Landownership Concentration and the Expansion of Education

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Abstract

We study the relationship between large landownership concentration and the expansion of mass education in nineteenth-century Prussia. Cross-sectional estimates show a negative association between landownership concentration and enrollment rates. Fixed-effects panel estimates indicate that regions with an initially stronger landownership concentration exhibit increasing enrollment rates. This relationship is not driven by differences in the supply of schooling. We argue that the implementation of agricultural reforms including the stepwise abolition of serfdom is an important driver of the change in enrollment. The results are consistent with the interpretation that emancipation from labor coercion increased the private demand for education.

Keywords: Land concentration, Education, Serfdom, Peasants' emancipation, Prussian economic history
JEL classification: O43, Q15, I25, N33

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1 Introduction

Countries characterized by the concentration of political power in the hands of a small elite and with a vast majority of the population without effective rights or protection tend to stagnate in terms of economic growth (Acemoglu et al., 2001, 2002; Ang, 2013). Under the premise that political power is linked to the ownership of land, the distribution of land constitutes an important element of growth and stagnation. As formalized in the theoretical model of Galor et al. (2009), an unequal distribution of land might delay the implementation of educational institutions and, indirectly, affect growth. The delay in the expansion of formal education is caused by large landowners influencing the political process to prevent educational reforms and reduce the mobility of the rural labor force. Similarly, Engerman and Sokoloff (1997) and Sokoloff and Engerman (2000) suggest that the elite in Latin America opposed the expansion of suffrage and mass investment in human capital to prevent the poor majority from gaining power.

This paper documents the relationship between the concentration of large landownership and primary school education in nineteenth-century Prussia. Until the agricultural reforms of the early nineteenth century, ownership of feudal estates was associated with a set of prerogatives including the coercion of labor from the local peasantry. Regions with a high number of large feudal estates are regions where a large number of peasants lived under coercive institutions such as serfdom. We argue that the concentration of large landownership is thus suitable for capturing the regional distribution of the extent of serfdom, an institution that likely affected peasants' incentives to invest in formal education.[1]

We construct a unique county-level panel dataset spanning the entire nineteenth century which allows us to exploit both the cross-sectional and the time dimension of the relationship between landownership concentration and education. We can trace this relationship across five time periods throughout the century (1816, 1849, 1864, 1886, and 1896). In fact, the occurrence of agricultural reforms that rearranged the relationship between the landed nobility and the peasantry introduces changes in a relationship that, hitherto, seemed to be "fairly stable over time" (Easterly, 2007, p. 759). We thus investigate the cross-sectional relationship between land concentration and the level of primary school enrollment rates and changes in this relationship during the nineteenth century.

Both the cross section and the panel structure have certain advantages in terms of identification. Organizing our data as a panel allows us to rule out time-invariant unobserved heterogeneity by means of the inclusion of county-fixed effects. Estimating separate cross sections allows us to introduce an instrumental variable approach that permits us to speculate on a causal interpretation of the estimated relationship between landownership concentration and

[1] We argue that our measure of landownership concentration more adequately captures the extent of serfdom than other measures of inequality such as the Gini coefficient. In fact, the size of noble estates is closely associated with the intensity of labor dues (see Harnisch, 1986). We corroborate this interpretation using the regional concentration of knight estates and the share of the county area covered by knight estates. Knight estates were large landholdings associated with noble prerogatives which extensively relied on serf labor.

education. In particular, we use contemporary soil-texture data to identify arguably exogenous variation in landownership concentration (see also Frankema, 2010).[2] This approach is related to Easterly (2007) who uses the crop suitability of the soil to identify exogenous variation in inequality.

Estimates of separate cross sections for our five time periods show a negative but fading association between landownership concentration and the level of schooling. Using the five cross sections in a panel allows for the inspection of time heterogeneity in the relationship of interest. We find that counties with an initially stronger concentration of large landownership exhibit higher increases in enrollment rates in nineteenth-century Prussia. We interpret these findings as the result of the agricultural reforms and the abolition of labor coercion. The institutional change which relieved peasants from feudal duties and granted freedom of occupational choice can explain the increase in school enrollment in counties characterized by a high concentration of large estates. The stepwise implementation of the reform is consistent with the time pattern of our results.

Our contribution to the literature is twofold. First, we show how the relationship between the concentration of large estates and education *changes* over the nineteenth century. Second, we add to the existing literature by discussing the demand and supply side of formal education. Different from existing literature, this paper argues that landownership concentration adversely affects mass education by affecting the private demand for formal schooling rather than by affecting the supply of schooling through political process. The literature focuses primarily on the political channel to explain the negative relationship between landownership inequality and education. According to this literature the mechanism works through large landowners who influence the political process to prevent changes in the supply of schooling by voting against the expansion of public spending on education.[3]

Our panel estimates document that, in the Prussian context, there is no significant relationship between the concentration of large landownership and changes in the supply of schooling measured in terms of school density and teacher-child ratio. Thus, our main result cannot be driven by differences in the supply of schooling. We argue that it was the institution of serfdom which initially diminished the private demand for education. The agricultural reforms produced a new class of peasants, free from labor coercion and free to choose an occupation, that increased its private demand for education. This can explain the finding that school enrollment progressively increases in regions with an initially larger stock of large landownership. We provide quantitative evidence in support of this mechanism using cross-sectional data on the stock of peasants that had redeemed land and coercive labor services by 1848. Using these

[2]The use of historical data is advantageous since it excludes any possible endogenous changes in soil texture due to changes in cultivation. In general, both historical and contemporary soil-texture classifications only represent the physical composition of the soil and do not respond directly to the overall fertility of the soil.

[3]The literature usually argues that large landowners are protective of their economic status and oppose redistributive taxation for public goods such as schooling (see Acemoglu and Robinson, 2006b; Gallego, 2010; Galor et al., 2009; Go and Lindert, 2010; Naidu, 2012; Ramcharan, 2010). However, Acemoglu and Robinson (2006a) argue that after 1870, Prussian landowners had a high level of entrenchment and low political rents which made it unprofitable to block changes toward industrialization.

data, we estimate the relationship between emancipation and changes in enrollment rates, while holding the concentration of large landownership constant. Consistent with our hypothesis, we find that a larger stock of emancipated peasants is related to greater changes in enrollment rates.

The emancipation from serfdom was a highly heterogeneous process. Consequently, our empirical findings are consistent with alternative interpretations which might be mutually non-exclusive. The industrialization arguably increased the demand for education (see also Galor and Moav, 2006; Galor et al., 2009). Consequently, if the landed nobility had increasing stakes in industrial production process this could create a pattern of results complementary to our findings. More in general, the forces that led to the abolition of feudal relations can be correlated with the process of the modernization and industrialization of Prussia, which in turn might have triggered the increase in the demand for education. Since institutional arrangements are usually interdependent, they are difficult to disentangle as they do not exist in isolation (Ogilvie, 2007; Ogilvie and Carus, 2014). We aim at alleviating such concerns empirically by controlling for a wide range of confounding factors.

We proceed as follows. Section 2 reviews the related literature; Section 3 provides the theoretical and historical background emphasizing the Prussian reforms in agriculture and education; Section 4 describes the data; Section 5 introduces the model and empirical analysis; it addresses the issue of causality showing instrumental variable estimates and presents results from estimating panel models; Section 6 discusses possible mechanisms; Section 7 concludes.

2 Related literature

The literature on the long-run economic consequences of inequality for human capital is vast. Galor and Zeira (1993) show that in the presence of credit market imperfections, income distribution has a long-lasting effect on investment in human capital. Other scholars stress the redistributive channel. In particular, Alesina and Rodrik (1994) and Persson and Tabellini (1994) hypothesize that in a more egalitarian society, taxation of physical capital and of human capital is lower, enhancing economic growth.[4]

Similarly, Ramcharan (2010) studies the effect of economic inequality on redistributive policy. The author studies the relationship in the U.S. between land inequality (measured by the Gini coefficient) and education expenditure using census data, at the county level, for the period 1890-1930. The paper shows that greater inequality is strongly associated with less redistribution and therefore with less expenditure on education. Ramcharan (2010) identifies exogenous variation in land inequality using geographic variables such as surface elevation, rainfall, and crop choice.[5]

Galor et al. (2009) investigate the negative relationship between inequality in landownership and the accumulation of human capital. Their theoretical model shows that due to a low

[4] For an exhaustive review of the literature see Galor (2011).

[5] For the long-run effects of property rights on health and educational outcomes, the reader is referred to Banerjee and Iyer (2005).

degree of complementarity between human capital and the agricultural sector, large landowners opposed the implementation of human capital promoting institutions such as public schooling.[6] They test the prediction of their model for the U.S. using variation in the distribution of landownership and educational expenditure, across states and over time, for the period 1900-1940. Consistent with their theoretical predictions, they find that greater land inequality has a negative effect on education expenditures. In order to ensure that the effect is causal, they instrument landownership inequality through the interaction between nationwide changes in the relative price of agricultural crops that are associated with economies of scale and variation in climatic characteristics across states. Kourtellos et al. (2013) also test the hypothesis on a cross section of countries, finding that higher levels of land inequality delay the expansion of schooling.

Go and Lindert (2010) explain differences in enrollment rates between the North and the South by analyzing U.S. counties in 1850. They point to local governments having more autonomy and the population having a more equally distributed political voice in the North. Among other things, they test whether extending the voting power to lower-income groups raised the taxes paid for schooling and thus the enrollment rates in primary schools. Similarly, Vollrath (2013) finds that landownership inequality, measured by the Gini coefficient, predicts taxes for local school funding at the U.S. county level in 1890.

Other studies that attempt to establish the effect of political or economic inequality on education focus primarily on cross-country differences. By estimating the correlation between schooling and literacy rates with inequality in political power, Mariscal and Sokoloff (2000) show how the extension of the franchise in Latin America increased schooling. The relationship between the extension of the franchise and schooling has also been analyzed by Acemoglu and Robinson (2000). Gallego (2010) explores the role of historical variables and political institutions to explain differences in schooling in former colonies. He argues that the degree of democratization positively affects primary education, whereas the decentralization of political power is more related to differences in higher levels of schooling, such as secondary and higher education. Aghion et al. (2012) argue that democratization does not play an important role and suggest instead military rivalry as an important factor behind countries' decision to invest in mass primary education.

Using agricultural endowments as an instrument for inequality, Easterly (2007) tests the hypothesis of Engerman and Sokoloff (1997). He finds that inequality—measured with the Gini coefficient and as the share of income accrued to the top quintile—has a significant negative causal effect on income per capita (in 2002), institutions, and secondary school enrollment rates for the period 1998-2002 (Easterly, 2007, p. 766, Table 4). Nunn (2008) also provides some support to the Engerman and Sokoloff hypothesis, finding that slavery was detrimental

[6] Similarly, Galor and Moav (2006) suggest that the complementarity in production between physical and human capital created an incentive for capitalists to support the provision of public education.

to subsequent economic performance. Yet his analysis suggests that the detrimental effect of slavery on development did not arise from initial economic inequality.

Our paper contributes to the literature by establishing the relationship between the concentration of large landownership, a proxy for the extent of serfdom, and primary school enrollment rates at the county level for a single country. This is, to our knowledge, the first study that explores this relationship for a country in Europe. It should also be noted that our study focuses on the demand-side expansion, that is, enrollment rates and not on the supply of education, i.e., school funding. More importantly, our dataset allows us to study how the relationship between landownership concentration and education changed throughout the nineteenth century, a period characterized by important structural and institutional changes.

3 Theoretical and historical background

Our paper is aligned with the literature that emphasizes the role inequality plays in public education. According to Sokoloff and Engerman (2000), inequality in the distribution of income indirectly affects education through the quality of institutions (such as democracy), which in turn has a direct effect on public schooling. Galor et al. (2009) instead claim that inequality in the distribution of landownership adversely affects expenditure in public schooling. Due to low complementarities between agriculture and education, large landowners vote against taxation for school financing. In fact, in most agrarian economies, landowners hold the economic and political power and might influence the political process to prevent redistributional policies such as investments in public education.

In Prussia, large landowners were largely exempt from the payment of taxes and did not directly participate in the financing of schools (see Section 3.2). Yet large landowners were highly interested in maintaining the status of power and benefits derived from noble landownership, which an educated population posed a threat to.

Similar to the model of Galor et al., our framework assumes that education increases the productivity of workers. Analogous to Lagerlöf (2009) who models the long-run evolution of property rights, we assume that under serfdom (which in Lagerlöf's model is a mild form of slavery) the landed elite 'owns' part of the peasants' labor and pays these workers less than their marginal product.[7] Under extraction it can be beneficial for the elites to invest in the education of serfs to tax increases in labor productivity. Yet there are reasons to believe that the costs from investing in serf education might exceed the benefits. Since human capital accumulates at the individual level, investments are hard to observe. Monitoring the quality and effort put into investing in education would be extremely costly. Furthermore, higher levels of education might increase the outside option for serfs, raising their incentives to migrate. This imposes a substantial risk for the large landowner.[8] Finally, the low degree of complementarity between

[7] Note that the model of Lagerlöf does not consider investments in human capital.

[8] Acemoglu and Wolitzky (2011) develop a model of labor coercion. However, in their model an increase in the marginal product of labor in competing sectors, for instance due to investments in education, increases the value of the outside option and discourages coercion.

human capital and land also discouraged investments in workers' education under serfdom (Galor et al., 2009). Therefore, under serfdom, landowners oppose the spread of education among the peasantry and the serfs themselves have few incentives to invest in education.

Due to the abolition of serfdom and the emancipation of the peasants in Prussia, peasants could regain full possession of their labor and (or) choose a different occupation in which they could earn the competitive market wage. This increased the private demand for education. Coincidentally, the landed nobility could either change its attitude toward a more capitalistic agricultural production or increase its stake in the industrialization process. This might even raise incentives to promote mass education. In such a framework, we expect to find an increase in investments in education and, therefore, a positive relationship between landownership concentration and changes in education.[9]

3.1 Agricultural institutions in Prussia

The Prussian agricultural system was basically demarcated by the river Elbe. Agriculture in the eastern areas was dominated by large landholdings and the *Gutsherrschaft* system. The noble landowners (also known as Junkers) managed large demesnes, leasing small parcels of their land to villeins to extract rents in the form of labor services and fees. In contrast, in western areas the *Grundherrschaft* system, characterized by smaller landholdings, was more prevalent: noble landowners relied on cash rents and leased most of their land to the peasants.[10]

Yet, this division was not unambiguous and the characteristics varied widely within these areas (Rosenberg, 1944). The amount of labor services usually depended on the attributes of the contracted land, and were heaviest in the regions with large noble demesnes (Melton, 1988, p 149). At the end of the eighteenth century, most of the peasants were still serfs who were not allowed to relocate without financial compensation and the permission of the lord. Becoming the legal owner of the land they cultivated was rarely possible.

Ogilvie and Carus (2014) argue that serfs experienced a range of institutional constraints on their choices, which were imposed by the manor, the village community, and the state. In fact, lords seem to have "barred serfs from activities that competed with demesne enterprises" (Ogilvie, 2014, p. 39). The relationship between the Prussian nobility and peasantry is famously depicted by Berdahl (1988, p. 5): "The nobleman's experience of domination was immediate and direct, personal and complete. [...] Patrimonial rule, sanctified by the images of paternalistic concern, became the hallmark of the nobility's accepted mode of domination of the peasantry down to the end of the eighteenth century."

Labor services varied at the local level and ranged from at least two days a week to daily work. In parts of Pomerania, for example, peasant families had to provide two servants, a boy, and four horses in order to work daily on the lord's demesne. School-age children were tasked

[9] Falkinger and Grossmann (2013) propose a model in which oligarchic landownership is a crucial obstacle to entrepreneurship and structural change. They provide empirical evidence from Latin America, India, Taiwan, and South Korea which shows that land reforms are associated with the emergence of small manufacturing businesses.

