More Hands, More Power? The Impact of Immigration on Farming and Technology Choices in US Agriculture in Early 20th Century*

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Abstract

What channels, other than factor prices, do local economies use to absorb an inflow of immigrants? This paper answers this question in the context of US agriculture in the first three decades of the 20th century. We use the location of past immigrants as instrument for the location choice of farmers to estimate the effects of changes in agricultural labor supply on a number of margins of adjustment (output mix, technological choices and organizational structure) at the county level data using historic records of the Census of Agriculture. We find that an increase in labor supply due to immigration induced a shift away from capital-intensive crops, a reduction in farm size and a more capital intensive input mix. Greater adjustments in crop mix appear to have taken place in counties that had a lower degree of specialization in a given crop, as these counties may have been less constrained to make crop changes. On the contrary, in counties that were more specialized, adjustments in technological and organization changes were preferred. Nevertheless, an increase in the number of workers per acre farmed in a particular country led the farms to a lower capital-labor ratio, even once accounting for changes in crop or farm size, thus suggesting that these adjustments we document did not fully absorb the increase in labor supply without impacting wages.

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1 Introduction

How do labor markets adjust to an inflow of new workers? This question has been the basic motivation of the literature (and the policy debate) regarding the impact of immigration in the United States and elsewhere in the world. While there is still a discussion about the precise estimates of the effects of immigration on the labor market outcomes of natives, the overall conclusion implies, somewhat surprisingly, that there is a fairly small impact of immigration on the wages and employment of natives. While some authors have suggested that this is because native workers, even those with skill levels similar to those of migrants, are not perfect substitutes for immigrant labor (see for example Cortés 2008 and Peri 2009), others have argued that this may be explained by adjustments in technology or output mix which attenuate the wage and employment effects of the inflow of workers (see Hanson and Slaughter 2002 and Lewis 2011 among others). For example, in response to an inflow of low-skill labor in the economy firms may increase the production of goods that are more labor intensive, generating a shift in the labor demand that allows the local economy to absorb the inflow of workers at the existing wages.[1] Also, new labor intensive technologies could be endogenously generated or adopted in response to a labor inflow as in the theory of directed technological change of Acemoglu (2002).

This paper examines how firms, or farms in this specific case, adapted to increases in labor supply that were generated by inflows of immigrants in the years between 1910 and 1940. In a related study, Lewis 2011 uses data from the Survey of Manufactures for the late 1980s and early 1990s and finds that immigration-induced increments in the relative supply of low-skilled labor made firms less likely to adopt automation machinery. This paper extend the results in Lewis (2011) by analyzing a different sector and historical period and studying additional margins of adjustment such as organizational choices and the size of firms, farms in our case.

The early decades of the twentieth century provide an interesting setting in which this analysis can be conducted for several reasons. First, immigration flows over this period were large (e.g, in the early decades of the century, the fraction of population that is foreign was larger than during the last few decades in the United States), making this a context from which lessons are potentially relevant for today's markets. Second, the US economy at that time was much more concentrated in agriculture, a sector that received a large number of immigrants and one in which capital and technologies can be easily measured. Indeed, during this period a large number of immigrants were working in the agricultural sector (although an even larger number of immigrants worked in manufacturing): 17 percent of all migrants arriving were farmers in their country of origin, and more than 10 percent of the immigrants in the United States reported to be farm workers.[2] Observing how these inflows may have fostered changes in technologies

[1] This mechanism corresponds to the Rybczynski theorem, the standard adjustment mechanism to changes in relative endowments in Heckscher-Ohlin trade models.

[2] According to authors' calculations using Census micro samples for 1910 to 1940, and the Reports of the Commis-

or crop choice is facilitated by the availability of relevant data in the United States Agricultural Census and by a large number of contemporaneous studies that describe in detail the production processes of various crops. In contrast, in today's economy most immigrants work in the services sector where techniques and capital are difficult to measure. Third, the period from 1910 to 1940 is particularly appealing because the "frontier" was almost completely established, limiting the incorporation of new land as a mechanism to absorb the inflow of immigrant workers. Finally, this is a period in which important technological transformations became available to farmers with the arrival of the combustion engine and tractors as a new source of draft power.

Overview. In this paper we examine whether, between 1910 and 1940, immigration-induced shocks to the (relative) supply of low-skilled labor caused farms in the United States to modify their choice of crops and production technology. In the empirical section we consider a variety of adjustment mechanisms through which farms can respond to an increase in the relative availability of labor. More specifically, we try to assess the importance of crop choice and technology-related adjustments, and then go on to explore the effects on variables that are related to technology choice and adoption, and organizational choices.

Our approach to this question follows a simple motivating framework. We start by thinking of local labor markets as small open economies with access to a similar set of production technologies. We also consider agriculture as a single sector that uses three factors of production: labor (mostly unskilled), capital and land, which we assume fixed. In this context, the effects of an increase in the endowment of labor depend on whether capital and technology can be adjusted. First, if neither capital nor technology can adjust, an increase in labor should lead to a fall in the capital/labor ratio, a decrease in wages and an increase in the overall production through a scale effect. The capital/output ratio would also fall as output would rise. However, in the case in which capital is mobile but the production technology cannot be adjusted, the impact of an inflow of workers will greatly depend on whether labor is complementary or substitute to the other two factors: land and capital. When capital, land and labor are complementary, we would observe that as the number of workers per acre rise, the capital-labor ratio decreases and the capital-land ratio increases. The capital-output ratio may increase or decrease but the wage would certainly fall, and the magnitude of the wage decline will be greater in the case in which capital does not adjust.

Things are different if we consider the fact that agriculture includes several crops (goods) and that there are more sectors. In this case, if local economies are capable of changing their production mix, we would expect capital to reallocate across sectors in response to the labor inflow. As long as the economy is in the "cone of diversification" this adjustment implies that the inflow of workers would bring no changes in the relative factor prices. Finally, the economy

sioner for Immigration between 1900 and 1930.

could also respond to the immigrant flow by slowing the adoption of labor-saving technology which is more likely to happen if the economy is particularly well-suited for a given type of production.

This simple framework thus gives us the key elements to identify the possible adjustments in US agriculture to immigration-induced labor supply shifts over the period 1910 to 1940. Specifically, we estimate the impact that an increase in the number of farmers or low skill workers per acre of farmland has on agricultural outcomes. These outcomes are selected in accordance with the theoretical framework and include: scale of production, crop choice, draft power choice and direct measures of capital, output and land allocation. Such variables obtained from the Census of Agriculture, some of which were digitalized for the purpose of this study. Data on the number of immigrants, farmers and low skill workers in each county were built using the Population Census of the United States.[3]

We exploit the panel dimension of the dataset to control for national trends and other confounding factors using county and state-by-year fixed effects. To obtain causal estimates of the responses of capital, output mix and technology to changes in labor supply, we use immigration inflows as shocks to the *total* labor supply. In order to deal with the endogenous location of immigrants across local labor markets we follow Card (2001) and allocate immigrants following the location of past immigrants. Furthermore, to avoid potential problems arising because of persistent shocks to agricultural markets we use the location of all past immigrants, regardless of their occupation and their sector of employment. Our instrument appears to be fairly strong and robust over this period, when used to predict the location of immigrant farmers, all (migrants and native) farmers and low-skilled workers per acre at the county level.

Our results suggest that the increases in the relative endowment of labor due to immigration influenced the production and organization of agriculture in the United States during the early 20th century. And, although consistent with our motivational frameowork, these effects are unlikely to have muted the effects on wages. We first present evidence that the share of land allocated to specific crops was altered by the endowment of agricultural workers. By comparing counties within a given state, we find that an increase in the amount of labor per acre reduced the share of land allocated to wheat and raised the share of land allocated to hay and corn as well as the share of land in which no crops were produced. A decline in land allocated to cotton is also observed, although with no statistical significance. The organization of agricultural production (which may be akin to a change in "techniques") also appears to have been altered in response to the inflow of new workers. First, higher labor availability appears to have led to farms becoming smaller, a result that is mostly driven by the fact that very large farms (more than 175 acres) become less common at the expense of medium sized farms (50 to 100 acres).

[3]For earlier years we used the public use micro samples, but for the final year of our sample we obtained the data from the 100% census tables.

There is also evidence of a decline in the share of land managed by owners rather than tenants or managers, although this is only evident in the subsample of counties that have a higher degree of crop specialization.

We also look at measures of draft power that proxy for the adoption of mechanized technologies and fail to find strong evidence of changes in the number of tractors, mules or horses for the overall sample of counties. The estimated coefficients of the effects on the number of tractors are negative, which is consistent with the theoretical framework, but are not sufficiently precise. We do find, however, evidence of a less capital-intensive input mix as capital-labor ratios declined.

We also study whether the estimated effects are heterogenous in terms of the degree of crop specialization. We find that in counties that had a lower degree of specialization in a given crop, greater adjustments in crop mix appear to have taken place. This may be because, as opposed to diversified counties, specialized counties may have been more constrained to make crop changes. On the contrary, in counties that were more specialized, adjustments in technological and organization changes were preferred.

We examine whether the results are driven by an alternative causal channel in which the shifts in agricultural outcomes are explained by a transmission of agricultural knowledge generated by immigration. We test this hypothesis by analyzing whether the estimated effects differ according to the prevalent ethnic group at a given county and find evidence against this hypothesis.

The empirical results suggest a large degree of complementarity between land and capital and indicate that capital and labor over this period were mildly substitutable or neutral. We complement these findings with a decomposition exercise, in which we try to assess how much of the effects of labor shocks on input mix can be attributed to shifts in the method of the production and find that such shifts cannot explain the estimated effect on the capital-land ratio. Thus, the part of the observed change in the ratio of inputs appears to stem from changes in input ratios within a given method of production. Moreover, we observe changes in output productivity per crop and find no evidence of significant effects. Such results are consistent with previous findings indicating complementarity between land and capital and mild substitutability between labor and capital.

The results in this paper taken altogether indicate that, while output and production changes were able to absorb part of the labor supply shock induced by the arrival of immigrant farmers over the period, these adjustments seemed to have insufficient to completely attenuate the impact on factor prices. Thus, it is unlikely that wages did not fall in response to the change in relative factor endowment brought about by immigration.

