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

How do technological progress and the adoption of new technology respond to the availability of complementary factors or the price of such factors? This paper attempts to answer this question in the context of US agriculture in the first half of the twentieth century and its response to immigration flows at the local level. Using the past prevalence of immigrants as an instrument for the location choice of waves of immigration between 1900 and 1940, the paper estimates the impact of an increase in the number of immigrant farmers on measures of capital and technology adoption at the county and state level using data from the Census of Agriculture. It finds that larger immigrant flows led to slower adoption of labor-saving technologies, as proxied by various sources of draft power, and a shift towards more labor-intensive crops. At the same time, an increase in the number of immigrants in a particular county led that county's farms to be less capital intensive: a one percent increase in the number of immigrant farmers translated into a fall in the capital to labor ratio in that county of about 0.2 percent. This holds even when one controls for the potential scale effects, changes in the crop mixes and controls for state-level variations over time. A fall of similar magnitude is observed for the capital to output ratio but in this case, it seems to be driven by the changes in the crops planted. Overall, these results seem to indicate that, although technology adoption responded to the labor influx of capital, it was unable to entirely absorb the change caused by immigration into local agricultural markets.

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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 lot of debate regarding the precise estimates of this effect, the overall conclusion appears to be, somewhat surprisingly, that the effects of immigration on native wages and employment are fairly limited. While some have suggested that this is because natives, even those with skill-levels that are closer to that of migrants, are not perfect substitutes for immigrant labor (see for example Cortés 2008), others have argued that this may be explained by other factors of production being reallocated in response to this inflow of workers.

One of the margins of adjustments at play that is often mentioned is that capital or technology will change in response to the skill/quantity of labor available, attenuating the potential effects on native employment and wages. For example, it may be that in response to the inflow of low-skill labor in the economy, firms become more likely to use technologies that are less capital-intensive and more labor intensive. New technologies could even be endogenously generated in response to that inflow as in the theory of directed technological change of Acemoglu (2002). While this hypothesis is an interesting one, identifying this channel in today's economy poses some problems. First, most immigrants work in the service sector where techniques and capital are more difficult to measure. Data sources for the manufacturing sector, where a smaller fraction of immigrants are employed, are difficult to find although Lewis (2005) finds evidence of that in cities where more migrants are located, firms are less likely to implement technological innovations.

This paper examines a different context where the potential for finding evidence of this channel may be easier. The last large wave of immigration to the United States before the current one, in the early decades of the twentieth century, provides an interesting setting in which the analysis can be conducted. The flow over this period was as large (in proportion to the native labor force) as the current flow, making this a context from which lessons are potentially relevant for today's markets. The big difference between the US economy in those years and today, however, is that it was, at this time, much more concentrated in manufacturing and agriculture, two sectors where capital and technologies are potentially much more easily measured. Furthermore, a large number of immigrants were working in the agricultural sector (although less so than in the manufacturing sector): 17 percent of all migrants were farmers in their country of origin and more than 10 percent were farmers in the United States at the moment of the Census. Furthermore, the agricultural sector is one where measuring the adoption of new technologies and the use of capital is facilitated by a large number of studies detailing the production process of various crops and the methods used in each case. The period from 1900 to 1940 is particularly appealing in this context as the "frontier" had been established already, preventing the economy from adjusting to the labor flow by simply increasing the amount of land available. Furthermore, this is the beginning of mechanization for many farms (4 percent of farms in 1920 had a tractor but this fraction rises to 23 by 1940).

Particularly, this study will examine whether, between 1900 and 1940, larger inflows of immigrant farmers in local markets caused farms in the United States to modify the way they organized production. This will include a variety of adjustment channels that could respond to an increase in the available labor and attempt to measure how important these potential mechanisms can be in understanding the impact of immigration on local labor markets.

We first approach this question by imagining local labor markets as small open economies with access to a similar set of production technologies. In this context, an increase in the endowment of a factor depends on whether capital and technology can adjust to this change. When neither capital nor technology can be reallocated, an increase in labor should lead to a fall in the capital/labor ratio, a decrease in the wages and an increase in the overall production through a scale effect. The capital/output ratio would also fall as output would rise. In the case where capital is mobile, on the other hand, we would expect that capital would reallocate across sectors in such a way to keep the capital/labor ratio across sectors constant. No effect should be observed on wages in this case but we should observe a reallocation of resources from sectors that are highly capital intensive to others that are less so. The aggregate capital/output ratio should fall in this case. Finally, the economy could also respond to the immigrant flow by slowing the adoption of labor-saving technology. This could be accompanied by a change in the wages and the capital/labor ratio although it may not need to. This simple framework thus gives us the key elements to identify the sources of adjustments in the early 20th century US agriculture.

