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THE EFFECTS OF IMMIGRATION ON AGRICULTURAL DEVELOPMENT: BRAZIL IN THE AGE OF MASS MIGRATION

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ABSTRACT

We study the effects of immigration during the Age of Mass Migration (1855-1920) on Brazil's agricultural development in 1920. Instrumenting for a municipality's immigrant share using the interaction of aggregate immigrant inflows and the expansion of Brazil's railway network, we find that a greater share of European immigrants in a municipality led to an increase in farm values. The bulk of the effect was the product of more intense cultivation of land. We also find that it is unlikely that immigration slowed Brazil's structural transformation. Our results imply that immigration into an emerging agricultural economy can substantially contribute to agricultural development.

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A data appendix is available at http://www.nber.org/data-appendix/w32083

1 Introduction

Immigration and agriculture are intimately connected. In modern developed economies, particularly in the United States, immigration is an important source of labor for the agricultural sector.[1] Moreover, the major immigrant countries of the Americas—the United States, Argentina, and Brazil—all experienced a formative period of agricultural frontier expansion during the *Age of Mass Migration*—a period, roughly 1840–1920, in which over 50 million people migrated from Europe to the Americas (Hatton and Ward 2019; Hatton and Williamson 1998).[2] Within this historical context, this paper investigates the role of immigration in driving the development of the destination country's agricultural sector.[3]

In particular, we study the effects of European immigration to Brazil in the period 1855–1920 on the development of the Brazilian agricultural sector in 1920. Brazil at this time was an overwhelmingly agrarian economy with a nascent industrial sector. Brazilian policymakers, responding to labor demand driven by the expanding agricultural frontier and growing coffee sector and by the decline and eventual abolition of slavery in 1888, initially developed immigration subsidy programs encouraging immigration from Europe to provide labor for the agricultural sector.[4] But even outside of these programs, immigrants entered the agricultural sector in large numbers (Klein 1995). We investigate whether and through what mechanisms immigration supported the development of this sector, which we operationalize by comparing the per-hectare value of farms across Brazilian municipalities with different European immigrant shares of population. Given the long-standing debate in development economics regarding the role of agricultural development in delaying or promoting economic progress in general (e.g., Asher et al. 2022; Dinkelman, Kumchulesi, and Mariotti 2024; Prebisch 1962; Singer 1950), we also investigate the contribution of immigration to the country's ongoing structural transformation.[5] Although it is difficult to draw direct conclusions from historical settings for modern economies, the value of studying the Age of Mass Migration to understanding the economics of migration generally and the effects of immigration in particular is widely recognized,[6] stemming in part from

[1] See, for instance, Baldone, Coderoni, and Esposti (2021), Ifft and Jodlowski (2022), Kostandini, Mykerezi, and Escalante (2014), Richards (2018), and Zahniser et al. (2012).

[2] See, for instance, Cance (1925), Coulter (1909), Droller, Fiszbein, and Pérez (2023), Hatton and Williamson (1998), Holloway (1980), and O'Rourke and Williamson (1999) on the relationship of immigration and the growth of the agricultural sector in these countries. A similar experience also characterizes Canadian agricultural history.

[3] See Abramitzky et al. (2023), Bazzi et al. (2016), Clemens, Lewis, and Postel (2018), Lafortune, Tessada, and González-Velosa (2015), Lanza, Manier, and Musacchio (2023), Lew and Cater (2018), and Sequeira, Nunn, and Qian (2020) on the relationship between immigration and agriculture in historical context.

[4] The desire to attract specifically European migrants was at least partially founded on beliefs of white superiority and the widespread desire among Brazilian policymakers to "whiten" Brazil's population through immigration and intermarriage (da Costa 2000; Machado 2006; Slenes 2010).

[5] We focus on the total effect of immigration on structural transformation, not only the effect of immigration-induced agricultural development on structural transformation.

[6] See Abramitzky and Boustan (2017) on the value of studying the Age of Mass Migration to understanding the economics of immigration. See Abramitzky et al. (2023), Clemens, Lewis, and Postel (2018), Droller (2018), Lafortune, Tessada, and González-Velosa (2015), Lee, Peri, and Yasenov (2022), Price, vom Lehn, and Wilson (2023), Sequeira, Nunn, and Qian (2020),

the unparalleled size of the movement and the ability to observe long-run effects. Given the unique features of the Brazilian economy, agricultural sector, and immigration experience, our historical setting provides an opportunity to study the effects of immigration on the emerging agricultural sector of a developing country.

The main empirical challenge that we face in our analysis is the potential endogeneity of immigrants' location choice within Brazil. To address this challenge without the benefit of panel data, we adapt to the Brazilian case an identification strategy developed by Sequeira, Nunn, and Qian (2020) to study the effects of immigration in the United States during the Age of Mass Migration in a cross-sectional framework.[7] This strategy creates an instrumental variable for a municipality's immigrant share of population based on the interaction of aggregate immigrant arrivals and the rollout of the rail network, which the historical evidence shows was an important method for immigrants to reach their destinations (Holloway 1980; Lanza, Manier, and Musacchio 2023; Minale, Rocha, and Vigna 2024).[8] Intuitively, we compare two municipalities, one of which was linked to the railroad in the year of a large immigration inflow, and the other of which was linked just after. The former, by virtue of having access to the rail network in the year of a large inflow, is predicted to have had a greater share of immigrants relative to population by 1920. This method enables us to control for rail linkage directly, addressing concerns that rail was built targeting specific areas or had direct effects on the local economy, and ensures that we do not simply compare linked and unlinked places. The main identification assumption is that a municipality's *timing* of rail construction (conditional on ever being linked) was independent of *aggregate* immigration (Sequeira, Nunn, and Qian 2020). To support this assumption, we show that municipalities linked during immigration booms were similar to those linked during lulls.[9]

We digitized a wide array of municipality-level data from the 1920 Brazilian census (Directoria Geral de Estatística 1922), which was the first successful Brazilian census after 1872 and the first to collect agricultural data for the whole country.[10] Our main finding, established by both our OLS and IV estimates, is that municipalities with a higher population share of European immigrants in 1920 had greater farm values

and Tabellini (2020) for examples of historical studies of the effects of immigration or immigration restriction. Abramitzky and Boustan (2017), Abramitzky, Boustan, and Eriksson (2012), Collins and Zimran (2023), Hatton and Williamson (1998), and Spitzer and Zimran (2018), among others, exploit historical perspective to better understand other aspects of the economics of migration such as selection, returns to migration and assimilation.

[7] Minale, Rocha, and Vigna (2024) use a similar strategy to study the effects of immigrant diversity in Brazil. Droller's (2018) study of the long-run effects of immigration in Argentina and Panza and Zylberberg's (2024) study of immigration in Mandatory Palestine use similar instrumental variables strategies.

[8] Indeed, the *Hospedaria dos Imigrantes* in Santos, where immigrants were lodged at arrival in São Paulo, was linked directly to the railway network, and immigrants were often provided with tickets to reach their destinations. The same was true of the immigrant hostels in the other major ports of arrival.

[9] Our results are robust to various ways of controlling for duration of rail linkage. We also show that, as expected, random reassignment of rail linkage years across ever-linked municipalities cannot reproduce our results.

[10] We also use data from the São Paulo Census of 1904–1905 (Secreteria da Agricultura 1906–1910), which includes detailed agricultural information, but only for the state of São Paulo.

per hectare, which we interpret as indicating greater development of the agricultural sector. Our preferred specifications imply that a one-standard deviation increase in a municipality's population share of European immigrants generated a 0.7-standard deviation increase in its farm values per hectare. The effect on farm values is present for total farm value and separately for each of its three constituent components—land, infrastructure, and tools and machines. The finding that immigration affected components of farm value besides land is crucial for two reasons. First, it alleviates the concern that our outcome variable captures local characteristics other than agricultural development, which would be capitalized in land values.[11] Second, the value of infrastructure, tools, and machines is linked to the development and productivity of the agricultural sector, which is our ultimate object of interest. We show that our results are robust to using different variations of our instrument, to explicitly controlling for historical factors that could have influenced agricultural development and migrant settlement, including the prevalence of enslaved labor in the period before emancipation and mass immigration, and to excluding a variety of sets of municipalities that may have been systematically different from the average municipality—immigrant colony locations, large coffee producers, the earliest places linked to the railway, and large population centers.

We find that changing land use patterns are the primary mechanism driving the effect of immigration on agricultural development. In particular, we show that a greater share of European immigrants in population led to an increase in the share of farmland cultivated (as opposed to being left fallow or as forest), and that this increase in the intensity of cultivation was responsible for about one quarter of the effect of immigration on farm values.[12] We interpret these findings as exemplifying the important role that immigrant incentives, either unofficial or official, can play in shaping the effect of immigration in general and land-use transformation in particular. Specifically, we argue that our results can be explained by a combination of the unique incentives offered to immigrants in the government-subsidized immigration program—in which expanding cultivation was necessary to continue to provide immigrants with their main form of compensation, as we discuss below—as well as by the differences in incentives faced by temporary migrants relative to natives and permanent migrants.

We also investigate several other potential mechanisms, which prove to have not been present or to have been unimportant relative to the land-use mechanism. We find no evidence of a higher population share of immigrants having been associated with higher density of population or agricultural employment, ruling out a mechanism in which immigrant arrivals increased the local demand for land or agricultural products, or

[11] This is further supported by the fact that we find that a higher share of European immigrants in population generated an increase in the value of agricultural output per hectare.

[12] We also find that there was no effect of immigration on agricultural output per *cultivated* hectare; that is, the increase in output per hectare coming from immigration was driven by the cultivation of additional land.

provided agricultural labor that would otherwise be absent to aid in the exploitation of land. We do find that immigration was associated with an increase in the adoption of agricultural tools (but not machines), and with an increase in the cultivation of coffee, which was Brazil's primary export in this period. But these channels do not explain a substantial portion of the effect of immigration.

The long-standing debate regarding the effect of agricultural development on a country's structural transformation (Asher et al. 2022; Prebisch 1962; Singer 1950)—which is also present in Brazilian historiography (Suzigan 2000, pp. 23–47)—raises the possibility that immigration, by facilitating agricultural development, slowed Brazil's structural transformation, casting doubt on whether the overall effect of immigration was positive for the Brazilian economy. Given our focus on the effects of immigration on agricultural development, understanding the total effect of immigration on structural transformation is of particular interest.[13] To this end, we test whether immigration impacted a variety of outcomes related to Brazil's structural transformation, finding that immigration did not slow, and in fact may have accelerated it. Notably, we find that immigration contributed to a decline in the agricultural share of the labor force. Together with our results for farm values, this implies that immigration fostered an agricultural sector that was more productive while demanding less labor—a factor that has been identified as an essential driver of structural transformation (e.g., Caselli 2005; Herrendorf, Rogerson, and Valentinyi 2014; Montero and Yang 2022). We also find a positive effect of immigration on the literacy of both native- and foreign-born individuals, suggestive evidence that immigration was associated with increased employment in industry and services, and no evidence that immigration reduced female labor force participation.[14] We find no evidence of an adverse impact of immigration on institutions in the form of an increased numbers of rentiers, whose presence may have held back development, or of an inflated public sector arising in response to immigration.

The main contribution of this paper is to advance the literature on the effects of immigration on the agricultural sector of destination countries,[15] which in turn advances the literature on the effects of immigration on the destination economy in general.[16] The bulk of existing research on the effects of immigration on agriculture focuses on the short-run effects of policy-induced removals of immigrant labor from already established agricultural settings in the United States, such as the 1920s immigration quotas (Abramitzky et al. 2023), the termination of the Bracero program in 1964 (Clemens, Lewis, and Postel 2018), or increases

[13] Although we cannot definitively rule it out, our results suggest that immigration's indirect effect on structural transformation through agricultural development did not cancel out its direct effect on structural transformation.

[14] Goldin and Sokoloff (1982, 1984) and Olivetti (2014) link female labor force participation to industrialization.

[15] Other papers on this topic include Abramitzky et al. (2023), Baldone, Coderoni, and Esposti (2021), Bazzi et al. (2016), Clemens, Lewis, and Postel (2018), Droller, Fiszbein, and Pérez (2023), Ifft and Jodlowski (2022), Kostandini, Mykerezi, and Escalante (2014), Lafortune, Tessada, and González-Velosa (2015), Lanza, Manier, and Musacchio (2023), Lew and Cater (2018), Richards (2018), San (2023), and Sequeira, Nunn, and Qian (2020).

[16] Bansak, Simpson, and Zavodny (2020) provide an overview of this literature.

in immigration enforcement intensity (e.g., Richards 2018). Our context, on the other hand, enables a focus on the direct effects of immigration itself (rather than its removal) on the development of an emerging agricultural sector. We show that immigration into an emerging agricultural economy can have substantial effects on the course of agricultural development, in particular on land-use transformation, and that the incentives faced by migrants are likely to play an important role in shaping the effects of immigration.

Ultimately, these results shed light on the effects of immigration in a less-studied context—developing countries. The effects of immigration in developing countries may be quite different from those in developed countries because of substantial differences in economic structure (such as a larger agricultural sector) and institutions, and because these countries may attract different types of migrants or migrants from different places of origin than do more developed countries.[17] But most literature on the effects of immigration focuses on developed-country destinations (e.g., Hanson 2009). We enrich this literature by shedding new light on the effects of immigration in a highly agricultural economy at an early stage of development. Our results show that migration can have positive effects in developing countries despite weak institutions, inequality, and an economic structure geared towards primary production.

This paper also contributes to the literature on the Age of Mass Migration (e.g., Abramitzky and Boustan 2017; Hatton and Ward 2019). This literature has focused largely on the United States, and in particular on the United States in the latter years of the Age of Mass Migration (e.g., Abramitzky et al. 2023; Tabellini 2020). Latin America remains understudied, with the existing literature focusing primarily on Argentina. Brazil, despite being the third-most popular overall destination and the second-most popular destination after the United States in the 1890s (Ferenczi and Willcox 1929; Sánchez-Alonso 2019),[18] has received relatively little attention. The value of studying Brazil is enhanced by the fact that its economy and immigration experience were quite different from those of the United States and Argentina. Besides the unique interaction in Brazil of subsidized immigration, commodity production, and the legacy of slavery, Brazil's wages and per-capita GDP were substantially lower (Bolt and van Zanden 2020; Williamson 1995), its agricultural sector comprised a larger share of the economy, and its institutions were uniquely extractive. Indeed, although both the United States and Argentina were also agricultural, Brazil's sector was substantially larger as a share of the labor force, and especially of the immigrant labor force—about 40 percent in 1920, as compared to about 15 percent in the United States and 17 percent in Argentina in 1895. Moreover, in both the United

[17] See Ratha and Shaw (2007) and World Bank (2016) for broad discussions of immigration in developing countries. See Alix-Garcia and Saah (2010), Altındağ, Bakiş, and Rozo (2020), Baez (2011), Bahar, Ibáñez, and Rozo (2021), Biavaschi et al. (2018), Böhme and Kups (2017), Cortes (2004), Dustmann et al. (2017), Engler et al. (2023), Hanson (2009), Hatton and Williamson (2002, 2005), Knight and Tribin (2023), Lebow (2024), and Verme and Schuettler (2021) for particular examples of studies of the effects of immigration in modern developing countries.

[18] Canada was a close fourth (Ferenczi and Willcox 1929, p. 172).

States and Argentina, the bulk of immigration provided labor to the manufacturing sector (Droller 2018; Lafortune, Lewis, and Tessada 2019), especially in the latter part of the Age of Mass Migration; in Brazil, only about 20 percent of the immigrant labor force was employed in industry in 1920.

We also add to a relatively small literature in economics on Brazilian immigration during the Age of Mass Migration. Within this literature, this paper is most closely related to Lanza, Manier, and Musacchio (2023), who document a positive relationship between subsidized immigration and coffee productivity in the state of São Paulo. Beyond this, most research focuses on the effects of historical immigration on modern income and human capital accumulation in specific regions of Brazil (e.g., de Carvalho Filho and Monasterio 2012; Klein 1995; Minale, Rocha, and Vigna 2024; Stolz, Baten, and Botelho 2013; Witzel de Souza 2018). This paper provides the first causal study of the effects of immigration on agricultural development and structural change in the Age of Mass Migration that covers the entirety of Brazil, all crops, and the whole of the immigration flow, whether subsidized or unsubsidized, contributing to the long-standing debate about the role of immigration in the development of the largest Latin American economy (e.g., Alston et al. 2016; Holloway 1980; Papadia 2019).