Layout. The rest of the paper is organized as follows. In section 2 we present a simple conceptual framework that will be used to motivate the empirical model and interpret the results of our estimations. Section 4 describes the data used in this paper and discusses the relevant historical background of agriculture in the early twentieth century in the US. In section 3 we present the empirical strategy and in section 5 we show the main results. Finally, in section 6 we present the conclusions.

2 Theoretical framework

2.1 An agricultural production function

We propose to conceive the agricultural production as a function that combines 3 inputs, labor (L), capital (K) and land (T), as $Y = F(L, K, T)$. Assume that the function $F(\cdot)$ displays constant returns to scale in its arguments. Since we will study the agricultural production of a county within the United States, we will assume that capital is supplied elastically to that market and that the interest rate is fixed at the national level. This implies that:

$$d \ln \left(\frac{\partial Y}{\partial K} \right) = 0 \tag{1}$$

Using the characteristics of the constant returns to scale function, this translates into:

$$d \ln K = \frac{L \frac{\partial^2 Y}{\partial K \partial L}}{T \frac{\partial^2 Y}{\partial K \partial T} + L \frac{\partial^2 Y}{\partial K \partial L}} d \ln L + \frac{T \frac{\partial^2 Y}{\partial K \partial T}}{T \frac{\partial^2 Y}{\partial K \partial T} + L \frac{\partial^2 Y}{\partial K \partial L}} d \ln T \tag{2}$$

We can then derive the following expressions, which describe the impact of a change in the endowment of labor per land on the capital-to-labor and the capital-to-land ratios:

$$d \ln K - d \ln L = - \frac{T \frac{\partial^2 Y}{\partial K \partial T}}{T \frac{\partial^2 Y}{\partial K \partial T} + L \frac{\partial^2 Y}{\partial K \partial L}} (d \ln L - d \ln T) \tag{3}$$

$$d \ln K - d \ln T = \frac{L \frac{\partial^2 Y}{\partial K \partial L}}{T \frac{\partial^2 Y}{\partial K \partial T} + L \frac{\partial^2 Y}{\partial K \partial L}} (d \ln L - d \ln T) \tag{4}$$

The denominators in equations (3) and (4) are positive if the production function displays decreasing returns to capital. Therefore, the signs of the numerators will indicate input complementarity and substitutability. Equation (3) shows that a decline in the capital to labor ratio in response to a shock to the labor per land endowment indicates q-complementarity between capital and land. Equation (4) shows that if the capital-land ratio increases in response to a rise in the labor-to-land ratio, then capital and labor are q-complementary. In this argument we are adapting from Lewis (2011) and extending the application to a more general production function and a different set of inputs.

Furthermore, this setting implies that if both capital and labor and capital and land are q-complements, the output per labor ratio would fall and the output per land would increase in response to a shock to the labor per land endowment, since:

$$d\ln Y - d\ln L = \frac{(\alpha+\beta-1)L\frac{\partial^2 Y}{\partial K \partial L} + (\alpha-1)T\frac{\partial^2 Y}{\partial K \partial T}}{T\frac{\partial^2 Y}{\partial K \partial T} + L\frac{\partial^2 Y}{\partial K \partial L}}(d\ln L - d\ln T) \tag{5}$$

and

$$d\ln Y - d\ln T = \frac{(\alpha+\beta)L\frac{\partial^2 Y}{\partial K \partial L} + \alpha T\frac{\partial^2 Y}{\partial K \partial T}}{T\frac{\partial^2 Y}{\partial K \partial T} + L\frac{\partial^2 Y}{\partial K \partial L}}(d\ln L - d\ln T) \tag{6}$$

where $\alpha = \frac{L\frac{\partial Y}{\partial L}}{Y}$ and $\beta = \frac{K\frac{\partial Y}{\partial K}}{Y}$.

The sign of the capital to output ratio depends on the relative size of the two cross-derivatives. If capital and land are much more complementary than capital and labor, then capital-to-output ratio should fall.

Finally, in this setting, the wage response would depend on the relative level of capital and labor complementarity. Formally,

$$d\ln w = \left(\epsilon_{\alpha,L} + \frac{L\frac{\partial^2 Y}{\partial K \partial L}}{T\frac{\partial^2 Y}{\partial K \partial T} + L\frac{\partial^2 Y}{\partial K \partial L}}\epsilon_{\alpha,K}\right)(d\ln L - d\ln T) \tag{7}$$

where $\epsilon_{\alpha,x}$ represents the elasticity of α with respect to x. It is easy to show that $\epsilon_{\alpha,L} < 0$ and that the sign of $\epsilon_{\alpha,K}$ depends on whether capital and labor are substitutes or complements in the production function. If capital and labor are neither complements nor substitutes in the production function, the wage would decrease by a factor depending of the elasticity of α with respect to L, that is, on how large are the decreasing returns to labor. If capital and labor are either strong substitutes or strong complements, the wage effect of a change in endowments will be greatly attenuated. When capital and labor are great substitutes, capital can adjust and thus diminish the impact of the inflow of workers on the wage. If capital and labor are great complements, the inflow of workers will lead to a strong positive response of capital and this will raise the productivity of each worker, thus diminishing the wage effect of the change in endowments.

2.2 Additional Considerations

The model put forth in the previous section considers a single good economy (or alternatively an economy where we can use an aggregate production function). However, in the standard trade models we need to take into account the possibility of having multiple goods being produced in each of the local economies. Thus, to interpret our empirical results we need to allow the inflow of labor to be absorbed into the economy by increasing the share of the production devoted to more labor intensive outputs or more labor intensive technologies. Such adjustments are predicted by the Rybczynski Theorem, a core result of Heckscher-Ohlin (HO) trade theory (Rybczynski, 1955). The present study provides suggestive evidence of whether such adjustments took place.

In this environment, capital and land within each industry would change in response to the inflow of workers, in a way such that the input ratios are fixed within an industry. Thus, as exogenous immigration shocks would not affect the capital labor ratios within each sector, wage and other input prices would remain fixed. Counties receiving more immigrants may absorb the extra labor by changing the output mix, mobilizing factors in favor of those crops that are labor intensive. There will be an expansion in the production of labor intensive crops (e.g., cotton) and a contraction in the production of capital intensive crops (e.g., wheat). These disproportionate changes in the output mix will be absorbed by imports and exports across regions. However, this result hinges on the assumption that technology does not change in response to the relative abundance of labor. It also assumes that each sector, or crop, cannot be produced using a different technique (or organizational structure) with a different input mix. If this option was available, counties may be able to hire the extra labor at the existing wage by increasing the relative use of labor intensive technologies. We now look for evidence of these patterns in the data.

3 Empirical Strategy

3.1 Baseline equation

Using the simple framework explaining how immigration could impact output and technological choices of producers, we explore these relationships empirically in the context of agriculture in *local* economies in the US in the early 20th century. In the construction of our empirical model we take into account three other adjustment mechanisms that can affect our estimates of the responses of agriculture and which are different from those discussed in section 2. The first mechanism corresponds to the skating rink effect, i.e. an outflow of native workers that leaves total labor supply unchanged in response to the arrival of new immigrants. We address this issue by studying the impact of changes in *total* number of farmers regardless of their country of birth. Thus, our estimates take into consideration the fact that immigration does not lead to a one-to-one increase in the total availability of workers in a local economy (county).[4]

Second, in response to an inflow of immigrants, there may be an adjustment in the amount of

[4]In studies of contemporary immigration to the US, Borjas, Freeman, and Katz (1997) and Cortés (2008) provide evidence that immigration leads to a displacement of natives. However, these displacement flows may not be large enough to fully offset the immigration inflows. In such case, immigration inflows may effectively translate into a higher labor supply, as seems to be the case in our sample.

cultivated land. In our empirical specifications we consider this potential change and divide all labor supply measures by the amount of land farmed.[5] We also adjust our instrumental variable strategy to control for this endogenous response of land farmed.

Finally, an increase in the supply of workers of a given occupation due to immigration may induce natives (and former immigrants) to choose different occupations in the same county. Therefore, in some specifications we will consider the full stock of low-skilled workers and thus account for the potential change in occupations generated by the immigration.

Our main estimation equations is:

$$y_{ist} = \theta \log \frac{L_{ist}}{T_{ist}} + \beta' \log X_{ist} + \nu_i + \mu_t + \upsilon_{st} + \epsilon_{ist} \quad (8)$$

where the left hand side variable is an agricultural outcome observed in year t, state s and county i. L_{ist} represents the corresponding measure of labor supply which can either be the stock of all farmers or the stock of low skilled workers in county i. The variable T_{ist} measures the area devoted to farmland in each county. The term X_{ist} is a vector of county level time-varying controls. The terms ν_i and μ_t are, respectively, county and year specific fixed effects and υ_{st} is a vector of state-by-year fixed effects. Regressions are weighted by amount of farmland in 1900 and standard errors are clustered at the county-level to adjust for heteroscedasticity and within-county correlation over time.[6]

The coefficient of interest is θ, which we interpret as the effect on agricultural decisions of a change in the endowment of labor per area of farmland. Estimates of θ based on OLS regressions are unlikely to be informative of the causal effect of labor supply since workers potentially select their location based on unobserved determinants of agricultural outcomes. Moreover, the many shocks that hit the agricultural sector over this period may have simultaneously affected the allocation of labor supply. In the next subsection we discuss the possible sources of these confounding factors explain our strategy to deal with these issues.

3.2 Confounding factors and identification strategy

During the early 20th century, major transformations took place in the agricultural sector, some of which were fostered by international shocks or environmental phenomena. These transformations affected regions differently, to the extent that natural and institutional conditions led

[5] During the 19th century, the development of US agriculture was characterized by a westward expansion. This expansion came to a dramatic slowdown by 1910, when the settlement was so dense that many claimed the frontier had virtually closed. However, the number of acres farmed could still be altered by cutting down trees in wooded lands or putting under cultivation areas that were not yet exploited.

[6] To study the correlation pattern, we also derive estimates of the county level effects using standard errors clustered by state. Those standard errors were very similar to those clustered by county, suggesting a low degree of correlation of the error terms across counties in the same state.

to regional specialization in farming practices. Indeed, regional specialization in the production of crops characterized early 20th century agriculture. While the South concentrated in cotton, the region spanning from North Dakota to Texas constituted the *Wheat Belt* and the region spanning from eastern Nebraska to Ohio specialized mostly on corn. Given that many of the transformations that affected agriculture over the period likely affected the location and the production decisions made by farmers, they should be taken into account in our identification strategy, in which we make an effort to isolate the causal effect on agriculture of immigration-induced labor supply shocks from potential confounding factors.