[10] Note that the transition from Gutsherrschaft to Grundherrschaft does not follow a strict geographical discontinuity at the river Elbe.

with menial service (*Gesindezwang*), which forced them to work as servants in the Junkers' households. In the provinces of Pomerania and Silesia, Junkers drafted the most promising and capable peasant children to work as full-time servants (Carsten, 1988, p 63). Additionally, children were also burdened with the corvée (here: *Scharwerk*) which, as the parish priest of Dombrowken (a village in East Prussia) complained in 1773, was so much work that children were kept from attending school even in the winter (Carsten, 1988, p 65).[11]

Many noble villages had ordinances that publicly proclaimed the punishments associated with the failure to fulfill the labor service obligations. In cases when peasants did not show up to work on time, provided the lord with only "delinquent field hands, unfit or worn-out wagons or horses" or treated the property of the lord carelessly, these labor controls were enforced by the police official of the village who was appointed by the lord (cited after Berdahl, 1988, p. 56-58).

The power of noble landowners extended further than the control over their subjects' labor. The landed nobility held prerogatives such as police power, patrimonial judicial authority (*Patrimonialgerichtsbarkeit*) and the right to appoint the village priest (*Patronatsrecht*). Important for our analysis, the noble landowners were also responsible for the education of their subjects. They appointed the schoolmaster and provided the instructions under which the school was to operate. In some cases they even prescribed the content of the school curriculum (Berdahl, 1988, p. 55-63).

In the eastern parts of Prussia, serfdom was legally abolished for the first time in the royal domains in 1799. After the defeat by Napoleon, a series of agrarian reforms was initiated which freed agricultural workers at a piecemeal rate. The 'Oktoberedikt' of 1807 made all peasants free people, starting from November 11 (St Martin's Day), 1810. In 1811 the reformer Hardenberg passed the Edict of Regulation on landownership, according to which peasants gained the legal right to own landed property of any type.[12] This reform applied to peasants with weak rights of ownership, i.e., non-heritable tenancy or cancelable tenancy, who became able to redeem the land by ceding one-third or respectively up to half of the land to their landlord.[13] Due to the opposition of large landholders to the edict, its scope was restricted in the Declaration of 1816 which excluded peasants on small parcels of land (*nicht spannfähige Nahrungen*).

Much more invasive than having only weak rights of legal landownership was the fact that the coercion of labor services remained effective. The landlords demanded that any reform of labor coercion needed to clarify the amount of compensation for foregone services. Hence, the agrarian reforms did not gain momentum - also due to the ongoing war on Napoleon -

[11] Henning (1969) compares the servile duties in regions of East Prussia and Westphalia in the eighteenth century. Even within East Prussia there was a lot of variation: 77 percent of peasants in the *Oberland*, 4 percent in the *Binnenland*, and 8 percent in the *Küstengebiet* had to provide between 251 and 500 days of manorial service per year. In Westphalia, roughly 30 per cent of the peasants had to provide manorial services for 26 to 52 days per year; roughly 50 percent had to work nine to 15 days per year, and the rest provided even fewer services, whenever required.

[12] "Edikt, die Regulierung der gutsherrlichen und bäuerlichen Verhältnisse betreffend."

[13] Because of this practice, and due to the dissolution of the common lands, the average farm size of the large landholders grew strongly until the mid-nineteenth century (Schiller, 2003).

until the Dissolution Edict of 1821.[14] This edict allowed peasants to redeem labor services by compensating the manorial lord for foregone earnings with the amount of 25 times their annual value in either money or land. However, the release from labor services only applied to peasants with strong rights of ownership. The emancipation of the peasantry with weak rights thus resembled a two-step process where peasants first had to redeem land to become legal owners and then had to redeem labor services (Harnisch, 1974, p 154). Thus, by 1848 many peasants still claimed that they had no personal freedom, since they were obligated to fulfill their duties whether as serf-tenants or as owners of the land (Carsten, 1988, p. 98).

Excluded from both edicts were peasants on small parcels of land who were still required to provide labor services. This limitation reduced the share of peasants affected by the reform to one-third of the peasantry. In this way, the Junkers were still able to draw from a large labor force (Harnisch, 1984). It was only with the Commutation Law in 1850[15] that all peasants ultimately gained complete legal emancipation and were able to redeem small parcels as well as servile duties (Pierenkemper and Tilly, 2004; Bowman, 1980). More generally, "although many of the powers of the lord to intrude into the lives of peasants legally ended with peasant emancipation in 1807, noble estate owners continued to exercise police and judicial powers over the residents of their estates and villages well into the nineteenth century" (Berdahl, 1988, p. 55).[16]

During the Napoleonic occupation between 1794 and 1814, the western parts, which belonged to Prussia after 1815, introduced the Napoleonic Code which basically meant the abolition of feudal privileges. Serfdom was therefore abolished *de jure* in Rhineland in 1805 and in Westphalia in 1808. Redemption of labor services was based on the payment of 15 times their annual value in the Rhineland, and 25 times their annual value in Westphalia. In fact, Westphalian nobles blocked many of the changes introduced by the Napoleonic Code. While the code remained effective after 1815 in the areas west of the river Rhine, all other areas (re-)established Prussian law (*Allgemeines Landrecht*).[17]

3.2 Education reform and school financing

It was not before 1806 that mass education became an increasingly relevant issue in Prussia. In fact, the King's previous edicts for compulsory education were attempts to persuade local lords to provide education at their own expense (Lindert, 2003, 2004). The war against France triggered a "decade of feverish activity" (Schleunes, 1979, p. 317) during which the expansion of schooling grew very quickly. Wilhelm von Humboldt, head of cultural and educational affairs at the time, favored a general education over specialization and advocated a unified schooling

[14] "Ordnung wegen Ablösung der Dienste, Natural- und Geldleistungen von Grundstücken, welche eigenthümlich, zu Erbzins- oder Erbpachtsrecht besessen wurden."

[15] "Gesetz, betreffend die Ablösung der Reallasten und die Regulierung der gutsherrlichen und bäuerlichen Verhältnisse."

[16] For a timeline of the legislation regulating the abolition of serfdom and noble privileges see Online Appendix C, Table C-12.

[17] For more details about the regional adoption of the reforms the reader is referred to Acemoglu et al. (2011) and the corresponding online appendix.

system, which would educate everybody equally.[18] Yet, although the level of education improved over the course of the nineteenth century, many noble large estate owners continued to think of education as dangerous for peasants (Berdahl, 1988). In 1831 one county administrator wrote that more than a bit of education "causes a certain decline in their [the peasant's] level of productivity."(Berdahl, 1988, cited in p. 65)

The composition of resources for school funds in Prussia was not legally fixed, and it differed at the very local level. Large parts of the expenses were covered by school assets such as estates, entitlements or capital rents. Assets were managed by so-called schooling societies, which were bodies of the municipality that received additional taxes from the heads of each household (excluding noble landowners) proportional to their wealth and income, and independent of their religious denomination and number of children. If society funds were not sufficient to support schools and teachers, tuition fees were charged.

Important for our case, the noble estate owners (*Gutsbesitzer*) were obliged to support families that could not afford to pay for schooling. Otherwise, they were exempt from all taxes and therefore from any financial support for the schools (Kuhlemann, 1991). In addition, very poor school districts received financial support from the King (Königliches Statistisches Bureau in Berlin, 1889, pp. 58-59). It was only in 1888 that tuition fees were abolished and public funding became fixed. The exemption of noble estate owners from school financing and school taxes, which had been legitimated in the '*Allgemeines Landrecht*' in 1794, was finally abolished in 1906.

4 Data

4.1 Prussian census data

In order to test whether the concentration of large landownership is associated with the expansion of education in Prussia, we draw on county-level census data. Our data refer to five points in time (1816, 1849, 1864, 1886, and 1896) spanning the entire nineteenth century and are digitized from various sources published on behalf of the Royal Prussian Statistical Bureau in Berlin.[19] The censuses contain a wealth of information, including data on education, landholdings by farm size, population, religion, and occupations. Such data allow us to study variations in the relationship between landownership concentration and education over time while holding indicators of development fixed. Our main results are based on a panel approach, accounting for time-invariant unobserved heterogeneity. Furthermore, when analyzing the cross sections separately, we apply an instrumental variable approach.

[18] Humboldt thought that: Every man obviously is only a good craftsman, merchant, soldier or businessman if he in general, and without regard to his profession, is a decent and enlightened person and citizen according to his class. If school instruction is giving him what is necessary to achieve this, he will accomplish the abilities of his profession with ease and will keep the freedom, as it often happens in life, to change from one to another (own translation from von Humboldt (1964, p. 218)).

[19] See Becker et al. (2014) and Online Appendix A for more details about the data and sources.

Changes in the administrative boundaries throughout the nineteenth century complicate the analysis of Prussian county-level data. The number of counties in Prussia increased during the nineteenth century due to the fact that some counties were split into two or more units for administrative reasons (mostly population growth) or due to the acquisition of new territory. For better comparability, and to ensure that our results are not driven by changes in administrative boundaries, we aggregate our variables to a common set of counties following the borders as determined at the beginning of the period under analysis.

For our dependent variable, we can draw on enrollment rates for the years 1816, 1849, 1864, 1886, and 1896. Primary school enrollment rates indicate the school attendance of six to 14-year-old children.[20]

Data on landownership by size are available for the years 1816, 1849, 1858, 1882, and 1895. The Prussian censuses counted the number of landholdings per county and classified them into size bins.[21] The first full census in 1816 classified landholdings in three groups: properties or leasehold estates of up to 15 Prussian Morgen (henceforth PM), from 15 to 300 PM, and more than 300 PM.[22] This categorization reflects the contemporary agricultural structure of farming. Farmers with less than 15 PM usually required some additional form of non-farming income. Landholdings between 15 and 300 PM were generally large enough for the subsistence of a family, whereas farms with more than 300 PM were usually cultivated by paid laborers and coerced labor, while the owner was not expected to perform any manual work (Harnisch, 1984).

Following the Prussian classification, our measure of concentration of large landownership is the ratio of landholdings larger than 300 PM (circa 75 hectares) over the total number of holdings per county. To allow intertemporal comparisons, we define large holdings as those which exceed 300 PM in the years 1816, 1849, and 1858, and 100 hectares (equal to 392 PM) in 1882 and 1895.[23] Our indicator is bounded between 0 and 1: the larger the indicator, the higher the share—the stronger the concentration—of large landowners in the county.[24]

Clearly, landownership concentration is an imperfect measure of the extent of serfdom. Ideally we would prefer to observe the actual extensive and intensive margins of serfdom. However, it is intuitive that larger estates rely more heavily on non-family laborers (forced or paid work). We thus argue that a larger share of the population is subject to coercive institutions in regions

[20] Consistent with the definition of mandatory schooling at the time, we consider both elementary schools (*Elementarschulen*) and middle schools (*Mittelschulen*) as primary schools. In a few cases enrollment rates exceed 100 percent. This could be due to children commuting from neighboring counties or because of the enrollment in school of children older than 14.

[21] It is important to note that the original census data contain both types of tenure: landownership and landholding. Throughout the paper we use these terms interchangeably. Also note that the number of estates might not be equal to the number of landowners (or landholders), since they might own (or hold) more estates at the same time. Similarly, we are aware that both the King and the Church owned vast amounts of land. Unfortunately, the data do not allow us to identify the landowner. See Eddie (2008) for a discussion of farm statistics and property statistics.

[22] One PM is equal to circa 0.25 hectare.

[23] This change in size is due to the redefinition of bin sizes by the Prussian Statistical Bureau when reforming measurement from PM to hectare. The censuses of 1849 and 1858 extended the classification of landholdings from three to five bins. From 1882 onwards, the census considered only the arable land which was classified into six bins, increasing to seven bins in the 1895 census. The total area of holdings by bin category was not published until 1882, so an alternative calculation of conventional measures of inequality is not straightforward.

[24] Since political power was to a large extent proportional to the size of the possessed land (Eddie, 2008, p. 86), the share of largest landholdings might also capture a dimension of political inequality.

where the distribution of land is very unequal. Additionally, we test the robustness of our results with regard to alternative measures of serfdom such as the number and the size of knight estates, which is only available for a later period (1856). These estates were large properties whose ownership was associated with noble prerogatives such as labor coercion. Furthermore, we corroborate our findings using information on the number of emancipated serfs.

Our large set of covariates aims to control for the demand and supply of education. We include the share of Protestant population—as Protestants are expected to have a higher preference for education—the share of urban population, the share of the population employed in the industrial sector,[25] the share of population employed in agriculture, and population density.[26] The age structure of the county might also influence the demand for education.[27] In our case, this factor is proxied by the child dependency ratio, calculated as the share of young population (0 to 14/18) over the working population (15/19 to 65/70). Additionally, we control for the share of people whose first language is not German.[28] This variable controls for differences between the former Polish parts of Prussia (the provinces of Poznan, Silesia, and Prussia) and Germany, where the demand for education might have been lower for linguistic and cultural reasons. This variable is inversely correlated with the share of Protestants, as the Polish population was predominantly Catholic. Finally, we control for the supply of schools using school density, defined as the number of schools per square kilometer.

Quite importantly, variations in the inheritance laws across Prussia might affect our analysis. In fact, inheritance laws follow a geographic pattern: The north-eastern parts of Prussia are dominated by non-partible inheritance (*Anerbenrecht*), while the south-western parts are characterized by partible inheritance (*Realteilung*). This clearly leads to a different average size of landownership in the south-western counties. In our empirical analysis, we take this institutional difference into account with a binary variable which takes the value one in counties with partible inheritance.

4.2 Descriptive statistics

Table 1 provides descriptive statistics of our variables for each year, separately. The first thing to note is the relatively high overall level of enrollment. By 1816, about 60 percent of children aged six to 14 were enrolled in primary schools (see also Becker and Woessmann, 2010). Subsequently, we can observe an increase in average enrollment rates over time, rising from 60 percent in 1816 to 95 percent in 1895. Interestingly, the enrollment rate in 1864 is lower than in the previous census in 1849.[29]

[25] Given the absence of industrialization in Prussia in the first decades of the nineteenth century, for 1816 we include the number of looms over the total population as an indicator of non-agricultural occupation.

[26] The 1816 census only provides information on the laborers in agriculture whereas the 1849 census provides information on the total population in agriculture, including family members.

[27] For the relationship between fertility and education in pre-demographic transition Prussia, see Becker et al. (2010, 2012, 2013).

[28] Unfortunately, the earliest available census data on spoken languages are from 1861. Comparison with information from later periods provides a largely time-invariant distribution of non-German speakers.

[29] This peculiarity can also be found in a study by Lindert (2004, p. 91, Tab. 5.1).

The variable *Land concentration* indicates the share of the largest holdings in the county. In 1816, 1.7 percent of holdings belonged to this category (>300 PM). Due to the inconsistency of the definitions, we can only compare the values of landownership concentration for 1816, 1849, and 1864 directly. The descriptive statistics show that the share of large landholdings increased during the first half of the nineteenth century, reaching a share of 2.1 percent in 1858.[30] This evidence is consistent with accounts of the agrarian reforms in Prussia, which stress how the landed elite benefited most from the reforms (Schiller, 2003). As mentioned above, a direct comparison of the landownership data for the earlier cross sections with data from 1882 and 1895 is not straightforward, since the latter censuses only account for the size of arable land. Furthermore, the unit of measurement in these censuses is the hectare and thus the top bin category changes to 100 hectare.[31] This explains why our concentration index decreases to 0.8 percent in 1882 and to 0.7 percent in 1895.[32]

The progress of industrialization is depicted by the increasing urbanization rate which rises from 25 percent to 32 percent, and the industrial employment which increases from approximately 1 percent to 13 percent. These variables provide large variations both across counties and over time, whereas variables such as the religious denomination, language, and inheritance system are rather time-invariant.