As a result, our findings help to clarify the long-debated role of immigration in the development of the Brazilian economy. Confirming the assertions of the historical literature (Buciferro 2021; Colistete 2015; Holloway 1980; Milliet 1941; Monbeig 1984; Vidal Luna, Klein, and Summerhill 2014), we find that immigrant labor was an important force in driving the growth of Brazil's agricultural sector. But contrary to this prior scholarship, we find that this was not primarily because immigrants uniquely enabled the production of coffee or solved agricultural labor shortages created by the abolition of slavery and the expansion of the agricultural frontier.[19] Instead, immigrant labor was unique in that it drove land-use transformation, causing land to be cultivated more intensely. Importantly, we do not find that the gains that immigration brought to the agricultural sector were accompanied by effects that limited structural transformation. On the whole, then, our results imply that immigration enabled Brazil to exploit its natural resource endowments, and may have eventually set it on the course of broad-based economic development.

[19]This is not to say that immigration on aggregate was not important in these regards from a macroeconomic perspective. We discuss this distinction in further detail below.

2 Background

2.1 The Effects of Immigration on Agriculture

Understanding the effects of immigration on the economies of receiving countries is a fundamental goal of the economics of migration (Bansak, Simpson, and Zavodny 2020; Borjas 2014). The bulk of the literature on this subject, including canonical studies, focuses on the labor-market effects of immigration, largely in the United States (e.g., Abramitzky and Boustan 2017; Borjas 2003; Card 1990, 2005; Hanson 2009; Kerr and Kerr 2011) and other modern developed countries (e.g., Dustmann, Schönberg, and Stuhler 2016; Manacorda, Manning, and Wadsworth 2012). A smaller but still substantial literature examines the effects of immigration on a variety of other outcomes in developed-country destinations.[20] In recent years, a literature has grown studying these issues in historical context, largely in the setting of the Age of Mass Migration. The overall picture emerging from the literature is that immigration during this period induced industrialization, innovation, and overall development in the United States without harming native workers (e.g., Sequeira, Nunn, and Qian 2020; Tabellini 2020). Similarly, immigration enhanced industrialization in Argentina by providing capital and high-skilled labor to the industrial sector (Droller 2018; Droller, Fiszbein, and Pérez 2023).

There is also a smaller literature on the effects of immigration on the agricultural sector of destination countries. The bulk of this literature focuses on the effects of immigration restriction on outcomes such as agricultural productivity, mechanization, crop mix, and innovation. In modern settings, much of this work is based on increases in the intensity in immigration enforcement in the United States, which is found to reduce immigrant labor supply and lead to declines in area cultivated, increases in innovation, shifts to a less labor-intensive crop mix, and rising agricultural wages (Ifft and Jodlowski 2022; Kostandini, Mykerezi, and Escalante 2014; Richards 2018). In historical settings, attention is concentrated on the effects in the United States of the 1920s immigration quotas and of the termination of the Bracero program in 1964, which are found to have had minimal labor market effects (Abramitzky et al. 2023; Clemens, Lewis, and Postel 2018), but to have driven mechanization (Abramitzky et al. 2023; Lew and Cater 2018) and innovation (San 2023).[21]

[20] These outcomes include health (Ager et al. 2024), industrial production (Droller 2018; Kim 2007; Lafortune, Lewis, and Tessada 2019; Tabellini 2020), foreign direct investment (Burchardi, Chaney, and Hassan 2019), long-run development (Minale, Rocha, and Vigna 2024; Sequeira, Nunn, and Qian 2020), trade (Dunlevy and Hutchinson 1999), productivity (Peri 2012), crime (Abramitzky et al. 2024), innovation (Moser, Voena, and Waldinger 2014), public goods provision (Mayda, Senses, and Steingress 2023), firm performance (Mahajan et al. 2024), and election results (Mayda, Peri, and Steingress 2022; Tabellini 2020), among others.

[21] Lee, Peri, and Yasenov (2022) study Mexican repatriations from the United States in the 1930s, finding negative labor market effects on natives.

A smaller set of historical studies focuses on the effects of immigration *per se* on agriculture. Using a network-based shift-share instrument, Lafortune, Tessada, and González-Velosa (2015) study the effects of US immigration in the period 1910–1940 on the US agricultural sector. They find that immigration-induced increases in labor supply generated a shift towards more labor-intensive crops and a reduction in the capital-labor ratio, with little or no impact on land prices or farm size. Sequeira, Nunn, and Qian (2020) also analyze the effects of immigration on agricultural outcomes in the United States, though these are a secondary focus of their analysis. They find little evidence of an impact of immigration on farm values from 1860–1920, but a substantial positive effect in 1930, which they attribute to superior agricultural expertise among immigrants.

Two patterns among the existing literature on the effects of immigration on the agricultural sector of the destination country underscore the contribution of this paper. First, as discussed above, the bulk of the literature focuses not on immigration itself, but on immigration restriction or enforcement, the effects of which need not parallel those of immigration. Second, most of the papers discussed above focus on the interplay of immigration and agriculture over a short time horizon and in a setting where agriculture was already well established.[22] This paper, on the other hand, directly studies the effects of immigration on agriculture over a longer period in an emerging frontier setting in which immigration was, in large part, targeted towards areas in which agriculture was nascent. In this sense, our focus is on the seldom-studied interplay between agricultural development and immigration.[23]

Our focus on the effects of immigration in an agricultural economy at an early stage of development is also important because the bulk of the existing literature on the effects of immigration focuses on migration from poor to rich countries. This is true of studies of the modern United States, which draws the bulk of its migrants from Latin America and Asia (Abramitzky and Boustan 2017). It is also true of studies of the United States during the Age of Mass Migration, during which most immigrants came from countries with substantially lower wages (Williamson 1995). There are a number of reasons to suspect that the effects of immigration in developing countries are different from those in developed countries. All of the factors that combine to determine these effects—the origins and selection of immigrants, their substitutability with natives, the sectors comprising their economies, and the duration of immigrants' stays in the destination, among other factors—are likely to be different. Although there is a growing literature on the effects of immigration in developing countries,[24] more such work is needed. This paper draws on the benefits of the

[22]For instance, studies of the effects of immigration in the United States do not focus on the period of frontier expansion.

[23]Bazzi et al. (2016) study the effects of internal migration to Indonesia's agricultural frontier.

[24]Examples include Alix-Garcia and Saah (2010), Baez (2011), Biavaschi et al. (2018), Gindling (2009), Knight and Tribin (2023), Lanza, Manier, and Musacchio (2023), Lebow (2024), and Özden and Wagner (2014). See Böhme and Kups (2017) and Verme and Schuettler (2021) for a review. Historically, large-scale South-South migration flows were mostly forced and involuntary (Crawley and Teye 2024). Much of the empirical research on migration to developing countries focuses on the

Age of Mass Migration as a laboratory for the economics of migration and on the unique features of the Brazilian economy to add to this literature.

2.2 Brazil in the Age of Mass Migration

Over 3.5 million European immigrants entered Brazil between 1850 and 1920, with nearly 1.5 million of these arriving between 1888—when the government implemented a subsidized immigration program, in large part to provide labor for the agricultural sector after the abolition of slavery—and 1900 (Figure 1 plots immigration rates relative to population over this period). This made Brazil the second most popular immigrant destination in the New World in this period, trailing only the United States (Ferenczi and Willcox 1929, p. 550).[25] The largest single group of immigrants in this period were from Italy—a low-wage developing country (Federico, Nuvolari, and Vasta 2019), where immigrants from the north of the country were recruited for subsidized labor contracts. Over 80 percent of immigrants to Brazil were subsidized in the pre-1900 period, possibly reflecting the limited attractiveness of Brazil as a destination due to its low wages and living standards relative to other main immigrant receiving countries, the fresh memory of slavery, and the perceptions of an adverse disease environment (Papadia 2019).

Existing literature on Brazilian immigration has focused primarily on the experience of the state of São Paulo, which was the destination of most immigrants.[26] But all southeastern states received large numbers of migrants, as did the south of Brazil, the latter despite being unsuitable for coffee production and being characterized by a climate and productive structure closer to that of Europe than to that of the rest of the country. Even the sparsely populated north and center-west featured municipalities where immigration had a large impact on the composition of the local population. The only region to have almost entirely missed out on mass immigration was the northeast, which was in sharp economic decline following the decreased importance of its two main cash crops—sugar and cotton (Leff 1997).

Despite this decline, cotton and sugar combined still made up around a quarter of the total value of agricultural production in 1920. Coffee on its own amounted to around the same value, making it Brazil's most valuable crop. Amongst food crops, maize stands out, making up around 24 percent of agricultural

effects of refugee flows. There is also a literature on aspects of refugee migration other than its effects (e.g., Chiovelli et al. 2021; Mobarak, Sharif, and Shrestha 2023).

[25] European immigration to Brazil began with the establishment of agricultural colonies in southern Brazil by German and Italian immigrants in the 1820s (Foerster 1919). There was also a wave of immigration of Americans from the US South in the wake of the Civil War (Dawsey and Dawsey 1995; Tampellini 2024) and efforts made to recruit European sharecroppers to grow coffee after Pedro II's crackdown on the illegal Atlantic slave trade in 1850 (Barman 1999).

[26] Online Appendix Figure A.1 presents a map of political divisions of Brazil, showing the country's regions and the states that each contains.

production.[27] Overall, however, the agricultural sector was strongly geared towards exports, despite strong growth in the internal market for food crops starting from the mid 19th century, principally aimed at supplying the rapidly expanding Southeast (Pereira 2025). Indeed, around 55 percent of the value of agricultural production in 1920 was made up of export-oriented crops.[28]

The *colonato* contract was at the center of the subsidized immigration program, which was particularly important in São Paulo as the epicenter of coffee production (Lanza, Manier, and Musacchio 2023).[29] Under this scheme, immigrants received free passage and lodging, and were responsible for caring for and harvesting coffee trees for a three-year contract period during which they could also grow food crops for their own consumption and for sale on the market (Holloway 1980, p. 78; Sánchez-Alonso 2019). In order to reduce the incentive for return migration, the *colonato* contract required adult male immigrants to be accompanied by their families (Klein 1995). However, the evidence shows that this requirement was not strictly enforced.[30] It is estimated that about 46 percent of immigrants eventually returned to Europe (Levy 1974, p. 66, cited by Sánchez-Alonso 2019, p. 8),[31] with the highest rates among Italians.[32]

The immigrant experience for *colonos* in Brazil began at reception centers, known as Immigrant Hostels (*Hospedarias dos Imigrantes*), which were present in each of the three main entry ports: Santos in the state of São Paulo, Rio de Janeiro, and Salvador in the state of Bahia. At these hostels, immigrants could sleep, eat, and, if necessary, receive medical attention or vaccinations after being registered. The hostels also had direct access to railways, which facilitated the transportation of immigrants to their final destination. The São Paulo hostel, which processed most migrants, was the main venue for the matching of immigrants arriving under the subsidy program and the employers. In general, these immigrants had one week after arrival to find a farm on which to work, and upon signing a contract would be provided with a train ticket to their destination (Holloway 1980; Lanza, Manier, and Musacchio 2023).

[27] Directoria Geral de Estatística (1922, Volume III, 2^a Parte: Agricultura, pp. XIX)

[28] These are cotton, sugarcane, tobacco, castor, coffee, cacao, coconut, and rubber. Using data from Instituto Brasileiro de Geografia e Estatística (1990, pp. 299-356), we can calculate the share of production exported for some of these crops. For coffee and cocoa, this share is over 80 percent, precisely 84 percent and 81 percent, respectively. For cotton, the share is 54 percent, while for sugarcane it is around 30 percent. The latter relatively low number is explained, amongst other things, by the fact that sugarcane is the main input in the production of Brazilian alcoholic beverages.

[29] Subsidized immigrants were also recruited for mining in Minas Gerais.

[30] Indeed, Lesser (2013) documents that in order to receive the subsidy, single migrants that had met during or just after the voyage reported to be a "family."

[31] Only 46 percent of immigrants remained permanently in the state of São Paulo (Sánchez-Albornoz 1986), and about 35 percent of all immigrant arrivals processed at São Paulo from 1911 to 1920 were returnees (Holloway 1980, p. 56; see also Klein 1995, p. 210). Beyond the size of the return flow, Sánchez-Alonso (2019, p. 9) points out that "with the available evidence, we cannot assume either positive or negative selection in return migrations because no relevant data on the characteristics of returned migrants exist." She does, however, indicate that most Italians returning were likely not returning after failure in the Brazilian economy. Cinel (1991, p. 112) argues that return rates for Italians were higher for those working in industry or commerce than for those working in agriculture, that returns from the states of Rio Grande do Sul and Santa Catarina were uncommon, and that returns from the state of São Paulo were much more common in comparison.

[32] Italian data on return migration, which are available from 1905 onwards, indicate that about 50 percent of immigrants returned to Italy at least once (Cinel 1991).

The rail network on which these immigrants traveled has been identified as a major factor in Brazil's economic development in the late nineteenth and early twentieth centuries, providing substantial social savings (Summerhill 2003, 2005). This role is remarkable given the relatively slow and fragmented development of the network (Herranz-Loncán 2014; Summerhill 2003) and the fact that decisions regarding the placement of railways did not always follow an economic logic. Although existing settlements of population and economic activity were targeted, the placement of rail was heavily influenced by the interests of local landowners and the government's efforts to appease them (Bignon, Esteves, and Herranz-Loncán 2015; Summerhill 1997). The railways were financed by both private local and foreign (especially British) capital. The central and local governments were not as active as they were, for example, in United States (Leff 1997; Summerhill 1997). Nonetheless, government intervention was essential in kick-starting railway construction and in sustaining unprofitable lines, which were politically important due to the influence of local landowners.

Brazilian immigration changed substantially at the beginning of the twentieth century (Klein 1995, p. 208). Concerns about the conditions of migrants in Brazil, particularly of those residing in colonies and working on coffee plantations, led to bans on subsidized migration by several European governments (Lesser 2013). Most notably, the 1902 Italian *Decreto Prinetti*, which made subsidized emigration illegal, was targeted mainly at limiting migration to Brazil.[33] In part as a result of these bans, but also because of the opportunities offered by the growth of the frontier economy (Klein 1995), subsidized migrants no longer made up the majority of entrants to the country, with their share falling to about 40 percent (Cameron 1931). Although these bans did not halt mass migration to Brazil, as Figure 1 shows, they did reduce its magnitude relative to population and led to a change in the distribution of migrants' countries of origin: Figure 2 shows a decline in the share of immigration coming from Italy with a commensurate increase in the share from Portugal and Spain. There was also a change in the main immigrant sources within Italy, with migrants before 1902 coming primarily from the north and those after coming primarily from the south.[34] The shift in migrant origins was coupled with changes in settlement and occupations: whereas immigrants arriving before 1900 were almost entirely directed to agricultural areas, those entering after 1900 settled in large numbers in cities in the states of São Paulo and Rio de Janeiro (Foerster 1919, p. 289), where they worked in small workshops or as unskilled industrial labor.[35] As a result, the share of immigrants employed

[33]Prussia also nominally prohibited emigration to Brazil as early as 1859, and similar measures were implemented for the whole German empire from 1871 (Fausto 1999). The decline in immigration was also driven in part by shocks to coffee demand due to business cycles in Europe and difficulties in adjusting coffee supply to market conditions as a result of the long life of coffee trees and the lag time between their planting and entrance into production (Vidal Luna and Klein 2014).

[34]See Online Appendix Figure A.2 for the division of immigrants by origin in the 1920 census.

