ABSTRACT

Title of dissertation: ESSAYS ON MIGRATION AND AGRICULTURAL DEVELOPMENT

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The economic consequences of international migration have spurred vigorous debates among policy makers. There also are discussions within the economics literature, with labor economists disagreeing on whether immigration is beneficial for host economies and development economists having dissenting views about the impact of emigration and remittances on source countries. In this dissertation I make a contribution to both academic debates.

The two empirical studies in the dissertation are motivated by a core result of the Hecksher-Olin theory which states that open economies can absorb factor supply shocks by adapting their technology and output mix, thereby attenuating the effects of the shocks on factor prices. I investigate if local agricultural economies adapted their crop and technology mix in response to migration-induced changes in the availability of factors. In order to identify the causal effects of migration-induced shocks on agriculture, an empirical strategy that combines regional-level fixed effects with instrumental variables is used. The

instruments are constructed exploiting within-country variation in the historic location choices of migrants as well as arguably exogenous national shocks to migration.

In the second chapter I investigate the question in the context of a migrant sending economy, the Philippines, and derive causal province-level estimates of the effects of emigration and remittance flows on measures of the size of agriculture and the use of capital-intensive farming practices. I also estimate the effects on the adoption of risk-coping mechanisms since remittances may play an insurance role. I provide evidence that remittances have transformed farming practices, increasing the degree of specialization, the production of high value commercial crops and the adoption of mechanized farming. These effects seem to be driven by an increase in the availability of working capital and the provision of insurance. In contrast, I find no evidence that emigration has an impact on farming practices, something that can be explained by the absence of hiring constraints and the existence of a highly elastic labor supply. Overall, the findings suggest that, to the extent that agricultural production in most developing countries is limited by insurance and capital constraints and not by labor shortages, remittances can be a source of insurance and investment finance that fosters agricultural development.

The third chapter is a study of adjustments to immigration-induced changes in labor supply in a host economy, written in collaboration with Jeanne Lafortune and José Tessada. In contrast to the Philippines' study, we find an impact of early 20th century labor supply shocks on agricultural practices in the United

States, something that can be explained by the fact that the US, as opposed to the Philippines, is a land-abundant country. We find that an immigration-induced increase in farm labor led to changes in crop choice and in several measures of production organization such as farm size, tenancy and use of tractors and animal traction. We also study effects on input mix and land and capital productivity which, according to a simple theoretical framework, will provide insights about the wage effects of immigration. Overall, our results suggest that even though the US agricultural sector adapted to an increase in labor supply through output and technological adjustments, such adjustments were insufficient to mitigate the wage effects of immigration.

ESSAYS ON MIGRATION AND AGRICULTURAL DEVELOPMENT

by

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I began my research project inspired by the international migrants who take great risks and make huge sacrifices for the sake of their loved ones. To them, I dedicate my dissertation.

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Chapter 1

Introduction

Approximately 215 million people live outside their country of birth. This movement of individuals between nations is largely driven by workers flowing in search for better economic opportunities (UNDP, 2009). The economic consequences of these labor flows are a vigorously debated topic among policy makers worldwide, and this controversy is reflected in the design of contradictory and contentious migration policies. There are also debates in the academic literature, with labor economists discussing whether immigration is beneficial for host economies and development economists having dissenting views about the impact of emigration on source countries.[1] This dissertation makes a contribution to both the labor and development economics academic discussions.

As workers migrate from labor-abundant to labor-scarce economies, they shift the relative endowment of labor in both the host and the sending economies. This will likely increase the prices of substitute factors in the sending economies and depress them in the receiving countries. For instance, native workers who have similar skills to immigrants may see their wages decline. There will be an opposite impact of migration on the prices of complementary factors; with increases in host economies and declines in sending countries.

There are, however, mechanisms other than factor price shifts through

[1] See the surveys in Hanson (2010) and Friedberg and Hunt (1995).

which economies can adjust to migration-induced labor supply shocks. This can explain why much of the literature investigating the labor market effects of immigration inflows have found small to moderate effects on the wages of natives (e.g. Card (2001) and Altonji and Card (1991)). While the economic literature does not predict the magnitude by which wages will be affected by an immigration inflow, the small effects estimated in studies that compare the impact of immigration across local markets have nevertheless been surprising. A core result of the Hecksher-Olin theory provides a plausible explanation.

Indeed, as predicted by the Rybczynski Theorem, open economies may adjust to a factor supply shock by changing their output mix in favor of those sectors that employ more intensely the factor whose relative supply is expanding (Rybczynski, 1955). Host economies may therefore absorb the influx of labor by increasing the relative production of labor-intensive goods while sending economies will accommodate it by reducing the relative importance of labor-intensive industries.[2] These changes in output mix will shift the relative demand for labor, thereby attenuating the impact that the migration shock has on wages. In the most extreme cases, the adjustments in product mix will be large enough to make the effects of migration on wages negligible. A second mechanism through which economies can absorb labor supply shocks is by shifting their technology mix. In this environment, host (sending) economies will adjust to a growth (decline) in the relative availability of labor by increasing (decreasing)

[2]This mechanism may only operate in open economies, given that the disproportionate changes in output mix must be absorbed by changes in net exports.

the relative adoption of labor-intensive technologies.

In chapters 2 and 3 of the dissertation I investigate the existence of adjustments in technology and output mix in response to migration-induced labor supply shocks. In this way, I contribute to the literature exploring how international migration affects production technologies. The findings of this research are of policy interest to the extent that, by changing the relative demand of labor, adjustments in industry composition and technology mix will also attenuate the effects of migration on the prices of inputs.

In chapter 2, I investigate the topic in the context of a sending economy, the Philippines, which is one of the largest migrant exporters in the world. I do not limit my analysis to the impact of the outflow of workers, as I also study the effect of remittances sent by migrants, which significantly alter the availability of financial capital in the Philippines. In chapter 3, I study technological and production adjustments to migration from the perspective of a host economy. In collaboration with Jeanne Lafortune and José Tessada, I investigate this question using US data from 1910-1940, years that span the great European immigration to the US, and thus contribute to the fairly small and recent literature that explores technological and production adjustments to immigration.

Both chapters in my dissertation focus only on output and technological adjustments in the agriculture sector. I therefore explore the link between international migration and agricultural development from the perspective of both a sending and a host economy. In the second chapter, I explore whether emigration and remittances in the Philippines facilitated shifts from agriculture towards more capital-intensive sectors and the adoption of mechanized farming practices, which are transformations that characterize the process of economic development. In the third chapter, my co-authors and I study the role that immigration had in the process of agricultural mechanization in the US, which showed great advances during the period we study. There are two benefits of focusing on agriculture. First, given the relatively large labor requirements that characterize agricultural production in developing economies, we can expect large adjustments to labor supply shocks. Indeed, both the US in the Early 20th Century and the Philippines in contemporary times are characterized by an agricultural sector in which there are still large labor requirements. Moreover, we may expect large adjustments to the inflow of remittances sent by migrants to the Philippines, to the extent that in this country agricultural production is likely limited by the availability of financial capital. Second, measuring adjustments in agricultural production and technologies is facilitated by the availability of data and documentation on the use of technology and capital, output mix and labor requirements in agriculture. The focus on agriculture may, however, come with a downside if most of the adjustments due to immigration occur in other sectors of the economy.

An immediate issue in any empirical study of the effect of migration or remittance flows on agricultural production and technologies is the endogeneity of such flows. As discussed in the second chapter, migration and remittances in the Philippines are not randomly allocated; they are selective processes that are likely based on unobserved characteristics related to agricultural outcomes.

Similarly, the location choice of immigrants to the US in the early 20th century might have been based on unobserved demand factors that are correlated with agricultural conditions. To address these problems, I implement a methodology that is common to both chapters of my dissertation. Namely, I construct instrumental variables that exploit the fact that, due to the importance of social networks in migrants' location choices, there is within-country variation in the historic location choices of migrants. To the extent that such location choices are determined mostly by the strength of the network, they may not have a direct influence on cross-regional differentials of recent changes in the relative performance of agriculture. More specifically, in chapter 2, I take advantage of the fact that Filipino migrants are widely dispersed overseas and that there is significant variation in the destinations across provinces. This leads to regional variation in macroeconomic shocks at the destination countries that differentially impact the returns and opportunities of migration. I use such shocks to construct instrumental variables of migration and remittances. To my knowledge, a similar instrumental variable design has not been used in previous studies of the impact of emigration on sending economies. Furthermore, my study is one of the first to have instrumented separately for both emigration and remittance flows.

In Chapter 3, my coauthors and I build instruments that exploit the tendency of new immigrants to move to enclaves established by earlier immigrants of the same ethnicity.[3] This regional variation in the earlier distribution of im-

[3]For examples of papers that use a similar approach, see Card (2001), Cortés (2008), and Lewis (2010).

migrants is a valid instrument to the extent that it is assumed not to have a direct impact on differentials in agricultural outcomes and can be used to predict immigration flows. In an attempt to diminish the potential link between these location choices and agricultural progresses, we construct the instruments using the past distribution of all immigrants as opposed to the past distribution of immigrants involved in agriculture.

Thus, the methodology in both chapters exploits within-country variation in arguably exogenous shocks that affect migration flows. A key conceptual problem with this approach is that the effect that a migration shock has on the regional supply of labor may be offset by internal migration flows across regions. Thus, as discussed in chapter 3 of this dissertation, an inflow of immigrants to a US county may not have raised the supply of agricultural workers, since native farmers may have moved to neighboring counties in response to immigrant inflows. Similarly, in chapter 2, I discuss that the effect of international migration out of any given Filipino province on that province's labor supply may have been attenuated by the inflow of workers from neighboring regions. An analogous argument can be made to argue that the province-level effects of an inflow of remittances might have been diffused by cross-province flows of financial capital in the Philippines.

This issue is assessed in both chapters of the dissertation with the analysis suggesting that, in neither case, the impact of international migration shocks is totaly undone by internal migration. In the Philippines' study I find suggestive evidence of a minimal impact of migration shocks on the labor supply of neighboring regions. Unfortunately, due to data limitations I am unable to make a similar analysis of the possible spillover effects of remittance shocks to neighboring regions. Coefficients estimated in the Philippines' study are therefore interpreted as estimates of the causal effects of emigration and remittances on province level agriculture markets, and as lower bounds of the overall impacts of emigration and remittances on the national economy. In the case of the US study, my coauthors and I provide evidence that the county-level effects of immigration are not completely attenuated by the displacement of natives. Moreover, we specify an empirical model in which we estimate the effects of changes in the endowment of *total* agricultural labor, as opposed to changes in the endowment of *immigrant* labor. The estimated parameters therefore account for any offsetting flows of natives.

Chapter 2 presents robust evidence of an impact of remittances on farming practices in the Philippines. Remittances appear to increase specialization, the production of high value commercial crops and the adoption of mechanized technologies. A 10 percent increase in remittances, which is the typical two-year shock received by a province, increases the probability that farms grow high value crops by 2-3 percent and specialize in one crop by 1 percent. Moreover, the probability that rice farms use mechanized equipment increases by 2-5 percent. The magnitude of these effects are small, which is not surprising given that the estimates average over the whole local agricultural economy and therefore include farms that are not direct recipients of remittances. The increase in the adoption of capital-intensive crops and technologies in response to an inflow of financial capital is consistent with the predictions of the Rybczynski framework. Moreover, I provide auxiliary evidence suggesting that the impact of remittances on farming practices also operated via a risk-mitigating channel, with remittances substituting for income-smoothing agricultural practices used by farmers such as crop diversification.

In contrast, I do not find evidence that the outflow of workers affects the Philippines' agricultural practices. This result can be explained by the existence of a highly elastic supply of labor and the absence of hiring constraints. As presented in the seminal work by Lewis (1954), a very elastic labor supply reflects the existence of “surplus labor". In such an environment, the abundance of labor relative to other inputs of production is so large that its marginal productivity is negligible. The withdrawal of workers therefore has a minimal impact on production.

Indeed, the Philippines approaches the textbook case of a land-scarce economy. It is a heavily populated island nation with few river deltas, scarce arable land and high rural unemployment levels. In contrast, the US in the early 20th century was the quintessential land-abundant country, as the agricultural frontier was finishing to be established. The results in the third chapter, which show that labor shocks had an impact on the US agricultural production, are therefore not surprising. My coauthors and I suggest that in the early 20th century an immigration-induced increase in the stock of workers per acre led to changes in crop choice and in the organization of production. An increase in the relative availability of labor appears to have had an impact on output mix, decreasing the land allocated to wheat and cotton and increasing the land allocated to corn and hay. We also find evidence showing that an increase in the relative supply of labor led to a decline in the average farm size, in the number of tractors per acre and in the extent of farmland operated by owners. We find this set of results to be consistent with a framework in which agricultural economies absorb a labor inflow by slowing the adoption of labor saving techniques. Moreover, we find these adjustments to labor supply shocks to be larger in counties where tenancy was a prevalent institution, something that can be explained by the fact that, in these regions, agricultural labor was even more scarce.

While the initial set of results highlight the role of changes in output mix and production techniques as mechanisms to adjust to an influx of labor inputs, other findings indicate that the shocks to labor supply were not entirely absorbed through these channels. We study the effects of labor supply shocks on capital-labor ratios and land and capital productivity. These results seem to suggest that the wage effects from the immigration-induced labor supply shock were not completely attenuated by Rybczynski-type adjustments.

Overall, the results in this dissertation provide evidence of how local economies adapt their product mix and technologies to input availability shocks. The findings contribute to the academic debates about the economic consequences of migration in sending and host economies. In the study of the Philippines I find that, in an environment in which agricultural production is limited by insurance and capital constraints and not by labor shortages, remittances sent by international migrants can facilitate productive investments in agriculture. When looking at the US, where labor was more scarce, my coauthors and I find that, even if an economy absorbs an increase in labor supply influx via output and technological adjustments, such adjustments may be insufficient to mitigate the wage effects of immigration.

Chapter 2

The Effects of Emigration and Remittances on Agriculture: Evidence from the Philippines

2.1 Introduction

Approximately 140 million people born in developing countries live outside their country of birth (World Bank, 2008). Reported remittances from these migrants have become the main source of private capital inflows in dozens of developing countries (World Bank, 2006). Many view with optimism the development gains that remittances may have, and argue that easing restrictions to the international mobility of labor is indispensable in an effective agenda to help poor countries (e.g. Birsdall, Rodrik, and Subramanian (2005) and Pritchett (2006)). However, large productivity costs might be involved in this process, since emigration can significantly reduce the size of the productive workforce and have disruptive effects on family members left behind. Thus, without a separate assessment of how the departure of workers and the inflow of remittances affect the sending economies, it is difficult to make a proper appraisal of the development impacts of these phenomena. There are, however, very few empirical studies that estimate the causal impacts of remittances and emigration separately.

In this paper I derive separate estimates of the effects of emigration and remittances on Philippines' local agricultural economies. Given the high labor requirements of agricultural production and the credit and insurance shortages that typically affect rural economies, adjustments to the outflow of labor and the inflow of remittances in the agriculture sector are likely to be large. By increasing the availability of capital and reducing the supply of labor, remittances and emigration can generate shifts from agriculture towards more capital-intensive sectors and, in this way, promote a structural transformation that characterizes economic development. This shift in the relative endowment of capital and labor may also lead to the adoption of more mechanized farming practices. Moreover, if remittances to the sending economies are used as insurance, they may substitute for alternative risk-mitigating strategies used by farmers left behind. In this paper I investigate whether in local economies the inflow of capital from remittances and the outflow of workers from international migration have: i) led to a decline of the Philippines' agriculture sector; and ii) enabled the adoption of more mechanized and riskier farming practices in the Philippines' agricultural sector. I interpret the results in light of a conceptual framework that illustrates how the possible effects of migration and remittances on agriculture depend on the existence of resource and insurance constraints and on the relative abundance of production inputs.

In this empirical exercise I face two important challenges. First, the observed relationships of agricultural outcomes with emigration and remittances cannot be interpreted as causal. Migration and remittances are not randomly allocated; they are selective processes that are likely to be based on unobservable characteristics. Reverse causality is also a big concern, since agricultural outcomes such as crop failures may induce migration outflows and generate a greater inflow of remittances from abroad. Second, due to the close linkages between emigration and remittance receipts, isolating their independent effects is a challenging task. The difficulty rests on the need to find suitable instruments that can separately predict the amount of remittances and the magnitude of migration outflows. In this paper I surmount these problems by exploiting variation in macroeconomic shocks faced by Filipino migrants at their country of destination. Specifically, I exploit arguably exogenous shocks that affect the employment opportunities of potential Filipino migrants and the purchasing power of migrants' earnings. Here I take advantage of the distinct features that characterize international migration patterns in the Philippines. Filipino migrants are widely dispersed overseas, making them susceptible to more varied shocks at the destination countries than, say, Mexican migrants who mostly go to the United States. Moreover, there is significant variation in the destination choice across Filipino provinces. I take advantage of this cross-province variation to construct two province-level instruments that measure demand and exchange rate shocks faced by potential Filipino migrants at the host countries.[1]

Thus, the Philippines' pattern of international migration has features that

[1]By exploiting the large variation in shocks faced by Filipino migrants at the destination, I follow Yang (2008) and Yang and Martinez (2005) who obtain reduced form estimates of the impact of exchange rate shocks on household consumption, educational investments and poverty. I extend their approach by deriving instrumental variable estimates of the effects of remittances and emigration.

makes the identification strategy possible. In addition, there are several other reasons that make this country a good environment to study the effects of migration on agricultural production. The Philippines has a long tradition of international migration where the “overseas employment of Filipino workers" has been actively encouraged by the government.[2] Currently, migrants from the Philippines amount to 10 percent of the country's workforce and remittances sent home are equivalent to 13 percent of the country's GDP (World Bank, 2008). Moreover, the agricultural sector is of vital importance, contributing one third of the country's total employment. Since forty percent of overseas migrants come from rural areas, there may be large adjustments to emigration and remittances in agricultural production.

I draw on data from the 1991 and 2002 agricultural censuses of the Philippines and a set of migration, income and labor force surveys administered by the National Statistics Office (NSO) of the Philippines. In a first set of results I show that neither remittances nor migration modify the size of the agricultural sector as measured by labor inputs allocated to agriculture, farms and farmed area. However, because the estimates on farms and farmed area are somewhat imprecise, I am unable to rule out the possibility that the absence of effects along these two margins simply reflects lack of precision in the estimation. In a sec-

[2] In the 1970s a policy aimed at promoting the overseas employment of Filipino workers was enacted. Agreements were made with oil-rich Gulf countries that had insufficient labor to complete ambitious infrastructure projects. In addition to making agreements with potential host countries, the Filipino government actively recruited migrants in the local market and secured their overseas employment. Nowadays the government has limited its role to the legal assistance of Filipino workers and the licensing and regulation of approximately 1000 private agencies in charge of all recruitment activities (Ruiz (2008), Asis (2006)).

ond set of results I find evidence that remittances, holding emigration constant, have an effect on input and output mixes within agriculture production of remittances. Specifically, a 10 percent growth in remittances appears to increase the fraction of farms that produce high value commercial crops by 2 percentage points and the fraction of farms that specialize in the production of one crop by 1 percentage point. Remittances also increase the share of farms using mechanized farming methods in rice production by 2-4 percentage points. The effects are economically significant, especially given that the estimates are an average over the entire population, including non-remittance recipient households, and that agricultural responses are slow due to their seasonal nature. In contrast, there are no economically or statistically significant effects of emigration on the adoption of specialized or mechanized farming practices.