Figure 1 and Figure 2 depict the geographic distribution of enrollment rates and the concentration of landownership in 1849, respectively. Enrollment rates are higher in the central part of Prussia, whereas they tend to be lower in the eastern regions, especially in the province of Posen. Becker and Woessmann (2009) suggest that due to the influence of the Protestant Reformation, literacy, as a by-product of Protestantism, tended to spread almost concentrically around Wittenberg. The geographic distribution of the share of large landownership is almost diametrical to Figure 1: regions with lower enrollment rates are characterized by a relatively high concentration of large holdings. Western provinces are characterized by a prevalence of small holdings, yet a certain degree of variation among western counties exists.

5 Land concentration and the expansion of education

This section empirically analyzes the relationship between landownership concentration and enrollment rates. We start by presenting results from five separate cross sections. We also introduce an instrumental variable based on soil characteristics which aims at addressing concerns of endogeneity. We then proceed to a panel specification that allows us to account for time-invariant unobserved heterogeneity at the county level by introducing fixed effects.

[30] The year 1864 in the table headings refers to the date for which data on the dependent variable enrollment rates are available.
[31] 100 hectares are equal to 392 PM.
[32] Note also that the variables are aggregated using the borders of the beginning of the period under analysis.

5.1 Cross-sectional results

In a first step, we construct a panel dataset consisting of 280 counties i observed at five points in time t (1816, 1849, 1864, 1886, 1896). In order to maintain constant borders, we aggregate the data to resemble the administrative structure in place at the beginning of our period of analysis. We test our hypothesis of a negative but declining association between landownership concentration and the level of schooling by estimating five separate cross sections, one for each time period. We estimate a standard OLS model where the enrollment rate *Edu* for county i in a given year t is a function of the concentration of large landownership *Land*, plus the vector of covariates X:

$$\text{Edu}_{i,t} = \alpha_1 + \beta_1 \cdot \text{Land}_{i,t} + X'_{i,t} \cdot \gamma_1 + \varepsilon_{i,t} \qquad \forall\, t \in \{1816, 1849, 1864, 1886, 1896\}, \tag{1}$$

where β_1 is the coefficient of interest.

We standardize the share of large landownership with a mean of zero and unit standard deviation in order to neutralize the change in the unit of measurement of land which affects the last two time periods. In this way we can compare the coefficient of interest β_1 over the five time periods. The results of the OLS estimates are presented in panel A of Table 2. For each time period we find that regions with a higher concentration of large landownership exhibit lower levels of education. The coefficient of interest is large and significant for 1816, 1849, and 1864, insignificant for 1886, and again significant for 1896. The magnitude of the coefficients suggests that the relationship between landownership concentration and enrollment rates declines throughout the nineteenth century.

5.2 Addressing endogeneity

The coefficients estimated by OLS cannot be interpreted as causal, as an omitted variable which is correlated with both landownership and enrollment rates might bias our results. Reverse causality is also an issue. Peasants with a higher level of education might be comparatively more able to appeal to the royal court to obtain better tenant or redemption conditions. Peasants with a higher level of education might also increase the productivity of the field on which they work. In a fixed-rent regime, this could imply that higher-educated peasants are more able to redeem their land and labor services, resulting in a more equal distribution of land. If this were the case, OLS estimates would be upwardly biased toward zero. On the other hand, higher-educated peasants might have a stronger incentive to cede their (small) estate to the noble landowner in order to reap the benefits of education in other trades. This would increase landownership concentration and bias the education estimate downward.

We aim at addressing these issues by adopting an instrumental variable approach. Following Easterly (2007), we use variation in the geological composition of the soil (soil texture) to

identify arguably exogenous variation in farm size. Soil texture is an exogenous natural factor which does not change over time and cannot be altered by human intervention. In fact, soil texture is based on the relative particle size proportions of sand, silt, and clay.[33] Differences in soil texture are related to differences in soil quality which historically generated a heterogeneous demand for land.

Historically, regions which exhibited relatively poorer soil quality (i.e., high sand content), and therefore a lower marginal value of land, experienced a lower demand for land, were settled relatively late, and were thus characterized by higher average farm sizes. This is indeed the pattern that was followed by north-eastern European regions during the Middle Ages where the local lords, in order to attract more agricultural workers and encourage immigration, granted the peasants higher levels of freedom compared to the manorial system in the West (Rosenberg, 1943). The so-called second serfdom developed only after the Black Death epidemics in the fourteenth century when local lords in sparsely populated Eastern Europe tried to bond the peasants to their soil and established the roots of landownership concentration that we also observe in the nineteenth century.[34]

On the other hand, regions with relatively higher soil quality (i.e., high silt or clay content) experienced a stronger demand for land, which determined a more accentuated land fragmentation and more secure property rights. According to Boserup (1965), Binswanger and McIntire (1987), and Binswanger and Rosenzweig (1986), increasing population pressure resulted in the increasing intensification of land use and in growing pressure for security of land tenure (Eastwood et al., 2010). In fact, we find that in regions of the Rhineland and parts of Saxony and Silesia, where the soil is dominated by clay content, farm size is small on average, leading to a low landownership concentration (compare Figures 2 and 3). Measures of soil quality might influence crop choice which, in turn, due to economies of scale, might affect the final distribution of land (Vollrath, 2009). The advantage of our instrument with respect to crop choice is that soil texture is a 'true' exogenous variable, whereas crop choice remains a choice variable, although dependent on the type of terrain.[35]

To construct our instrument we use contemporary data from an 1866 census that assesses the composition of the soil at the county level and classifies it into three main categories: (*i*) loam and clay soils (henceforth: clay soils), (*ii*) sandy-loam and loamy-sand soils (henceforth: loamy soils), (*iii*) and sand soils. Consistent with the mentioned empirical regularities in agricultural

[33] Sand is relatively round while silt and clay particles are rather slim and flat. Soils with round particles can absorb higher amounts of air and water which is beneficial for plant growth due to the available space between the particles. However, soils with a large sand content cannot retain water since empty spaces are large, leading to higher probability of draught and crop failure due to draught. See Online Appendix B for more details.

[34] Historically, the western parts of Europe were comparatively more densely populated. Yet, during the Middle Ages, the Black Death and other plagues depopulated these regions. Thus serf labor became more valuable to the lords, and peasants achieved more bargaining power resulting in more freedom and the progressive abolition of the manorial system. On the other hand, Eastern European regions, including Prussian regions east of the river Elbe, were more sparsely populated. Here, depopulation (also due to the Thirty Years' War) and a larger land-labor ratio led to opposite results. The lords tried to control peasants' mobility by confiscating their land and bonding them to the manorial demesnes (Brenner, 1976; Domar, 1970; Aston and Philpin, 2010).

[35] In this fashion, Easterly (2007) uses the suitability of crops such as sugar and wheat, instead of actual crop production, to identify exogenous variation in inequality.

economics, simple OLS regressions show that landownership concentration is strongly correlated with loamy soils, a soil with higher sand content compared to clay soils. This can be observed in Online Appendix B, Figure B-5.

Thus, our first stage is expressed by the following equation:

$$\text{Land}_{i,t} = \alpha_2 + \beta_2 \cdot \text{Soil}_i + X'_{i,t}\gamma_2 + \eta_{i,t} \tag{2}$$

where *Land* is the variable for landownership concentration, *Soil* is the share of loamy soils (i.e., lower quality soil), and X is the vector of covariates as in equation 4.

Our instrumental variable strategy rests on the assumption that soil texture affects enrollment rates only through the size of landholdings. A correlation of soil texture with crops that require different intensities of human capital, or with crops related to particular institutions, would violate the exclusion restriction. For example, variations in soil productivity for different crops might lead to variations in the employment of children in agriculture, which would keep them out of school. On the other hand, a higher value of land could enable tenants to purchase more education. Indeed, even though studies in agricultural economics corroborate a strong relationship between farm size and soil quality (Bhalla and Roy, 1988; Bhalla, 1988; Benjamin, 1995), we cannot exclude that political and labor market institutions have time-varying relationships with soil texture, leading to a violation of the exogeneity assumption.

As argued by Ogilvie (2007) and Ogilvie and Carus (2014), institutions do not exist in isolation. Individual institutions are usually part of an institutional framework, i.e., there are certain interdependencies among parts of the framework. According to this argument, it is unlikely that we are able to study an institutional change such as the the abolition of serfdom in isolation. To the extent that the relationship between soil texture and feudal relations is time varying, one can argue that other (unobserved) institutions that have a time-varying relationship with soil texture have a direct effect on our outcome.[36] In the context of the so-called Brenner debate, it could be argued that the extent of serfdom is related to the autonomy of village communities (Aston and Philpin, 2010). Changes in both could be related to soil texture, i.e., an increase in the autonomy of village communities has a time-varying relationship with the composition of soils. The exclusion restriction would then be violated if village autonomy systematically affected the level of education through channels other than feudal relations as proxied by the concentration of landownership. In light of these possible violations of the exclusion restriction, the instrumental variable estimates should be interpreted with caution.

[36] Many studies in agricultural economics corroborate our strategy (see Bhalla and Roy, 1988; Bhalla, 1988; Benjamin, 1995). They find that the systematic negative relationship between farm size and productivity vanishes when measures of soil texture are controlled for. This implies that differences in farm size related to productivity are fully absorbed by differences in soil texture. We provide further evidence that our identification strategy is valid by including extensive controls for land productivity or crop yields. After accounting for measures of productivity or suitability to certain crops, soil texture is arguably related to the size of landholdings through channels unrelated to human capital. Furthermore, our subsequent panel analysis captures all time-invariant heterogeneity arising from crops related to particular institutions by including county-fixed effects.

5.3 Instrumental variable results

First stage estimates of equation 2 are presented in panel B of Table 2. The share of loamy soils is significantly positively correlated with landownership concentration. The power of the instrument is summarized by the first-stage F-statistic in panel C. The values exceed the standard threshold value of 10 (Stock and Yogo, 2005). The relationship between loamy soils and landownership concentration in panel B declines over time as indicated by the first three periods (1816, 1849, and 1864) for which we also have a consistent unit of measurement. This could indicate that the redistribution of landownership caused by the agrarian reforms and determined by market forces during the nineteenth century renders the relationship between soil quality and farm size weaker. As previously mentioned, this might constitute a serious threat to our identification strategy. Therefore we have to interpret the instrumental variable estimates with caution. The possible impact of the agrarian reforms and the process of peasant emancipation on investments in education is discussed in more detail in the following sections.

Second stage estimates are presented in panel C of Table 2. The results confirm the significant negative relationship between landownership concentration and education for the first half of the nineteenth century. Similar to the OLS, we observe a fading effect over time when comparing the magnitude of the coefficients across the five cross sections. The coefficients decrease in size and cease to be statistically different from zero from the 1864 cross section onwards. For the 1896 cross section, we find that the relationship is actually positive, although insignificant.

In terms of magnitude, we find that if we increased the landownership concentration of the average county by one standard deviation (for example, from the average value of 1.7% to 3.8% in 1816) the enrollment rate would be 16.9 percentage points lower in 1816 and 7.3 percentage points lower in 1849. A similar increase in landownership concentration does not lead to significant differences in enrollment rates from 1864 onwards.[37]

The IV estimates indicate that, at least for the first half of the nineteenth century, the OLS estimates are biased toward zero. Yet the magnitude of the bias differs according to the time period. In 1816 the IV coefficient is about 2.6 times the OLS coefficient, whereas in 1849 the IV coefficient is 1.6 times larger. The bias toward zero of the OLS estimates might arise due to measurement error in landownership concentration. It is possible that the measure of landownership concentration is more noisy at the beginning of the century when cadastres were less advanced or non-existent, thus explaining the largest difference between IV and OLS estimate. The magnitude of our bias is in line with the estimates of Easterly (2007). Instrumenting inequality using the ratio between the suitability of wheat to sugar crops, Easterly finds that IV estimates are approximately three-times larger than OLS estimates (Easterly, 2007, p.766, Table 4). A similar ratio between IV and OLS estimates is found by Ramcharan (2010).

[37] The estimated coefficients are slightly higher when using a sample of counties following the borders of 1849. In such a sample, the coefficient of the 1864 cross section is -0.058 and statistically significant. The coefficients for 1886 and 1896 remain insignificant. Our findings do not, however, depend on the threshold of 300 PM chosen to define large landholdings. For instance, for 1849 and 1864 it is possible to use the top bin category of over 600 PM, and for 1896 the top bin category of over 200 ha. Results are qualitatively similar when using these categories.

The coefficients of our control variables confirm the findings of the existing literature.[38] We find a significant positive relationship between school density and enrollment rates throughout the entire period. However, excluding this variable hardly affects the coefficient on landownership concentration. This result suggests that the supply of schools was not the mechanism through which large landowners opposed the spread of mass education. We discuss this and other possible mechanisms in more detail in Section 6.1.

Panel D of Table 2 addresses some of the concerns regarding the exclusion restriction by including a historical measure of land rent (the '*Grundsteuerreinertrag*' — henceforth GRE) to control for heterogeneity in agricultural productivity.[39] The GRE is defined as the income from agrarian use of land net of the costs of farming (see Online Appendix A for further details). In brief, the GRE approximates net farm income per acre before taxes, and thus corresponds to the concept of land rent.[40] We use the price-deflated average land rent per unit of farmland, which is a measure similar to TFP in agriculture (Kopsidis and Wolf, 2012, p. 643). The inclusion of the GRE does not affect the pattern of the results. The results are also robust to alternative measures of agricultural productivity such as per hectare yields or crop prices for grains of wheat, rye, oat, barley, and potatoes (see Cinnirella and Hornung, 2013).

Finally, since coercion of labor services was historically more prevalent in the eastern parts of Prussia, in panel E we provide results excluding counties west of the river Elbe. The coefficients estimated for this subsample are slightly larger on average than in the full sample. The decline in the magnitude of the coefficients across time periods appears to be more gradual in East Elbia.[41]

5.4 Panel models

In this section we make use of the panel structure of our dataset to analyze changes in the relationship of interest while simultaneously addressing the issue of unobserved heterogeneity. Time-invariant unobserved heterogeneity across counties might affect our cross-sectional estimates. Panel models that include county-fixed effects, thus exploiting the variation *within counties*, address this problem. The panel structure allows us to also include time-fixed effects which capture shocks that are constant across counties.

[38] The coefficients are omitted here, but can be found in an earlier version of this paper (see Cinnirella and Hornung, 2013). Similar to Becker and Woessmann (2009), we find a positive relationship between Protestantism and enrollment rates. Consistent with the study of Becker et al. (2011) the variable for industrialization becomes positive after 1849 and is highly significant after 1886. Furthermore, counties with a larger share of non-German population show significantly lower levels of schooling.

[39] We thank Nikolaus Wolf and Michael Kopsidis for making these data available to us.

[40] The GRE was stipulated by the tax administration as an assessment base for the land tax. By assessing the GRE, the tax administration explicitly aimed at determining the net earnings per Prussian acre of land for different kinds of farm land (arable, pasture, meadow, and horticulture) in different parts of the state (Kopsidis and Wolf, 2012, p. 6). In fact, when the GRE was determinded, soil texture was included as one dimension. Thus, controlling for the GRE will result in controlling for all aspects of agricultural productivity other than soil texture. The GRE is strongly positively correlated with yields. For instance, the correlation between GRE and rye yields in 1886 is 0.84; the correlation with wheat yields is 0.72.

[41] The first-stage F-statistics indicate that, in the East Elbia sample, the instrument loamy soils is weakly correlated with landownership concentration, especially during the second half of the nineteenth century.

The panel approach provides evidence on changes over time of the relationship between the concentration of large landownership and enrollment rates. The reforms of the early nineteenth century changed the relationship between the landed nobility and the peasants. Thus, if our hypothesis on the emancipation from serfdom is correct, we expect that counties in which the extent of serfdom declined will exhibit an increasing demand for education. Under the reasonable assumption that counties with an initially stronger concentration of landownership are those that experienced a stronger decline in serfdom, we expect this to be reflected by increases in enrollment rates.

