Centre for
Economic
and Financial
Research
at
New Economic
School

June 2013

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Working Paper No 196

CEFIR / NES Working Paper series

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Abstract: We use mass mobilization for World War I as an exogenous source of variation in the labor force to test the extent of agricultural surplus in one of the most quintessential examples of labor surplus, late imperial Russia. We construct district-level panel data describing agricultural production in the Russian Empire before and during the World War I. We show that districts that experienced greater mass mobilization responded by decreasing area under crops. We next demonstrate the differential effects of mobilization for commune and private farm production, peak and slack season production and cereals and animal husbandry production. Taken together, these results suggest that peasants responded to mass mobilization in a dramatic way. We estimate the upper bound of labor surplus in the agricultural sector to be significantly lower than previous estimates; however, our estimate is conditional on this peculiar pattern of labor removal.

1. Introduction.

Labor surplus is at the heart of many historical understandings of economic development. The focus on surplus labor stems from a compelling idea: if the marginal productivity of labor in agriculture is zero, removing some labor from agriculture and moving it to industry can dramatically improve aggregate output without sacrificing a fall in agricultural production.[1] Despite the widespread theoretical interest, the empirical evidence on the existence and extent of labor surplus is scant. Even for Imperial Russia, which has been one of the quintessential examples of labor surplus, we find no rigorous empirical analysis of the question of labor surplus in the Russian countryside before the Great War.[2] This lack of evidence is not because of a lack of interest in pinning down the extent of labor surplus. Already in 1901, a government commission estimated labor surplus in the Russian countryside at fifty-one percent of the labor force; and more recently, Robert Allen (2003) stresses that the labor surplus in the Russian countryside before collectivization was substantial. Indeed, knowing the nature of labor surplus is crucial for understanding which development policies will be (have been) successful as labor surplus affects the calculus of costs and benefits (Fei and Ranis 1964); and, in the Russian context, the extent of labor surplus influences not only interpretation of collectivization as a development policy but also the causes of the Russian Revolution, one of the most noteworthy events of the twentieth century.

We contend that the lack of evidence reflects the difficulty behind constructing a credible test of the extent of labor surplus. We argue that using mass mobilization as an exogenous source of variation provides a unique opportunity to test the extent of labor surplus in the Russian countryside at the time of the Great War (WWI). While studying the effects of mobilization during WWI on the rural sector is interesting in its own right, we aim to kill two birds with one stone by aiming directly at the question of labor surplus. We

1 Equating labor surplus with the condition that marginal productivity of labor is zero is a bit narrow-minded. This condition is a sufficient, but not a necessary condition for labor surplus. Sen (1966) argues the MPL=0 is not even a sufficient condition.

2 Both Antel and Gregory (1994) (in the early Soviet period) and Nafziger (2010) (in late Imperial Russia) precede us in providing suggestive empirical evidence of peasant household responsiveness to market and shadow prices in output and factor markets, which would not occur if the amount of labor surplus is sufficiently high.

will then discuss the effect of mobilization on peasants' marketing decisions during the war years in order to shed light on our understanding of the causes of the Russian Revolution.

Why is mass mobilization a good test of labor surplus? To answer this question, we first need to discuss two important aspects of how any test of labor surplus is made operational: 1) the pattern of labor removal and 2) how the response to the removal is observed (Ajaz and Ray 2012). The specific pattern of labor removal and the observed response could affect the link between labor and output. For example, consider two different patterns of labor removal. The first removes whole households at once and the second only removes one member per household. Production might go down in the first pattern simply because inter-family redistribution of land does not adjust within the specified testing period, while the second pattern may result in no change in output precisely because intra-family redistribution of land occurs relatively easily and quickly (Sen 1967). Since agricultural households can generally reoptimize after labor has been removed, labor surplus can exist even when the marginal productivity of labor is above zero. Conversely, even if a social planner can design an allocation of resources such that some amount of labor can be removed without causing output to fall, labor surplus still might not exist if the incentive compatible responses to any pattern of labor removal fail to generate the socially optimal allocation. Thus, following the definition in Ajaz and Ray (2012), we condition our concept of labor surplus on a particular pattern of labor removal and define labor surplus to mean that some amount of labor can be removed without reducing output once peasants have had a chance to update their optimization problem, given the change in labor but holding other factors fixed. The extent of labor surplus will then generously be defined as the upper bound on the amount of labor removed over all the patterns of labor removal that satisfy the above existence condition.

We suggest two ways to operationalize the hypothesis that there existed labor surplus in Russian agriculture before WWI, a strong form and a weak form. The strong form states that mass mobilization will have no effect on output. In this hypothesis, labor surplus is defined as above and the pattern of labor removal is exactly mass mobilization. This hypothesis is not a straw man since many authors viewed labor surplus to mean that marginal productivity of labor is zero and assumed that the extent of surplus labor, given by Litoshenko, for example, was higher than the amount of labor removed by mobilization.

The weak form states that there is a significant amount of surplus labor before WWI but on average mass mobilization exhausted it. Taking given that mass mobilization is the pattern of removal and allowing for the corresponding reorganizations, if agricultural output still falls, this would be evidence against the strong form of the hypothesis. If we then can make a convincing case that this pattern of labor removal was not unreasonable compared to the optimal, incentive-compatible labor-removal mechanism, then we have strong evidence against the extent of labor surplus is at the level given by the previous literature. If the strong form fails, the weak form is more difficult to test but we intend to evaluate several versions of this hypothesis to get at the extent of labor surplus.