With this model in mind, we estimate the causal impact of immigration on the organization of agriculture in the United States from 1900 to 1940. Since migrants obviously may select their location depending on local economic conditions, an instrument a la Card (2001), that is based on the past prevalence of a given destination for each country of birth, is used to isolate the causal effect. To reduce the likelihood of the problem that farmers in the past may have selected their location anticipating changes in economic conditions, the instrument uses the past location choices of immigrants of all occupations, not just those involved in agriculture. Furthermore, we can complement this data using gross immigration flows from the Report of the Commissioner of Immigration which allows us to measure the number of migrants who were farmers in their country of origin entering the United States every year.[1] Our instrument appears to be fairly strong and robust over this period, when used to predict the location of immigrants at the state or at the county level.

The organization of the agricultural production is measured using digitalized data from

[1] For more details on this data, see Lafortune and Tessada (2010).

the Census of Agriculture from 1900 to 1940. This source, published every decade, provides aggregate-level data on numerous outcomes: scale of production, crop choice, draft power choice and direct measures of capital and output. There are measured either at the county level or at the state level. [2] We can then match each county/state to the number of immigrant farmers in this region, measured from the Public Use Micro Sample of the Census for the same period (Ruggles, Sobek, Alexander, Fitch, Goeken, Hall, King, and Ronnander 2008).

Having combined these two elements, we estimate the causal impact of having fewer/more immigrant farmers in a local market on the outcomes mentioned above. Our estimation framework attempts to capture national trends and time-invariant characteristics of the local markets using fixed effects. Furthermore, we explore variants in the specifications to allow us to distinguish between the various hypotheses elaborated in the theoretical section.

Our results suggest that immigration influenced the organization of agriculture in rural sectors of the United States in the early 20th century, although only partially preventing the impact of immigration on labor markets. First and reassuringly so, the scale of production, as measured in terms of area farmed or number of farmed remained unchanged. On the other hand, having more immigrant farmers per acre farmed does increase the output value produced per acre suggesting that immigrants did not simply replace native farmers (which we also demonstrate directly is not the case).

We also find evidence that the type of output produced was also significantly altered by the immigrant flows. In particular, local economies with a larger number of immigrant farmers were more likely to produce crops that are more labor intensive and less likely to produce crops that demand more capital inputs, such as corn. This is consistent with a model where capital moves across sectors within an economy in order to adjust to the labor inflow.

The choice of technique also appears to have responded to the inflow of migrant farmers. First, the number of horses decreased when the number of immigrant farmers increases. Although the results for tractors are much weaker due to the limited data availability, there also seems to be a response such that the number of tractors fall in response to a larger labor input. Thus, farms appear to have responded to the inflow of immigrant labor by decreasing their requirement in terms of draft power, potentially substituting it for labor instead. Mechanization appears to have been slowed down in this case as well. Part of this may be driven by changes in the output mix.

Finally, we estimate the effect of the change in the stock of immigrant farmers on a measure of the demand for capital, using the real value of equipment and machinery as proxy. We find that in response to an increase in the number of immigrant farmers, there is a decrease in the capital-labor ratio. This result is robust to introducing controls for scale and crop mix, thus suggesting

[2] The number of outcomes available at the county level is currently limited by the amount of data we have already digitalized. This should be increased soon.

that it is not coming solely from the observed changes in the crop mix as a result of immigration.

The rest of the paper is organized as follows. In section 2 we present a brief summary of the historical context of agriculture in the United States during the period under study. In section 3 we summarize the motivating theory in order to provide a basic framework to interpret the results and estimations. Section 4 introduces a summary of the data used in this paper, and a brief overview of some data we are still processing. In section 5 we explain the empirical specification and the instrumental variable we use in this paper. Finally, in section 6 we show the main results and in section 7 we offer (eventually) some final remarks.

2 Historical background: American Agriculture in the Early 20th Century

Technology During the 19th century, the development of US agriculture was characterized by a westward expansion. This process was over by 1890 with the closing of the frontier. During the early years of the 20th century newly settled areas matured, and big technological transformations took place.

The shift from animal draft to tractors stands out as one of the most important technological transformations in this period (see for example Cochrane, 1993; Olmstead and Rhode, 2001). The diffusion of tractors was very rapid, although there was a significant variation in the pace of the adoption across regions (Olmstead and Rhode, 2008). Tractors worked faster and their maintenance required much less labor than the caring of horses, thus implying a big change in the technology mix used in farms, in particular we can consider the adoption of tractor to be a labor-saving technology. Moreover, the adoption of tractors freed the labor and land devoted to the production of animal feed (e.g. hay). Improvements in the design of tractors between 1910 and 1940 improved the machine's versatility, so by the end of this period tractors could be used for plowing, harrowing, belt work and cultivation (Olmstead and Rhode, 2008).

A second, an equally important technological transformation, was the development or irrigation. Inadequate precipitation in the arid regions of the American West required settlers of the new frontier to develop systems of artificial irrigation. Expansion of irrigation was a result of a mixture of private and state-sponsored ventures together with significant investments in irrigation by the federal government. A remarkable example of the expansion of irrigation and its effects on agriculture corresponds to the case of California, where grand scale irrigation programs literally transformed the environment stands out (Olmstead and Rhode, 2008).