[35]This was particularly the case of Italian immigrants (Cinel 1991).

in manufacturing increased from about 0.8 percent in 1900 to 13 percent in 1920.[36]

Although it is well established that immigrants were more numerate and literate than the Brazilian population (Rocha, Ferraz, and Soares 2017; Stolz, Baten, and Botelho 2013), direct evidence on the selection of immigrants is limited. It is possible that subsidized immigrants were negatively selected, as subsidies significantly relaxed liquidity constraints, allowing the relatively poor and unskilled to migrate (Angelucci 2015; Belot and Hatton 2012; Chiquiar and Hanson 2005; McKenzie and Rapoport 2010; Orrenius and Zavodny 2005; Sánchez-Alonso 2019; Spitzer and Zimran 2018). Beyond this speculation, the few studies addressing the selection of Italian and Portuguese migrants, the two major immigrant groups in Brazil, provide mixed evidence.[37]

Recent scholarship has debated to what extent immigrants were able to achieve upward mobility. The consensus in the literature is that immigrants were able to transition to land ownership after a few years on the *fazenda* (Klein 1995; Lanza 2021; Sánchez-Alonso 2019). More specifically, Holloway (1980, p. xvi) documents that many first-generation immigrants were likely to become owners of small and medium-sized farms. However, the specific mechanisms through which immigrants achieved this transition have not been identified.

Altogether, Brazil's immigration and economy bear some important similarities to those of the other major migrant destinations of the Age of Mass Migration—the prevalence, at least from the later nineteenth century, of migrants from the poorer European periphery, the high rate of return migration (c.f., Bandiera, Rasul, and Viarengo 2013), and, in Argentina's case, the agricultural sector's share of the economy (Droller and Fiszbein 2021; Lesser 2013). But many features set it apart. Most dramatically, there were substantial differences in development between Brazil and the other two major migrant-receiving countries in the Americas, as shown in Figure 3: Brazil was, by a substantial margin, the poorest of the three countries (Bolt and van Zanden 2020); indeed, Argentina was one of the 10 richest countries in the world at the eve of World War I and had living standards similar to those of the United States (Spruk 2019). In addition, the concentration of Brazilian immigrants in agriculture was unique in comparison to Argentina and the

[36]Directoria Geral de Estatística (1922, Volume IV, 5^a Parte (Tomo 1): População, pp. X–XIII).

[37]Fernández-Sánchez and Tortorici (2024) show that Portuguese migrants, who mostly moved to Brazil, were on average positively selected on the basis of literacy. Determining the selection of Italians is more difficult given the highly segmented destination choice patterns of this group (Hatton and Williamson 1998; Spitzer and Zimran 2024). But given the early dominance of northern Italy in the migratory flow to Brazil, due in part to the fact that migration subsidies were offered exclusively to migrants from the north of Italy (Hatton and Williamson 1998, p. 102), and that migrants from this region to the United States were negatively selected (Spitzer and Zimran 2018), it is likely that the early migrants were negatively selected. Hatton and Williamson (1998, p. 121) also find that farmers from Italy, who tended to be relatively poor, were more likely to travel to Brazil than they were to the United States. However, the shift of Italian emigration to a largely southern-Italian phenomenon at the turn of the twentieth century may have been associated with a more positive selection, as migrants from this region who emigrated to the United States were positively selected (Spitzer and Zimran 2018, 2024).

United States, where most immigrants provided labor outside the agricultural sector (Pérez 2017): in Brazil, approximately 40 percent of immigrant men worked in agriculture in 1920 (Online Appendix Figure A.3) as opposed to about 15 percent in the United States and 17 percent in Argentina in 1895. Subsidized migration was also uniquely important in Brazil. The United States explicitly banned subsidized migration beginning in 1885, and although there is evidence of subsidized immigration in Argentina, it did not have the relevance it did in Brazil (Lesser 2013). Brazil also had weaker institutions and worse governance, reflected in low access to justice and an inefficient public sector, as well as a high concentration of economic power and a highly unequal land distribution (Naritomi, Soares, and Assunção 2012).[38]

2.3 Existing Research on the Effects of Brazilian Immigration

Research addressing the effects of immigration in Brazil dates at least to Dean's (1969) classic account of the industrialization of the state of São Paulo, which had become the manufacturing engine of Brazil by 1920 (Palma et al. 2021). Dean (1969) assigns a direct role to migrants, but the crucial immigrant in this account is the bourgeois immigrant—relatively wealthy and skilled, and mostly active in industry and commerce—rather than the modal immigrant worker in agriculture. Other scholars almost uniformly see European immigration as having been a positive factor in the development of the Brazilian economy, particularly the agricultural sector. Focusing on Brazil's southeast, and especially on the state of São Paulo, this literature has highlighted the importance of immigrant labor in three interconnected developments in the late nineteenth century—the replacement of enslaved labor, the expansion of the agricultural frontier, and the production of coffee, Brazil's main export (Buciferro 2021; Colistete 2015; Holloway 1980; Milliet 1941; Monbeig 1984; Vidal Luna, Klein, and Summerhill 2014).

Among the more recent econometric literature on the Brazilian experience of the Age of Mass Migration, Lanza, Manier, and Musacchio (2023), whose work is most closely related to ours, provide the clearest evidence on the effects of immigration. They use the same farm-level data for the state of São Paulo that we use in part of our analysis (though aggregated to the municipality level in their case) to study the effect of immigration as part of the subsidized immigration program on coffee production and capital adoption in agriculture. Arguing that the assignment of immigrants to municipalities within this program was random and comparing municipalities with a greater immigrant share to those with a smaller share, they find that a greater share of immigrants was associated with greater coffee output per farm and the adoption of more agricultural tools in 1920.

[38]While substantial inequality was present in Argentina in the early twentieth century, it was not nearly as extreme as in other Latin American societies (Sokoloff and Engerman 2000).

Other studies focus in large part on the long-run effects of European immigration, showing that nineteenth-century settlement patterns had persistent effects on development and human capital accumulation. De Carvalho Filho and Monasterio (2012) show that government-sponsored immigrant colonies in southern Brazil (Rio Grande do Sul) shaped the spatial distribution of long-term development outcomes, with municipalities closer to the original settlement sites having less poverty and lower illiteracy rates by 2000. Rocha, Ferraz, and Soares (2017) find similar results for São Paulo, highlighting that immigrant selection was the main mechanism of persistence, as state-sponsored settlements consistently attracted high-skilled immigrants over time. Moreover, Witzel de Souza (2018) demonstrates that institutionalized demand for education of immigrants also influenced the path dependence of human capital accumulation throughout the twentieth century. This is consistent with de Carvalho Filho and Colistete (2010), who find that locations in São Paulo that received immigrants from countries with an established public education system had better test scores and higher income per capita more than hundred years later. Similarly, Stolz, Baten, and Botelho (2013) find evidence of a substantial effect of historical selective immigration on GDP per capita.[39]

What remains absent in the literature is a study that assesses the effects of both subsidized and unsubsidized immigration on contemporary agricultural outcomes that covers all of Brazil while also addressing the potential for endogenous location choices of immigrants. This paper contributes such a study.

3 Conceptual Framework

The simplest way in which immigration could influence agricultural development is by adding to the agricultural labor force. In an environment in which the agricultural frontier is rapidly expanding, a shortage of labor could prevent land from being cultivated; therefore, additional labor provided by immigration can increase the value of previously unused or underused land. Such an effect need not prevail, however, if, for instance, native and immigrant labor were perfectly substitutable and natives relocated within Brazil in response to the arrival of immigrant labor.[40] Similar arguments could be made for immigrants increasing the local demand for land or agricultural products and investing in farm capital in the form of tools and machines where land would otherwise be uncultivated or in lower demand.

[39] Feler, Musacchio, and Reis (2016) study the effects of immigration on banking in the 1940s and 1950s. Tang and Monteiro (2023) also study Japanese immigration as an instrument for education. Minale, Rocha, and Vigna (2024) study the long-run effects of diversity in immigrants' source countries during the Age of Mass Migration. Nakaguma, Pereira, and Viaro (2023) study the effects of immigration on voting patterns.

[40] This relocation could also come in the form of immigration to a municipality deterring in-migration by natives. Note that immigrant arrivals could lead to the increase of land values elsewhere in Brazil, if, for instance, immigrant arrivals led natives to relocate to the frontier where labor was previously scarce. Unfortunately, no identification strategy based on the comparison of different municipalities within Brazil can identify such an effect absent detailed data on internal migration, which to our knowledge do not exist.

The predicted effect of immigration is also complicated by the likelihood that immigrants and natives were fundamentally different from one another, and thus not perfectly substitutable. In the Brazilian context, immigrants may have possessed certain characteristics that made them particularly productive agricultural workers, such as specialized agricultural knowledge or greater human capital. In this sense, a greater concentration of immigrants would spur local agricultural development, which would ultimately be reflected in higher farm values and output. Similarly, the complementarity of immigrant labor with capital may have differed from that of native labor. Such differences could, for instance, imply that immigrant labor was uniquely suited to enabling the cultivation of coffee, though the reverse may also have been true.

Immigrants also faced different incentives than natives. For instance, temporary migrants, who made up a substantial share of migrants to Brazil, may have been incentivized to supply more labor than natives or permanent immigrants while in Brazil, which would in turn contribute to greater land values where they settled. This mechanism is consistent with evidence that temporary immigrants substitute inter-temporally, supplying more labor in the destination and enjoying greater leisure at home.[41] Indeed, Sánchez-Alonso (2019, p. 9) points out that migration (and eventual return migration) was "part of a lifetime strategy for improving living standards at home" for Italians.

The *colonato* contract under which many immigrants worked also created a unique set of incentives. The typical *colono* had three main sources of compensation—the fixed wage paid for caring for coffee trees, the piece rate paid at harvest, and access to land on which to grow crops for his own consumption and for sale on the market (Holloway 1980, pp. 74–78). Indeed, technological considerations often led to new land being brought into coffee cultivation by plantation owners in order to provide land for *colonos* to cultivate food crops, which was seen as the chief benefit of the *colonato* arrangement (Holloway 1980, pp. 78, 87–89; Sánchez-Alonso 2019, p. 13).[42] Moreover, the relatively poor conditions faced by plantation workers provided an incentive to save in order to move up the agricultural ladder, and the cultivation of food crops was one of the main mechanisms by which this was done (Holloway 1980, pp. 140–142). All of these incentives could lead land to be cultivated more intensively than it otherwise would have been.

Immigration's effect on agriculture would likely have also spilled over into other sectors of the economy. It has been posited that greater agricultural productivity could encourage structural transformation (Caselli 2005; Dinkelman, Kumchulesi, and Mariotti 2024; Herrendorf, Rogerson, and Valentinyi 2014; Johnston and Mellor 1961; Montero and Yang 2022; Timmer 1988). On the other hand, it has also been suggested that

[41] See Dustmann (1994, 2000), Dustmann, Bentolila, and Faini (1996), Dustmann and Görlach (2016), Epstein and Venturini (2011), Galor and Stark (1991), Hill (1987), Holloway (1980), Klinthäll (2006), Kyarko and Chartouni (2017), Vijverberg and Zeager (1994), and Wahba (2022).

[42] Contractors planting coffee trees were compensated similarly (Vidal Luna and Klein 2014).

it can lead to specialization in primary production, discourage human and physical capital accumulation, hinder the development of other sectors of the economy, and ultimately delay structural change (Matsuyama 1982; Prebisch 1962; Singer 1950). The existing empirical literature is equally ambiguous (Asher et al. 2022; Bustos, Caprettini, and Ponticelli 2016; Bustos, Garber, and Ponticelli 2020; Foster and Rosenzweig 1996; Hornbeck and Keskin 2015), suggesting that the effect of agricultural development may be strongly context-dependent. In the Brazilian case, one body of literature argues that industry only started to develop rapidly once the agricultural export sector, led by coffee, was disrupted by events such as the First World War and the Great Depression. Another, however, has argued that the development of the agricultural export sector was a crucial precursor for the development of other sectors of the economy, particularly industry (Suzigan 2000). Any such indirect effect of immigration on industry would have compounded or counteracted any direct effects of immigration on this sector.

4 Data

Our analysis is based primarily on data that we digitized for this project from the 1920 Population and Agricultural Census of Brazil (Directoria Geral de Estatística 1922). The 1920 census was the first complete population census successfully carried out in Brazil since 1872, and the first ever agricultural census covering the whole country. While this means that our analysis must be cross-sectional in nature, the census provides a very rich set of variables at the municipality level that capture economic, population, human capital, and labor force characteristics.[43] We also use complementary data from a variety of other sources, mainly as control variables throughout the analysis, as well as farm-level data from the state of São Paulo from its 1904–1905 census. Altogether, to our knowledge, this is the most comprehensive municipality-level dataset that has been assembled to date for early-twentieth-century Brazil.

4.1 Main Outcome Variables

The 1920 census provides data on the average monetary value of farms (agricultural establishments) by municipality in *milréis*—the currency of Brazil at the time.[44] These establishments were often made up of a single plot of land, but could also refer to multiple plots in the same municipality managed by the same person, group of people, or organization (e.g., the government).[45] Combined with information on the

[43] We exclude Acre from the analysis, as data for this territory are not consistently reported.

[44] Directoria Geral de Estatística (1922, Volume III, 1^a Parte: Agricultura, pp. 298-385).

[45] As defined in the census, agricultural establishments are "the whole extension of land subject to the exclusive administration of an owner, tenant, stakeholder or administrator, who directly manages the cultivation of crops or livestock by themselves or

size of farms, these data enable us to compute our main outcome variable—the average value of farms per hectare of land. This variable is intended to measure agricultural development, which includes any factor making the local agricultural sector more productive and valuable. The census reports farm value in total and broken down into three components—land, infrastructure, and tools and machinery. The latter two are directly related to the development and productivity of the agricultural sector. Land, as an immobile factor of production, will capitalize in its value any local characteristic that improves agricultural productivity. However, land values may also capitalize local amenities and other characteristics that are unrelated to agricultural development. For this reason, we focus both on total farm values as well as on farm values divided into its several components. Importantly, farm values capture both backward- (resulting from past investments capitalized in farm values) and forward- (resulting from the expected trajectory of the local economy) looking aspects of development, thus capturing the long-term productive potential of the local agricultural sector.[46]

4.2 Other Outcome Variables

We also collect data on a series of factors that may have affected the value of farms through their relationship with immigration. The first set of variables concerns the labor force: we construct measures of population density (inhabitants per square kilometer) and agricultural employment density (workers employed in agriculture per square kilometer).[47] To measure land use, we use data on the share of farm land cultivated and the share of cultivated farmland by planted crop.[48] We also measure the use of tools and machines in agriculture (beyond the value measures): specifically we use data on the share of farms with tools—plows, harrows, seeders, cultivators, harvesters, and tractors—and machines in the form of devices employed for processing crops.[49]

with the help of paid staff" (Directoria Geral de Estatística 1922, Volume III, 1^a Parte: Agricultura, p. 7). Land cultivated in urban settings was excluded from the census, as were farms with an annual production worth less than 500 milréis. This essentially means excluding establishments practicing subsistence agriculture, and focusing instead on commercially oriented farms. For perspective, 500 milréis was approximately 107 times the average daily wage of a plough-man living in a rural area in 1920 (Directoria Geral de Estatística 1922, Volume V, 2^a Parte: Salarios, p. XXV).

[46]The 1920 census also reports, and we have collected, data on total agricultural production broken down into 14 crops (Directoria Geral de Estatística 1922, Volume III, 2^a Parte: Agricultura, pp. 3-155). We combine this information with current prices for each of these crops, also from the Census, to compute the value of agricultural production per hectare and per cultivated hectare—variables that capture agricultural productivity explicitly—which we use as an alternative measure of agricultural development. For our main analysis, we prefer to focus on farm values rather than on output because, as mentioned, the former reflect the long-run productivity of the local agricultural sector, whereas the output observed in 1920 will be determined in large part by idiosyncratic shocks and cropping decisions.

[47]We also have data on population density from the 1890 census.

[48]These crops include rice, maize, wheat, beans, potatoes, manioc, cotton, sugarcane, tobacco, castor beans, coffee, cocoa, coconut, and rubber.

