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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 contribute substantially to agricultural development.

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 Williamson, 1998; Hatton and Ward, 2019; O'Rourke and Williamson, 1999). Within this historical context, this paper investigates the role of immigration in driving the development of the destination country's agricultural sector.

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, as well as 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. 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

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

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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,[2] we also investigate the contribution of immigration to the country's ongoing structural transformation.

The main empirical challenge that we face is the potential endogeneity of immigrants' location choice within Brazil. To address this challenge, we adapt to the Brazilian case an identification strategy developed by Sequeira et al. (2020) to study the effects of immigration in the United States during the Age of Mass Migration. 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 was the main means of transportation for immigrants to reach their destinations (Holloway, 1980; Lanza et al., 2023; Minale et al., 2024). Intuitively, we compare two municipalities, one of which was linked to the railroad just before a large national-level immigration inflow, and the other of which was linked just after. The former, by virtue of being more easily accessible to the large number of immigrant arrivals, is predicted to have had a greater population share of immigrants 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. To support this assumption, we show that municipalities linked just before immigration boom years were similar to those linked just before immigration lull years.

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.[3] Our main finding is that municipalities with a higher population share of European immigrants in 1920 had greater farm values per hectare, which we interpret as indicating greater development of the agricultural sector. Our preferred IV specification implies 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.[4] Second, the value of infrastructure, tools, and machines is linked directly to the development and productivity of the agricultural sector, which is our ultimate object of interest.

We find that changing land use patterns were the primary mechanism for immigration's effect on agricultural development. 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). This increase in cultivation intensity was responsible for about one quarter of the effect of immigration on farm values.[5] 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, at least in part, 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 well as by the differences in incentives faced by temporary immigrants relative to natives and permanent immigrants.[6]

Mirroring the broader debate in development economics, Brazilian historiography (Suzigan, 2000, pp. 23–47) raises the possibility that immigration, by facilitating agricultural development, slowed Brazil's structural transformation. To shed light on this issue, we study the total effect of immigration on a variety of outcomes related to Brazil's structural transformation.[7] We find that immigration did not slow, and in fact may have accelerated, Brazil's structural transformation. In particular, 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., Herrendorf et al., 2014; Caselli, 2005; 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 the participation of women in the labor force relative to men. 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.

1.1. Literature review and contribution

The main contribution of this paper is to advance the literature on the effects of immigration on the destination economy, and in particular that focusing on the effects of immigration on the destination country's agricultural sector.[8] The bulk of this literature focuses on the effects of immigration restriction on outcomes such as agricultural productivity, mechanization, crop mix, and innovation, typically over a short time horizon and in settings where agriculture was already well established.[9] In modern settings, much of this work is based on increases in the intensity of immigration enforcement in the United States, which is found to reduce immigrant labor supply and lead to

[2] See, for instance, Asher et al. (2023), Dinkelman et al. (2024), Prebisch (1962), Singer (1950).

[3] We also use data from the São Paulo Census of 1904–1905 (Secreteria da Agricultura, Commercio e Obras Publicas do Estado de São Paulo, 1906–1910), which includes detailed agricultural information, but only for the state of São Paulo.

[4] This is further supported by the fact that a higher share of European immigrants in population also generated an increase in the value of agricultural output per hectare. These findings indicate that, even if expectations of future productivity were priced into the value of land, immediate effects were also important.

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

[6] We do not claim that these incentives were the sole drivers of the increase in cultivation intensity, nor do we quantify the extent of their influence. Our goal is to show that the mechanism that we document is plausible in our context by discussing aspects of Brazilian immigration that may have contributed to increased cultivation intensity.

[7] Our goal here is to determine the *total* effect of immigration on structural transformation, not to separate the direct effect of immigration on structural transformation and the indirect effect of immigration-induced agricultural development.

[8] Other papers on this topic include Baldone et al. (2021), Richards (2018), San (2023), Abramitzky et al. (2023), Sequeira et al. (2020), Lafortune et al. (2015), Bazzi et al. (2016), Ifft and Jodlowski (2022), Kostandini et al. (2014), Lanza et al. (2023), Droller et al. (2023), Lew and Cater (2018), Clemens et al. (2018), Cance (1925). Escamilla-Guerrero et al. (2026) provide a more detailed review of this literature and the others discussed below.

