# Serfdom and Agricultural Efficiency: Evidence from the Russian Empire

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Working paper
February 2010

## Abstract

How did the institution of serfdom influence the agricultural performance of peasants? What form of rent was allowed to maximize the serfs' efficiency? Our paper addresses these questions by comparing agricultural productivity in the provinces with the different contributions made by various categories of peasants. We operate with province-level data for 50 provinces of European Russia that covers the period from the 1800s to the 1880s. Our findings are the following: 1) Serfs demonstrated significantly lower efficiency than state peasants and free people. The last two categories of peasants farmed producing about double the yield of serfs. 2) The form of rent significantly affected serf productivity. However, the evidence that we provide is not conclusive because of the possibility of reversed causality problem that is not solved yet. 3) The effect of serfdom lasted for a considerable time after the implementation of the Emancipation reforms.

# 1 Introduction

Soviet historians blamed serfdom as a key reason for the low agricultural productivity of Russian peasants. But actually serfs were just one part of all labor engaged in agriculture. According to the census of population (1859), landlords' serfs numbered less than a half (47%) of all peasants. The other groups of peasants were freer than serfs and they did not suffer from exploitation and expropriation as much as serfs did. In our research we exploit the non-uniformity of serf distribution over the European part of the Russian Empire to study the effect of serfdom on agriculture.

Serfs paid landlords two forms of rent. One form of rent was payment in kind or in cash and the other was work done under the direction of the landlord. These two types led to different agriculture organization in the Russian village. In our research we also study the effect of the different forms of rent.

Our study is based on the decade aggregated and all cereals aggregated set of data for 50 provinces of the European part of the Russian Empire. It covers the period from the 1800s to the 1880s.

We provide evidence that serfs demonstrated significantly lower efficiency than other categories of peasants. This result is robust for all sets of instrument that we have tested in our study. There is also some evidence that the form of rent significantly affected productivity. This result is not conclusive enough due to the potential endogenity problem. Finally, we show that the effect of serfdom lasted long enough after the adoption of the Emancipation reforms.

The rest of the paper is organized as follows. In section 2 we review related literature. In section 3 we provide some historical overview where we consider different types of peasants in the Russian Empire in the period under study. In section 4 we formulate our hypotheses and describe the data. Section 5 presents the results of OLS and IV estimations. We draw conclusions in section 6.

## 2 Literature

A lot of studies that are devoted to Russian serfdom were made by soviet historians. Most of them blame serfdom as a-the reason for the decline of Russian agriculture in the middle of the 19th century. All researchers who study the pre-Emancipation period face the problem of poor statistics for that period. Most of the historians' research is based on small fragmentary data samples and large sets of anecdotal evidences.

One of the historians' works that is related to our research is a study done by Kovalchenko (1959). The author tested several possible explanations for low productivity such as technology (crop per capita, land usage, area under crop increase, etc.) and agricultural organization. He presumes that serfdom was the main cause of low agricultural efficiency in many provinces in European Russia.

At the same time, Dennison (2004) argues that good institutions could be adopted by landlords. They might reduce inefficiency of even provide some benefits to serfs. The article is based on a case study of the Sheremetiev estate Voshchazhnikovo. According to this article, the Sheremetievs did not just exploit serfs but tried to improve their living conditions. But the author notes that such solicitous masters were only found among landlords on large estates. Most serfs did not experience such care. In our study we examine how great the average efficiency of the serf-based economy was.

There are several versions of the cause of the Emancipation Reform. One of them argues that the Reform was promoted by the nobility because serfdom had become unprofitable for landlords. A paper written by Domar and Machina (1984) contradicts this view. The authors provide a set of models. Outputs of all estimations do not support the hypothesis that serf agriculture was profitless. However these models are based on assumptions that are quite questionable.

We should mention a study by Fogel and Engerman (1974). They provide some evidence that slavery in the USA was economically efficient. In our study we deal with a form of rent that required forced labor. This enables a discussion of the efficiency of forced labor using evidence from Russia.

Our study is partly related to Nafziger (2007). The author explores the influence of institutions on agricultural productivity in the post-Emancipation period. He studies the effect of the commune that was the strongest social and economic institution in the Russian village after Emancipation. The model that is presented in his paper studies how the institution of the commune affected agricultural efficiency through repartitions of land within the commune. In our research we explore the effect of serfdom which was the strongest social and economic institution and which concerned about half the population in the pre-Emancipation period.

## 3 Background information

The territory of Russia grew dramatically from 1500 to 1800. It appended vast territories of Siberia, southern lands near the Black and Caspian Seas and a part of Europe. After 1800 the social and political institutions in the area still depended on the story of the land before annexation.

From this point of view, the European part of the Russian Empire can be divided into two parts. Western lands were annexed from the Polish–Lithuanian Commonwealth after the Khmelnitsky uprising in the middle of the 17th century and during the three Partitions of Poland in 1772, 1793 and 1795. It was a densely populated territory with strong social and economic institutions. These institutions did not change dramatically after the repartition.

Territory to the south, east and north of Moscow was sparsely- populated. When the Russian annexed these lands they installed their institutions. From now on we will call the western part by this name and call all the other territory of European Russia the eastern part.

Below we consider the Russian social institutions that played an important role in agriculture. Next we will describe some western particularities.

The eastern part

The story of Russian serfdom started in the 15th century. Most peasants were initially free. They leased land from its owner (state or landlord) and paid rent to him. The most usual forms of rent were that some agricultural products were given to the landowner or some work was done for him. The first type was a prototype of 'obrok' and the second was a prototype of 'barshchina' (these forms of rent are described below). Often the rent was a mixture of these two types. Peasants paid rent only while they used land. They could stop agricultural activity and move to another territory if they had paid all the rent. At that time in Russia there were a lot of unused land and such migration was quite a common thing.

The end of the15th and the beginning of the 16th century was the time of the rise of the landed nobility. In order to protect this new class, the authority limited peasant migration. Ioann III stated in Sudebnik in 1497 that the only time period in which migration was allowed was a two-week interval once in a year: so-called Juriev Day. The more necessary nobility support was to the authorities, the fewer rights the authority left to the nobility's peasants. By 1649 all categories of peasants were already attached to the places where they lived. Since 1649 the search for runaway peasants became officially unlimited. Since then the nobility's peasants became inseparably attached to their masters.

In 1718-1724 Peter I introduced reform that classified all types of farmers into four main categories. 54% of all peasants lived on the nobility's land so they became landlord serfs. 23% of peasants lived on state land. All those farmers became state peasants. 12% of all peasants lived on the land of the Russian Church. They became monastic serfs but in 1764 they were reclassified as state peasants. The last large category of farmers (7%) was peasants who lived on the sovereign's family land. They were classified as 'udel'nye' serfs. At that time, all rights and duties of each of these new groups were accurately formulated. Below we outline the characteristics of landlords' serfs, state peasants and; 'udel'nye' serfs.

After the reform, landlords' serfs became more and more personally dependent on their masters. They had no personal property that could not be taken from them by their landlord. He could tell them what work to do and how to do it. The landlord could interfere in the private life of his serfs. For example he could even tell them whom to marry.

The two types of duties that were paid to a landlord were ‘barshchina’ and ‘obrok’. In the former case, the landlord divided his arable land into two parts. One part was given to his serfs. They worked on this land to feed themselves and their families. The yield from this land went to the serfs. The other part of land was the landlord’s plot. Serfs paid ‘barschina’ working several days a week on this plot. All yields from the landlord’s plot went to the landlord.

‘Obrok’ was payment in kind or in cash. In this system, the landlord provided all (or almost all) his arable land to his serfs. He did not manage them thoroughly but monitored their incomes. The volume of ‘obrok’ payment could easily be changed by the landlord as there was no contract between him and his serfs. Serfs could ask for a pass from their landlord to leave their village temporarily which serfs sometimes did.

State peasants were freer than serfs. This group consisted of personally free peasants who paid taxes and rent. The rent was ‘obrok’ with a small portion of ‘barschina’. They were attached to the land but could apply for a pass to go to work in other places. Actually, state peasants got passes considerably more often than landlord serfs did. But this was not a migration because they were registered in their village. State peasants had a wider set of possible occupations than landlords’ serfs. Although they could not own land they often sold the right to lease land plots to each other. So that was quite similar to ownership.