We test these predictions by regressing enrollment rates on the earliest available measure of landownership concentration in 1816. Since land size was measured shortly after the first reforms, we can interpret this variable as capturing the initial distribution of large estates. Hence, we do not have to worry about the possible feedback effects of education on landownership during the course of the century.[42] Thus, to capture changes in the relationship with education, we interact initial landownership concentration with each of the time-period dummies and we estimate the following model:[43]

$$\text{Edu}_{i,t} = \alpha_i + \delta_t + \sum_t \beta_t \cdot \text{Land}_{i,1816} \cdot \delta_t + \sum_t X'_{i,t} \cdot \gamma_3 \cdot \delta_t + \upsilon_{i,t} \qquad t = 1816, 1849, 1864, 1886, 1896 \tag{3}$$

where α_i and δ_t are county and time-fixed effects, respectively. Since initial landownership concentration is time invariant, the coefficients for the interaction terms are estimated with respect to a reference year, in this case 1816. We include a full set of interactions of control variables with time dummies. The vector X contains county-level measures of the share of Protestants, the share of the population living in urban centers, the share of the population working in the industrial sector, the share of the population working in agriculture, population density, and the child dependency ratio. In addition, we control for school density, for inheritance laws using a binary variable which takes the value one for partible inheritance, and the share of the population whose first language is not German. In our baseline specification these control variables vary across counties i and over time t.

The panel estimates are presented in Table 3. Our baseline estimates in column 1 show that counties with an initially stronger concentration of large estates exhibit higher enrollment rates with respect to 1816. Importantly, this differential increases over time. The coefficient for 1849 indicates a 3.2 percentage points higher enrollment rate for counties with a one standard deviation higher initial concentration of large estates. The differential is 6.3 percentage points,

[42] Another advantage of this specification is that the change in the unit of measurement of farm size at the end of the century does not affect the estimates.

[43] Since the process of land redistribution in the nineteenth century is likely endogenous to the process we are studying, we decided to use the distribution of land at the beginning of the century (1816). It is important to note that our results are qualitatively similar even if we allow landownership concentration to vary over time instead of fixing it at the 1816 values: the coefficients of the interaction terms indicate that the differential in enrollment rates associated with the differential in landownership concentration changes from negative to positive over time.

thus twice as large by 1896. A comparison of the coefficients for the interaction terms clearly indicates that the differential in enrollment rates increases in the second half of the nineteenth century. In the last row of Table 3 we present the results of testing whether the coefficients for 1886 and 1896 are jointly significantly different from those for 1849 and 1864. We can always reject the null hypothesis at the 1 percent level that the coefficients *do not* differ, i.e., the differential in enrollment rates is significantly larger at the end of the nineteenth century. This finding is consistent with the stepwise extension of eligibility for the emancipation of serfs as described in Section 3.1. The abolition of serfdom at a piecemeal rate and the process of modernization that characterized the nineteenth century affected the relationship between the nobility and the peasantry and their incentives to invest in education.

In the baseline specification in column 1 we allow the control variables to vary over time. However, changes in these variables might be endogenous to changes in feudal relations. In column 2 we fix the control variables to the initial year 1816 and interact them with the time-period dummies, similar to the variable of interest. The coefficients for interacted land concentration become slightly smaller but the pattern of the results is not affected. Another possible concern is that our results are driven by differences in agricultural systems between the eastern and western regions of Prussia. In column 3 we estimate our fully-flexible model, excluding counties located west of the river Elbe. We find that both the magnitude and the time pattern of the coefficients remains unaffected: regions with an initially higher concentration of large landownership exhibit significantly larger increments in enrollment rates.

In columns 4 and 5 we test whether our findings are robust to alternative proxies for the extent of serfdom. Column 4 uses the ratio of knight estates (*Rittergüter*) to total landholdings in a county.[44] We can safely assume that knight estates held all noble prerogatives such as the right to coerce labor. Therefore this variable is well-suited to capture changes in the relationship between large landowners and peasants over time.[45] The estimates using knight estates in column 4 confirm our previous findings: regions with a larger number of noble estates experience stronger increases in enrollment rates.

In a further step toward capturing the extent of serfdom we use the *size* of knight estates. We construct a variable which measures the share of the county area covered by knight estates (hereafter: *knights' area*). As argued above, the size of a noble landholding should be positively correlated with the share of population under labor coercion. Figure 4 shows that land concentration is positively correlated with *knights' area* in all five periods. This lends further support to our claim that landownership concentration is a valid proxy for the extent of serfdom. In column 5, we estimate our model using *knights' area* interacted with the time dummies. Results are qualitatively similar though slightly weaker in terms of magnitude.

[44] The earliest published census of knight estates is available for the year 1856. The distribution of knight estates is however fairly stable over time. According to Rauer (1857), only 324 of the 11,714 estates had lost their noble prerogatives, mainly due to partition, since the Matrikel of 1834.

[45] Knight estates are quite large (on average 2386 PM or 600 ha) and are therefore generally included in our measure of landownership concentration. However, on average only 50% of the large estates are knight estates and the correlation between landownership concentration and the share of knight estates is roughly 80%.

5.5 Robustness checks

In this section, we test the robustness of the fully-flexible panel estimates against the inclusion of additional control variables. Time-varying omitted variables could still bias our county-fixed effect estimates. In particular, changing land rents and/or cash-crop prices could affect both landownership concentration and enrollment rates, biasing our panel estimates.[46]

Similar to our cross-sectional analysis, in column 1 of Table 4, we include the GRE measure of land rent. The GRE is defined as the income from agrarian use of land, net of the costs of farming, and constitutes our most accurate available measure of agricultural productivity. As the GRE was determined in 1865 it is also a time-invariant variable. We thus interact the GRE with the different time periods. The magnitude and the time pattern of the coefficients are very similar to the baseline estimates in Table 3.

In column 2, we alternatively add county-level controls for crop yields. Detailed information on per-hectare yields for the most important grains (rye and wheat) are available for the years 1886 and 1896. For the earlier time periods (1816, 1849, and 1864), we compute the average across the available years (1886 and 1896) and interact it with the time-period dummies. Including crop yields to account for differences in agricultural productivity does not affect our estimates.[47]

Increasing market integration with declining agricultural prices could cause a shift from an agricultural to an industrial economy, which might explain heterogeneity in the demand for education. In column 3 we include an agricultural price index which measures the average price of the five most important crops for the period 1837–60, weighted by the number of hectares allocated to each crop.[48] Due to the lack of time variation, we again interact the index with time-period dummies. The estimates presented in column 3 show that the magnitude and time pattern of the coefficients are virtually unaffected.

The expansion of the Prussian railroad system led to an increase in rural-urban migration (see Hornung, 2014). Migration to cities might be stronger in regions where emancipation occurred comparatively earlier due to the fact that the rural population had access to markets via railroads. In column 4 we add a binary variable that turns one after a county gains access to a railroad line interacted with time-period dummies. The coefficients on landownership concentration are, however, hardly affected. Our results are further confirmed when excluding counties in which the landed nobility was less influential, namely counties that have an urbanization rate of at least 90 percent (column 5).[49]

[46] The results presented in this section are virtually identical if we use time-varying landownership concentration or measures for knight estates.

[47] The lower number of observations in column 2 ($n = 264$) occurs due to 3 counties cultivating neither wheat nor rye. Additionally including yields for oat, barley, and potato does not change our results but reduces the number of observations substantially.

[48] Only including the price index for wheat and/or rye results in qualitatively similar results.

[49] Effectively, this excludes the so-called city counties which consist only of a city and no rural part. It could be argued that we should also exclude all other cities, since urban and rural landownership (and education) might be very different. Unfortunately, we can only separate urban and rural data in the 1849 cross section. Estimates using only the level of rural enrollment and landownership data, leaving all other variables unchanged, return results in line with those found in the cross section (see Cinnirella and Hornung, 2013).

In sum, results from a fully-flexible model provide evidence that counties with an initially stronger presence of landed nobility experience stronger increase in enrollment rates throughout the nineteenth century. Specifications altering the set of control variables, the set of observations, or using variations of the main explanatory variable, confirm the overall pattern of results.

6 The mechanism

6.1 Supply of education

In the previous section we consistently find that regions with an initially stronger concentration of large landownership exhibit comparatively larger increases in enrollment rates. The pattern of coefficients derived from the fully-flexible model indicates an acceleration of the positive differential in the second half of the nineteenth century. A simultaneous increase in the supply of public education in counties characterized by a stronger concentration of large estates could explain the time pattern of the results. This would be in contrast to our interpretation, according to which an increase in the demand for education related to the process of serfs' emancipation explains the increasing relationship between large estates and enrollment rates.

In fact, as discussed in section 3.1, the landed nobility were liable to support the construction of schools and the appointment of school-masters and teachers. Therefore, the provision of infrastructure and teachers could have been used to incentivize the spread of mass primary education. To test whether this was the case, we present panel estimates of the relationship between initial landownership concentration and (*i*) school density,[50] as well as (*ii*) the teacher-child ratio. We thus estimate equations 3 using education-supply variables as dependent variables. The results are presented in Table 5.

The flexible estimates of the full population of Prussian counties in column 1 do not show any clear pattern. The point estimates suggest decreases in school density in counties with a stronger concentration of large estates but the coefficients never reach a level of statistical significance. At the bottom of Table 5 we test for the joint significance of the coefficients of the time interactions. The high *p-value* does not allow us to reject the hypothesis that the coefficients for the different time periods are jointly zero. In column 2, we estimate the same model for the subsample of counties located east of the river Elbe. Even in this case we do not detect any significant relationship between land concentration and school density. Therefore, the increments in enrollment rates that occurred in counties with large landownership were not accompanied by increments in school density.

In columns 3 and 4 we estimate the same model using the teacher-child ratio as the dependent variable. The point estimates indicate a negative relationship for the whole of Prussia, but the coefficients are never statistically significant. For the east Elbian subsample the coefficients

[50] School density is defined as the number of elementary and middle schools per square kilometer in the county.

turn positive but remain insignificant. Again, we cannot reject the null hypothesis that the coefficients are jointly insignificant. [51]

In sum, we do not find evidence of a significant relationship between the concentration of large estates and improvements in the supply of education in the form of school density or teacher-child ratio over the course of the nineteenth century. It is neither a higher provision of schools nor teachers which drive the increasing enrollment rates in counties with an initially larger share of landownership concentration.

6.2 Emancipated peasants' demand for education

So far we have found that increases in enrollment rates are more pronounced in regions with an initially stronger concentration of large estates which, on the other hand, does not affect the supply of schooling. This result is puzzling as the literature argues that the detrimental effects of land inequality on human capital is engendered through school financing (Galor et al., 2009; Ramcharan, 2010). In addition, it is not immediately obvious why the relationship between landownership concentration and enrollment rates should increase throughout the nineteenth century.

We suggest that the stepwise process of emancipation from serfdom explains changes in the relationship between landownership concentration and education, as estimated in the panel. The incentive of former serfs to invest in education was initially limited by feudal relations. Once free, the peasants could reap the benefits of investments in human capital and likely increased their demand for education. The pattern of results is thus consistent with a stepwise process of emancipation.

We can test the emancipation hypothesis using cross-sectional data on the extent of emancipation from serfdom achieved by 1848. We collected additional data on the number of cases of land and labor redemptions, which indicates the achievement of complete independence from a feudal landlord. Consistent with our hypothesis, we expect to find that increases in enrollment rates are more accentuated in regions with a larger share of emancipated serfs. Our measure for emancipation is constructed as the share of peasants who redeemed their land *and* labor duties.[52] Thus, we examine the relationship between the level of emancipation achieved in 1848 and the differential in the enrollment rate between 1816 and 1849, holding landownership concentration fixed.

$$\text{Edu}_{i,t} - \text{Edu}_{i,t-1} = \alpha_4 + \delta_4 \cdot \text{Emanc}_{i,t} + \beta_4 \cdot \text{Land}_{i,t} + X'_{i,t} \cdot \gamma_4 + \nu_{i,t} \tag{4}$$

[51] An alternative measure for the supply of education are teachers' wages which are available for the cross section in 1886. Cross-sectional regressions suggest that teacher wages were significantly lower in counties with higher landownership concentration, even after accounting for differences in prices and urbanization. This indicates a possible lower quality of teachers in landowner dominated regions (results available from the authors upon request).

[52] For further information see Online Appendix C. As the initial number of serfs is unknown, we construct the denominator to include the initial rural population as of 1816, net of serfs on small parcels who could only redeem under the legislation of 1850.

where $\text{Edu}_{i,t} - \text{Edu}_{i,t-1}$ is the difference in enrollment rates between 1849 and 1816. The estimates include our usual set of control variables.[53] It might be the case that peasants in more prosperous regions were able to redeem land and labor comparatively earlier. Therefore, in addition, all the specifications include a variable that accounts for county variations in income, namely county-level per capita income tax revenues.[54] The results are presented in Table 6.

Consistent with our hypothesis, we find that counties with a larger share of emancipated peasants, i.e., peasants that had command over land and labor, exhibit significantly larger changes in enrollment rates (column 1). It is important to note that this result is obtained for a given level of landownership concentration. Consistent with the findings of our panel estimates, landownership concentration is positively correlated with changes in educational attainment. This result indicates that changes in education are not only driven by the additional demand from former serfs but also by other factors associated with landownership concentration. As mentioned above these might be a range of factors including higher stakes in the industrialization process, stronger enforcement of compulsory schooling, or unobserved institutional changes that are not captured by serf emancipation.[55]

In columns 2 and 3 we replace landownership concentration with our alternative proxy for the extent of serfdom—the share of knight-estates and knights' area. Findings remain qualitatively similar. Column 4 restricts the sample to regions east of the river Elbe. The results are qualitatively similar but are estimated with less precision, as indicated by larger standard errors.[56]

With the data at hand, any explanation of the exact reason why the demand for education increased with the emancipation of the peasantry can only be speculative. We argue that the process of emancipation, together with the freedom of occupational choice, allowed former serf families to reap the benefits of education and thus increased the incentives to invest in children's human capital. In combination with fewer time constraints, due to a decline in labor coercion which allowed children to attend school, the main obstacles to investment in human capital were thus reduced. However, the findings are also consistent with the view that the enforcement of mandatory schooling increased in regions with formerly strong feudal relations. Our findings are also consistent with the hypothesis that large landowners changed their attitude regarding mass education due to their increasing stakes in the industrial sector or when they recognized increasing complementarities between agriculture and education. The process of mechanization and the adoption of new technologies in agriculture is consistent with this view (Goldin and

[53] We acknowledge that these results cannot be interpreted as causal. The instrument previously used to identify exogenous variation in landownership concentration is a poor instrument in this setting. Soil texture is not able to predict the different timing and extent of serf emancipation which depends, among other things, on the formal and informal institutional characteristics of each region.

[54] Per capita income tax revenues are constructed from the total amount of tax revenues in Prussian Thaler from direct taxes—such as income tax, class tax, trade tax, building tax, and property tax—divided by the total population (Meitzen, 1868, vol. 4).

[55] We also have data on "partial" emancipation, namely cases in which peasants redeemed only their land and not yet their labor duties. Consistent with our hypothesis we do not find a significant relationship between partial emancipation and enrollment rates (Cinnirella and Hornung, 2013).

[56] One could argue that the lack of significance on the coefficient for landownership concentration in the East sample is due to the nobility's lower stakes in the industrialization process in these less-developed regions.

Katz, 2000). However, the study of the complementarities between agriculture and education throughout the nineteenth century is beyond the scope of this paper and is left to future research.

7 Conclusion

Nineteenth-century Prussia offers the possibility to study how the concentration of large landownership, a proxy for the extent of serfdom, affected the spread of primary education. Using a unique county-level database that covers the entire nineteenth century, we find that, cross sectionally, counties with a higher concentration of large landownership exhibit significantly lower levels of school enrollment. This relationship is especially strong in the early period and becomes insignificant toward the end of the century. To address concerns regarding omitted variables and reverse causality, we adopt an instrumental variable approach based on soil texture. Under the assumption that the instruments are exogenous, our IV estimates confirm a negative effect of landownership concentration on the level of education.