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

declines in area cultivated, increases in innovation, shifts to a less labor-intensive crop mix, and rising agricultural wages (Ifft and Jodlowski, 2022; Kostandini et al., 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 (Clemens et al., 2018; Abramitzky et al., 2023), but to have driven mechanization (Lew and Cater, 2018; Abramitzky et al., 2023) and innovation (San, 2023).[10]

The effects of immigration restriction and enforcement, however, need not parallel the effects of immigration itself. A smaller set of historical studies focuses on the effects of immigration *per se* on agriculture. Using a network-based shift-share instrument, Lafortune et al. (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 et al. (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.

This paper—benefiting from unique features of the Brazilian economy, agricultural sector, and immigration experience—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. That is, our focus is on the seldom-studied interplay between agricultural development and immigration.[11] We show that immigration into an emerging agricultural economy can have substantial effects on the course of agricultural development, and in particular on land-use transformation.

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 (including 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. But the literature on the effects of immigration focuses largely on the modern United States (e.g., Abramitzky and Boustan, 2017; Card, 1990; Hanson, 2009; Kerr and Kerr, 2011; Borjas, 2003; Card, 2005) and other modern developed countries (e.g., Dustmann et al., 2016; Manacorda et al., 2012). Even historical studies of the United States during the Age of Mass Migration shed light on migration from poor to rich countries, as most US immigrants in this period came from countries with substantially lower wages (Williamson, 1995). Although there is a growing literature on the effects of immigration in developing countries,[12] more such work is needed. We enrich this literature by shedding new light on the effects of immigration in an agrarian economy at an early stage of development. Our results show that migration can have positive effects in a developing country 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), which has focused largely on the United States, especially in the latter years of this phenomenon (e.g., Tabellini, 2020; Abramitzky et al., 2023). Latin America remains understudied, with the existing literature focusing primarily on Argentina.[13] 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), has received relatively little attention. The value of studying Brazil is enhanced by the fact that its economy, institutions, and immigration experience were quite different from those of the United States and Argentina.

Finally, we add to the economics literature on immigration to Brazil during the Age of Mass Migration. Within this literature, this paper is most closely related to Lanza et al. (2023). 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 quasi-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. Beyond this, most research focuses on the long-run effects of European immigration, showing that nineteenth-century settlement patterns had persistent effects on development and human capital accumulation, measured in the later twentieth and twenty-first centuries.[14]

This paper provides the first causal study of the contemporaneous effects of immigration on agricultural development and structural change that covers the entirety of Brazil, all crops, and the whole of the immigration flow, whether subsidized or unsubsidized. It thus contributes 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). 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 (Holloway, 1980; Milliet, 1941; Monbeig, 1984; Vidal Luna et al., 2014; Colistete, 2015; Buciferro, 2021), 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.[15] 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 set it on the course of broad-based economic development.

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

[10] Lee et al. (2022) study Mexican repatriations from the United States in the 1930s, finding negative labor market effects on natives.

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

[12] See Böhme and Kups (2017), Verme and Schuettler (2021) for a review.

[13] The overall picture regarding the effects of immigration emerging from this literature is that immigration during this period induced industrialization, innovation, and overall development in the United States without harming native workers (e.g., Sequeira et al., 2020; Tabellini, 2020). Similarly, immigration enhanced industrialization in Argentina by providing capital and high-skilled labor to the industrial sector (Droller, 2018; Droller et al., 2023).

[14] See de Carvalho Filho and Monasterio (2012), Rocha et al. (2017), Witzel de Souza (2018), de Carvalho Filho and Colistete (2010), Stolz et al. (2013), Feler et al. (2016), Tang and Monteiro (2023), Minale et al. (2024), Nakaguma et al. (2023), Klein (1995).

[15] 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.

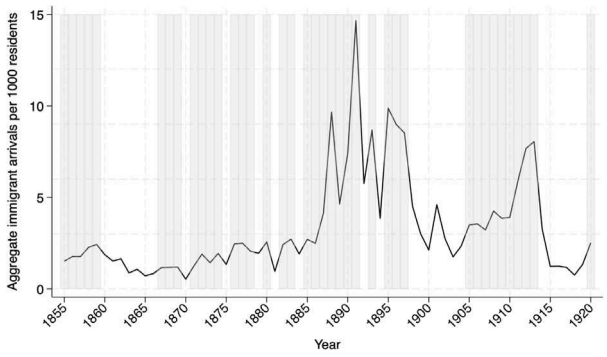


Fig. 1. Immigrant arrivals to Brazil by year, and immigration lulls and booms. *Note:* The graph shows immigrant arrivals in Brazil (1850–1920). Shaded areas are immigration booms, defined as years with an immigrant flow above the previous five years' moving average. The remaining periods are lulls. Gaps in the population data were linearly interpolated to calculate arrival rates. *Source:* Directoria Geral de Estatística (1908), Instituto Brasileiro de Geografia e Estatística (1954) for aggregate immigration numbers. Instituto Brasileiro de Geografia e Estatística (1954), Bolt and van Zanden (2020) for population numbers.