All state peasants were administered by a special Department of State Property (it became the Ministry of State Property in 1837). Its officials operated with macro level data. So they interfered peasant affairs more rarely than landlords interfered in their serf’s affairs. For example the volume of rent for state peasants was very seldom revised.

‘Udel’nye’ serfs were personally dependent on the sovereign’s family. But they were administered by the officials like state peasants. This administration was less thorough than the administration of landlord serfs. ‘Udel’nye’ serfs were exploited less than landlord serfs in order to protect the reputation of royalty. For this reasons we treat ‘udel’nye’ serfs as state peasants.

Free population

The southern and eastern borders of Russia were restless places in the 16$^{th}$ to18$^{th}$ centuries. Permanent raids by nomads and the cavalry of the Crimean and Siberian Khanates

wreaked havoc in the frontier areas. So several Cossack hosts were established on the southern and eastern borders. A free non-taxable population lived in the Cossack hosts who protected the borders and actively took part in military operations of the Russian monarch. Before the 19th century these lands had been populated by granting the following benefit to migrants. Runaway peasants did not return to their master from there. But the authorities stopped this benefit in the 19th century when these lands became populated enough. New runaway peasants were sought for thoroughly and returned back. In the East, Cossack lands were the main source of free labor in agriculture.

The distribution of different peasant types that existed in the 19th century was the following. Landlord serfs lived mostly in the central part of European Russia. The share of this category decreased with distance from the center. Before the rule of Peter I the monarchs granted noblemen densely populated land not far from Moscow, the capital of the country at that time[1]. The State had quite enough land in the central part to supply this demand. Catherine II (ruled from 1762 till 1796) almost stopped granting noblemen with state peasants. So the distribution pattern of state peasants did not change significantly since that time.

The western part

Western lands were of another kind. Almost all landlords' serfs had to pay severe 'barshchina' to their master. Very often serfs did not have their own plots and worked for the landlord seven days a week just for food. They were not hired labor because they were not able to leave their landlord. Serfs' rebellions often occurred in this area. After the annexation of these lands by the Russian Empire, almost all the local gentry saved their lands. Although some laws were issued to protect serfs, the situation did not change dramatically. So in the mid 1810s the Russian Emperor Alexander I freed all landlords' serfs in three Baltic provinces where exploitation was the most severe. Serfs obtain personal freedom but did not get land. They had to lease land or work for hire.

[1] It seems reasonable that most nobles demanded closer lands with many serfs, who generated profit, rather than waste lands farther away.

The severe conditions of serfs in the Baltic provinces are explained in some historical works[2]. These papers point to the fact that the Baltic nobility had German origins while the peasants were Estonians and Letts. This difference and some particularities of political institutions, led to the extreme poverty of serfs and exploitation by landlords.

We take the western border of Russia just before the Khmelnitsky uprising as a line between the western and eastern parts. Smolenskaya province we classify as an eastern province because it was controlled by Poland for too short a period to install western institutions.

### The Emancipation reforms

In 1861-1866 Alexander II introduced a set of reforms that granted personal freedom to all types of peasants. Landlords (or the State, in the case of state peasants) provided land plots to their peasants. These plots could be bought up. The State provided long term loans to each peasant to pay for a larger portion of the land cost. Peasant had to pay the rest of the land cost to his landlord himself. For some years, peasants could not leave their landlord and had to pay 'obrok' or 'barshchina' to him.

As long a peasant did not pay off all debt, he was attached to the landlord. This category of still attached peasants was called 'vremennoobyazannie' peasants. In 1881 the redemption was speeded up. All peasants bought plots from landlords by 1883. They were still borrowers of state loans but since then they worked for landlords only for hire.

## 4 Data and hypotheses

### Use of history for our study

We consider the time period from the very beginning of 19$^{th}$ century to the end of the 1880s. We pay more attention to the pre-Emancipation period. We expect that the form of agricultural organization influenced agricultural productivity.

[2] Kuznetsov and Lebedev (1958).

The channels of such influence might be the following. The first channel was incentives. The income of the free population and state peasants could not be monitored so thoroughly as the income of landlords' serfs. The landlord could easily expropriate all excess serf income and/or increase the rent. This possibility could reduce the incentive of serfs to work more.

The second channel worked through investment. There is plenty of evidence that many landlords were oriented to short term profits, not to long term development[3] . This policy led to extra extraction of resources from serf households that reduced their investment into agriculture.

At the same time, 'barshchina' provided landlords with a strong instrument of coercion (compared to 'obrok'). The landlord could provide serfs with a minimal amount of land, capital and time which was just enough to survive on. In such cases, serfs had to work as hard as possible to feed themselves and their families. So the landlord was able to recognize the actual efficiency of his serfs in evidence on their plots. Then the landlord would press his serfs for the same efficiency on his land. This recognition could not be precise if the portions of land, capital and time that the landlord left to his serfs were not the same[4]. In this case, the landlord could keep his serfs at subsistence level, too. But their maximal efficiency would be different on the master's plot and on their plots because of the different land/time ratio or capital/land ratio. Nevertheless, this possibility for coercion may have caused an excess of 'barshchina' productivity over 'obrok' productivity.

## Hypotheses

In the first half of the19th century the free population had a strongly non-uniform distribution across the European part of the Russian Empire as did state peasants. Even among landlords' serfs, the 'barshchina/obrok' ratio varied from one province to another. We expect this variation in agriculture organization to also be a significant source of variation in agricultural efficiency.

[3] Skrebitskiy (1868)

[4] In 1797 Paul I introduced a law that prescribed to limit 'barshchina' time, that serfs worked on landlords' plots, by three days. But this law was too often simply ignored by landlords.

Our main hypothesis is that serfdom has a significant negative effect on agricultural efficiency with respect to state peasants. We also expect a positive effect of freedom on agricultural efficiency with respect to state peasants who had limited freedom.

The freer peasants were, the more alternative ways of earning they had. So the negative effect of serfdom may work not only through less efficient use of labor force but also through the non-optimal allocation of the labor force. In the case of serfdom, some opportunities for higher profitability were missed because of mismanagement by landlords.

We also expect ‘barshchina' rent to lead to higher agricultural efficiency than ‘obrok’ rent. Finally, we expect the pre-Emancipation pattern of agriculture organization to influence agriculture after the Emancipation reform and even after he full redemption of peasants debts in 1883.

## Data Sources

The quality of agricultural statistics changed during the 19 century, so the level of data particularity differs in different decades.

Agricultural statistics in the Russian Empire were in quite a poor condition till the end of the century. A special agricultural program was launched only in 1883. Since this time, perfect annual data is available for each crop at the ‘uezd’-level (‘uezd’ was a subdivision of a province).

Before the 1860 the sources of agricultural statistics were the annual governors’ reports and statistics of the Ministry of the Interior (Ministerstvo Vnutrennikh Del) and the Ministry of State Property (Ministerstvo Gosudarstvennikh Imuxhestv). This province-level data includes agricultural indices (yield, total seeded grain) aggregated by all crops. Since these indices are quite volatile soviet historians aggregated them by decades. We managed to get this decade aggregated data. Were often data for some years were missing. So the decade averages were actually calculated using the data for 5-7 or even 3 years. We also have information about how many years aggregation was made for each province in each decade.

Data for the 1860s has a similar format to the pre-Emancipation one, but all crops are grouped into spring and winter crops. Data for the 1870s is more detailed. It includes annual information about a wide range of crops.

It was yield (the ratio of harvested amount of grain to seeded amount of grain) that was measured in the pre-Emancipation period. Yield was measured by partial threshing[5]. So the actual data that was used for statistical needs was the estimations of yield and total amount of seeded grain. Total harvested amount of grain was calculated from these figures. This approach can draw some criticism because of the possibility of the bias of such estimates. But the leading historian on the subject Nifontov (1974) showed that these yield estimations are adequate[6].

We pay most attention in our work to the pre-Emancipation period. So we have standardized the collected data to the format of available pre-Emancipation statistics: all-crop aggregation and decade aggregation.