There is a vast literature on labor surplus, however, there are few, if at all, convincing empirical tests of the existence of labor surplus (Shultz 1964, Sen 1967, Basu 1992 etc.; summarized by Ajaz and Raj 2012). To illustrate the controversy in testing for the existence of labor surplus, we point to a recent paper by Foster and Rosenzweig (2010) who claim to find surplus labor in modern India because the distribution of land is such that there are many small farms with low levels of mechanization that could be reorganized to profit from higher levels of mechanization. Foster and Rosenzweig (2010) give empirical evidence of labor surplus by showing how exogenous increases in land holdings improve profitability through investment in machinery. A social planner could then simply change the distribution of land to guarantee for a group of farmers the minimal size of farm that would make mechanization profitable; labor could be removed and output would not fall. We argue that this empirical approach is not a test of labor surplus. To see this, recall the condition for labor surplus: whether some pattern of labor removal exists such that the corresponding behavioral response will generate no loss in agricultural output, holding all else fixed. In the above scenario, no pattern of labor removal alone would lead to the behavioral responses that would cause small farms to become profitable. In addition to labor removal, land and credit markets should permit poor farmers to consolidate landholdings and borrow funds such that it will become profitable to mechanize, and there is nothing in the evidence of Foster and Rosenzweig (2010) that suggests that this will happen. To put it in a slightly different way, any pattern of labor removal would generate a loss in output if institutional constraints prevented the distribution of land to adjust; yet, if institutional constraints were not present, there would be no surplus labor in the first place

because farms would have already had optimal levels of mechanization and scale. Thus, we reject this concept of labor surplus as a means to operationalize a test of labor surplus.

Russian mass mobilization was not an arbitrary pattern of removal; the tsarist government tried hard to organize the mobilization in a way that would secure a high enough level of agricultural production and minimize output loss. We are not the first paper to use mass mobilization as an exogenous source of variation in labor supply. Acemoglu et al (2004) uses mass mobilization during WWII to identify the labor supply impact on female wages in the US. Our use of mass mobilization is similar to the seminal study by Schultz (1964) who takes advantage of the Indian influenza epidemic of 191819 which killed 9% of the rural labor force to demonstrate that the provinces that had the highest death rates attributed to the epidemic also had the largest percentage decline in area under crops. He argues that this empirical relationship proves that surplus labor did not exist. Sen (1967) and later Ajaz and Ray (2012) point out that this epidemic hit entire households and Schultz's study did not give adequate time for the land to be subsequently redistributed. Consequently, this study is a poor test of labor surplus. In contrast, our approach does not suffer from these criticisms because mass mobilization only removed individual household members and land could be easily redistributed within the household. Moreover, the Russian institutional context was such that the commune (in which most of the rural population lived) had well-established mechanisms in place to redistribute land within the commune to limit surplus labor (Nafziger 2010).

To investigate the hypothesis of labor surplus empirically, we look at the effect of mass mobilization on area under crops for wheat and rye in both peasant farms in the commune and private farms (land tenure status – commune vs. private – determines the difference between the two), using a newly constructed district level panel dataset. This test works well in establishing an upper bound to labor surplus since wheat and rye were less labor-intensive than animal husbandry and many of the other crops.[3] We find that mobilization is negatively related to area under crops. Second, we find that private farms suffered from the mobilization more than the commune peasant farm. In some cases, we observe expansions of area under crops even in districts hit relatively hard by mobilization.

3 Cropped area does not capture changes in labor inputs per plot. For robustness, we plan to look at yields.

One obvious explanation for this pattern is the substitution of wage labor with commune labor. As mobilization occurs, wage pressure combined with price ceilings on agricultural goods resulted in private farms withdrawing from production. This wage labor then moves back to the commune, compensating for the lost labor from mobilization. Third, we find seasonal substitution within crop production: the removal of labor leaves the household more strapped in peak season than slack season, causing a shift from summer crops to winter ones. Observing the large amount of substitution together with a drop in area under crops, one might wonder whether labor surplus really existed in the countryside. In fact, our results suggest that the majority of labor extracted by mass mobilization does not satisfy the conditions for surplus labor. However, the sheer magnitude of those who were mobilized (40 percent of male population in 18-43 ages) makes answering the question of the extent of labor surplus difficult. While we can easily rule out such large numbers as above (the strong hypothesis), we cannot rule out labor surplus all together (the weak hypothesis). This is our contribution to the economic history of Russian development in the early 20th century.

We next aim to understand the extent of labor surplus indirectly because it has important implications for the effect of mass mobilization on peasants' marketing strategies. Kondrat'iev (1922) argues that (1) peasants in commune farms became wealthier, but (2) withdrew from rural-urban trade because of the lack of industrial goods. The second hypothesis could then explain the food shortage in the cities during the winter of 1916/17, widely considered the trigger of the Russian Revolution. With our data, we can address the second of these two hypotheses and find evidence against Kondrat'iev. Our findings on labor surplus and Kondrat'iev's hypotheses question the dominant interpretation for the continental economies during the Great War -- that the collapse of rural-urban trade caused mass unrests in many countries (Broadberry and Harrison 2005). To further confirm our findings on the rural side of the trade for grain, we show that demand for cereals mattered. Indeed, we observe a smaller drop in area-under-crops in private farms in more urbanized districts and in the districts where the army (the largest consumer of grain) was located.

The paper proceeds as follows: in section 2, we discuss the necessary historical details; in section 3, we develop our hypotheses; in section 4, we present the data and methods of analysis; in section 5 we discuss the results and section 6 concludes.