program—and 1900 (Fig. 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). The largest single group of immigrants in this period were from Italy, 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).

São Paulo state was the destination of most immigrants.[16] 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. Among food crops, maize stands out, making up about 24 percent of agricultural production. Overall, however, the agricultural sector was geared towards exports, despite strong growth in the internal market for food crops starting from the mid 19th century, principally driven by the rapidly expanding southeast (Pereira, 2026). Indeed, around 55 percent of the value of agricultural production in 1920 was made up of export-oriented crops (Instituto Brasileiro de Geografia e Estatística, 1990).

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. 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. 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.

The provision of land for *colonos* to cultivate food crops was seen as the most important part of their compensation. In practice, food crops were often cultivated on the same land on which coffee trees were planted—interrow cropping. The need to continue to provide this compensation to immigrants 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, pp. 74–78, 87–89; Sánchez-Alonso 2019, p. 13). The peculiar incentives faced by migrants did not escape foreign observers at the time. The French agronomist J. Picard (1903) observed that, because the *colonato* program gave immigrants ownership of the staple crops they planted, more care was exercised in their cultivation—care that also benefitted the cash crops for which the migrants were responsible.

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 (Lesser, 2013). Ultimately, it is estimated that about 46 percent of immigrants eventually returned to Europe (Levy 1974, p. 66, cited by Sánchez-Alonso 2019, p. 8),[17] with the highest rates among Italians, who were noted for aiming to accumulate savings before returning home (Sánchez-Alonso, 2019, p. 9) and for whom migration (and eventual return migration) was "part of a lifetime strategy for improving living standards at home" (Sánchez-Alonso, 2019, p. 19).[18]

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 receive medical attention or vaccinations after being registered. 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, 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 et al., 2023). The short time horizon in which to choose their final destination meant that immigrants had very little information about their final destination. This lack of choice and the limitations to free movement within Brazil for some time after arriving in the country led to widespread discontent

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

[17] 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). Note that it was not the case that 46 percent of immigrants returned to their home countries. Instead, 46 percent of arrivals resulted in a return, with many immigrants arriving and returning several times. For instance, if an immigrant entered four times and returned three times, this is a 75-percent gross return rate, but a zero percent net return rate because the immigrant remains in Brazil.

[18] 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). 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.

among immigrants, especially in the earlier phases of mass immigration (da Costa, 2000; Fausto, 1999).

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 (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 (Summerhill, 1997; Bignon et al., 2015). 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 led to bans on subsidized migration by several European governments (Lesser, 2013). These concerns encompassed both the conditions of immigrants on coffee plantations and those in migrant colonies—rural settlements for migrants created by private planters in cooperation with the state and which were viewed as being located in economically unfavorable locations (Cameron, 1931). Most notably, the 1902 Italian *Decreto Prinetti*, which made subsidized emigration illegal, was targeted mainly at limiting migration to Brazil.[19] 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 Fig. 1 shows, they did reduce its magnitude relative to population and led to a change in the distribution of migrants' countries of origin: Fig. 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.[20] The Spanish immigrants resembled the Italians in many ways—they were largely brought in by immigration subsidies, settled primarily in rural areas, and had high rates of return migration (or migration to other locations in Latin America). The Portuguese, on the other hand, were quite different. They were less likely to be subsidized, relying instead on networks deriving from Brazil's colonial history. They were also most likely of the three major immigrant groups to settle in urban areas, where they often entered the service sector (Sánchez-Alonso, 2007; Klein, 1992, 1993; Sánchez-Alonso, 2019).

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. As a result, the share of immigrants employed in manufacturing increased from about 0.8 percent in 1900 to 13 percent in 1920.