The goal of our research is to study the effect agriculture organization (serfdom, free peasantry and state peasantry) on agricultural efficiency. How can the variation in agricultural organization be caught? In our research we apply two approaches. The first one is based on the estimation of different categories of labor that was engaged in agriculture. Unfortunately the exact figures for labor are unavailable so we used data on categories of population as a proxy for labor. In the second approach we utilize agricultural statistics: how much crop was done by different categories of farmers.

Both data sets on agricultural organization include information about only one time period: 1840-1860 for crop and population data. We assume that agricultural organization did not change much during the first half of 19$^{th}$ century[7]. Extend the data to all the pre-Emancipation period under study. This does not allow us to try panel estimation so we try pooled regression estimation instead.

[5] The key feature of this approach is that the data for harvested and seeded amounts of crop was collected not for all arable land but for a number of small plots distributed over the province. This allowed to estimate average yield in the province. Total data (for all arable land) was collected only for seeded amount of grain.

[6] He provided a set of arguments that estimations of yield agreed with actual yield. One of them is that estimations that were made by independent organizations on different test plots gave quite similar results.

[7] The significant changes in population structure were caused by Baltic reform of Alexander I. We make some adjustments in the data for three Baltic provinces in the pre-reform period.

The available data on agricultural organization requires some adjustments. First, it does not reflect the results of Baltic reform of Alexander I when all landlord serfs were freed. The 1820s and 1830s is likely to be transitional period in these provinces. There is a problem of the classification of former landlord serfs at this period because they were no more fully dependent serfs but didn't become fully free to that moment. Actually we have data on yield for only one Baltic province for 1820s and no data on yield for Baltic province for 1830s. We excluded this observation in order to avoid misclassification. So the data for Baltic provinces that is included in our sample covers the time periods of 1800-1820 and 1840-1860. For 1800-1820 we classify peasants that farmed on the landlords land as landlord serfs. For 1840-1860 we classify peasants that farmed on the landlords land as free people.

Summary statistics and a correlation matrix are provided in Table 3 and Table 5. We are going to deal with high correlations between some independent variables by means of IV estimation.

## Model description

As noted above, we are going to use two sets of data (population and crop) that describe agricultural organization. The population set includes data on the categories of state peasants, 'barshchina' serfs, 'obrok' serfs and free people in the total labor force.

Regarding the crop set, we have groups of state peasants' crop, free people's crop, crop prepared by serfs for landlords and serfs' crop grown for themselves. The last two coefficients require some explanation.

'Barshchina' serfs spent some time working for their master (on the landlord's plot) and some time working for themselves (on their plots). 'Obrok' serfs worked only for themselves but made some payments in kind or in cash. Landlords provided 'obrok' serfs with a higher share of their land. If the landlord had only 'obrok' serfs he usually provided them with all his land. Crop grown by serfs for landlords was total crop prepared only by ' barshchina' serfs on landlords' plots. Serfs' crop for themselves was a sum of the total crop grown by 'barshchina' serfs on their plots and that grown by 'obrok' serfs.

We use the ratio of harvested amount of grain to seeded amount of grain as the measure of productivity which we call yield. The reason is that the initial data for agricultural statistics were estimations of yield and total crop. We use the initial data to reduce noise in the dependent variable.

We mentioned above that often the decade agricultural data was averaged by less than ten years. That was caused by the lack of data. The more data was used in decade aggregation the more reliable would be the agricultural index. It seems reasonable to put more weight to observations with more reliable figures. So, we weight each observation proportional the number of years for which data is available for a given province in a given decade. Table 4 provides information about such availability of agricultural data.

# 5 Estimation

## OLS estimation

In order to test whether agricultural organization affected productivity, we estimate the following model:

$$\text{Grain yield}_{it}=\beta_0+ \boldsymbol{\beta_1}\mathbf{`X_{it}}+ \boldsymbol{\beta_2}\mathbf{`S_i}+d_t+\varepsilon_{it}$$

Where $\mathbf{X_{it}}$ is the set of agricultural organization variables, $\mathbf{S_i}$ is the set of controls for land quality and climate, and $d_t$ is time effect. For population classification we report the results of two regressions. In the first one we distinguish between ‘barshchina’ and ‘obrok’ serfs. In the second we aggregate all landlord serfs in one group (the variable *landlords' serfs*).For crop classification we report the results of two regressions too. In the first one we distinguish between ‘barshchina’ crop and serfs’ crop for themselves. In the second we aggregate all landlord serfs in one group (the variable *total serfs' crop*).

Table 6 presents regression results for population structure and crop structure of agricultural organization respectively. Column 1 provides results without the aggregation that was mentioned above; column 2 provides results with such aggregation.

The results are consistent with the expectations that we stated above. Free people are more efficient in both classifications. From the population structure regression it follows that both 'barshchina' and 'obrok' households are less efficient that state peasants, but the former are more efficient than the latter..

Crop on landlords' plots (*crop on landlords' plots* in crop classification) produced a much higher yield than all crop of 'barshrchina' serfs (*barshrchina serfs* in population classification aggregates crop on landlords plot and crop on 'barshchina' serfs' plots). This means that the yield on landlords' plot was higher than the yield on 'barshchina' serfs' plots. We interpret this fact in the following manner.

A landlord could choose better land for his plot (actually landlords did this according to historical anecdotes[8]). He could also allocate labor and capital for his plot more than it should be in an equal distribution. For example, he could (and landlords did this too) make serfs spend disproportionately more time on his plot so that they were not able to work so thoroughly on their own plots. In this case, a positive sign for the *crop on landlords' plots* coefficient does not mean that landlords' management was more efficient than serfs' self-organization. It could mean that a landlord increased productivity on his plot at the cost of productivity reduction on the serfs' plots. The average effect of barchina is negative in comparison with state peasants.

The size of the effect is the following. The transformation of one state peasant into a 'barshchina' serf would reduce his agricultural efficiency by 0.876. This is equal to 0.876/3.521 *100%=25% reduction of yield and 0.876/(3.521-1) *100%=36% reduction of profitability of grain planting. The transformation into 'obrok' serf would cause a 44% reduction of yield and a 62% fall in profitability. At the same time the transformation of state peasant into free men would cause a 20% increase of yield.

*Total serfs' crop* is less quantitatively interpretable. This parameter is the sum of 'obrok' serfs' crop and 'barshchina' serfs' crop on their plots. So the coefficient at this parameter is an average of the productivity of 'obrok' serfs' and the productivity of 'barshchina' serfs' on their plots.

Instrument variables

[8] Semevskiy (1881), Semevskiy (1901), Skrebitskiy (1868), Kluchevskiy (1959).

The key identifying assumption in our analysis is that the distribution of different types of agricultural organization is uncorrelated with agricultural productivity other than through the influence of agricultural organization on agricultural productivity. There are two potential reasons why this assumption may not be satisfied. The first is the effect of reversed causality. Landlords set 'barshchina' in southern provinces with fertile land more often than in provinces less suitable for agriculture. So the type of rent in a landlord's household could possibly depend on yield. The same problem may occur in free population distribution or state peasants; distribution. Even if population distribution does not depend on yield, crop structure could depend on it. A freer population could choose some other occupations if yield was low enough (in other words seed only if the yield is high). The second reason for failure of the assumption mentioned above is the potential problem of omitted variables.

To solve this problem we do instrumental estimation. The explanation for our choice of instruments is the following. First, we consider separately the eastern and western parts of the country where the stories of the development of agricultural organization were different. In the eastern provinces we exploit the fact that the fraction of landlord serfs declined as the distance from Moscow increased. The same tendency was seen for population density. We choose population density calculated for the earliest time moment and distance from Moscow as the variables that were responsible for the share of landlords' serfs.

In the east the free population lived mostly at the eastern and southern edge of European Russia. As we mentioned in the historical review, settlements of free people were founded to resist the raids of nomads and warlike neighbors. We construct the dummy variable *raids_east* that equals 1 only for the provinces (Donskoe Voysko, Stavropolskaya, Samarskaya, Astrakhanskaya and Orenburgskaya provinces) that suffered from such raids. This instrument stands for the free population in the 19$^{th}$ century.