2. Historical Background: Russian agriculture before and during WWI

Agriculture was the largest sector of Russian economy before the First World War, accounting for 44.26 percent of national income in 1913 (Markevich and Harrison 2011) and employing an even larger share of workers, up to 72 percent of the gainfully occupied population according to some estimates (Gukhman 1926, cited by Davies 1990 p. 251). Labor productivity in agriculture was substantially lower than in the whole economy, suggesting that too many people were involved into land cultivation. In addition, labor was concentrated in the European core of the empire, especially in the Black Earth provinces, while the outskirts remained relatively unpopulated.

For a long time now, the economic and historical literature have viewed imperfect markets in land and labor as the main factors of low labor productivity in Russian agriculture. The conventional view is that the institution of the commune was mainly responsible for these market imperfections and their consequences (Gerschenkron 1965). The commune restricted Russian peasants in their mobility and land rights. First, the commune controlled the allocation of peasant labor directly: peasants could not leave the commune without its consent, either permanently or temporarily. The commune was often very strict in this respect because of peasants' mutual responsibility for tax payments. Second, in repartition communes (80 percent of all communes), the land which peasants received as a result of the 1861 emancipation belonged to the commune, not to an individual peasant or household (but peasants cultivated this land individually). Collective property rights in repartition communes meant that land was a very illiquid asset and this prevented its optimal allocation and led to overinvestment of labor into agricultural activities and overpopulation of the Russian village. Some authors argue that, in the end, the commune produced labor surplus in the countryside. Litoshenko (1926 published in 2001 p.150) argues that about forty percent of labor (after accounting for the cottage industry) remained unutilized in an average peasant household. Anfimov (1969) produced an even larger figure of fifty-one percent.

The most binding institutional limitations associated with the commune were removed by the 1906 Stolypin reform. The peasants received rights to exit the commune without its content and to privatize land. The reform improved both the allocation of land and labor, promoting rural-urban and rural-rural migration in the empire (Chernina et. al 2012; Castañeda Dower and Markevich 2012). However, due to the government's limited capacity to carry out the reform, the ownership structure in the countryside changed only partially. Over the years of the reform implementation, only 22 percent of households with about ten percent of the land left the commune while many applications to take advantage of various aspects of the reform went unprocessed.

In 1906 about two-thirds (65.3%) of all non-state land was in communal ownership and only about one third was in private (Kondrat'iev 1922 p. 6). The distinction between communal and private ownership only related to the differences in property rights in land. Private land could belong to gentry, merchants, urban citizens, and even to peasants. In the latter case, it meant that peasants bought this land from gentry after the 1861 emancipation; for this land, they could enjoy the full scale of benefits granted by private land status. Private land could be cultivated by large farms or alternatively could be leased to peasants in small plots. According to the 1916 agricultural census that distinguished land belonging to large and individual farms (individual farm is a farm where the owner personally participates in the production), the former cultivated 7.9 percent of land and the latter 92.1 percent.

In 1913 the value added output produced in Russian agriculture equaled 8.288 billion rubles or 44 percent of GDP; grain production composed 48.3 percent of this figure, potatoes - 15.6 per cent, industrial crops and husbandry – 8 and 28 percent accordingly (Markevich and Harrison 2011). In terms of sown area, however, the share of grain was much larger, about 90 percent (Davis 1990 p. 81). The four main crops – wheat, rye, oat and barley – produced the bulk of cereals. Rye was the main traditional crop of Russian peasants and used mainly for in-household consumption. Wheat was the most important market and export crop. The share of wheat in agricultural production rapidly increased in the late Russian Empire in parallel with the development of internal markets and an export boom. Barley was another market crop and oat was mainly used for livestock feeding. Agricultural specialization and distribution of land between the main crops depended on

local climate conditions and the proximity to grain markets; in general, rye dominated in the north, while wheat did in the south. To cultivate these cereals farms generally used the three-field system (fallow - summer crops - winter crops). Given the seasonal nature of three-field system, agricultural production did not allow cultivating summer and winter crops on the same plot during the same year. Peasants could transfer labor between seasons and they also could redistribute efforts between seasons changing the distribution of their leisure over the year. In terms of labor demand, summer was the peak season and winter was the slack one. Technology remained quite primitive with horse as a main driving power pulling the traditional light wooden plough in a three-field rotation system; but the situation was rapidly changing. In particular, the amount of advanced agricultural machines in the countryside rapidly increased during the last pre-war years and stopped to grow only after the start of the war.

The Great War produced a huge negative shock to labor in the Russian countryside. During 1914 – 1917 about fourteen million males were mobilized into the army in addition to a million and half who were already in the regular army at the outbreak of the war. The Russian mobilization law classified all males between 18 and 43 into four groups, in reserve, first- and second-class home guards, and expelled. The first three groups were subject to mobilization under different circumstances. Soldiers in reserves had to be mobilized first, then first- and second-class home guards. Within each group, waves of mobilization could vary by age. In practice, the timing of mobilization of various groups varied between regions as well. By the start of 1916 summer season (May 15th) ten million males had been mobilized.

Mobilized males composed about forty percent of all males aged 18-43.[4] However, this share varied substantially across regions because of the very complicated Russian 1874 and 1912 mobilization laws. First, the law excluded from mobilization all non-Cossack males from two provinces in the Far East and one in Central Asia as well as all non-Russian population (Russian population broadly defined, including Belarusian, Ukrainians) from Caucasus, Siberian, Kazakhstan and Central Asian provinces. In contrast, Russian Cossacks concentrated in several provinces were subject to more extensive mobilization.

4 The huge labor reduction in agriculture was partially compensated by refugees and prisoners-of-the-war: 460,900 prisoners-of-the-war and 354,000 refugees were employed in agriculture by 1916 (Sidorov 1973 p. 452; Gatrell 2005 p. 156). But, it is easy to see that the overall drop in labor was large.