[49]Directoria Geral de Estatística (1922, Volume III, 3^a Parte: Agricultura, pp. 17–105.). A primary example is machines used for processing and distilling sugar in on-farm, refineries.

We also examine four sets of outcome variables related to structural change. To measure human capital formation, we use data on literacy—the share of individuals who could read and write—which the census reports separately for immigrants and natives.[50] As indicators of economic structure, we use data on the share of workers employed in agriculture, in industry, in services, and in the public sector. We also use the population share of individuals living on income from property or investments (rentiers) as a measure of the presence of local landed elites.[51] Finally, we collect data on the female to male ratio among the employed population by economic sector (agriculture and industry).

4.3 Explanatory Variables

We use data on the total population and number of European immigrants by municipality to construct our main explanatory variable—the population share of European immigrants by municipality.[52] We also calculate the share of each individual immigrant group (e.g. Italians, Portuguese, etc.) in population, as the immigration data are reported by nationality. We focus on European immigration for two reasons. First, the historical literature has documented that, during the Age of Mass Migration, nearly 90 percent of the immigrant flows to Brazil came from Europe (Lesser 2013; Sánchez-Alonso 2019). Second, the exogenous variation that our identification strategy relies on is partially the product of shocks to European immigration. Because European immigration to Brazil began as early as the 1820s, this 1920 measure of the immigrant share of population captures enduring settlement patterns that account for return migration and life cycle changes over several decades, fitting with our goal of studying the cumulative effects of immigration. It is important to note that, because we focus on the share of Europeans in population, rather than solely on the number of immigrants, we are implicitly controlling for population in our analysis. The census also reports, and we collect, data on the share of landowners in a municipality who were foreign born.[53]

Our identification strategy also relies on annual variation in aggregate immigrant arrivals in Brazil and variation in railway access at the municipality level. We obtain data on immigrant arrivals from Directoria Geral de Estatística (1908) and Instituto Brasileiro de Geografia e Estatística (1954). Information provided by Giesbrecht (2023) enables us to identify the first station built in each municipality as well as the year

[50] Directoria Geral de Estatística (1922, Volume IV, 1^a Parte: População, pp. 20–481)

[51] Directoria Geral de Estatística (1922, Volume V, 5^a Parte: População, Tomo I pp. 180–625, Tomo II pp. 6–825.)

[52] Directoria Geral de Estatística (1922, Volume IV, 1^a Parte: População, pp. 550-887). The computation of this variable implies excluding immigrants mainly from Asia (Japan) and South America (Argentina, Paraguay, and Uruguay), who represented about 12 percent of the immigrant population, though we will show that the results are not sensitive to their inclusion. The exact text of the immigrant data in the original source is "Popoulção estrangeira do estado de XX segundo a nacioladidade e o sexo, inclusivo os estrangeiros que adoptaram a nacionalidade braziliera."

[53] Directoria Geral de Estatística (1922, Vol III, 1^a Parte 1: Agricultura, pp. 210-297). The categories of landowners reported alongside the foreign born are Brazilian born individuals, multiple or undetermined persons, and the federal, state and municipal governments.

when its construction was completed—that is, the year when each municipality was linked to the railway network. We then compute two further variables with this information—the number of years that a given municipality had been connected to the railway network by 1920 and an indicator variable for municipalities that were not connected by 1920.

4.4 Control Variables

We collect data on a number of municipality characteristics that may have affected farm value and immigrant settlement to include as control variables in our analysis. To capture proximity to international and domestic markets, we create three variables—distance to the nearest port or frontier custom house, distance to the nearest principal city, and distance to the nearest principal town.[54] We also collect data on the location of immigrant colonies from the same source, complemented by data from Gagliardi (1958) for the state of São Paulo. We also create a battery of variables to control for differences in geographic conditions across municipalities, including surface area, ruggedness, altitude, latitude, and longitude. Next, we use data from the Global Agro-Ecological Zones project (Food and Agriculture Organization 2021) to construct three variables that capture the suitability of land for agriculture and the adaptability of land for the production of different crops. These variables consist of the first two principal components of suitability for all major crops reported in the census except rubber,[55] and the Herfindahl-Hirschman Index (HHI) of suitability, capturing how concentrated land suitability is in each municipality. Finally, we collect data from the 1872 census (Núcleo de Pesquisa em História Econômica e Demográfica 2012), including the share of Europeans in population, agricultural employment, employment in the justice sector, the number of slaves, the share of the population that was white, literacy, and school attendance. These are useful in enabling a test of instrument validity, as they are predetermined relative to mass immigration. They also enable us to control for a variety of factors that might be concerning, such as the legacy of enslaved labor.[56]

4.5 Farm-Level Data

We complement our municipal-level analysis with data from the 1904–1905 Agricultural Census of the state of São Paulo (Secreteria da Agricultura 1906–1910). The data from this source are similar to those coming

[54] These features are identified using a map of Brazil created by the International Bureau of the American Republics (IBAR) in 1905, shown in Online Appendix Figure A.5.

[55] Specifically, this is the low input, we do not consider irrigated-land suitability data for beans, cocoa, coconut, coffee, cotton, maize, potato, rice (dry and wet), sugar, tobacco, and wheat. The source does not include suitability for rubber.

[56] Because they require us to change our unit of observation from the 1920 municipality to minimum comparable areas between 1872 and 1920, we do not include these controls in our main results, but we show that our results are robust to their inclusion.

from the 1920 census, reporting the share of cultivated farm land, the share of cultivated farm land by planted crop, employment density (workers per hectare), and the breakdown of employment by foreign or native birth. But these data are reported at the level of the farm rather than the municipality. In total, we have information for over 40,000 farms across 163 municipalities. This source provides information on land values, as well as farm ownership—that is, whether the farm was owned by a foreign- or native-born person—and on the share of native and foreign workers.[57]

4.6 Summary Statistics

Online Appendix Tables A.1 and A.2 present summary statistics for all of the variables in our dataset. Figure 4 presents maps displaying the geographic distribution of our main outcome variable (panel a) and our main explanatory variable of interest (panel b). The south and southeast are shown at increased magnification, as these regions received the majority of migrants. A number of features of our data are readily apparent. The first is the presence of substantial immigration in regions other than states of São Paulo and Rio Grande do Sul—the traditionally-examined migrant destinations. In fact, immigration was as intense as in these states as in many municipalities of the center-west, southeast, and north regions. The second is that there is a concentration of high farm values and high immigrant shares in the vicinity of São Paulo, in the main coffee-growing area of the southeast. We will present a number of exercises verifying that our results are not solely driven by this region or the expansion of the coffee frontier. The third is that there was considerable variation in farm values and immigrant shares throughout the country. The fourth is that immigrant origins varied significantly across municipalities, with immigrants drawn from a wide geographic range including European countries (Italy, Portugal, Germany, Spain), neighboring South American nations (Argentina, Paraguay, Uruguay), the Middle East, and Asia (see Online Appendix Figure A.4).

Panel (a) of Figure 5 presents the geographic evolution of the Brazilian railway network over time—part of the variation that contributes to our instrumental variables strategy. The expansion of the network inland from major ports over time is clear, with the share of municipalities connected to the rail network increasing from virtually 0 percent in 1860 to about 40 percent by 1920.[58] Notably, there appears to have been an important regional component to the rail network. Rail was virtually absent from the north, and evolved into

[57]The digitized data were kindly shared with us by Renato Colistete. See Bassanezi and Francisco (2003) (who first digitized the data), Colistete (2015), and Vidal Luna, Klein, and Summerhill (2014) for previous uses of this source.

[58]The first railway station was completed in 1854. Online Appendix Figure A.6 illustrates the share of municipalities connected by decade. While Brazil's railway network expanded significantly, the share of connected municipalities was smaller than that in the United States, where the share of connected counties increased from 20 percent in 1850 to about 90 percent in 1920. Similarly, Brazil's railway mileage in 1914 was equivalent to that of the United States in the 1850s (Herranz-Loncán 2014; Sequeira, Nunn, and Qian 2020; Summerhill 2003).

several geographically distinct networks rather than one unified one. For this reason, and because differences across regions in migrant settlement patterns, we posit, verify, and exploit the fact that the impact of rail on immigrant settlement patterns may have varied by region.

5 Empirical Strategy

5.1 Estimating Equation

Our main estimating equation for the effect of immigration on farm value is given by

$$f_i = \psi s_i + \mathbf{x}_i' \Pi + \lambda_j + \varepsilon_i,$$

where f_i is average farm value per hectare in municipality i, s_i is the population share of European immigrants in municipality i, λ_j are region or state fixed effects, and $\mathbf{x}_i$ is a vector of municipality-level covariates.[59] As we explain below in discussing our instrumentation strategy, we control for the years a municipality had been connected to the rail network (or some function of this variable) and whether it had not yet been linked by 1920. Our main results are reported with robust standard errors, but all results are robust to correcting for spatial correlation (Colella et al. 2019; Conley 1999), as we show in Online Appendix B.

Regardless of the richness of our controls, estimating the causal impact of immigration on agricultural development is complicated by the likely endogeneity of immigrants' destination choices.[60] For instance, immigrants may have settled in places with better land quality (beyond our ability to control for it), or where other factors, such as better management, were available. Immigrants' settlement patterns may also have been influenced by local elites, whose presence could have impacted agricultural productivity.

The direction of the resulting bias, however, is unclear. A natural concern is that our estimates would overstate the effect of immigration if immigrants were to disproportionately settle in areas where local characteristics were responsible for greater output or land values. The available historical evidence, however, suggests that immigrants often did not settle in the most economically favorable locations, meaning that our

[59] These include the number of years with railway connection, an indicator variable for municipalities with no railway connection, geographic characteristics (surface area, ruggedness, altitude, latitude, and longitude), land characteristics (the Herfindahl-Hirschman Index of crop suitability and the first two principal components of suitability for all major crops reported in the census), and market access characteristics (linear and quadratic distance to the nearest city, principal town, port, and custom house.

[60] Notably, Lanza, Manier, and Musacchio (2023) argue that the placement of immigrants by the official immigrant recruitment system was random, which contributes to the validity of our OLS regressions. But these represented only a portion of the immigrant arrivals—which also included unsubsidized immigrants and immigrants to other states—whose effects we are interested in understanding.

estimates might instead be biased downwards.[61] One reason is that immigrants had very little information about their final destination and often had little say in where they would settle within a state or broader region, needing to choose a destination based on existing labor demand upon arrival (Lanza, Manier, and Musacchio 2023). This lack of choice and the limitations to free movement within Brazil for some time after arriving in the country led to widespread discontent among immigrants, especially in the earlier phases of mass immigration (da Costa 2000; Fausto 1999). Although it has been shown that municipalities featuring migrant colonies—rural settlements for migrants created by private planters in cooperation with the state—experienced faster development later on (de Carvalho Filho and Monasterio 2012; Rocha, Ferraz, and Soares 2017), this type of migration was not generally seen as particularly fruitful by contemporaries, who viewed migrant colonies as being located in economically unfavorable locations (Cameron 1931). It is also possible that migrants had incentives to settle in areas predisposed to have lower land values. For instance, some migrants may have chosen to settle in less economically dynamic areas with lower land values in exchange for the prospect of an easier access to land ownership, or might have only been able to acquire more marginal land. Historians have argued that the prospect of land ownership was indeed a strong pull factor for migrants, especially for the largest immigrant group, Italians (Holloway 1980).[62]

5.2 Instrumental Variables Strategy

To overcome the identification challenge, we implement an instrumental variable strategy based on the interaction of immigrant inflows and the expansion of the Brazilian rail network, following Sequeira, Nunn, and Qian's (2020) study of the effects of immigration during the Age of Mass Migration in the United States. The intuition of this instrument is to compare two otherwise identical municipalities, one of which was linked just before a year of large immigrant inflows and the other of which was linked just after. Because of the importance of rail in transporting migrants to their destinations, they would be more likely to settle in a municipality that was linked to rail at the time of their arrival. The municipality linked to rail just before the large immigrant inflow would thus receive immigrants from that wave, while that linked in the following year would not. These initial settlement patterns would then affect subsequent settlement patterns by creating migrant networks that subsequent immigrants might follow into these destinations. For this reason, even

[61] Measurement error in our regressor of interest could also be responsible for attenuating our estimates and would be addressed by instrumentation.

[62] In Online Appendix Table A.3, we perform a balance test in which we regress the 1920 share of Europeans in population on a variety of 1872 municipality variables and geographic characteristics and fixed effects. In order to use the 1872 census for this test, we aggregate our 1920 municipalities into larger minimum comparable areas (Online Appendix Figure A.7). Unsurprisingly, we find evidence of imbalance. For instance, municipalities that would have a higher share of immigrants in 1920 had lower rates of school attendance in 1872. These results reinforce the need to develop an identification strategy to address endogenous sorting of immigrants and to show that the results are robust to controlling for 1872 characteristics, both of which we do below.

temporary immigration—important in light of the high rate of return migration—and immigration after the initial wave into a municipality would be affected by this variation.

We construct an instrument for the immigrant share of population, s_i, which we refer to as ς_i, of the form

$$\varsigma_i = \frac{1}{\theta_i} \sum_{t=1855}^{1920} m_t \times r_{it-1},$$

where m_t is the immigration flow to Brazil in year t, normalized by Brazil's population, r_{it-1} is an indicator variable for the presence of a train station in municipality i in year $t-1$,[63] and θ_i is the number of years that municipality i had been connected to the railway network by 1920.[64] This equation captures a number of refinements that we make to Sequeira, Nunn, and Qian's (2020) identification strategy and some departures that we make from it. The first is that we use annual data on the state of the rail network rather than data by decade. We also make a slight departure by dividing by the number of years that a municipality was linked to the rail network (θ_i) rather than the number of years in the study period, though our results are robust to using Sequeira, Nunn, and Qian's (2020) normalization. Dividing by the number of years linked gives a sense of the number of immigrants that we might expect to observe at a given point in time, which is what we observe in the 1920 census.[65]

Another departure that we make from Sequeira, Nunn, and Qian's (2020) implementation is that we do not multiply the instrument by a scaling factor, which they refer to as β—the coefficient from a so-called "zero-stage" panel regression of a place's immigrant share in one period on the product of the preceding period's rail access and aggregate immigrant inflow. We must make this departure because we lack panel data on immigrant shares and thus cannot estimate the "zero-stage" equation. From a technical perspective, the factor β is immaterial to the estimation, as it is simply a constant scaling factor and thus does not contribute to the first-stage relationship between the actual 1920 immigrant share and the instrument; this departure thus has no practical impact upon our results. Although the "zero-stage" estimation has no bearing on the results in Sequeira, Nunn, and Qian's (2020) identification strategy, it is used in that paper to establish the validity of the interaction between railway access and immigrant inflows in predicting immigrant shares. In the Brazilian context, this validity is established both by our first-stage estimation and in panel data for the state of São Paulo by Minale, Rocha, and Vigna (2024).

[63] That is, whether municipality i was linked in year $t-1$ or in any year previously. We focus on railway linkage in year $t-1$ rather than in year t to ensure that municipality is linked for the entire year rather than only some, potentially small, fraction.

[64] In Online Appendix C, we show that our results are robust to an alternative definition of rail connectedness in which a municipality is considered connected to the rail network if another municipality whose centroid is within 100km of its own has a rail station.

[65] In the presence of high rates of return migration, actual immigrant shares are likely to be more reflective of annual immigrant flows; normalizing by number of years linked implies that our measure approximates an annual inflow.

Panel (b) of Figure 5 presents a map of the value of the instrument for each municipality. While the geographic extent of the non-zero instrument value matches that of the railroad (by construction), as shown in panel (a), this map also makes clear that the variation across space is not precisely the same as that in panel (a)—a fact arising from incorporating variation in immigrant inflows across years into the construction of the instrument. Given the potential for heterogeneity in the predictive power of the instrument in the first stage, we interact the instrument with region indicators.[66] The first-stage regression equation for our IV strategy is thus

$$s_i = \gamma_j \varsigma_i + x_i' \Omega + \lambda_j + u_i,$$

where γ_j is a region-specific coefficient. In Online Appendix D, we also show that our results are robust to allowing γ to vary at the more disaggregated state level instead.