Unfortunately we have not managed to find an instrument variable to distinguish 'obrok' and 'barshchina' in the east. It turned out that fertility of land is a good predictor for the choice of landlords. This inability to distinguish 'barshchina' and 'obrok' makes us combine different types of landlord households into one group.

In the western provinces the distribution of landlords' serfs was more or less uniform. We instrument this parameter with a constant. The following dummy variable was constructed. It is

equal 1 if the province is western and 0 otherwise. This *western_province* dummy is used as the instrument for the portion of landlords' serfs in the west.

We do the following to instrument free population in the west. The dummy *reform_west* was constructed. It is equal 1 or the three Baltic provinces (Estlyandskaya, Liflyandskaya and Kurlyandskaya provinces)[9] after the reform. It is equal 0 for these Baltic provinces in 1800-1820 and for all other western provinces in all pre-Emancipation period. *reform_west* is an instrument for free population in the west. As mentioned in the historical section, the necessity for the emancipation of the Baltic serfs appeared due to the ethnic difference between the nobility and peasants. So *reform_west* is likely to be an exogenous variable.

We use the following set of instruments:

*Moscow dist**(1-*western_province*), *density_1795**(1-*western_province*), *raids_east, western_province, reform_west.*

Both *Moscow_dist* and *density_1795* stand for the share of landlords serfs. So we try specifications with both variables and with only one of these variables.

Population density in the western part of the country is distributed more or less uniformly. So we also try a specification where population density stands for the percentage of landlord serfs as in the eastern provinces. In that case we multiply *western_province* by *density_1795* as this variable stands for the share of landlord serfs in the west. We also multiply *reform_west* by *density_1795* because only landlord serfs were freed and state peasants were still not free. So the set of instruments are the following:

*Moscow_dist**(1-*western_province*), *density_1795**(1-*western_province*), *raids_east, density_1795*western_province, density_1795*reform_west.*

Here we cannot exclude *density_1795**(1-*western_province*) from the set of instruments otherwise our argumentation about the analogous use of density for eastern and western provinces does not work. Here we try only two specifications: with *Moscow_dist**(1-*western_province*) and without it.

Actually we may add some endogenity when we include population density into the set of instruments. The reason is that before the period under study serfs could be traded without land

[9] In these provinces serfs were emancipated in the middle of the 1810s

and then led to estate of their new master. So landlords could possibly buy serfs in nonagricultural regions (where yield was lower) and led them to agricultural regions with a higher yield. We believe that such migration did not shape the distribution of population density. Nevertheless we cannot fully trust specifications where we include population density. So we use the following set of instruments as the primary one because it is the most exogenous specification:

*Moscow_dist**(1-*western_province*), *raids_east, western_province, reform_west.*

We compare the results of this set with the results of the other specifications to obtain a robustness check.

Above we have described the variables that instrument population structure. We do not find other variables that could explain crop structure not through population structure and not add endogenity at the same time. So we use the same sets of instruments for both population and crop structures.

First stage estimation results for the primary instrument set are provided in Table 7 for both crop and population classifications. In the case of population classification F-statistics for excluded instruments equal 95.0 for *landlords' serfs* and 92.3 for *free people*. In the case of crop classification F-statistics for excluded instruments equal 167.0 for *total serfs' crop* 155.2 for *free people's crop*. But such a high values of F-statistics is not only the result of good instrument validity but also the result of a small variation in agriculture organization variables. This variation is due to the Baltic provinces and due to the different sample size for different decades.

IV estimation results

Table 8 and Table 9 present the results of IV estimation. Different sets of instruments give quite similar results. The difference between free population efficiency and serf efficiency remains fixed. All coefficient variation in each table is due to variation in the value of the constant that stands for state peasants' efficiency. Since we have aggregated landlord serfs into one group we can change our benchmark from state peasant to landlord serfs.

Table 10 and Table 11 present regression results with serf efficiency as a benchmark. The results of all IV estimations are similar to OLS results for serf efficiency and free people efficiency. Estimation of state peasants' efficiency is not so stable. It varies from one specification to another. All IV estimations of that coefficient are higher than OLS estimation. Moreover, both population and crop specifications give the same results.

IV results agree with the hypotheses that we stated above. The main difference between OLS and IV estimation is the following. From OLS estimation it follows that free people were significantly more efficient than state peasants. But from IV estimation it follows that free people were as efficient as state peasants. Moreover, state peasants were slightly more efficient than free people in the case of crop specification.

Similar efficiency of state peasants and free people can be easily explained. State peasants were self-organized. They were not managed as serfs. They did not face the risk of expropriation of income if it increased. They had property that belonged to them that could suddenly be taken away by someone. They could even sell the right to rent a particular plot as if they owned it. There were three main differences between state peasants and free people. First, state peasants could not move easily from one place to another. Then they had a rather limited set of possible occupations alternative to agriculture. Finally, they paid fixed 'obrok' rent. The first distinction could negatively influence agricultural efficiency as it might limit agricultural actions. The second one could stimulate them to work more in agriculture because of the unavailability of some other highly profitable activities. The third distinction resulted in two effects. Rent reduced self-investments in agriculture because capital was moved away from the village. But this rent was fixed and did not change with the increase in peasants' income. So rent did not discourage them like serfs who could suffer from the expropriation of extra income or from rent increase in the case of a temporarily high income. So the logic that we have used to explain serfs' disadvantage does work here. We cannot hypothesize whether free people would work better or not.

However there is one more explanation of lower serf productivity. Serfs lived mostly in the highly populated center of European Russia while state peasants and free people lived far from Moscow. This geographic variation of peasant types could be correlated with the amount of the available land per worker. Serf farming could possibly suffer from soil depletion so we should check whether yield experienced the effect of agricultural organization or just the effect of the sufficiency of the amount of arable land. To do this we have tried two more controls in our

regression equation. The first control is the amount of arable land in a province divided by the total current population. The second control is crop per unit of arable land. The results are presented in Table 12 and Table 13.New controls do not considerably change the results of IV estimation of agricultural organization variables. So the effect of lack of land does not explain the lower efficiency of serfs.

Post-Emancipation productivity

In this section we study the effect of pre-Emancipation agricultural organization on post-Emancipation productivity. Technically we would estimate the effect of 1850s agricultural organization on the agricultural productivity in 1860s, 1870s and 1880s.

The results of estimation are presented in Table 14 and Table 15. The coefficients for 1800-1860 simply repeat the results of our pre-Emancipation estimations. For 1860s, 1870s and 1880s we try the following models. The dependent variable is yield in the corresponding decade. The regressors are agricultural organization variables for 1850s, geography and land quality controls. The results are provided for least squares and instrumental variables estimation methods for both population and crop classifications.

No wonder that the effect pre-reform agricultural organization extends to 1860-1880. In the 1860s, former serfs were still attached to their landlords and paid ‘barshchina’ or ‘obrok’. ‘Vremennoobyazannie’ peasants still constituted about 15% of all peasants in 1881 and were attached to their landlords and paid ‘barshchina’ or ‘obrok’. Agricultural data for the 1870s include figures for 1870-1872 when the share of ‘vremennoobyazannie’ peasants was substantially higher than 15%.

Agricultural data for the 1880s include figures for 1883-1887 when there were no vremennoobyazannie peasants at all. This means that the effect of pre-reform agricultural organization was prolonged after complete emancipation.

Interpretation of such effects may be the following. First, peasants did not manage to accumulate enough capital for such a short period without landlord expropriation. Second, the manner in which households farmed changed gradually. In the pre-emancipation period the income of state peasants and free people depended on their efforts. They could improve their

social conditions if they worked harder. Landlord serfs suffered from expropriation and the risk of rent increase. Lack of incentives could lead to lower efforts by serfs who had developed that habit. After the Emancipation reforms, this bad habit of and lack of initiative may have caused lower efficiency of former serfs.

## 6 Conclusion

In this paper we document the effect of serfdom on the agricultural efficiency of Russian peasants. We have used decade aggregated agricultural, province-level data for the period from the 1800s to the 1880s and population data for the pre-Emancipation period. Our identification was based on exogenous variation of the distribution of different categories of peasants and crops grown by these groups. The results of our study are the following. First, we found that landlords' serfs were at a statistically significant disadvantage compared to state peasants and free people. This result passed the robustness check by IV estimations using different sets of instruments. We provide two main explanations of these productivity relations.