Second, Russian law granted a lot of complete expulsions and privileges (that put an individual either into the first or second class home guard) based on family status – the number of sons in a family, the existence and number of other breadwinners, existence of a brother in the army, etc. Roughly 50 percent of males had various privileges based on family status. A crucial detail about family status was that the status of potential draftee was determined at the age of 21 (the age of conscription in peace time), and not according to his current status. Third, there were health expulsions and privileges which 17 percent of males had; this number was relatively small in comparison to other European countries (Germany - 37%, France – 21% etc.). Fourth, there were privileges based on education level. Finally, additional expulsion and privileges could be granted if an individual's occupation was considered necessary for national defense (Golovin 2001).

The majority of authors (Kondrat'iev 1922, Anfimov 1962, Sidorov 1973, Gatrell 2005) agree that the war produced a shortage of labor in the countryside (except Litoshenko 1925 published in 2001 who still argued that there was labor surplus at least in the peasant household (p.153)), and links this shortage with the decrease in agricultural output. Total output and the production of cereals in particular fell by 20 percent by 1916. The literature agrees that private land farms suffered more from the labor shortage; according to Anfimov (1962) private farms cut their area under crops by 22.3 percent, while peasants only cut by 11.3 percent. Private farms were mostly involved in exporting grains before the war and the collapse of foreign trade (because of blockade) would hit private farms more. Since private farms were an important player in the internal grain market, the amount of grain brought to the market decreased.

The literature disagrees about how mass mobilization and the war affected how much grain peasants' chose to sell on the market. On the one hand, Kondrat'iev (1922), Litoshenko (1925 published in 2001) and Gatrell (2005) argue that peasant welfare increased because of the change in relative agricultural prices at least in grain producing provinces. According to this view, increasing food prices more than compensated for any loss of peasants' incomes from mass mobilization. Due to the very low level of food consumption before the war, cereals were likely not inferior goods. Peasants increased consumption in kind and decreased the share of cereals for markets. The government tried to regulate grain markets but without success. In the end, this contributed to food shortage

in cities, unrest and to the Russian Revolution. In stark contrast, Anfimov (1962) argues that peasants' welfare went down because of relatively larger decline in production than in prices. According to this view, the food shortage in urban areas during the 1916/1917 winter was caused mainly by the decline in agricultural production and the collapse of Russian transportation system, rather than the decrease in market share of peasants' grain production; in this view, the decrease in peasants' welfare contributed to the Russian Revolution directly. One way to reconcile these two views is to pin down the extent of labor surplus in the countryside.

3. Hypotheses

The economic consequences of mass mobilization from a neoclassical perspective are relatively straightforward and can be decomposed into the income and substitution effects once one knows the shape of the household utility function. Under the standard assumptions, the household will substitute labor for leisure, use laborsaving production technologies and switch to less labor-intensive production. In short, the prices of leisure and labor inputs increase and the income effect reinforces the substitution effect if leisure is an inferior good and counterbalances it if leisure is a normal good. In either case, assuming optimal production before mass mobilization, agricultural output should decrease in the aggregate.

One concern is that the neoclassical model treats production and consumption decisions as separable, but there is a long line of literature on the rural economy that assumes otherwise (Chayanov 1986). In the simple version of the Chayanov model (which implicitly assumes labor surplus), peasant production is an increasing function of household consumption. One interpretation of this model would then expect production to decrease following the removal of a household member. However, the key driving force in the model is family structure and, in particular, the absolute number of dependents, which would not have been altered by mass mobilization.

To further tease out the extent of labor surplus, we consider two types of substitution, commune labor for wage labor and slack season labor for peak season labor. For the owners of private farms, all else equal, a shortage of labor drives down profits. We expect then labor to be reallocated from private farms to the commune as labor is removed from the countryside because private farms must hire labor, which became increasingly

more costly and private farms became much less profitable. The difference in the effect of mobilization for private and commune farms was self-reinforcing because commune households could substitute their losses in labor with the labor they supplied to private farms before the war; commune households which had supplied labor to private farms might want to compensate losses in their incomes (in contrast, to the Chayanov model). Since the opportunity cost of commune labor is higher during the peak season than the slack season, the household may choose to allocate more labor to the slack season even if labor productivity is higher during the peak season.

Capital for labor substitution patterns provides an additional way to check the question of labor surplus. If there was labor surplus before the WWI, machines went to districts where it was less sharp. And we should expect that these districts would demonstrate larger decline of output. In opposite if there was no surplus of labor, distribution of machines across districts was determined by other factors, and number of machines in a district would be positively correlated with change in agricultural production because of substitution labor for capital. In addition to substitution within production, farms may move away from animal husbandry and labor-intensive crops such as cotton, beets, potatoes, etc., and move towards cereals such as wheat and rye that were relatively less labor-intensive.

If we encounter all these substitutions together with drop in output, and given that the pattern of labor removal was structured in a way to minimize losses, we could reject the existence of labor surplus in Russian agriculture before the Great War at least at the magnitude of mobilization. In contrast, the strong form of labor surplus would argue that mobilization would have no effect on area under crops (recall that area under crops is our preferred measure of total output).

Finally, for the peasant household, income for a particular household member is the average product while income for the laborer is simply wage income. The marginal productivity of labor in a commune household farm may be lower than the wage equivalent on private farms. Thus, when labor is removed from the peasant household, the average product may increase for the remaining family members. Since the peasants have an ownership stake in the commune, certain amounts of labor removal will be beneficial for the remaining peasants. This question got huge attention during and after the Great War

(Kondrat'iev 1922) when income elasticity of agricultural surplus became an important policy issue because the government had problems to secure the grain supply to cities.