Crops During the early 20th century, corn and wheat were America's leading crops in terms of acres harvested and value of output. Together with hay and cotton, the area devoted to these crops amounted to the majority of the cropland in the country. For example, in 1910 82% of the total area dedicated to crop production in the US was used in the production of these four crops.

Interestingly, there were large differences in the labor requirements of these crops. For instance, whereas cotton production in 1909 required 129 man hours per acre, the labor requirement for the production of wheat was just 16 man hours per acre; in the case of corn, the labor requirement was 25 man hours per acre (Elwood, Lloyd, Schmuts, and McKibben, 1939; Holley and Lloyd, 1938; Macy, Lloyd, and McKibben, 1938). There were also differences in the adoption of machinery across crops. Historical analysis of the agricultural sector indicate that introduction of mechanical technologies was particularly widespread in the case of wheat production. Overall, the prevalence in the use of mechanical threshers, reapers, binders and combiners made of wheat a capital intensive crop (Olmstead and Rhode, 2008).

Existing Historical Literature In the economic history literature of US agriculture the idea that the evolution of technology is an endogenous response to the availability of factors is now new. The work of Hayami and Ruttan (1985) introduced an "induced innovation" framework where agricultural technical change is induced by the relative scarcity of land or labor. Even though we won't be exploring patterns of innovation, this paper complements this literature by studying the response of technology adoption to exogenous changes in the availability of low-skilled labor and the composition of labor supply in general.

3 Theoretical Framework

We study whether immigration influenced agricultural decisions in the early 20th century in the United States. A simple open economy model with trade in goods provides a useful framework to analyze this question. Consider, for clarity, a small open economy where capital and labor are factors of production and marginal products of all factors are determined by capital-labor ratios. The impact of an inflow of workers due to immigration will depend on the degree of flexibility in the allocation of capital and technology.

Consider first an environment where the possibility to make adjustments in capital and technology is limited due to, for instance, a short time frame. Labor can, on the other hand, move across industries.[3] If the marginal productivity of labor is diminishing, then immigration will lower the equilibrium wage. The extra labor will be distributed across industries so that wages are equalized, and no arbitrage is possible. The increase in the labor endowment will result in an increase in the output of all sectors.

Now consider an environment in which capital can be adjusted. If capital is mobile, it will

[3]This framework is known in the trade literature as the specific-factors model.

be reallocated in response to the extra labor from immigration flows in order to keep capital-labor ratios in each sector and/or region constant. The allocation of factors will favor labor intensive industries, and as a result, the economy will disproportionately produce more of the labor-intensive goods. The absence of changes in labor productivity means the extra labor will be fully employed at the existing wages. Opportunities for trade across sectors are essential to this result as they allow changes in output mix to be absorbed by imports and exports. The absorbtion of changes in factor endowments via adjustments in output mix and with no changes in factor prices in a situation where there is trade in goods is known in the trade literature as *factor price insensitivity*.

The predicted increase the labor intensive output and contraction in capital intensive production in response to an influx of labor is known in the trade literature as the Rybczinski theorem. An alternative prediction emerges if we consider an alternative scenario in which adjustments in technology are possible. In this case, adjustments towards a labor-intensive technology will ameliorate the impact that increases in labor endowments could have on factor prices. Thus, rather than adjusting the output mix, the economy will react by shifting the *method of production*.

A nice feature of this framework is that it delivers testable implications that can be studied in the context of the agricultural sector in the United States during the first decades of the 20th century. In the context of our study, Rybczinski-type adjustments imply that (exogenous) immigration shocks will not affect the capital labor ratios *within each sector*. Counties and states receiving more immigrants will 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 or corn). These disproportionate changes in the output mix will be absorbed by imports and exports across regions.

Alternatively, we can test for adjustments in technology (as opposed to adjustments in crop mix) in response to immigration. Following Lewis (2005), we can distinguish adjustments in technology from adjustments in output mix by looking at changes in the technology used to produce the *same* crops. In our work, we will interpret changes in the use of tractors *keeping the crop mix constant* as evidence of technological adjustments.[4]

[4] As we explained in section]refsec-history, irrigation was another significant technology improvement incorporated into agricultural practices around this. If data becomes available we also plan on using this as a measure of technology adoption, although it is less clear whether irrigation was complementary or substitute for labor.

4 Data and Descriptive Statistics

4.1 Sources

Data for this paper is drawn from two main sources: the US Population Census and the US Census of Agriculture. The US Population Census data is obtained from the one percent micro samples of the 1910 - 1940 Integrated Public Use Microdata Series (IPUMS) and from the 1900 published county level summary tables.

We use county level aggregates from the Census of Agriculture as no farm level data is available. We obtain data by decade for the period 1910-1940. Some variables (all of them for the period 1900-1910) were downloaded from the Census tables provided by NHGIS. For states in the "Great Plains" region, county level variables are available in digital version at the Inter-University Consortium for Political and Social Research (ICPSR) repository.[5] Some key variables, including acres and production by crop, were only available in printed Census books for all other states and were thus digitalized for the purpose of this study.