The results in this paper underscore the importance of assessing the impacts of emigration and remittances separately, to the extent that the effects on the sending economies depend on the characteristics of local labor, capital and insurance markets. The findings are consistent with a framework in which the capital inflow from remittances increases investments in agriculture by relaxing credit constraints and/or by reducing the cost of credit. Moreover, in the absence of complete insurance markets, remittances appear to be used as an insurance mechanism that can substitute for alternative risk-coping strategies such as crop diversification. Emigration, on the other hand, has no impact on production, consistent with a local economy that faces a highly elastic supply of labor. Given that shortages of capital and insurance, not of labor, usually constrain agricultural production in developing countries, results in this paper favor the view of remittances as an important source of investment finance and insurance that can promote agricultural development.

Most studies of the impact of migration on source economies do not isolate the estimates of the effect of the departure of workers from the effect of remittance receipts. In the literature that focuses on agricultural production outcomes the one exception, to my knowledge, is the study by Taylor, Rozelle, and de Braw (2003) that explores the links between migration, remittance and crop incomes in rural China. The authors find that the loss of labor to migration has a negative effect on household cropping income in source areas and that remittance receipts partially compensate for this lost-labor effect by increasing crop yields at the household level. My paper complements this result by directly observing positive effects of remittances on the adoption of mechanized technologies on local agricultural economies and by providing suggestive evidence of an insurance role of remittances.

In contrast to Taylor, Rozelle, and de Braw (2003), I use an identification strategy that exploits shocks experienced by migrants at the destination. This is a departure from the existing literature on the effects of migration and remittances on agriculture, in which, in general, previous work dealt with the endogenous nature of the explanatory variables of interest by using as instrumental variables historical and village level migration rates or measures of mobility barriers.[3]

[3]Some examples of studies that construct instruments with historic and/or village level migration measures are Taylor, Rozelle, and de Braw (2003),Taylor and Lopez-Feldman (2010), Mendola (2008), de Braw (2010). Measures of mobility barriers such as language knowledge,

The success of such identification strategies depends on the assumption that the instruments only affect agricultural outcomes through their impact on current migration or remittance levels. However, instruments that are constructed from mobility barriers, local migration prevalence and past migration patterns may have a direct impact on agriculture through other channels, such as commercial trade. Also, village and historic migration patterns might be influenced by unobserved community characteristics - such as access to public services– that have an effect on agricultural outcomes. Finally, past migration patterns and mobility barriers can lead to increased economic opportunities, directly affecting agriculture. Thus, the exclusion restriction may fail in identification strategies that use measures of mobility barriers, historic migration and village migration prevalence as instrumental variables. I argue that the empirical approach I use in this paper requires a weaker identification assumption.

My results are consistent with recent studies showing that remittance inflows can increase productive investments in the sending communities (e.g. Dustmann and Kirchkamp (2002), Woodruff and Zenteno (2007), Yang (2008)). Thus, they contradict the literature showing that remittances are mainly used for leisure or current consumption with limited effects in the long-run.[4] Moreover this paper is one of the few studies that provides micro-data evidence indicating an insurance role of remittances in the sending economy. My findings are consistent with the results of Yang and Choi (2007), which show that remittances in

education of household members and distance to border crossing are used by Mendola (2008) and Miluka, Carletto, Davis, and Zezza (2010).

[4]Rapoport and Docquier (2005) provide a review.

the Philippines are used to buffer negative income weather-related shocks. In a related study, Mendola (2008) shows that farmers with international migrants in Bangladesh are more likely to adopt rice varieties with greater yield variability.

The rest of this paper is organized as follows. Section 2.2 reviews a simple conceptual framework that illustrates the potential effects of migration and remittances on agricultural production. Section 2.3 describes the empirical strategy and discusses the data sources employed. Section 2.4 presents the results of the main estimations. Section 2.5 discusses alternative explanations to the results and section 2.6 concludes.

2.2 Conceptual Framework

The goal of this section is to develop some intuition about how emigration and remittances can affect production decisions in local agricultural economies that will help frame the interpretation of the results. I start by likening emigration and remittances to shocks that alter the endowment of labor and working capital, respectively. I discuss how the effect on production via changes in input endowment will depend on the characteristics of the credit and labor markets (adapting from Banerjee and Duflo (2008)). I then consider the role of remittances as an insurance mechanism that, by smoothing consumption across states of nature, may alter the risk taking behavior of farmers. Finally, I discuss alternative channels through which remittances and migration may impact agricultural production (e.g. impact on prices of non-tradables).

Consider an economy in which output prices are determined competitively. Agricultural households weigh the profits of two alternative production methods or goods: “modern", which is indexed by subscript M, and “traditional", which is indexed by subscript T. Production technologies can be described by $Q_M = F_M(Z, K)$ and $Q_T = F_T(Z, L)$, where Z corresponds to a vector of fixed inputs and household characteristics. Thus, these alternative technologies differ in whether they use capital or labor.

I start by providing a graphical illustration of the impact of emigration on the farmer's production decisions. I consider two alternative scenarios: i) farmers are *constrained* in the labor market, and are therefore unable to invest in an efficient amount of labor in the production of Q_T, and ii) farmers are unconstrained. Both possibilities are shown in Figure 1, which depicts the marginal product of labor in the production of Q_T. Let w_1 denote the initial cost of labor. In the first scenario, the farmer faces a binding constraint in the hiring market and therefore invests a quantity of labor L_0, at which the marginal product exceeds the marginal cost, w_1. Emigration will increase labor shortages, reducing the quantity of labor invested to $L_0^{'}$. Thus, an outflow of workers will unambiguously reduce output level Q_T. Now assume that the farmer is unconstrained and can choose an efficient amount of labor, L_1 . Emigration will only affect production of Q_T if it increases the marginal wage faced by the farmer. An increase in wages to w_2 will reduce the quantity of labor to L_2 and, as a result, the output of the traditional technology will decline. However, the wage level will remain unaffected if the aggregate supply of labor faced by the farmer is elastic, as will be the case if there is a readily available pool of laborers that can easily substitute for the migrant workers. If this is the case, the production of Q_T will remain unaltered.

The analysis in the case of remittances is analogous. In an environment in which the farm is bound by a credit market constraint, an inflow of capital from remittances will unambiguously have an impact on Q_M. In the absence of credit constraints, remittances will only affect production of Q_M if they reduce the marginal cost of capital faced by the farmer and this will depend on the elasticity of the supply of capital in the local market.

Thus far, I have interpreted remittances and migration as shocks to the availability of factor endowments in a local economy. An alternative channel through which remittances may affect agricultural production is by constituting a risk-mitigating device. A body of empirical and theoretical literature has highlighted the insurance motives of migration among agricultural households (e.g. Stark (1993), Yang and Choi (2007), Mendola (2008), Rosenzwieg and Stark (1989)). In the presence of imperfect insurance markets, agricultural households may use alternative mechanisms to cope with risk. One alternative is to diversify income sources by engaging in several economic activities. Another alternative is to diversify income sources via migration. As discussed by Morduch (1995) such smoothing mechanisms often substitute for each other, so if agricultural households use remittances to smooth consumption across states of nature, their need to diversify income sources by engaging in multiple farming activities will be reduced.

The empirical results in this paper are mainly interpreted in the light of the impact that remittances and emigration can have on production by changing the input endowments in the local market and the farmer's exposure to risk. Thus, I abstract from alternative mechanisms through which an impact on agriculture may occur. Admittedly, there are other causal channels that can be considered. Remittances can increase the demand of non-tradable goods and, to the extent that the relative profitability of the non-tradable sector rises, lead to a decline in agricultural production. Remittances may also affect agricultural production by modifying the consumption of leisure of remittance-recipient households. Also, migration can alter farming practices if there is a transmission of agricultural technical knowledge from the country of destination to the community of origin. The possibility of alternative mechanisms will be taken into account in the interpretation of the empirical results.

2.3 Data and Empirical Strategy

2.3.1 Basic Specification and Identification Strategy

As described in the previous section, by changing the availability of labor and capital in local markets emigration and remittances may facilitate the transition out of agriculture towards more capital intensive sectors and/or increase the production of capital intensive outputs and the adoption of capital-intensive technologies. Moreover, by buffering income shocks, remittances may reduce the need of alternative mechanisms to diversify income sources. In this paper, I test for these adjustments and derive estimates of the effects of remittances and emigration on measures of: i) the size of the agriculture sector; ii) the adoption of capital-intensive technologies iii) crop choice; and iv) crop diversification. The basic regression model relates measures of migration and remittances in local markets to agricultural outcomes. The unit of analysis of the estimation is a city or municipality.[5] The variables measuring migration and remittances are defined at the more aggregate *province* level. A province is an administrative division equivalent to a US state and is the finest unit at which the migration and remittance data can be obtained. The estimating equation is as follows:

$$y_{ipt} = \alpha + \theta M_{pt} + \delta R_{pt} + \beta X_{ipt} + \gamma W_{pt} + \nu_{ip} + \mu_t + \epsilon_{ipt} \tag{2.1}$$

where y_{ipt} is an agricultural outcome for municipality i in province p and year t; M_{pt} and R_{pt} are respectively the log of the stock of migrants and the log of the total level of cash remittance receipts in province p and year t; X_{ipt} is a set of municipality-level time-varying controls; W_{pt} is a set of province level time-varying controls; ν_{ip} and μ_t are, respectively, municipality and year fixed effects. The equation is estimated for $t = 1991, 2002$ since these are the years for which the agricultural data is electronically available. All regressions are weighted by number of farms.[6]

[5]The local administrative units that provinces in the Philippines are subdivided into are defined as *cities* and *municipalities*. These two categories differ in terms of population size and tax revenue, with municipalities being smaller, more abundant, more likely rural, and analogous to “towns". For simplicity, in this paper I will use the term *municipality* as a general category that encompasses all local administration units, even though larger units are strictly defined as “cities".

[6]Since there are no farm-level covariates in the specification, estimates are equivalent to those

The coefficients of interest are θ and δ. Since the regressors of interest vary at a more aggregate level than the unit of analysis, within-province correlation of the error will cause a downward bias in conventional estimates of the standard errors. I therefore allow for an arbitrary variance-covariance structure by clustering standard errors at the province-by-year level.[7]

As discussed in the introduction, a causal interpretation of Ordinary Least Squares (OLS) estimates of θ and δ in equation 2.1 is inappropriate, since M_{pt} and R_{pt} may be endogenous. Migration outflows and remittance receipts are not random processes. They are based on unobserved characteristics of the local economy, such as productivity shocks or the quality of public services that may have an impact on agricultural practices. Reverse causality is also a big concern since agricultural shocks in source economies probably have an influence on migration and remittance decisions (e.g Munshi (2003) and Yang and Choi (2007)). Moreover, migration, remittance and agriculture production decisions may be determined simultaneously if households jointly allocate labor and production resources on the sending community and abroad. To address these issues, I implement an identification strategy that uses municipality-level fixed effects in combination with instrumental variables.

Municipality-level fixed effects control for potentially confounding time-invariant characteristics. With two observations per municipality (1991 and 2002), the estimates of θ and δ that I obtain from equation 2.1 are equivalent

obtained in farm-level regressions. Farm-level covariates had a negligible impact in the value and precision of the estimates of interest.

[7]Serial correlation of the error terms is not a source of concern, as this is a model with fixed effects and two time periods (Wooldridge, 2002).

to those from the first differenced specification:

$$\Delta y_{ip} = \theta \Delta M_p + \delta \Delta R_p + \beta \Delta X_{ip} + \gamma \Delta W_p + \Delta \epsilon_{ip} \quad (2.2)$$

The results I present in this paper correspond to estimates of a fixed effects model as in 2.1, instead of a first difference model, as in 2.2.

To deal with potential time-varying confounding factors I construct instrumental variables. In this identification strategy I take advantage of the large variation in destination choices made by Filipino migrants, which makes them susceptible to very diverse shocks at the host countries. Column 1 in Table 2.1 shows the distribution of migrant workers across countries in 1991. Saudi Arabia was the preferred destination with 28 percent of the migrants, and the US was the second most preferred with 13 percent of the migrants. No other country hosted more than 10 percent of the total stock of migrants. Columns 2 and 3 present the variation in the economic shocks experienced by migrants at these destinations. Such shocks are arguably exogenous to conditions of the Filipino agricultural economy as their variation is related to global economic events such as the introduction of the Euro, the Asian Financial Crisis and the Gulf War. Also importantly, the GDP and exchange rate shocks are not highly correlated.

Moreover, the probability of choosing a given destination country varies across provinces. I illustrate this feature in Table 2.2, which shows the 1991 distribution among the major destination countries of migrants from the 10 provinces with highest overall migration levels. Although there were 77 provinces in the Philippines in 1991, for simplicity I list the distribution for only the 10 provinces with highest migration. Clearly, the importance of each location varies across provinces. For example, Saudi Arabia hosted 70 percent of the migrants from Magindao but only 10 percent of the migrants from Negros Occidental. This leads to considerable variation across provinces in the shocks at the destination experienced by migrants.

In addition, there is historic persistence in the destination choices made by migrants. Migrants from given provinces persistently favor certain destinations.[8] This phenomenon probably reflects the important role that networks play in the distribution of information to prospective migrants of the opportunities abroad.[9] I exploit these characteristics of Filipino migration to construct instrumental variables that measure exogenous shocks faced by migrants at the destination.[10]

The instruments for ΔM_p (where M_p is the log of migration) and ΔR_p (where R_p is the log of remittances) are denoted by ΔZ_{1p} and ΔZ_{2p}, and described as follows:

$$\Delta Z_{1p} = \Delta log(\sum_d \pi_{pd} GDP_d) \tag{2.3}$$

[8]This is evident from the results of a simple OLS regression of the 2002 share of province-level migrants in each country on the 1991 share of province-level migrants in each country with province-level fixed effects. The estimated coefficient is 0.56 and significant at 1 percent.

[9]Recruitment agencies in the Philippines match migrant workers with employers abroad. An overwhelming majority of these agencies have headquarters in Manila, and a few have branches in major cities such as Davao or Cebu. Migrants from other areas learn about job opportunities abroad from informal brokers who are often part of the same social network (Agunias, 2010).

[10]McKenzie and Rapaport (2006), Yang (2008), Yang and Martinez (2005) and Antman (Forthcoming) also exploit shocks at the migrants' destination in their empirical strategies.

$$\Delta Z_{2p} = \Delta log(\sum_d \pi_{pd} XR_d) \tag{2.4}$$

where π_{pd} is the share of migrants from province p going to country d in 1991; GDP_d is the GDP in country d, with a two year lag; XR_d is the exchange rate in Filipino pesos with respect to the currency in country d at time t[11]

The instrument described by 2.3 can be interpreted as a measure of proportionate changes in the size of the economy of the *expected* destination of migrants from province p. Weights are assigned in terms of the relative importance of each destination as measured by the 1991 distribution of migrants, π_{pd}. Given that migration from the Philippines is largely demand-driven, real shocks at the destination should impact migration and remittance patterns. I choose a lagged measure of GDP instead of a contemporaneous variable because the stock of migrants at time t likely migrated in response to a past demand shock at the destination. However, results presented in section 4 will show that very similar results are obtained in specifications that use contemporaneous measures and that the estimates are insensitive to the lag period.[12]

The instrument in 2.4 proxies a proportionate change in the exchange rate faced by migrants from province p at their “expected" destination. Shocks to

[11] Exchange rate values are in 2002 Filipino pesos. Nominal exchange rates were obtained from the International Monetary Fund International Finance Statistics and converted to 2002 constant Filipino pesos using the consumer price index reported by NSO. GDP are reported at PPP and constant prices using data from the International Monetary Fund, World Economic Outlook Database.

[12] Of course, other proxy measures of the demand of migrants, such as per-capita GDP and unemployment rate, can be considered. In results not presented here, I explore such alternatives. I chose the GDP variables chosen based on a set of criteria that considered power, linear independence between the instruments and measurement error.

the exchange rates have an impact on the purchasing power in Filipino pesos of the migrants' earnings and, therefore, may affect the volumes of migration and remittances.

Both instruments are constructed using the 1991 baseline distribution across countries of migrants from province p (i.e., π_{pd}). It is important to use a predetermined distribution across countries for the validity of the instrument, since the choice of the migrants' destination could have responded to the agricultural outcomes. Details of the construction of the instrument are available in the Data Appendix.

The use of time and level fixed effects in combination with instrumental variables will lead to a valid identification strategy as long as two conditions hold. First, the 1991 distribution of migrants across destinations is not correlated with changes in agricultural outcomes within municipalities between 1991 and 2002. Second, changes in GDP and exchange rates at the destination are exogenous to changes in agricultural outcomes within municipalities. In contrast, there will not be a threat to the identification strategy if the 1991 destination choice is determined by unobserved time-invariant province characteristics. Thus, the identification strategy is not violated even if wealthier provinces persistently send migrants to countries with the best economic opportunities, since time-invariant characteristics will be controlled for with the province-level fixed effects. The identification also will not be violated if the instruments capture external shocks that impact agricultural production in ways that are not differential across provinces. Thus, the identification assumption will hold even if the instruments capture national shocks to agricultural prices or exports, since common national shocks will be controlled for in the constant term.

The proposed identification strategy will be violated if the 1991 destination choice of migrants from a given province was based on province-specific productivity shocks that persisted through the decade and had a differential impact on agricultural outcomes in municipalities within that province. It will also be violated if, for example, the instruments proxy for external shocks to agricultural prices that differentially affect municipality-level agricultural outcomes. To control for possible confounding factors that may be correlated with changes in the agricultural outcomes of municipalities over the decade, I include a rich set of municipality and province level time-varying predetermined covariates. These variables are constructed by interacting year dummies with 1991 province and municipality level demographic, economic and agricultural characteristics.[13] In the results section, I evaluate the sensitivity of the first stage estimates to the inclusion of this set of control variables. A substantial change in the instrument coefficients suggests a threat to the validity of the identification assumption.

2.3.2 Data

Agricultural Outcomes. To construct outcome variables that measure the size of the agricultural sector, crop mix and the use of capital intensive farming tech-

[13] The controls were constructed by interacting year dummies with 1991 province and municipality level measures of: i) demographic characteristics (i.e. share of household heads with no high school diploma, average age of household head, share of female adults, share of married adults, share of rural population); ii) economic conditions (i.e., unemployment rates and hours worked); iii) agriculture characteristics (farm area, area planted, area irrigated, livestock heads, rice farms)

nologies, I use information from two sources: the Census of Agriculture and Fisheries of the Philippines (CAF) and the Labor Force Survey (LFS). I restrict the empirical analysis to 1991 and 2002 as these are the only years for which electronic data of the CAF is available

The CAF is administered approximately every ten years by the National Statistics Office (NSO) of the Philippines and enumerates all agricultural establishments in the country. Electronic data is only available for 1991 and 2002. The CAF collects information on area, crop choice and use of farming equipment. Since the CAF has no information on the value of agricultural production, agricultural income or quantities produced, I assess the scale of agricultural production with measures of the number of farms and area farmed. I complement the analysis using outcome measures of labor inputs allocated to agriculture that I gather from the LFS, a quarterly nationwide household survey designed to gather labor market information. Data in the CAF is not used to build labor input variables because only members of agricultural households are enumerated in this census. This is an important drawback given the important role hired labor plays in the Philippines' agriculture (Dawe, Moya, and Casiwan, 2006).

To learn about the effects on crop mix and diversification, I use detailed data from the CAF on the different types of crops grown. To study the effects on mechanized technologies, I use data in the CAF that document the use of equipment and machinery, owned and rented, and access to irrigation systems. As will be discussed in section 2.4.4, I restrict the study of capital-intensive technologies to farms that produce rice. Without such a restriction, observed changes in the method of production could be masking changes in the composition of crops. In section 2.4.3, I present evidence that ameliorates concern of endogenous selection from restricting the analysis to rice farms.

Data on the use of equipment in the CAF is finely disaggregated to 40 different types of machinery. To simplify the analysis, I build three categories that correspond to the use of mechanized technologies in the three main stages of the rice cultivation process: 1) tillage or land preparation (plowing and ripping the soil); 2) cultivation (planting and weeding); and 3) post-harvesting (includes the process of *threshing* in which the harvested rice grain is separated from its the stalk). This classification is guided by the economics literature that studies agricultural mechanization patterns (Pingali, 2007).