4. Data and Methods.

We construct a district (*uezd*) level dataset to study the effect of the mobilization on agriculture. We use 1913 and 1914 as benchmark years and 1916 – the last pre-revolutionary year - as a treatment year. The dataset covers the whole Russian Empire, excluding Finland. There were more than eight hundred districts in the empire in 1913. We have fewer observations for 1916 than for 1913. First, about ten percent of Russian territory was occupied by the central powers by 1916. Second, a number of provinces did not send their grain figures to the centre, either at all or without the distribution by district.

We combine various official sources to construct the dataset. First, we construct the mobilization measure using data on gender imbalance in the Russian countryside from the first All-Russian agricultural census conducted between May and July of 1916 (Ministry of Agriculture of Russian Empire, 1916a), and deducting gender imbalance in rural areas before the war known from 1913 official statistics (Central Statistical Committee, 1913b).[5] The overall quality of the census was quite high (Kovalchenko et al. 1988), and it is considered as one of the main source on geographical distribution of mobilization into the Russian army in the literature (Golovin 2001). According to the census, total imbalance was about 10 mln people in 1916. If one deducts 1913 imbalance (about 1 mln) and inflow of refugees and prisoners of the war (0.8 mln), the obtained figure (8.2 mln) fits quite well to the number of people mobilized by May, 15 1916 (10 mln), known from military sources. The difference is due to mobilization from urban areas and from Western provinces occupied by Germans.

Second, we use data on area under crops of wheat and rye in 1913, 1914 and 1916 (Central Statistical Committee 1913c, 1914, Special Food Committee 1916).[6] For each district-year, we have two observations: one for private farms (those on private land) and

5 By construction, mobilization measure equals zeros for all 1913 and 1914 observations. In the table 1 we report descriptive statistics for the mobilization measure both for all years (i.e. including 1913 and 1914 zeroes) and for 1916 only.

6 In our case, yields are not a better indicator of production than area-under-crops. First, we have much less data on yields than on area-under-crops. We need to address potential attrition bias. Second, yields suffer from an omitted variable, namely weather – an important factor in agriculture especially a century ago.

the other for commune peasant farms (those on commune land). Unfortunately, there are some missing values in the 1916 Special food committee volume.[7] We cannot employ data on area under crops from the 1916 census volume, which covers the whole empire, because the census did not distinguish private and commune farms but large and individual farms land, i.e. census data could not be matched with 1913 or 1914 data. We employ provincial prices on rye, summer and winter wheat (Ministry of Agriculture 1913, 1914 and 1916) to construct a unified price-weighted area under crops index.

We do not have data on capital that varies over time. Only one agricultural machines and equipment census was conducted in the Russian Empire in 1910. We employ its results published separately for private and commune farms (Central Statistical Committee 1913a). Russian pre-war statistics on horses and cattle is of problematic quality (Vainshtein 1969). So we employ data from the 1916 agricultural census, but we do not have separate figures for private and commune farms because of the reason discussed above.

Table 1 presents summary statistics. One hundred and eighty thousand rural citizens lived in an average Russian district. The largest district in terms of population was about eight times larger and the smallest more than twenty times smaller. Between 1913 and 1916, seven thousand people were mobilized from the countryside in an average district. We estimate the mobilization measure as the difference between 1916 and 1913 gender imbalance (we determined the latter as difference between rural female and rural male population) and this does not account for possible internal migration unbalanced by gender. Because of that our gender imbalance could be negative. This happens if males dominated in war inflows of refugees, prisoners-of-the-war or migrants from other districts and their number was larger than number of mobilized males. According to our estimates, 143,000 people were the maximum number of draftees in a district. We overestimate actual mobilization if females dominated the war migration inflows and underestimate it if the opposite is true.

7 For the main outcome variable, there is attrition and it appears to be selection on observable variables (i.e. distance to the war front, size of rural population, etc.). We used inverse probability weights to correct for attrition bias and did not find much of an adjustment in the point estimate, but we plan to do a more extensive analysis of attrition bias.

Average area under crops per district composed about 16,000 hectares for summer wheat, 5300 for winter wheat, 600 for summer rye and 19,100 for winter rye. These areas varied substantially between districts. Over the war years, the average area under summer wheat and winter rye in a district decreased by about 4000 and 2500 hectares correspondingly, while area under winter wheat and summer rye slightly increased. Unfortunately, we do not have many district-level yield figures.

In 1916 there were about 94,500 heads of cattle (cows, sheep and goats) in a district and almost 57,000 horses. The 1910 agricultural machine census showed that the average number per district was almost 3,000. This number includes seeding machines, harvesting machines, threshing machines, winnowing machines, mowing machines and horse rakes. Urban population in an average district was low, only about 13 percent; the 97 percent in Saint-Petersburg district was an exception.

We employ two empirical approaches to explore the relationships of interest, both of which take advantage of the panel structure of the data. First, we estimate the following equation:

$$Y_{itj}=\alpha M_{it}+\beta P_{it}+C_j+\varphi_j+\tau_{1913}+\xi_{1914}+\varepsilon_{itj} \quad (1)$$

where subscripts *i* and *t* index districts and years, respectively, and *j* marks commune and private farms. *P* stands for rural population. C is a dummy for commune farms, τ_{1913} and ξ_{1914} are year dummies, and φ_i is a district fixed effect. Finally, ε is an error term, assumed to be uncorrelated across districts, but not necessarily within districts as we cluster standard errors at the district level.