The first one is based on incentives. A landlord could easily monitor the income of his serfs. A higher income could cause an instantaneous rent increase or the expropriation of the excess of a serf's assets. The free population and state peasants did not suffer from such extortion so they had all incentives to work harder in order to increase their wealth.

The second explanation works through investments. According to plenty of historical facts, many landlords did not worry about the long- term development of serf farming. They preferred immediate profits. These preferences led to extra extraction of resources from serf households that reduced investments by serfs in agriculture.

There is also one possible interpretation of that effect. State peasants and the free population mostly lived far from Moscow. Landlords' serfs lived in the densely populated center of European Russia. So the latter could suffer from lack of arable land. For this reason we included a regressor that stands for arable land allotment and crop per unit of arable land. This does not significantly change the effect of serfdom.

Secondly, we found weak evidence of any excess of the efficiency of 'barshchina' serfs over that of 'obrok' serfs. Moreover, crop that was grown on landlords' plots was more

productive than that of 'barshchina' serfs on their plots. A possible interpretation of that result is that landlords could choose better land for their plots and/or make serfs work more on their plots. Landlords could also press their serfs to demonstrate high productivity on their (landlords') plots.

Unfortunately, serfs that lived in areas with fertile soil were mainly 'barshchina' serfs. 'Obrok' serfs lived mainly in areas with moderately fertile soil. This fact allows an alternative interpretation through endogenity of rent type distribution. This problem should be solved by a proper instrument for rent type. But we have not yet found such an instrument. Finally, we obtained some evidence that pre-reform agricultural organization influenced the post-reform efficiency of peasants.

Below we provide some self-criticism of our findings.

First, a harvested/seeded ratio is not the only indicator of agricultural efficiency. One may increase a crop (e.g. seed thicker or use more land) to increase the total harvested amount of grain. At the same time, this tactic would be likely to reduce the harvested/seeded ratio. Low quality of data does not allow us to use output per worker as an indicator of efficiency. The main problem is that we do not actually know the share of labor that was involved in grain planting. So estimations of output per worker would be too noisy. In our specification, this problem is not so crucial because the shares of different categories of peasants are almost proportional to the shares of different categories of crops. So the shares of different categories of labor that was involved in grain planting were quite similar in each province.

Controlling for the amount of arable land per person or crop per unit of arable land does not considerably change the results. However this may be caused by the low quality of data on arable land, by total population use as a proxy of labor in grain planting, or by a reversed causality problem. The last problem means that actually thickness of sowing or land use decision may be caused by the usual value of yield.

Another problem appears because of the aggregation of all cereals into one category. There might be a relatively high correlation between the geographical location of provinces and agricultural organization. The set of cereals could vary geographically too, so yield variation could be caused by a variation in cereal set. We deal with this problem using data on different cereals for the 1870s and 1880s.

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# Appendix 1

Figure 1

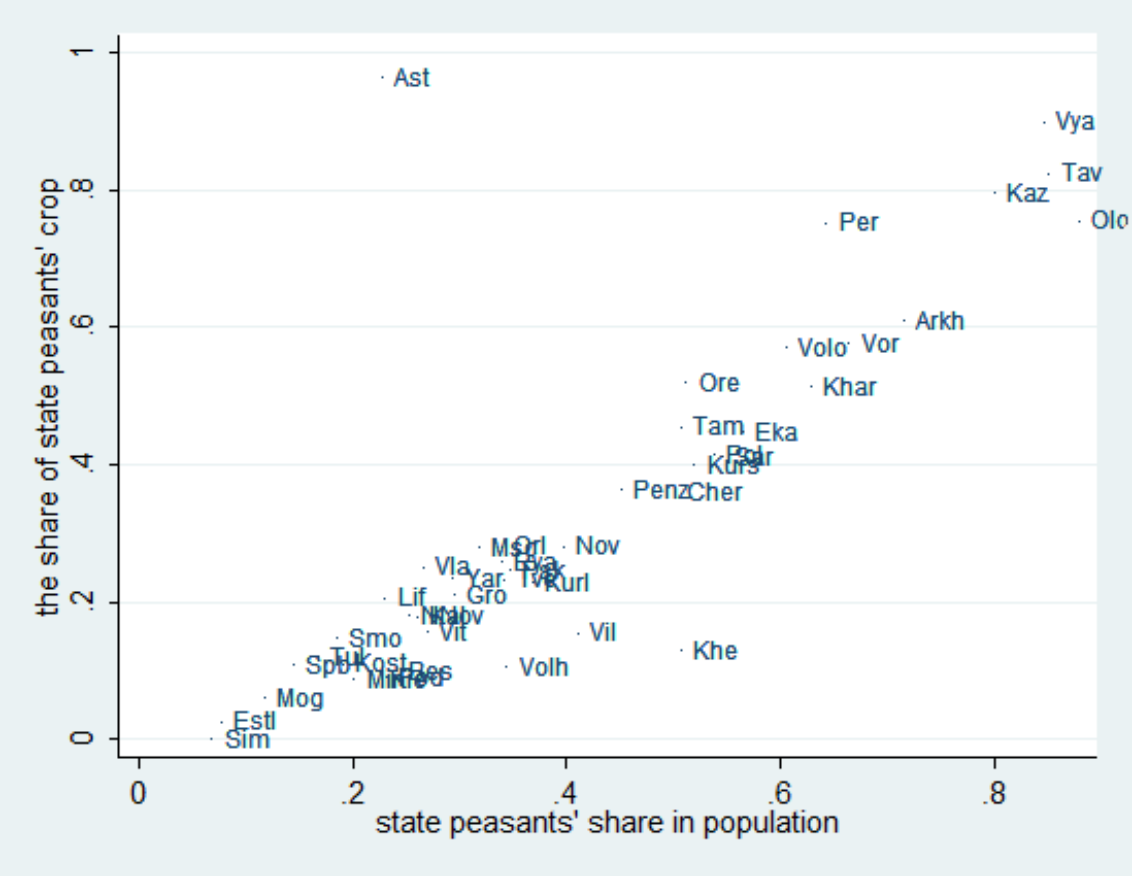
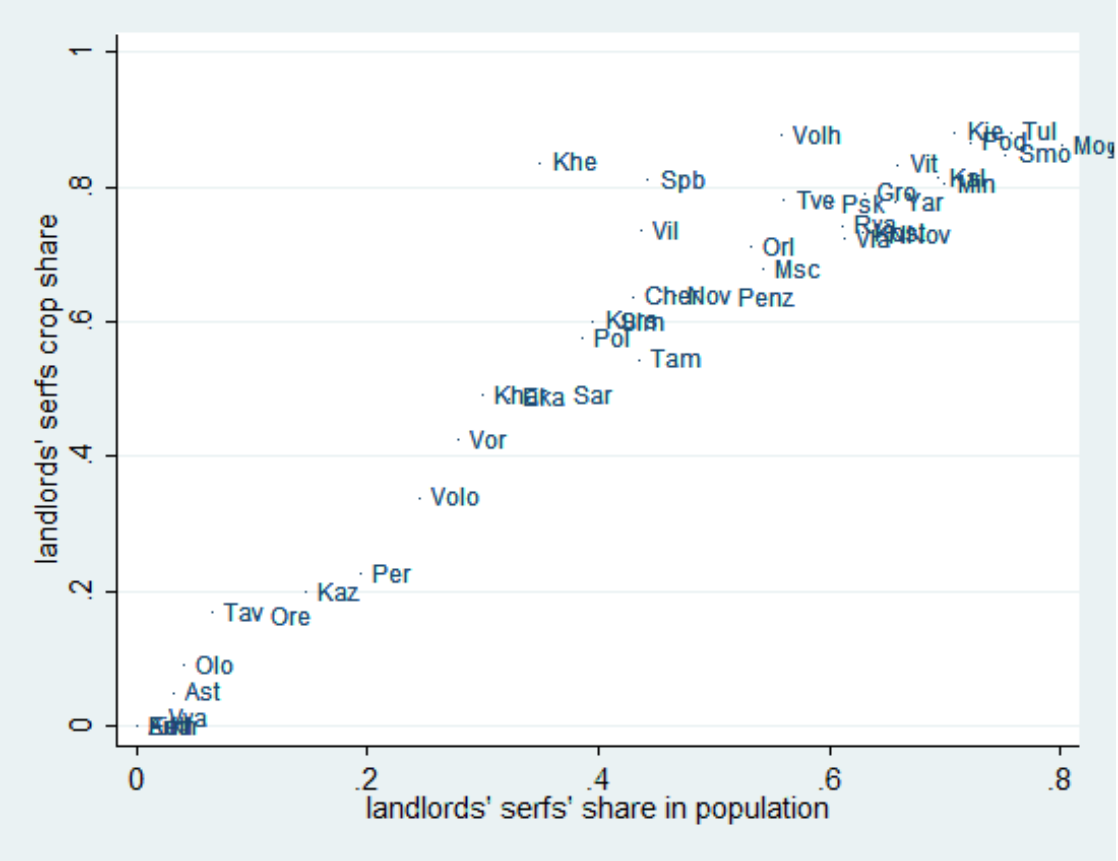