1. The mechanization of land preparation typically involves the substitution of animal drawn plows to hand tractors. Also known as *power tillers*, these are two-wheeled machines that work the soil by means of rotating blades. The adoption of hand tractors can reduce labor input requirements per hectare in up to 75 percent (Pingali, Hossain, and Gerpacio, 1997).[14] From data in the CAF I build measures of frequency in the use of hand tractors by rice farms.

2. The mechanization of the cultivation and harvesting operations in rice farms can occur through the adoption of mechanical cultivators, fertilizer

[14]In the absence of hand tractors, a rice farmer that plows 1 hectare with a water buffalo typically slogs 30 kilometers through a deeply muddy field and repeats this process several times (Dawe, Moya, and Casiwan, 2006).

distributors and weeders.[15] Using the CAF I build variables that indicate the frequency in the use of any of these machines among rice farms.

3. Finally, the mechanization of post-harvest activities typically involves the use of mechanical threshers to substitute manual labor. Generally, farmers use small axial threshers that are easily mobile and suited to be hired in contract operations.[16] Very rarely, farmers use combiners, which are large machines that combine into a single operation the process of reaping and threshing. Information on the use of these post-harvest technologies is available in the CAF.

The CAF also has information on the availability and type of irrigation systems, which can be public (built by the government) or private. In the Philippines in the 90s, 2 out of 3 irrigated farms had private systems, mostly consisting of *communal* systems that are built and operated by farmer associations, sometimes with the support of government subsidized loans. Generally, these are simple gravity-type canal systems that divert river flows and are built with local materials (David, 1995). I use data in the CAF to build outcomes measuring access to private irrigation systems.

Table 2.3 presents summary statistics of 1991 agricultural characteristics for

[15]The adoption of mechanical cultivators/transplanters can generate significant reductions in labor requirements. In the Philippines, rice seedlings are usually started in seedling beds and must be transplanted to flooded fields for cultivation. Transplanting seedlings by hand is a backbreaking work that requires bending over to place up to a quarter million separate seedlings per hectare (Dawe, Moya, and Casiwan, 2006). Mechanical cultivators are designed to substitute labor in this process.

[16]In the absence of mechanical threshers, rice grains have to be separated from the stalks by treading or by beating the stalks against boards or racks; a very arduous task (Pingali, Hossain, and Gerpacio, 1997).

the 1210 municipalities used in the empirical analysis. In 1991 a typical municipality had 241 farms that had, on average, an area of 2.2 hectares. Statistics of farm production are reported in Panel B for the four most important crops in the country (i.e. rice, corn, coconut and banana) as well as for "high value commercial crops"[17]. The latter group consists of crops that are identified as most profitable by the Department of Agriculture of the Philippines.[18] In 1991 a typical municipality had approximately half of its farms producing rice, coconut and banana in at least one parcel. Corn production was less frequent. Half of the farms produced at least one high value commercial crop in at least one parcel.

Panels C and D present statistics describing specialization and mechanization levels. Panel C shows that in a typical municipality 15 percent of the farms grew only one crop, 13 percent grew two crops and 58 percent grew three or more. Panel D shows the frequency in the use of different types of machinery among rice farms. Cultivation equipment, which consists of weeders, transplanters or sprayers, was the most frequent.

Migration and Remittance Variables. Data on migration and remittances are obtained from the Survey of Overseas Filipinos (SOF) and the Family Income and Expenditure Survey (FIES). Both surveys are conducted by the NSO. The SOF is a nationwide survey administered yearly through a rider questionnaire in the October Labor Force Survey. Information is collected for household mem-

[17]Rice(palay), corn, coconut and banana account for 70 percent of the value of production in agriculture, at constant prices (Bureau of Agricultural Statistics, 2002).

[18]High value commercial crops are majorly composed by mango and also include tubers (i.e. camote (sweet potato), gabi (taro) and cassava) and vegetables (i.e. eggplant, tomatoes, stringbeans and alugbati (Malabar spinach)).

bers who were abroad within the last five years, whether they have returned or not. Crucially for my analysis, the SOF collects information on the countries visited by the migrants and the dates of their visits. The FIES is a nationwide survey of households undertaken every three years by the NSO to collect data on family income and expenditures. The province is the finest administrative unit at which these surveys are representative. Provinces are the primary administrative division in the Philippines, and are further subdivided into more than a thousand cities and municipalities.

I use the SOF to construct province-level variables of migration for 1991 and 2002 and to build the 1991 distribution of migrants across destinations. Because the collection of the SOF started in 1993, retrospective histories on migration are used to build the 1991 variables, creating measurement error issues that are enhanced in first-differences equations like 2.2. Measurement error in remittances variables is also very likely. Remittances data are collected from the FIES, and can be easily mismeasured and misreported by survey respondents. Moreover, data for 2002 are not directly available and have to be proxied with information of 2003. [19]

The Data Appendix discusses the construction of the instruments in detail. It presents a list of provinces that were dropped from the sample. The provinces of the Metropolitan Manila are dropped due to the fact that they are completely urban. Provinces with very low migration levels are dropped because the accu-

[19]These measurement issues, which are discussed in more detail in the data appendix, underscore the relevance of using instrumental variables. If measurement errors are classical, so the measurement error is independent of the true value of the mismeasured variable, the use of instrumental variables can lead to consistent estimates.

racy of the distribution of migrants across countries will be unreliable. The remaining sample has 65 provinces, which are identified using the 1991 province boundaries.[20] Details of the threshold used to eliminate a province from the sample are also in the appendix.

2.4 Results

2.4.1 First Stage Regressions

Table 2.4 presents the results of the estimation of the first stage equations. Columns (1) and (6) show the results of a baseline specification, and the next columns add extra sets of controls. Estimated coefficients are interpreted as elasticities. All specifications include municipality level fixed effects and standard errors are clustered by province and year.

The point estimates of the migration models in columns (1) through (4) indicate that a 10 percent increase in the expected GDP at the destination is associated with an increase in the stock of migrants of 4.13- 4.79 percent whereas the exchange rate coefficients are not statistically significant. The magnitude and significance of the elasticities of migration are generally invariant to the inclusion of additional controls. This suggests that the correlation between the instruments and the province level controls is small, a reassuring finding that favors the assumption of the instrumental variables being exogenous to unobserved characteristics determining migration.

[20] During the 1990s, there were several changes to the Philippines' administrative divisions. All variables in this paper were constructed using the 1991 province divisions.

Results from the remittances model, as shown in columns (6) to (10), indicate that a 10 percent increase in the exchange rate is associated with an increase in the stock of remittances of 4.83 -5.84 percent and this result also appears to be robust to the inclusion of additional controls. This estimate is similar to the estimation by Yang (2008), who finds an implied elasticity of remittances to exchange rate shocks of 0.60.[21] Finally, the results indicate that a 10 percent increase in the expected GDP at the destination is associated with an increase in remittances that ranges from 1.82 to 2.42 percent.

Table 2.4 also reports the F statistics of a joint significance test of the excluded instruments. The F-statistics in the migration models range from 16 to 22, while the F-statistics in the remittances model go from 10 to 12. As suggested in a weak instrument test by Stock and Yogo (2005), the fact that the F-statistics exceed the critical value of 7.03 indicates that, whenever I report a 5 percent significance, the true significance is not below 10 percent. However, in models with multiple endogenous variables, F statistics are not totally informative about instrument weakness. If instruments are highly collinear, they may lack linear independent relevance even when they are jointly significant, thereby making the model underidentified. Reassuringly, the first stage results show that each instrument provides independent variation to predict the endogenous variables: the stock of migrants depends only on GDP, while remittances are mostly predicted by the exchange rate.

[21] However, it should be pointed out that Yang estimates elasticities at the level of remittance-receiving households, making his estimates not entirely comparable to those in my paper.

The fact that the GDP shock has an impact on the growth of migrants can be explained by the fact that the decision to migrate in the Philippines is largely demand-driven. Recruitment agencies in the Philippines operate as middlemen by matching potential migrants with employers abroad. Thus, the existence of job vacancies in host countries largely affects the magnitude of migration flows. Moreover the majority of Filipino migrants work in non-tradable sectors, such as domestic services, which are greatly affected by the host country's domestic conditions.[22] Changes in remittances are, on the other hand, largely affected by shocks to the exchange rate. Increases in exchange rate raise the value in Filipino pesos of the migrant's earnings and generate incentives to remit more.[23]

Very similar results from the first stage estimates are obtained when using alternative lags of the GDP instruments, as shown in columns (2), (3), (6) and (7) of Appendix Table 2.1. Columns (4) and (8) show the first stage estimates in models in which current and lagged values of GDP and exchange rates are used as instruments. The loss in statistical significance of the instruments reflects their high collinearity. I also considered alternative instrumental variables, including further lags of economic shocks. There was generally a loss in instrument power, so I have opted for the more parsimonious specification above.

[22] Appendix Table 2.1 reports the 1991 distribution of Filipino migrants across occupations.

[23] However, as discussed by Yang (2008), there is no reason why the *whole* change in the Filipino value of migrants earnings appears as higher remittances sent home. Migrants may decide to increase their savings overseas and wait until their return date to accrue all the gains from the currency appreciation.

2.4.2 Impact of emigration and remittances on the agriculture sector

The framework developed in section 2.2 suggests several ways in which remittances and migration can affect the agricultural sector. A possible impact is the decline in the size of agriculture, to the extent that a loss in labor supply and a greater availability of capital enables a transition to more capital-intensive sectors such as manufacturing. I explore this hypothesis in this subsection.

Initially, I estimate the effects of migration and remittances on two measures of the size of the agriculture sector: the log number of farms and the log total area of farms in each municipality. Table 2.5 presents the estimated elasticities from OLS and IV regressions. There are some results that are worth highlighting. First, the IV estimates suggest the absence of significant effects of emigration and remittances on the farms or the farmed area. For all specifications, the IV estimated elasticities are not significantly different from zero, a result that is generally insensitive to the inclusion of additional controls. All estimates are, however, large in magnitude and have relatively large standard errors, so I cannot rule out the possibility that the lack of statistically significant impacts is due to lack of precision in the estimation. Note that Hausman tests do not reject the null hypothesis that the OLS and IV coefficients are equal, a result that can be explained by the lack of precision.[24]

[24] In regressions not presented here, I find that results using dependent variables in levels as opposed to logs are qualitatively similar.

In the absence of precise estimates of the effects on the number of farms and area farmed, I look for additional evidence of the impact of remittances and emigration on the agricultural sector. Even with no adjustments in the number of farms or farmed area, remittances and migration may have an impact on the amount of labor in the agriculture sector. I therefore explore whether fewer labor inputs are allocated to the agriculture sector in response to emigration and remittances. As mentioned in section 3.2, I utilize data from the LFS to investigate this question.

To implement the analysis, the main estimating equation described in 2.1 is modified. The LFS is a survey of a smaller scale that is not designed to build variables at small geographic units like the municipality. The smallest geographic units at which the survey is representative is the province. This precludes me from building municipality level outcomes and estimating regressions from a balanced panel of municipalities, as in 2.1. Instead, I estimate the following person-level model :

$$y_{jpt} = \theta M_{pt} + \delta R_{pt} + \beta X_{jpt} + \gamma W_{pt} + \upsilon_p + \mu_t + \epsilon_{jt} \tag{2.5}$$

where y_{jpt} is a variable that measures employment and hours worked in the agriculture/production sector for individual j in province p and year t; M_{pt} and R_{pt} are respectively the log of the stock of migrants and the log of the total level of cash remittance receipts in province p and year t; X_{jpt} is a set of individual-level time-varying controls; W_{pt} is a set of province level time-varying controls;

v_p and μ_t are, respectively, province and year fixed effects. The equation is estimated for $t = 1991, 2002$. Standard errors are clustered at the province-by-year level to account for within-province correlation of the error terms.

The results presented in Table 2.6 consistently support the view that emigration and remittances have no impact on labor inputs allocated to the agriculture or the production sectors. The models in columns (1)-(2) are estimated for a sample of individuals aged 15 or more with the outcome variable being an indicator that takes the value of one if the individual's primary occupation is in agriculture. The coefficients measure the effect in percentage points of a 1 percent increase in remittances or emigration. Overall, the estimated coefficients are not significant and are very small in magnitude. Consider, for instance, the effect of a 10 percent growth in remittances, which is the two-year shock received by a typical province. The IV estimate with full controls indicates that a 10 percent growth in remittances decreases the probability an individual works in agriculture by 0.5 percentage points, and this effect is not statistically different from zero. Also, as shown in columns (3)-(4), emigration and remittance appear to have no significant impacts on the probability an individual works in the production sector.[25] As a specification check, I estimate the models in columns (1)-(4) using only a sample of individuals who are in the labor force. The results, which are reported in Appendix Table 2.2, are qualitatively and quantitatively similar.

[25]The production sector, as defined by the NSO, comprises manufacturing, construction and transportation.

Given the absence of effects on the probability that an individual works in the agriculture or production sectors, I investigate adjustments at the intensive margin. Columns (5)-(6) in Table 2.6 present estimates of models in which the dependent variable is the number of hours worked for individuals working in agriculture. Columns (7)-(8) show analogous estimates for individuals working in production. The coefficients measure the effect of a 1 percent increase in remittances or emigration in number of hours. Overall, the results consistently show the absence of effects of migration and remittances on the amount of hours devoted to either sector. In general, the magnitudes and standard errors of all estimates presented in Table 2.6 are small. Given that even impacts of a very small magnitude fall outside the regular confidence intervals, I interpret the results as tightly estimated zero effects.[26]

2.4.3 Impact of emigration and remittances on crop choice

Having found little evidence of a shift away from agriculture, I now investigate possible adjustments to remittances and emigration within agriculture. I derive estimates of causal effects on crop choice and livestock accumulation and explore whether there have been shifts to more capital-intensive or riskier output mixes. I estimate versions of equation 2.1 in which the outcome variables are the share of farms in a given municipality that produce a particular crop in at least one parcel of land. I focus on the production of rice, corn, coconut and

[26]For example, the effect in hours worked in agriculture of a 10 percent increase in remittances lies inside [-0.5, 0.2] with 95 percent probability.

banana, which, as was mentioned in section 2.3.2, are the most important crops in the country. I also build outcome variables measuring the probability that farms grow high value commercial crops.

Table 2.7 presents estimates from OLS and IV regressions. Each coefficient shows the effect in percentage points of a 1 percent increase in remittances or migration. The estimated coefficient of remittances on rice, which is significantly negative using OLS, is not significant in the estimated equation. IV estimates of the effects of emigration are not significant either. The lack of adjustments to emigration and remittances in the production of rice is not surprising. Rice is not only one of the most widely grown crops in the Philippines, it is also the dominant staple crop and is grown by many farmers in the Philippines for self consumption (Dawe, Moya, and Casiwan, 2006). Moreover, since rice productivity largely depends on special topographic characteristics, shifts to alternative crops imply large adjustment costs.[27]

In general, IV estimates indicate that the effect of emigration on the probability that farms produce any given crop is not significantly different from zero. As will be discussed in section 2.5, the absence of a significant emigration effect is consistent with the presence of a readily available pool of workers that can easily substitute for the labor lost to migration. I do find, on the contrary, that remittances have a significant effect on crop choice. Remittances have a negative and statistically significant impact on the fraction of farms producing corn,

[27]Pingali, Hossain, and Gerpacio (1997) discuss in detail the implications of climatic and topographic conditions on rice productivity.

coconut and banana. To assess the magnitudes of the estimates for remittances, consider again a 10 percent increase in the province-level remittance receipts, which is equivalent to the shock in a typical province within two years over the sample period. The results indicate that such a shock would reduce the fraction of farms that produce: corn, by 1.8-1.2 percentage points; coconut, by 2.8-2.9 percentage points; banana, by 3.0 -4.0 percentage points. High value crops, on the other hand, increase by 2.0-3.2 percentage points in response to a 10 percent growth in remittances. Unfortunately, I know of no other studies deriving similar estimations that can be used as a comparison benchmark. However, given that the estimates in this paper average over households that receive and do not receive remittances, and that crop mix adjustments are slow due to the seasonal nature of agricultural production, the magnitudes of these coefficients seem reasonable and of practical relevance.

These results suggest that remittances, by alleviating credit constraints or reducing the cost of capital, may be facilitating investments in the production of higher value crops. Indeed, high working capital requirements have been identified as a barrier that limits the possibilities that farmers in the Philippines can shift production from low-return crops, such as corn and coconut, to high-return crops, such as mango (Briones, 2008).[28] However, it is worth noting that the results can only be interpreted as suggestive evidence of shifts in the volume

[28]This interpretation of the results is in line with the ethnographic study by McKay (2003). Drawing on interviews from a case study undertaken during 1991-1992 and 1996-1997 in the Philippines' island of Northern Luzon, she finds that men whose spouses are overseas migrants use cash remittances from their absent wives as capital to produce new "modern commercial crops".

of production since the outcome variables measure crop choice and not output volumes. Changes in the intensity of production are, therefore, not measured.

The effects of remittances on crop choice could also be reflecting changes in risk-coping strategies. First, farmers may be changing their diversification patterns, increasing their specialization in a given crop. Second, by engaging in the production of high-value crops, they are increasing their risk exposure since the marketing channels for these crops are less established.[29] The discussion presented in section 2.2 suggests that remittances may serve an insurance purpose, thereby altering the risk-mitigating devices used by farmers in the sending economies. Indeed, previous findings by Yang and Choi (2007) suggest that remittances may be used to buffer negative weather-related income shocks in the Philippines. If remittances are used to smooth consumption across states of nature, there may be less need for the use of alternative risk-mitigating strategies, such as the diversification of income sources through diversified cropping. I test this hypothesis directly by determining whether remittances reduce the fraction of farmers that engage in crop diversification. I estimate equation 2.1 using measures of crop diversification as outcome variables. The results are presented in Table 2.8. The IV estimates indicate that a 10 percent growth in the province-level remittances receipts reduce by 2.5-2.8 percentage points the fraction of farms that produce three or more crops and increase by 1.1-1.3 percentage points the fraction of farms that specialize in the production of one crop.

[29] Dawe, Moya, and Casiwan (2006) discuss the greater uncertainty faced by farmers that commercialize high-value crops.

Note, however, that specialization in one crop does not always lead to greater risk exposure. Two such situations are considered. First, movement to a single, conservative activity from a mix of riskier activities may actually lead to a reduction in risk exposure. This may be particularly true if farmers move to specialization in rice production, since in the Philippines the price of rice is artificially stabilized by government buffer-stock operations.[30] To assess this possibility I replicate the estimates in Table 2.8 after excluding farms engaged in rice production. Table 2.9 shows the results, which are qualitatively and quantitatively similar to the results in Table 2.8, suggesting that the observed movements to a specialized cropping activity were not entirely driven by shifts to specialization in rice. Second, the underlying mechanism explaining the movements to crop specialization may be greater capital availability as opposed to a shift in a risk-coping mechanism. This will be the case if remittances are used by farmers to move from the production of several crops with low capital requirements to the specialization in a more capital intensive crop. I explore this issue by deriving estimates of equation 2.1 in which the dependent variables measure patterns of specialization in high-value commercial crops as well as patterns of specialization in traditional, non high-value crops. High-value commercial crops generally require greater upfront capital investments (Briones, 2008). The results are presented in Table 2.10. The IV estimates indicate that remittances increase

[30]For years the Philippines' government has implemented buffer-stock operations in the rice sector to stabilize prices paid to producers and guarantee supply for the consumers. The National Food Authority of the Philippines (NFA) procures rice from farmers during peak harvest seasons, stores it in rice mills and sells it in seasons in which prices are high. Such stabilization policies are exclusive to rice.

the probability of specialization in both, high-value and traditional non high-value crops. A 10 percent growth in remittances increases the probability that farms specialize in the production of one high-value commercial crop by 2.9-3.9 percentage points, and in the production of one traditional non high-value commercial crop, by 4.6-8.4 percentage points. These additional results favor the view that the positive effect of remittances on crop specialization relates to the role of remittances as a risk-mitigating device.