Second, we present a differenced model, allowing us to condition the change in the outcome variable on the level of certain variables for which we have data for only one particular year. For this model, we also include province and commune specific linear trends. Namely, we employ the following equation:

$$\Delta Y_{itj}=\alpha\Delta M_{it}+\beta\Delta P_{it}+\gamma' AM_{ij}+\delta' X_i+C_j+\varphi_k+\tau_{191416}+\varepsilon_{itj} \quad (2)$$

where Δ stands for the first differences and t index changes between 1913 and 1914 or 1914 and 1916 accordingly; AM is a vector of controls that includes number of agricultural machines and agricultural tools in 1910 in a district in possession of either commune farms or private farms; X is a vector of controls that includes 1916 cattle and horses in a district; φ_k are province fixed effects; τ_{191416} is a time dummy; and the rest of the notation is the same as in equation (1). While horses and cattle in 1916 are endogenously determined, we nevertheless think it would be a mistake to omit them entirely from the analysis, although we exclude them from our preferred specification. We modify both (1) and (2) to explore the effect of mobilization and its interactions with a number of variables.

5. Results: The Economic Consequences of Mass Mobilization.

TABLE 2: We start with the effect of mass mobilization for Russian agriculture by looking at the effect on total area-under-crops of winter and summer wheat and winter and summer rye. The negative and significant coefficient on mobilization reported in the first column of table 2 demonstrates that mobilization decreases total area under crops. The magnitude of the effect is large; an increase in mobilization by one standard deviation (13.32, or 6.87% of average rural population in a district) decreased area-under-crops by 3463 hectares or by 8.44% in an average district. The results in first differences are similar (columns 2). The main results hold even if we allow for a private farm-specific and province-specific linear time trend (column 3). In column 4, we rerun the specification in column 1 using an index of area under crops that is weighted by grain prices (normalized by wholesale foodstuffs prices) and find even stronger results. In column 5, we include a dummy variable that indicates whether a district is located in the front line provinces where the army – the largest consumer of grain – was located. We find that army demand did matter. In column 6, we test whether rural population density explains away the effect of mobilization and it does not. Finally, in column 7, we run a placebo regression, imputing

the mobilization figures to 1914 to see if mobilization explains the differences in area under crops in the peace years. We find no effect.

TABLE 3: We next investigate whether farm behavior is consistent with a neoclassical response to mass mobilization in which we would expect to see conservation of costly labor inputs. In columns 1 and 2 of table 3, we present the results of treating the effect of mobilization for commune and private farms separately by adding the interaction between mobilization and the commune farms dummy. We find support that private farms suffered more from mobilization than commune farms. One standard deviation increase in the number of draftees in a district increased area under crops by 13720 hectares in the commune farms and decreased by 20380 hectares in the private farms. We interpret the positive effect of mobilization for commune farms as strong evidence for the substitution of commune labor for labor on private farms. Mass mobilization affected summer and winter crops differently as well. In columns 3-6, we see that the drop in private farms is more pronounced for summer than for winter grains, while the opposite is true for the increase in commune farms. Peasants coped with mass mobilization as well by substituting with labor in the slack season when labor was cheaper. In the first difference specification, there is no positive effect of mobilization for commune farms during the peak season (column 4).

We explore several additional possibilities for farms to substitute away from costly labor. Since commune farms were much less specialized in a particular type of agricultural activity than private farms and normally do both grain and cattle production simultaneously, we allow this type of substitution to vary by farm type. The coefficients on the interaction terms reported in column 8 of table 3 shows that private firms in districts with larger amount of cattle decreased areas under summer wheat and rye less, but the opposite was true for the commune farms (the coefficient on the triple interaction has different sign and is larger in magnitude then the coefficient on the interaction between mobilization and cattle). The magnitudes of both effects are substantial. We also present evidence of capital for labor substitution because of the change in relative prices in column 9 of table 3. One standard deviation increase in number of agricultural machines (7.45) in district farms diminished the negative effect of mobilization by nearly a half (0.04*7.45/0.67=0.44). We also note that if the presence of agricultural machines in a district before the war was a proxy for the marginal productivity of labor because of

differences in labor surplus, then the sign of the coefficient is inconsistent with labor surplus before the war. Again the effect differs for private and commune farms.

TABLE 4: Did mass mobilization affect peasants' marketing strategies? Since we do not observe household consumption or market supply, our evidence is indirect. We first investigate whether peasants substituted wheat for rye (we assume that peasants' consumption preferences did not change over time), because wheat was the market grain while rye was mostly for home consumption. In table 4, we see that, on average, mobilization decreased the production of summer wheat; 1 st. dev. increase in mobilization led to a decrease in area-under-summer wheat by 5860 hectares or by roughly one-third in a district with average area under rye (column 1), controlling for the relative price of wheat to rye. However, commune farms responded to substitute away from rye production towards wheat production. Again, we differences in winter/ summer for wheat and rye substitution (columns 3 and 4). While we cannot rule out that peasants might have held onto this increase in grain because there were fewer industrial goods to receive in return, we can look for differential effects for more urbanized districts (i.e. greater scope for trade). The government actively developed new industries in old urban locations during the war. However, one should be careful interpreting the results because urbanization is also a proxy for additional demand for industrial labor in a district. Under the alternative interpretation one should expect a more pronounced rather than less pronounced decrease in production during the war. The coefficient on the interaction term between the mobilization variable and urbanization is positive but not statistically significantly different from zero (column 5). If we allow the demand effect to differ by type of farm (columns 6-7), introducing the triple interaction term between urban share, the commune farms dummy and the mobilization variable as well as interactions between the mobilization variable and the commune farms dummy and the commune farms dummy and urban share, we do find evidence of the demand for food from urban areas effect for private farms. One standard deviation increase in district urban share (0.13) counterbalanced 16 percent of mobilization effect (0.13*2.91/2.36=0.16). The negative coefficients on the triple interactions allow several interpretations. On the one hand, they might be interpreted in support of commune-for-private-labor-substitution story; on the other hand, one might argue that commune farms could respond better to labor demand from urban centers

during the war. Another possibility is that commune farms were more oriented towards self-consumption and reacted to market demand less (the latter interpretation, however, cannot explain the negative effect).