One of the events that had a major impact on agricultural production was the onset of the First World War which boosted international demand for US agricultural products. This period of prosperity in agriculture came to a precipitous stop in 1920 when agricultural prices suddenly dropped, in part due to a post-war decline in exports. The high level of farm mortgages accumulated during the previous decades led many farmers to bankruptcy. There was an increase in tenancy, since farmers who were forced from ownership had to rent land in order to continue farming. The agricultural south, the corn belt and the agricultural mountain states were particularly hit. By the end of the 1920s the low agricultural prices had not recovered and in fact were subject to greater downward pressure as the shift from horses to tractors increased supply. The onset of the Great Depression dramatically worsened the situation.[7]. Moreover, there was great agricultural damage in the Great Plains region due to a major environmental catastrophe that became widely known as the “Dust Bowl" . Due to a severe drought and erosion, the soil was blown off from the fields in huge dust storms that, in some areas, removed almost 75 percent of the soil (Hornbeck, 2012).

In the 1920s the government responded to the difficulties in the agricultural sector with a series of policies aimed at increasing farm prices, such as subsidized loans to cooperatives that would buy and store agricultural produce. This proved insufficient, and a more aggressive supply intervention was implemented in 1933 as part of the New Deal. The First Agricultural Adjustment Act (AAA) determined the maximum acreage to be planted of each major crop in each state and growing season. The acreage was then allotted to each farm on the basis of its recent cropping history and payments were made to individual farmers to encourage compliance. Good weather, increases in fertilizer use and violation in the allotments limited the effects of the First AAA, which, in 1936 was declared unconstitutional. In 1938 a Second AAA was implemented. This incorporated a system of quotas that could be instituted upon agreement of two-thirds of the growers and the implementation of government purchase operations to keep prices above a minimum threshold. With some modifications, the Second AAA endured for the next 35 years.

[7]Farm prices declined further, lowering the farmers’ terms of trade by 37 percent in the period 1929-1932. The economic distress was particularly severe for farmers with high levels of debt: foreclosures increased, peaking at 38.1 per thousand in 1932 (Walton and Rockoff, 1998)

Identification Strategy. Thus, international events such as the First World War and policy measures such as the AAA constitute factors likely affected agricultural production and employment decisions and should be taken into account in our identification strategy. We first consider shocks that generate a co-movement of agricultural labor supply and agricultural production decisions in a way that was not differential across regions. We deal with these shocks by including a set of year fixed effects, μ_t and try in this way to isolate the impact of events such as the onset of World War I, which increased the price of US crops and affected the availability of labor at a national level. We also control for time-invariant county-specific characteristics that determine the location patterns of agricultural workers with county level fixed effects, ν_i. In this way, confounding factors such as the geographic conditions that jointly influence agricultural practices and the location choices of farmers (e.g., rivers, weather, distance to the coast) are partialled out.

Nonetheless, the numerous transformations affecting the agricultural sector over this period constitute sources of unobservable time-varying shocks that may have affected agricultural outcomes and labor outcomes in a differential manner across regions. Moreover, farmers and low skilled workers may have selected their location based on such time-varying unobserved determinants of agricultural outcomes. We use several approaches to deal with these issues.

First, we include state-year fixed effects in the regression v_{st}. This means that we will only be exploiting within state variation *between counties within a given state*. Our identification strategy will therefore not be affected by, say, state level policies, such as the AAA, that simultaneously affected crop choice and agricultural employment. There may be, however, policies implemented at the county level and other confounding shocks that could be associated with the within-state location decision of workers and agricultural county level outcomes. To deal with this issue we implement, in second place, an instrumental variable strategy that exploits exogenous variation in the county-level stock of immigrants and use it to predict the relative level of agricultural labor in each county.

More specifically, we build an instrument that exploits the tendency of newly arriving immigrants to move to enclaves established by earlier immigrants of the same country. Similar identification strategies have been used previously by Card (2001), Cortés (2008), and Lewis (2011). Formally, the instrument for the logarithm of the stock per acre of all farmers or low-skill workers per acre in county i and year t is:

$$\log\left(\sum_j \frac{N_{jsi,1900}}{N_{j,1900}} L_{jt} / T_{i,1900}\right) \tag{9}$$

where $N_{jsi,1900}$ is the stock of immigrants from ethnic group j in state s and county i in 1900; $\frac{N_{jsi,1900}}{N_{j,1900}}$ is the fraction of immigrants from ethnic group j that were located in county i in 1900; and, L_{jt} is the stock of farmers or low-skill workers from ethnic group j in the United States in decade t and $T_{i,1900}$ is the acres farmed in 1900. Thus, the instrument uses the 1900 distribution of immigrants across counties to allocate the national stock of farmers or low-skill workers in each decade. It should be noted that the location shares, $\frac{N_{jsi,1900}}{N_{j,1900}}$, are obtained from Census tabulates, as opposed to micro-samples. This makes their measurement more reliable and thereby attenuates concerns of measurement-error bias.

The identification strategy that combines the instrumental variable with year, county and state-by-year fixed effects has two requirements to be valid. First, the total national stock of immigrant farmers from a particular ethnic group at time t must not be correlated with differential shocks to agriculture across counties within a given state. Second, the location choice made by immigrants in 1900 among counties within a given state should be uncorrelated with differential changes in the agricultural practices in these counties over the next decade. Regarding this second condition, note that with this instrument the stock of farmers/low-skill workers will be predicted using the 1900 ethnic group distribution of *all immigrants* as opposed to the ethnic distribution of *immigrant farmers*. This is preferred because the location choices of *farmers* in 1900 may be more related to anticipated changes in agricultural practices than the location choices of *all immigrants* and, therefore, ameliorates concerns of identification.

Note that this identification strategy is not violated if, for example, states in the South were less likely to adopt combustion engine technologies and, simultaneously, were less likely to attract immigrants. Instead, our identification strategy will be violated if county specific shocks *within each state* are highly persistent and if the same shocks that determined the county level distribution of 1900 immigrants within each state affect county-level agricultural outcomes at time t. We use two approaches to deal with this issue. First, as was discussed above, the instrument uses the past location choices of immigrants of all occupations, not only of those involved in agriculture, reducing the concern that farmers in the past may have selected their location within each state anticipating changes in agricultural conditions. Second, in addition to the instrumental variables and the fixed effects, we include a rich set of time-varying (exogenous) controls that proxy for differential trends for counties with different agricultural conditions. These controls are built from interactions between decade dummies and key county level variables that measure the number of farms in 1900, the 1900 allocation of land across crops, the 1900 share of whites in the population and the 1900 distribution of farms across tenancy systems. Thus, for example, we control for the fact that, within the same state, a county that had a large share of tenants or a large share of wheat in 1900 may have evolved differently than a county with a large share of owner-operators or one with lots of cotton plantations. Below we evaluate the sensitivity of the first stage estimates to the inclusion of this set of control variables. A substantial change in the coefficient of the instrumental variable in the first stage regression would suggest a threat to the validity of the identification assumption.

Finally, we explore the possibility that the Dust Bowl, a major regional shock affecting the agriculture sector, may have led to large variations in the results. We therefore test whether our results are sensitive to the exclusion of Oklahoma, Kansas and Nebraska, which were the states most affected by the Dust Bowl.[8]

4 Data and Descriptive Statistics

The estimations are conducted using county data for the years 1910 and 1940 and for all US states except for Hawaii, Alaska and the District of Columbia. Given that during this period county boundaries changed, with some counties merging or ceasing to exist, we track all the boundary changes and grouped the counties whenever it was necessary to keep the unit of observation constant over time. We exclude counties in which the number of predicted farmers (as based on the instrumental variable described above) was less than 0.1. We also exclude counties in which the number of low-skill was predicted to be less than 0.6 for those regressions in which that variable is used. Thus, the regressions that use the instrument of predicted farmers were estimated with a balanced panel of 2,695 counties. In the case of the regressions that use the instrument of low skilled workers, the balanced panel has 2,707 counties. The average number of counties by state is 58 with the smallest including only 3 counties (Delaware) and the largest, 219 (Texas).

4.1 Labor supply and immigration data

We use county level aggregate tables from the United States Decennial Population Census (100% summary tables) to record the number of farmers and low skilled workers in each county in the period 1910-1940. Since we are also interested in the stock of immigrant farmers in each county, we use the one percent micro samples of the 1910-1940 Integrated Public Use Microdata Series (IPUMS; see Ruggles, Sobek, Alexander, Fitch, Goeken, Hall, King, and Ronnander 2008) to identify immigrants who work as farmers or as low skilled workers. Farmers are defined as individuals whose primary occupation, as reported in the Census, is being a farmer or a farm laborer. Low skilled workers are also defined using occupational categories in the census and include farmers as well as laborers, servants, fishermen, housekeepers and other low skilled trades. Immigrants are defined as individuals who are registered in the US Census and were born outside the US, as is traditional in the literature. Unfortunately, we are only able to compute county level stocks of immigrant farmers for the period 1910-1930 because the county identification variable is unavailable for 1940. However, we can obtain the national flows necessary to build our instrument, L_{jt} in equation (9), from that source.

The shares of immigrants located in each county that are used to compute the instrument,

[8] Hornbeck (2012) details that counties with the highest erosion levels during the Dust Bowl were located in these three states.

$\frac{N_{jsi,1900}}{N_{j,1900}}$ in equation (9), are built from data on the number of immigrants in every county by country of birth. This data is available in the 1900 Census county level tables that are available in digital format at the National Historical Geographic Information System (NHGIS).

4.2 Agriculture data

We use data from the 1910, 1920, 1930 and 1940 Censuses of Agriculture to construct a wide variety of agricultural variables at the county level. [9] To the best of our knowledge, there is no public data available at the farm level nor any other finer level of disaggregation. Also, we are not aware of available data on agricultural income or wages.[10]

Our framework suggests that, in response to changes in labor supply due to immigration, the first type of adjustment that one could expect is a change in output towards a more labor intensive mix. In the context of a local agricultural economy, such changes in output mix corresponds to shifts in crop production. We therefore obtain measures of physical output, value and area planted for the four most important crops during this period: corn, wheat, hay and cotton. [11] To measure individual crop production, we use variables of physical output per crop reported in the Census (e.g., bales of corn and tons of hay.). To measure overall crop production we use the monetary value of crop production provided in the Census and deflate it using the CPI.[12] Finally, we obtain a proxy for the price of each output in the county by dividing the value of the crop reported by the physical output of that crop.