Overall, the results presented in this section suggest that greater remittances, for a given migration level, have induced a shift to more capital intensive crops and a more specialized crop mix. In regressions not presented here, I check for the robustness of the results to the removal of data from one province at a time and find that the results from the estimates of the crop choice models in Table 2.7 and the specialization models in Table 2.8 are not significantly altered. The results in this section also provide interesting insights regarding the selection patterns of migration and remittances. Comparisons between the IV and OLS estimates in Tables 2.8 and 2.7 suggest that remittances are disproportionately allocated to provinces where farms are more likely to produce corn, banana and coconut and choose a diversified crop mix. In turn, remittances are less likely to be sent to provinces in which the production of rice and high value commercial crops is frequent or in which farms are very likely to specialize. Interestingly, the distribution in the case of migration runs in the opposite direction. This confirms the view that the distribution of migration and remittances across locations are not independent of determinants of agricultural production and, also, suggests that the unobserved factors determining the selection of remittances and migration are different.

2.4.4 Impact of emigration and remittances on the use of mechanized technologies

I now explore whether emigration and remittances have had an impact on the adoption of farming technologies. I specifically study if rice farms changed to more capital-intensive methods of production in response to increased emigration and remittances. Restricting the analysis to rice farms and rice-production machinery is crucial, since the production processes of different crops vary in terms of technology mix. Without such a restriction, observed changes in the method of production could be masking changes in the composition of crops. For example, if there is a shift in production from coconut to rice, increases in the fraction of farms using threshers may be observed, since the use of threshers is used to produce rice but not coconut. Restricting the sample of farms engaged in rice production allows me isolate technology effects that are not reflecting changes in crop choice. This also facilitates to a large extent the definition of the mechanization variables. I draw on the large literature describing mechanization in rice production in the Philippines to guide the construction of the outcomes and the interpretation the results (e.g. Takahashi and Otzuka (2009) ; Ahammed and Herdt (1983); Dawe, Moya, and Casiwan (2006); IRRI (1986)). Of course, limiting the analysis to rice production generates concerns about selection bias since the probability of producing rice could be a margin of adjustment to emigration and/or remittance shocks. However, the results in subsection 2.4.3 should ameliorate such concerns. As was shown in table 2.7, neither migration nor remittances have a statistically significant impact on the fraction of farms that produce rice; the estimated coefficients and standard errors are small in magnitude, a result that holds for OLS and IV regressions and is robust to the inclusion of controls.

In Table 2.11, I present estimates of the effects of remittances and emigration on the use of mechanized technologies in rice production. The outcome variables measure the share of rice farms that use hand tractors, cultivation and post-harvest equipment, as well as the share of rice farms that have access to private irrigation.[31] The coefficients in the table report the effect in the outcomes, measured in percentage points, of a 1 percent increase in remittances or migration.

The OLS estimates in Panel A show that remittances have a small and insignificant correlation with the percentage of farms that use mechanized technologies. In contrast, IV estimates are larger, positive and, with the exception of the cultivation model, statistically significant. The IV results imply that a 10 percent increase in remittances, which is equivalent to the shock received by a typical province within two years, led to an increase in the fraction of farms that use: handtractors (2.0-2.9 percentage points); post harvest equipment (4.2-

[31] As discussed in section 2.3.2, these systems mostly consist of simple gravity-type canal systems that divert river flows and are built by farmers' communities with local materials.

5.3 percentage points) ; and post-harvest irrigation (2.1-2.2 percentage points). The difference between the OLS and IV estimates of the remittance effects suggests that remittances have been disproportionately allocated to locations where mechanized farming is less frequent, stressing the importance of the instrumental variable strategy.[32]

The positive impact of remittances in the access to irrigation and the use of hand-tractors and threshers are consistent with remittances facilitating the adoption of capital-intensive technologies among rice farmers by simply reducing the cost of working capital. They may also alleviate capital constraints that can arise in an environment in which credit markets do not operate smoothly, as is the case of the Philippines' rice sector. Indeed, as discussed in Floro and Ray (1996) credit markets in the Philippines' rice sector operate with imperfections.[33]

This result complements previous studies finding that remittances increase productive investments in the sending economies (e.g. Woodruff and Zenteno (2007), Yang (2008)) and, more directly, studies showing that land productivity and productive investments can increase for migrant sending agricultural households (e.g. Taylor and Lopez-Feldman (2010), Mendola (2008)). It is also in line with ethnographic evidence showing that remittance flows to the Philippines are

[32]Results of Hausman tests, presented in the table, reject the null of equality between OLS and IV coefficients with p-values of less than 0.01, except in the case of the cultivation equipment model.

[33]Floro and Ray (1996) provide a detailed description of credit institutions in the Philippines rice economy. Rice farmers are rationed out by formal financial institutions and therefore resort to informal lending from marketing agents such as rice traders, millers and wholesalers. These agents engage in moneylending as a means to acquire claims over the produced output. They are better informed relative to formal lenders of the potential of morally hazardous behavior by borrowers and, unlike formal financial institutions, they are willing to accept agricultural production and labor as a collateral.

used to finance investments in agricultural machinery.[34]

As opposed to remittances, emigration appears to have no causal effect on the adoption of capital-intensive technologies, as shown in Panel B of Table 2.11. The absence of a causal impact of emigration on the use of mechanized farming technologies can be explained in terms of the framework in section 2.2. If the labor market is well functioning and the aggregate supply of labor is sufficiently elastic, emigration may not lead to adjustments in agricultural production. I analyze this issue in more detail in the next section.

Note also, that a comparison of the IV estimates with the OLS results suggests that emigration is disproportionately selected from locations with frequent mechanized farming. This result is in line to those obtained in section 2.4.3 in which the contrasts between the OLS and IV estimate indicated that migrants are more likely to leave from regions where high-value commercial crop production and specialization is frequent. On the other hand, the results from this and the previous sections showed that remittances are more likely to be allocated to regions where mechanized farming, high value commercial crop production and specialization is less frequent. Taken together, these findings suggest that emigration is more likely to come from regions with greater agricultural development whereas remittances, for a given migration level, are disproportionately sent to regions where agricultural specialization and mechanization is less fre-

[34]The field work reports by UN -INSTRAW (2008) presents testimonies of Filipino farmers in Oriental Mindoro who used remittances from family members in Italy to buy land. Others invest in motor pumps, fertilizers, hand tractors and threshers. The ethnographic study by McKay (2003) in the Philippines provides anecdotal evidence of the use of remittances in agricultural productive investments by the husbands of female overseas domestic workers.

quent.

2.5 Discussion

The results in section 2.4.2 suggest that remittances and emigration do not cause a relative decline in the size of the agriculture sector. A second set of results in sections 2.4.3 and 2.4.4 suggest that, holding emigration constant, remittances have a positive impact on the choice of more specialized and capital-intensive crop mixes and on the adoption of mechanized technologies. In contrast, emigration has no effect on farming practices. A likely explanation of these findings is that remittances facilitate productive investments and change the risk-coping strategies of farmers in the sending economies. There is however, an alternative causal channel that could explain the results and deserves consideration.

Specifically, if the transfer of information on agricultural practices from migrants is in an unobserved way correlated with remittances, the results estimated in this paper require a different interpretation. International anecdotal evidence suggests that migration often leads to the flow of ideas and knowledge back to the sending countries (UNDP, 2009). Moreover, the transmission of farmer technical knowledge can be a major determinant in the choice of agricultural practices.[35] Therefore, the estimated effects of remittances on crop mix and

[35] For example, in a study of rice production patterns in South East Asia, Pingali, Hossain, and Gerpacio (1997) indicate that differences in farm productivity are more affected by farmer technical knowledge than by access to technology or inputs, making knowledge the "scarce resource".

farming technologies presented in this paper could be reflecting the impact of knowledge transmission on agricultural practices rather than the effect of a capital flow. However, I view the distribution of Filipino migrants across occupations in their destination countries as evidence against this alternative interpretation of the results. Most migrants work as production workers, household helpers or in other service sector occupations, whereas agricultural occupations are very infrequent. Only 3 percent of migrant workers in 1991 worked in agriculture.[36] Given that very few Filipino migrants work in the agriculture sector abroad, the role of migration as a transmission channel of farming knowledge is likely to be small.

The absence of effects from emigration on farming practices also merits further consideration. As discussed in section 2.2, in the absence of hiring constraints, the effects of emigration on agricultural production can be small if labor supply in the local markets is highly elastic. This very elastic labor supply might be reflecting the existence of “surplus labor", as presented in the seminal work by Lewis (1954). In an environment in which the abundance of labor relative to other inputs of production is so large that its marginal productivity is negligible, the withdrawal of workers will have a minimal impact on production. The high rural unemployment rates during the sample period and the importance of hired labor in the agricultural sector favor this interpretation.[37]

However, the absence of significant effects of emigration on farming prac-

[36] Appendix Table 2.3 shows the occupational distribution of Filipino workers for 1991.

[37] According to Dawe, Moya, and Casiwan (2006), approximately 70 percent of total labor used in rice production is hired. During the 1990s, rural unemployment rates reached 25 percent during the 1990s (Herrin and Pernia, 2003).

tices in local markets does not imply that emigration has no effect on farming at the national level. If agricultural labor moves across provinces in response to the outflow of labor, the effects of emigration will spread across the national economy. To the extent that cross-province migration flows offset each other, net changes in province level relative endowments due to emigration may be very small. Thus, the full effects of emigration will not be captured by the province-level flow coefficients estimated in this paper.[38]

I assess this issue by studying the effects of emigration on the labor endowment of neighboring provinces. Specifically, I search for evidence of cross-province spillover effects within a given *region*. *Regions*, as defined by the NSO, consist of groups of contiguous provinces that have similar cultural and ethnic characteristics. In 1991 there were 16 regions. The map in figure 2 illustrates both the regional and province level divisions. Combining data from SOF and LSF and using the same instrumental variable described above, I estimate the following person-level equation:

$$y_{jprt} = \lambda_1 M_{p,t} + \lambda_2 M_{r-p,t} + \rho_1 R_{p,t} + \rho_2 R_{r-p,t} + \beta X_{jprt} + \gamma W_{prt} + \alpha_{pr} + \mu_t + \varepsilon_{jprt} \tag{2.6}$$

y_{jprt} is a binary variable indicating whether individual j in province p, region r and year t was in the labor force; M_{r-pt} is the log of the stock of

[38] A similar methodological challenge has been faced by researchers using exogenous shocks at the regional level to identify the causal effects of immigration on the host countries. See, for instance, the discussions in Card (2001), Cortés (2008), Borjas (2003) and Friedberg and Hunt (1995).

migrants in year t from all provinces in region r except for province p ; R_{r-pt} is the log stock of remittances in year t from all provinces in region r except for province p ; X_{jprt} is a set of individual level time-varying controls; W_{prt} is a set of province level time-varying controls; α_{pr} and μ_t are, respectively, province and time fixed effects. The equation is estimated for the sample of individuals aged 15 or more with $t = 1991, 2002$.

The coefficients λ_2 and ρ_2 capture the effects on the labor supply of province p of migration and remittance shocks in neighboring provinces. Results from these estimates are presented in Table 2.12. The coefficients measure the impact on labor force participation, in percentage points, of a 1 percent growth in remittances or in emigration. Overall, I fail to find statistically significant impacts of remittances and migration from neighboring provinces on the labor supply of province p, and these results are invariant to the inclusion of controls.[39]

Thus, the results suggest that labor force participation does not respond to remittance and migration shocks in neighboring provinces. This can be interpreted as suggestive evidence that favors the assumption of closed province-level factor markets. However, it is important to note a caveat to this conclusion: the evidence presented in Table 2.12 does not test for spillover effects of emigration and remittances across *regions* that would also lead to attenuation bias. The inability to account for intra-national factor mobility in response to emigration and remittances is a limitation of the identification strategy that cannot

[39]The first stage regressions of these estimations are shown in Appendix Table 2.4. Each instrument has independent predictive power in a respective first stage equation.

be ignored. Coefficients estimated in this study should then be interpreted as estimates of the causal effects of emigration and remittances on province level agriculture markets and as lower bounds of the overall impacts of emigration and remittances on the national economy.

2.6 Conclusion

This paper presents evidence suggesting that international migration and remittances from migrants are not leading to a relative decline in the size of agricultural sector. Instead, remittances seem to be transforming productive practices within agriculture. I provide robust evidence showing that, for a given emigration level, remittances have a positive impact on the choice of more specialized crop mixes, the production of high value commercial crops and the adoption of mechanized technologies. Additional evidence suggests that the channels through which remittances affect farming practices are by increasing the availability of working capital and serving an insurance purpose. Considering that, due to the seasonal nature of agricultural production, adjustments in farming are slow and that the estimates in this paper average over the whole local agricultural economy and therefore include farms that are not direct recipients of remittances, the magnitudes of the estimated effects are economically significant. In contrast, I find no evidence that emigration has an impact on farming practices, something that can be explained by the absence of hiring constraints and an elastic local labor supply.

The results in this paper contradict views that remittances primarily sustain current consumption without having an impact in productive investments. They also provide empirical evidence supporting the risk-mitigating role of remittance flows. Finally, the results do not support the view of a disruptive effect of the outflow of migrant workers on agricultural production. Overall, the findings in the paper underscore the importance of assessing separately the effect of emigration and the effect of remittances. To the extent that shortages of capital and insurance, and not of labor, constrain production in most agricultural economies in developing countries, emigration can have a minor disruptive effect while remittances may foster agricultural development.

By providing a separate assessment of the impact of remittances and migration, the results in this paper also shed light on the consequences of choosing between policies that encourage more migration or policies that increase remittances. While policies that encourage more migration may face a higher political cost at the host countries, policies that increase remittances for a given level of migrants (such as reducing the cost of remittances or facilitating financial services to migrants) are usually less controversial. The findings in this paper point at the positive impact that facilitating the transfer of remittances, for a given level of migrants, may have on the development at the origin economy. Further investigation of the differential effects of remittances and migration is left for future research.

Figure 2.1. Effects of a Reduction in Labor Supply

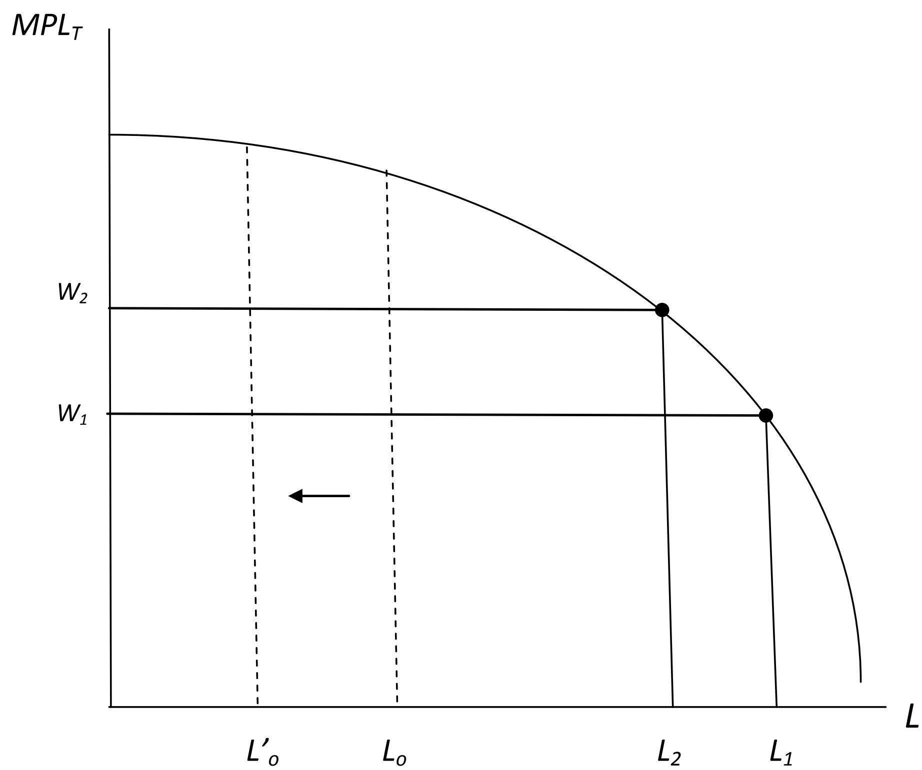
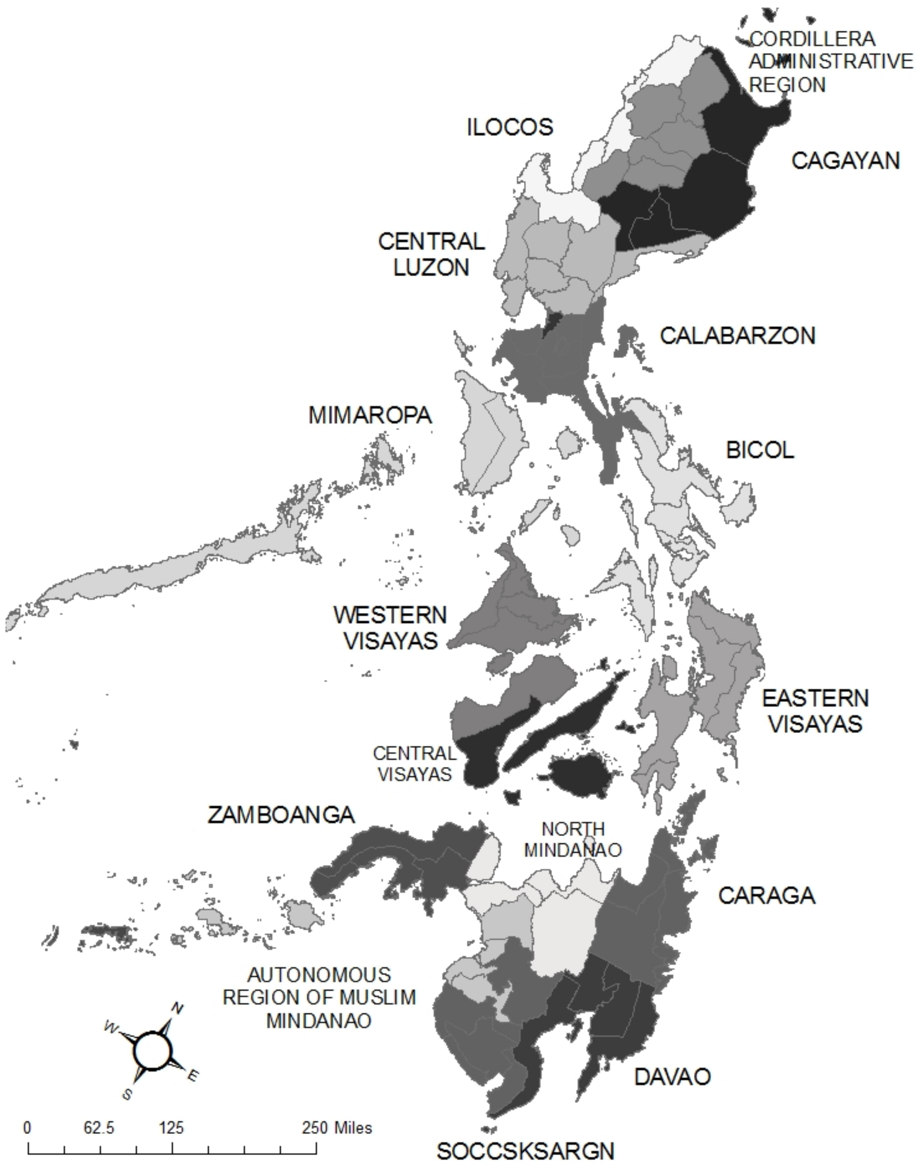


Figure 2.2. Regions and provinces of the Philippines



Note:Lines indicate province borders. Different colors are for different regions. Labels indicate the name of each region.