We gather data for all states in the US with the exception of Hawaii, Alaska and the District of Columbia. Some county boundaries changed over this period, with some counties merging or ceasing to exist. To account for this, we restrict the sample in the county level regressions to counties that were consistently existing over the sample period.[6]

4.2 Immigration data

We use the United States Decennial Population Census data to identify immigrants who work as farmers. As is traditional in the literature, immigrants are defined as individuals who are registered in the US Census and were born outside the US. We define farmers as individuals whose primary occupation, as reported in the Census, is being a farmer or a farm laborer. Between 1900 and 1930, we can compute the county level stocks of immigrant farmers using these definitions. Unfortunately, we are unable to compute 1940 county level stocks as the county identification variable is unavailable for that year.

We also use the 1900 Census state summary tables reporting the number of immigrants in every county by country of birth, available in digital format from the NHGIS. These data will be the basis for the construction of our instrument which will exploit the tendency of new migrants to locate where previous migrants of the same ethnic group or country have located.

[5] This includes the states of Colorado, Iowa, Kansas, Minnesota, Montana, Nebraska, New Mexico, North Dakota, Oklahoma, South Dakota, Texas, and Wyoming

[6] This still implies that counties which split or merge may not be accounted properly and this will be eventually corrected.

4.3 Agriculture data

We use tables from all the Census of Agriculture available between 1910 and 1940 to obtain data on a wide variety of agricultural outcomes. Unfortunately, no data on factor prices are available in any of the Censuses. All data can be obtained aggregated at the state and county level, but no farm level data is accessible.[7]

We start our empirical analysis by considering the impact of immigration on two outcomes that measure the scale of agricultural activity: the number of farms and area of land in farms.[8] We are aware of the potential pitfall stemming from the use of number of farms as a measure of the scale of activity, as changes in this variable may simply result from the division of larger farms while the actual scale of production is constant. The acres of land in farms is also an imperfect measure of activity as it includes woodland, unimproved brush land and land in swamps or forests. At best, these two variables provide an approximate, albeit noisy, assessment of the size of the agricultural sector.

We are also interested in the effects of immigration on crop mix. To construct the relevant outcomes, we use county and state level measures of production and land area devoted to production for the four most important crops in this period: corn, wheat, hay and cotton. During all of the period of study these crops ranked highest in terms of area farmed. Their combined area amounted to the majority of the cropland in the country. For instance, in 1910 82% of the total area dedicated to crop production in the US was destined to the production of these four crops.

To measure technological adoption, this paper uses the number of horses, mules and tractors in each county or state as proxy measures of draft power. As discussed by Olmstead and Rhode (2008), 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. The shift from animal draft to tractors has been documented as one of the most important technological innovations in modern agriculture (see, for instance, Cochrane 1993 and Olmstead and Rhode 2001). Tractors worked faster and their maintenance required much less labor than caring for horses. Moreover, the adoption of tractors freed the labor and land devoted to the production of animal feed (e.g. hay). So, ideally we would like to explore not just capital intensity but also how the substitution of animal draft power by tractors was affected by the abundance of labor, inasmuch as this represents capital upgrading or technology adoption. Unfortunately, data on tractors is only available for the years 1930-1940. Data on horses and mules is, on the other hand, available for

[7]To the best of our knowledge the published data does not contain any finer level of disaggregation beyond counties.

[8]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."

the whole period.

Finally, we study the the impact of immigration on capital-labor ratios. 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 as the most adequate measure of the stock of capital in the farms, in particular if we want to capture technology adoption at the aggregate level in each county or state. County level measures of this outcome are already available in digital format.

4.4 Summary Statistics

Table 1 gives main summary statistics for the population characteristics and agricultural outcomes in the 1910-1940 sample of states. On average, there was a stock of 17,263 immigrant farmers in each state, a number that corresponds to approximately 8 to 10 percent of the total stock of farmers in this sample.

States have on average 131,200 farms and 20 million acres in farmland. Note, however, that not all of this farmland was devoted to crop production, as areas used in livestock, woodlands or unimproved forests and brushland are also included in the Census. There is a large variation in these measures. For example, the number of farms in 1910 ranged from 495,489 in Texas to 3,163 in Nevada.

The average value of implements and machinery per state is 31,709 thousands of 1910 dollars. This amounts to approximately 5% of the average value of farm property. Large variations are observed across states; the same can be said regarding the number of tractors and draft animals. Tractor utilization is low; indeed, an average farm in 1930 had 0.14 tractors, 0.85 mules and 2.14 horses. There are fewer observations for tractors as this variable is not available before 1930. The production and acreage crops also vary considerably across states. Data for cotton is missing for several states in which no cotton production was reported.

5 Empirical Strategy

Our empirical analysis will be based on the estimation of regressions that describe the relationship between agricultural outcomes and the stock of immigrants working in agriculture.