Figure 2


landlords' serfs crop share
0
.2
.4
.6
.8
1
landlords' serfs' share in population
0
.2
.4
.6
.8
Volh
Khe
Spb
Vil
Orl
Msc
Penz
Pol
Tam
Sar
Vor
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# Appendix 2

Table1. State peasants' crop share and state peasants share in population

| State peasants' crop is a dependent variable | | |
|---|---|---|
| | Coef. | Robust Std. Err. |
| state peasants | 0.962 | 0.060 |
| Constant | -0.056 | 0.034 |

Table 2. Crop share of landlords' serfs and share in population of landlords' serfs

| Total serfs' crop is a dependent variable | | |
|---|---|---|
| | Coef. | Robust Std. Err. |
| landlords' serfs | 1.132 | 0.033 |
| Constant | 0.083 | 0.018 |

Table 3. Summary statistics

| Variable | Obs | Mean | Std. Dev. | Min | Max |
|---|---|---|---|---|---|
| grain yield | 159 | 3.39 | 0.72 | 2.05 | 5.09 |
| free people | 270 | 0.13 | 0.20 | 0.02 | 0.92 |
| landlords' serfs | 270 | 0.42 | 0.24 | 0.00 | 0.80 |
| state peasants | 270 | 0.45 | 0.23 | 0.00 | 0.93 |
| free people's crop | 282 | 0.07 | 0.18 | 0.00 | 0.97 |
| total serfs' crop | 288 | 0.57 | 0.29 | 0.00 | 0.98 |
| state peasants' crop | 282 | 0.35 | 0.25 | 0.02 | 0.99 |
| chernozem | 300 | 0.41 | 0.44 | 0.0 | 1.0 |
| longitude | 300 | 6.61 | 8.47 | -7 | 28 |
| latitude | 300 | 8.81 | 4.25 | 0 | 18 |
| western province | 300 | 0.36 | 0.48 | 0 | 1 |
| arable land per capita | 282 | 2.24 | 0.92 | 0.42 | 4.84 |
| crop per unit of arable land | 294 | 0.53 | 0.35 | 0.10 | 2.40 |

Table 4. Availability of agricultural data

| | grain_yield | | | | | weight |
|---|---|---|---|---|---|---|
| Decade | Obs | Mean | Std. Dev. | Min | Max | Mean |
| 1800s | 37 | 3.58 | 0.81 | 2.27 | 5.06 | 0.90 |
| 1810s | 16 | 3.40 | 0.76 | 2.25 | 4.42 | 0.93 |
| 1820s | 10 | 3.41 | 0.79 | 2.16 | 4.58 | 0.90 |
| 1830s | 0 | - | - | - | - | - |
| 1840s | 48 | 3.36 | 0.63 | 2.24 | 4.93 | 0.95 |
| 1850s | 48 | 3.28 | 0.72 | 2.05 | 5.09 | 0.92 |
| 1860s | 50 | 3.24 | 0.81 | 2.05 | 5.49 | 0.30 |
| 1870s | 48 | 3.65 | 0.79 | 1.94 | 5.98 | 0.29 |
| 1880s | 49 | 4.05 | 0.74 | 2.83 | 5.92 | 0.50 |

Table 5. Correlation matrix

| | grain yield | free people | landlords' serfs | state peasants | free people's crop | total serfs' crop | state peasants' crop | chernozem | longitude | latitude | western province | arable land per capita | crop per unit of arable land |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| grain yield | 1.00 | | | | | | | | | | | | |
| free people | 0.32 | 1.00 | | | | | | | | | | | |
| Landlords' serfs | -0.47 | -0.47 | 1.00 | | | | | | | | | | |
| state peasants | 0.26 | -0.29 | -0.71 | 1.00 | | | | | | | | | |
| free people's crop | 0.39 | 0.80 | -0.44 | -0.16 | 1.00 | | | | | | | | |
| total serfs' crop | -0.44 | -0.49 | 0.95 | -0.64 | -0.49 | 1.00 | | | | | | | |
| state peasants' crop | 0.22 | 0.00 | -0.77 | 0.84 | -0.14 | -0.79 | 1.00 | | | | | | |
| chernozem | 0.38 | -0.25 | -0.16 | 0.37 | -0.22 | -0.06 | 0.22 | 1.00 | | | | | |
| longitude | -0.09 | -0.18 | -0.33 | 0.50 | -0.29 | -0.40 | 0.66 | 0.19 | 1.00 | | | | |
| latitude | -0.24 | 0.07 | -0.12 | 0.07 | 0.27 | -0.22 | 0.06 | -0.71 | 0.18 | 1.00 | | | |
| western province | 0.26 | 0.23 | 0.12 | -0.31 | 0.33 | 0.19 | -0.45 | 0.06 | -0.66 | -0.36 | 1.00 | | |
| arable land per capita | 0.14 | -0.17 | -0.08 | 0.23 | -0.23 | 0.08 | 0.07 | 0.52 | -0.04 | -0.56 | 0.15 | 1.00 | |
| crop per unit of arable land | 0.13 | 0.12 | -0.30 | 0.23 | 0.26 | -0.37 | 0.24 | -0.33 | 0.18 | 0.54 | -0.16 | -0.60 | 1.00 |

Table 6. OLS estimation with and without separation into rent type. Population and crop structures in one table

| COEFFICIENT | OLS | OLS |
|---|---|---|
| | grain yield | |
| free people | 0.765*** | 0.709*** |
| | [0.238] | [0.232] |
| barchina serfs | -0.877*** | |
| | [0.317] | |
| obrok serfs | -1.531*** | |
| | [0.286] | |
| Landlords' serfs | | -1.168*** |
| | | [0.241] |
| chernozem | 0.779*** | 0.797*** |
| | [0.163] | [0.168] |
| longitude&latitude | Yes | Yes |
| time dummies | Yes | Yes |
| Constant | 3.181*** | 3.331*** |
| | [0.325] | [0.292] |
| Observations | 147 | 147 |
| R-squared | 0.487 | 0.475 |

| COEFFICIENT | OLS | OLS |
|---|---|---|
| | grain yield | |
| free people's crop | 0.701* | 0.639* |
| | [0.369] | [0.357] |
| crop on landlords' plots | 0.673 | |
| | [0.702] | |
| crop on serfs' plots | -1.903*** | |
| | [0.376] | |
| total serfs' crop | | -1.085*** |
| | | [0.211] |
| chernozem | 0.536*** | 0.820*** |
| | [0.188] | [0.163] |
| longitude&latitude | Yes | Yes |
| time dummies | Yes | Yes |
| Constant | 3.545*** | 3.629*** |
| | [0.282] | [0.261] |
| Observations | 152 | 152 |
| R-squared | 0.489 | 0.453 |

