are not exported in years with fewer shipments. The spike in 1847 is likely due to continued and aggravated crop failures on the British Isles and recovering harvests in the East, compare Vanhaute et al. (2007).

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E.6. Correlation between international grain prices and exports

We construct a price index with as a weighted average of grain prices (barley, rye, oat, and wheat), with weights proportional to grain types share in exports. This index appears to correlate well with aggregate exports of those grains as apparent in Figure E.6 and Table E.1.

Figure E.6: Grain-type-weighted price index, prices, and grain exports, 1579-1856
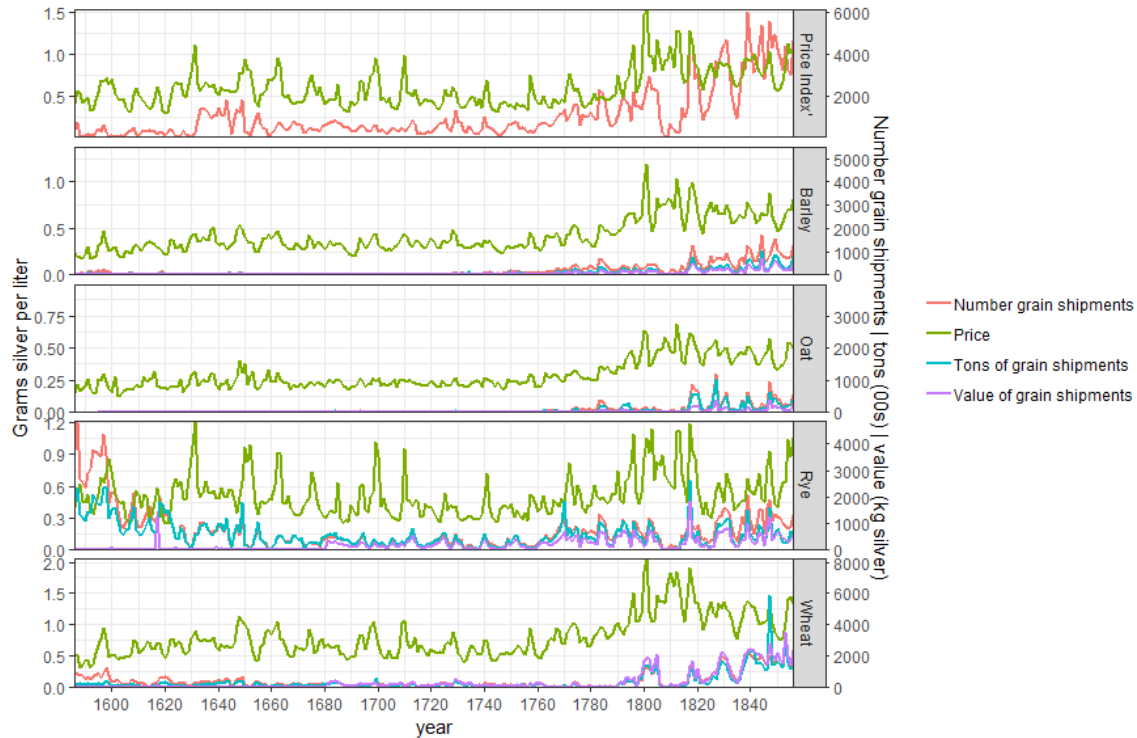
Notes: Figure shows the movement of prices of different grains (price index in first panel) and their exports. Choice of price series based on longest available series. Prices of rye (Arnhem) from Allen (2008) and prices of barley, wheat and oats (England) from Clark (2004). No long price series for buckwheat (which is not frequently exported) appears to exist. Price index calculated as weighted average of grain prices, with weights proportional to grain types share in number of shipments.

Table E.1: Correlation grain-type-weighted price index, prices, and grain exports, 1579-1856

	Price Index	Barley	Oat	Rye	Wheat
Number of grain shipments	0.5063557	0.622435	0.6203867	0.1260173	0.4451744
Tons of grain shipments	0.495561	0.5938744	0.5806027	0.1278217	0.4729609
Amount tax of grain shipments	0.5360389	0.6007349	0.5412738	0.26655	0.5560674

Notes: Table shows correlation between price (index) by grain type and their exports. Sources and index construction as in Figure E.6.

**F. French grain imports from the Baltic versus the rest of the world**

Knowledge on France's international trade from 1716 to 1821 has been advanced by the TOFLIT18 project[69] that, among other sources, uses the records of the *Balance du Commerce* (Charles et al., 2019). These data capture the value of goods more often than the quantity in contrast to the Sound Toll, which only captures the tax amount (and not the value) and quantities. Therefore, a direct comparison is complicated as is explored further in Charles & Daudin (2018).

We nevertheless attempt a comparison in Figure F.1. Two conclusions can be drawn. First, for the years (1752-1780) where the Balance distinguishes the value of grain imports from the Baltic to total grain imports, their share is very low, which may of course also be due to re-exporting of grain, e.g. in the Netherlands, that masks the Baltic origin of grains. Indeed the Netherlands are the primary source of France's (Bordeaux's) grain imports[70] Second we observe that the revenue of the Sound Toll tax of grain shipments bound for France, which to some degree is proportional to their value but subject to changes in the tax regimes, often spike during the same years as France's overall value of grain imports. This may indicate that during those years more grain was shipped directly to France, rather than through intermediaries (e.g. the Netherlands)

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[69]See http://toflit18.medialab.sciences-po.fr//home
[70]This can be verified under http://toflit18.medialab.sciences-po.fr//exploration/network.