The most important result is derived when analyzing the change in the relationship between large landownership and enrollment rates. In a panel approach with county-fixed effects we find that counties with an initially stronger concentration of large estates exhibit larger increments in enrollment rates. This finding is consistent with the hypothesis that the abolition of serfdom and the freedom of occupational choice led to a rise in the private demand for education. Our interpretation is further supported by the finding that regions with an initially stronger concentration of landownership did not experience changes in the supply of schools or teachers. We additionally corroborate our interpretation by showing that counties with a higher share of emancipated peasants experienced larger changes in enrollment rates.

The findings of this paper support the notion that a significant amount of the accumulation of human capital in nineteenth-century Prussia can be explained by changes in the private demand for education, triggered by the introduction of institutional reforms that abolished traditional feudal relations.

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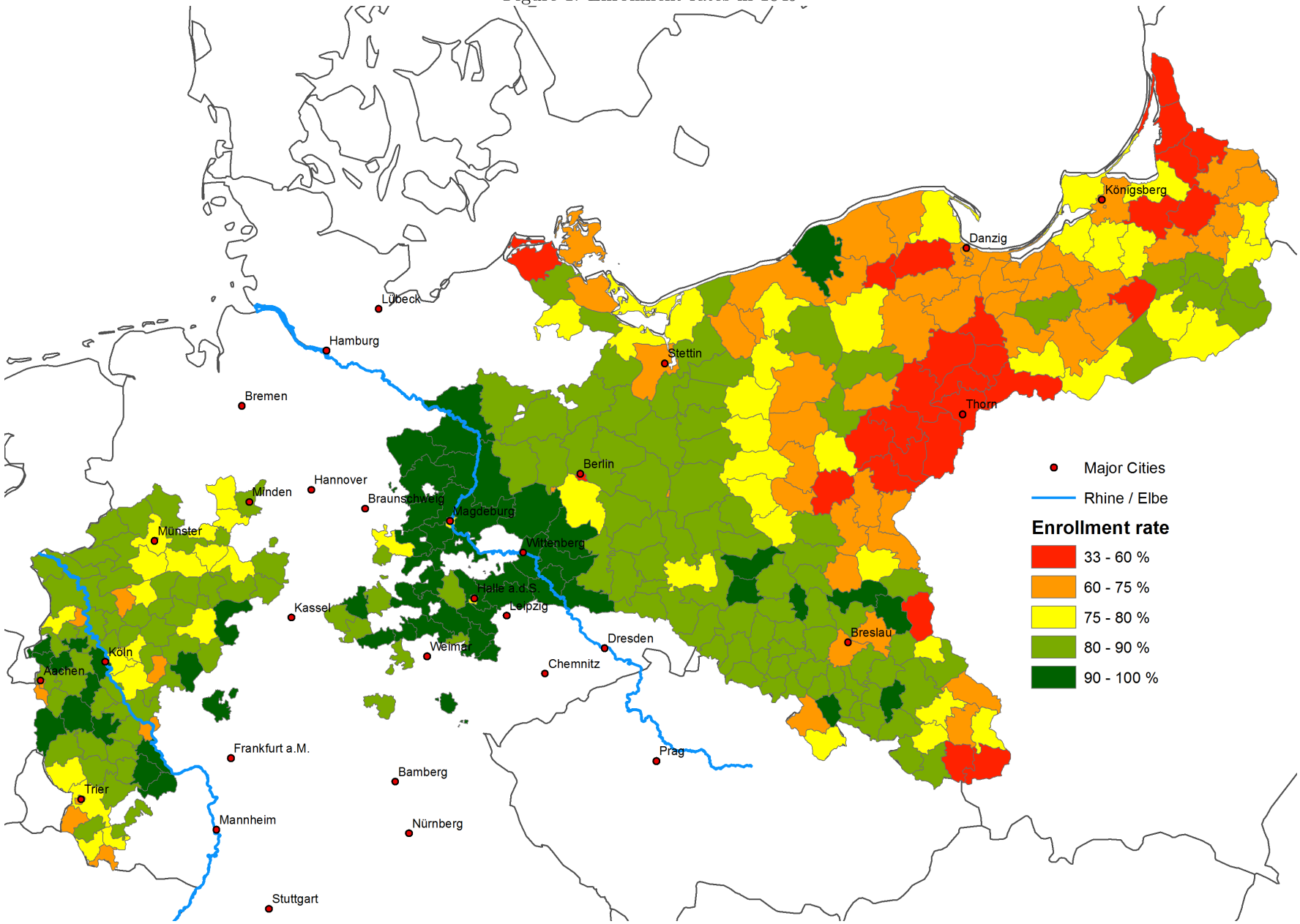
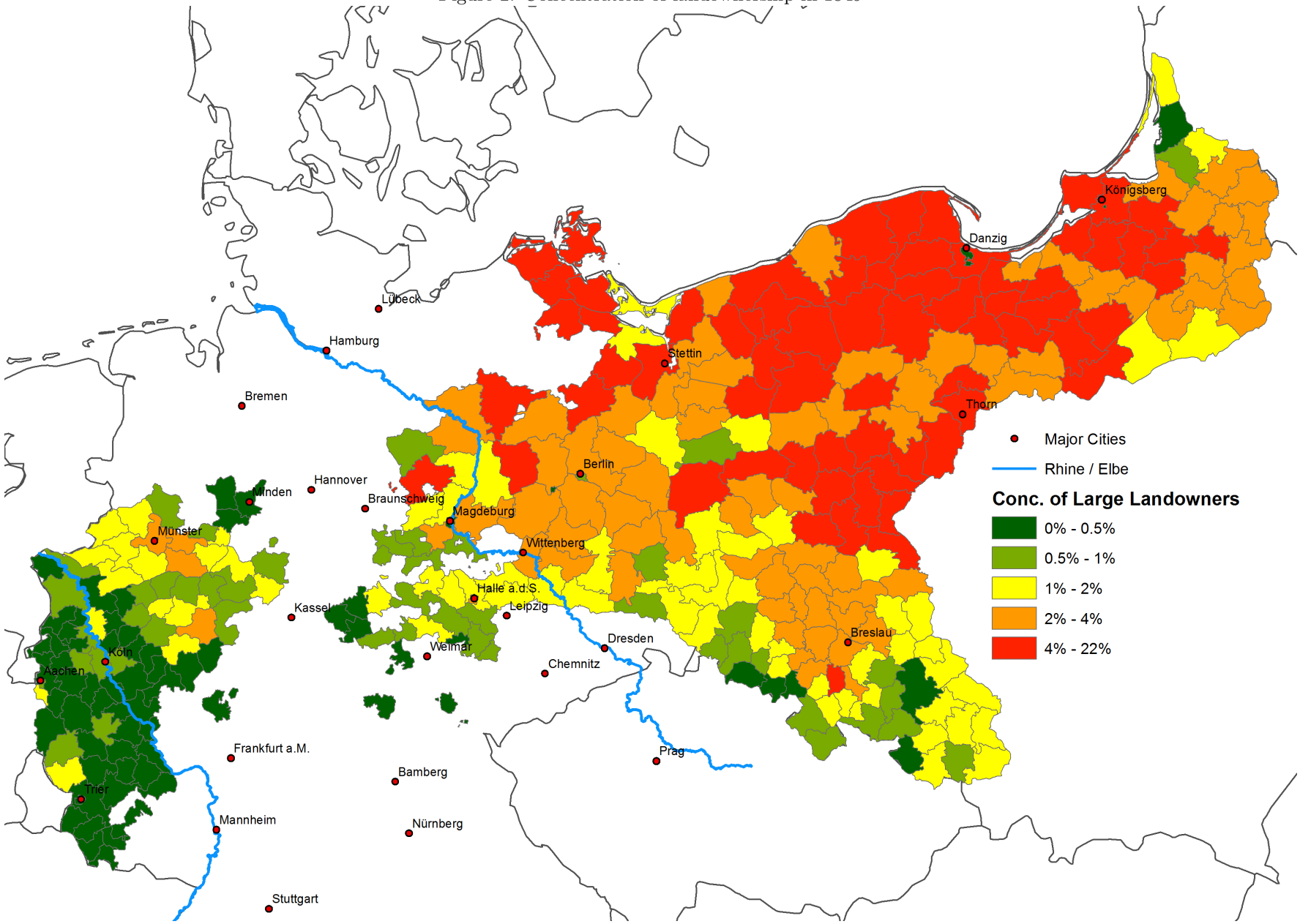
Figure 1: Enrollment rates in 1849



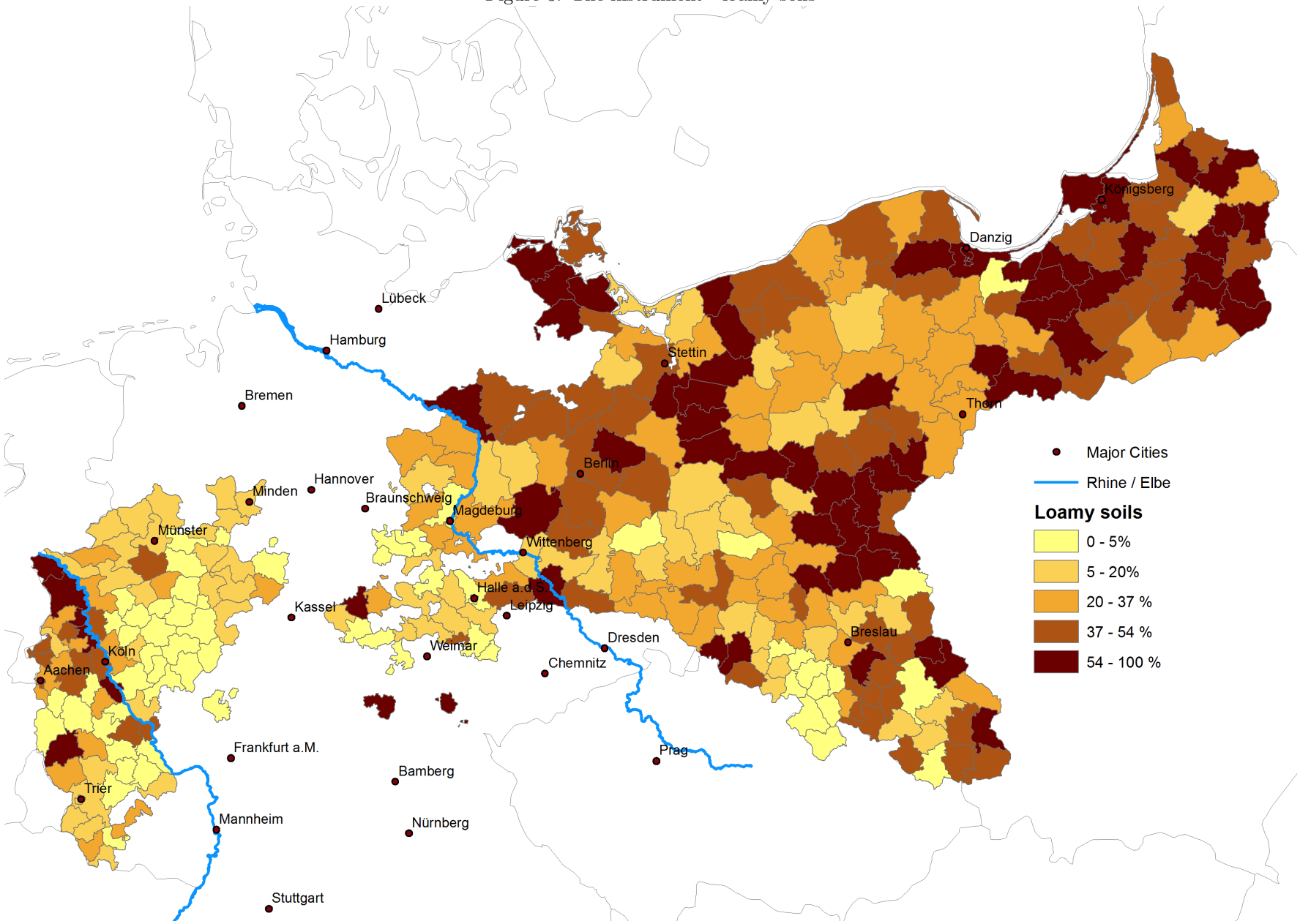
Note: The map depicts the Prussian county structure as of 1849. The enrollment rates are constructed as the number of pupils enrolled in primary and middle schools over the number of children aged 6-14. Source: Own illustration; see main text for details.

Figure 2: Concentration of landownership in 1849



Note: The map depicts the Prussian county structure as of 1849. The concentration of landownership, measured as the percentage of landowners with more than 300 PM, is roughly classified into quintiles. Source: Own illustration; see main text for details.

Figure 3: The instrument—loamy soils



Note: The map depicts the Prussian county structure as of 1849. Shades of brown according to the the share of soil that is classified as loamy soils.
Source: Own illustration; see main text for details.

Figure 4: Correlation between the share of large estates (number) and the share of knight estates (area)