Table 7. First stage estimation results for primary IV specification. Population and crop classifications in one table

| COEFFICIENT | landlords' serfs | free people |
|---|---|---|
| western_province | -0.257*** | 0.022 |
| | [0.0473] | [0.0167] |
| reform_west | -0.511*** | 0.669*** |
| | [0.0439] | [0.0509] |
| raids_east | 0.0248 | 0.553*** |
| | [0.0858] | [0.0625] |
| Moscow_dist*(1-western_province) | -0.0601*** | 0.00752*** |
| | [0.00659] | [0.00211] |
| chernozem | -0.160*** | -0.0369* |
| | [0.0608] | [0.0212] |
| longitude | -0.000848 | -0.00345** |
| | [0.00332] | [0.00148] |
| latitude | -0.0162** | -0.00131 |
| | [0.00702] | [0.00285] |
| dum_00 | 0.00858 | 0.00796 |
| | [0.0348] | [0.0105] |
| dum_10 | -0.0521 | 0.00262 |
| | [0.0344] | [0.0122] |
| dum_20 | 0.000306 | 0.0247 |
| | [0.0526] | [0.0240] |
| dum_40 | 0.00242 | 0.00412 |
| | [0.0304] | [0.0124] |
| Constant | 0.973*** | 0.0725** |
| | [0.0820] | [0.0332] |
| Observations | 147 | 147 |
| R-squared | 0.690 | 0.922 |

| COEFFICIENT | total serfs' crop | free people's crop |
|---|---|---|
| western_province | -0.242*** | 0.0648*** |
| | [0.0511] | [0.0117] |
| reform_west | -0.753*** | 0.750*** |
| | [0.0429] | [0.0353] |
| raids_east | -0.00764 | 0.128*** |
| | [0.122] | [0.0453] |
| Moscow_dist*(1-western_province) | -0.0634*** | 0.00379*** |
| | [0.00775] | [0.00141] |
| chernozem | -0.0985 | 0.0615*** |
| | [0.0624] | [0.0189] |
| longitude | -0.00745* | -0.00124 |
| | [0.00403] | [0.000818] |
| latitude | -0.0126 | 0.0104*** |
| | [0.00782] | [0.00256] |
| dum_00 | 0.00386 | -0.00315 |
| | [0.0350] | [0.0105] |
| dum_10 | -0.0687* | -0.000807 |
| | [0.0360] | [0.0135] |
| dum_20 | -0.0398 | 0.0129 |
| | [0.0631] | [0.0185] |
| dum_40 | 0.00238 | 0.00139 |
| | [0.0310] | [0.0105] |
| Constant | 1.118*** | -0.119*** |
| | [0.0891] | [0.0304] |
| Observations | 153 | 152 |
| R-squared | 0.752 | 0.916 |

Table 8. IV estimation results. State peasants as a benchmark. Population classification

| | grain yield | | | | | |
|---|---|---|---|---|---|---|
| COEFFICIENT | OLS | IV_primary[10] | IV_dummy Mosc_dens | IV_density Mosc_dens | IV_dummy dens | IV_density dens |
| Landlords' serfs | -1.168*** | -2.242*** | -2.164*** | -2.092*** | -2.123*** | -1.999*** |
| | [0.241] | [0.360] | [0.331] | [0.324] | [0.335] | [0.366] |
| free peaple | 0.709*** | 0.0239 | 0.0804 | 0.147 | 0.105 | 0.211 |
| | [0.232] | [0.329] | [0.308] | [0.313] | [0.308] | [0.337] |
| chernozem | 0.797*** | 0.480** | 0.504** | 0.529*** | 0.516*** | 0.557*** |
| | [0.168] | [0.210] | [0.199] | [0.200] | [0.195] | [0.205] |
| longitude&latitude | Yes | Yes | Yes | Yes | Yes | Yes |
| time dummies | Yes | Yes | Yes | Yes | Yes | Yes |
| Constant | 3.331*** | 4.304*** | 4.231*** | 4.160*** | 4.194*** | 4.074*** |
| | [0.292] | [0.406] | [0.379] | [0.375] | [0.379] | [0.407] |
| Observations | 147 | 147 | 147 | 147 | 147 | 147 |
| R-squared | 0.475 | 0.398 | 0.408 | 0.417 | 0.414 | 0.428 |

[10] We use the following names for our instrument sets

IV_primary: Moscow_dist*(1-western_province), raids_east, western_province, reform_west;
IV_dummy_Mosc_dens: Moscow_dist*(1-western_province), density_1795*(1-western_province), raids_east, western_province, reform_west;

IV_density_Mosc_dens: Moscow_dist*(1-western_province), density_1795*(1-western_province), raids_east, density_1795*western_province, density_1795*reform_west;

IV_dummy_dens: density_1795*(1-western_province), raids_east, western_province,reform_west;
IV_density_dens: density_1795*(1-western_province), raids_east, density_1795*western_province, density_1795*reform_west.

Table 9. IV estimation results. State peasants as a benchmark. Crop classification

| | grain yield | | | | | |
|---|---|---|---|---|---|---|
| COEFFICIENT | OLS | IV_primary | IV_dummy Mosc_dens | IV_density Mosc_dens | IV_dummy dens | IV_density dens |
| state peasants' crop | -1.085*** | -2.189*** | -1.966*** | -2.085*** | -1.830*** | -2.468*** |
| | [0.211] | [0.348] | [0.297] | [0.322] | [0.296] | [0.496] |
| free people's crop | 0.639* | -0.646 | -0.418 | -0.469 | -0.247 | -0.984 |
| | [0.357] | [0.465] | [0.423] | [0.467] | [0.425] | [0.685] |
| chernozem | 0.820*** | 0.759*** | 0.774*** | 0.761*** | 0.780*** | 0.744*** |
| | [0.163] | [0.167] | [0.160] | [0.163] | [0.156] | [0.174] |
| longitude&latitude | Yes | Yes | Yes | Yes | Yes | Yes |
| time dummies | Yes | Yes | Yes | Yes | Yes | Yes |
| Constant | 3.629*** | 4.531*** | 4.347*** | 4.444*** | 4.236*** | 4.754*** |
| | [0.261] | [0.339] | [0.302] | [0.321] | [0.299] | [0.442] |
| Observations | 152 | 152 | 152 | 150 | 152 | 150 |
| R-squared | 0.453 | 0.372 | 0.401 | 0.387 | 0.416 | 0.325 |

Table 10. IV estimation results. Lan serfs as a benchmark. Population classification

| | grain yield | | | | | |
|---|---|---|---|---|---|---|
| COEFFICIENT | OLS | IV_primary | IV_dummy Mosc_dens | IV_density Mosc_dens | IV_dummy dens | IV_density dens |
| state peasants | 1.168*** | 2.242*** | 2.164*** | 2.092*** | 2.123*** | 1.999*** |
| | [0.241] | [0.360] | [0.331] | [0.324] | [0.335] | [0.366] |
| free peaple | 1.876*** | 2.266*** | 2.245*** | 2.239*** | 2.229*** | 2.211*** |
| | [0.195] | [0.210] | [0.208] | [0.216] | [0.210] | [0.221] |
| chernozem | 0.797*** | 0.480** | 0.504** | 0.529*** | 0.516*** | 0.557*** |
| | [0.168] | [0.210] | [0.199] | [0.200] | [0.195] | [0.205] |
| longitude&latitude | Yes | Yes | Yes | Yes | Yes | Yes |
| time dummies | Yes | Yes | Yes | Yes | Yes | Yes |
| Constant | 2.163*** | 2.061*** | 2.067*** | 2.067*** | 2.071*** | 2.075*** |
| | [0.209] | [0.199] | [0.198] | [0.199] | [0.199] | [0.199] |
| Observations | 147 | 147 | 147 | 147 | 147 | 147 |
| R-squared | 0.475 | 0.398 | 0.408 | 0.417 | 0.414 | 0.428 |