Although it is well established that immigrants were more numerate and literate than the Brazilian population (Rocha et al., 2017; Stolz et al., 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. The few studies addressing selection of Italian and Portuguese migrants, the two major immigrant groups in Brazil, provide mixed evidence.[21]

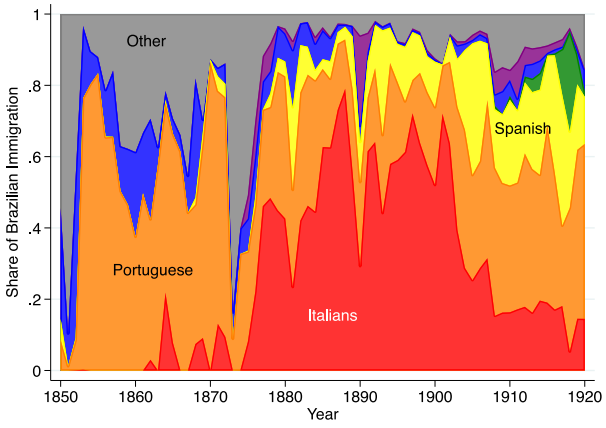


Fig. 2. Distribution of origin countries for Brazilian immigration.
Note: The graph shows the share of immigration to Brazil by source country (1850–1920). The color key is as follows: Italians (red), Portuguese (orange), Spanish (yellow), Japanese (green), Germans (blue), Russians (purple), and other (gray). (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)
Source: Directoria Geral de Estatística (1908), Instituto Brasileiro de Geografia e Estatística (1954).

Buciferro (2021) argues that immigrant laborers were intensively exploited by native landowners—a condition that immigrants were willing to endure only because working in agriculture offered opportunities to transition into farm ownership. Indeed, one of the incentives driving immigrants in exerting labor effort was the possibility of eventually owning land—the prospect of which was a strong pull factor for migrants, especially for Italians—and immigrants were reputed for their hard work and desire to save (Cinel, 1991; Sánchez-Alonso, 2007; Florea, 2023; Holloway, 1980; Lesser, 2013). Holloway (1980, pp. 140–142) points out that 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. Recent scholarship, however, 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

[19] 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).

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

[21] 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).

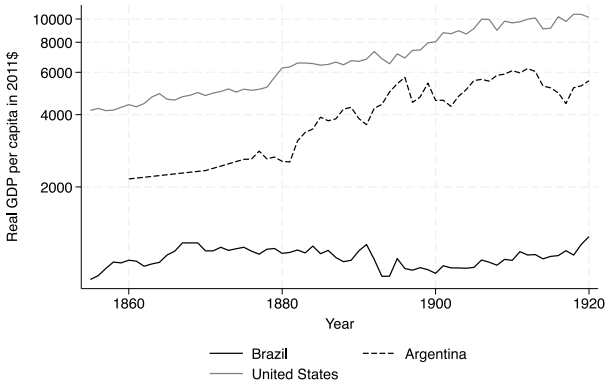


Fig. 3. Real GDP per capita in major immigrant destinations.
Note: The graph shows real GDP per capita (ca. 1850 to 1920) for Brazil and the other two major immigrant destinations in the Americas: Argentina and the United States.
Source: Brazil: Prados de la Escosura (2009), Barro and Ursúa (2008), Bolt and van Zanden (2020); US: Sutch (2006), Prados de la Escosura (2009), Bolt and van Zanden (2020); Argentina: Prados de la Escosura (2009), Bértola and Ocampo (2012), Bolt and van Zanden (2020).

immigrants were likely to become owners of small and medium-sized farms.

The effects of immigration on other aspects of Brazilian economic development remain the subject of debate. 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). Insofar as immigration drove the development of this sector, it may have thus delayed or accelerated industrialization, compounding or counteracting any direct effects of immigration on industry.

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, and, in Argentina's case, the agricultural sector's share of the economy (Lesser, 2013; Droller and Fiszbein, 2021). 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 Fig. 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). Commodity production was also uniquely important in Brazil relative to these other countries. In addition, the concentration of Brazilian immigrants in agriculture was unique in comparison to Argentina and the 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 Fig. 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 et al., 2012).

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.[22] 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.

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. 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 (or not) to enabling the cultivation of coffee.