Figure F.1: Value of french grain imports as recorded by local sources and toll on Baltic exports to France, 1750-1825
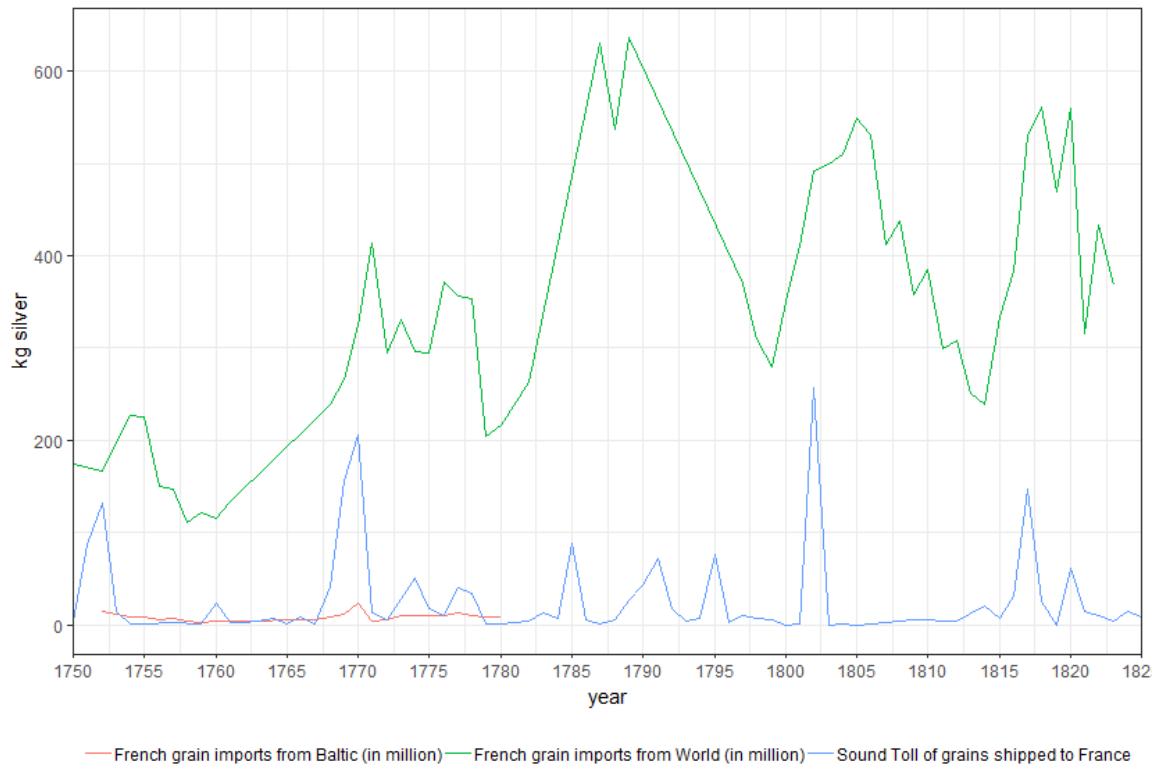
Notes: Based on Charles & Daudin (2018) and Sound Toll. All variables are denoted in kg of silver. Note that Sound Toll revenues are not in millions.

G. Unfree labor: De-jure Reform Dates and Sources

Table G.1: De-jure reform dates of unfree labor and sources

Type of 'unfreedom' *German term*	Serfdom *Leibeigenschaft*	Movement ban *Schollenbindung*	Cannot sell inherited land No *Erbzinsrecht*	Expropriation legal *Bauernlegen*	Cannot bequeath *Erbrecht*	Cannot sue *Gutsgerichtbarkeit*	Children included *Gesindezwang*
Brandenburg[a]	1653-1805	1536-				-1526	1518-
Courland[b]	-25.08.1817						
Denmark[c]	1733-20.06.1788	1709-20.06.1788				1660[d]-	
Estonia[e]	-1680, 1710-23.03.1816	1645[f]-			1680-1804[g]	1680	
Funen Sjaelland	1614-11.11.1807	1490–1702, 1709-1788					
Holstein[h]	1575-1.01.1805	1524-1766				1524-	
Poland	1496-22.07.1807	1496-				1521-1791	
Livonia[i]	-26.03.1819	1668[j]-1849	1607-1818		-1804[k]		
Mecklenburg[l]	1654-1820	1616-, 1646-	1607	1621-	1606-	18.01.1301	1645-
Oldenburg (Eutin exclave)	-1814	1526-1788					
Pommerania (West)	1616- 4.07.1806	1616-		1616-		-1811	
Pommerania (East)[m]	1653-1807/1850	1616-		-1708	1818		1616-
Prussia[n]	1614-9.10.1807	1577-11.11.1810		1350-1709		-2.01.1849	-11.11.1810
Russia[o]	-19.02.1861	1597-				19.01.1765-19.02.1861	
Saaremaa/Osel	1589-23.03.1816						
Saxony	-1781						
Silesia	-1804						
Schleswig[p]	1575-1.01.1805	1617-1766				1524-	
Swedish Ingria	-1680, 1710-23.03.1861						

Notes: Table shows de-jure reform dates of unfree labor. Dates succeeded and preceded by "-" mark start and end dates, respectively. When missing, this may either be due to an unknown dates or due to gradual implementation/abolition. When ending date is missing, it can be assumed for most countries that unfreedom ended with serfdom.

[a] Kaak (2007, p.76)
[b] Tuchtenhagen (2016)
[c] Blum (1978, p. 356)
[d] Rasmussen (2010, p. 12)
[e] Tuchtenhagen (2016, p. 33-35)
[f] Kasekamp (2017, p. 53)
[g] Moon (2001, p.43)
[h] Rasmussen (2010, p. 9), North (1999, p. 108)
[i] Tuchtenhagen (2016, p. 45)
[j] Kasekamp (2017, p. 53)
[k] Moon (2001, p.43)
[l] Klußmann (2003, p. 3-20)
[m] Tuchtenhagen (2016, p.37)
[n] Moon (2001, pp.9)
[o] Adamczyk (2006, p.79)
[p] Rasmussen (2010, p. 9), North (1999, p. 108)

H. The Export Hypothesis in the Russian Heartland

Among all countries around the Baltic Sea, historians have contested the applicability of the export hypothesis most strongly in Russia. Their main argument is that while grain exports to the West rose, national markets played an even bigger role in labor coercion. There is also evidence of peasant entrepreneurs who supplied to those markets and landowner who were more interested in proto-industry and manufacturing (Stanziani, 2010, pp.18).