6. Conclusion.

We find strong evidence that the mass mobilization into the army of forty percent of working age males during the Great War caused a wide range of various adjustments in allocation of input factors in the Russian countryside. Households re-calculated their optimization problem in the new war environment. Specifically, we find that in those districts where there were more draftees, there were larger declines in area under crops for wheat and rye. With these results, we contribute to development economics and economic history literatures, which often view agriculture in the late Russian Empire as suffering from an amount of labor surplus far in excess of the number of draftees mobilized. Thus, our evidence allows us to rule out the strong form of the labor surplus hypothesis as well as the weak form for magnitudes of labor surplus as high as forty percent of the rural male labor force. However, we do not reject the weak hypothesis of labor surplus at lower magnitudes.

These results should be interpreted carefully given that we study the extent of labor surplus after both the Stolypin agrarian reform in 1906 and the emancipation of the serfs in 1861. Both of these reforms could have influenced the extent of labor surplus; however, the direction of influence is not clear and demands more research. Moreover, even if the direction of influence is known, the degree to which institutional constraints, and not household behavior, are the root of labor surplus must be carefully analyzed.

The effects of mass mobilization also provide a better understanding of the causes of the 1917 Russian Revolution, in particular, of the peasants' contribution to it. We find that commune farms increased grain production during the war, partially offsetting the dramatic decline in private farm production. In addition, we do not find support for the hypothesis that peasants reduced the marketing of grains, widely viewed since Kondrat'iev (1922) as the reason for the decline in rural-urban trade and the consequent food shortage that triggered the revolution.

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Table 1: Descriptive Statistics.

Variable	N	Mean	St. Dev.	Min	Max
Total area under winter and summer wheat and rye (000 hectares)	3792	41.05	70.29	0	1089.57
Total area under summer wheat and rye (000 hectares)	3870	16.70	56.76	0	1073.89
Total area under winter wheat and rye (000 hectares)	3802	24.52	31.48	0	290.19
Area under summer wheat (000 hectares)	3870	16.09	55.88	0	1046.01
Area under winter wheat (000 hectares)	3802	5.33	18.53	0	258.76
Area under summer rye (000 hectares)	3870	0.61	3.76	0	99.63
Area under winter rye (000 hectares)	3815	19.16	26.01	0	240.28
Price-weighted area under crops	3792	35.89	61.25	0	851.76
Mobilization (estimated as difference in 1916 and 1913 gender imbalance for 1916 and zeroes for 1913 and 1914)	2112	4.48	10.08	-93.65	143.55
Mobilization by 1916 (without 1913 and 1914)	586	16.16	13.32	-93.65	143.55
Commune	4578	0.5	.5	0	1
Rural population (000)	2020	193.83	126.23	0	1487.27
Rural density in 1913 (persons per sq km)	720	38.99	27.24	0.009	193.5
Urban share	2193	0.15	0.15	0	0.97
Cattle (000)	588	94.55	98.47	1.54	1193.67
Horses (000)	588	56.84	70.68	.08	1001.22
Agricultural Machines (000)	1504	2.90	7.45	0	85.11
Agricultural Tools (000)	1504	27.40	38.73	0	504.99
Relative winter wheat to rye price, normalized by wholesale foodstuffs prices	279	1.31	0.21	0.64	2.76
Relative summer wheat to rye price, normalized by wholesale foodstuffs prices	279	1.30	0.21	0.80	2.84
Relative summer wheat to winter wheat price	279	1.00	0.13	0.76	1.91
Front province dummy (zeroes for 1913 and 1914 by construction)	2189	0.03	0.17	0	1

Table 2: The Effect of Mass Mobilization on Area under Crops

Dependent Variable	TWR AREA	TWR AREA	TWR AREA	TWR AREA Index	TWR AREA	TWR AREA	TWR AREA
Estimation	Pooled OLS	FD	FD	Pooled OLS	Pooled OLS	Pooled OLS	Pooled OLS
VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Mobilization	-0.26***	-0.33***	-0.25**	-0.44***	-0.26**	-0.67***	0.06
	[0.101]	[0.123]	[0.115]	[0.129]	[0.101]	[0.175]	[0.082]
Commune	45.07***			38.23***	45.07***	44.22***	38.80***
	[2.701]			[2.293]	[2.702]	[2.698]	[2.967]
Front Province					[0.230]		
					3.51*		
					[1.938]		
Mobiliz*Rural Density in 1913						0.01***	
						[0.002]	
Rural Population	0.04	0.02*	0.13**	0.02	0.04	0.07*	0.02
	[0.023]	[0.011]	[0.016]	[0.018]	[0.024]	[0.036]	[0.021]
Horses in 1916			-0.04				
			[0.050]				
Cattle in 1916			-0.05**				
			[0.023]				
Agricultural Machines in 1910		0.45**	0.47**				
		[0.223]	[0.228]				
Agricultural Tools in 1910		0.18***	0.23***				
		[0.043]	[0.048]				
Year Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
District Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Commune and Province Trends	No	Yes	Yes	No	No	No	No
Constant	12.18**	8.84	32.36**	14.39***	11.50**	7.50	18.82***
	[4.878]	[12.032]	[14.450]	[4.261]	[5.120]	[6.410]	[4.868]
Observations	3,755	2,309	2,121	3,755	3,755	3,666	2,548
R-squared	0.249	0.214	0.220	0.249	0.249	0.247	0.210
Number of Districts	731			731	731	712	726

Table 3: Mass Mobilization and Substitution.