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.[23] Similarly, as discussed above, the *colonato* contract, under which many immigrants worked, also created a unique set of incentives that may have driven 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 (Lewis, 1954; Schultz, 1964). It has been posited that greater agricultural productivity could encourage structural transformation (Herrendorf et al., 2014; Caselli, 2005; Dinkelman et al., 2024; Johnston and Mellor, 1961; Timmer, 1988; Montero and Yang, 2022). On the other hand, it has also been suggested that 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; Singer, 1950; Prebisch, 1962). The existing empirical literature is equally ambiguous (Foster and Rosenzweig, 1996; Hornbeck and Keskin, 2015; Bustos et al., 2016, 2020; Asher et al., 2023), suggesting that the effect of agricultural development may be strongly context-dependent.

[22] 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. But 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. Similarly, such an identification strategy will not be able to capture effects of immigration on the national-level labor force, which may have been important in helping to drive frontier development.

[23] See Dustmann (1994, 2000), Dustmann et al. (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), Wahba (2022).

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).[24] 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 constrains our analysis to a cross-sectional design, the census provides a very rich set of variables at the municipality level that capture economic, population, human capital, and labor force characteristics. 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*. 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). Combined with information on the size of farms, these data enable us to compute our main outcome variable—the average value of farms per hectare of land. The census reports farm value in total and broken down into three components—land, infrastructure, and tools and machinery—which we also analyze separately.

Farm values are intended to measure agricultural development, which includes any factor making the local agricultural sector more productive and valuable. Two components of farm value—infrastructure and tools and machines—are directly related to the development and productivity of the agricultural sector. The other component, land, as an immobile factor of production, will capitalize in its value any local characteristic that improves agricultural productivity. Land values will also capture both backward- (resulting from past investments capitalized in farm values) and forward-looking (resulting from the expected trajectory of the local economy) aspects of development, thus capturing the long-term productive potential of the local agricultural sector.

While agricultural development will, for these reasons, lead to increases in farm values, this measure may also capture some other features of development and of local economies. In addition to agricultural development, land values will also capitalize local amenities and other characteristics, including expectations about other aspects of a location's future development, that are unrelated to agricultural development.

For two main reasons, we are confident that the results reported below are not confounded by these potential issues of interpretation. That is, that even if local non-agricultural amenities and expectations (including expectations about agricultural productivity, which we are interested in capturing) were priced into land values, effects on agriculture, both immediate and long-term, were also important. First, we will show that our results hold not only for farm values in total or for land values, but for each of the several components of farm value.

Second, we also find supportive evidence from an alternative measure of agricultural productivity. In particular, we use data from the 1920 census on total agricultural production broken down into 14 crops. 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. We use these variables as alternative measures of agricultural development, and our results for these outcomes further support our findings. For our main analysis, we prefer to focus on farm values rather than on output. As argued, farm values reflect the long-run productivity of the local agricultural sector, and are therefore a more reliable measure of the permanent effects of immigration on agricultural development than output observed at a single point in time. Output in 1920, by contrast, would have been determined in large part by idiosyncratic shocks and short-run cropping decisions, making it a noisier proxy for the underlying productivity gains we seek to capture.

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). To measure land use, we use data on the share of farm land cultivated and the share of cultivated farmland by planted crop. We also measure the use of tools and machines in agriculture (beyond the value measures). 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.

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. 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. 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. 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.[25] 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.

Our identification strategy also relies on annual variation in aggregate immigrant arrivals in Brazil and variation in railway access

[24] Online Appendix B lists the specific sources within this census that we use.

[25] We discuss this potential issue of interpretation in more detail below.

at the municipality level. We obtain data on immigrant arrivals from Directoria Geral de Estatística (1908), 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 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.[26] 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, 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.[27]

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, Commercio e Obras Publicas do Estado de São Paulo, 1906–1910). The data from this source are similar to those coming 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.

[26] 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 Fig. A.5.

[27] 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.

4.6. Summary statistics

Online Appendix Tables A.1 and A.2 present summary statistics for all of the variables in our dataset. Fig. 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. 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 Fig. A.4).

Panel (a) of Fig. 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.[28] There appears to have been an important regional component to the rail network. Rail was virtually absent from the north, and evolved into several geographically distinct networks rather than one unified one.