The controls most crucial to our identification are, following Sequeira, Nunn, and Qian (2020), the number of years that a municipality was connected to the railway network by 1920 and an indicator variable for municipalities that were not connected by 1920.[67] These controls address the obvious concern that rail linkage may have had direct effects on economic activity (Summerhill 2005), and that the location of rail construction was not random, likely targeting areas where economic activity was or would be greater (e.g., Atack et al. 2010; Donaldson and Hornbeck 2016; Zimran 2020): among other things, these controls ensure that we do not compare municipalities linked to the rail network to municipalities not linked to the network.

As in Minale, Rocha, and Vigna's (2024) and Sequeira, Nunn, and Qian's (2020) application of this identification strategy, controlling for (some function of) years of linkage and the linkage indicator implies that identification arises from the functional form restriction in which the control for years of rail linkage is linear (or otherwise constrained) whereas the instrument is a non-linear function of a municipality's years of rail linkage (since the year of linkage is the sole determinant of years of linkage).[68] But, again as in Sequeira, Nunn, and Qian's (2020) application, the non-linearity of the instrument is not arbitrary, but is instead the product of actual variations in Brazilian immigration rates. In addition, our normalization by years linked

[66] Abadie, Gu, and Shen (2024) show that limiting attention to subsamples in which the instrument does have a strong first stage can result in bias. They also show, however, that the method that we implement, also used by Deryugina et al. (2019), Dix-Carneiro and Kovak (2017), Jackson, Johnson, and Persico (2016), and Pascali (2017), provides more reliable estimates. Abadie, Gu, and Shen (2024) caution that this method may be problematic where there are many different subsamples, but our case, with five regions in Brazil, is unlikely to face such issues. In Online Appendix Figure A.8, we illustrate the relationship between the instrument and the instrumented variable at the regional level, also splitting the sample along the time dimension. The time dimension indicates that the instrument is especially effective in predicting the immigrant share of a municipality for rail linkages taking place after 1900 in all regions except for the Northeast, where there was little immigration. This helps to better understand the source of identification.

[67] Online Appendix Table A.4 presents analogs of our main results in which we control for quadratic or exponential (instead of a linear) functions of years linked, or in which we include fixed effects for each decade of linkage. The results are qualitatively unchanged relative to our main specifications, presented in Table 2.

[68] We illustrate this nonlinearity graphically in Online Appendix Figure A.9.

to the network provides further non-linearity. The combination of the linear control for years of linkage, the control for whether a place was ever linked, and an instrument in which the variation is determined by immigrant arrivals is simply to ensure that the identification derives not from how long a place was linked to the rail network but only from when in the immigration cycle it was linked.

As in the case of Sequeira, Nunn, and Qian's (2020) application of this instrumentation approach, the main identification assumption is that when (but not whether) a municipality was linked to the rail network was not dependent on aggregate immigration levels. Thus, perhaps the main identification concern facing our instrument is that municipalities connected to the railway network during an immigration boom may have been systematically different from those connected during an immigration lull. Such differences could arise if, for example, aggregate immigrant flows increased when locations with greater economic potential were connected to the railway network.[69] This concern is mitigated by the fact that the historical literature has documented that these fluctuations were influenced by a number of global and national macroeconomic factors, including changes in the price of coffee, the increase in labor demand due to the abolition of slavery, the implementation of the Decreto Prinetti in 1902, the First World War, and global macroeconomic shocks such as the Panic of 1907 (Hatton and Williamson 1998; Sequeira, Nunn, and Qian 2020; Spitzer 2015; Spitzer, Tortorici, and Zimran 2025).

To address these concerns more formally, we follow Sequeira, Nunn, and Qian (2020) by comparing the observable characteristics of locations that became linked during immigration lulls to those linked during immigration booms. More specifically, we use data from the 1872 Population Census of Brazil to capture early migrant settlement (population share of European immigrants), racial composition (population share of whites), human capital (literacy rate and share of children attending school), state capacity (justice workers per 1,000 inhabitants), economic structure (share of employment in agriculture), and the presence of slavery (population share of slaves). We operationalize this test by defining booms as years with an immigrant inflow above the previous five years' moving average and defining lulls conversely. The booms and lulls are identified in Figure 1. Columns (1)–(3) of Table 1 present the means of the observable characteristics for the full sample and for each group of locations. Column (4) tests for the statistical significance of differences between the groups, finding that the two sets of municipalities were, in fact, systematically different. These differences, however, were, for the most part, with respect to geographic variables, likely because of the gradual rollout of the railway from the coast. Likley as a result of this simple source of imbalance, columns (5) and (6), which repeat the analysis controlling for region and state fixed effects respectively (which we

[69]Similarly, such differences might arise if, in periods where a large immigrant inflow was expected, a particular effort was made to connect particularly productive or unproductive areas to the rail network.

include in our analysis), show that the differences are largely explained by the linkage of different parts of the country at different times, and that within region and states the differences are statistically significant in only a small number of cases. Indeed, when making within-state comparisons (as we do in our main results), we find a statistically significant difference only in the 1872 share of agricultural labor. Moreover, this difference is small and, as we will show below, our results are robust to controlling for 1872 characteristics of municipalities such as the share of labor in agriculture. Thus, the evidence does not support concerns that railway expansion may have responded to immigrant inflows or vice versa.

6 Main Results and Robustness

Table 2 presents our main results, estimated both by OLS (panel A) and using the instrumental-variables strategy introduced above (panel B). All variables discussed in this table are standardized, meaning that the coefficients can be interpreted as standardized coefficients. Columns (1)–(4) use total farm values per hectare as the outcome, while columns (5)–(7) divide the farm value outcome into its constituent components—land, infrastructure, and tools and machines. Our OLS results reveal a statistically significant positive relationship between the share of European immigrants and farm value per hectare: a one-standard deviation increase in the immigrant share was associated with a 0.6-standard deviation increase in farm value. Adding controls for land quality (column 2) and distance to domestic and international markets (column 3) has only a negligible effect on the magnitude of the estimates and has little impact on their precision. To address the concern that farm values were particularly high in São Paulo (Klein and Luna 2018), we also add state fixed effects in order to exploit only within-state variation, finding that our results remain virtually unchanged (column 4). Dividing farm value into its constituent components shows that the effect of immigration was realized for all three—roughly equally for land and infrastructure, and with a somewhat smaller effect for tools and machines. Notably, that the effect goes beyond the value of land alone suggests that the results are not purely the product of greater demand for land or of local amenities capitalized into the value of immobile factors (Bleakley and Rhode 2024). The effect on tools and machines also indicates an interesting complementarity between immigration and capital. We investigate these potential mechanisms in more detail below.

Panel B of Table 2 presents our instrumental variables estimates. This panel shows, in support of the relevance of our instrument, that our first-stage F-statistics are nearly 5 times larger than the weak instrument critical value of the LIML estimator with one endogenous regressor and 5 instruments, 4.84 (Bound, Jaeger, and Baker 1995; Stock and Yogo 2005).[70] Our IV estimates corroborate the OLS estimates

[70]We use LIML given that the critical values for this estimator decrease as the number of excluded instruments increases,

of panel A, revealing a statistically significant positive effect of a greater share of European immigrants on farm values in general and on each component. In our preferred specification in column (4), which controls for state fixed effects, we find that a one-standard deviation increase in the share of immigrants yielded approximately a 0.7-standard deviation increase in farm value.

In columns (1)–(4) of Online Appendix Table A.5, we extent the analysis to the value of agricultural output per hectare of land. As above, our results reveal a positive and statistically significant relationship between the share of European immigrants in population and this measure of agricultural development; in particular, we find that a one-standard deviation increase in the share of Europeans in population was associated with a 0.3-standard deviation increase in the value of output per hectare.

In Table 3, we verify the robustness of our results to a number of sample restrictions.[71] These sample restrictions address concerns that should, in principle, be addressed by our instrumental variables strategy, but which are nevertheless useful in ensuring that specific subsets of our sample are not driving our results.[72] In Panel A, we exclude municipalities that contained immigrant colonies. These settlements were the product of partnerships between private planters and national or state governments, which led to the creation of new rural communities. This form of immigration has been associated with faster long-run economic development as a result of greater human capital accumulation (Rocha, Ferraz, and Soares 2017), but colonies may also have been built in locations considered economically unfavorable at the time (Cameron 1931). Given the peculiar developmental history of these places, their farm value could have been the product of forces other than immigration. In Panel B, we exclude areas that were large producers of coffee in order to account for the crucial role that this commodity played in shaping local development and attracting immigrant labor force. We define large coffee producers as those municipalities in the top decile of agricultural land share dedicated to coffee production. Concretely, this translates into excluding municipalities with a share of land dedicated to coffee production above 60 percent.[73] In Panel C, we exclude municipalities obtaining a railway station in the first three decades of the rail network expansion. It is possible that municipalities connected earlier may have been systematically different from those connected later on in a way that our controls are not be able to capture. Panel D, excludes large population centers—defined as municipalities in the top quartile of the

a property that fits our setting well, but the results are very similar if we employ two stage least squares, as shown in Online Appendix E. This is important as some of our robustness checks are based on 2SLS estimation. Our F-statistics are also greater than thresholds for smaller numbers of instruments, which may be important given that not all of the 5 instruments may enter into the first stage significantly.

[71] We do the same for the individual components of farm value in Online Appendix F.

[72] Online Appendix Figure A.10 shows which municipalities are dropped in each case.

[73] We obtain similar results if we drop the top decile of municipalities by agricultural land area dedicated to coffee, or the top decile of municipalities by volume of coffee production. The former approach, as shown in Online Appendix Figure A.10, involves excluding the bulk of São Paulo's coffee-producing region, which stands out in Figure 4.

population distribution in 1920—in order to address the concern that economic centers may be significantly influencing our results or that agriculture may not have been particularly important in these places. In a similar vein, in Panels E and F, we exclude municipalities that we identify as industry and service hubs. These are municipalities in the upper quartile of employment shares in the respective industry.[74] In all cases, we find no reason to believe that our results were driven by any of the concerns that we address, and, in general, we find little evidence that these concerns even influence the magnitude of our estimates.[75]

As an additional robustness test, we implement our IV strategy controlling for local historical factors that could have influenced farm values, migrant settlement, and railway construction. In particular, we control for the 1872 characteristics listed in Table 1. These characteristics include the share of population enslaved in 1872, which is particularly relevant as mass immigration in Brazil was seen as a mechanism to compensate for the decline and eventual abolition of slavery.[76] It is also possible that enslaved labor was replaced in part through a more intense use of tools and machines, directly affecting their price and the overall value of farms.[77] Online Appendix Table A.7 shows that the magnitude and significance of our findings remain essentially unchanged after controlling for these factors. Moreover, the 1872 control variables have little to no power to predict 1920 farm values, implying that our findings are unlikely to be driven by persistent effects of historical factors, including the replacement of enslaved labor.

In Online Appendix Table A.8, we divide the immigrant share into its constituent national origin components—Italians, Spanish, Portuguese, and others.[78] Interestingly, we find that, of the two major immigrant groups (Italians and Portuguese), only Italian immigrants appear to have had an impact on farm values, perhaps because the Portuguese were more likely to settle in urban areas and less likely to work in agriculture (Klein 1993). It is also possible that the Portuguese immigrants were simply too similar to native Brazilians to have a differential impact on the agricultural sector, suggesting, as we will develop in more

[74] In this calculation, we exclude domestic services from service employment in order to capture professions more closely related to high added value services. Note that in the census, domestic services are also reported separately.

[75] In Online Appendix Table A.6, we present the results of a randomization exercise in which we randomly reassign rail linkage years within the set of ever-linked municipalities and compute our first-stage and reduced form estimates. As expected, we find that there is a statistically significant (at the 5-percent level) relationship between randomly reassigned rail linkage and the share of Europeans (the first stage of our IV strategy) or land values (the reduced form) in only about 5 percent of randomizations; the IV estimate is not significant in any randomization. These results provide strong support to our argument that identification comes from random variation generated by the timing of railway connection (before an immigration boom or lull).

[76] It is not clear, however, to what extent immigrants replaced enslaved labor in a local, rather than aggregate, sense, as the expansion of the agricultural frontier also implied that migrants often settled in places where slavery had previously not been prevalent (Palma et al. 2021).

[77] Indeed, in cases of compensated emancipation, the compensation may have been used to purchase agricultural capital.

[78] Each column is a single regression (as opposed to one for each nationality). Because our IV and OLS estimates are largely similar, and because additional instruments would be required to separately estimate the effects of each nationality's share of population, we focus here only on OLS estimates. A map of the largest immigrant group by municipality is presented in Online Appendix Figure A.4. Online Appendix Table A.9 presents analogous results to our main analysis in Table 2, in which we use immigrants from all places of origin, rather than just Europe. The results are qualitatively the same as those of the main analysis.

detail below, that the effect that we document is driven by some unique characteristic of immigrants relative to natives rather than through simple labor provision.[79]

In Table 4, we test whether the impact of immigration was the product of immigrant labor or of immigrant land owners in order to better understand how immigrants affected the agricultural sector.[80] Columns (1) and (2) use the same municipality-level data from the 1920 Census as in our analysis above. Column (1) shows that a greater share of European immigrants led to a greater share of farms that were foreign owned.[81] But in column (2), we find no evidence that foreign ownership was associated with greater farm values; indeed, the point estimate for the coefficient on the share of farms owned by the foreign born is negative.[82]

The 1920 census, however, does not enable us to explicitly separate native- and foreign-born agricultural workers (it permits only the observation of the share of Europeans in the whole population). The 1904–1905 Agricultural Census of the State of São Paulo, however, makes such a distinction, and also provides information on land values, the nationality of farm owners, and number of foreign and domestic workers for over 40,000 farms across 163 municipalities (Secreteria da Agricultura 1906–1910). Moreover, because the data are reported at the level of the farm, we can include municipality fixed effects to control for unobserved factors at the municipality level that could have influenced land value. For instance, historical studies have documented that well before 1920, the agricultural frontier in the Paraíba Valley had closed and the productivity of once prosperous farms started to decline (Dean 1976; Stein 1953).[83] Column (3) of Table 4 substantiates our main result using the farm-level data, showing that a greater share of foreign-born workers was associated with greater land values per hectare. Column (4) shows that foreign ownership had no such association. Column (5) includes both variables in the regression. While we continue to find that a greater share of foreign-born workers was associated with greater land values, the coefficient on foreign ownership is statistically significant and *negative*.

This finding is line with previous literature arguing that bourgeois immigrants in the agricultural sector—both those who started off as landowners and those who became landowners at a later stage—had no detectable generalized positive effect on Brazilian local development because of an insurmountable advantage of

[79]Because Italians were the most important immigrant group in the pre-1900 period and the Portuguese were the most important group after 1900 (Figure 2), these results may also shed some light on the potential effects of immigrants by period, which our data are not otherwise equipped to address.

[80]Online Appendix Figure A.11 presents the spatial distribution of foreign farm ownership.

[81]Around 12 percent of nationwide agricultural establishments (Directoria Geral de Estatística 1922, Volume III, 1^a Parte: Agricultura, p. XXVIII) and 8.6 percent in the average municipality were foreign owned (Online Appendix Table A.1). The correlation of the two variables across municipalities is about 0.87.

[82]We perform this exercise while recognizing the potential endogeneity of the share of farms owed by the foreign born in addition to the European share of population.

[83]In our main results, this specific concern should also be addressed by the combination of our instrumental variables strategy and our controls for latitude, longitude, distance to coast, and crop suitability.

domestic planters, potentially arising from superior knowledge, better access to capital, or better managerial skills (Dean 1969). It is also consistent with the notion of immigrants who had previously worked on coffee plantations accumulating savings and purchasing smaller plots (Carlson 2022, p. 705; Holloway 1980, p. 147; Klein 1992, p. 510), which may have been on lower quality land because of advantages enjoyed by native planters, and which may have not been able to realize the economies of scale of a larger plantation.[84]

7 Mechanism

Having established a large and robust causal effects of European immigration on farm values per hectare, we now examine the primary mechanism for this effect. In this section, our focus is on what we identify as the most important mechanism—immigration leading to more intense cultivation of land. We also provide a brief discussion, which we develop more completely in Online Appendix G, of other potential mechanisms that we find to either have not been present or to have been present but less important than the cultivation intensity mechanism.