Table 2.1. Countries of destination of overseas workers in 1991

Country	Percentage of Total	Real GDP growth (1991-2002)	Exchange rate growth (1991-2002)
Kingdom of Saudi Arabia	28.4%	21%	-0.4%
United States of America	13.1%	42%	-0.4%
Italy	6.3%	18%	-37.9%
Japan	6.3%	10%	4.0%
Hong Kong	6.2%	42%	-0.6%
Greece	4.4%	33%	-46.3%
Singapore	4.1%	98%	-6.5%
United Arab Emirates	3.3%	57%	-0.4%
Kuwait	2.2%	152%	-5.5%
Malaysia	1.8%	92%	-28.6%
Taiwan	1.0%	79%	-22.8%

Notes: Column 1 reports the share of total filipino migrants in each country. Data is built using retrospective information of migration from the Surveys of Overseas Filipinos 1993-1996. See the data appendix for details.Column 2 reports the real change in GDP over the period. Changes are computed using GDP in constant prices.Column 3 reports the change in the real exchange rate: constant Filipino pesos per currency unit. The change is calculated as the 2002 exchange rate minus the 1991 exchange rate divided by the latter.Exchange rate and GDP data are obtained from the IMF World Economic Outlook Database

Table 2.2. Province level distribution of migrants across destination countries

Province(*)	Country of destination					
	Saudi Arabia	USA	Hong Kong	Italy	Other countries	Total
Maguindanao	71%	0%	0%	0%	29%	100%
Bulacan	49%	0%	20%	0%	31%	100%
Iloilo	46%	0%	0%	0%	54%	100%
Quezon	38%	0%	36%	13%	13%	100%
Pampanga	37%	13%	0%	12%	38%	100%
NCR-2nd Dist.	27%	9%	0%	9%	55%	100%
Cagayan	24%	22%	0%	22%	32%	100%
Ilocos Norte	19%	56%	0%	0%	26%	100%
Batangas	15%	11%	0%	48%	26%	100%
Negros Occidental	10%	19%	10%	0%	62%	100%

Note- (*) In 1991 there were 77 provinces in the Philippines. For simplicity, I list in this table the 10 provinces with highest migration levels. (**) NCR is the acronym for National Capital Region. Data is built using retrospective information of migration from the Surveys of Overseas Filipinos 1993-1996. See the data appendix for details in which this variable was built.

Table 2.3. Summary Statistics

	Mean (1)	Stdev (2)
Panel A:		
No of Farms	241	240
Area farms (Ha)	671	798
Average farm size (Ha.)	2.20	3.65
Panel B: Fraction of farms that produce/raise:		
Rice	0.47	0.30
Corn	0.31	0.26
Coconut	0.54	0.21
Banana	0.50	0.21
High valued crops	0.51	0.22
Panel C: Fraction of farms that grow:		
One crop	0.15	0.11
Two crops	0.18	0.09
Three or more crops	0.58	0.24
Panel D: Fraction of rice farms that use:		
Private irrigation systems	0.31	0.28
Hand tractors	0.22	0.27
Cultivation equipment	0.57	0.31
Post harvest equipment	0.24	0.28
Number of municipalities	1210	

Source: 1991 CAF

Table 2.4. First Stage

Dependent variable:	Log (Stock of Migrants)					Log (Remittances)				
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Log GDP - 2 years lag	0.441***	0.413***	0.413***	0.415***	0.479***	0.231*	0.198*	0.182*	0.242*	0.240**
	(0.130)	(0.117)	(0.113)	(0.131)	(0.112)	(0.124)	(0.119)	(0.103)	(0.128)	(0.112)
Log Exchange Rate	0.289	0.267	0.256	0.284	0.195	0.483**	0.584***	0.530***	0.494**	0.578***
	(0.252)	(0.242)	(0.240)	(0.244)	(0.236)	(0.202)	(0.207)	(0.192)	(0.198)	(0.201)
Province demographic controls	No	Yes	No	No	Yes	No	Yes	No	No	Yes
Province agricultural controls	No	No	Yes	No	Yes	No	No	Yes	No	Yes
Province economic controls	No	No	No	Yes	Yes	No	No	No	Yes	Yes
F excluded instruments	18.92	16.97	17.67	17.14	22.18	10.34	10.12	11.69	10.07	10.66
Observations	2420	2420	2420	2420	2420	2420	2420	2420	2420	2420

Note- The table presents first stage results of an IV estimation of equation 2.1. Columns (1)-(5) correspond to first stage regressions in which the endogenous variable is the log-stock of migrants. In columns (6)-(10) the endogenous variable is the log-stock of remittances. Weighted Least Square estimates were the weights are the number of farms per municipality in 1991. Standard errors clustered by province and year. All models include municipality and year fixed effects. Province level controls consist of interactions between 1991 means and decade dummies. * Denotes statistical significance at the 10% level; ** at the 5% level; *** at the 1% level

Table 2.5. Log area and log number of farms

	Log (No of farms)		Log (Area farm)	
	(1)	(2)	(3)	(4)
	Panel A: OLS estimates			
Log (remittances)	0.259***	0.081	-0.072	-0.168***
	(0.089)	(0.057)	(0.070)	(0.061)
Log (stock of migrants)	-0.019	0.088	0.102	0.190***
	(0.109)	(0.053)	(0.069)	(0.071)
	Panel B: IV estimates			
Log (remittances)	-0.080	-0.098	-0.442	-0.425
	(0.417)	(0.231)	(0.410)	(0.318)
Log (stock of migrants)	0.363	0.219	0.335	0.463
	(0.410)	(0.216)	(0.354)	(0.306)
Province level time varying controls	No	Yes	No	Yes
Hausman p-value	0.60	0.72	0.42	0.66
Observations	2420	2420	2420	2420

Note- The table presents results of an IV estimation of equation 2.1. Standard errors clustered by province and year. All models include municipality and year fixed effects. Province level controls consist of interactions between 1991 means and decade dummies. * Denotes statistical significance at the 10% level; ** at the 5% level; *** at the 1% level

Table 2.6. Labor inputs in the agriculture and production sectors

	Works in agriculture sector (ppts)		Works in production sector (ppts)		Hours in agriculture sector (hours)		Hours in production sector (hours)	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
				Panel A: OLS estimates				
Log (remittances)	-0.007	-0.017	0.006	0.007	-0.011***	-0.003	0.010***	0.005
	(0.011)	(0.012)	(0.008)	(0.008)	(0.004)	(0.002)	(0.003)	-0.003
Log (stock of migrants)	-0.017	0.004	0.009	0.004	0.007	0.003	0.004	0.002
	(0.018)	(0.019)	(0.009)	(0.009)	(0.005)	(0.004)	(0.004)	(0.004)
				Panel B: IV estimates				
Log (remittances)	-0.055	-0.049	0.055**	0.076*	-0.024	-0.019	0.004***	0.072
	(0.081)	(0.104)	(0.024)	(0.044)	(0.015)	(0.020)	(0.002)	(0.105)
Log (stock of migrants)	-0.063	-0.058	0.022	0.077	-0.015	-0.014	0.004	-0.087
	(0.132)	(0.173)	(0.034)	(0.060)	(0.097)	(0.098)	(0.002)	(0.151)
Province level controls	No	Yes	No	Yes	No	Yes	No	Yes
Mean dependent variable (% or hours)	25	25	17	17	33	33	44	44
Hausman p-value	0.36	0.70	0.04	0.06	0.13	0.00	0.00	0.52
Clusters	130	130	130	130	130	130	130	130
Observations	195,599	195,599	195,599	195,599	38,261	38,261	26,331	26,331

Note- Columns (1)-(4) present estimates of the percentage point change in the probability of working in agriculture/production if the stock of remittances/migration increases in 1 percent. Columns (5)-(8) present estimates of the change in hours worked in agriculture/production if the stock of remittances/emigration increases in 1 percent. Standard errors clustered by province and year. All models include province and year fixed effects. Province level controls consist of interactions between 1991 means and decade dummies. * Denotes statistical significance at the 10% level; ** at the 5% level; *** at the 1% level

Table 2.7. Effects of remittances and migration on crop choice

	Share of farms that grow:									
	Rice		Corn		Coconut		Banana		High Value Crops	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Panel A: OLS										
Log (remittances)	-0.104***	-0.100***	0.027	0.008	-0.007	-0.011	-0.051***	-0.021	-0.031**	-0.035**
	(0.023)	(0.014)	(0.020)	(0.011)	(0.015)	(0.012)	(0.017)	(0.015)	(0.014)	(0.015)
Log (stock of migrants)	0.079**	0.090***	-0.033**	-0.033***	-0.019	-0.022*	-0.001	-0.035**	0.007	0.001
	(0.033)	(0.020)	(0.016)	(0.010)	(0.015)	(0.012)	(0.018)	(0.015)	(0.016)	(0.017)
Panel B: IV										
Log (remittances)	0.029	0.063	-0.187*	-0.124***	-0.289*	-0.278**	-0.398**	-0.304***	0.326**	0.200**
	(0.075)	(0.087)	(0.113)	(0.044)	(0.159)	(0.138)	(0.157)	(0.083)	(0.163)	(0.094)
Log (stock of migrants)	-0.041	-0.068	0.160	0.165*	0.216	0.219	0.163	0.152	-0.181	-0.165
	(0.092)	(0.090)	(0.102)	(0.091)	(0.142)	(0.190)	(0.146)	(0.098)	(0.131)	(0.116)
Province level controls	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes
Mean dependent variable (%)	42	42	22	22	52	52	56	56	57	57
Hausman test p-value	0.05	0.03	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00
Observations	2420	2420	2420	2420	2420	2420	2420	2420	2420	2420

Note- The table presents estimates of the percentage point change in the share of farms growing each crop if the stock of remittances/migrants increase in 1 percent. These are obtained from an IV estimation of equation 2.1. Weighted Least Square estimates were the weights are the number of farms per municipality in 1991. Standard errors clustered by province and year. All models include municipality and year fixed effects. Province level controls consist of interactions between 1991 means and decade dummies. * Denotes statistical significance at the 10% level; ** at the 5% level; *** at the 1% level

Table 2.8. Effects of emigration and remittances on crop diversification

	Share of farms that grow:					
	One crop		Two crops		Three or more crops	
	(1)	(2)	(3)	(4)	(5)	(6)
			Panel A: OLS			
Log (remittances)	0.017**	0.014*	-0.003	-0.015*	-0.026	-0.022
	(0.008)	(0.007)	(0.008)	(0.008)	(0.020)	(0.018)
Log (stock of migrants)	0.010	0.013	0.015	0.013	-0.037	-0.019
	(0.009)	(0.008)	(0.009)	(0.009)	(0.023)	(0.019)
			Panel B: IV			
Log (remittances)	0.128**	0.114**	0.080	0.059	-0.275**	-0.251***
	(0.063)	(0.046)	(0.057)	(0.041)	(0.138)	(0.096)
Log (stock of migrants)	-0.074	0.052	-0.044	-0.035	0.158	0.158
	(0.056)	(0.041)	(0.048)	(0.037)	(0.120)	(0.120)
Province level controls	No	Yes	No	Yes	No	Yes
Mean dependent variable (%)	16	16	24	24	55	55
Hausman test p-value	0.01	0.08	0.15	0.27	0.02	0.05
Observations	2420	2420	2420	2420	2420	2420

Note- The table presents estimates of the percentage point change in the share of farms that grow either one, two or more than two crops in response to a 1 percent change in the stock of remittances/migrants. These are obtained from an IV estimation of equation 2.1. Weighted Least Square estimates were the weights are the number of farms per municipality in 1991. Standard errors clustered by province and year. All models include municipality and year fixed effects. Province level controls consist of interactions between 1991 means and decade dummies. * Denotes statistical significance at the 10% level; ** at the 5% level; *** at the 1% level

Table 2.9. Effects of emigration and remittances on crop diversification- excluding rice

	Share of farms that grow (excluding rice):					
	One crop		Two crops		Three or more crops	
	(1)	(2)	(3)	(4)	(5)	(6)
			Panel A: OLS			
Log (remittances)	0.012	0.001	-0.004	-0.040***	-0.056	0.038
	(0.009)	(0.010)	(0.015)	(0.012)	(0.034)	(0.027)
Log (stock of migrants)	0.016	0.025**	0.008	0.029***	-0.027	-0.072***
	(0.010)	(0.011)	(0.012)	(0.010)	(0.029)	(0.024)
			Panel B: IV			
Log (remittances)	0.159**	0.146***	0.011	0.013	-0.283*	-0.270**
	(0.079)	(0.055)	(0.063)	(0.042)	(0.163)	(0.116)
Log (stock of migrants)	-0.094	-0.085	0.015	0.000	0.150	0.165
	(0.068)	(0.052)	(0.054)	(0.039)	(0.148)	(0.112)
Province level controls	No	Yes	No	Yes	No	Yes
Mean dependent variable (%)	18	18	23	23	47	47
Hausman test p-value	0.01	0.00	0.39	0.15	0.09	0.00
Observations	2420	2420	2420	2420	2420	2420

Note- The table presents estimates of the percentage point change in the share of non-rice-growing farms that grow either one, two or more than two crops when there is a 1 percent change in the stock of remittances/migrants. These are obtained from an IV estimation of equation 2.1. Weighted Least Square estimates were the weights are the number of farms per municipality in 1991. Standard errors clustered by province and year. All models include municipality and year fixed effects. Province level controls consist of interactions between 1991 means and decade dummies. * Denotes statistical significance at the 10% level; ** at the 5% level; *** at the 1% level

Table 2.10. Effects of crop diversification- high value crops vs. non-high value crops

	Share of farms that grow:							
	One high value crop		Three or more high value crops		One non-high value crop		Three or more non high value crops	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Panel A: OLS							
Log (remittances)	0.005*	0.007**	-0.065***	-0.080***	0.003	0.015***	-0.016	-0.048***
	(0.003)	(0.003)	(0.018)	(0.013)	(0.007)	(0.005)	(0.018)	(0.012)
Log (stock of migrants)	-0.001	0.001	0.000	-0.021	0.016*	0.005	-0.023	-0.006
	(0.003)	(0.003)	(0.022)	(0.019)	(0.009)	(0.007)	(0.019)	(0.015)
	Panel B: IV							
Log (remittances)	0.039***	0.029***	-0.052	-0.086	0.084**	0.046*	-0.229***	-0.163***
	(0.014)	(0.010)	(0.092)	(0.061)	(0.036)	(0.027)	(0.084)	(0.059)
Log (stock of migrants)	-0.019	-0.017	0.025	0.020	-0.046	-0.020	0.142*	0.102*
	(0.019)	(0.018)	(0.085)	(0.059)	(0.034)	(0.026)	(0.080)	(0.060)
Province level controls	No	Yes	No	Yes	No	Yes	No	Yes
Mean dependent variable (%)	2.7	2.7	44.8	44.8	13.9	13.9	54.5	54.5
Hausman test p-value	0.00	0.02	0.21	0.04	0.07	0.12	0.00	0.02
Observations	2420	2420	2420	2420	2420	2420	2420	2420

Note- The table presents estimates of the percentage point change in the share of farms that grow each crop when there is a 1 percent change in the stock of remittances/migrants. These are obtained from an IV estimation of equation 2.1. Weighted Least Square estimates were the weights are the number of farms per municipality in 1991. Standard errors clustered by province and year. All models include municipality and year fixed effects. Province level controls consist of interactions between 1991 means and decade dummies. * Denotes statistical significance at the 10% level; ** at the 5% level; *** at the 1% level

Table 2.11. Effects of emigration and remittances on the use of machinery in rice farms

	Share of rice farms that use:							
	Hand tractors		Cultivation equipment		Post harvest equipment		Private irrigation	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Panel A: OLS estimates							
Log (remittances)	0.007	0.018	0.002	0.000	-0.070	-0.051	-0.001	0.011
	(0.021)	(0.016)	(0.021)	(0.017)	(0.047)	(0.038)	(0.012)	(0.014)
Log (stock of migrants)	0.032	0.034	0.060**	0.088***	0.167**	0.166***	-0.004	-0.007
	(0.033)	(0.022)	(0.028)	(0.025)	(0.070)	(0.056)	(0.015)	(0.020)
	Panel B: IV estimates							
Log (remittances)	0.288*	0.203**	0.153	0.233	0.533*	0.420**	0.219**	0.212***
	(0.157)	(0.087)	(0.228)	(0.145)	(0.313)	(0.209)	(0.111)	(0.060)
Log (stock of migrants)	-0.134	-0.051	-0.104	-0.147	-0.381	-0.130	-0.167	-0.134
	(0.149)	(0.092)	(0.204)	(0.155)	(0.403)	(0.242)	(0.110)	(0.109)
Province level controls	No	Yes	No	Yes	No	Yes	No	Yes
Mean dependent variable (%)	36	36	65	65	38	38	36	36
Hausman test p-value	0.00	0.00	0.72	0.14	0.00	0.00	0.01	0.00
Observations	2420	2420	2420	2420	2420	2420	2420	2420

Note- The table presents estimates of the percentage point change in the share of rice farms that use each equipment when there is a 1 percent change in the stock of remittances/migrants. These are obtained in an IV estimation of equation 2.1. Weighted Least Square estimates were the weights are the number of farms per municipality in 1991. Standard errors clustered by province and year. All models include municipality and year fixed effects. Province level controls consist of interactions between 1991 means and decade dummies. * Denotes statistical significance at the 10% level; ** at the 5% level; *** at the 1% level

Table 2.12. Regional spillover effects on factor supply

	Labor Force Participation	
	(1)	(2)
Log (remittances in rest of region)	0.077	0.084
	(0.130)	(0.116)
Log (migration in rest of region)	-0.070	-0.085
	(0.214)	(0.204)
Log (remittances in own province)	-0.099	-0.108
	(0.085)	(0.096)
Log (migration in own province)	0.159	0.174
	(0.159)	(0.168)
Province controls	No	Yes
Clusters	130	130
Observations	196,599	196,599

Note- Standard errors clustered by province and year. All models include province and year fixed effects. Province level controls consist of interactions between 1991 means and decade dummies. * Denotes statistical significance at the 10% level; ** at the 5% level; *** at the 1% level

2.7 Appendix

2.7.1 Construction of migration and remittance variables

Migration stocks by province. Province level migration stocks were calculated using data from the Survey of Overseas Filipinos (SOF), which is a nationwide yearly survey conducted since 1993 by the National Statistics Office of the Philippines (NSO). The SOF collects information of all households reporting that any members were abroad in the last five years from a rider questionnaire in the October Labor Force Survey. The 2002 overseas migrants stocks was directly calculated by province using information on the number of household members abroad in 2002 SOF. The 1991 province stock of migrants was instead calculated using retrospective information of the 1993 survey. Adapting from Yang (2008) I use the following questions to identify whether a family member was overseas in 1991: (i) When did the family member last leave for overseas? ; (ii) When did the family member return from his/her last departure (if at all)?; (iii) How many months has the family member worked/been working abroad during the last five years? Questions (i) and (ii) can be used to identify migrants who were abroad in 1991 from *last* trip. In order to identify migrants who were abroad in 1991 from a trip previous to the last one I use question (iii) and assume that stays overseas were continues. If in October 1993 households report that a family members has spent two or more years abroad and has not returned, I infer that the migrant was abroad in 1991. Thus, the migration stock variables may be subject to measurement error issues that can be particularly severe in first difference estimations like the one conducted in this paper. If measurement error is uncorrelated with the unobserved explanatory variable, the estimated effects will be attenuated. This highlights the importance of the IV approach.