Using agricultural studies of the period, we assess the relative labor-intensity and degree of mechanization of each of these crops. Specifically, we use the result of studies conducted by the National Research Project during the 1930s that determine the trends in the amount of labor used to produce corn, cotton, wheat and oats between 1909 and 1936 (Elwood, Lloyd, Schmuts, and McKibben, 1939; Holley and Lloyd, 1938; Macy, Lloyd, and McKibben, 1938). The estimations of labor requirements in these monographs were based on a retrospective nationally representative survey conducted by the National Research Project in 1936 and complemented with other secondary sources.[13] The studies show that the average number of hours of labor required to grow

[9] Some of the relevant variables were available in digital format at the NHGIS and the Inter-University Consortium for Political and Social Research (ICPSR) repository. However, for some years and states, key variables such as tractors and acres and production by crop were only available in printed Census books, so we worked in their digitalization for the purpose of this study.

[10] Expenses for labor are available, but the definition changed too many times over the period to make the comparison meaningful.

[11] During 1910-1940, these crops ranked highest in terms of area farmed. Their combined area amounted to the majority of the cropland in the country. In 1910, for example, 82% of the total area dedicated to crop production was allocated to these four crops.

[12] We use the historic CPI series provided by the Minneapolis Fed in http://www.minneapolisfed.org/

[13] The authors present very detailed estimates of labor requirements, that are disaggregated by regions, stages of production and production methods. They also report averages of total labor requirements at the national level. Calculations are done for several years, ranging from 1909 to 1936.

and harvest an acre of corn was 28.7 in 1909-1913 and 22.5 in 1932-1936. Cotton was by far the most labor intensive crop: labor requirements per acre ranged from 105 hours in 1907-1911 to 88 hours in the period 1933-1936. Production and harvesting of an acre of wheat required an average of 12.7 hours of work in 1909-1913 and just 6.1 hours in 1934-1936. The studies also show how these crops differed in their ability to integrate new technologies. Wheat stood out as the crop with fewer labor requirements and whose production suffered the greatest transformations in technology, as threshers, reapers, combiners and tractors were rapidly introduced (Olmstead and Rhode, 2008). The accounts from contemporary researchers and economic historians state that, in addition to the simplicity of the essential operations in the tasks required to produce wheat, the large scale of farms and the topographic characteristics of wheat producing regions facilitated mechanization and the use of tractors (Olmstead and Rhode (2001) and Elwood, Lloyd, Schmuts, and McKibben (1939); Holley and Lloyd (1938); Macy, Lloyd, and McKibben (1938)). On the contrary, cotton stood out as the crop that mostly "resisted the tendency to mechanization in agriculture". The literature has attributed this lag in cotton mechanization to the relative complexity of the operations associated with its production, the small scale of farms and the uneven terrain. It has also been argued that the long-term share tenancy contracts in cotton production may have reduced the incentives to adopt the existing technologies, which mechanized only specific stages of production leaving peaks in the labor requirements (for a discussion, see Whatley (1987)). Finally, the labor requirements of hay and corn were in between those of cotton and wheat (Elwood, Lloyd, Schmuts, and McKibben, 1939; Holley and Lloyd, 1938; Macy, Lloyd, and McKibben, 1938).

Changes in labor supply due to immigration can also be absorbed via adjustments in the methods and organization of agricultural production. To measure this margins we collect county-level data on the scale and organization of farms as well as the use of inputs in production. To measure scale, we obtain data on the number of farms and farm area per county, as well as data on the number of farms within several specified area ranges.[14]. We also use data on the number of farms by type of operator; this is, the number of farms per county that are operated by owners, tenants or managers.[15] Measures of scale and tenancy are likely correlated with the use of technologies since large farms and farms cultivated by their owner were more likely to be capital-intensive than smaller and tenant-operated farms.

To proxy for changes in input choices, we measure draft power using data on the number of

[14]According to the 1920 Census General Report, a *farm* for census purposes is defined as: "all the land which is directly farmed by one person managing or conducting agricultural operations, either by his own labor alone or with the assistance of members of his household or hired employees. The term *agricultural operations* is used as a general term, referring to the work of growing crops, producing other agricultural products, and raising domestic animals, poultry, and bees."

[15]According to the Census General Report a farm will be classified as operated by: i) the owner, if it is "operated by the person who owns it"; ii) the renter, if it is "operated by the person who rents it either for a fixed money rental or for a share of products"; iii) the manager, if it is "operated for the owner or under general supervision by salaried managers or overseers".

horses, mules and tractors in each county. This variable choice is motivated by Olmstead and Rhode (2008), who document that the adoption and diffusion of new farm technologies in the US went hand-in-hand with the adoption of draft power coming from draft animals or from tractors (see, for instance, Cochrane 1993 and Olmstead and Rhode 2001). The period we study saw a rapid adoption of tractors that has been documented as one of the most important technological innovations in modern agriculture.[16]. The diffusion of tractors was very rapid, although there was a significant variation in the pace of the adoption across regions.[17] Since tractors worked faster, their maintenance required much less labor than caring for horses and their adoption freed the labor and land devoted to the production of animal feed (e.g. hay).[18] Thus, we explore how the substitution of animal traction by tractors was affected by an increase in the amount of labor, since this shift in draft power represents capital upgrading or technology adoption. County level data on the number of tractors started being reported in the Census of 1930 and 1940. There is, however, information on the total number of tractors in the United States in 1920, which amounted only to 200 tractors. Since the national number of tractors is very low, we use zeroes as a proxy of the number of tractors in every county in 1920.

Finally, we exploit additional data in the Agricultural Census to obtain measures of capital. In all the relevant years, the Census of Agriculture reports values for four categories of farm assets: land, buildings, livestock and implements and machinery. We choose the value of implements and machinery to measure the stock of capital in the farms. County level measures of this outcome were available in digital format and, like the value of crop production, were deflated using the CPI.

4.3 Summary Statistics

Table 1 gives main summary statistics for the population characteristics and agricultural outcomes in the 1910-1940 sample of counties. On average, there was a stock of 528 immigrant farmers in each county, a number that corresponds to approximately 11 percent of the total stock of farmers per county. Farmers represent about 47 percent of all low-skill workers in a given county and the county-level stock of low-skill workers is, on average, 10,306.

[16]From 1920 onwards there was a dramatic transformation in the use of combustion engine draft power. While only 4 percent of farms in 1920 had a tractor, by 1940 this fraction had increased to 23 percent. Improvements in the design and progress in mass production made tractors more versatile and affordable, facilitating the expansion in their adoption. By 1940, tractors could be used for plowing, harrowing, belt work and cultivation (Olmstead and Rhode, 2008).

[17]The Pacific and West North Central regions were leaders in the adoption by 1920.Improvements in design in the mid 1920s sped the diffusion in the East North Central region and, to a lesser extent, in the southern regions (Olmstead and Rhode, 2001).

[18]According to contemporary studies cited by Olmstead and Rhode (2001), in 1944 the tractor saved roughly 940 million man-hours in field operations and 760 million man-hours in caring for draft animals relative to the 1917-1921 period. This is equivalent to 8 percent of total labor requirements in 1944 (Olmstead and Rhode, 2001). Moreover, as Olmstead and Rhode (2008) and Bogue (1983), the adoption of tractors freed the labor devoted to the production of animal feed (e.g. hay and oats).

Counties have on average 2,917 farms and 592 thousand acres in farmland. Note, however, that not all of the farmland was devoted to crop production, as areas used in livestock, woodlands or unimproved forests and brushland are also included in the Census. Thus, even though the land devoted to the four main crops amounts to 82% of the total crop area, it only constitutes 29% of the total farmland, as is shown in Table 1. Table 1 also reports productivity measures. While an average of 21 bushels of corn were produced per acre, in the case of wheat, 14 bushels per acre were produced. An average acre of hay produced 1.3 ton and one of cotton, about 0.4 bales. Data for crops is missing for several states in which no cotton or wheat production was reported. Note, also, that there is a large variation in these measures of land allocation and productivity by county.

Farms over this period were very large. More than 50 percent of all farms had an area greater than 100 acres. Sixty-four percent of farms were farmed by their owner and 30 percent by their tenants.

The value of implements and machinery in 1910 dollars was 420 per worker and 3.58 per acre. Horses, over this period, were still the major source of draft power with close to 8,500 on average in a county. In contrast, a typical county had approximately 2,400 mules and 300 tractors. Large variations in these input mix and draft power measures are observed across counties.

5 Results

5.1 First stage

Estimation of the first stage of equation (8) is presented in Table 2, where each observation is a county-year cell. The table presents regressions for 3 different sets of outcomes. Panel A reports regressions where the left-hand side variable is the log number of immigrant farmers. Unlike Panels B and C, Panel A reports regressions that only include observations for the years 1910-1930, since 1940 measures of immigrant farmers per county are not available. Although the log number of immigrant farmers will not be used as an endogenous regressor, we present its first stage in Panel A to show that the relevance of the instrument comes is due to the fact that it predict the location of immigrant farmers, as opposed to the natives. Panel B presents the results of a first stage in which the left-hand side variable is the log number of all farmers, (both native and foreign) and Panel C presents the first-stage results when the left-hand side variable consists of the log of all low-skill workers. The construction of a measure of labor supply in terms of the availability of low-skill workers is motivated by the possibility that farmers and low-skill workers are substitutable.

All specifications include decade, county and state-by-county fixed effects. Column (2) adds, as an additional control, the predicted stock of either non-farmers or high-skill immigrants.[19] These controls in column (2) are included to test whether the predictive power of the instrument is driven by the fact that in the computation of the 1900 location distribution of immigrants, non-farmers and high-skill workers were included. Column (3) includes the set of time varying county level controls built from interactions of decade dummies and the 1900 value of agricultural variables. Finally, column (4) is estimated after excluding all counties in states which were mostly affected by the Dust Bowl.