We investigate the extent of serfdom in Russia in Figure H.1, which plots the share of serfs in 1745, 1782, 1835, and 1858, which are the 4 earliest census years. In the two years (1745 and 1782) that the census covers 2 of the Baltic provinces (Estonia, Livonia (present-day Latvia)), they stand out with high share of serfs, which is in agreement with our results regarding northern Estonia. In the subsequent censuses (1835 and 1858) they are missing due to having abolished serfdom in 1816 and 1819, respectively. While we do argue for an export hypothesis in those Baltic provinces/Estonia, they are certainly very distinct from the remainder of Russia and are often taken separately from the developments of serfdom in the Russian heartland, mainly due to the ruling of a German elite (Moon, 2001).

Focusing on the rest of Russia, the heartland, serfdom appears to be concentrated in the Central Black Earth Region in the central, far west that is renown for its high soil quality, and from there appears to extent eastward, which may be a reaction to domestic demand that is reported to have accelerated in the East following prolonged settlement (Moon, 2001). We note that in vicinity to heartland Russia's major export ports (St. Petersburg and Odessa), the share of serfs does not reach the levels of the central, east-west stretch, which may be viewed as evidence against an export hypothesis.

**Figure H.1:** Share of serfs in Russia, 1745, 1782, 1835, 1858

(a) 1745

(b) 1782

(c) 1835

(d) 1858
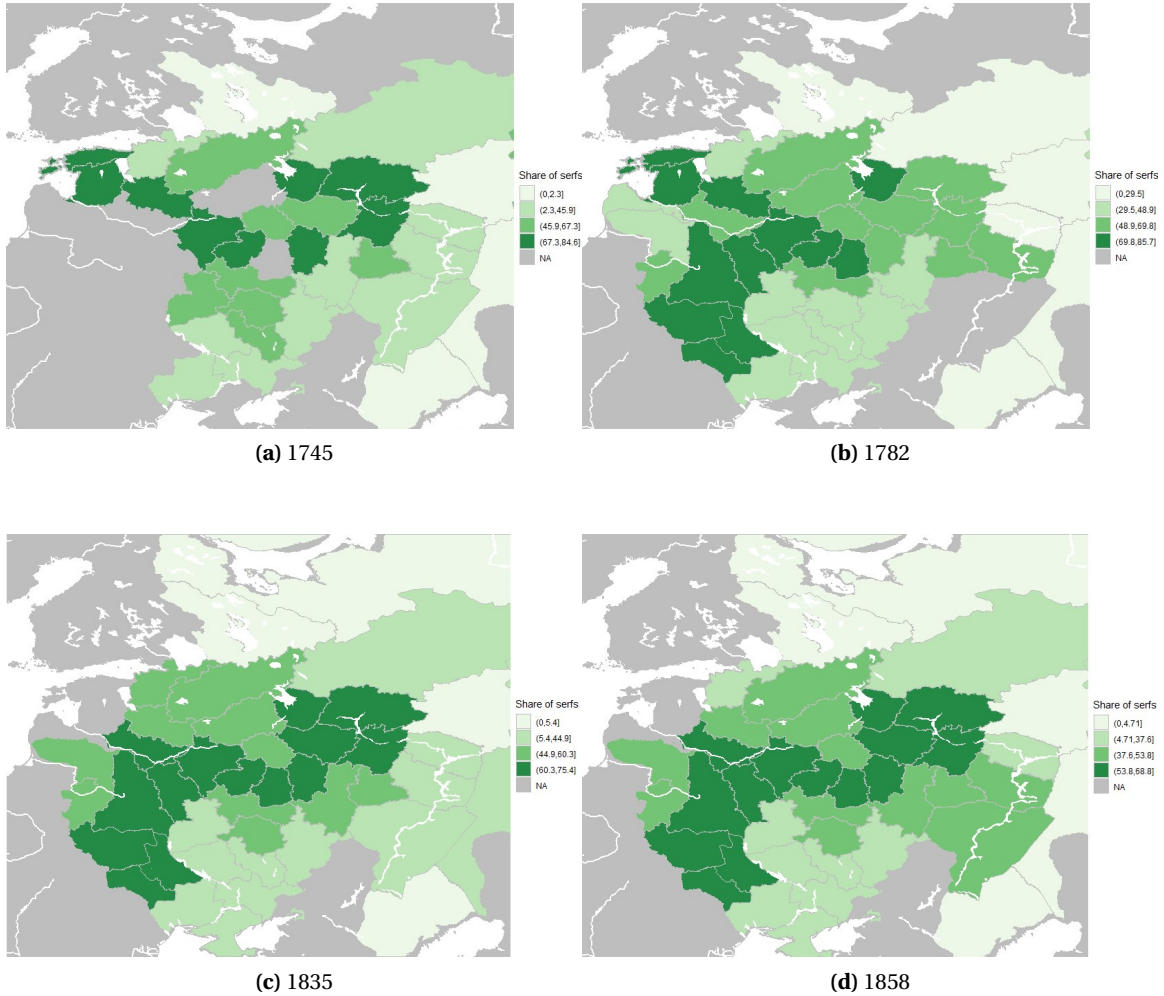
Notes: Based on Russian censuses spreadsheets and shapefiles taken from Kessler & Markevich (2015). Shares are out of total population and plotted based on quartile in each panel. The shown panels represent the 4 earliest Russian censuses. Missing values stem from either territories not belonging to the Russian Empire at the time or those not captured by the census. In the case of Estonian and Livonia (present-day Latvia), their abolition of serfdom (in 1816 and 1819, respectively) explains why they are missing in the 1835 and 1858 census.

Indeed, an investigation of Russian grain exports would be incomplete without focusing on Odessa. Founded in 1794 by royal Russian decree, it soon became Russia's primary grain export port (with an interruption during the Russo-Turkish war 1828-29) (Puryear, 1934). We obtain data concerning the tons of grain exported from 1812 onward and contrast them by grain type with the exports of St Petersburg in Figure H.2. It emerges that Odessa's tonnage by far exceeds that of St Petersburg's (which, in part, may be because we do not capture exports that do not leave the Baltic Sea) and that it was heavily specialized

in exporting wheat unlike St Petersburg, which mainly export Rye like its Baltic peers. It is striking that throughout Odessa's export boom, Kherson governate that Odessa belonged to saw it share decline from 40.4 % in 1782 to 38.6% in 1835, and to 28.8% in 1858, contrary to what one would expect during an export hypothesis. We leave it to future research to provide more detailed accounts, for example to draw on estate records that may discern sales to international and domestic markets. Also the potentially differential implications of wheat and rye production for coercion may be distinguished, since wheat appears to foster less coercion than the commonly higher-priced rye, which may add some validity to Engerman & Sokoloff's (1997) account that only higher-priced crops allow the landowner to cover the costs of coercion.