We approach this exercise in three steps, presenting results for both the main mechanism and for other mechanisms discussed in Online Appendix G. First, in Table 5, we use our instrumental variables strategy to test whether the variables that operationalize our proposed mechanisms were, in fact, affected by immigration. Next, in Table 6, we evaluate the impact of controlling individually for each mechanism on the coefficient on the European share in our instrumental variables analysis, with column (7) of this table showing the impact of controlling for all mechanisms. Finally, in Table 7 we implement a Gelbach (2016) decomposition to determine the portion of the coefficient change on the European share that is explained by each of the proposed mechanisms.[85]

7.1 Empirical Evidence

We find that the most important mechanism for the effect of immigration concerns land use, specifically cultivation intensity, which we capture with the share of farmland cultivated (as opposed to being left fallow

[84] In Online Appendix Table A.10, we study the relationship between the share of Europeans in population and the share of farms that were foreign-owned on the one hand and average farm size and the land Gini coefficient on the other. We find that the share of Europeans is negatively related to farm size. Foreign ownership on its own is not related to average farm size, but becomes positively related to it when also controlling for the share of Europeans in a municipality. Including both variables at the same time also makes the negative coefficient for the share of Europeans larger in absolute value. In Online Appendix Table A.11, we show that the pattern, that it is the share Europeans and not the share foreign-owned farms that has explanatory power, holds also for output and for individual aspects of farm value.

[85] Because of technical difficulties arising from our use of multiple instruments the decomposition is performed for the OLS analog of the regressions, not for the IV estimates, so the decomposition is not precise. But given the similarity of the OLS and IV results, this is not a major concern.

or forest). The hypothesis is that some characteristic of the immigrants enabled or caused greater utilization of the available resources, leading, for example, to more intense cultivation of land.

Column (1) of Table 5 shows that a one-standard deviation greater share of Europeans increased the share of farm land cultivated by 0.8 standard deviations. Column (2) of Table 6 controls for the cultivated share of farms. This factor was associated with greater farm values—a one-standard deviation increase in the share cultivated was associated with a 0.4-standard deviation increase in farm value per hectare—and its inclusion leads to a substantial decline in the magnitude of the European share coefficient from a coefficient of over 0.7 to about 0.5, which constitutes evidence that this is a mechanism through which the effect of the immigration share passed. This is confirmed by the Gelbach (2016) decomposition in Table 7, which shows that it was the cultivated share of farms that was responsible for the bulk of the reduction in the effect of the share of Europeans on farm values when controls are added. Based on these results, we conclude that European immigrants led a greater share of farm land to be cultivated, raising its value.

The results of columns (5)–(8) of Online Appendix Table A.5 provide further support for this mechanism. Whereas columns (1)–(4) find a strong positive effect of the share of Europeans in population on the value of agricultural production per hectare, columns (5)–(8) reveal no effect (or perhaps even a slight negative effect) of the share of Europeans in population on the value of agricultural production per *cultivated* hectare. This result is consistent with an increase in cultivation driving the effects that we document—when we condition on the extent of cultivation, there is no effect on output.

7.2 Discussion

Economic theory and the historical literature provide two (non-mutually exclusive) potential interpretations of our evidence regarding the cultivation intensity mechanism. These interpretations demonstrate that the mechanism that we propose is plausible in our context, and illustrate the potentially important role for official and non-official incentives faced by immigrants to shape the impact of immigration. The first is that immigrants may have supplied more labor than native workers, substituting away from leisure, and in particular that temporary immigrants may have supplied more labor than natives or permanent immigrants. A substantial literature has shown, both theoretically and empirically, that when immigration is temporary, immigrants substitute inter-temporally, supplying more labor in the destination while enjoying greater leisure when returning home.[86] Given the high rates of return migration to Europe from Brazil, it is plausible that

[86]See Dustmann (1994, 2000), Dustmann, Bentolila, and Faini (1996), Dustmann and Görlach (2016), Epstein and Venturini (2011), Galor and Stark (1991), Hill (1987), Klinthäll (2006), Kyarko and Chartouni (2017), Vijverberg and Zeager (1994), and Wahba (2022).

this inter-temporal substitution operated in our case, and Italians in particular were noted for aiming to accumulate savings and return home (Sánchez-Alonso 2019, p. 9). This literature has also highlighted that migrants were reputed for their hard work and desire to save (Cinel 1991; Florea 2023; Holloway 1980; Sánchez-Alonso 2007). The historical literature also provides evidence of a potentially related mechanism in which permanent immigrants who did not yet own land but who sought to transition into landownership and escape the hardships of the plantation would have been incentivized to increase their labor supply until they had saved sufficiently to acquire land. Indeed, one of the incentives driving immigrants in exerting labor effort was the possibility of eventually owning land (Holloway 1980; Lesser 2013).

The unique features of the *colonato* contract may also have incentivized more intensive cultivation of the land. Buciferro (2021) argues that immigrant laborers were intensively exploited by native landowners—a condition that immigrants were willing to endure only because work on the coffee plantations offered opportunities for movement up the agricultural ladder into farm ownership. Moreover, the interrow cropping privileges provided to *colonos*, which were seen as the most important part of their compensation, both led to more intensive cultivation of land in new coffee groves and required the opening of new land to coffee production in order to enable the continued provision of the interrow cropping privileges, which would have competed with more mature trees (Holloway 1980).[87] The peculiar incentives faced by migrants did not escape foreign observers at the time. The French agronomist J. Picard (1903 [1996]) observed that the *colonato* program gave immigrants ownership of the staple crops they planted, leading to more care in their cultivation—care that also benefitted the cash crops for which the migrants were responsible.[88]

7.3 Other Mechanisms

In Online Appendix G, we consider three additional mechanisms that we find to have not been present or to have been unimportant relative to the cultivation intensity mechanism. First, we find no evidence that a greater share of European immigrants was association with greater population density or agricultural employment density, ruling out a mechanism in which immigrants were uniquely responsible for the provision

[87] These patterns can explain both the results from the land intensity mechanism and are consistent with our findings in Table 4 that land managed by immigrants was less valuable than that managed by natives—many of the incentives enumerated above would have faded when immigrants became landowners.

[88] Online Appendix Table A.12 studies the relationship between the share of Europeans and the share of foreign-owned farms on the one hand and measures of land utilization on the other. In general, we find that, as in Table 4 and Table A.11, it is the share of Europeans rather than the share of foreign-owned farms that has explanatory power for these outcomes. In Panel A, where we study the use of total farm land, we find that, besides a higher share of Europeans being associated with more farm land devoted to overall cultivation, it is also specifically related to more land being devoted to coffee, cash crops, and food crop production. Though not dispositive, this result is consistent with an interpretation in which more intense cultivation is driven in part by production of additional crops as part of an interrow cropping strategy. Panel B focuses on land use out of cultivated land, showing that a higher share of Europeans was associated with higher share of land devoted to coffee and less to food crops.

of labor on the agricultural frontier or caused an increase in the local demand for land or agricultural products. The null effects of the share of immigrants in population on population density or the density of agricultural labor are surprising in light of the general view (e.g., Klein 1995) that immigration was a crucial source of labor for the expanding agricultural frontier. Our interpretation of our results is that, while immigrants may have provided this labor in the aggregate sense, it was not the case that immigrants had a unique propensity to enter agricultural labor. That is, they were substitutable with natives in their propensity to fill gaps in the agricultural labor force. Moreover, these results are consistent with immigrants "crowding out" natives, either by causing them to move elsewhere or in an indirect sense by deterring them from settling in areas on the expanding frontier. The results may also be the product of immigrants moving to the expanding frontier themselves to acquire land after accumulating sufficient savings (Carlson 2022, p. 706).

Next, we test for a mechanism in which immigration led to a shift in the crop mix, with immigrants uniquely enabling the production of more coffee. While we do find that a greater immigrant share led to more coffee cultivation, and that this increase in coffee cultivation was in part responsible for growing farm values, the magnitude of this mechanism is small relative to the cultivation intensity mechanism, as shown by the decomposition in Table 7.

Finally, we test whether immigration led to an increase in adoption of tools or machines in agriculture. We find evidence of an effect of immigration on tool adoption but not on machine adoption, and of tool adoption on farm values, but we also find that the magnitude of this mechanism was small relative to the cultivation intensity mechanism.

8 Implications for Development and Structural Change

As outlined in section 3, there are a variety of possible implications of agricultural development for the rest of the Brazilian economy and its transition to industrialization and sustained economic growth beyond the primary sector (e.g., Asher et al. 2022; Bustos, Garber, and Ponticelli 2020; Hornbeck and Keskin 2015; Lewis 1954; Matsuyama 1982; Montero and Yang 2022; Schultz 1964; Timmer 1988), which, in combination with immigration's direct effect on these outcomes may have led immigration to impact Brazil's structural transformation.

In this section, we ask whether immigration's effect on agricultural development was accompanied by effects on other sectors—either direct or as consequences of the effect on agriculture—that would limit Brazil's structural transformation.[89] An important caveat is that we can only answer this question in the

[89]To be clear, we are not aiming to determine the effect of agricultural development driven by immigration on structural

short run, since we observe our outcomes shortly after the end of mass migration. In principle, development and structural transformation may have continued along the same lines or changed direction in unpredictable ways in the decades after our outcomes are observed, for instance due to a lag in the manifestation of the effects of migration through channels like human capital accumulation. At the same time, our shorter-term analysis has the advantage of not being influenced by subsequent events, such as the introduction of import substitution policies and the many regime changes experienced by Brazil from the 1930s until the 1980s, which had their own, sometimes substantial, economic consequences (Ferraz, Finan, and Martinez-Bravo 2024).

In Table 8,we implement our IV strategy as above, but focus on a variety of outcomes that capture differences in human capital formation (Panel A), economic structure (Panel B), economic specialization (Panel C), political economy (Panel D), and female labor force participation (Panel E). For each set of variables, we present two specifications—one including the whole sample and another in which we exclude large population centers (municipalities in the top quartile of Brazil's population distribution) in order to ensure that places that may not have been particularly reliant on agriculture to begin with do not drive our results. On the whole, we find no evidence that migration negatively affected other parts of the economy, or that it slowed down structural transformation. In fact there are indications that the reverse may have been true.

8.1 Human Capital

Human capital accumulation has been shown to have been an important contributor to structural transformation and industrialization in the late nineteenth and early twentieth centuries (Galor and Moav 2006; Squicciarini 2020). Human capital formation has previously been positively linked to immigration in Brazil (de Carvalho Filho and Monasterio 2012; Rocha, Ferraz, and Soares 2017; Witzel de Souza 2018), although not in a causal framework such as ours. We capture human capital by analyzing the literacy rates of the whole population, of natives, of females (both native and foreign born), and of children between the ages of 7 and 14 (both native and foreign born). These variables are intended to capture spillovers from migrants to the rest of the population. We find in panel A of Table 8 that European immigration had a strong positive

transformation; instead, our goal is to measure the net effect of immigration. In Online Appendix Table A.13, however, we try to distinguish to some extent between these channels. In particular, we include the outcome of our main analysis (farm values) as a control in the structural transformation regressions of Table 8. The pattern that clearly emerges is that the effects of immigration on structural change and broader economic development do not depend on the positive effects of immigration on the agricultural sector, as evidenced by the almost universally insignificant coefficients for farm values. At the same time, the positive effects of immigration on broader development remain positive and statistically significant even after including farm values. These results suggest that it is not the case that immigration's indirect effect on structural transformation via agriculture canceled out its direct effect, and indeed that such an indirect effect was not of major importance.

effect on all of our literacy measures: a one-standard deviation increase in the share of migrants in the population led to a 0.7–0.8-standard deviation increase in each of the measures of literacy. The positive link between immigration and human capital found in previous work is thus confirmed. This is not surprising: immigrants had greater human capital to begin with and they were often successful in lobbying for the creation of schools (de Carvalho Filho and Colistete 2010). These schools were presumably one of the channels through which the provision of education improved at the local level, leading to higher literacy for the overall population.

8.2 Economic Structure

Next, we focus on employment shares by sector, specifically on the share of the labor force employed in agriculture, in industry, and in services, which are standard ways to measure structural transformation, as they capture the reallocation of labor from traditional to modern economic activities (e.g., Caselli and Coleman 2001; Heldring, Robinson, and Vollmer 2021). We operationalize these measures by using the actual share of employment in agriculture,[90] industry, and services.[91] These measures give an indication of the degree to which immigration aided or slowed down structural change.

We find in Panel B of Table 8 that municipalities with a higher share of immigrants in population had a lower share of workers employed in agriculture, even when excluding large urban centers. That is, our results on the whole point to a valuable agricultural sector that occupied a lower share of the labor force. This supports the view of agricultural development as a driver of overall economic development. We also find suggestive evidence that a greater immigrant share led to a higher share of workers employed in industry and services: the coefficients for industrial and services employment are positive, though not statistically significant. In any case, we find no evidence that immigration *reduced* industrial or service employment, which would indicate a slowing of structural change.

8.3 Economic Specialization

To delve further in the effect of immigration on structural change and to account for skewness in the distribution of the share of employment in agriculture, industry and services,[92] we classify certain areas

[90] Note that the outcome in this case is the share of agricultural workers out of the labor force. The analysis in Tables 5, 6, and 7 above focused on the ratio of agricultural employment to area.

[91] As in Table 3, we exclude domestic services from service employment. Our aim is to capture professions closely related to economic development and structural transformation.

[92] All three variables exhibit a substantial skewness, negative in the case of agricultural employment, and positive in the case industry and services employment

as hubs of agriculture, industry, or services, defined as being in the upper quartile of the distribution of such employment across municipalities. We find that a higher share of Europeans generated a statistically significantly lower probability of being an agricultural hub in both the full and the non-urban samples (Panel C). Conversely, the probability of being an industry hub increases with the European share of the population, though the coefficient is not statistically significant when urban areas are excluded from the sample. For service hubs, instead, we find positive and statistically significant results, both in the full sample and in the non-urban sample. This set of results is consistent with immigration accelerating structural transformation in Brazil.

8.4 Political Economy

We also study the effect of immigration on two variables capturing the presence and influence of local landed elites (Panel D). The first is the share of population made up of rentiers—people relying on returns to wealth as their main source of income. The second is the share of the population employed in public administration, capturing the tendency for local oligarchs to exert their influence by placing loyalists in public administration (Graham 1990).[93] Indeed, many parts of Brazil were characterized by a large-plantation-based agricultural sector and connected oligarchic system known as *coronelismo*, in which local landed elites offered votes in exchange for aid, employment, and protection, in a classic example of clientelism and patronage (Nunes Leal 1977; Woodard 2005).[94] The influence of landed elites is connected with underdevelopment in the Brazilian context, as the rapid growth following the military coup of 1964, which weakened these elites' grip on power, demonstrates (Ferraz, Finan, and Martinez-Bravo 2024). We find no relationship between immigration and rentiers or public administration employees. Thus, immigration, despite its positive effect on the agricultural sector, did not create a larger class of people living off their landed property or an inflated public sector.

8.5 Sex Ratio in Employment

Finally, we analyze the effect of immigration on the sex ratio, measured as women per man. We examine this ratio in the population as a whole, in total employment, and in two key economic sectors—agriculture and industry. The availability of surplus female labor has been cited as an important pre-requisite for industrialization and female labor is an important contributor to early industrialization (e.g., Goldin and

[93] Directoria Geral de Estatística (1922, Volume V, 5^a Parte: População, Tomo I pp. 180–625, Tomo II pp. 6–825.)