The estimated equations are:

$$y_{it} = \theta F_{it} + \beta' X_{jt} + \nu_j + \mu_t + \epsilon_{it} \tag{1}$$

where the left hand side variable is an agricultural outcome in year t and region i (where i is a subscript for counties in county-level regressions and states in state-level regressions) ; F_{it}

represents the stock of immigrants who work in agriculture; X_{it} is a vector of regional time-varying controls; ν_i and μ_t are, respectively, region and year specific fixed effects. In the county level regressions, state-by-year fixed effects are also included. All variables enter our equations in logarithmic form.

In both models, standard errors are clustered at the corresponding "region" level, to adjust for heteroscedasticity and within-"region" correlation over time (i.e. standard errors in regressions with county-level data are clustered at the county level; clustering at the state level is used in regressions with state-level variables).[9]

The coefficient of interest is θ, which we interpret as the effect immigrant farmers have on agricultural production decisions. Since immigrants are not randomly distributed across counties or states, ordinary least squares estimates of θ may not reflect causal effects. Immigrants potentially select their place of residence based on unobserved demand conditions that are correlated with agricultural outcomes. To account for this, we implement an identification strategy that combines the use of instrumental variables and fixed effects.

Any time-invariant region-specific characteristic that may lead to greater population stocks of farmer immigrants can be controlled for by state/county level fixed effects. For instance, geographic conditions that jointly influence agricultural practices and migration costs (e.g., rivers, distance to the coast) are controlled for with fixed effects. Co-movement of the variables of interest due to aggregate trends is also for using year fixed effects.

Instrument As we mentioned before, and in spite of the fixed effects, the OLS estimate of θ will be biased if immigrants chose their location based on time-varying unobserved determinants of regional economic outcomes. We therefore consider an instrumental variable strategy 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 **?**, Cortés (2008), and Lewis (2005).

Formally, the instrument for the logarithm of the stock of immigrant farmers working in region i at time t (where region is a county or a state) is given by

$$\ln\left(\sum_j \frac{N_{ji,1900}}{N_{i,1900}} F_{jt}\right) \tag{2}$$

where $N_{ji,1900}$ is the stock of immigrants from ethnic group j in region i in 1900; $N_{j,1900}$ is the stock of immigrants from ethnic group j in the United States in 1900; and, F_{jt} is the stock of farmers from ethnic group j in the United States in decade t.

[9] 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 across counties in the same state.

Two requirements should hold for our identification strategy 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 regions. Second, the location decisions of immigrants in 1900 should be uncorrelated with regional differentials in the changes in agricultural practices occurring in the later decades.

Thus, our identification strategy will be violated if regional specific shocks are highly persistent and the same shocks that attracted earlier immigrants affect regional agricultural outcomes at time *t*. To reduce the concern that farmers in the past may have selected their location anticipating changes in economic conditions, the instrument uses the past location choices of immigrants of all occupations, not just those involved in agriculture.

Estimation of the first stage of equation (1) is presented in Table 1. Columns 1 and 2 show the results for the state and county level specifications, respectively. As can be seen, the instrument appears to be a good predictor of the logarithm of the regional stock of immigrant farmers.

Even after accounting for the endogeneity of the regional stock of immigrant farmers, an empirical challenge remains. As discussed by Borjas (2003), possible relocation decisions made by natives in response to immigration shocks should be considered in the interpretation of estimates derived from the variation of immigration shocks across regions. If natives leave their location in response to an influx of immigrants and these displacement effects are large, the estimates from our empirical exercise would be biased downward with respect to the full effect of immigration on agricultural practices. The effect of an increase in the stock of immigrant farmers would be quickly diffused across all regions, but our identification will only capture this impact partially.

We study the size of the displacement effects by running IV estimates of equation 1 in which the dependent variable is the (logarithm) of the stock of native farmers. Results are presented in Table 3, where the first and second columns correspond to the state and county level specifications, respectively. It should be noted that estimates from county level regressions must be interpreted in terms of variation *within a given state*, as state-by-year fixed effects have been included.

In the state regression, the estimated effect of the stock of immigrant farmers on native farmers is not significantly different from zero. In the county level regressions this impact is positive and significant, but it is not robust to the inclusion of scale controls and state-time fixed effects.[10] If immigrants were indeed attracting –as opposed to displacing– natives, our estimates of the impact of the immigrant stock on agricultural practices will include the extra boost from the additional inflow of natives, thus expanding even further the labor force and changing its composition. In order to check that some of our results are not affected by this particular specification we also consider an alternative specification of (1) where we evaluate the full labor supply

[10]Differences between both specifications could be arising from greater precision in the county level estimates or could reflect that immigration generates inflows of natives within particular states and not across states.

effects by including the stock of natives as an endogenous covariate in addition to the stock of immigrants.[11]

An alternative specification of equation (1) would weight each observation by the number of farms (or an alternative measure of the scale of production). This could render gains in terms of precision and would allow us to interpret the coefficients as estimates of the average effect per farm. To reduce the risk of correlation between the weight and the outcome, we could use the 1900 number of farms as weights. In this draft version of the paper, we don't present the weighted estimates. This work is still in progress.