5. Empirical strategy

5.1. Estimating equation

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

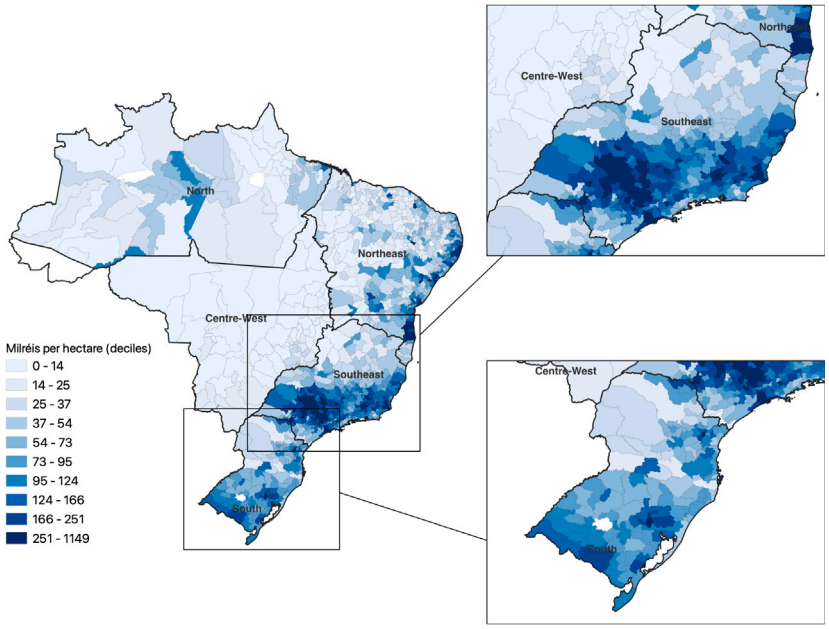
$$f_i = \psi s_i + \mathbf{x}_i' \Pi + \lambda_j + \epsilon_i,$$

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.[29] Our main results are reported with robust standard errors, but all results are robust to various corrections for spatial correlation (Colella et al., 2020; Conley, 1999), as we show in Online Appendix C.

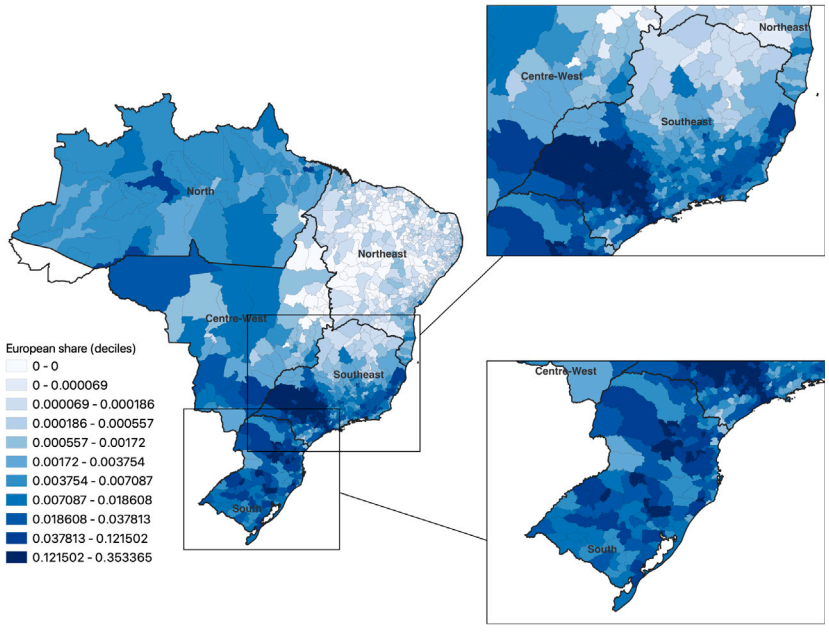
Regardless of the richness of our controls, estimating the causal impact of immigration on agricultural development is complicated

[28] The first railway station was completed in 1854. Online Appendix Fig. 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; Summerhill, 2003; Sequeira et al., 2020).

[29] 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). As we explain below in discussing our instrumentation strategy, we also 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.