Remittance levels by province. Remittance levels by province can be obtained from two sources: the Survey of Overseas Filipinos (SOF) or the Family Income and Expenditure Survey (FIES). The FIES is a nationwide survey of households undertaken every three years by the NSO to collect data on family income and expenditures. Remittance measures from both data sources are imperfect. First, due to the definition of the survey universe, remittances in the SOF are only reported by households with a member who migrated in the last five years. Remittances to households that have no family members abroad are, therefore, not reported in the SOF. The FIES, on the other hand, provides information of remittances received by all households including those with no migrant members. However, the FIES is conducted every three years and its administration does not always coincide with that of the CAF. In 1991 both the FIES and the CAF were conducted, but this was not the case for 2002 as the FIES was administered only until 2003. Remittance data from the SOF is, on the contrary, available for 2002 but not for 1991 as the administration of this survey started in 1993.

In this study I use the deflated 2003 province-level stocks of remittances as a proxy for the 2002 stocks. The use of this proxy and the possibility of misreporting remittances by survey respondents creates concerns of measurement error. Moreover, as discussed before, the estimation in first differences implemented in this paper will make measurement error problems even more severe. The instrumental variable approach in this paper is used to address this problem.[40]

2.7.2 Construction of the instrumental variables

Shares of migrants across destinations (i.e. π_{pd}) I construct variables measuring the fraction of the province level stocks of migrants in each country of destination using data from the SOF. Provinces that have too few migrants are dropped from the sample, as the accuracy of the distribution is unreliable.[41] For the provinces remaining I identify the two more common destination countries and compute the distribution of migrants between these two destinations. If the number of migrants choosing the second destination is less than four, I only use the first destination. If two destinations host less than two thirds of the migrants and the third destination has less than four migrants, I compute the distribution among the top three destinations.[42]

[40] Indeed, empirical results are not substantially affected when estimates are derived using the stocks of remittances from the 2002 SOF instead of the 2003 FIES.

[41] The threshold used for being dropped out of the sample is less than four migrants reported in the survey. These provinces are Camiguin, Agusan Del Sur, Siquijor, Davao Oriental, Sulu, Bukidnon, Southern Leyte, Romblon, Misamis Occidental. The provinces of Metro Manila are also dropped from the sample in spite of them having high migration levels due to the fact that they are mainly urban.

[42] A similar approach is used by Antman (2010).

Macroeconomic variables of destination countries Nominal exchange rates of the destination country currencies with respect to the Filipino peso were computed using the end-of-period USD exchange rates in the IMF International Finance Statistics database. I then converted the exchange rates to 2002 constant Filipino pesos using the consumer price index reported by NSO. The exchange rates in 2002 Filipino pesos were used to build the instruments.

GDP levels were collected from the International Monetary Fund World Economic Outlook Database. These variables were obtained at current PPP international dollars and then adjusted to constant prices. The adjustment to constant prices was done using the corresponding real GDP growth rates. These growth rates were calculated from the series of GDP in national currency constant prices in the World Economic Outlook database. After this adjustment, the GDP in constant PPP international dollars were used to build the instruments.

Appendix Table 2.1. First stage alternative specifications

Dependent variable:	Log Stock of Migrants				Log Stock of Remittances			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Log GDP - contemporaneous	0.460***			1.428	0.225**			-3.750*
	(0.101)			(2.971)	(0.110)			(2.069)
Log Exchange Rate - contemporaneous	0.233			2.442	0.600***			5.082
	(0.225)			(10.071)	(0.197)			(8.333)
Log GDP - 1 year lagged		0.476***		-4.594		0.242**		7.272
		(0.109)		(6.174)		(0.112)		(4.441)
Log Exchange Rate - 1 year lagged		0.207		-1.472		0.573***		-2.198
		(0.233)		(10.653)		(0.200)		(9.005)
Log GDP - 2 year lagged			0.492***	0.618			0.255**	-7.729
			(0.109)	(6.535)			(0.127)	(4.902)
Log Exchange Rate - 2 year lagged			0.140	4.980			0.488**	3.961
			(0.230)	(6.012)			(0.195)	(5.655)
F excluded instruments	21.86	22.09	22.50	6.63	10.29	10.30	9.05	10.18
Observations	2420	2420	2420	2420	2420	2420	2420	2420

Note- Weighted Least Square estimates were the weights are the number of farms per municipality in 1991. Standard errors clustered by province and year. All models include municipality and year fixed effects. Province level controls consist of interactions between 1991 means and decade dummies. * Denotes statistical significance at the 10% level; ** at the 5% level; *** at the 1% level

Appendix Table 2.2. Labor inputs in the production and agriculture sectors

	Works in agriculture sector (pct points)		Works in production sector (pct points)	
	(1)	(2)	(3)	(4)
	Panel A: OLS estimates			
Log (remittances)	-0.019	-0.018	0.006	0.007
	(0.015)	(0.018)	(0.008)	(0.008)
Log (stock of migrants)	-0.020	0.004	0.009	0.004
	(0.027)	(0.030)	(0.009)	(0.009)
	Panel B: IV estimates			
Log (remittances)	-0.079	-0.055	0.055*	0.073
	(0.086)	(0.114)	(0.028)	(0.045)
Log (stock of migrants)	0.022	-0.004	-0.028	-0.078
	(0.138)	(0.188)	(0.043)	(0.062)
Province level controls	No	Yes	No	Yes
Mean dependent variable (%)	35	35	20	20
Hausman p-value	0.70	0.72	0.04	0.07
Clusters	130	130	130	130
Observations	133,416	133,416	133,416	133,416

Note- Columns (1)-(4) present estimates of the percentage point change in the probability of working in agriculture/production if the stock of remittances/emigration increases in 1 percent. Weighted Least Square estimates were the weights are the number of farms per municipality in 1991. Standard errors clustered by province and year. All models include municipality and year fixed effects. Province level controls consist of interactions between 1991 means and decade dummies. * Denotes statistical significance at the 10% level; ** at the 5% level; *** at the 1% level

Appendix Table 2.3. Occupation of Filipino Migrants in 1991

Production workers and laborers	29%
Household helpers	27%
Professionals, technical workers and managers	18%
Service workers (excluding household helpers)	13%
Clerks and sales workers	7%
Agricultural workers	**3%**
Unknown	2%
Total	100%

Note-Data is built using retrospective information of migration from the Surveys of Overseas Filipinos 1993-1996. See the data appendix for details in which this variable was built.

Appendix Table 2.4. First stage

Dependent variable	Log migration in own province		Log remittances in own province		Log migration in rest of region		Log remittances in rest of region	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Log (GDP in province)	0.349*	0.465***	-0.109	0.252	0.172**	0.176*	-0.005	0.099
	(0.183)	(0.169)	(0.232)	(0.248)	(0.086)	(0.097)	(0.140)	(0.149)
Log (EXR in province)	0.156	0.130	0.453***	0.380***	-0.048	-0.050	-0.036	-0.061
	(0.102)	(0.079)	(0.114)	(0.114)	(0.034)	(0.035)	(0.068)	(0.066)
Log (GDP in rest of region)	-0.368	-0.251	-1.092*	-0.904	1.029***	1.069***	0.695*	0.648*
	(0.361)	(0.254)	(0.594)	(0.552)	(0.308)	(0.311)	(0.370)	(0.380)
Log (EXR in rest of region)	-0.189	0.066	-0.087	0.254	0.385***	0.383***	0.836***	0.891***
	(0.218)	(0.161)	(0.242)	(0.235)	(0.075)	(0.091)	(0.204)	(0.214)
Province level controls	No	Yes	No	Yes	No	Yes	No	Yes
Clusters	130	130	130	130	130	130	130	130
F- excluded instruments	4.54	6.28	6.16	5.83	10.29	7.50	7.35	7.03

Note- Standard errors clustered by province and year. All models include province and year fixed effects. Province level controls consist of interactions between 1991 means and decade dummies. * Denotes statistical significance at the 10% level; ** at the 5% level; *** at the 1% level

Chapter 3

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

Note: This chapter of the dissertation is coauthored with Jeanne Lafortune and José Tessada

3.1 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 discussion about the precise estimates of the effect of immigration on native wages and employment, the overall conclusion implies, somewhat surprisingly, that there is a fairly small impact of immigration for natives. While some 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 other factors of production which attenuate the wage and employment effects of the 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, in response to the inflow of low-skill labor in the economy, firms may increase the production of goods and/or use technologies that are less capital-intensive and more labor intensive. Furthermore, 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 services sector where techniques and capital are difficult to measure. Second, current immigrant waves do not represent a large fraction of employment in the manufacturing sector where the data is available. However, Lewis (2010), using data from the Survey of Manufactures for the late 1980s and early 1990s, finds that immigration-induced increments in the relative supply of low-skilled labor made firms less likely to adopt automation machinery.

This chapter examines how firms, or farms in this specific case, adapt to the changes in labor supply driven by flows of immigrants arriving to a local labor market. 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 (with foreign born population representing a larger fraction of total population than it is today), 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 manufacturing and agriculture, two sectors in which capital and technologies can be more easily measured than in the services sector. Indeed, observing the adoption of technologies and crops in the agricultural sector is facilitated by the availability of relevant variables in the Agricultural Census and by a large number of contemporaneous studies that describe in detail the production processes of various crops. Furthermore, during this period a large number of immigrants were working in the agricultural sector (although an even larger number of immigrants worked in the manufacturing sector):

17 percent of all migrants arriving during this period were farmers in their country of origin, and more than 10 percent of the immigrants in the United States reported to be farm workers.[1] Finally, the period from 1910 to 1940 is particularly appealing for two additional reasons. First, the fact that the "frontier" was almost completely established, limited the incorporation of new land as a mechanism to absorb the inflow of immigrant workers. Second, 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 chapter we examine whether, between 1910 and 1940, immigration-induced shocks to agricultural labor caused farms in the United States to modify their production and technology choices. We consider a variety of adjustment channels that could respond to an increase in the relative availability of labor and try to assess the importance of these potential mechanisms of adjustment.

We approach this question by thinking of local labor markets as small open economies with access to a similar set of production technologies. In this context, the effects of an increase in the endowment of labor depend on whether capital and technology can be adjusted. First, when 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.

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

[1] According to authors' calculations using Census micro samples and the Reports of the Commissioner for Immigration.

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. 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 could also respond to the immigrant flow by slowing the adoption of labor-saving technology.

This simple framework thus gives us the key elements to identify the sources of adjustments in the early 20th century US agriculture. With this framework in mind, we estimate the impact of an immigration-induced shock to labor supply on the organization of agricultural production in the United States from 1910 to 1940. We use the Census of Agriculture from 1910 to 1940 to measure county-level data on several outcomes: scale of production, crop choice, draft power choice and direct measures of capital, output and land allocation.[2] We match each county to the number of farmers and low skill workers in this region, measured from the Census of the United States. We estimate the impact of an increase in the number of farm or low skill workers per acre of farm land in a county on the agricultural outcomes to account for the possible response in terms of land use and also to match the elements of our theoretical model. 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 estimates of

[2]Part of the data from these sources was digitalized for the purpose of this chapter.

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.

Preview of the Results. Our results suggest that immigration influenced the organization of agriculture in rural sectors of the United States in the early 20th century. 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 relative availability of labor reduces the share of land allocated to wheat and increases the share of land allocated to hay and corn. A decline in land allocated to cotton is also observed, although with marginal 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 one percent increase in the number of farm workers per acre increase the number of farms per acre by 0.4 percent. This is mostly driven by the fact that very large farms (more than 175 acres) become less common at the expense of medium farms (50 to 100 acres). There is weaker evidence that the land in farms managed by tenants rather than owners increased as a result of a greater availability of labor.

We also look at measures of draft power that proxy for the adoption of mechanized technologies and find evidence that the adoption of tractors was altered in response to the immigration-induced labor supply shocks. Specifically, we find that a one percent increase in the farmers-land ratio reduced the number of tractors per acre by 3.4 percent. We also find evidence of a negative impact on the number of horses per acre and of a positive impact in the number of mules per acre.

Our theoretical framework suggests that, in an environment with no adjustments in technology or production mix, the responses in capital-labor and capital-land ratios to a change in the labor-land ratio indicate the degree of complementarity or substitutability between inputs. 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.

We provide some evidence against an underlying causal channel behind in which immigrant farmers affect agricultural practices via a transmission of knowledge. We also study whether the estimated effects are heterogenous along several dimensions and find evidence suggesting that in counties where tenancy was more frequent there are larger responses to changes in labor supply. This may be explained by the fact that these agricultural economies were characterized by thin labor markets, making them more susceptible to shocks in labor supply.

The results in this chapter 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 chapter is organized as follows. In section 3.2 we present a brief summary of the main events in the history of agriculture in the United States during the period we study, which will prove relevant in the discussion of the empirical strategy. In section 3.3 we present a simple conceptual framework that will be used to motivate the empirical model and interpret the results of our estimations. Section 3.4 describes the data used in this chapter and section 3.5 presents the empirical strategy. Finally, in section 3.6 we show the main results and in section 3.7 we present some conclusions.

3.2 Historical background: American Agriculture in 1900-1940

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. The sharp decline in the incorporation of new lands in farming led to a reduction in the rate of growth of crop production. Moreover, there was a movement of labor to large urban industrial areas. While supply experienced a decline in its rate of growth, the international demand of US agricultural products increased during the wartime years, boosting agricultural prices and land values and improving the economic conditions of many farmers. Thus, the first two decades of the 20th century were characterized by agricultural prosperity.

The 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.

In order to compensate for the lower food prices, farmers made an effort to increase productivity. 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). This 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, 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).[3] The diffusion of tractors was very rapid, although there was a significant variation in the pace of the adoption across regions. 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).

Much of the regional variation in the adoption of tractors was associated with the regional specialization in the production of crops that 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. The characteristics of each of these crops influenced the degree of mechanization in production.[4] 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

[3]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).

[4]The National Research Project conducted a series of studies during the 1930s to 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. 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. The studies show that the average number of hours of labor required to grow 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.

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).

The transformations in farming technologies experienced during this period brought gains to the more productive farmers. However, 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. 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). 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, Forthcoming).

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.

Thus, this was a period of major transformations in the agricultural sector, some of which were fostered by international shocks or environmental phenomena. Moreover, these transformations affected regions differently, to the extent that natural and institutional conditions led to regional specialization in farming practices. To the extent that many of these events likely affected the location and 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. In section 3.5 we will discuss in detail how we will address these empirical challenges.

3.3 Theoretical Framework

3.3.1 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 $F(.)$ 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:

$$d \ln \left(\frac{\partial Y}{\partial K} \right) = 0 \tag{3.1}$$

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

$$d \ln K = \frac{L \frac{\partial^2 Y}{\partial K \partial L}}{T \frac{\partial^2 Y}{\partial K \partial T} + L \frac{\partial^2 Y}{\partial K \partial L}} d \ln L + \frac{T \frac{\partial^2 Y}{\partial K \partial T}}{T \frac{\partial^2 Y}{\partial K \partial T} + L \frac{\partial^2 Y}{\partial K \partial L}} d \ln T \tag{3.2}$$

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:

$$d \ln K - d \ln L = - \frac{T \frac{\partial^2 Y}{\partial K \partial T}}{T \frac{\partial^2 Y}{\partial K \partial T} + L \frac{\partial^2 Y}{\partial K \partial L}} (d \ln L - d \ln T) \tag{3.3}$$

$$d \ln K - d \ln T = \frac{L \frac{\partial^2 Y}{\partial K \partial L}}{T \frac{\partial^2 Y}{\partial K \partial T} + L \frac{\partial^2 Y}{\partial K \partial L}} (d \ln L - d \ln T) \tag{3.4}$$

The denominators in fractions (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 (2010) 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:

$$d \ln Y - d \ln L = \frac{(\alpha + \beta - 1) L \frac{\partial^2 Y}{\partial K \partial L} + (\alpha - 1) T \frac{\partial^2 Y}{\partial K \partial T}}{T \frac{\partial^2 Y}{\partial K \partial T} + L \frac{\partial^2 Y}{\partial K \partial L}} (d \ln L - d \ln T) \tag{3.5}$$

and

$$d \ln Y - d \ln T = \frac{(\alpha + \beta) L \frac{\partial^2 Y}{\partial K \partial L} + \alpha T \frac{\partial^2 Y}{\partial K \partial T}}{T \frac{\partial^2 Y}{\partial K \partial T} + L \frac{\partial^2 Y}{\partial K \partial L}} (d \ln L - d \ln T) \tag{3.6}$$

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,

$$d \ln w = (\epsilon_{\alpha,L} + \frac{L\frac{\partial^2 Y}{\partial K \partial L}}{T\frac{\partial^2 Y}{\partial K \partial T} + L\frac{\partial^2 Y}{\partial K \partial L}}\epsilon_{\alpha,K})(d \ln L - d \ln T) \tag{3.7}$$

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.

3.3.2 An alternative model

An alternative model would 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 increase in exactly the same amount as the inflow of workers, thus keeping the input ratios fixed within an industry. Exogenous immigration shocks would not affect the capital labor ratios within each sector. Therefore, 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. Alternatively, 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.

3.4 Data and Descriptive Statistics

3.4.1 Sources

Data for this chapter was drawn from two main sources: the US Census of Agriculture and the US Population Census. The US Population Census data was obtained from the one percent micro samples of the 1910-1940 Integrated Public Use Microdata Series (IPUMS, Ruggles, Sobek, Alexander, Fitch, Goeken, Hall, King, and Ronnander 2008) and from the 1900-1940 published 100 percent county level summary tables.

Data for the Census of Agriculture was collected at the county level, since no farm level data is available. Some of the relevant variables were available in digital format at the National Historical Geographic Information System (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.

Our analysis is based in county data of all US states except for Hawaii, Alaska and the District of Columbia. However, county boundaries changed over this period, with some counties merging or ceasing to exist. We therefore tracked all the boundary changes and grouped the counties whenever it was necessary to keep the unit of observation constant over time. We also exclude any county for which the number of predicted farmers (based on our instrument described below) was less than 0.1 (and any county where the number of low-skill was predicted to be less than 0.6 in regressions where that variable is used). This generated a balanced panel of 2,697 counties. The average number of counties by state is 58 with the smallest including only 3 counties (Delaware) and the largest, 235 (Texas).

3.4.2 Labor supply and immigration data

We use county level aggregate tables from the United States Decennial Population Census 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 United States Decennial Population Census data to identify immigrants who work as farmers. As is traditional in the literature, we define immigrants as individuals who are registered in the US Census and were born outside the US. Farmers are defined as individuals whose primary occupation, as reported in the Census, is being a farmer or a farm laborer. 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.

We also obtain data on the number of immigrants in every county by country of birth. This data is available in the 1900 Census county level tables, which are available in digital format at the NHGIS. This variable is used to construct an instrumental variable which exploits the tendency of new migrants to go the same location that previous immigrants from the same ethnic group have chosen.

3.4.3 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. 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.

Among the relevant outcomes are county level measures of crop production. We therefore obtain measures of physical output and area planted for the four most important crops during this period: corn, wheat, hay and cotton. [5] 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.[6] Since not all of measures of crop production were available in digital format, we worked on their digitalization for the purpose of this study.

[5]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.

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

We are also interested in measures of the scale and the organization of agricultural production. 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.[7]. 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.[8]

To investigate the adoption of mechanized farming practices, we use proxy measures of draft power that are built from data on the number of 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. Thus, we explore how the substitution of animal draft power by tractors was affected by an increase in the amount of labor, since this shift represents capital upgrading or technology adoption. County level data on the number of mules and horses was not available in digital format for some states and years and was therefore digitalized for the purpose of the study. 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.

[7]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."

[8]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".

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 were also deflated as explained before.

3.4.4 Summary Statistics

Table 3.1 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 452 immigrant farmers in each county, a number that corresponds to approximately 10 percent of the total stock of farmers per county. Farmers represent about 45 percent of all low-skill workers in a given county and the county-level stock of low-skill workers is, on average, 9390.

Counties have on average 2548 farms and 453 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 3.1. There is a large variation in these measures by county. An average of 22 bushels of corn per acre was produced while wheat offers an average of 13 bushels per acre. 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.[9]

[9]In addition, we have yet to digitalized data for hay tons in 1940.