[94] This phenomenon was particularly severe in rural areas, but the situation was only marginally different in coastal cities and other urban centers, where other power groups, such as merchants and professionals, exerted influence alongside traditional elites

Sokoloff 1982, 1984; Olivetti 2014), meaning that the sex ratio in general and in employment is informative of structural transformation. Migration during the Age of Mass Migration was male dominated (Hatton and Williamson 1998), leading to potentially severely skewed sex ratios in locations where more migrants settled. Skewed sex ratios, in turn, can have adverse consequences for attitudes towards women in the workplace and female labor market participation (Grosjean and Khattar 2019). The economic changes arising from immigration may have also reduced employment opportunities for women, who, in the Brazilian context, found gainful employment in the industrial and service sectors more often than in the primary sector (Pena 1981). Reduced opportunities for women and a generally lower labor market participation may have negatively affected economic development.

As expected, we find in Panel E of Table 8 a more male-skewed sex ratio in municipalities with more immigrants. The effect is large both for the overall sample and when we exclude major population centers. But this male-skewed sex ratio in the population does not translate into a statistically significantly male-skewed sex ratio in either overall employment or employment in agriculture and industry. The lack of such an effect suggests the presence of countervailing forces, which led to women compensating for the lower presence in the population with greater labor force participation.[95]

9 Conclusion

In this paper, we study the effects of immigration on the agricultural sector of the destination economy in a setting of an emerging frontier agricultural economy. This analysis adds to the broad literature studying the effects of immigration in destination economies, and complements existing research on the interplay of agriculture and immigration that mostly focuses on the short-run consequences of immigration enforcement or restriction. In particular, our study is situated in the context of Brazil in the Age of Mass Migration, enabling us to benefit from the broad utility of studying this period for the economics of immigration and specifically from Brazil's unique economy, immigration experience, and position among destination countries in this context. Focusing on Brazil's agricultural sector, we find that immigration led to an increase in farm values and output per hectare, coming primarily from an increase in the share of land cultivated. We find no evidence that migration slowed Brazil's structural transformation through its effect on agricultural development. Indeed we find suggestive evidence that it may have accelerated it by fostering human capital accumulation, reducing agricultural employment, increasing employment in industry and

[95]Female labor force participation for immigrant and native women was very similar, at 18 and 17 percent, respectively.

services, and increasing female labor market participation.

This paper also provides an important insight into the effects of immigration to the United States in the Age of Mass Migration, albeit in a counterfactual sense. Specifically, the paper sheds light on the what the effects may have been had immigrants settled in large numbers in the US South—another post-slavery economy driven by commodity agriculture. In reality, few immigrants to the United States settled outside the northeast and midwest. But contemporaries repeatedly discussed a desire for the labor supply that immigrants would provide in the South (Benton-Cohen 2018; Goldin 1994; US Congress 1911). Indeed, there were a number of unsuccessful efforts to encourage Europeans to settle in the US South, and subsidized immigration—an important feature of Brazilian immigration—was considered but was ultimately banned by the Foran Act in 1885. In the later years of the Age of Mass Migration, southern and eastern European immigrants were criticized for their supposed unwillingness to settle in the US South (Benton-Cohen 2018; Coulter 1909; Zimran 2022). As a result, what may have occurred if these large flows had materialized, either spontaneously or if subsidized immigration had come to fruition, remains unknown. This paper sheds light on what might have been.[96]

[96]For a further comparative perspective on the US South and Brazil, see Graham (1981).

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Figures

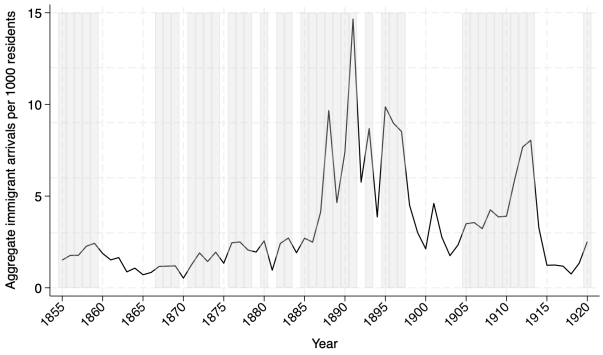


Figure 1: Immigrant arrivals to Brazil by year, and immigration lulls and booms

Source: Directoria Geral de Estatística (1908) and Instituto Brasileiro de Geografia e Estatística (1954) for aggregate immigration numbers. Bolt and van Zanden (2020) and Instituto Brasileiro de Geografia e Estatística (1954) for population numbers.

Note: The graph shows immigrant arrivals in Brazil (1850-1920). Shaded areas are immigration booms, defined as years with an immigrant flow above the previous five years' moving average. The remaining periods are lulls. Gaps in the population data were linearly interpolated to calculate arrival rates.

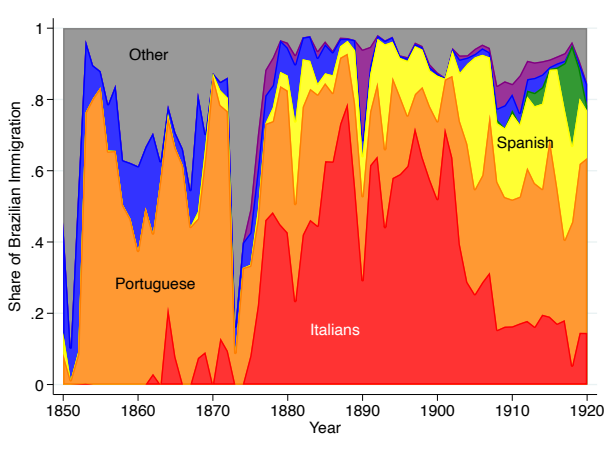


Figure 2: Distribution of origin countries for Brazilian immigration

Source: Directoria Geral de Estatística (1908) and Instituto Brasileiro de Geografia e Estatística (1954).

Note: The graph shows the share of immigration to Brazil by source country (1850-1920). The color key is as follows: Italians (red), Portuguese (orange), Spanish (yellow), Japanese (green), Germans (blue), Russians (purple), and other (gray).

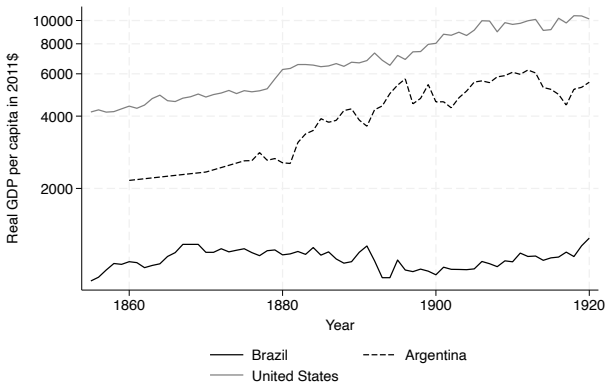
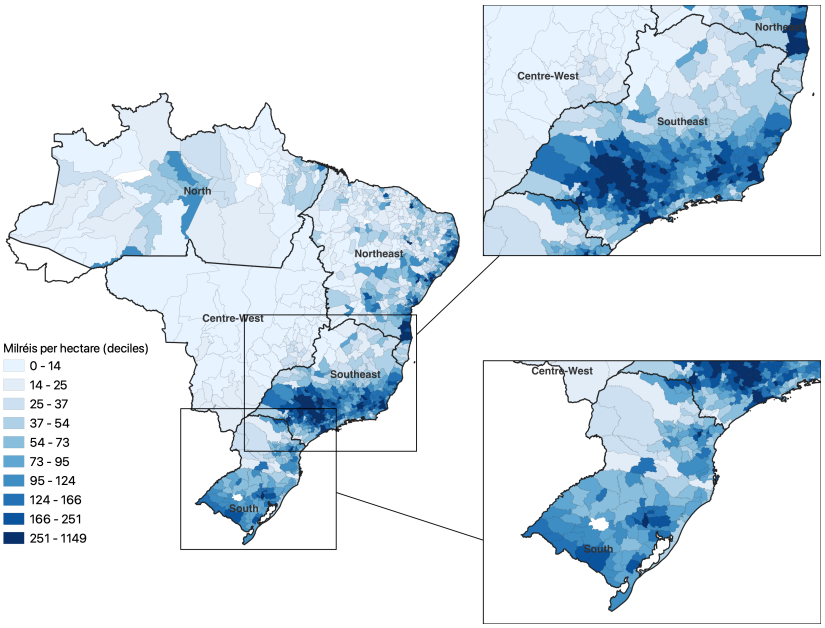


Figure 3: Real GDP per capita in major immigrant destinations

Source: Brazil: Barro and Ursúa (2008), Bolt and van Zanden (2020), and Prados de la Escosura (2009); US: Bolt and van Zanden (2020), Prados de la Escosura (2009), and Sutch (2006); Argentina: Bértola and Ocampo (2012), Bolt and van Zanden (2020), and Prados de la Escosura (2009).

Note: The graph shows real GDP per capita (ca. 1850 to 1920) for Brazil and the other two major immigrant destinations in the Americas: Argentina and the United States.

(a) Farm value per hectare



(b) Population share of European immigrants

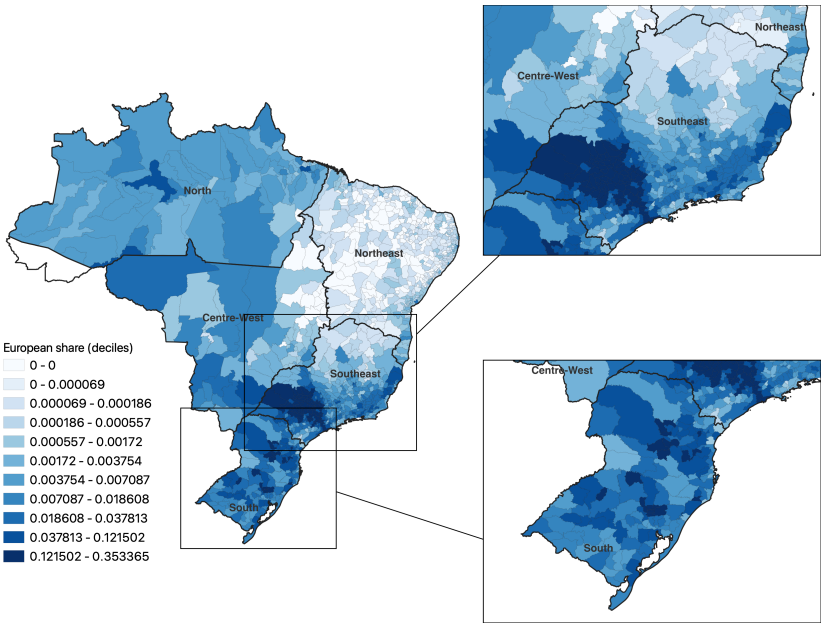
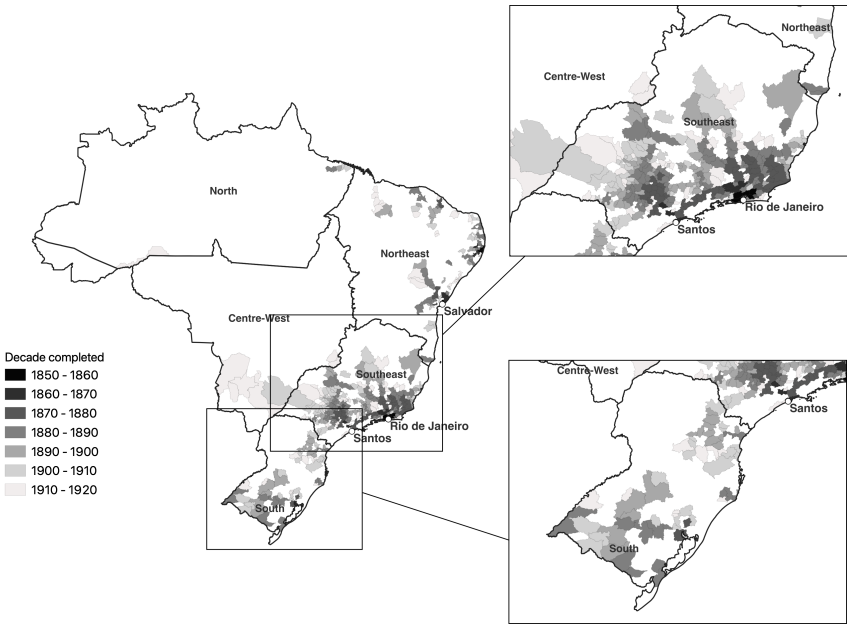


Figure 4: Farm values and immigration

Source: Directoria Geral de Estatística (1922) and Instituto Brasileiro de Geografia e Estatística (2011)

Note: The maps display the spatial distribution of (a) farm value per hectare and (b) the population share of immigrants. The zoomed-in areas illustrate the variation in these variables within and across regions.

(a) Expansion of Brazil's railway network (1850–1920)



(b) Predicted share of European immigrants

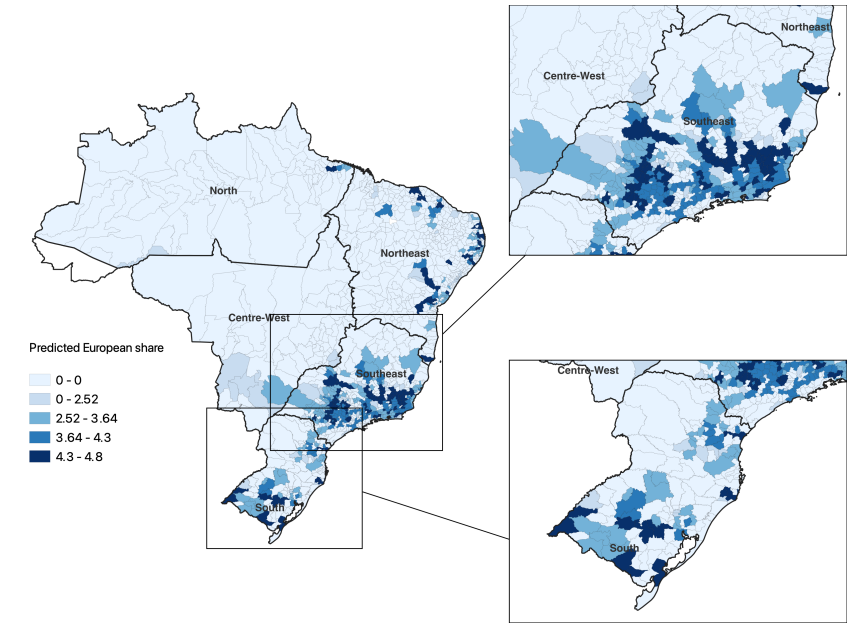


Figure 5: Geographic distribution of the railway and the instrument

Source: Directoria Geral de Estatística (1922), Giesbrecht (2023), and Instituto Brasileiro de Geografia e Estatística (2011).

Note: The maps display (a) the rollout of Brazil's railway network over time and (b) the predicted share of European immigrants.

Tables

Table 1: Balance test for observables: rail connection during immigration booms and lulls

	Full sample	**Boom**	**Lull**	**Difference**	**Cond. Diff. Regions**	**Cond. Diff. States**
	(1)	(2)	(3)	(4)	(5)	(6)
Euro share 1872	0.01	0.02	0.01	-0.01	-0.01	-0.00
Population 1872 (1,000s)	16.41	20.80	17.67	-3.13	-3.42	-1.11
Agricultural employment 1872	0.31	0.32	0.29	-0.03*	-0.03*	-0.03**
Justice work. 1872	0.24	0.23	0.29	0.06	0.05	0.04
Slave share 1872	0.14	0.17	0.15	-0.02	-0.00	0.00
White share 1872	0.38	0.43	0.41	-0.02	0.00	0.01
Literacy 1872	0.15	0.15	0.16	0.01	0.01	0.01
School attendance 1872	0.13	0.12	0.14	0.01	0.01	0.01
Distance (port/custom house)	249.70	221.06	186.05	-35.01	-3.86	1.69
Distance (city)	50.15	43.97	33.18	-10.80**	-8.22*	-6.47
Ruggedness	100.95	120.53	100.40	-20.13**	-11.35	-6.41
Altitude	401.77	495.58	404.27	-91.30**	-23.27	-4.27
Latitude	-14.25	-18.42	-16.44	1.98*	0.02	-0.16
Longitude	-43.58	-44.37	-43.02	1.35*	0.00	-0.07
Land quality	-0.01	-0.31	-0.30	0.01	-0.16	-0.13
Observations	605	168	77	245	245	245

Note: *** p<0.01, ** p<0.05, * p<0.1. Column (1) shows the average value of each variable for the whole sample (including municipalities never linked to the railroad). Columns (2) and (3) show the averages for the two groups of municipalities—those connected during a boom in aggregate immigration and those connected during a lull. Booms and lulls are defined and illustrated in Figure 1. Column (4) illustrates the results of a equality of means test; columns (5) and (6) do the same conditioning on regional and state fixed effects respectively. For this exercise we use minimum comparable areas rather than municipalities. This is necessary to link data across census years, given the creation and suppression of municipalities over time. Online Appendix Figure A.7 provides an illustration of minimum comparable areas and municipalities across the Brazilian territory created to link the 1872 and 1920 census data.