(a) Farm value per hectare



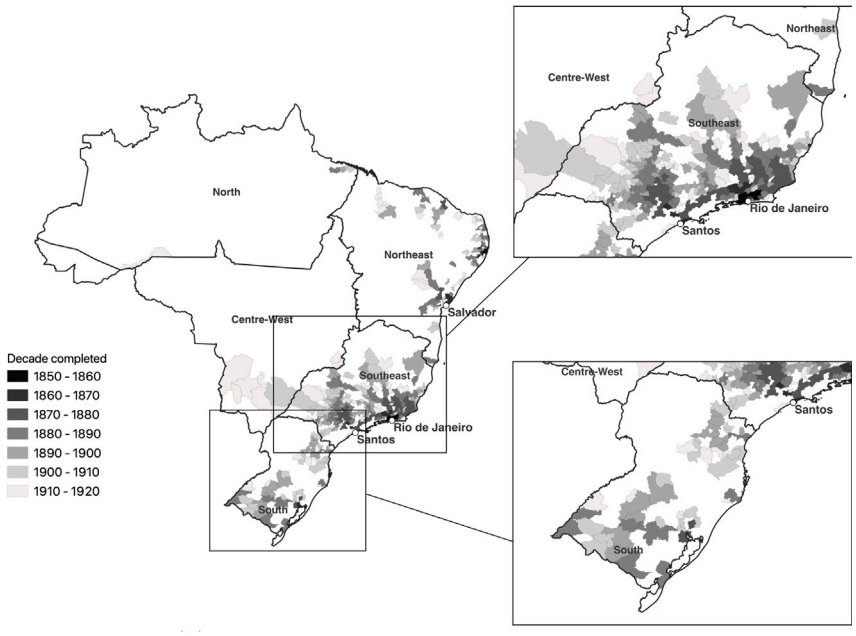
(b) Population share of European immigrants

Fig. 4. Farm values and immigration.
Note: The maps display the spatial distribution of (a) farm value per hectare and (b) the population share of immigrants. The magnified areas illustrate the variation in these variables within and across regions.
Source: Directoria Geral de Estatística (1922), Instituto Brasileiro de Geografia e Estatística (2011)

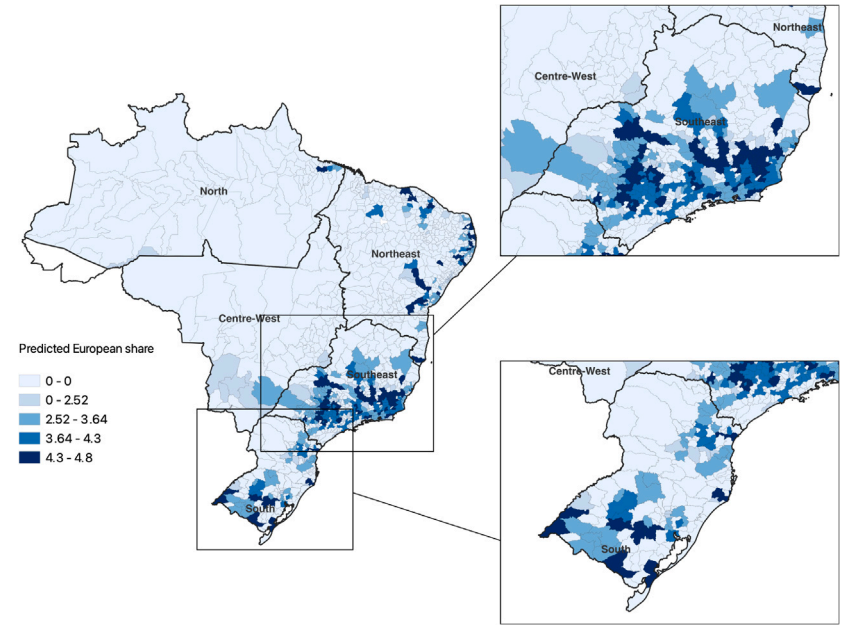
by the likely endogeneity of immigrants' destination choices.[30] For instance, immigrants may have settled in places with better land quality (beyond our ability to control for it), or where other factors, such as better management, were available. Immigrants' settlement patterns may also have been 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

[30] Notably, Lanza et al. (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.



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



(b) Predicted share of European immigrants

Fig. 5. Geographic distribution of the railway and the instrument.
Note: The maps display (a) the rollout of Brazil's railway network over time and (b) the predicted share of European immigrants.
Source: Giesbrecht (2023), Directoria Geral de Estatística (1922), Instituto Brasileiro de Geografia e Estatística (2011).

did not settle in the most economically favorable locations, meaning that our estimates might instead be biased downwards. As discussed in Section 2, immigrant colonies were located in less favorable locations and immigrants 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.[31]

[31] In Online Appendix Table A.3, we characterize the differences, in terms of a variety of 1872 municipality variables and geographic characteristics, between municipalities that would have a higher and lower share of Europeans in population in 1920. We do this unconditionally, as well as conditional on geographic fixed effects. In order to use the 1872 census for this test, we aggregate our 1920 municipalities into larger minimum comparable areas (Online Appendix Fig. A.7). Unsurprisingly, we find that municipalities that would later host a higher share of immigrants were different from other municipalities. 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.