Table 11. IV estimation results. Landlords' serfs as a benchmark. Crop classification

| | grain yield | | | | | |
|---|---|---|---|---|---|---|
| COEFFICIENT | OLS | IV_primary | IV_dummy Mosc_dens | IV_density Mosc_dens | IV_dummy dens | IV_density dens |
| state peasants crop | 1.085*** | 2.189*** | 1.966*** | 2.085*** | 1.830*** | 2.468*** |
| | [0.211] | [0.348] | [0.297] | [0.322] | [0.296] | [0.496] |
| free people's crop | 1.724*** | 1.543*** | 1.549*** | 1.616*** | 1.583*** | 1.484*** |
| | [0.273] | [0.236] | [0.236] | [0.252] | [0.239] | [0.280] |
| chernozem | 0.820*** | 0.759*** | 0.774*** | 0.761*** | 0.780*** | 0.744*** |
| | [0.163] | [0.167] | [0.160] | [0.163] | [0.156] | [0.174] |
| longitude&latitude | Yes | Yes | Yes | Yes | Yes | Yes |
| time dummies | Yes | Yes | Yes | Yes | Yes | Yes |
| Constant | 2.544*** | 2.342*** | 2.381*** | 2.359*** | 2.407*** | 2.286*** |
| | [0.221] | [0.216] | [0.208] | [0.211] | [0.206] | [0.239] |
| Observations | 152 | 152 | 152 | 150 | 152 | 150 |
| R-squared | 0.453 | 0.372 | 0.401 | 0.387 | 0.416 | 0.325 |

Table 12. Control for land use. Population classification

| | grain yield | | | | | |
|---|---|---|---|---|---|---|
| COEFFICIENT | OLS | IV_primary | OLS estimation | IV_primary | OLS estimation | IV_primary |
| state peasants | 1.168*** | 2.242*** | 1.243*** | 2.648*** | 1.130*** | 2.663*** |
| | [0.241] | [0.360] | [0.267] | [0.502] | [0.289] | [0.503] |
| free peaple | 1.876*** | 2.266*** | 1.886*** | 2.004*** | 1.834*** | 2.562*** |
| | [0.195] | [0.210] | [0.218] | [0.229] | [0.247] | [0.294] |
| arable land per capita | | | -0.074 | -0.162** | | |
| | | | [0.0759] | [0.0801] | | |
| crop per unit of arable land | | | | | -0.0673 | 0.453* |
| | | | | | [0.200] | [0.231] |
| chernozem | 0.797*** | 0.480** | 0.817*** | 0.386 | 0.808*** | 0.346 |
| | [0.168] | [0.210] | [0.182] | [0.251] | [0.177] | [0.251] |
| longitude&latitude | Yes | Yes | Yes | Yes | Yes | Yes |
| time dummies | Yes | Yes | Yes | Yes | Yes | Yes |
| Constant | 2.163*** | 2.061*** | 2.385*** | 2.602*** | 2.195*** | 1.799*** |
| | [0.209] | [0.199] | [0.278] | [0.325] | [0.245] | [0.245] |
| Observations | 147 | 147 | 141 | 141 | 145 | 145 |
| R-squared | 0.475 | 0.398 | 0.474 | 0.363 | 0.477 | 0.349 |

Table 13. Control for land use. Crop classification

| | grain yield | | | | | |
|---|---|---|---|---|---|---|
| COEFFICIENT | OLS | IV_primary | OLS | IV_primary | OLS | IV_primary |
| state peasants' crop | 1.085*** | 2.189*** | 1.111*** | 2.360*** | 0.860*** | 2.191*** |
| | [0.211] | [0.348] | [0.225] | [0.385] | [0.268] | [0.415] |
| free people's crop | 1.724*** | 1.543*** | 1.705*** | 1.458*** | 1.639*** | 1.482*** |
| | [0.273] | [0.236] | [0.284] | [0.241] | [0.292] | [0.251] |
| arable land per capita | | | -0.0266 | -0.0937 | | |
| | | | [0.0739] | [0.0788] | | |
| crop per unit of arable land | | | | | -0.406** | 0.0679 |
| | | | | | [0.201] | [0.243] |
| chernozem | 0.820*** | 0.759*** | 0.831*** | 0.787*** | 0.871*** | 0.773*** |
| | [0.163] | [0.167] | [0.170] | [0.185] | [0.164] | [0.167] |
| longitude&latitude | Yes | Yes | Yes | Yes | Yes | Yes |
| time dummies | Yes | Yes | Yes | Yes | Yes | Yes |
| Constant | 2.544*** | 2.342*** | 2.609*** | 2.569*** | 2.730*** | 2.282*** |
| | [0.221] | [0.216] | [0.261] | [0.292] | [0.254] | [0.275] |
| Observations | 152 | 152 | 149 | 149 | 150 | 150 |
| R-squared | 0.453 | 0.372 | 0.453 | 0.354 | 0.469 | 0.38 |

Table 14. Time effect. Population classification

| time period | 1800-1860 | 1860s | 1870s | 1880s | | 1800-1860 | 1860s | 1870s | 1880s |
|---|---|---|---|---|---|---|---|---|---|
| | | | | grain_yield | | | | | |
| COEFFICIENT | OLS | | | | | IV_primary | | | |
| state peasants | 1.168*** | 0.129 | 0.0197 | 0.535* | | 2.242*** | 1.544* | 1.087 | 1.318*** |
| | [0.241] | [0.648] | [0.359] | [0.313] | | [0.360] | [0.845] | [0.848] | [0.448] |
| free peaple | 1.876*** | 1.829*** | 1.777*** | 1.780*** | | 2.266*** | 2.334*** | 2.201*** | 2.156*** |
| | [0.195] | [0.553] | [0.470] | [0.332] | | [0.210] | [0.544] | [0.421] | [0.341] |
| chernozem | 0.797*** | 1.418*** | 1.608*** | 1.605*** | | 0.480** | 1.062** | 1.340*** | 1.423*** |
| | [0.168] | [0.357] | [0.369] | [0.210] | | [0.210] | [0.455] | [0.433] | [0.228] |
| longitude&latitude | Yes | Yes | Yes | Yes | | Yes | Yes | Yes | Yes |
| time dummies | Yes | No | No | No | | Yes | No | No | No |
| Constant | 2.168*** | 1.740*** | 2.436*** | 2.734*** | | 2.061*** | 1.577*** | 2.282*** | 2.612*** |
| | [0.215] | [0.414] | [0.332] | [0.242] | | [0.199] | [0.462] | [0.330] | [0.255] |
| Observations | 147 | 46 | 45 | 46 | | 147 | 46 | 45 | 46 |
| R-squared | 0.475 | 0.475 | 0.483 | 0.755 | | 0.398 | 0.383 | 0.428 | 0.719 |

Table 15. Time effect. Crop classification

| time period | 1800-1860 | 1860s | 1870s | 1880s | | 1800-1860 | 1860s | 1870s | 1880s |
|---|---|---|---|---|---|---|---|---|---|
| | | | | grain_yield | | | | | |
| COEFFICIENT | | OLS | | | | | IV_primary | | |
| state peasants' crop | 1.085*** | 0.292 | 0.262 | 0.525* | | 2.189*** | 1.598** | 1.334 | 1.159** |
| | [0.211] | [0.565] | [0.305] | [0.261] | | [0.348] | [0.798] | [0.890] | [0.459] |
| free people's crop | 1.724*** | 1.757*** | 1.808*** | 1.729*** | | 1.543*** | 1.854*** | 1.868*** | 1.920*** |
| | [0.273] | [0.584] | [0.473] | [0.365] | | [0.236] | [0.489] | [0.388] | [0.340] |
| chernozem | 0.820*** | 0.986*** | 1.156*** | 1.310*** | | 0.759*** | 0.965*** | 1.143*** | 1.286*** |
| | [0.163] | [0.230] | [0.347] | [0.213] | | [0.167] | [0.340] | [0.316] | [0.183] |
| longitude&latitude | Yes | Yes | Yes | Yes | | Yes | Yes | Yes | Yes |
| time dummies | Yes | No | No | No | | Yes | No | No | No |
| Constant | 2.628*** | 2.341*** | 3.057*** | 3.297*** | | 2.342*** | 2.061*** | 2.824*** | 3.175*** |
| | [0.239] | [0.257] | [0.307] | [0.258] | | [0.216] | [0.424] | [0.339] | [0.238] |
| Observations | 152 | 47 | 47 | 47 | | 152 | 47 | 47 | 47 |
| R-squared | 0.453 | 0.473 | 0.501 | 0.736 | | 0.372 | 0.381 | 0.435 | 0.707 |