Panel A indicates that the first stage relationship between the instrument and the stock of immigrant farmers is strong, even though the instrument was constructed using the 1900 location choices of immigrants of all occupations, not only of those involved in agriculture, and that we only exploit labor input variation and ignore land adjustments. A predicted change of 1 percent in the stock of immigrant farmers translates into a change in the actual number of immigrants per acre of 0.4 to 0.5 percent. This result is robust to the inclusion of the predicted location of non-farmers, the inclusion of time varying county variables and the exclusion of the states more affected by the Dust Bowl. The fact that the first stage estimate is relatively insensitive to the inclusion of proxy measures of county-level agricultural trends is reassuring. This favors the identification assumption that the instruments are uncorrelated with unobserved county-level agricultural trends.

Panel B shows the results of specifications in which the instrument is used to predict the total number of farmers (both immigrants and natives). Although immigrants represent just 10 percent of all farmers in our sample period, the change in the stock of all farmers per acre seems to be significantly driven by the immigrant flows. An increase in 1 percent in the predicted number of farmers in a county translates into an increase of about 0.2 percent in the number of total farmers per acre in that county. Thus, these results suggest that the effect of the inflow of immigrants on the county-level endowment of labor was not completely undone by natives out-migrating from counties that have an immigrant influx. The reduction in the significance level of coefficients with respect to Panel A is not surprising, as it can be explained by the inclusion of native farmers in the dependent variable. Finally, the instrument does not lose its predictive power when a control for the predicted stock of non immigrant farmers and the set of time-varying country level controls are included.

The last panel presents the result of an analogous regression to that in Panel B, but the instrument allocates the national stock of low skilled immigrants to predict the stock of all low skilled workers. The results indicate that low-skilled immigration had an impact on the endowment of low-skilled workers per acre, a result that is robust to all specifications except for the model in column (2) when the high-skilled control is included. This may be simply due to the fact that few

[19] Predicted stocks of non-farmers (high-skill workers) are constructed using the formula in (2) were L_{jt} is the stock of non-farmers (high-skill workers) from ethnic group j in decade t.

immigrants over this period were high-skilled and thus that this specification is highly demanding on the data. Reassuringly, the point estimate does not change very much, but the precision of the estimate falls significantly.

Thus, the first stage provides some evidence in favor of the identification assumption. The fact that the instrumental variables are relatively insensitive to an observed set of time-varying covariates, supports the assumption of exogeneity to unobserved time-varying factors. Nonetheless, even if this identification assumption is valid, the interpretation of the estimates still depends on the validity of the exclusion restriction. Specifically, our identification strategy assumes that the only casual channel through which the immigration shocks affect agricultural production decisions is by changing the availability of labor relative to land. However, if immigrants have transformed agricultural outcomes by importing knowledge on agricultural practices from foreign countries, then our interpretation of the results would be inaccurate. In section 5.5, we provide an assessment of the importance of this alternative causal channel.

5.2 Adjustments in Crop Choice

As we discussed in section 2, the US agricultural economy may have absorbed the labor supply shock generated by immigrant inflows by shifting production towards goods that employ labor more intensively. In this case, we would expect that in response to an immigration-driven increase in labor supply, the acreage devoted to capital intensive crops decreases while the land devoted to labor intensive crops declines.

Table 3 presents the results of estimates in which the outcome variable is the area planted on four types of crops- corn, wheat, hay and cotton-, as well as area with no crops. For each outcome, the first column presents the regressions with the extensive set of fixed effects (i.e., year, county and state-by year). The second column adds the time-varying controls and the last excludes observations in the Dust Bowl states. Panel A presents the estimates from an OLS regression. The results show that the correlation between the number of farmers per acre and the share devoted to each crop is very small but in all cases positive, indicating that immigrants tended to locate in counties where crop production overall was growing. Panel B presents the results of instrumental variable (IV) models in which the instrumented endogenous variable is the log stock of all farmers per acre. We find that, within each state, an exogenous increase in the relative availability of farmers or low skill workers of 1 percent results in a decline in the share of land allocated to wheat of 0.05 to 0.08 percent. There is also an increase in the share of land devoted to corn and hay as well as the share of land in which no crops are produced. The land allocated to cotton appears to decline, but the results are not statistically significant. The impacts of changes in the relative availability of low skilled workers presented in Panel C are less precise. However, the magnitude and signs are very similar to those in Panel B. In general, all results are insensitive to the inclusion of time varying county level controls and to the exclusion of the states most affected by the Dust Bowl.

The findings in Table 3 showing a decline in the area allocated to wheat are consistent with our framework. As discussed in section 4, wheat is by far the less labor intensive crop in the study. Shifting production from wheat to corn and hay is therefore consistent with an environment in which the local agricultural economy absorbs an increase in labor supply by moving away from a more capital-intensive output mix. A decline in the production of cotton would not be, on the other hand, not consistent since this is the more labor intensive good. While the coefficients in Panels B and C are not statistically different from zero, their negative signs persist even if we restrict the sample to counties with a strictly positive production. Increases in the share of land with no crop production may be consistent with our framework if this farm area is mostly devoted to livestock and the labor requirements in this activity exceeds those of wheat. Unfortunately, we don't have the data nor the labor requirement records to confirm this hypothesis.

Thus, we can interpret the observed adjustments in the allocation of land across crops using the theoretical framework that suggests that shifts in output mix are responses to changes in the relative availability of inputs, as predicted by the Rybczynski Theorem. Nonetheless, aside from this causal channel, the results could be driven by two alternative mechanisms. First, if the market for crops is relatively local, immigrants may demand a different basket of consumption goods and thus influence the price of the different crops. To explore that, we constructed a proxy for the log of output price by dividing the value of crops by their physical output and regressed this proxy price on county and state-decade fixed effects. Overall, this suggests that about 40 to 70 percent of price variation can be explained by these fixed effects (more in the case of hay prices, less in the case of wheat prices). This suggests that the assumption in our framework that prices are exogenously given and that the output market is not local may not be entirely accurate. We therefore test whether the price of the output responded to the inflow of immigrants and present the results in Panel A of table 4. The format of this table replicates that of table 3 except that it presents only IV results using the log of all farmers as the endogenous variable. In neither case we observe that the price of output responded significantly to a change in the labor input at the county level. This evidence suggests that the immigrants did not change crop allocation through a demand mechanism or that the crop allocation change was large enough to alter the local prices of the crop.

In another possible causal channel, an inflow of immigrants may change the crop mix within a county if it changes the productivity of the production function of a given crop. This may happen because the labor of immigrants is not a perfect substitutes with the labor of natives or because immigrants bring from their countries of origin innovative knowledge about agricultural production techniques. By estimating the models in Panel B of table 4 we explore this hypothesis.

In these models we estimate the causal effect of a change in the labor input with the land productivity (measured as physical output per acre) for each crop. Once more, the results reveals little evidence in favor of an alternative causal mechanism. Instead, the evidence favors the hypothesis that the shifts in crop mix observed in each county can be explained by differences in the labor requirements of some of these crops.

5.3 Adjustments in the organization of production

Shifts in crop mix as those described in subsection 5.2, are just one possible adjustment mechanism to changes in labor supply. Agricultural economies may also absorb an immigration-induced labor supply shock through adjustments in the organization of production. In this section we examine whether such adjustments took place using as outcome variables farm size and tenancy. As discussed above, economic historians have documented that a larger farm size facilitated the adoption of mechanized farming technologies, such as tractors. Moreover, tenancy arrangements have been shown to have an influence on mechanization, to the extent that long-term tenancy contracts reduced the incentives for labor-saving technological investments.

We start by studying the impact of labor supply shocks on farm size. The first two columns of Table 5 present the results of models of the number of farms per acre (i.e., the inverse of the average size of a farm). Columns (3) through (12) show estimates of models of the share of all farms by size category: very small (less than 20 acres), small (between 20 and 50), medium (between 50 and 100), large (between 100 and 175) and very large (more than 175 acres). Panel A presents OLS estimates of the correlation between farm scale and the stock of farmers per acre. Panels B and C show IV estimates of the effects on farm scale of an increase in the per-acre supply of farmers and low-skilled workers, respectively.

Results in the first two columns of Panel A show that, when comparing counties within the same state, an increase in the number of farmers per acre in a county is associated with smaller farms. These OLS estimates are smaller than the IV coefficients in Panel B, suggesting that immigrant farmers are disproportionately located in counties that have small farms. As shown in the first two columns of Panel B, the causal impact of a 1 percent increase in the number of workers per acre is an increase in 0.4 percent in the number of farms per acre. Subsequent columns in Panel B suggests that this decline in the average size of a farm is driven by a decline in the number of very large farms and an increase in the number of medium sized farms. Once more, we find the results not to be altered by the inclusion of time-varying county level controls. [20] Similar conclusions are reached from the results in Panel C, which show estimates of the effects of changes in the supply of low skilled workers per acre.

[20] The exclusion of counties in Dust Bowl states also has no impact on the estimation. These results are not presented in the table for space constraints but are available upon request.

We look for more evidence of changes in the organization of production by studying the impact on tenancy of changes in labor supply. The results are presented in Table 6. Panels in this table are organized in the same way as in Table 5. IV estimates in the first three columns of Panels B and C of the effects on the fraction of farmed operated by owners are negative, but not statistically different from zero. The effects on the fraction of farms operated by managers and tenants in the remaining columns are not significant either, but have a positive sign. Comparisons with the OLS correlations in Panel A are an indication that immigrant farmers are more likely to be located in counties where more farmland is operated by tenanted farms. While the lack of significant IV estimates of the effects may indicate the absence of adjustments in these margins, it may also be due to lack of precision in the estimation. In such case, the signs of the estimated coefficients would constitute weak evidence of shifts away from ownership, which is consistent with our theoretical framework. As discussed in section 4, farms cultivated by owners tended to be more capital-intensive than tenant-operated farms. Also, agricultural economies where land was frequently farmed by tenants were characterized by thin labor markets. As discussed by Whatley (1987), given the seasonal nature of agricultural production, thin labor markets were very costly for farmers. Tenant contracts were implemented to reduce the costs of fluctuations in labor requirements. In such an environment, immigration-induced labor inflows may have had effect.