Figure H.2: Russia's Baltic and Black Sea grain exports by grain type, 1812-56
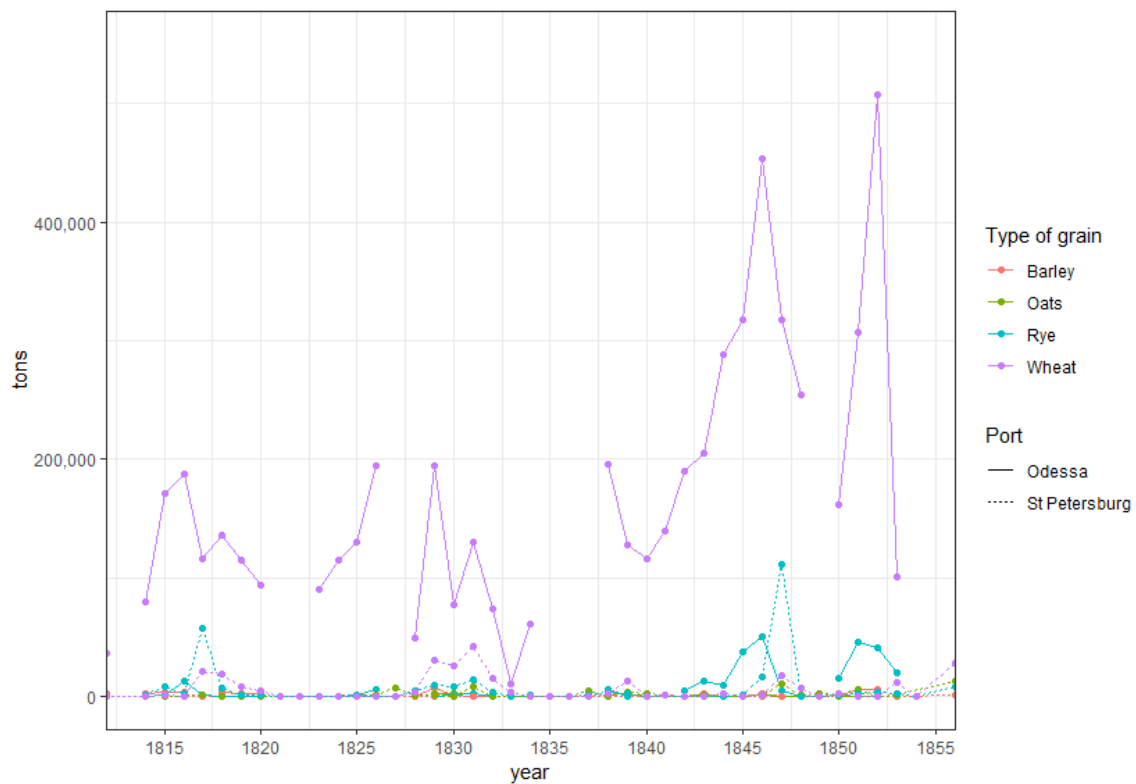
Notes: St. Petersburg exports based on Sound Toll, implying that they might be understated since they do not include intra-Baltic trade. Odessa export data obtained from the Black Sea Project, see https://cities.blacksea.gr/en/odessa/5-7/.

I. Denmark: Further descriptive statistics

Table I.1: Descriptive statistics for key variables for Denmark

Statistic	N	Mean	St. Dev.	Min	Pctl(25)	Pctl(75)	Max
Net grain sales of estate (tons)	11,977	22.301	48.495	−100.888	−4.800	52.438	264.913
% farm worker	12,507	0.103	0.304	0	0	0	1
% of observations when serfdom was in place	12,507	0.777	0.416	0	1	1	1
% children	12,507	0.005	0.071	0	0	0	1
% male	12,507	0.982	0.133	0	1	1	1
% master	12,507	0.053	0.224	0	0	0	1

J. Estonia: Further descriptive statistics and results

Table J.1: Descriptive statistics for key variables in the *Wackenbücher*

Statistic	N	Mean	St. Dev.	Min	Pctl(25)	Pctl(75)	Max
Distance to Tallinn	32,508	120.492	71.817	3.985	59.693	156.329	198.483
# corvée days/week per HH member with draught animal	12,150	0.963	0.491	0.125	0.667	1.000	6.000
# corvée days/week per HH member without draught animal	10,634	0.964	0.863	0.000	0.500	1.000	18.000
# able-bodied adult men	21,060	1.476	0.656	0.000	1.000	2.000	5.000
# able-bodied adult women	19,788	1.396	0.612	1.000	1.000	2.000	8.000
# total HH member	24,884	3.207	1.471	1.000	2.000	4.000	21.000
Used land	32,608	0.137	0.218	0	0	0.2	14
Unused land	32,608	0.145	0.573	0	0	0	15
# horses	14,669	1.431	0.608	1.000	1.000	2.000	5.000
# cows	16,414	1.901	0.929	1.000	1.000	2.000	12.000
# sheep	9,808	0.640	0.297	0.000	0.500	1.000	4.000
# chicken	7,108	1.591	0.982	0.000	1.000	2.000	8.000