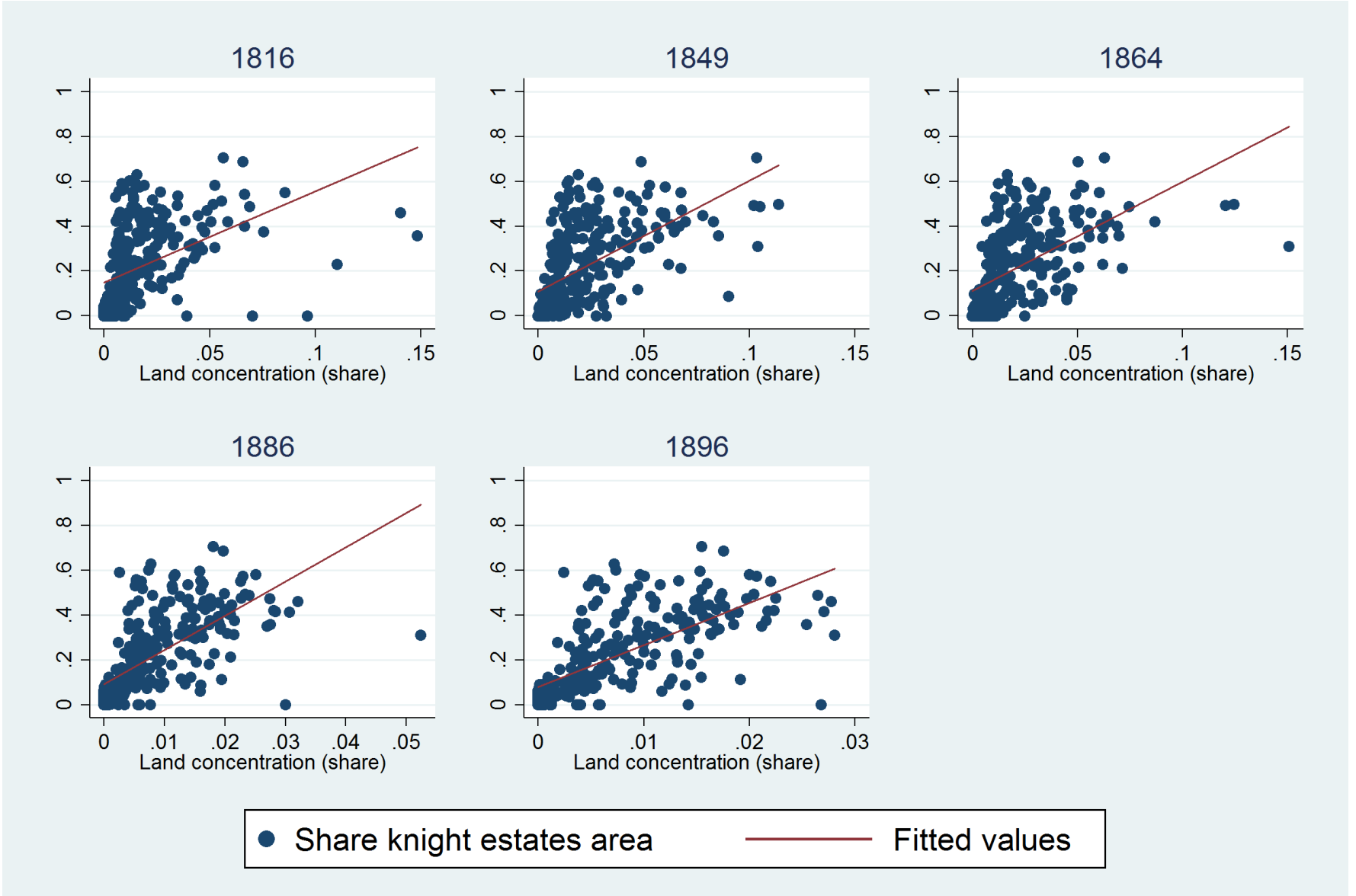


Table 1: Descriptive statistics

Variables	(1)	(2)	(3)	(4)	(5)
	1816	1849	1864	1886	1896
	mean/sd	mean/sd	mean/sd	mean/sd	mean/sd
Enrollment rate (6-14)	0.603	0.822	0.772	0.935	0.945
	(0.193)	(0.102)	(0.096)	(0.062)	(0.056)
Land concentration (share)	0.017	0.021	0.021	0.008	0.007
	(0.021)	(0.022)	(0.021)	(0.008)	(0.007)
Protestant (share)	0.610	0.591	0.586	0.583	0.581
	(0.404)	(0.403)	(0.401)	(0.395)	(0.390)
Urban (share)	0.255	0.258	0.274	0.302	0.323
	(0.183)	(0.190)	(0.198)	(0.206)	(0.210)
Population density	0.722	1.901	2.392	3.145	3.430
	(1.860)	(8.963)	(11.940)	(16.609)	(17.433)
Industrial (share)	0.009	0.077	0.087	0.124	0.131
	(0.020)	(0.039)	(0.048)	(0.056)	(0.057)
Agricultural (share)	0.093	0.535	0.179	0.196	0.189
	(0.039)	(0.184)	(0.064)	(0.073)	(0.078)
Child dependency ratio	0.629	0.643	0.594	0.895	0.773
	(0.069)	(0.076)	(0.063)	(0.108)	(0.097)
Non-German speakers (share)	0.107	0.102	0.102	0.097	0.104
	(0.240)	(0.235)	(0.235)	(0.232)	(0.228)
Inheritance (dummy)	0.251	0.279	0.279	0.279	0.279
	(0.434)	(0.449)	(0.449)	(0.449)	(0.449)
School density	0.126	0.190	0.207	0.154	0.159
	(0.265)	(0.790)	(0.811)	(0.295)	(0.249)
Teacher-student ratio (per 100)	1.132	1.059	1.089	0.972	1.215
	(0.533)	(0.269)	(0.268)	(0.219)	(0.251)
Loamy soils (share)	0.286	0.284	0.284	0.284	0.284
	(0.217)	(0.217)	(0.217)	(0.217)	(0.217)
Real GRE per area	3.142	3.235	3.235	3.235	3.235
	(2.072)	(2.153)	(2.153)	(2.153)	(2.153)
Observations	267	280	280	280	280

Note: Standard deviation in parenthesis. Source: See Online Appendix A for data sources and details.

Table 2: Landownership concentration and enrollment rates

	(1)	(2)	(3)	(4)	(5)
	1816	1849	1864	1886	1896
Panel A: OLS - Education and landownership concentration					
DepVar: Enrollment rate (share)					
Land concentration	-0.064***	-0.046***	-0.036***	-0.002	-0.007**
	(0.011)	(0.005)	(0.005)	(0.003)	(0.004)
Observations	267	280	280	280	280
R-squared	0.51	0.44	0.35	0.61	0.62
Panel B: IV First stage - Soil texture and landownership concentration					
DepVar: Landownership concentration (std)					
Loamy soils (share)	1.313***	1.089***	0.907***	1.050***	0.912***
	(0.350)	(0.230)	(0.261)	(0.250)	(0.252)
Observations	267	280	280	280	280
R-squared	0.32	0.39	0.47	0.48	0.49
Panel C: IV Second stage - Education and landownership concentration					
DepVar: Enrollment rate (share)					
Land concentration	-0.169***	-0.073***	-0.040	-0.008	0.02
	(0.043)	(0.020)	(0.026)	(0.012)	(0.016)
Observations	267	280	280	280	280
Kleibergen-Paap F-statistic	14.0	22.5	12.1	17.6	13.1
Panel D: IV Second stage - Controlling for land productivity (GRE)					
DepVar: Enrollment rate (share)					
Land concentration	-0.170***	-0.069***	-0.039	-0.008	0.021
	(0.046)	(0.020)	(0.027)	(0.012)	(0.015)
Observations	267	280	280	280	280
First-stage F-stat	12.1	21.7	11.5	19.5	14.0
Panel E: IV Second stage - Controlling for GRE in a sample east of river Elbe					
DepVar: Enrollment rate (share)					
Land concentration	-0.143***	-0.115**	-0.081	-0.015	-0.012
	(0.053)	(0.046)	(0.058)	(0.024)	(0.021)
Observations	151	151	151	151	151
Kleibergen-Paap F-statistic	5.6	5.9	3.7	4.0	2.8

Note: The table shows county-level OLS and IV-estimates for five separate cross sections. Land concentration is standardized with mean zero and unit standard deviation. Landownership concentration is instrumented by the share of loamy soils in panel C, D, and E. Robust standard errors in parentheses. Panels D and E add the GRE as control for agricultural productivity; Panel E excludes all counties west of the river Elbe. All regressions include the full set of baseline controls: % protestant, % urban, % industrial, % agricultural, child dependency ratio, population density, school density, inheritance law, % first language not German, and a constant. Significance: *** p<0.01, ** p<0.05, * p<0.1. See Online Appendix A for data sources and details.

Table 3: Panel estimates

Dep. var.: Enrollment rate	Share large landholdings			Knight Estates	
	(1)	(2)	(3)	(4)	(5)
	Land 1816	Controls 1816	East Elbe	Knight est. (no.)	Knight est. (area)
Land concentration*1849	0.032***	0.029**	0.032**	0.016*	0.017*
	(0.012)	(0.013)	(0.013)	(0.009)	(0.010)
Land concentration*1864	0.044***	0.037***	0.039***	0.020**	0.021**
	(0.011)	(0.013)	(0.013)	(0.010)	(0.010)
Land concentration*1886	0.067***	0.058***	0.054***	0.043***	0.032***
	(0.010)	(0.011)	(0.011)	(0.009)	(0.010)
Land concentration*1896	0.063***	0.056***	0.056***	0.043***	0.037***
	(0.013)	(0.013)	(0.012)	(0.009)	(0.010)
Time-fixed effects	Yes	Yes	Yes	Yes	Yes
County-fixed effects	Yes	Yes	Yes	Yes	Yes
Control variables * Year	Yes	Yes	Yes	Yes	Yes
Observations	1335	1335	755	1389	1389
Number of counties	267	267	151	280	280
R-squared	0.82	0.81	0.85	0.81	0.81
p-value: β_{1849}, $\beta_{1864} = \beta_{1886}$, β_{1896}	0.0001	0.0003	0.0033	0.0000	0.0056

Note: The table shows fully-flexible county-level panel estimates. All explanatory variables are interacted with time-period dummies for the years 1816, 1849, 1864, 1886, 1896. Measures of land concentration are standardized with mean zero and unit standard deviation. The omitted reference year is 1816. Columns 1-3 use the initial distribution of landownership concentration; Column 2 fixes all control variables in 1816, Column 3 restricts the sample to counties located east of the Elbe; Column 4 uses the share of knight-estates; Column 5 uses the land covered by knight estates. Controls: % protestant, % urban, % industrial, % agricultural, child dependency ratio, population density, school density, % first language not German, and a constant. Standard errors in parentheses are clustered at the county level. 13 observations drop out from the analysis because of missing information for the district of Cologne in columns 1-3. Significance: *** p<0.01, ** p<0.05, * p<0.1. Source: See Online Appendix A for data sources and details.

Table 4: Panel estimates — robustness checks

Dep. var.: Enrollment rate	(1) Land rent	(2) Agri. yields	(3) Crop prices	(4) Railroads	(5) No cities
Land concentration*1849	0.031**	0.033***	0.032***	0.033***	0.030***
	(0.012)	(0.009)	(0.012)	(0.012)	(0.010)
Land concentration*1864	0.043***	0.045***	0.044***	0.044***	0.042***
	(0.012)	(0.008)	(0.011)	(0.011)	(0.008)
Land concentration*1886	0.066***	0.067***	0.067***	0.067***	0.062***
	(0.010)	(0.007)	(0.010)	(0.010)	(0.008)
Land concentration*1896	0.063***	0.062***	0.064***	0.064***	0.060***
	(0.012)	(0.009)	(0.013)	(0.013)	(0.009)
Time-fixed effects	Yes	Yes	Yes	Yes	Yes
County-fixed effects	Yes	Yes	Yes	Yes	Yes
Control variables * Year	Yes	Yes	Yes	Yes	Yes
Observations	1335	1308	1300	1335	1305
Number of counties	267	264	260	267	261
R-squared	0.83	0.85	0.82	0.82	0.85
p-value: β_{1849}, $\beta_{1864} = \beta_{1886}$, β_{1896}	0.0000	0.0000	0.0001	0.0001	0.0000

Note: The table shows fully-flexible county-level panel estimates. All explanatory variables are interacted with time-period dummies for the years 1816, 1849, 1864, 1886, 1896. The omitted reference year is 1816. The initial distribution of landownership concentration is standardized with mean zero and unit standard deviation. 'Land rent' adds controls for agricultural productivity; 'Agri. yields' adds controls for rye and wheat yields; 'Crop prices' adds a price-index of the five most important crops for the period 1837-60 weighted by the area devoted to each crop; 'Railroads' adds a control for railroad access; 'No cities' drops counties with an urbanization rate >90%. Controls: % protestant, % urban, % industrial, % agricultural, child dependency ratio, population density, school density, % first language not German, and a constant. Standard errors in parentheses are clustered at the county level. 13 observations drop out from the analysis because of missing information for the district of Cologne in the 1816 data. Significance: *** p<0.01, ** p<0.05, * p<0.1. Source: See Online Appendix A for data sources and details.

Table 5: Landownership concentration and the supply of schooling

Dep. var.: Enrollment rate	School density		Teacher-child ratio	
	(1)	(2)	(3)	(4)
	Whole Prussia	East Elbe	Whole Prussia	East Elbe
Land concentration*1849	-0.011	-0.001	-0.027	0.032
	(0.012)	(0.011)	(0.047)	(0.043)
Land concentration*1864	-0.006	0.005	-0.019	0.043
	(0.008)	(0.005)	(0.057)	(0.045)
Land concentration*1886	-0.032	-0.021	-0.027	0.050
	(0.019)	(0.020)	(0.059)	(0.050)
Land concentration*1896	-0.027	-0.018	-0.047	0.033
	(0.018)	(0.018)	(0.063)	(0.052)
Time-fixed effects	Yes	Yes	Yes	Yes
County-fixed effects	Yes	Yes	Yes	Yes
Control variables	Yes	Yes	Yes	Yes
Observations	1335	755	1335	755
Number of counties	267	151	267	151
R-squared	0.66	0.68	0.52	0.62
p-value joint significance β_τ	0.3991	0.5368	0.2515	0.1874

Note: The table shows fully-flexible county-level panel estimates. All explanatory variables are interacted with time-period dummies for the years 1816, 1849, 1864, 1886, 1896. The omitted reference year is 1816. The initial distribution of landownership concentration is standardized with mean zero and unit standard deviation. Controls: % protestant, % urban, % industrial, % agricultural, child dependency ratio, population density, inheritance, % first language not German, and a constant. Standard errors in parentheses are clustered at the county level. Significance: *** p<0.01, ** p<0.05, * p<0.1. Source: See Online Appendix A for data sources and details.

Table 6: Peasants' emancipation and the demand for education

Dep. var.: Δ Enrollment rate	Redemption of Labor			
	(1)	(2)	(3)	(4)
	Large landown.	Knight est. (no.)	Knight est. (area)	East
Share emancipated	0.024**	0.021**	0.017**	0.029*
	(0.010)	(0.009)	(0.009)	(0.016)
Land concentration	0.025*			0.017
	(0.014)			(0.015)
Knight estates (no.)		0.021**		
		(0.009)		
Knight estates (area)			0.016*	
			(0.009)	
Control variables	Yes	Yes	Yes	Yes
Observations	261	261	261	195
R-squared	0.33	0.33	0.32	0.39

Note: The table shows OLS estimates for a cross section in 1849. The dependent variable is the first difference between enrollment rates in 1849 and 1816. All measures of emancipation and land concentration are standardized with mean zero and unit standard deviation. Column 4 exclude all counties west of the river Elbe. Controls: Tax revenue p.c., % protestant, % urban, % industrial, % agricultural, child dependency ratio, population density, school density, inheritance, % first language not German, and a constant. Robust standard errors in parentheses. Significance: *** p<0.01, ** p<0.05, * p<0.1. Source: See Online Appendix A for data sources and details.

Online Appendix A Variable definitions and data sources

We present variable definitions and data sources in Appendix Tables A1-A5. This county-level database covers all Prussian counties over the nineteenth century. The data were collected in several censuses by the Royal Prussian Statistical Bureau and obtained from several sources. We combine these data to prepare five cross sections using censuses from the years 1816, 1849, 1864, 1886 and 1896, if available, or as close as possible to these years. We accounted for changes in the administrative boundaries of counties by adjusting all data to follow the borders as determined at the beginning of the period under analysis. Demographers consider nineteenth-century county-level data from Prussia as a unique source of highest-quality data for analysis at a micro-regional level (Galloway et al., 1994). Some of the data used for the 1886 and 1896 cross section were taken from Galloway (2007). See Becker et al. (2014) for further information regarding the data.

Table A-7: 1816 variables

Enrollment rate (6-14)	Number of attending students in public elementary schools (Öffentliche Elementarschulen), private elementary schools (Privat-Elementarschulen), public middle schools for boys or girls (Öffentliche Buerger- und Mittelschulen für Söhne oder Töchter), and private middle schools for boys or girls (Private Bürger- und Mittelschulen für Söhne oder Töchter) in 1816 over number of children at recommended school age between 6 and 14 in 1816 (Public elementary schools were the only school type equally available in rural areas and towns at the time. Data on private and middle schools are available for the 172 medium and large towns.)
Large landholdings (share)	Share of estates larger than 300 PM. The 1816 census classifies landownership in 3 groups: properties or leasehold estates with up to 15 Prussian Morgen (PM), 15 to 300 PM and more than 300 PM.
Protestant (share)	Share of total population that is Protestant in 1816.
Urban (share)	Share of total population living in cities which held city rights in 1816.
Industrial (share)	Number of looms in 1819 over total population in 1816 (since Prussia was not industrialized in 1816, we chose this as an indicator of proto-industrial occupations).
Agricultural (share)	Number of servants in agriculture in 1819 over total population in 1816 (no data is available for the total number of people in agriculture for this period).
Child dependency ratio	Ratio of the population younger than 15 years old to the population between 15 and 60 years in 1816.
Population density	Number of people per square kilometer of land area in the county in 1816.
School density	Number of elementary and middle schools per square kilometer of land area in the county in 1816.
Inheritance (dummy)	Unity for counties that predominantly practiced partible inheritance (*Naturalteilung*) and zero for counties that predominantly practiced non partible inheritance (*Anerbenrecht*). (Coded using county-level maps of historical inheritance laws from ca. 1900 (Sering, 1897-1905).)
First language not German (share)	Share of total population that is not of German descent (Königliches Statistisches Bureau in Berlin, 1861-1934, vol. 10).
Teachers per children 6-14	Number of elementary- and middle-school teachers per 100 children at recommended school age (6 to 14 years) in 1816.
Railroad access (dummy)	Zero in 1816 since the first railroad line was build only in 1838 (Hornung, 2014).