6 Preliminary Results

6.1 Immigration and native mobility

As a first outcome, we estimate the causal impact of the arrival of immigrant farmers on the number of native farmers. These results are presented in Table 3. Various alternative specifications are explored. In column (1), no additional controls are included and the results indicate in this case that an increase in the immigrant population, far from leading to displacing the natives, attract them. This result, however, is only weakly significant and does not hold in column (2) once we also control for changes in the size of area farmed within a region. Once we focus on variation within a state, as in columns (4) and (5), the coefficient becomes negative but clearly insignificant. Overall, these results indicate that an exogenous increase in the number of immigrant farmers in a particular county did not leave natives to flee the area in response. This is important as it indicates that the shock to the immigrant stock we measure translated into an increase in the overall number of workers available in the regional economy.

6.2 Adjustments in the Scale of Production

We then turn by studying the impact of immigration on the scale of production. Table 4 presents the results for two measures of scale: number of farms and farmland. Panel A presents the results of an ordinary least square (OLS) regression while Panel B includes the parameter estimates of an instrumental variable strategy. For both outcomes, looking across states would lead us to conclude that welcoming more immigrant farmers is associated with an expansion of the agricultural sector. The IV estimates are clearly larger than the OLS results. However, these

[11] We are currently exploring identification strategies where we estimate the full the endogeneity of the location of natives is taken into account. We are also studying identification strategies a la Smith (2007), using estimates of the current population based on national survival rates and pre-period regional distribution of farmers as instruments for the stock of natives. These instruments can be interpreted as estimates of the stock of natives per county or state in the absence of immigration effects. This draft of the paper does not include the results from this empirical exercise, as it is still in progress.

results are not robust to changes in the specification: when we includes state-year fixed effects, the magnitude of the coefficients falls and lose all significance, thus they no longer allow us to claim that the arrival of more immigrant farmers led to more acres being farmed. In any case, the absence of any effect in the overall scale of production suggests the existence of adjustments in other margins; such as changes in crop mix, change in the intensity of use and adoption of (labor-saving) technologies. We now turn our attention to those margins.

6.3 Adjustments in Crop Production

As we explained in section 2, wheat, hay, corn and cotton are the main crops produced in the United States in this period, thus we focus our empirical work only on them. To assess the relative capital-labor intensities of these crops we rely on detailed contemporary studies of labor and capital requirements to guide us in the classification of the crops along this dimension (see Elwood, Lloyd, Schmuts, and McKibben 1939). If Rybczynski-type adjustments in crop mix are present, we would expect that the acreage devoted to capital intensive crops would decrease and that devoted to labor intensive crop would increase in response to an immigration-driven increase in labor supply. This hypothesis is evaluated in Table 5. The most capital intensive crop (wheat) is found to follow this simple intuition: more immigrant farmers lead to a lower share of total acreages to be devoted to wheat. On the other hand, cotton is found to increase its acreage, but this result is not robust to the inclusion of state-year fixed effects. Finally, both hay and corn appear to experience modest increases in acreage. While firms did not increase their overall acreage, as shown in table 4, they appear to have reallocated land use favoring crops that required lower levels of labor input.

The next table then evaluates the impact of immigration on the land productivity of different types of output. The simple correlations are all indicating no relationship between the size of the immigrant farmer stock and the output per acre of various crops. The instrumental variable results (presented in Panel B), however, suggest a different story. The fall in output per acre of wheat measured as a response to immigration is fairly substantial. This is consistent with farms reorganizing production within crop and not just across them. It appears that these results only get stronger as we include additional controls. On the other hand, the productivity of corn and hay appears to increase with larger immigrant stocks but the effect is only significant when a limited set of controls are included in the regression. In the case of cotton we find no effect of immigration on land productivity.

6.4 Adjustments to Production Technology

To measure changes in the choice of production technology, this paper uses the number of mules, horses and tractors in each state as proxy measures of draft power and capital use; tractors also represent a proxy of adoption of (labor-saving) technology. This decision is guided by accounts of economic historians stating that the adoption and diffusion of new farm technologies in the US went hand-in-hand with the adoption of draft power coming from animals or tractors (Olmstead and Rhode, 2008). Estimates of the impact of immigration on the use of draft power are only presented at the state level due to the limited county level data availability.