Overall, these results suggest that changes in the relative availability of agricultural labor changed the organization of agricultural production. In particular, in response to an increase in the number of farmers per acre, there was a shift to smaller farms. This result consistent with a scenario in which farms adjusted to an immigration-induced change in the relative endowment of agricultural labor by electing ways to arrange production that was more labor-saving. Shifts from ownership to tenancy arrangements would also be consistent with such a scenario, but the evidence we provide of adjustments in this margin is much weaker than the evidence we provide of shifts in the scale of production. Nonetheless, in section 5.5 below we present results showing that a relative decline in ownership consistent with our theoretical framework did take place, but only on a sample of countries.

5.4 Adjustments to Input Mix

If local agricultural economies absorb an increase in the relative availability of labor by moving to more labor-intensive technologies or output mixes, we should be able to see a shift in input mix. In this section we search for evidence in this direction, and start by looking for adjustments in measures of draft power. Table 7 reports the estimates of models of the effects of changes in labor supply on the county-level number of horses, mules and tractors. The number of observations in the tractors models is significantly lower because this variable was not reported in 1910.

Panel A shows results from OLS regressions that indicate that agricultural workers tend to locate in counties where there is a large number of horses and mules per acre. In contrast, the IV estimates in Panels B and C show that a larger endowment of agricultural or low skilled workers per acre has no statistically significant effect on draft power measures. While the estimates are not significantly different from zero, the signs of the coefficients suggest a slowdown in the adoption of tractors and horses and an increase in the use of mules. These shifts would be consistent with a scenario in which farms adjusted to an immigration-induced labor shock by slowing the adoption of labor saving technologies, such as tractors.

We turn to a more direct measure of capital (i.e., the real value of implements and machinery used in agriculture) to examine adjustments in input mix. Table 8 presents the results of estimates of changes in the capital-labor and capital-land ratios in response to changes in the labor-land ratio. The first panel shows the OLS results while Panel B presents IV estimates of the causal impact of having more farmers per acre. Panel C shows IV estimates of an analogous model in which the endogenous variable is the number of low-skill workers per unit of land. Columns (2) and (5) correspond to estimates in which time-varying county controls are included while columns (3) and (6) correspond to estimates that exclude states highly affected by the Dust Bowl.

IV estimates in columns (1)-(3) report negative changes in the capital-labor ratio in response to an increase in the relative endowment of labor. An increase of one percent in the labor-land ratio leads to a fall in the capital labor ratio of approximately one percent. Such a shift mix is consistent with a scenario in which farms move to more capital-intensive technologies or input mixes. In columns (4)-(6) we see that, in contrast, a change in the relative supply of labor has no significant effect on capital-land ratios.

5.5 Heterogeneity by specialization

At a theoretical level we can think that the capacity of adjustment through output mix depends on how productive a county is in the production of a given crop. We explore whether there is any evidence of this by classifying counties by high or low producers of a specific crop in 1900.[21] The intuition is that, if a farm is largely specialized in the production of a crop, its capacity to change the level of production in this crop may be much more limited, as there may be saturation or fixed, specialized investments. This is explored in Panel A of Table 9, which presents models in which the outcome variable is the share of land allocated to each crop. The results appear to match the intuition we provided: larger adjustments in the production of a given crop are observed in counties that had a *low production* of such crop in 1900. In the case of corn and hay, we strongly reject the equality of the two coefficients.

[21] Counties that devote more than 25% of the farmland to the production of a given crop are defined as "high producers" of this crop.

In contrast, Panel B shows that the greater adjustments in productivity took place in countries that had *a high production*. This may be because, as opposed to shifting their output mix, counties that were specialized adjusted their technologies in response to an increase in the relative endowment of labor. We explore this issue in greater detail in Table 10. We analyze whether counties that were more specialized (and, therefore, were unable to adjust as much through output mix changes), made greater adjustments in technologies than counties that diversified. A specialized county is defined as one that had in 1900 more than 25% of its production in a given crop. The results of this analysis are presented in Table 10 and are consistent with our hypothesis: counties that were more specialized in 1900 responded to the labor supply shock by altering the technologies and organization of their production to a greater extent than counties that were diversified. These counties had greater declines in their ownership shares and in the capital-labor ratios. They also saw greater declines in the average farm size, although the differences are not statistically different when compared with the diversified counties. Finally, they experienced greater adjustments in the use of mules. Coefficients suggesting a decline in the use of tractors are also larger in the case of the specialized counties, but are not statistically significant.

To confirm that the categorization between “high" and “low producing" counties is not artificial, we replicate the exercise but, instead, we separate counties between those that had, on average, larger and smaller farms in 1900. We find no evidence of similar patterns as those displayed in Table 10. We also separate the counties between those that had in 1900 high or low tenancy rates and between those located in South or non-South states, since tenancy incidence and region may be correlated with the degree of specialization. Again, we don't find a pattern that replicates the results obtained from deriving separate estimates according to the degree of specialization. [22]

5.6 An alternative causal channel

Thus far, we have interpreted our estimates in light of a framework in which an immigration shock affects agricultural production decisions by changing the relative endowment of labor inputs. However, one can consider an alternative causal path, aside from this labor supply mechanism, that explains our results. In particular, changes in the availability of workers due to immigration may affect agricultural outcomes if immigration involves a transfer of knowledge on agricultural practices. Indeed, economic historians have provided some anecdotal evidence that suggests this kind of mechanism. For instance, Olmstead and Rhode (2008) describe how German mennonites, who migrated to the Great Plains in the late nineteenth century, introduced to the US the “Turkey" wheat, a kind of winter variety that was entirely new to North America. The introduction of “Turkey" wheat was a notable breakthrough that played a critical role in

[22]The results of these estimations are not presented due to space restrictions, but are available upon request.

the successful spread of wheat cultivation to Kansas, Nebraska, Oklahoma and the surrounding region.

In Table 11 we provide auxiliary evidence to assess the importance of this alternative causal channel. We re-estimate the main results in this paper but modify the baseline equation 8 by introducing interactions between the measure of agricultural labor $\log \frac{L_{ist}}{T_{ist}}$ and dummy variables that indicate if the major ethnic group migrating to the region is of German or British origin.[23] Thus, with these interactions we test if the impact of immigration-induced labor supply shocks varies by the origin of the most prevalent immigrant group. If a transfer of knowledge is the main channel driving our results and if immigrants from different origins bring knowledge on different practices, the regional impacts should depend on the origin of the immigrant groups.

The results in Table 11 show that differences between the two major ethnic groups are not statistically significant, with the exception of the share of cotton, a margin that appears to have been subject to larger adjustments in counties located in states with a high concentration of German immigrants. In the case of all other outcomes, adjustments in mostly German counties are not statistically different from adjustments in mostly English counties. We interpret this as evidence against the hypothesis according to which the observed adjustments in output and technologies are explained by an inflow of agricultural knowledge brought by immigration.

5.7 Impact on aggregate factor prices

The main limitation in the interpretation of the results is the assumption that we are observing shifts in input within a particular output or method of production. As an alternative, we perform a simple back-of-the-envelope exercise in which we try to assess how much of the observed change in the input ratio caused by shifts in the relative endowment of labor can be explained by changes in the method of production. Ideally, we would perform such exercise and decompose both the observed change in (K/T) as well as the change in (K/L). Unfortunately, with the information available we are only able to perform the analysis for the case of the capital-land ratio because we do not observe labor inputs by farm size and land ownership categories. Consider the following equation, in which we express the aggregate level capital-land ratio as the sum of the capital-land ratios within each method of production

$$(K/T) = \sum_i \omega_i \frac{k_i}{t_i} \tag{10}$$

[23]We build these dummy variables using information on the country of origin of immigrants arriving to each state. Immigrants who were born in Australia, English Canada, England, Scotland, and Wales are classified as having a English origin, while those coming from Austria, Germany, Luxembourg, Netherlands and Switzerland are classified as having a German ancestry. We then build a dummy variable that identifies states in which either of these groups represented the majority of immigrants. We focus on these two ethnic groups only since they represented the main ethnic group in the majority of states during our reference period.

where K/T is the aggregate-level capital-land ratio, (k_i/t_i) is the ratio within a specific method of production i and ω_i measures the relative importance of each method i . We can decompose the aggregate change in capital-land ratio into two components: that accounted for by changes in the ratios *within each method of production i* and that accounted for by changes in the relative importance of each method:

$$\Delta(K/T) = \sum_i [\Delta\omega_i * (k_i/t_i)] + \sum_i [\omega_i * \Delta(k_i/t_i)] \tag{11}$$

We can obtain an analogous version of (11) in which we decompose the elasticity of (K/T) with respect to (L/T):

$$\frac{\Delta(K/T)}{(K/T)\Delta ln(L/T)} = \frac{\sum_i \Delta\omega_i(k_i/t_i)}{(K/T) * \Delta ln(L/T)} + \frac{\sum_i \omega_i \Delta(k_i/t_i)}{(K/T)\Delta ln(L/T)} \tag{12}$$

With simple algebra we obtain:

$$\beta = \underbrace{\frac{\sum_i \theta_i(k_i/t_i)}{(K/T)}}_{\text{Shifts in methods of production}} + \underbrace{\Psi}_{\text{Shifts within methods of production}} \tag{13}$$

where β is the elasticity of (K/T) with respect to L/T; Ψ is the second term at the right hand side of (3)); and θ_i is the change in the of ω_i in response to a change in log of L/T.[24]. We can obtain estimates of the parameter β from the results in table 8 and can also make an estimation of the first term to the right hand side of 13, which captures the component of β that is accounted for by shifts in the methods of production. If we use farm size and tenancy as proxy measures of each method of production, then an estimate of θ_i can be obtained from the estimated regressions in section 5.3 while the rest of the terms can be obtained from the Census reports of 1900.

As shown in column (5) of Table 8), the estimated elasticity of (K/T) with respect to (L/T) is -0.216 in the model with controls although it is not significant. This would correspond to the total effect as measured at the left hand side of equation 13. When we try how much of this adjustment can be explained by changes in farm size, we find that the documented effect of immigration on farm size cannot explain this pattern as very large farm sizes had the smallest amount of measured capital per acre in 1900 and thus that the shrinking of farm size would have lead to an increase in the K/T ratio of 0.62. This is consistent with the "inverse relationship" between farm size and productivity observed in almost all contexts. Thus, this would suggest that the estimate obtained must be driven by the fact that within each farm size, increase in labor availability led to a large decrease in the capital to land ratio. When looking at the role of

[24]More specifically, this is $\theta_i = \frac{(\Delta\omega_i)}{\Delta ln(L/T)}$

changes in tenure of the land, we observe that the shift away from land cultivated by owners to land cultivated by tenants would have led to a decrease in the capital to land ratio as tenants (and even more so managers) used less capital on their land in 1900. However, the fraction of the total effect that could be explained by this shift would be very small (-0.04 out of -0.216) suggesting that the estimated coefficient is not driven by changes in land tenure. These calculations suggest that, while shifts in crops and methods of production seem to have played an important role in absorbing changes in labor supply, the adjustments in input use within a given production method were also important.