Table J.2: Estonia findings **excluding distance to Pärnau**, 1732

| | HH's corveé days per week | | | | | |
| | Without draught animal | | With draught animal | | With and without draught animal | |
	(1)	(2)	(3)	(4)	(5)	(6)
Distance to Tallinn (in km)	-0.005***	-0.006***	−0.003***	−0.002***	−0.0002	-0.004***
	(0.001)	(0.001)	(0.0002)	(0.0003)	(0.001)	(0.001)
Constant	−1.141***	−0.658	0.929***	0.239	−0.689**	−2.554**
	(0.287)	(2.147)	(0.091)	(0.220)	(0.287)	(1.005)
Observations	4,955	1,868	6,154	2,179	6,265	2,206
R^2	0.233	0.354	0.421	0.404	0.268	0.286
Adjusted R^2	0.230	0.349	0.420	0.401	0.266	0.282
Additional controls:						
Type of manor	Y	Y	Y	Y	Y	Y
Farm animals	Y	Y	Y	Y	Y	Y
Other dues	Y	Y	Y	Y	Y	Y
Potential yield	Y	Y	Y	Y	Y	Y
Drought intensity	Y	Y	Y	Y	Y	Y
Forested land	N	Y	N	Y	N	Y

Notes: Cross-section of Northern Estonian households as recorded in the *Wackenbuch* of their manor. Type of manor distinguishes between church, knight and state manors. Multiply the coefficients by 1440, the number of minutes per day, to convert them to the change in corvée minutes per household per week. Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.
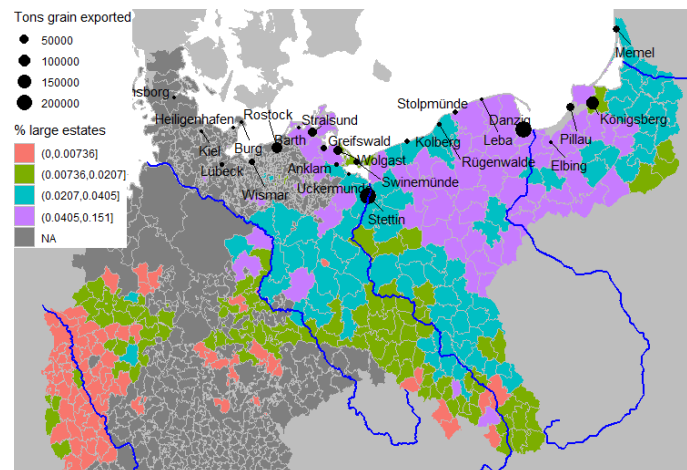
K. Prussia: Further descriptive statistics

Figure K.1: Share of large estates, 1816, 1849, 1856
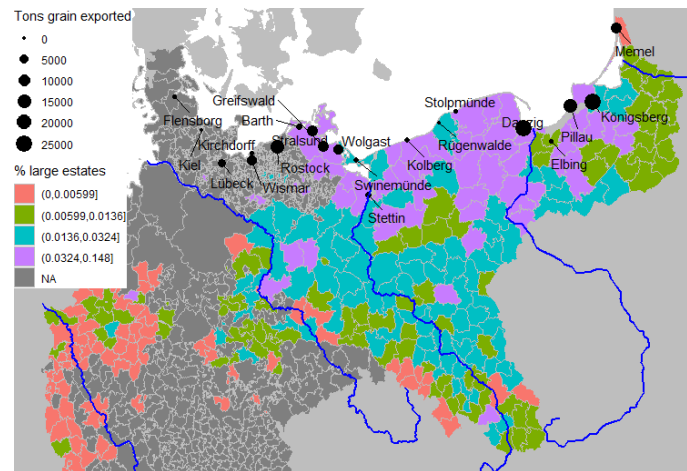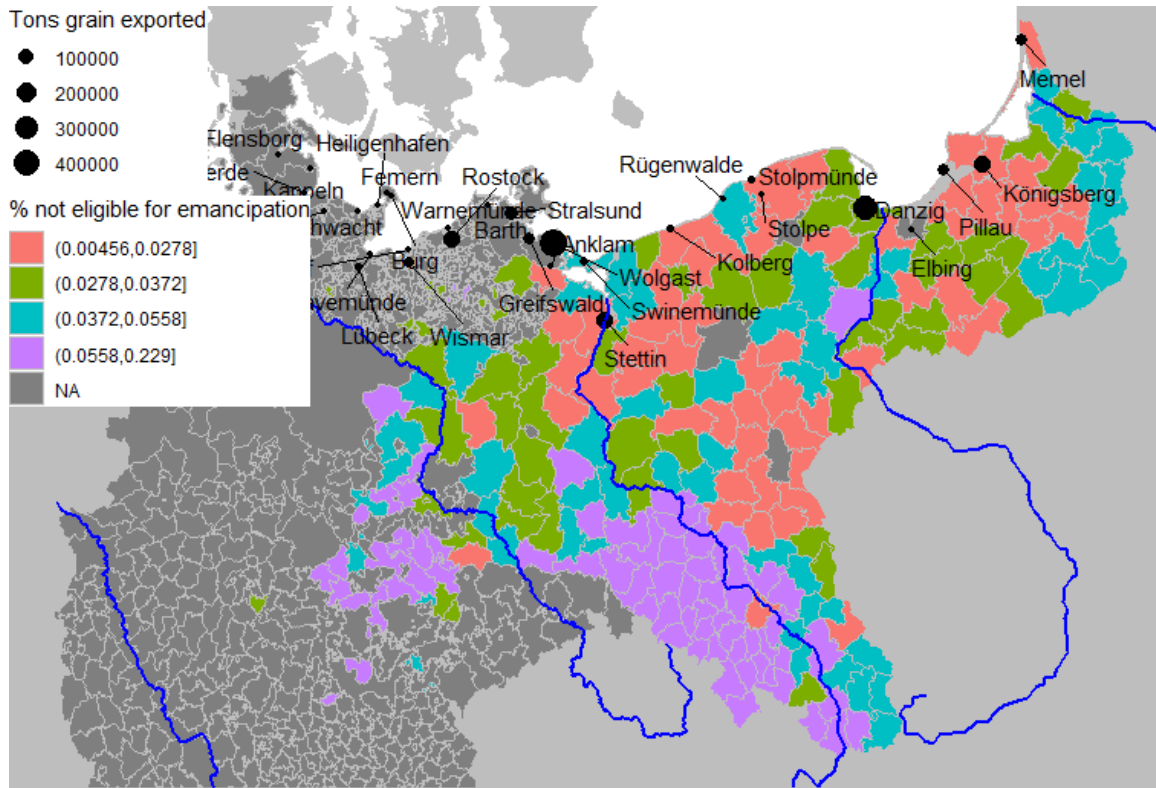