Table 2: European immigration and farm value

	Farm Value per hectare				**Land**	**Infrastructure**	**Tools & Machines**
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
					Panel A: OLS		
Share Europeans	0.587***	0.599***	0.596***	0.606***	0.570***	0.599***	0.430***
	(0.0571)	(0.0579)	(0.0570)	(0.0665)	(0.0660)	(0.0659)	(0.0549)
Observations	1,289	1,289	1,289	1,289	1,289	1,289	1,289
R^2	0.542	0.557	0.575	0.595	0.605	0.463	0.404
					Panel B: IV		
Share Europeans	0.691***	0.671***	0.733***	0.741***	0.732***	0.575***	0.749***
	(0.152)	(0.117)	(0.117)	(0.118)	(0.120)	(0.140)	(0.124)
Observations	1,289	1,289	1,289	1,289	1,289	1,289	1,289
1^{st}*stage* F-stat	16.87	22.21	22.61	22.31	22.31	22.31	22.31
Railway years	✓	✓	✓	✓	✓	✓	✓
No rail	✓	✓	✓	✓	✓	✓	✓
Geo Controls	✓	✓	✓	✓	✓	✓	✓
Region FE	✓	✓	✓				
Land adaptability		✓	✓	✓	✓	✓	✓
Land quality		✓	✓	✓	✓	✓	✓
Dom market access			✓	✓	✓	✓	✓
Int market access			✓	✓	✓	✓	✓
State FE				✓	✓	✓	✓

Note: *** p<0.01, ** p<0.05, * p<0.1. Robust standard errors in parentheses. The unit of observation is a municipality. All municipalities are included in the analysis. The IV regressions are estimated using the limited information maximum likelihood (LIML) estimator. The instruments are the predicted share of Europeans interacted with region indicators, which instrument for the actual share of Europeans. *Railway years* is the number of years with railway connection. *No rail* is an indicator variable for municipalities with no railway connection. *Geo controls* include surface area, ruggedness, altitude, latitude, and longitude. *Land adaptability* is the Herfindahl-Hirschman Index (HHI) of crop suitability. *Land quality* includes the first two principal components of suitability for all major crops reported in the census. *Dom market access* includes the linear and quadratic distance to the nearest city and principal town. *Int market access* includes the linear and quadratic distance to the nearest port or custom house. All continuous variables are standardized to have mean zero and standard deviation one.

Table 3: European immigration and farm value, robustness tests

	Farm Value per hectare							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Panel A: no immigrant colonies				***Panel B: no large coffee producers***			
Share Europeans	0.549***	0.606***	0.665***	0.658***	0.960**	0.700***	0.808***	0.669***
	(0.150)	(0.125)	(0.124)	(0.121)	(0.434)	(0.213)	(0.211)	(0.152)
Observations	1,159	1,159	1,159	1,159	1,157	1,157	1,157	1,157
1^{st}*stage* F-stat	17.47	21.20	21.34	22.01	7.92	10.61	10.91	13.27
	Panel C: no early railway connections				***Panel D: no large population centers***			
Share Europeans	0.500**	0.566***	0.662***	0.628***	0.788***	0.722***	0.799***	0.763***
	(0.207)	(0.147)	(0.155)	(0.164)	(0.252)	(0.159)	(0.173)	(0.149)
Observations	1,111	1,111	1,111	1,111	968	968	968	968
1^{st}*stage* F-stat	13.57	16.87	16.68	20.37	11.62	14.23	14.16	16.06
	Panel E: no industry hubs				***Panel F: no service hubs***			
Share Europeans	0.755***	0.714***	0.782***	0.863***	0.331	0.493**	0.593***	0.680***
	(0.135)	(0.113)	(0.115)	(0.114)	(0.292)	(0.193)	(0.209)	(0.161)
Observations	965	965	965	965	967	967	967	967
1^{st}*stage* F-stat	17.93	20.61	19.89	22.53	15.10	16.70	16.38	19.71
Railway controls	✓	✓	✓	✓	✓	✓	✓	✓
Geo controls	✓	✓	✓	✓	✓	✓	✓	✓
Region FE	✓	✓	✓		✓	✓	✓	
Land controls		✓	✓	✓		✓	✓	✓
Market access controls			✓	✓			✓	✓
State FE				✓				✓

Note: *** p<0.01, ** p<0.05, * p<0.1. Robust standard errors in parentheses. The unit of observation is a municipality. All municipalities are included in the analysis except those indicated in each panel. All regressions are estimated by instrumental variables using the limited information maximum likelihood (LIML) estimator. The instruments are the predicted share of Europeans interacted with region indicators, which instrument for the actual share of Europeans. *Railway years* is the number of years with railway connection. *No rail* is an indicator variable for municipalities with no railway connection. *Geo controls* include surface area, ruggedness, altitude, latitude, and longitude. *Land controls* include the Herfindahl-Hirschman Index (HHI) of crop suitability and the first two principal components of suitability for all major crops reported in the census. *Market access controls* include the linear and quadratic distance to the nearest city, principal town, port, and custom house. All continuous variables are standardized to have mean zero and standard deviation one.

Table 4: Farm values and foreign ownership

	Municipality-level data			*Farm-level data*		
	Foreign-owned farms	**Farm value per hectare**		**Land value per hectare**		
	(1)	(2)		(3)	(4)	(5)
Share Europeans	0.814***	0.890**	Share for. work.	0.159***		0.199***
	(0.0692)	(0.355)		(0.0241)		(0.0254)
For.-owned farms		-0.292	For. owner		0.0656	-0.177***
		(0.268)			(0.0533)	(0.0606)
Observations	1,289	1,289		40,693	40,693	40,693
1^{st} stage F-stat	22.31	9.71	R^2	0.395	0.380	0.398
All controls	✓	✓				
Municipality FE				✓	✓	✓

Note: *** p<0.01, ** p<0.05, * p<0.1. Robust standard errors in parentheses. Regressions in columns (1) and (2) are estimated by instrumental variables using the limited information maximum likelihood (LIML) estimator. The instruments are the predicted share of Europeans interacted with region indicators, which instrument for the actual share of Europeans. All municipalities are included in the analysis. Regressions in columns (3) to (5) are estimated by ordinary least squares (OLS) using data for the state of São Paulo. *All controls* include the number of years with railway connection, an indicator variable for municipalities with no railway connection, geographic characteristics (surface area, ruggedness, altitude, latitude, and longitude), land characteristics (the Herfindahl-Hirschman Index of crop suitability and the first two principal components of suitability for all major crops reported in the census), market access characteristics (linear and quadratic distance to the nearest city, principal town, port, and custom house), and state fixed effects. All continuous variables are standardized to have mean zero and standard deviation one.

Table 5: Potential mechanisms and European immigration

	Cultivated share of farms	**Coffee share**	**Cash crops share (no coffee)**	**Population density**	**Agricultural emp. density**	**Share farms with tools**	**Share farms with machines**
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Share Europeans	0.824***	1.027***	0.0243	-0.232	-0.0944	0.701***	0.0463
	(0.183)	(0.205)	(0.119)	(0.182)	(0.172)	(0.111)	(0.144)
Observations	1,287	1,285	1,285	1,296	1,296	1,289	1,289
1^{st} stage F-stat	22.29	22.26	22.26	22.35	22.35	22.31	22.31
All controls	✓	✓	✓	✓	✓	✓	✓

Note: *** p<0.01, ** p<0.05, * p<0.1. Robust standard errors in parentheses. The unit of observation is a municipality. All municipalities are included in the analysis. All regressions are estimated by instrumental variables using the limited information maximum likelihood (LIML) estimator. The instruments are the predicted share of Europeans interacted with region indicators, which instrument for the actual share of Europeans. *All controls* include the number of years with railway connection, an indicator variable for municipalities with no railway connection, geographic characteristics (surface area, ruggedness, altitude, latitude, and longitude), land characteristics (the Herfindahl-Hirschman Index of crop suitability and the first two principal components of suitability for all major crops reported in the census), market access characteristics (linear and quadratic distance to the nearest city, principal town, port, and custom house), and state fixed effects. All continuous variables are standardized to have mean zero and standard deviation one.

Table 6: Farm value and potential mechanisms

	Farm Value per hectare					
	(1)	(2)	(3)	(4)	(5)	(6)
Share Europeans	0.726***	0.508***	0.521***	0.745***	0.577***	0.268*
	(0.118)	(0.153)	(0.143)	(0.102)	(0.142)	(0.143)
			Panel A: Land use			
Cultivated share		0.396***				0.411***
		(0.0648)				(0.0626)
Coffee share			0.236***			0.0644**
			(0.0456)			(0.0325)
Other cash crops share			0.132***			0.0903***
			(0.0247)			(0.0205)
			Panel B: Labor force			
Pop density				0.138**		0.255***
				(0.0596)		(0.0691)
Agr. emp. density				0.150***		-0.0472
				(0.0455)		(0.0399)
			Panel C: Tools & Machines			
Share farms with tools					0.0221	0.00405
					(0.0186)	(0.0161)
Share farms with machines					0.189***	0.189***
					(0.0504)	(0.0415)
Observations	1,232	1,232	1,232	1,232	1,232	1,232
$1^{st} stage$ F-stat	22.18	15.64	15.64	24.63	16.50	11.40
All controls	✓	✓	✓	✓	✓	✓

Note: *** p<0.01, ** p<0.05, * p<0.1. Robust standard errors in parentheses. The unit of observation is a municipality. All municipalities are included in the analysis. All regressions are estimated by instrumental variables using the limited information maximum likelihood (LIML) estimator. The instruments are the predicted share of Europeans interacted with region indicators, which instrument for the actual share of Europeans. *All controls* include the number of years with railway connection, an indicator variable for municipalities with no railway connection, geographic characteristics (surface area, ruggedness, altitude, latitude, and longitude), land characteristics (the Herfindahl-Hirschman Index of crop suitability and the first two principal components of suitability for all major crops reported in the census), market access characteristics (linear and quadratic distance to the nearest city, principal town, port, and custom house), and state fixed effects. All continuous variables are standardized to have mean zero and standard deviation one.

Table 7: Gelbach decomposition for the European share coefficient

	Outcome			
	Farm	**Land**	**Infrastructure**	**Tools & machines**
	(1)	(2)	(3)	(4)
Mechanism				
			Panel A: Land use	
Cultivated share of farms	0.189***	0.174***	0.200***	0.120***
	(0.040)	(0.040)	(0.040)	(0.030)
Coffee share	0.017**	0.019**	0.001	0.035***
	(0.008)	(0.008)	(0.008)	(0.012)
Other cash crops share	-0.004*	-0.005*	-0.002	-0.005*
	(0.002)	(0.003)	(0.002)	(0.003)
Total land use	0.201***	0.188***	0.199***	0.150***
	(0.038)	(0.037)	(0.038)	(0.029)
			Panel B: Labor force	
Pop density	0.062*	0.054**	0.084*	0.016
	(0.032)	(0.027)	(0.048)	(0.011)
Agr. emp. density	-0.006	-0.003	-0.017	0.005
	(0.006)	(0.006)	(0.011)	(0.007)
Total labor force	0.056**	0.051**	0.067	0.020**
	(0.028)	(0.024)	(0.042)	(0.010)
			Panel C: Tools & Machines	
Share of farms with tools	0.056***	0.055***	0.037***	0.083***
	(0.011)	(0.012)	(0.010)	(0.016)
Share of farms with machines	-0.000	-0.000	-0.000	0.003
	(0.000)	(0.000)	(0.001)	(0.006)
Total tools & machines	0.056***	0.055***	0.037***	0.086***
	(0.011)	(0.012)	(0.010)	(0.018)
All mechanisms	0.313***	0.294***	0.304***	0.257***
	(0.044)	(0.041)	(0.054)	(0.036)

Note: *** p<0.01, ** p<0.05, * p<0.1. Robust standard errors in parentheses. The unit of observation is a municipality. All municipalities are included in the analysis. All regressions are estimated by ordinary least squares (OLS). The table presents the results of a Gelbach (2016) decomposition for the coefficients in columns (4)–(7) of panel A of Table 2.

Table 8: Implications for development and structural change

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Panel A: Human capital formation (literacy)							
	Population		**Brazilians**		**Females**		**Children**	
Share Europeans	0.818***	0.825***	0.771***	0.786***	0.747***	0.735***	0.762***	0.780***
	(0.183)	(0.172)	(0.182)	(0.173)	(0.189)	(0.163)	(0.164)	(0.153)
Observations	1,296	973	1,296	973	1,296	973	1,296	973
1^{st} stage F-stat	22.35	16.04	22.35	16.04	22.35	16.04	22.35	16.04
	Panel B: Economic structure							
	Employed Agriculture		**Employed Industry**		**Employed Services**			
Share Europeans	-0.419**	-0.379*	0.276	0.191	0.224	0.281		
	(0.187)	(0.194)	(0.192)	(0.181)	(0.228)	(0.219)		
Observations	1,295	972	1,295	972	1,295	972		
1^{st} stage F-stat	22.38	16.09	22.38	16.09	22.38	16.09		
	Panel C: Specialization (probability of being a hub)							
	Agriculture hub		**Industry hub**		**Service hub**			
Share Europeans	-0.182***	-0.189**	0.211**	0.0820	0.305***	0.269***		
	(0.0664)	(0.0799)	(0.0831)	(0.0908)	(0.0738)	(0.0919)		
Observations	1,296	973	1,296	973	1,296	973		
1^{st} stage F-stat	22.35	16.04	22.35	16.04	22.35	16.04		
	Panel D: Political Economy							
	Rentiers		**Pub. admin**					
Share Europeans	0.0964	-0.000116	-0.177	-0.00301				
	(0.174)	(0.221)	(0.168)	(0.174)				
Observations	1,296	973	1,296	973				
1^{st} stage F-stat	22.35	16.04	22.35	16.04				
	Panel E: Female participation in labor markets (female to male ratio)							
	Population		**Employed**		**Agriculture**		**Industry**	
Share Europeans	-0.462***	-0.535***	-0.199	-0.0612	-0.248	-0.0332	0.154	0.123
	(0.131)	(0.172)	(0.145)	(0.162)	(0.162)	(0.192)	(0.104)	(0.141)
Observations	1,296	973	1,295	972	1,295	972	1,295	972
1^{st} stage F-stat	22.35	16.04	22.38	16.09	22.38	16.09	22.38	16.09
All controls	✓	✓	✓	✓	✓	✓	✓	✓

Note: *** p<0.01, ** p<0.05, * p<0.1. Robust standard errors in parentheses. The unit of observation is a municipality. Regressions in columns (1), (3), (5), and (7) include all municipalities. Regressions in columns (2), (4), (6), and (8) exclude municipalities in the top 25 percentiles of population. All regressions are estimated by instrumental variables using the limited information maximum likelihood (LIML) estimator. The instruments are the predicted share of Europeans interacted with region indicators, which instrument for the actual share of Europeans. *All controls* include the number of years with railway connection, an indicator variable for municipalities with no railway connection, geographic characteristics (surface area, ruggedness, altitude, latitude, and longitude), land characteristics (the Herfindahl-Hirschman Index of crop suitability and the first two principal components of suitability for all major crops reported in the census), market access characteristics (linear and quadratic distance to the nearest city, principal town, port, and custom house), and state fixed effects. All continuous variables are standardized to have mean zero and standard deviation one.