This thus implies that the wage of workers would have fallen in response to the inflow of immigrants since the capital-labor ratio within each production/crop appears to have fallen.

6 Conclusions

We present evidence that an immigration-induced increase in the stock of workers per acre led to changes in crop choice and in the organization of production in agriculture during the first decades of the 20th century in the United States. When comparing counties within a state, we find increases in the labor supply of farmers in a county (relative to farmland) led to a decline in the amount of land allocated to wheat, which was the most easily mechanizable and less labor intensive crop. In turn, there was an increase in the share of land allocated to corn and hay and in the share of land with no crop production. We also present evidence indicating that an increase in the relative availability of labor led to a reduction in the average farm size and a decline in the capital-labor ratio at which farms operate.

We also provide some evidence indicating that, compared to counties with a high degree of specialization in a given crop, diversified counties were more likely to respond to a labor supply shock by shifting their output mix. In contrast, counties that were more specialized and, therefore, were more constrained to shift their crop mix, were more likely to adjust the organization and technology of production. In these latter group of counties, a reduction in average farm size, in the land operated by owners, in the use of mules and in the capital-labor ratio is observed in response to increases in the labor supply of farmers.

All these results are consistent with a framework in which a local agricultural economy responds to an increase in labor supply by shifting its crop mix and by slowing the adoption of labor saving methods of production. We explore an alternative causal channel in which the increase in labor supply is driven by a transfer of agricultural knowledge from immigrants and provide auxiliary evidence against this hypothesis. Thus, our results highlight the role of changes in output mix and production techniques as mechanisms to adjust to an influx of labor inputs.

However, the negative impact of labor supply on the capital-labor ratio suggests that the shocks to the relative availability of labor were not entirely absorbed by changes in output mix and technological adjustments. Moreover, the results of the input-mix and the output-ratio regressions suggest that land and capital are complementary in production while labor and capital are mildly substitutable or neutral, which implies that the wage effects are not attenuated by adjustments in capital. However, these results are based on the assumption that each county can be represented by a unique aggregate production function, which is unlikely to be the case. We complement these findings with a decomposition exercise, in which we try to assess how much of the effects of labor shocks had on input mix can be attributed to shifts in the method of the production. Our findings provide suggestive evidence that these changes in the method of production do not fully explain the county-level changes we documented earlier. Overall, this set of findings suggests that wage effects from the immigration-induced labor supply shock were not completely attenuated by changes to the organization of production, a result that is relevant to academic and policy discussions about the labor markets effects of contemporary immigration.

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Table 1: Summary Statistis

Variable	Mean	SD	N
Labor supply measures			
Stock of immigrant farmers	528	1159	8,085
Stock of farmers	4,873	5,405	10,780
Stock of low skill workers	10,306	23,453	10,828
Predicted labor supply			
Predicted number of immigrant farmers	379	1,647	8,085
Predicted number of all farmers	2,575	13,347	10,780
Predicted number of low skill immigrants	1,649	8,509	10,828
Land allocation and crop choice			
Farms	2,917	2,890	10,828
Acres farmland	591,920	850,624	10,828
Share of total farm acres planted in corn	0.11	0.10	10,828
Share of total farm acres planted in wheat	0.06	0.09	10,828
Share of total farm acres planted in hay	0.08	0.07	10,828
Share of total farm acres planted in cotton	0.04	0.08	10,828
Crop productivity			
Bushels of corn per acre	21.22	12.50	10,513
Wheat productivity	14.14	7.60	9,230
Hay productivity	1.31	1.74	10,793
Cotton productivity	0.36	0.19	3,378
Land size and tenancy			
Share of very small farms (less than 20 acres)	0.05	0.06	10,828
Share of small farms (20 to 50)	0.22	0.18	10,828
Share of medium farms (50 to 100)	0.19	0.10	10,828
Share of large farms (100 to 175)	0.23	0.11	10,828
Share of very large farms (more than 175 acres)	0.30	0.24	10,828
Share of farms operated by owner	0.64	0.15	10,828
Share of farms operated by tenant	0.30	0.15	10,828
Share of farms operated by management	0.05	0.10	10,828
Capital intensity			
Capital-labor ratio	419.64	342.16	10,764
Capital-land ratio	3.58	3.34	10,828
Draft power			
Number of horses	8,484	10,753	10,828
Number of mules	2,345	4,599	10,828
Number of tractors	333	666	10,828

Table 2: First Stage

	(1)	(2)	(3)	(4)
	Panel A: Immigrant farmers			
Log predicted stock of immigrant farmers	0.387***	0.474***	0.398***	0.437***
	(0.137)	(0.174)	(0.129)	(0.134)
Log predicted stock of non immigrant farmers		-0.144		
		(0.219)		
R-squared	0.758	0.758	0.761	0.779
N	8085	8085	8085	7419
	Panel B: All farmers			
Log predicted stock of immigrant farmers	0.196***	0.243***	0.179***	0.193***
	(0.073)	(0.077)	(0.069)	(0.072)
Log predicted stock of non immigrant farmers		-0.086		
		(0.101)		
R-squared	0.907	0.907	0.910	0.908
N	10780	10780	10780	9892
	Panel C: All low skilled workers			
Log predicted stock of low skilled workers	0.188**	0.206	0.157**	0.184***
	(0.072)	(0.171)	(0.065)	(0.069)
Log predicted stock of high skilled workers		-0.023		
		(0.196)		
R-squared	0.941	0.941	0.944	0.943
N	10828	10828	10828	9940
1900 controls	No	No	Yes	Yes
Excluding dust bowl states	No	No	No	Yes

All regressions include fixed effects for county, time and fixed effects for each year*state. All regressions are weighted by the acres of farmland in 1900.

Standard errors are clustered at the county level.

*: 10% significance, **: 5% significance, ***: 1% significance

Table 3: Effects on crop acreage share

		Corn			Wheat			Hay			Cotton			No crop	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
Panel A: OLS															
Log(Farmers/T)	0.008***	0.007***	0.007***	0.004***	0.003**	0.002*	0.002**	0.003***	0.003***	0.017***	0.012***	0.012***	-0.040***	-0.035***	-0.035***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.002)	(0.002)	(0.002)	(0.006)	(0.006)	(0.006)
N	10780	10780	9892	10780	10780	9892	10780	10780	9892	10780	10780	9892	8085	8085	7419
Panel B: IV -farmers															
Log(Farmers/T)	0.057***	0.057***	0.062***	-0.054**	-0.077**	-0.067**	0.018**	0.013*	0.014*	-0.036	-0.046	-0.047	0.122*	0.143**	0.127*
	(0.019)	(0.020)	(0.021)	(0.025)	(0.033)	(0.029)	(0.009)	(0.008)	(0.008)	(0.030)	(0.032)	(0.031)	(0.066)	(0.073)	(0.067)
N	10780	10780	9892	10780	10780	9892	10780	10780	9892	10780	10780	9892	8085	8085	7419
Panel C: IV-low skilled workers															
Log(LowSkill/T)	0.059***	0.058**	0.063***	-0.065**	-0.102**	-0.087**	0.021**	0.019*	0.017*	-0.046	-0.050	-0.043	0.152*	0.195**	0.163**
	(0.022)	(0.025)	(0.024)	(0.029)	(0.044)	(0.035)	(0.010)	(0.011)	(0.009)	(0.039)	(0.043)	(0.038)	(0.078)	(0.097)	(0.082)
N	10828	10828	9940	10828	10828	9940	10828	10828	9940	10828	10828	9940	8121	8121	7455
1900 controls	No	Yes	Yes	No	Yes	Yes	No	Yes	Yes	No	Yes	Yes	No	Yes	Yes
Excl. Dust Bowl st.	No	No	Yes	No	No	Yes	No	No	Yes	No	No	Yes	No	No	Yes

The dependent variable is the share of total farmland allocated to each crop. All regressions include fixed effects for county and time and fixed effects for each year*state. Regressions are weighted by the acres of farmland in 1900.
Standard errors are clustered at the county level.
*: 10% significance, **: 5% significance, ***: 1% significance

Table 4: Effects on crop prices and productivity

	Corn			Wheat			Hay			Cotton		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Panel A: Effects on crop prices												
Log(Farmers/T)	-0.618	-0.736	-0.809	0.597	0.358	-0.018	-0.607	-0.922	-1.004	0.032	0.047	0.036
	(0.580)	(0.628)	(0.623)	(0.658)	(0.456)	(0.361)	(0.608)	(0.698)	(0.700)	(0.164)	(0.254)	(0.283)
N	7761	7761	7113	6279	6279	5644	10744	10744	9859	2417	2417	2338
Panel B: Effects on crop productivity												
Log(Farmers/T)	-0.145	-0.165	-0.013	-0.319	-0.330	-0.202	-0.166	-0.175	-0.098	-0.010	-0.318	-0.239
	(0.295)	(0.303)	(0.267)	(0.290)	(0.286)	(0.271)	(0.220)	(0.238)	(0.221)	(0.213)	(0.272)	(0.261)
N	10434	10434	9561	9049	9049	8187	10742	10742	9858	3283	3283	3176
1900 controls	No	Yes	Yes	No	Yes	Yes	No	Yes	Yes	No	Yes	Yes
Excl. Dust Bowl st.	No	No	Yes	No	No	Yes	No	No	Yes	No	No	Yes

The dependent variable is the log physical output per acre for each crop. All regressions include fixed effects for county and time and fixed effects for each year*state.

Standard errors are clustered at the county level.