(a) 1816
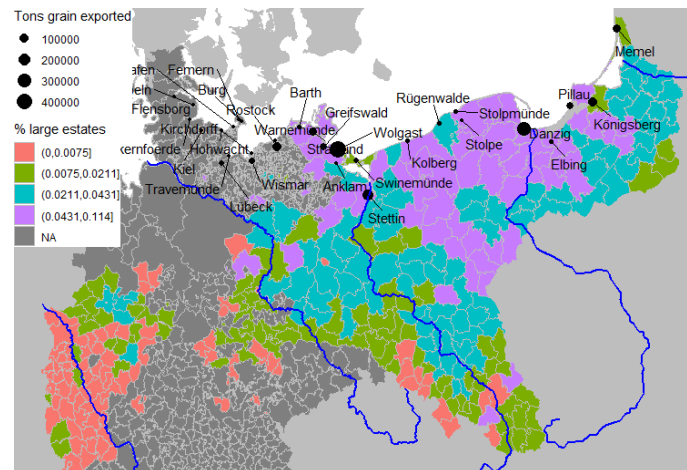
(b) 1849

(c) 1856

Notes: Based on digitized Prussian census ([Becker et al., 2014](#)) and Sound Toll trade during 5 prior years.

Figure K.2: Share of peasants not eligible for manumission due to their insecure tenure rights, 1848


Notes: Based on Meitzen's (1869) *nichtspannfähige bäuerliche Nahrungen*. All peasants would become eligible by 1850. Sound Toll trade during 5 prior years.

Table K.2: Descriptive statistics for selection of controls for Prussia

| Statistic	N	Mean	St. Dev.	Min	Pctl(25)	Pctl(75)	Max
% urban	755	0.276	0.168	0.031	0.173	0.326	1
% non-german	755	0.184	0.291	0.000	0.000	0.330	0.897
% protestant	755	0.711	0.339	0.012	0.478	0.983	1
% loamy soils	755	0.378	0.201	0.000	0.209	0.522	0.911
% primary enrollment	755	0.797	0.184	0.027	0.708	0.939	1

L. Scania: Further Descriptive Statistics

Figure L.1: Landownership by cultivator and grain exports, 1702-1856
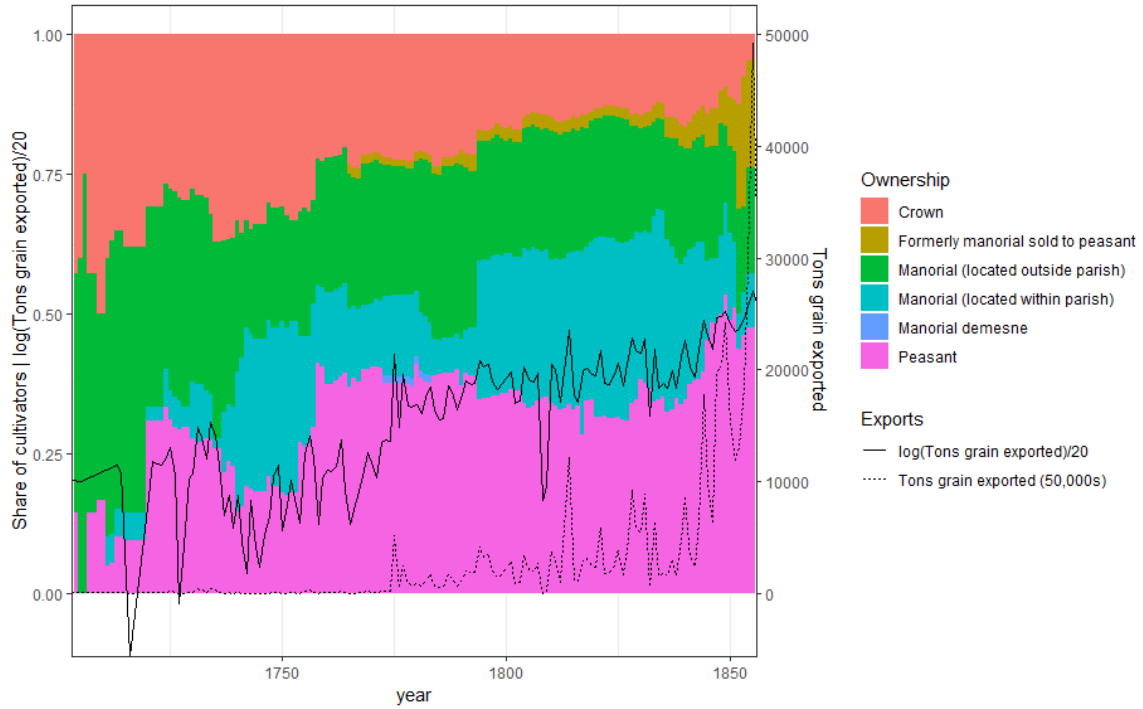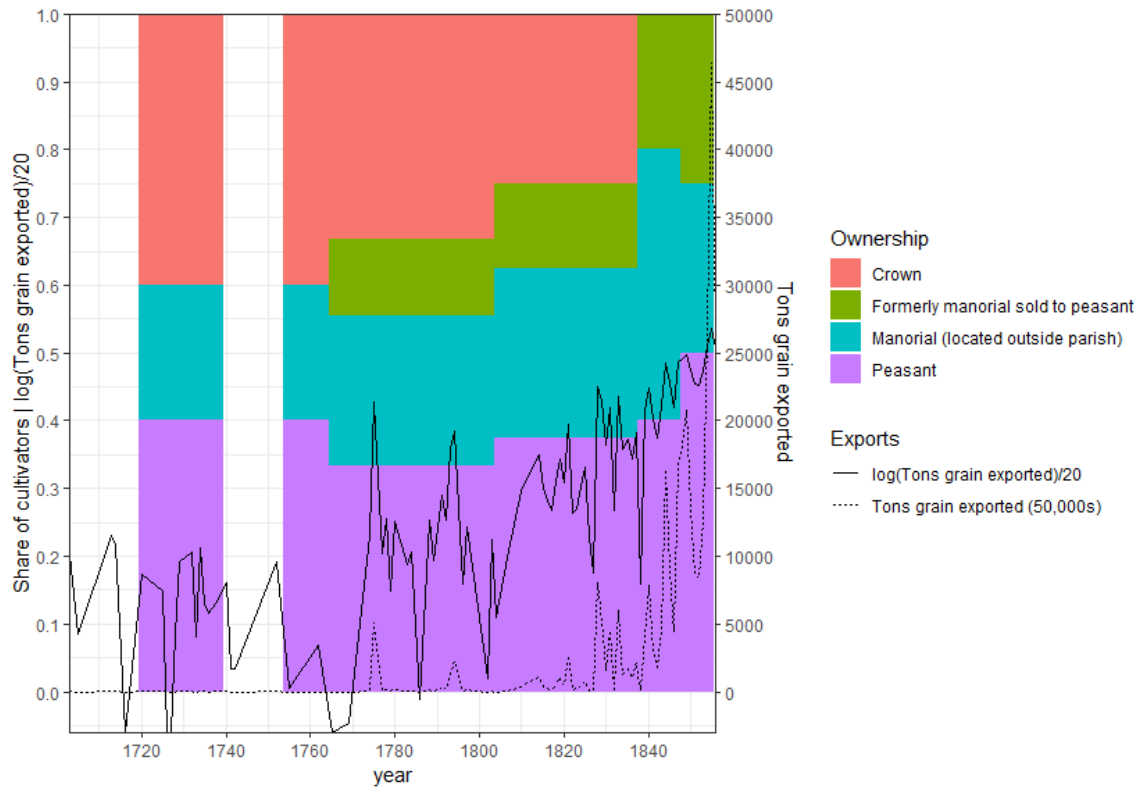