Table 7 presents the results from specifications that include a set of variables that control for scale effects. We see that the choice of technique also appears to have responded to the inflow of migrant farmers. In particular, we observe that the number of horses and the number of tractors appear to have declined in response to immigration (although in the case of tractors the estimation does not correspond to the whole period, due to limited data availability). These results suggest that farms may have responded to the inflow of immigrant labor by decreasing their requirement in terms of draft power, thus slowing their adoption of capital intensive technologies. If horses and tractors are also labor-saving technologies, increased labor supply as a result of immigration inflows lead to a slowdown in the penetration of the new technologies such as tractors. Surprisingly, we consistently find that the use of mules increases in response to an immigration inflow. Although they are also classified as draft power, so we expected the results to be similar to the case of horses and tractors, it might be possible that mules correspond to a cheaper method to execute certain tasks in combination with a more abundant labor force. However, we have not found so far any evidence that could explain this particular pattern

Next Step. The shift in the method of production that we infer from the decrease in draft power could be a result of another type of adjustment. As discussed by Lewis (2005), an apparent shift in the method of production estimated using aggregate quantities might be reflecting a change in the mix of goods. In order to distinguish between these two alternative adjustments, one should look at changes in technology in the production of the *same good*. Given that the available data does not have information on the specific use of the units of draft power by crop, we cannot estimate the previous equation separately for each crop. However, we can try an indirect method. Specifically, once more data is available we can estimate the draft power equations using a full set of crop mix controls. Even though crop production may be endogenous, these alternative specifications are also of interest. We are also exploring alternative ways to control for crop mix with, arguably, exogenous variables such as pre-period crop mix shares, which would help us get around the endogeneity of the contemporaneous crop mix.

6.5 Adjustments in the Capital Labor Ratios

No data on factor prices is available for this period, so we cannot directly test for effects of immigration on wages and rental rates. We use an alternative approach: by estimating the impact of immigration on capital labor ratios we test indirectly for the existence of effects on this margin.

Recall from our discussion in section 3 that if the economy responds to the extra labor by altering the output mix and capital is fully mobile, then this will reallocate between industries until the original capital-labor ratio is restored in each industry. These Rybczynski-type adjustments allow for the additional labor to be fully employed at the existing wages. We explore whether this is the case using county level data on the real value of equipment and machinery, which we use as a measure of capital demand.

Table 8 presents the results. In the simple specification of column (1), we find that an exogenous increase of one percent in the number of foreign-born farmers decrease the capital/labor by 0.06 percent. Assuming that capital and labor are more mobile within a state than across state boundaries, we compare these results to those in column (2) where state-year fixed effects are included. In this case our estimate is almost twice as large as the one in column (1): a rise of one percent in the number of foreign farmers leads to a decrease in the capital/labor ratio of about 0.11 percent. Including controls for scale and crop mix responses does not alter the coefficient by a large margin although it is still larger than the baseline in column (1). The results in columns (3) and (4) show that if we control for scale and crop mix the estimated effect of immigration on the demand for capital is not affected. This is thus consistent with a model where the production technology within states (and not just across) becomes less capital intensive as immigration increases.

7 Conclusions

TO BE WRITTEN

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Table 1. Summary statistics

	Observations	Mean	Std deviation
Stock of immigrant farmers	8817	307.27	668.13
Stock of native farmers	8817	3392.40	2827.15
Predicted stock of immigrant farmers	8817	2631.56	21093.18
Number of farms	8817	2139.31	1426.06
Acres of farmland (thousands)	8817	307472.80	239569.8
Acres of corn (thousands)	8817	32364.11	36405.86
Acres of wheat (thousands)	8817	19612.42	44263.47
Acres of hay (thousands)	8817	26204.85	29708.17
Acres of cotton (thousands)	8817	12200.36	29900.20
Corn production (thousands of bushells/acre)	8817	21.43	18.53
Wheat production (thousands of bushells/acre)	8817	14.03	101.16
Hay production (thousands of tons/acre)	8817	1.34	2.76
Cotton production (thousands of bales/acre)	8817	56.38	5219.22
Number of Tractors	96	25848.01	29904.59
Number of Horses	192	328,995	327,547
Number of Mules	192	98232.23	153,033
Capital/Labor ratio	8702	332.08	359.94

Table 2. First stage

	(1)	(2)	(3)	(4)	(5)
Predicted farmer flow	1.390***	1.368***	1.266***	0.816***	0.865***
	(0.269)	(0.269)	(0.269)	(0.313)	(0.316)
Acres farmed		0.320	0.240	0.642**	
		(0.252)	(0.255)	(0.327)	
Controls for scale	No	Yes	Yes	Yes	No
Controls for crop mix	No	No	Yes	Yes	No
State*year fixed effects	No	No	No	Yes	Yes
R^2	0.021	0.021	0.023	0.041	0.036
N	8820	8817	8817	8817	8820

Standard errors are clustered at the county level.
*: 10% significance, **: 5% significance, ***: 1% significance

Table 3. Instrumental variable estimates of the displacement effect

	(1)	(2)	(3)	(4)
Log stock of immigrant farmers	0.125*	0.097	-0.030	-0.049
	(0.075)	(0.075)	(0.183)	(0.180)
Log acres farmed		0.439**	0.411*	
		(0.187)	(0.246)	
Controls for scale	No	Yes	Yes	Yes
State*year fixed effects	No	No	Yes	Yes
R^2				
N	8820	8817	8817	8820

Standard errors are clustered at the county level.
*: 10% significance, **: 5% significance, ***: 1% significance

Table 4. Effects of immigration on scale and size of farms

	Acreage sown		Number of farms	
	(1)	(2)	(3)	(4)
		Panel A: OLS		
Log stock of immigrant farmers	0.005***	0.004***	0.002	0.002*
	(0.001)	(0.001)	(0.001)	(0.001)
N	8817	8817	8817	8817
		Panel B: IV		
Log stock of immigrant farmers	0.090***	0.017	0.047***	0.006
	(0.021)	(0.030)	(0.018)	(0.028)
N	8817	8817	8817	8817
State*year fixed effects	No	Yes	No	Yes

Standard errors are clustered at the county level.