*: 10% significance, **: 5% significance, ***: 1% significance

Table 5: Effects on scale of farms

	Farms per acre		Very small		Small		Medium		Large		Very large	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Panel A: OLS												
Log (Farmers/T)	0.250***	0.233***	0.003	0.003	0.017***	0.013***	0.007***	0.006***	0.009***	0.011***	-0.036***	-0.033***
	(0.028)	(0.028)	(0.002)	(0.002)	(0.005)	(0.005)	(0.002)	(0.002)	(0.003)	(0.003)	(0.006)	(0.006)
N	10780	10780	10780	10780	10780	10780	10780	10780	10780	10780	10780	10780
Panel B: IV- Farmers												
Log (Farmers/T)	0.415**	0.416***	0.009	0.003	0.009	0.016	0.069***	0.072***	0.026	0.046**	-0.113**	-0.137**
	(0.143)	(0.150)	(0.015)	(0.015)	(0.030)	(0.032)	(0.024)	(0.027)	(0.020)	(0.021)	(0.053)	(0.062)
N	10780	10780	10780	10780	10780	10780	10780	10780	10780	10780	10780	10780
Panel C: IV-Low skilled workers												
Log (LowSkill/T)	0.471**	0.554**	0.005	-0.001	0.020	0.035	0.091***	0.101***	0.023	0.059**	-0.138**	-0.194**
	(0.193)	(0.215)	(0.019)	(0.021)	(0.041)	(0.048)	(0.029)	(0.036)	(0.022)	(0.026)	(0.065)	(0.085)
N	10828	10828	10828	10828	10828	10828	10828	10828	10828	10828	10828	10828
1900 controls	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes

The dependent variable is the log number of farms in columns (1) and (2) and the share of total farms in each size category in columns (3) through (12). All regressions include fixed effects for county and time and fixed effects for each year*state. All regressions are weighted by the acres of farmland in 1900.

Standard errors are clustered at the county level.

*: 10% significance, **: 5% significance, ***: 1% significance

Table 6: Effects on tenancy

	Owner			Manager			Tenant		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
					Panel A: OLS				
Log(Farmers/T)	0.009	0.012	0.011	-0.020*	-0.020*	-0.020	0.011	0.008	0.009
	(0.009)	(0.009)	(0.009)	(0.012)	(0.012)	(0.013)	(0.008)	(0.008)	(0.009)
N	10780	10780	9892	10780	10780	9892	10780	10780	9892
					Panel B: IV- Farmers				
Log(Farmers/T)	-0.109	-0.150	-0.152	0.072	0.100	0.098	0.038	0.050	0.054
	(0.088)	(0.105)	(0.102)	(0.073)	(0.086)	(0.083)	(0.039)	(0.043)	(0.042)
N	10780	10780	9892	10780	10780	9892	10780	10780	9892
					Panel C: IV- Low skilled workers				
Log(Low Skilled/T)	-0.085	-0.133	-0.134	0.071	0.105	0.098	0.015	0.028	0.036
	(0.105)	(0.129)	(0.119)	(0.094)	(0.116)	(0.106)	(0.045)	(0.052)	(0.047)
N	10828	10828	9940	10828	10828	9940	10828	10828	9940
1900 controls	No	Yes	Yes	No	Yes	Yes	No	Yes	Yes
Excl. Dust Bowl st.	No	No	Yes	No	No	Yes	No	No	Yes

The dependent variable is the log of the share of land farmed operated by each type of individual. All regressions include fixed effects for county and time and fixed effects for each year*state. All regressions are weighted by the acres of farmland in 1900.

Standard errors are clustered at the county level.

*: 10% significance, **: 5% significance, ***: 1% significance

Table 7: Effects on draft power

	Horses			Mules			Tractors		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
					Panel A: OLS				
Log(Farmers/T)	0.147***	0.141***	0.143***	0.197***	0.220***	0.225***	0.042	0.079	0.077
	(0.023)	(0.024)	(0.026)	(0.041)	(0.040)	(0.042)	(0.126)	(0.118)	(0.125)
N	10780	10780	9892	10780	10780	9892	8085	8085	7419
					Panel B: IV-Farmers				
Log(Farmers/T)	-0.174	-0.177	-0.198	0.462*	0.460	0.388	-1.443	-1.622	-2.373
	(0.160)	(0.171)	(0.171)	(0.273)	(0.283)	(0.272)	(1.483)	(1.763)	(1.934)
N	10780	10780	9892	10780	10780	9892	8085	8085	7419
					Panel C: IV- Low skilled workers				
Log(LowSkill/T)	-0.206	-0.262	-0.318	0.472	0.469	0.300	-1.822	-2.119	-2.348
	(0.197)	(0.240)	(0.234)	(0.348)	(0.388)	(0.361)	(1.660)	(2.891)	(2.647)
N	10828	10828	9940	10828	10828	9940	8121	8121	7455
1900 controls	No	Yes	Yes	No	Yes	Yes	No	Yes	Yes
Excl. Dust Bowl st.	No	No	Yes	No	No	Yes	No	No	Yes

The dependent variable is the log number of horses per acre (columns 1-3), the log number of mules per acre (columns 4-6), and the log number of tractors per acre (columns 7-9). All regressions include fixed effects for county and time as well as fixed effects for each year*state. All regressions are weighted by the acres of farmland in 1900.

Standard errors are clustered at the county level.

*: 10% significance, **: 5% significance, ***: 1% significance

Table 8: Effects on capital ratios

	Capital-labor ratio			Capital-land ratio		
	(1)	(2)	(3)	(4)	(5)	(6)
	Panel A: OLS					
Log(Farmers/T)	-0.730***	-0.754***	-0.748***	0.270***	0.246***	0.252***
	(0.030)	(0.030)	(0.031)	(0.030)	(0.030)	(0.031)
N	10780	10780	9892	10780	10780	9892
	Panel B: IV-Farmers					
Log(Farmers/T)	-0.920***	-1.041***	-1.052***	0.080	-0.041	-0.052
	(0.251)	(0.272)	(0.266)	(0.251)	(0.272)	(0.266)
N	10780	10780	9892	10780	10780	9892
	Panel C- IV low skilled workers					
Log(Low Skill/T)	-1.074***	-1.322***	-1.252***	-0.008	-0.151	-0.113
	(0.377)	(0.461)	(0.413)	(0.348)	(0.403)	(0.365)
N	10828	10828	9940	10828	10828	9940
1900 controls	No	Yes	Yes	No	Yes	Yes
Excluding dust bowl states	No	No	Yes	No	No	Yes

The dependent variable is the log of the capital-labor ratio (in the first three columns) and the log of the capital-land ratio (in the last three).

All regressions include fixed effects for county and time and fixed effects for each year*state.

Standard errors are clustered at the county level.

*: 10% significance, **: 5% significance, ***: 1% significance

Table 9: Heterogeneity by specific crop specialization

	Corn (1)	Wheat (2)	Hay (3)	Cotton (4)
	Panel A: Share of land allocated			
Log(Farmers /T)*High producers	-0.023	-0.052	0.-051*	0.060
	(0.032)	(0.107)	(0.028)	(0.274)
Log(Farmers /T)*Low producers	0.054**	-0.077**	0.013**	-0.177
	(0.020)	(0.033)	(0.008)	(0.238)
P-value difference	0.000	0.788	0.020	0.423
N	10780	10780	10780	10780
	Panel B: Land productivity			
Log(Farmers /T)*High producers	0.934**	-0.912	0.060	-0.926**
	(0.429)	(0.582)	(0.274)	(0.413)
Log(Farmers /T)*Low producers	-0.119	-0.341	-0.177	-0.334
	(0.298)	(0.291)	(0.238)	(0.277)
P-value difference	0.000	0.146	0.247	0.019
N	10434	9049	10742	3283

The dependent variable in the first panel is the share of total farmland allocated to each crop.
The dependent variable in the second panel is the log physical output per acre for each crop.
All regressions include fixed effects for county and time and fixed effects for each year*state.
Standard errors are clustered at the county level.
*: 10% significance, **: 5% significance, ***: 1% significance

Table 10: Heterogeneity by overall crop specialization

	Farms/acre (1)	Owners (2)	Tenants (3)	Horses (4)	Mules (5)	Tractors (6)	K-L ratio (7)
Log(Farmers/T)*Diversified	0.416***	-0.155	0.052	-0.169	0.510*	-1.609	-1.082***
	(0.153)	(0.108)	(0.044)	(0.173)	(0.293)	(1.756)	(0.284)
Log(Farmers/T)*Specialized	0.421**	-0.222*	0.076	-0.063	1.181***	-2.379	-1.625***
	(0.196)	(0.132)	(0.058)	(0.236)	(0.422)	(2.063)	(0.358)
P-value difference	0.944	0.047	0.263	0.285	0.001	0.057	0.000
N	10780	10780	10780	10780	10780	8085	10780

The dependent variables are labeled in each column. All regressions include fixed effects for county and time and fixed effects for each year*state.
Standard errors are clustered at the county level.
*: 10% significance, **: 5% significance, ***: 1% significance

Table 11: Heterogeneity by main ethnic group

	(1)	(2)	(3)	(4)	(5)
	Panel A: Effects on crop share and farm size				
	Corn	Wheat	Hay	Cotton	Farms per acre
Log(Farmers/T)	0.061**	-0.077**	0.016*	-0.055	0.370**
	(0.025)	(0.038)	(0.009)	(0.040)	(0.178)
Log(Farmers/T)*German	-0.047	0.002	-0.020	0.114*	0.367
	(0.047)	(0.070)	(0.029)	(0.062)	(0.333)
Log(Farmers/T)*Anglo	0.021	0.003	-0.016	-0.096	0.141
	(0.059)	(0.068)	(0.051)	(0.101)	(0.343)
N	10780	10780	10780	10780	10780
	Panel B: Effects on tenancy and draft power				
	Land by owners	Land by tenants	Horses	Mules	Tractors
Log(Farmers/T)	-0.19	0.059	-0.143	0.256	-2.498
	(0.136)	(0.051)	(0.180)	(0.313)	(3.241)
Log(Farmers/T)*German	0.261	-0.070	0.224	1.197	2.716
	(0.190)	(0.106)	(0.391)	(0.813)	(3.911)
Log(Farmers/T)*Anglo	0.301	-0.038	-1.502	1.628	-0.028
	(0.237)	(0.153)	(1.253)	(1.190)	(3.904)
N	10780	10780	10780	10780	8085

The dependent variables are labeled in each column. All regressions include fixed effects for county and time, fixed effects for each year*state and interactions between 1900 characteristics and year dummies

Standard errors are clustered at the county level.

*: 10% significance, **: 5% significance, ***: 1% significance