Notes: Constructed from the Historical Database of Scanian Agriculture (Olsson et al., 2017) and the Sound Toll.

Figure L.2: Landownership by mantal (top 20 most frequently observed villages) and grain exports, 1702-1856
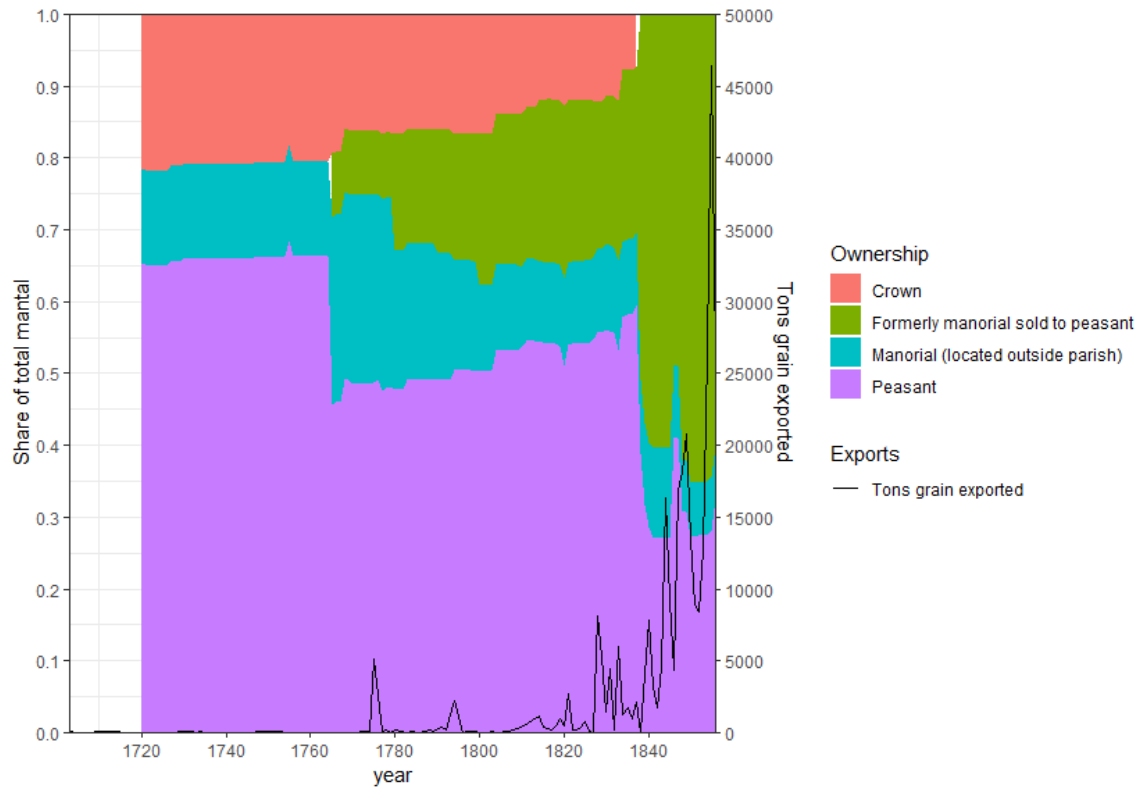
Notes: Constructed from the Historical Database of Scanian Agriculture (Olsson et al., 2017) and the Sound Toll.

Figure L.3: landownership by cultivator (top 20 most frequently observed villages) and grain exports, 1702-1856

M. Potential Yield of Different Grains

In the absence of (long) grain production series, we use *potential* yield as a proxy. Potential yield takes into account the requirements of different crops (we select the export grains barley, buckwheat, rye, and wheat), their availability per grid cell and labor input (mainly irrigation). Combined, a potential yield can be expressed as yield (in kg) per area (ha), see Figure M.1. As is common in the literature, we assume medium input that is reasonably achieved with Early-Modern technology and labor availability.

Figure M.1: Potential rain-fed dry yield of 4 crops with medium input.