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 tenants.

The value of implements and machinery in 1910 dollars was 420 per worker and 3.65 per acre. The value of crops in 1910 dollars was 1220 per worker and 12.0 per acre. Large variations are observed across states. The same can be said regarding the number of tractors and draft animals.

3.5 Empirical Strategy

In the empirical analysis we investigate whether agricultural economies in the US accommodated shocks in the relative availability of agricultural labor induced by immigration inflows by adjusting the organization of production and the allocation of inputs. In the construction of our empirical model we should take into account the fact that natives may reallocate in response to an immigration inflow by leaving or slowing their migration to regions where immigrants are less concentrated.[10] We address this issue by studying the impact of changes in *total* labor endowments, rather than on the endowments of immigrant labor. In this way, we take into consideration the effect of changes in labor endowment net of the reallocation of native workers.

Thus, our empirical strategy is based on the estimation of regressions that describe the relationship between agricultural outcomes and the stock of agricultural workers per

[10] 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.

acre of farmland. The main estimation equations is:

$$\log y_{ist} = \theta \log \frac{L_{ist}}{T_{ist}} + \beta' \log X_{ist} + \nu_i + \mu_t + \upsilon_{st} + \epsilon_{ist} \tag{3.8}$$

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 immigrant farmers, the stock of all farmers or the stock of low skilled workers in county i. The variable T_{ist} measures the area devoted to farmlands 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. All variables enter the equations in logarithmic form, as suggested by the theoretical framework in section 3.3 and regressions are weighted by the size of the farmland in 1900. Finally, standard errors are clustered at the county-level to adjust for heteroscedasticity and within-county correlation over time.[11]

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. Consider, for instance, events such as the mortgage crisis in the 1920s that led many farmers to bankruptcy. This event affected the location decision of farmers, who were mostly hit in the agricultural south, the corn belt and the mountain states, and at the same time transformed the agricultural patterns, reducing the intensity

[11] 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.

of production and farm ownership.

In order to isolate the causal parameter of interest from potentially confounding factors, we will use an instrumental variable strategy that uses fixed effects in combination with an instrumental variable. First, we use a set of year fixed effects, μ_t, to control for shocks that generate a co-movement of agricultural labor supply and agricultural patterns at the national level. In this way we attempt 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. Second, time-invariant county-specific characteristics that determine the location patterns of agricultural workers are controlled for 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 controlled for.

However, the OLS estimate of θ will be biased even in specifications with county and year fixed effects if agricultural workers chose their location based on time-varying unobserved determinants of regional agricultural performance. Indeed, one can consider several sources of unobservable regional time-varying shocks that might have simultaneously determined agricultural outcomes and the location of farmers. Some examples are the aggressive agricultural policies that were differentially implemented across states, such as the First AAA, and environmental shocks in specific regions, such as the Dust Bowl. Reverse causality is also an issue, to the extent that agricultural workers might have chosen their location in response to future changes in production choices and technologies. Consider, for instance, the variation across regions in the pace of adoption of new agricultural technologies and in the patterns of crop specialization discussed in Section 3.2. Farmers may have chosen their location in response to these technological transformations or as a result of the introduction of specific crops, leading to a reverse-causal relationship. To deal with these issues we introduce state by year fixed effects in combination with an instrumental variable. The use of state by year fixed effects, v_{st} means that we will only be exploiting cross-regional variation *between counties within a given state*. Our identification strategy will therefore not be affected by, say, state level policies such as the AAA discussed in 3.2 that simultaneously affected crop choice and agricultural employment. However, even within states, the location of farmers may respond to unobserved, time-varying demand determinants that influence agricultural outcomes at the county level. To deal with this, we exploit 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 (2010).

Formally, the instrument for the logarithm of the stock per acre of immigrant farmers, all farmers or low-skill workers in county i and year t is:

$$\log\left(\sum_j \frac{N_{jsi,1900}}{N_{j,1900}} L_{jt}\right) \tag{3.9}$$

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. Thus, the instrument uses the 1900 distribution across counties to allocate the national stock of immigrants in each decade. 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*. Furthermore, it assumes away land allocation responses to the change in labor input, because those may very well be endogenous.

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 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. Note that the 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. As was discussed above, the instrument uses the past location choices of immigrants of all occupations, not only of those involved in agriculture. This reduces the concern that farmers in the past may have selected their location within each state anticipating changes in agricultural conditions. Furthermore, the location shares are obtained from Census tabulates, as opposed to micro-samples, making their measurement more reliable and thereby attenuating concerns of measurement-error bias.

Nevertheless, there may still be confounding shocks associated with the within-state location decision of farmers in 1900 and with the relative agricultural performance of counties within a state over the following decades. To account for these confounding factors, 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 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 suggests a threat to the validity of the identification assumption.

Estimation of the first stage of equation (3.8) is presented in Table 3.2 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. This panel has fewer observations than the subsequent ones because it only includes 1910-1930, since in 1940, we are unable to identify immigrant farmers within each county. However, since we are interested in the effects of immigration-induced changes in labor supply, we present IV estimates in which the total stock of farmers and low skill workers as endogenous variable of interest. In this way, we use a measure of the change in labor supply that takes into account all adjustments in the availability of agricultural labor that may be induced by immigration, which includes not only an influx of immigrants but also a possible displacement of 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. In this case, we expect that changes in the supply of all low-skill workers, as opposed to only farmers, impact agricultural production decisions through changes in the wage. 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.[12] These controls are included to verify if 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: Oklahoma, Kansas and Nebraska.[13]

The first panel 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 0.3 to 0.4 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

[12]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.

[13]As shown in Hornbeck (Forthcoming), counties with the highest erosion levels were located in these three states.

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 seems to be significantly driven by the immigrant flows. The magnitudes of the coefficients are smaller, indicating that 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. Immigration is associated with a change in the labor supply per acre farmed within each county. The reduction in the significance level of coefficients with respect to Panel A 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 or the set of time-varying country level controls are included.

The last panel presents the result of an analogous regression in which an instrument that allocates the national stock of low skilled immigrants is used 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.

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, anecdotal evidence from economic historians suggest there may be an alternative causal channel that, if sufficiently prevalent, will invalidate the exclusion restriction. This anecdotal evidence indicates that immigrants may have transformed agricultural outcomes by importing knowledge on agricultural practices from foreign countries. In section 3.6.5 of this chapter we provide an assessment of the importance of this alternative causal channel.

3.6 Results

3.6.1 Adjustments in Crop Choice

As we discussed in section 3.3, 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. If these Rybczynski-type adjustments are present, we would expect that in response to an immigration-driven increase in labor supply, the acreage devoted to capital intensive crops decreases and that devoted to labor intensive crops declines. We explore this hypothesis in this section. In our empirical exercise we focus on wheat, hay, corn and cotton since, as we explained in section 3.2, these are the main crops produced in the United States in this period. To assess the relative capital-labor intensities of these crops we rely on detailed contemporary studies of labor and capital requirements that guide us in the classification of the crops along this dimension (see Elwood, Lloyd, Schmuts, and McKibben 1939).

The first panel of table 3.3 presents the ordinary least square (OLS) results. The correlation between the number of farmers per acre and the share devoted to each crop is very small but in all cases positive. 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 results in a decline in the share of land allocated to wheat and, marginally, to cotton. There is also an increase in the share of land devoted to corn and hay. The impacts of changes in the relative availability of low skilled workers is much weaker than the effects of changes in the stock of farmers, a result that is not surprising since low skilled workers may not all be potential participants in the agricultural labor market. 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 decline in wheat in response to the labor supply shock is consistent with a Rybczynski-type adjustment, since wheat is by far the less labor intensive crop in the study. The same cannot be said about the negative impact of labor supply in cotton, as this is the crop with the greatest labor requirements. This finding suggests that the observed effects on crop mix might be also reflecting alternative channels, such as adjustments in technology or in the organization of production.

3.6.2 Adjustments in the organization of production

Agricultural economies may 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 in 3.2, 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 3.4 present the results of models on the number of farms per acre (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 while Panel B shows IV estimates of the effects. Finally, Panel C presents the IV estimates of the effect of low-skill workers.

Results in Panel A show that, for comparisons within the same state, an increase in the number of workers per acre in a county is associated with smaller farms. These OLS estimates are smaller than the IV coefficients, suggesting that immigrants are disproportionately located in counties that have small farms. The causal impact of a change of 1 percent in the number of workers per acre is a change in 0.4 percent in the number of farms per acre, as can be seen in the first two columns. Subsequent columns suggests that this shift 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. [14]

More evidence of changes in the organization of production is presented in Table 3.5 where we now look at tenancy decisions. Panels in this table are organized in the same way as in Table 3.4. IV estimates in Panel B indicate that an increase of one percent in the stock of farmers per acre lead to an increase of 0.07 percent in the share of land tenanted and a decrease of approximately 0.19 percent in the share of land farmed by the owner. The effects on the fraction of farms operated by managers are not statistically different from zero. The effects of changes in the endowment of low skilled workers in Panel B have similar magnitudes but much less statistical power. 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.

Overall, these results indicate a change in the way the agricultural production was organized. In response to an increase in the number of farmers per acre, farms shrunk and more farmland was operated by tenants rather than by owners. This evidence of changes in scale and tenancy is consistent with a scenario in which farms adjusted to an immigration-induced change in the relative endowment of agricultural labor by slowing the use of mechanized technologies.

3.6.3 Adjustments to Input Mix

In this section we directly test whether there is evidence that farms responded to the inflow of labor by also changing their input mix, particularly within a given crop

[14]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.

or farm organization. Table 3.6 reports the estimates of regressions of the use of horses, mules and tractors. The choice of these outcomes 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). The number of observations in the tractors models is significantly lower because there are no observations for 1910.

The first panel reports OLS results indicating that agricultural workers tend to locate in counties where there is a large number of horses and mules per acre. However, the IV estimates in Panels B and C show that a larger endowment of agricultural or low skilled workers per acre leads to a decline in the relative number of tractors and an increase in the number of mules. While the estimates of the model of horses are negative, they are not significantly different from zero. Overall, the results in table 3.6 are consistent with a framework in which farms adjusted to an immigration-induced labor shock by slowing the adoption of labor saving technologies. In this case, they appear to have slowed down the shift from mules to tractors.[15] These results are not robust to the exclusion of Dustbowl States.

We now use a general measure of capital (i.e., the real value of implements and machinery used in agriculture) to examine adjustments in capital intensity. Table 3.7 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

[15] Mules were most common in the south, where their prevalence increased over time reflecting a substitution away from horses and oxen. Mules were stronger and more durable than horses, and were typically sold by higher prices(Olmstead and Rhode, 2008).

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.

As discussed in section 3.3, the adjustments in capital-labor and capital-land ratios in response to a change in the relative labor endowment will determine, in the case of a single output function, the degree of complementarity or substitutability between the factors. Assessing the degree of substitutability is relevant to the extent that it indicates the degree of adjustment in wages. We would therefore like to observe adjustments in input ratios *within* each crop. Unfortunately, we don't have data on input utilization at the crop level. Moreover, we are unable to control for crop production since this is clearly endogenous.

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. These effects are significant only after the output controls are included. An increase of one percent in the labor-land ratio leads to a fall in the capital labor ratio of about 1.1 to 1.2 percent and has no significant effect on the capital-land ratio. If we assume, for now, that the estimates of the model with output controls and state*year fixed effects correspond to adjustments within each crop and method of production, we can interpret the IV estimates in columns (1)- (3) as evidence that exogenous immigration shocks do affect the capital labor ratios *within each sector*, as opposed to what would occur in an environment in which labor supply shocks are entirely absorbed by Rybczinsky-type adjustments. Moreover, the negative sign of the estimates in columns (1)-(3) can be interpreted as evidence that land and capital are complementary in production while the negative, not statistically significant effects in columns (4)- (6) suggest that labor and capital are mildly substitutable or neutral. As discussed in section 3.3, this suggests that wage effects from the immigration-induced labor supply shock are not completely attenuated.

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:

$$(K/T) = \sum_i \omega_i \frac{k_i}{t_i} \tag{3.10}$$

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:

$$\Delta(K/T) = \sum_i [\Delta\omega_i * (k_i/t_i)] + \sum_i [\omega_i * \Delta(k_i/t_i)] \tag{3.11}$$

We can obtain an analogous version of (3.11) in which we decompose the elasticity of (K/T) with respect to (L/T):

$$\frac{\Delta(K/T)}{(K/T)\Delta ln(L/T)} = \frac{\sum_i \Delta\omega_i(k_i/t_i)}{(K/T)*\Delta ln(L/T)} + \frac{\sum_i \omega_i\Delta(k_i/t_i)}{(K/T)\Delta ln(L/T)} \tag{3.12}$$

With simple algebra we obtain:

$$\beta = \underbrace{\frac{\sum_i \theta_i(k_i/t_i)}{(K/T)}}_{\text{Shifts in methods of production}} + \underbrace{\Psi}_{\text{Shifts within methods of production}} \tag{3.13}$$

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.[16]. We can obtain estimates of the parameter β from the results in table 3.7 and can also make an estimation of the first term to the right hand side of 3.13, 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 3.6.2 while the rest of the terms can be obtained from the Census reports of 1900.

As shown in column (5) of Table 3.7), 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 3.13. 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

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

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 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.

3.6.4 Adjustments in output ratios

Finally, the model in Section 3.3 suggests that interesting insights can be obtained from looking at the impact of immigration-induced labor supply shocks on capital-output and output-land ratios. Estimates of these effects are presented in Table 3.8, which is organized in the same way as Table 3.7. Columns (1)-(3) show that there are no significant effects from shocks to the labor endowment on the capital-output ratio. If we were to assume that these estimates can be interpreted as shifts within a given output or method of production, in light of the model in section 3.3 we would find these results to be consistent with a scenario in which capital and labor are substitutes and capital and labor are complement. Nonetheless, given the sizable standard errors we are unable to rule out the possibility that the absence of effects simply reflects a lack in precision of the estimation. Columns (4)-(6) present the estimates of the effects on the output per land ratio which are, also, not statistically different from zero. Since we have crop-level data on land and output, we can replicate the results for this outcome *within each crop* and can therefore verify whether the absence of county-level shifts in land productivity also exists at the crop level or if, instead, the results are changes in productivity within crops.

The estimates of models of crop productivity are presented in Table 3.9, which has the same layout as the previous tables. In general, we don't find statistically significant adjustments in crop productivity in any of the crops, although the sizable standard errors indicate that the lack of an impact may be due to insufficient precision in the estimation. Thus, the results presented in table 3.8 don't seem to be masking shifts in productivity within each crop.

We can perform a decomposition exercise analogous to the one in section 3.6.3 in which we try to assess how much of the shifts in land productivity can be explained by shifts in the production method. The term in the left hand side of equation 3.13 would be the estimated elasticity of (Y/T) with respect to (L/T), which is -0.661 according to the estimate reported in column (5) of table 3.8. We estimate the portion explained by changes in size (first term in the right hand side of equation 3.13) to be 0.9, again because small farms are more productive than larger ones and immigration lead to a larger number of such farms. This means that the aggregate effect does not seem to be driven by changes in farm size. A similar conclusion is reached when we estimate the portion explained by changes in tenancy, which amounts to -0.18, because owner-farmed land was slightly less productive than tenant-occupied farm in the national 1900 sample, something that has not been shown to be true in other context. Nevertheless, this is a small fraction of the total measured effect mentioned above. Thus, overall, this is consistent with the conclusion from the previous decomposition exercise, which indicated that while some of the adjustments to the immigration-induced increases in the relative endowment of labor occur by shifts in methods of production, much of the adjustments will occur via changes within each method. On the other hand, in this case, we can actually do such decomposition with crops as the value of product per crop is available in the Census tables in 1900. Had farms in our sample simply changed the allocation of their crop as presented in Table 3.3, output per acre would have fallen by 0.59. This implies that almost all of the fall in the (Y/T) ratio was due to reallocation across crops instead of changes within each crop. Thus, we confirm that the (insignificant) change in land productivity observed at the aggregate level appears to be fully driven by changes in crops and not by change in productivity across crops.

3.6.5 Heterogeneous effects

Throughout this chapter we have assumed that changes in labor supply have a homogenous impact in all counties. However, responses in agricultural production decisions to labor supply shocks may vary across different dimensions. In this section we examine whether the impact of changes in labor supply differs across subgroups of counties.

Examining these differentials sheds light on the underlying mechanisms that can be driving the estimated effects. 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 was critical in the successful spread of wheat cultivation in Kansas, Nebraska, Oklahoma and the surrounding region.

In Table 3.10 we provide auxiliary evidence to assess the importance of this alternative causal channel. We re-estimate the main results in this chapter but modify the baseline equation 3.8 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.[17] 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.

In the odd columns of table 3.10, we present once more the estimates of the effects

[17]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.

of changes in the relative endowment of farmers using the baseline specification that were presented previously in tables 3.3-3.6. In the even columns we present the results of estimates of equations that include interactions with indicators of main ethnic groups. The first panel shows estimates in which the dependent variables are the land allocated to each crop and a measure of farm size. In the second panel we show estimates of the effects on tenancy and the main source of draft power. In general, we find no evidence of heterogeneous effects by ethnicity prevalence. The effects don't seem to depend on whether the state is one in which most immigrants are German or English. This can be seen from comparisons between odd and even columns and from the significance of the coefficients of the interaction terms. In all specifications, the interaction terms are not statistically significant. Moreover, there are no major differences between odd and even columns in the estimates of changes in the endowment of farmers relative to land. We interpret these results as auxiliary evidence against a causal channel in which exogenous immigration shocks affect agricultural outcomes via a transfer of agricultural knowledge from newly arrived immigrants.

We also explore whether the main effects in this chapter are differential in terms of county characteristics. Whether the counties absorb a change in labor supply due to immigration by adjusting technology use or output mix may depend on features that characterize the local agricultural economy. For instance, counties where the scale of production has traditionally been larger may have a greater scope to adjust their technology use in response to a labor influx.

To investigate this we estimate, first, a modified version of equation 3.8 in which the variable that measures the relative endowment of agricultural labor is interacted with a predetermined measure of the scale of farm production. The modified equation is:

$$\log y_{ist} = \alpha \log \frac{L_{ist}}{T_{ist}} * A_{is} + \gamma \log \frac{L_{ist}}{T_{ist}} * B_{is} + \beta \log X_{ist} + \nu_i + \mu_t + v_{st} + \epsilon_{ist} \tag{3.14}$$

where variable A_{is} is a dummy that indicates if the average farmsize of county i in 1900 exceeds the median value of the distribution and variable B_{is} indicates if the average farmsize is below the median. These binary variables are predetermined proxies that help predict whether counties have a relatively high or low average farmsize at time t.[18] Thus, comparisons between the estimates of α and γ will show if there are differential effects between these two types of counties. Second, we estimate a modified version of equation 3.14 in which the dummies A_{is} and B_{is} indicate whether the fraction of farms that were administered by owners in 1900 are, respectively, above or below the median of the distribution.[19] Comparisons between the coefficients of these dummy variables will therefore show if the prevalent form of tenancy in 1900 in the county influences how agricultural production responds to labor supply shocks. Finally, we repeat the estimation of equation 3.14 in which the dummy variables in the interactions indicate whether the county belongs to one of the states in the South or to the rest of the regions, so that comparisons between the coefficients indicate if there are heterogeneous effects by region.[20]

We present the results of this analysis in Table 3.11. The first panel shows the

[18]We construct the dummies using 1900 values of farmsize instead of time t values since the latter are endogenous. We find a high serial correlation between these variables, indicating that the 1900 average farmsize is good proxy of farmsize at time t.

[19]There is also, a high serial correlation in the the variable measuring the fraction of farms so the 1900 value is a good proxy of the value at time t.