Note: Unless otherwise specified, the source of the 1816 and 1819 census data is Mützell (1823-1825, vol. 5-6).

Table A-8: 1849 variables

Enrollment rate (6-14)	Number of attending students in public elementary schools (Öffentliche Elementarschulen) and public middle schools for boys or girls (Öffentliche Mittelschulen für Söhne oder Töchter) in 1849 over number of children at recommended school age between 6 and 14 in 1849.
Large landholdings (share)	Share of estates larger than 300 PM. (The 1849 census classifies landownership in 5 groups: possessions (*Besitzungen*) with up to 5 PM, 5 to 30 PM, 30 to 300 PM, 300 to 600 PM and more than 600 PM.)
Protestant (share)	Share of total population that is Protestant in 1849.
Urban (share)	Share of total population living in cities which held city rights in 1849.
Industrial (share)	Number people working as craftsmen or in factories in 1849 over total population in 1849
Agricultural (share)	Number of people in agriculture in 1849 over total population in 1849 (including subsidiary occupations in agriculture, all family members, servants and farm-laborers).
Child dependency ratio	Ratio of the population younger than 15 years old to the population between 15 and 60 years in 1849.
Population density	Number of people per square kilometer of land area in the county 1849.
School density	Number of elementary and middle schools per square kilometer of land area in the county 1849.
Inheritance (dummy)	Unity for counties that predominantly practiced partible inheritance (*Naturalteilung*) and zero for counties that predominantly practiced non partible inheritance (*Anerbenrecht*). (Coded using county-level maps of historical inheritance laws from ca. 1900 (Sering, 1897-1905).)
First language not German (share)	Share of total population that is not of German descent (Königliches Statistisches Bureau in Berlin, 1861-1934, vol. 10).
Teachers per children 6-14	Number of elementary- and middle-school teachers per 100 children at recommended school age (6 to 14 years) in 1849.
Railroad access (dummy)	Unity if a county was crossed by at least one railroad line in 1849 (Hornung, 2014).
Tax revenues per capita (1867)	Total amount of revenues from direct taxes in Prussian Thaler over the total population (Meitzen, 1868, vol. 4).

Note: Note: Unless otherwise specified, the source of the 1849 data is (Statistisches Bureau zu Berlin, 1851-1855, vol. 1-6b).

Table A-9: 1864 variables

Enrollment rate (6-14)	Number of attending students in public elementary schools (Öffentliche Elementarschulen), private elementary schools (Privat-Elementarschulen), public middle schools for boys or girls (Öffentliche Mittelschulen für Söhne oder Töchter), and private middle schools for boys or girls (Private Mittelschulen für Söhne oder Töchter) in 1864 over number of children at recommended school age between 6 and 14 in 1864.
Large landholdings (share)	Share of estates larger than 300 PM. (Meitzen (1868) classifies landownership in 5 groups: possessions (*Besitzungen*) with up to 5 PM, 5 to 30 PM, 30 to 300 PM, 300 to 600 PM and more than 600 PM.)
Protestant (share)	Share of total population that is Protestant in 1864.
Urban (share)	Share of total population living in cities which held city rights in 1864.
Industrial (share)	Number of people employed in mining and industry (including construction) in 1867 over total population in 1867 (Königliches Statistisches Bureau in Berlin, 1861-1934, vol. 16b).
Agricultural (share)	Number number of people employed in agriculture, forestry and hunting, and fishing in 1867 over total population in 1867 (Königliches Statistisches Bureau in Berlin, 1861-1934, vol. 16b).
Child dependency ratio	Ratio of the population younger than 15 years old to the population between 15 and 65 years in 1864.
Population density	Number of people per square kilometer of land area in the county in 1864.
School density	Number of elementary and middle schools per square kilometer of land area in the county 1864.
Inheritance (dummy)	Unity for counties that predominantly practiced partible inheritance (*Naturalteilung*) and zero for counties that predominantly practiced non partible inheritance (*Anerbenrecht*). (Coded using county-level maps of historical inheritance laws from ca. 1900 (Sering, 1897-1905).)
First language not German (share)	Share of total population that is not of German descent (Königliches Statistisches Bureau in Berlin, 1861-1934, vol. 10).
Teachers per children 6-14	Number of elementary- and middle-school teachers per 100 children at recommended school age (6 to 14 years) in 1864.
Knight estates (no.)	Number of knight estates (*Rittergüter*) over the total number of holdings in 1856 (Rauer, 1857).
Knight estates (area)	Area of knight estates (*Rittergüter*) over the total county area (Rauer, 1857).
GRE	The *Grundsteuerreinertrag* in real terms per area. The *Grundsteuerreinertrag* is defined as the income from agrarian use of land less all costs of farming and was originally judged by experts for tax purposes. The Prussian administration established the GRE to determine the net earnings per acre for different classes of farm land (Meitzen, 1868, vol. 4). The GRE is deflated with a county-level index of agricultural prices.
Agricultural prices	Average market prices in Prussian *Silbergroschen* for a bushel of wheat, rye, oat, and potatoes, over the period 1837-1860. (Prices were collected annually during the 15-day period of *Martinimarkt* (Meitzen, 1868, vol. 4).)
Railroad access (dummy)	Unity if a county was crossed by at least one railroad line in 1864 (Hornung, 2014).

Note: Unless otherwise specified, the source of the 1864 data is (Königliches Statistisches Bureau in Berlin, 1861-1934, vol. 10). Unfortunately the 1864 census is missing occupational information for the city counties (*Stadtkreise*). We thus access data from the 1867 census to construct the occupation controls.

Table A-10: 1886 variables

Enrollment rate (6-14)	Number of attending students in public primary schools (Öffentliche Volksschulen) in 1886 over number of children at recommended school age in 1886 (Königliches Statistisches Bureau in Berlin, 1861-1934, vol. 101).
Large landholdings (share)	Share of farms larger than 100 ha arable land 1882. (Königliches Statistisches Bureau in Berlin (1861-1934, vol. 76c) classifies farms in 6 groups: farms with arable land up to 1 hectare, 1 to 2 ha, 2 to 10 ha, 10 to 50 ha, 50 to 100 ha, and more than 100 ha.)
Protestant (share)	Share of total population that is Protestant in 1880 (Königliches Statistisches Bureau in Berlin, 1861-1934, vol. 66).
Urban (share)	Share of total population living in cities which held city rights in 1880 (Königliches Statistisches Bureau in Berlin, 1861-1934, vol. 61).
Industrial (share)	Number of people employed in mining and industry 1882 over total population in 1882 (Königliches Statistisches Bureau in Berlin, 1861-1934, vol. 76b).
Agricultural (share)	Number number of people employed in agriculture and animal husbandry in 1882 over total population in 1882 (Königliches Statistisches Bureau in Berlin, 1861-1934, vol. 76b).
Child dependency ratio	Ratio of the population younger than 19 years old to the population between 19 and 70 years in 1882 (Königliches Statistisches Bureau in Berlin, 1861-1934, vol. 76b).
Population density	Number of people per square kilometer of land area in the county in 1882 (Königliches Statistisches Bureau in Berlin, 1861-1934, vol. 76b).
School density	Number of schools per square kilometer of land area in the county in 1886 (Königliches Statistisches Bureau in Berlin, 1861-1934, vol. 101).
Inheritance (dummy)	Unity for counties that predominantly practiced partible inheritance (*Naturalteilung*) and zero for counties that predominantly practiced non partible inheritance (*Anerbenrecht*). (Coded using county-level maps of historical inheritance laws from ca. 1900 (Sering, 1897-1905).)
First language not German (share)	Share of students whose language spoken at home is not German in 1886 (Königliches Statistisches Bureau in Berlin, 1861-1934, vol. 101).
Teachers per children 6-14	Number of school teachers per 100 children at recommended school age (6 to 14 years) in 1886 (Königliches Statistisches Bureau in Berlin, 1861-1934, vol. 101).
Agricultural yields	Total yields of winter wheat, winter rye, summer barley, oats and potatoes per hectare in 1886 (Königliches Statistisches Bureau in Berlin, 1861-1934, vol. 92).

Table A-11: 1896 variables

Enrollment rate (6-14)	Number of attending students in public primary schools (Öffentliche Volksschulen) in 1896 over number of children at recommended school age in 1896 (Königliches Statistisches Bureau in Berlin, 1861-1934, vol. 151b).
Large landholdings (share)	Share of farms larger than 100 ha arable land 1895. (Königliches Statistisches Bureau in Berlin (1861-1934, vol. 142b) classifies farms in 7 groups: farms with arable land up to 0.5 hectare, 0.5 to 2 ha, 2 to 5 ha, 5 to 20 ha, 20 to 100 ha, more than 100 ha, and more than 200 ha.)
Protestant (share)	Share of total population that is Protestant in 1895 (Königliches Statistisches Bureau in Berlin, 1861-1934, vol. 148a).
Urban (share)	Share of total population living in cities which held city rights in 1895 (Königliches Statistisches Bureau in Berlin, 1861-1934, vol. 143).
Industrial (share)	Number of people employed in mining and industry 1895 over total population in 1895 (Königliches Statistisches Bureau in Berlin, 1861-1934, vol. 142a).
Agricultural (share)	Number number of people employed in agriculture and animal husbandry 1895 over total population in 1895 (Königliches Statistisches Bureau in Berlin, 1861-1934, vol. 142a).
Child dependency ratio	Ratio of the population younger than 19 years old to the population between 19 and 70 years in 1895 (Königliches Statistisches Bureau in Berlin, 1861-1934, vol. 143).
Population density	Number of people per square kilometer of land area in the county in 1895 (Königliches Statistisches Bureau in Berlin, 1861-1934, vol. 148a).
School density	Number of schools per square kilometer of land area in the county in 1896 (Königliches Statistisches Bureau in Berlin, 1861-1934, vol. 151b).
Inheritance (dummy)	Unity for counties that predominantly practiced partible inheritance (*Naturalteilung*) and zero for counties that predominantly practiced non partible inheritance (*Anerbenrecht*). (Coded using county-level maps of historical inheritance laws from ca. 1900 (Sering, 1897-1905).)
First language not German (share)	Share of total population whose mother tongue is not German in 1890 (Königliches Statistisches Bureau in Berlin, 1861-1934, vol. 121a).
Teachers per children 6-14	Number of school teachers per 100 children at recommended school age (6 to 14 years) in 1896 (Königliches Statistisches Bureau in Berlin, 1861-1934, vol. 151b).
Agricultural yields	Total yields of winter wheat, winter rye, summer barley, oats and potatoes per hectare in 1896 (Königliches Statistisches Bureau in Berlin, 1861-1934, vol. 147).

Online Appendix B Soil data

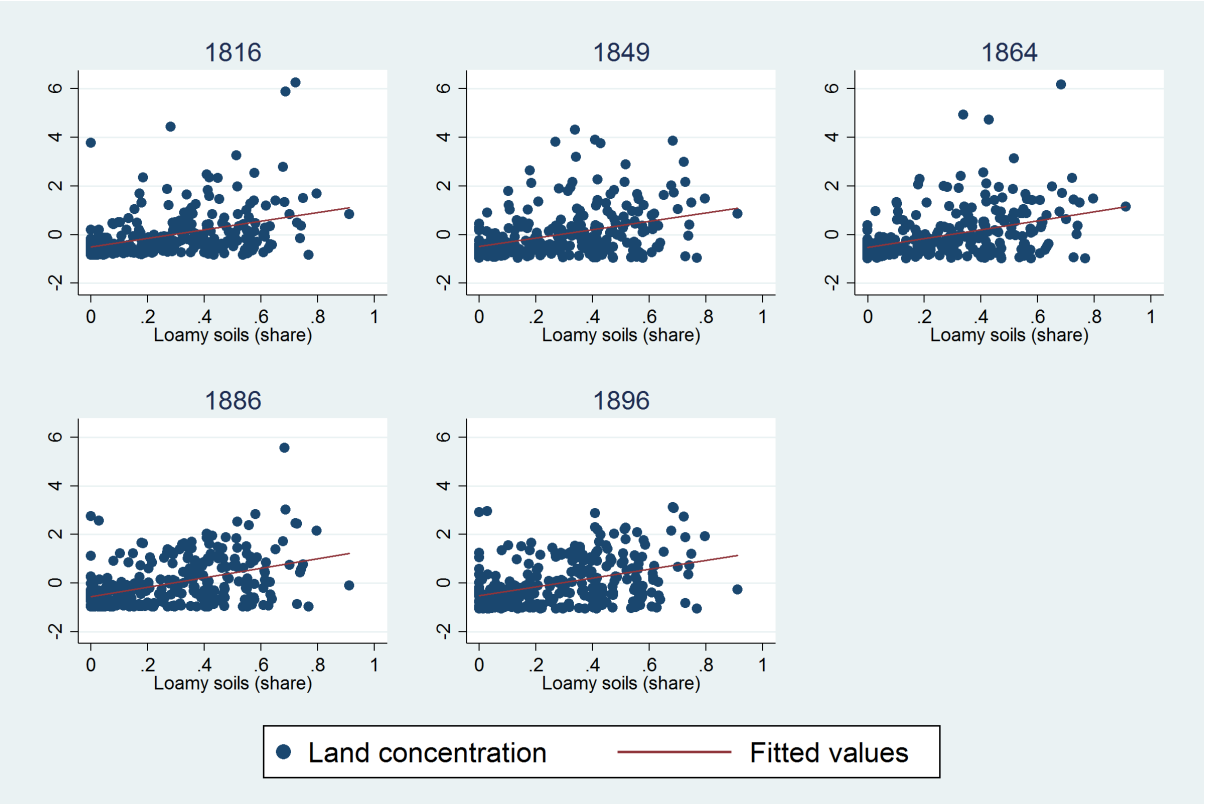
Soil-texture is a fundamental property and a permanent characteristic of soil. Soil texture is based on the relative particle size proportions of sand, silt, and clay that make up the soil mass. The instrument is developed using historical soil texture data from an 1866 classification of soils. As a means to unify land taxes across provinces, the Prussian government passed a law to determine soil, location, terrain, climate, humidity, accessibility, credit and all other aspects affecting the rate of return to each farm. This information was collected between 1861 and 1864 in each county by an assessment commission of four to ten members, half of which were elected by the local assembly and the other half chosen by the central government. Of the total 2,494 members of the commission, 701 were owners of knight estates and 1,181 were other landowners, while the rest were public servants and landless farmers. Land surveying was conducted by approximately 3,300 trained technical measurers. The local classification of soil was conducted by the three members of the commission, including the commissar and one technical measurer. The soil was either drilled or dug, classified and sketched into maps. Soil samples were taken so as to be compared to other soils in the same classification. The samples and their exact location had to be attached to the survey protocol and were sent to the district commission. The district commission visited each county and compared the samples. The classification into tax classes was then made available to the municipalities, to estate owners, and to county assemblies for objection. The average surveyed area was 568 Prussian Morgen per day, adding up to a total of 188,587 days of work. Given that the data provide county level averages of soil texture, possible biases due to systematic misreporting for purposes of tax evasion should be minimized.

The U.S. soil texture triangle allows us to illustrate and classify all possible combinations of the three particles. Combinations of sand, silt, and clay are called loam. The classification of soils is based on the particle size; sand is relatively round while silt and clay particles are rather slim and flat. Soils with round particles can absorb higher amounts of air and water which is beneficial for plant growth due to the available space between the particles. However, soils with a large sand content cannot retain water since empty spaces are large, leading to a higher probability of draught and crop failure due to draught.