(a) Barley

(b) Buckwheat


(c) Rye

(d) Wheat
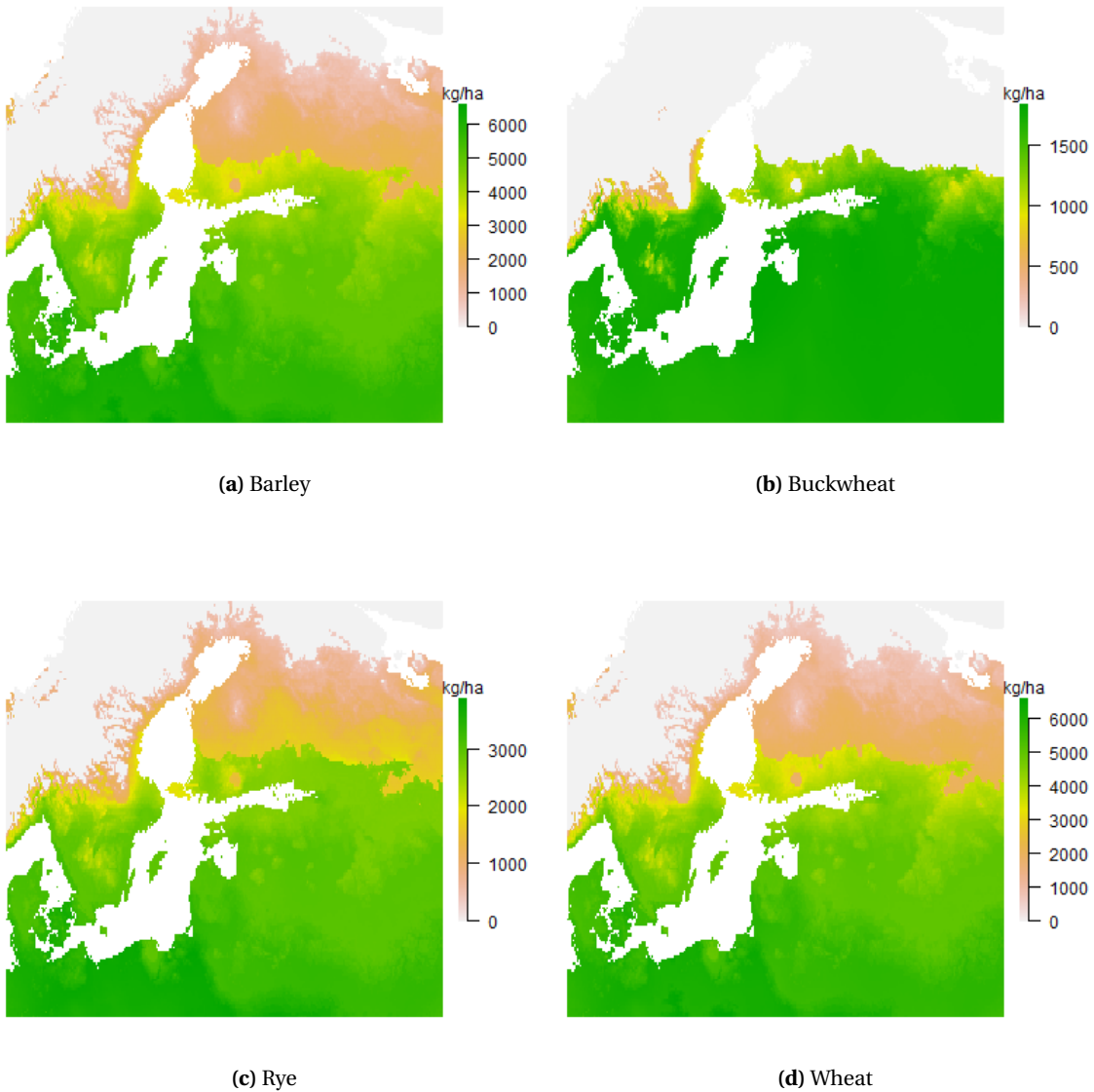
Notes: Data from FMO-GAEZ Library.

N. Palmer Drought Severity Index

In the absence of rainfall or other weather data, we use Palmer Drought severity index that is derived from tree ring growth. Figure shows an example of the the index from 1732. Calculated by square, the index ranges from dry to wet and there is considerable year-to-year variation for our sample region.

Figure N.1: Example of Palmer drought severity index in 1732
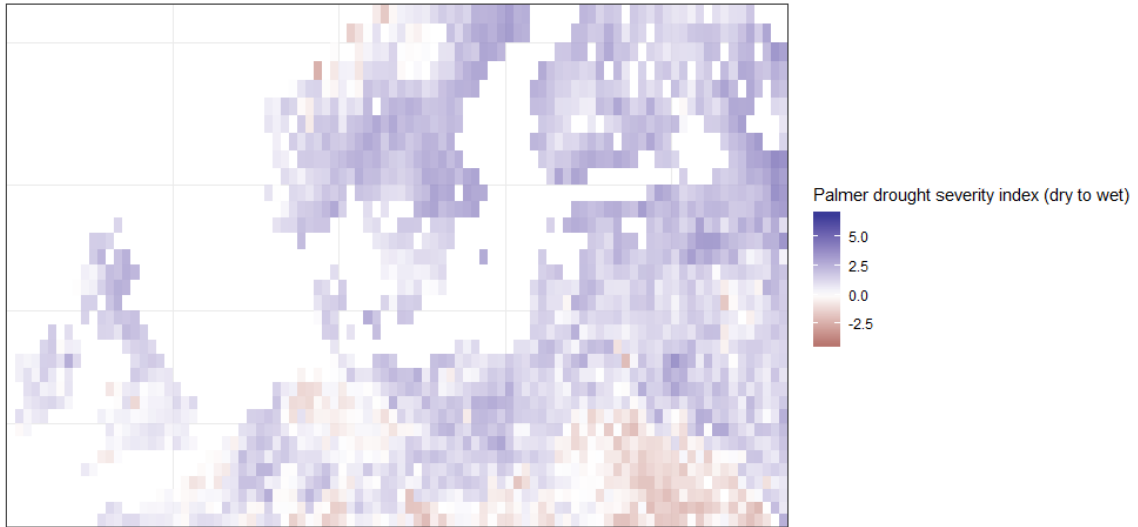
Notes: The Palmer drought severity index ranges from dry to wet and incorporates moisture supply (mainly rain) and demand factors (e.g. absorption capacity). Prior to any formal weather recording, this index is derived from tree ring growth. Data from IRI/LDEO Climate Data Library.