Dependent Variable	TWR AREA	TWR AREA	SWR AREA	SWR AREA	WWR AREA	WWR AREA	TWR AREA	TWR AREA	TWR AREA	TWR AREA
Estimation	Pooled OLS	FD	Pooled OLS	FD	Pooled OLS	FD	FD	FD	FD	FD
VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Mobilization	-1.53***	-1.12***	-1.33***	-0.72***	-0.48***	-0.32***	0.14	0.10	-0.67***	-0.64***
	[0.2]	[0.19]	[0.25]	[0.17]	[0.08]	[0.05]	[0.12]	[0.16]	[0.22]	[0.18]
Mobiliz*Commune	2.56***	1.71***	1.74***	0.47*	1.44***	1.00***		0.11		0.92***
	[0.28]	[0.25]	[0.47]	[0.26]	[0.13]	[0.13]		[0.24]		[0.17]
Mobiliz*Ag. Mach.									0.04***	-0.14***
									[0.01]	[0.03]
Mobiliz* AgM*Commune										0.16***
										[0.03]
AgMach*Commun e										0.45
										[1.08]
Mobiliz*Cattle							-0.00***	-0.01***		
							[0.00]	[0.00]		
Mobiliz*Cattle*Co mmune								0.01***		
								[0.00]		
Cattle*Commune								0.01		
								[0.28]		
Commune	33.73***		11.53***		20.03***					
	[2.55]		[1.68]		[1.14]					
Rural Population	0.04	0.02*	0.04*	0.02*	-0.00	0.00	0.03*	0.02	0.04*	0.03*
	[0.02]	[0.01]	[0.02]	[0.01]	[0.01]	[0.00]	[0.01]	[0.02]	[0.02]	[0.01]
Horses							-0.04	0.02	-0.04	0.02
							[0.05]	[0.04]	[0.05]	[0.05]
Cattle							-0.03	-0.02	-0.03	-0.05*
							[0.03]	[0.03]	[0.02]	[0.03]
Agricultural Machines		0.35*		0.19		0.29***	0.49**	0.09	-0.17	-0.62
		[0.21]		[0.22]		[0.1]	[0.23]	[0.19]	[0.21]	[1.14]
Agricultural Tools		0.09*		0.04		-0.02	0.23***	0.03	0.23***	0.16***
		[0.04]		[0.04]		[0.04]	[0.05]	[0.05]	[0.05]	[0.04]
Year Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
District Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Commune and Province Trends	No	Yes	No	Yes	No	Yes	Yes	Yes	Yes	Yes
Constant	18.06***	13.40	10.99**	21.59*	13.16***	-7.34***	28.31**	9.11	32.75**	21.16
	[4.8]	[12.28]	[4.86]	[12.39	[2.2]	[2.55]	[14.09]	[13.63]	[14.24]	[13.89]
Observations	3,755	2,309	3,768	2,322	3,755	2,309	2,121	2,121	2,121	2,121
R-squared	0.322	0.339	0.149	0.226	0.447	0.336	0.230	0.428	0.272	0.408
Number of Districts										

Robust standard errors in brackets. *** p<0.01, ** p<0.05, * p<0.1

Table 4: The Effect of Mass Mobilization on Marketing

Dependent Variable	SW Area		WW Area		TWR Area		TWR Area Index
Estimation	FD	FD	FD	FD	Pooled OLS		
VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Mobilization	-0.44***	-0.62***	0.12***	-0.08**	-0.23	-2.36***	-1.98***
	[0.121]	[0.161]	[0.042]	[0.034]	[0.197]	[0.310]	[0.295]
Mobilization* Commune		0.51***		0.23***		4.35***	3.37***
		[0.163]		[0.057]		[0.450]	[0.389]
Commune					45.14***	44.28***	38.43***
					[2.709]	[3.625]	[3.088]
Season Rye Area	-0.14	11.86***	-0.01	0.06			
	[0.233]	[4.210]	[0.050]	[0.051]			
Season Rye Area * mobilization	0.07***	-1.07***	0.01**	-0.00***			
	[0.020]	[0.257]	[0.004]	[0.002]			
Season Rye Area * mobilization * commune		1.16***		0.01**			
		[0.260]		[0.006]			
Season Rye Area * commune		-12.10***		-0.07			
		[4.228]		[0.070]			
Mobiliz*Urban					0.12	2.91***	2.17***
					[0.315]	[0.775]	[0.817]
Mobiliz* Urban*Commune						-5.67***	-4.33***
						[1.251]	[1.039]
Urban*Commune						-86.24***	-72.83***
						[13.318]	[11.407]
Urban Pop. Share					18.84	65.64***	79.35***
					[20.101]	[20.800]	[18.333]
Rural Population	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Ag. Mach.&Tools	Yes	Yes	Yes	Yes	No	No	No
Year Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
District Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Commune and Province Trends	Yes	Yes	Yes	Yes	No	No	No
Constant	14.36	14.96	-2.08***	-0.95**	-3.22	-5.38	-17.69
	[11.943]	[12.024]	[0.485]	[0.432]	[14.738]	[14.089]	[13.522]
Observations	2,322	2,322	2,309	2,309	3,746	3,746	3,746
R-squared	0.241	0.328	0.287	0.314	0.249	0.357	0.340
Number of Districts					726	726	726

Robust standard errors in brackets. *** p<0.01, ** p<0.05, * p<0.1