The contemporary Prussian data report the total area, the area of 'clay soils' (*Lehm- und Thonböden*), the area of 'sandy loam and loamy sand soils' (*sandiger Lehm und lehmiger Sand*), and the area of 'sandy soils' (*Sandboden*). The source of the soil data is Meitzen (1868, vol. 4). Our instrument loamy soils adopts the Prussian soil category 'loamy sand and sandy loam' which in the present day's classification depicts soils consisting of 50-85% sand, 0-50% silt, and 0-20% clay. Such loamy soils are moderately coarse to moderately fine. The reference categories that are included in the denominator are 'clay soils' nowadays classified as consisting of 0-50% sand, 20-100% clay, and 0-100% silt and 'sandy soils' nowadays classified as consisting of 85-100% sand, 0-15% clay, and 0-15% silt. The ideal soil texture for agricultural use has a composition of approximately 40% sand, 40% silt, and 20% clay. At this level of composition the soil has the highest ability to retain nutrition and water. Consequently, such soils should

be those with the highest demand. Whereas soils with a higher sand content should exhibit a lower demand and would be settled relatively late.

Figure B-5: Correlation between the instrument and the endogenous variable



Note: Graphs show simple correlation between the endogenous variable landownership concentration and the instrument share of loamy soils for the year 1816, 1849, 1864, 1886, and 1896.

Online Appendix C Data on peasants' emancipation

In order to analyze the mechanism through which landownership concentration affected education, in Section 6 we use data that quantify the achievements of the agrarian reforms originally provided by Meitzen (1868, vol. 4). These data provide information from a full scale county-level census of 1848.

The data report the number of redemption cases resolved by the local authorities at the end of 1848. We assume resolved cases to be equal to peasants that had become emancipated from serfdom. We consider only the category of peasants that held legal rights of ownership and redeemed all labor services due to the Edict of 1821. Those were former serfs that achieved the highest level of emancipation. Peasants on small parcels were exempted from the reform due to the Edict of 1816 until the Commutation Law in 1850 and are thus not covered by these data. Table C-12 below illustrates the timeline of the process of serf emancipation.

Table C-12: Timeline of the abolition of serfdom and noble privileges

Year	Description of event
1799	Peasant emancipation: abolition of serfdom on royal domains
1807	Peasant emancipation: abolition of serfdom; abolition of restrictions on mobility; abolition of menial service (*Gesindezwang*) for serf children
1811	Commutation of feudal tenures: transformation of feudal tenures into peasant land ownership (eligibility for peasants without hereditary rights)
1816	Restriction of scope of 1811 edict (exclusion of peasants on smaller plots of land)
1821	Commutation of feudal tenures: transformation of feudal tenures into peasant land ownership (eligibility for peasants with hereditary rights); transformation of labor services into compensation payments; procedures for division of commons and separation of holdings
1849	Abolition of the estate authority, police power and jurisdiction (*"Patrimonialgerichtsbarkeit"*)
1850	Commutation of feudal tenures: transformation of feudal tenures into peasant land ownership (eligibility for peasants on small plots of land); Constitution of Rentenbanken to finance compensation
1856	Reestablishment of estate authority and police power
1861	Abolition of tax exemptions for estate owners
1872	Reorganization of rural administration: division of municipalities and estate districts; abolition of estate owner's influence over municipalities; abolition of estate owner's school supervision
1928	Abolition of estate authority and policing power

Table C-13 below reports the increasing number of emancipated peasants over the second part of the nineteenth century. The fact that the absolute number of labor redemption cases continues to gain momentum toward the end of the century is consistent with the slow process of full emancipation in Prussia.

We exclude counties west of the river Elbe and in the district of Stralsund (Swedish Pomerania). Due to Napoleonic reforms these regions were institutionally different regarding redemption and emancipation from the rest of Prussia.

Table C-13: State-level emancipated peasants

Year	Redeemed land and labor
1848	289,651
1855	936,333
1865	1,348,178
1885	2,527,685

Note: The table reports the absolute numbers of redemption cases regarding labor services which was only possible after landownership was established. Source: Meitzen and Grossmann (1901).

Online Appendix D The supply of schooling

The Prussian Statistical Office provides detailed information on public primary school financing at the province level for 1861, 1864, 1867, 1871, 1878, and 1886. In Table D-14 we show the total amount of school funds per capita at the province level. Similarly to Lindert (2003, 2004), we find that eastern provinces had relatively smaller school funds compared to western provinces. For example, primary school funds amounted to about 1.4 Marks per capita in East and West Prussia in 1861,[57] whereas it amounted to 1.8 Marks in the western province of Rhineland. However, it is important to note that this difference may reflect differences in the cost of living. If we deflate school funds per capita with rye prices in 1861, funds in the provinces of East and West Prussia are 10 and 14 percent higher than in Rhineland, respectively.[58]

School funds can be divided into three broad categories: local taxes and endowments from school societies, tuition fees, and state funds. In Table D-15 we show the extent of state expenditures on public primary schooling at the province level. The data show that, throughout the period considered, poor eastern provinces such as East Prussia, West Prussia, and Posen benefited to a larger extent from state contributions than did the western provinces of Westphalia and Rhineland. Also, the province of Brandenburg received a relatively high contribution from the state. On the contrary, school funds in eastern provinces relied to a much lesser extent on tuition fees. In 1861 in the provinces of Rhineland and Westphalia, tuition fees accounted for 24 and 27 percent of the total school funds, respectively; whereas, in East and West Prussia tuition fees accounted for only 11 and 13 percent of the total school funds, respectively.

Thus, the aggregate data show that school funds in eastern areas were relatively smaller in nominal terms with respect to the richer and more urban regions of the west, though in real terms

[57] Note that both provinces of East and West Prussia belong to the East Elbe part of the Kingdom of Prussia.

[58] The gap between school funds in East and West Prussia also decreases if we deflate by wheat prices in 1861.

the gap might have been non-existent. Consistent with this finding, we observe no appreciable difference between east and west when looking at the number of schools and teachers per child at school age. In Figure D-6 and Figure D-7 we plot the number of schools and the number of teachers per 100 children (6 to 14) for 25 districts by year (1816, 1849, 1864, 1886, and 1896). To facilitate the interpretation, the districts are sorted from east to west. One can immediately observe that, if anything, eastern districts had more schools per child at school age compared to western districts. We obtain a very similar picture if we look at the number of teachers per child at school age.

Table D-14: Total expenditure for public primary schools, 1861-86

	1861	1864	1867	1871	1878	1886
Eastprussia	1.414	1.469	1.723	1.781	3.053	3.637
Westprussia	1.458	1.603	1.798	1.915	3.124	3.673
Poznan	1.190	1.253	1.399	1.695	2.687	3.508
Silesia	1.276	1.337	1.517	1.716	2.792	3.488
Pomerania	1.670	1.727	1.945	2.305	3.668	4.533
Brandenburg	1.963	1.953	2.109	2.468	3.515	4.220
Saxony	2.079	2.124	2.233	2.536	3.727	4.678
Westphalia	1.559	1.597	1.812	2.110	3.840	4.742
Rhineland	1.883	1.950	2.124	2.603	4.664	4.991

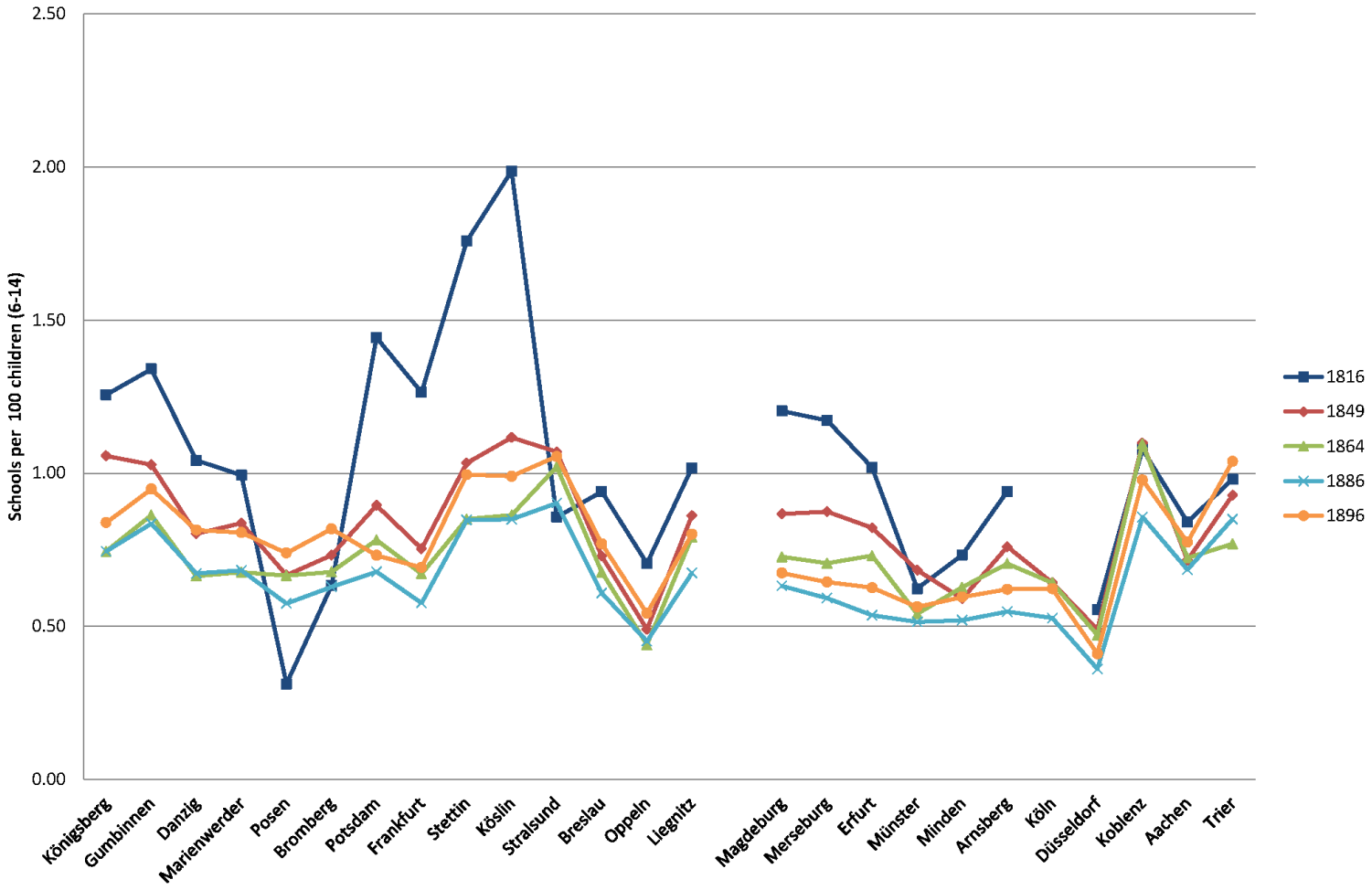
Note: Total expenditure for public primary schools in German Marks per capita at the province level. Source: Own calculations according to Königliches Statistisches Bureau in Berlin (1889).

Table D-15: State expenditures for public primary schools, 1861-86

	1861	1864	1867	1871	1878	1886
Eastprussia	0.079	0.077	0.095	0.142	0.636	0.742
Westprussia	0.103	0.096	0.111	0.169	0.499	0.667
Poznan	0.085	0.080	0.103	0.141	0.638	0.798
Silesia	0.035	0.038	0.050	0.074	0.325	0.424
Pomerania	0.063	0.052	0.060	0.119	0.807	0.908
Brandenburg	0.111	0.083	0.106	0.129	0.461	0.501
Saxony	0.090	0.068	0.079	0.109	0.356	0.378
Westphalia	0.058	0.044	0.069	0.096	0.392	0.376
Rhineland	0.039	0.041	0.058	0.087	0.397	0.410

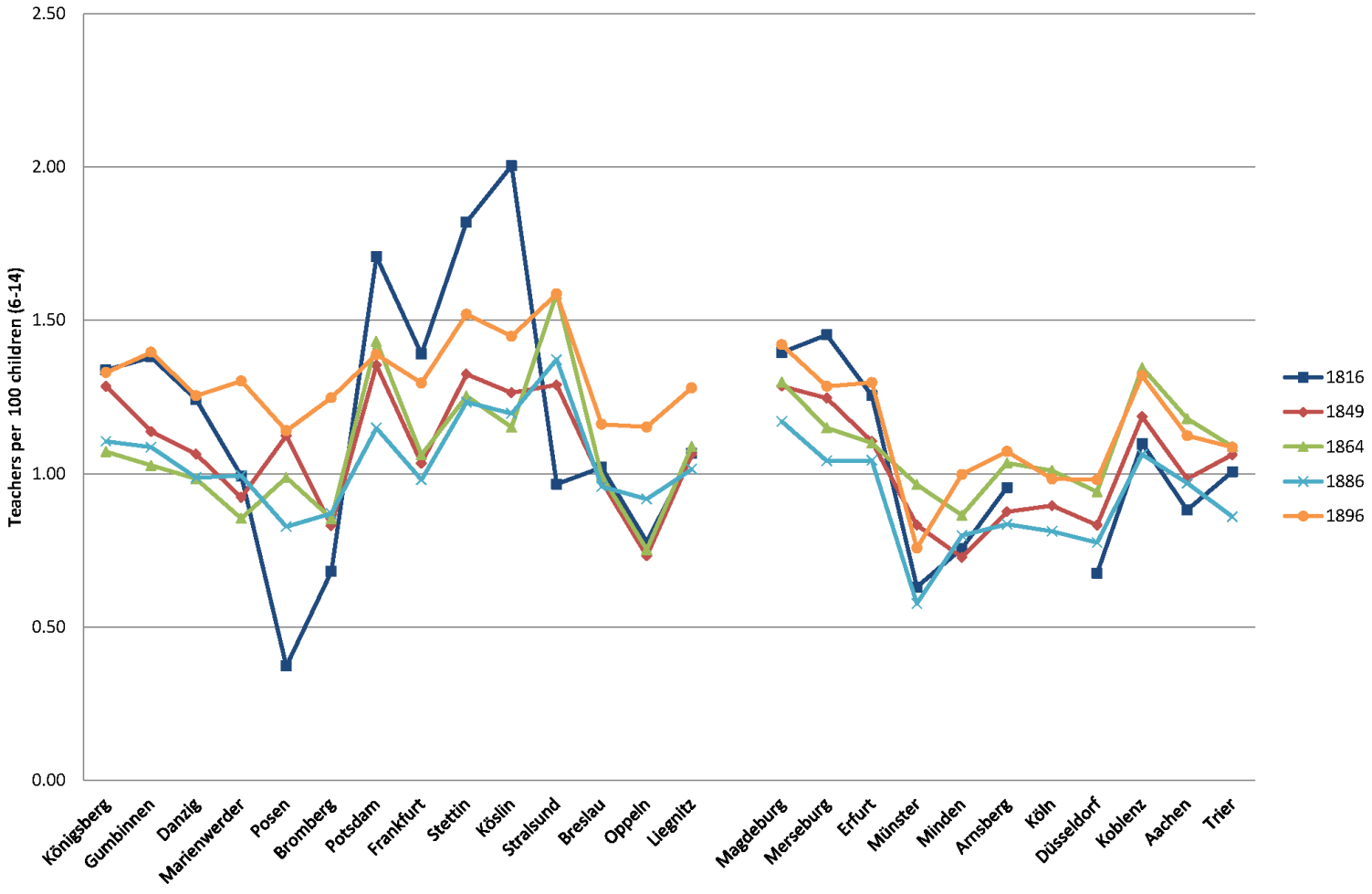
Note: State expenditures for public primary schools in German Marks per capita at the province level. Source: Own calculations according to Königliches Statistisches Bureau in Berlin (1889).

Figure D-6: Schools per 100 children, 1816-96



Note: Number of schools per 100 children at school-age (6-14) at the district level. Districts are approximately ordered from east to west, the gap roughly representing the river Elbe. Source: See Appendix A.2 for data sources and details.

Figure D-7: Teachers per 100 children, 1816-96



Note: Number of teachers per 100 children at school-age (6-14) at the district level. Districts are approximately ordered from east to west, the gap roughly representing the river Elbe. Source: See Appendix A.2 for data sources and details.

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