[20]The states in the South are: Alabama, Arkansas, Kentucky, Louisiana, Mississippi, Oklahoma, Tennessee, Texas. This classification is done using the US Census regional divisions.

results of an IV estimation of model 3.14 where A_{is} and B_{is} are dummies indicating if the average farmsize of county i in 1900 is above or below the median. The last row in the panel shows the p-value of a t-test of equality between the coefficients. If the p-value is below a given statistical level of reference we have evidence suggesting that α and γ are different, so the average farmsize in each county influences the effect on agricultural outcomes of an immigration-induced labor supply shock. Panels B and C are organized in analogous manner. In Panel B we present the IV estimates of the version of the model in which A_{is} and B_{is} indicate, respectively, if the share of farms administered by owners in 1900 in county i was above or below the median while in Panel C we present the results of estimates in which A_{is} and B_{is} indicate whether the county is in a southern state or in another region.

The p-values shown in Panel A indicate that, with a 5% significance level, we can only reject the null of equality between the coefficients of the interaction terms in the models of cotton and mules. Statistically significant adjustments in the land allocated to cotton and the number of mules in response to labor supply shocks appear to occur only in counties that had larger farms in 1900. Note, however, that even in these counties adjustments are only marginally significantly different from zero. Thus, with few exceptions, the average farmsize in the county does not seem to be an important source of heterogeneity in the adjustments.

On the contrary, when we separate counties by the prevalent type of tenancy in 1900, we find greater differences in the effects. As shown in Panel B, adjustments along many dimensions appear to be mostly driven by the subgroup of counties where tenancy was most frequent in 1900. This is the case of the models that measure land allocated to corn, land allocated to hay, farms per acre, land operated by tenants and number of tractors. The one exception is the effect in land allocated to cotton, which seems to be driven by the subsample of counties with more farms operated by owners in 1900. Moreover, the effect on land allocated to wheat is more significant for the subsample of counties with more tenancy, even though in terms of magnitude this effect is not significantly different from the effect among counties with more ownership. This heterogeneity in the effects by type of tenancy may translate to a differential effect by regions, since tenancy was more common in the South.[21] This is examined in Panel C, which shows that, along several dimensions, there were greater adjustments to labor supply shocks in southern counties. The effects on land allocated to corn, wheat and hay are only significant for southern counties. As regards to farm scale, counties from both regions appear to have reduced their farmsize in response to a greater supply of agricultural labor, but this effect is more significant and larger in magnitude for the sample of southern counties. Adjustments in the number of mules are an exception, as these effects are only significant for the non-southern counties.

Thus, larger responses to labor supply shocks seem to have taken place in southern counties and in counties in which tenancy was a more prevalent institution. The heterogeneity by tenancy may be explained by the fact that agricultural economies where land was frequently farmed by tenants were characterized by thin labor markets, so that labor supply shocks are likely to have larger effects in production. 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

[21] The subsample of counties that had a higher than median tenancy prevalence in 1900 includes counties from all regions in the US. Nonetheless, southern states (e.g, Alabama, South Carolina) are overepresented while northern states (Vermont, Michigan) are underepresented.

inflows are likely to have an important effect.

3.7 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. We find that within a state counties in which immigration stocks per acre increased, there was a decline in the land allocated to wheat (which was the most easily mechanizable and less labor intensive crop) and an increase in land allocated to corn and hay. A negative adjustment in cotton was also observed at marginally significant levels. We also present evidence indicating that an increase in the relative availability of labor led to a reduction in the average farm size, a decline in the extent of farmland operated by owners, and an increase in the extent of farmland operated by tenants. Finally, we provide some evidence that a greater endowment of labor slowed down the adoption of tractors and increased the use of mules.

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. We also provide some evidence indicating that these responses to labor supply shock are larger in counties in which tenancy is a common institution, a finding that may be reflecting the thin labor markets that characterized these agricultural economies.

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.

Table 3.1. Summary Statistics

Variable	N	mean	sd
Stock of all immigrant farmers	8190	452.01	972.39
Stock of all farmers	10920	4237.68	3711.65
Stock of all low-skill workers	10920	9390.20	23146.96
Predicted number of immigrant farmers	10920	311.53	1455.20
Predicted number of immigrant non-farmers	10920	902.07	4971.19
Predicted number of low-skill immigrants	10920	2155.13	12167.49
Number of farms	10920	2,548	1,810
Acres farmed	10909	453,002	446,460
Share of total acres planted in corn	10888	0.11	0.10
Share of total acres planted in wheat	10888	0.05	0.09
Share of total acres planted in hay	8178	0.09	0.07
Share of total acres planted in cotton	10888	0.04	0.08
Bushels of corn per acre	10694	21.35	13.45
Bushels of wheat per acre	9394	13.08	7.14
Tons of hay per acre	8152	1.34	0.51
Bales of cotton per acre	3418	0.36	0.20
Share of very small farms (less than 20 acres)	10888	0.05	0.06
Share of small farms (20 to 50)	10888	0.23	0.18
Share of medium farms (50 to 100)	10888	0.19	0.10
Share of large farms (100 to 175)	10888	0.23	0.11
Share of very large farms (more than 175 acres)	10888	0.30	0.25
Share farmed by owner	10888	0.64	0.15
Share farmed by tenant	10888	0.30	0.15
Share farmed by manager	10888	0.05	0.10
Capital-labor ratio	10805	420.63	348.27
Capital-output ratio	10876	0.69	7.18
Capital-land ratio	10884	3.65	3.39
Output-labor ratio	10805	1220.21	943.53
Output-land ratio	10884	12.00	13.00
Number of horses	8186	7746.31	6395.92
Number of mules	8186	2014.86	2558.87
Number of tractors	8182	383.07	576.18

Table 3.2. First Stage

	(1)	(2)	(3)	(4)
	Panel A: Log stock of immigrant farmers			
Log predicted stock of immigrant farmers	0.338**	0.450***	0.337***	0.386***
	(0.133)	(0.167)	(0.127)	(0.131)
Log predicted stock of non immigrant farmers		-0.189		
		(0.214)		
R-squared	0.755	0.755	0.756	0.779
N	8108	8108	8102	7466
	Panel B: Log stock of all farmers			
Log predicted stock of immigrant farmers	0.175***	0.235***	0.166***	0.180***
	(0.07)	(0.08)	(0.06)	(0.07)
Log predicted stock of non immigrant farmers		-0.112		
		(0.10)		
R-squared	0.906	0.906	0.908	0.906
N	10786	10786	10778	9930
	Panel C: Log stock of all low skilled workers			
Log predicted stock of low skilled workers	0.156**	0.198	0.143**	0.168**
	(0.065)	(0.177)	(0.063)	(0.067)
Log predicted stock of high skilled workers		-0.052		
		(0.189)		
1900 controls	No	No	Yes	Yes
Excluding dust bowl states	No	No	No	Yes
R-squared	0.940	0.940	0.943	0.941
N	10786	10786	10778	9930

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 3.3. Effects on crop acreage share

		Corn			Wheat			Hay			Cotton	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Panel A: OLS												
Log(Farmers/T)	0.006***	0.005***	0.006***	0.005***	0.004***	0.003***	0.002**	0.003***	0.002***	0.016***	0.014***	0.014***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.002)	(0.002)	(0.002)
Panel B: IV -farmers												
Log(Farmers/T)	0.046**	0.041**	0.041***	-0.067**	-0.095**	-0.082**	0.024**	0.023**	0.020**	-0.060*	-0.058*	-0.057*
	(0.018)	(0.017)	(0.016)	(0.032)	(0.040)	(0.035)	(0.011)	(0.011)	(0.010)	(0.032)	(0.032)	(0.031)
Panel C: IV-low skilled workers												
Log(LowSkill/T)	0.051**	0.043*	0.043**	-0.078**	-0.123**	-0.096**	0.025*	0.021	0.016	-0.075*	-0.070	-0.065*
	(0.025)	(0.024)	(0.020)	(0.039)	(0.056)	(0.042)	(0.013)	(0.013)	(0.011)	(0.043)	(0.044)	(0.039)
1900 controls	No	Yes	Yes	No	Yes	Yes	No	Yes	Yes	No	Yes	Yes
Excluding dust bowl states	No	No	Yes	No	No	Yes	No	No	Yes	No	No	Yes
N	10764	10756	9908	10764	10756	9908	10764	10756	9908	10764	10756	9908

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 3.4. 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)	0.235***	0.227***	0.004	0.003	0.018***	0.017***	0.006***	0.006***	0.007***	0.008***	-0.035***	-0.034***
	(0.027)	(0.027)	(0.002)	(0.002)	(0.004)	(0.004)	(0.002)	(0.002)	(0.003)	(0.003)	(0.006)	(0.006)
Panel B: IV- Farmers												
Log (Farmers/T)	0.368**	0.389**	0.006	0.001	0.024	0.032	0.074***	0.076***	0.029	0.050**	-0.134**	-0.159**
	(0.151)	(0.156)	(0.017)	(0.017)	(0.033)	(0.034)	(0.027)	(0.029)	(0.019)	(0.024)	(0.060)	(0.069)
Panel C: IV-Low skilled workers												
Log (LowSkill/T)	0.441**	0.504**	0.008	0.002	0.053	0.064	0.107***	0.115**	0.022	0.060**	-0.190**	-0.242**
	(0.216)	(0.232)	(0.024)	(0.025)	(0.048)	(0.053)	(0.039)	(0.045)	(0.024)	(0.031)	(0.085)	(0.105)
1900 controls	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes
N	10753	10745	10753	10745	10753	10745	10753	10745	10753	10745	10753	10745

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 3.5. Effects on tenancy

	Owner			Manager			Tenant		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Panel A: OLS									
Log (Farmers/T)	0.005	0.006	0.005	-0.018	-0.018	-0.018	0.013*	0.012	0.013
	(0.008)	(0.008)	(0.008)	(0.012)	(0.012)	(0.013)	(0.008)	(0.008)	(0.009)
Panel B: IV- Farmers									
Log (Farmers/T)	-0.180*	-0.199*	-0.203*	0.102	0.127	0.124	0.078*	0.072*	0.079**
	(0.100)	(0.111)	(0.109)	(0.085)	(0.096)	(0.093)	(0.042)	(0.040)	(0.040)
Panel C: IV- Low skilled workers									
Log (LowSkill/T)	-0.189	-0.214	-0.217*	0.124	0.160	0.147	0.065	0.053	0.070
	(0.126)	(0.142)	(0.131)	(0.119)	(0.138)	(0.125)	(0.051)	(0.049)	(0.046)
1900 controls	No	Yes	Yes	No	Yes	Yes	No	Yes	Yes
Excluding dust bowl states	No	No	Yes	No	No	Yes	No	No	Yes
N	10753	10745	9897	10753	10745	9897	10753	10745	9897

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 3.6. Effects on draft power

	Horses			Mules			Tractors		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Panel A: OLS									
Log (Farmers/T)	0.135***	0.132***	0.129***	0.178***	0.191***	0.188***	0.044	0.092	0.101
	(0.026)	(0.026)	(0.028)	(0.041)	(0.041)	(0.043)	(0.122)	(0.113)	(0.118)
Panel B: IV-Farmers									
Log (Farmers/T)	-0.179	-0.149	-0.176	0.542*	0.551*	0.470	-2.987*	-3.384*	-3.506
	(0.181)	(0.184)	(0.183)	(0.324)	(0.324)	(0.306)	(1.596)	(2.051)	(2.137)
Panel C: IV- Low skilled workers									
Log (LowSkill/T)	-0.148	-0.144	-0.237	0.604	0.575	0.388	-3.108*	-3.567	-3.406
	(0.240)	(0.261)	(0.258)	(0.439)	(0.447)	(0.393)	(1.694)	(2.707)	(2.646)
1900 controls	No	Yes	Yes	No	Yes	Yes	No	Yes	Yes
Excluding dust bowl states	No	No	Yes	No	No	Yes	No	No	Yes
N	10785	10777	9929	10786	10778	9930	8070	8064	7428

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 3.7. Effects on factor use ratio

	Capital-labor ratio			Capital-land ratio		
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: OLS						
Log (Farmers/T)	-0.746***	-0.759***	-0.752***	0.254***	0.241***	0.249***
	(0.025)	(0.026)	(0.028)	(0.025)	(0.026)	(0.028)
Panel B: IV-Farmers						
Log (Farmers/T)	-1.133***	-1.216***	-1.235***	-0.133	-0.216	-0.235
	(0.221)	(0.248)	(0.247)	(0.221)	(0.248)	(0.247)
Panel C- IV low skilled workers						
Log (LowSkill/T)	-1.380***	-1.568***	-1.484***	-0.293	-0.418	-0.378
	(0.414)	(0.489)	(0.436)	(0.311)	(0.368)	(0.332)
1900 controls	No	Yes	Yes	No	Yes	Yes
Excluding dust bowl states	No	No	Yes	No	No	Yes
N	10782	10774	9926	10764	10756	9908

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 3.8. Effects on output ratios

	Capital-output ratio			Output-land ratio		
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: OLS						
Log (Farmers/T)	-0.058	-0.059	-0.069	0.312***	0.300***	0.318***
	(0.087)	(0.085)	(0.089)	(0.087)	(0.085)	(0.089)
Panel B: IV-Farmers						
Log (Farmers/T)	-0.004	0.195	0.176	-0.129	-0.411	-0.411
	(0.755)	(0.769)	(0.745)	(0.803)	(0.835)	(0.812)
Panel C- IV Low skilled workers						
Log (Lowskill/T)	-0.043	0.243	0.148	-0.250	-0.661	-0.526
	(1.029)	(1.094)	(1.000)	(1.084)	(1.185)	(1.074)
1900 controls	No	Yes	Yes	No	Yes	Yes
Excluding dust bowl states	No	No	Yes	No	No	Yes
N	10761	10753	9905	10764	10756	9908

The dependent variable is the log of the capital-output ratio (in the first three columns) and the log of the output-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 3.9. Effects on crop productivity (log output per acre)

	Corn			Wheat			Hay			Cotton		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Panel A: OLS												
Log(Farmers/T)	0.045*	0.052*	0.049*	0.038**	0.035**	0.030*	0.043	0.048*	0.052*	0.069	0.088**	0.095**
	(0.027)	(0.027)	(0.028)	(0.017)	(0.017)	(0.018)	(0.028)	(0.028)	(0.029)	(0.053)	(0.043)	(0.044)
Panel B: IV- Farmers												
Log(Farmers/T)	-0.243	-0.175	-0.071	0.142	0.057	0.190	-0.281	-0.319	-0.282	-0.109	-0.276	-0.248
	(0.279)	(0.281)	(0.252)	(0.514)	(0.538)	(0.462)	(0.355)	(0.382)	(0.357)	(0.308)	(0.302)	(0.301)
Panel C: IV- Low skilled workers												
Log (Lowskill/T)	-0.762	-0.694	-0.329	-0.038	-0.111	0.099	-0.466	-0.532	-0.414	-0.370	-0.887	-0.806
	(0.536)	(0.550)	(0.393)	(0.501)	(0.517)	(0.398)	(0.501)	(0.552)	(0.466)	(0.733)	(0.997)	(0.986)
1900 controls	No	Yes	Yes	No	Yes	Yes	No	Yes	Yes	No	Yes	Yes
Excluding dust bowl states	No	No	Yes	No	No	Yes	No	No	Yes	No	No	Yes
N	10481	10473	9631	9039	9031	8209	8077	8071	7435	3250	3242	3175

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 3.10. Heterogeneity by main ethnic group

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	Panel A: Effects on crop share and farm size									
	Corn		Wheat		Hay		Cotton		Farms per acre	
Log(Farmers/T)	0.041**	0.036**	-0.095**	-0.089**	0.023**	0.021**	-0.058*	-0.061*	0.389**	0.362**
	(0.017)	(0.016)	(0.040)	(0.041)	(0.011)	(0.011)	(0.032)	(0.035)	(0.156)	(0.169)
Log(Farmers/T)*German		0.026		0.000		0.011		0.023		0.133
		(0.035)		(0.046)		(0.019)		(0.035)		(0.161)
Log(Farmers/T)*Anglo		0.028		-0.176		0.006		-0.023		0.172
		(0.045)		(0.216)		(0.050)		(0.057)		(0.315)
N	10756	10756	10756	10756	10756	10756	10756	10756	10745	10745
	Panel B: Effects on tenancy and draft power									
	Land by owners		Land by tenants		Horses		Mules		Tractors	
Log(Farmers/T)	-0.199*	-0.233*	0.072*	0.082*	-0.149	-0.097	0.551*	0.414	-3.384*	-4.252
	(0.111)	(0.130)	(0.040)	(0.044)	(0.184)	(0.181)	(0.324)	(0.322)	(2.051)	(3.367)
Log(Farmers/T)*German		0.152*		-0.052		-0.009		0.561		2.007
		(0.088)		(0.053)		(0.241)		(0.423)		(2.482)
Log(Farmers/T)*Anglo		0.273		-0.037		-1.346		1.366		0.987
		(0.185)		(0.124)		(1.044)		(1.106)		(4.355)
N	10745	10745	10745	10745	10777	10777	10778	10778	8064	8064

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 3.11. Heterogeneity by size and tenancy

	Corn	Wheat	Hay	Cotton	Farms per acre	Owners	Tenants	Horses	Mules	Tractors
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Panel A: IV estimates–interaction by farm size										
Ln(Farmers/T)*larger	0.045**	-0.068**	0.025**	-0.064*	0.363**	-0.181*	0.077*	-0.170	0.562*	-3.041*
	(0.018)	(0.033)	(0.011)	(0.033)	(0.154)	(0.102)	(0.043)	(0.183)	(0.331)	(1.650)
Ln(Farmers/T)*smaller	0.063***	-0.048*	0.013	0.003	0.448***	-0.159**	0.103***	-0.311**	0.235	-2.380**
	(0.015)	(0.026)	(0.010)	(0.025)	(0.111)	(0.069)	(0.033)	(0.149)	(0.262)	(1.086)
P-value - test equality	0.053	0.123	0.099	0.000	0.150	0.566	0.167	0.098	0.037	0.331
Panel B: IV estimates–interaction by type of operator										
Ln(Farmers/T)*owner	0.025	-0.062	0.012	-0.100**	0.244	-0.162	0.006	-0.191	0.769*	-2.318
	(0.018)	(0.038)	(0.012)	(0.045)	(0.157)	(0.116)	(0.044)	(0.197)	(0.447)	(1.506)
Ln(Farmers/T)*tenant	0.051***	-0.068**	0.027***	-0.050	0.398***	-0.184*	0.096**	-0.175	0.488	-3.902**
	(0.017)	(0.031)	(0.010)	(0.035)	(0.148)	(0.096)	(0.041)	(0.181)	(0.324)	(1.785)
P-value –test equality	0.002	0.704	0.012	0.002	0.008	0.632	0.000	0.855	0.136	0.004
N	10764	10764	10764	10764	10753	10753	10753	10785	10786	8070
Panel C: IV estimates–interaction by region										
Ln(Farmers/T)*South	0.059**	-0.084**	0.021*	-0.072*	0.326*	-0.208	0.063	-0.240	0.147	-5.276
	(0.026)	(0.043)	(0.011)	(0.043)	(0.186)	(0.131)	(0.044)	(0.222)	(0.329)	(4.050)
Ln(Farmers/T)*other	0.001	-0.010	0.034	-0.020	0.513***	-0.082	0.130	0.031	1.898***	-0.228
	(0.028)	(0.048)	(0.024)	(0.028)	(0.161)	(0.104)	(0.092)	(0.333)	(0.626)	(0.737)
P-value - test equality	0.072	0.146	0.065	0.222	0.002	0.229	0.137	0.551	0.010	0.427

The dependent variables are labeled in each column. All regressions include fixed effects for county and time and fixed effects for each year*state. The p-value shows the results of a Wald test of equality between both estimated coefficients. Standard errors are clustered at the county level.*: 10% significance, **: 5% significance, ***: 1% significance

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