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

Table 5. Effect of immigration on crop acreage

	Corn			Wheat			Hay			Cotton		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Panel A: OLS												
Log stock of immigrant farmers	0.013***	0.013***	0.011***	0.008	0.006	0.005	0.004	0.004	0.002	0.009*	0.008*	0.007*
	(0.003)	(0.003)	(0.003)	(0.005)	(0.005)	(0.005)	(0.003)	(0.002)	(0.002)	(0.004)	(0.004)	(0.004)
Log acres farmed			0.870***			0.694***			0.730***			0.155*
			(0.091)			(0.176)			(0.079)			(0.086)
Panel B: IV												
Log stock of immigrant farmers	0.065	0.203*	0.198*	-0.088	-0.504*	-0.511**	-0.188	0.303**	0.299**	0.445***	-0.044	-0.044
	(0.045)	(0.106)	(0.102)	(0.096)	(0.258)	(0.259)	(0.128)	(0.151)	(0.150)	(0.116)	(0.156)	(0.157)
Log acres farmed			0.760***			0.997***			0.556***			0.184
			(0.118)			(0.334)			(0.146)			(0.129)
Control for scale?	No	No	Yes	No	No	Yes	No	No	Yes	No	No	Yes
State*year fixed effects	No	Yes	Yes	No	Yes	Yes	No	Yes	Yes	No	Yes	Yes
N	8773	8773	8773	8772	8772	8772	8773	8773	8773	8820	8820	8820

Standard errors are clustered at the county level.
*: 10% significance, **: 5% significance, ***: 1% significance

Table 6. Effect of immigration on productivity of crops (physical output per acre)

	Corn			Wheat			Hay			Cotton		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Panel A: OLS												
Log stock of immigrant farmers	0.001	0.002	0.001	0.001	0.001	0.000	-0.001	-0.000	-0.000	-0.000	-0.001	-0.001
	(0.003)	(0.003)	(0.003)	(0.002)	(0.002)	(0.002)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Log acres farmed			0.095			0.153***			0.021			-0.011
			(0.081)			(0.049)			(0.026)			(0.014)
Panel B: IV												
Log stock of immigrant farmers	0.170***	0.084	0.083	-0.100***	-0.236**	-0.238**	0.066***	-0.033	-0.033	-0.019	-0.003	-0.003
	(0.044)	(0.066)	(0.066)	(0.038)	(0.105)	(0.106)	(0.018)	(0.028)	(0.028)	(0.019)	(0.035)	(0.034)
Log acres farmed			0.047			0.293**			0.041		-0.009	
			(0.096)			(0.124)			(0.031)		(0.025)	
Control for scale?	No	No	Yes	No	No	Yes	No	No	Yes	No	No	Yes
State*year fixed effects	No	Yes	Yes	No	Yes	Yes	No	Yes	Yes	No	Yes	Yes
N	8773	8773	8773	8772	8772	8772	8773	8773	8773	8820	8820	8820

Standard errors are clustered at the county level.
*: 10% significance, **: 5% significance, ***: 1% significance

Table 7. Effect of immigration on draft power

	Log (# of horses)	Log (# of mules)	Log (# of tractors)
Log stock of immigrant farmers	-0.205**	0.419***	-0.270**
	(0.080)	(0.154)	(0.117)
Log acres of farm	0.271***	-0.005	-0.075
	(0.093)	(0.147)	(0.193)
R-squared	0.972	0.986	0.981
Years in sample	1910-1940	1910-1940	1930-1940
Observations	192	192	96

Regression estimated using state level data.

Standard errors are clustered at the state level.

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

Table 8. Impact of immigration on capital-labor ratios

	(1)	(2)	(3)	(4)	(5)
			Panel A: OLS		
Log stock of immigrant farmers	-0.011***	-0.010***	-0.011***	-0.011***	-0.011***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Log acres farmed			0.504***	0.546***	0.595***
			(0.145)	(0.145)	(0.161)
			Panel B: IV		
Log stock of immigrant farmers	-0.060***	-0.114**	-0.081***	-0.068***	-0.115*
	(0.021)	(0.051)	(0.025)	(0.025)	(0.059)
Log acres farmed			0.525***	0.555***	0.658***
			(0.138)	(0.139)	(0.151)
Control for scale?	No	No	Yes	Yes	Yes
Control for crop mix	No	No	No	Yes	No
State*year fixed effects	No	Yes	No	No	Yes
N	8702	8702	8702	8702	8702

Standard errors are clustered at the county level.

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