5.2. Instrumental variables strategy

To overcome the identification challenge, we implement an instrumental variables strategy based on the interaction of immigrant inflows and the expansion of the Brazilian rail network, following Sequeira et al.'s (2020) study of the effects of immigration during the Age of Mass Migration in the United States.[32] 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 immigrants 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 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 $t-1$,[33] and θ_i is the number of years that municipality i had been connected to the railway network by 1920.[34]

Panel (b) of Fig. 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.[35] 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 E, 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 et al. (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. In our baseline specifications, the control for years of rail linkage in 1920 is linear, but our results are qualitatively insensitive to the use of alternative functional forms.[36] 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 Sequeira et al.'s (2020) and Minale et al.'s (2024) 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).[37] But, again as in their applications, the non-linearity of the instrument is not arbitrary, but is instead the product of actual variations in Brazilian immigration rates. The combination of the 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 ensures that the identification derives not from how long a place was linked to the rail network but by the interaction of when a municipality was first linked to the railroad and the state of the national-level immigration

[32] Minale et al. (2024), Droller (2018), Panza and Zylberberg (2024) use similar identification strategies in Brazil and in other settings.

[33] 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. In Online Appendix D, 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 100 km of its own has a rail station.

[34] This equation captures a number of refinements that we make to Sequeira et al.'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 et al.'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. 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. Another departure that we make from Sequeira et al.'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 et al.'s (2020) identification strategy, it is used in that paper to establish the relevance 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 et al. (2024).

[35] Abadie et al. (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), Jackson et al. (2016), Dix-Carneiro and Kovak (2017), Pascali (2017), provides more reliable estimates. Abadie et al. (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 Fig. 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.

[36] 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.

[37] We illustrate this nonlinearity graphically in Online Appendix Fig. A.9. Our normalization by years linked to the network provides further non-linearity.

cycle—specifically, fluctuations in the immigration cycle that deviate from the functional form used to control for years of linkage—when it first became linked. More simply, identification comes from when *in the immigration cycle* a municipality first becomes linked to the rail network. For instance, two municipalities connected just one year apart may have very different predicted immigration shares if one was connected just before an immigration boom and the other just before a lull, due to the sharp discontinuity in the immigration cycle between these years.

In this framework, compliers with the instrument — which drive the local average treatment effect (LATE) that it identifies — are municipalities that received a larger immigrant share in population because they happened to be linked to the rail network just before a large immigrant inflow (and vice versa), but that otherwise would not have attracted as high a share of immigrants. Such a municipality was likely on the frontier, and may have been linked only because it happened to lie between two targeted endpoints, and also happened to become linked at just the right time in the immigration cycle. Thus, for instance, large cities or extremely productive agricultural areas that would likely have attracted immigrants regardless of the timing of rail linkage do not drive the LATE. However, as we will show below, the IV and OLS estimates are quite similar, meaning that there is reason to believe that the LATE that we identify and the average treatment effect (ATE) of immigration were not very different.

As in other applications 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.[38] Thus, perhaps the main identification concern facing our instrument is that municipalities connected to the railway network just before immigration boom years may have been systematically different from those connected just before lull years. For instance, 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. 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 (Spitzer, 2015; Hatton and Williamson, 1998; Spitzer et al., 2025; Sequeira et al., 2020).

To address these concerns more formally, we follow Sequeira et al. (2020) by comparing the observable characteristics of locations that became linked just before immigration lull years to those linked just before boom years. 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 thousand 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 boom and lull years are identified in Fig. 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, come with respect to geographic variables, likely because of the gradual rollout of the railway from the coast. Columns (5) and (6) repeat the analysis controlling for region and state fixed effects respectively (which we include in our analysis). In column (6) there are statistically significant differences between the two groups only in ruggedness and longitude. There is also a marginally significant difference in literacy. As we will show below, our results are robust to controlling for all of these covariates. Thus, the evidence does not support concerns that railway expansion may have responded to immigrant inflows or vice versa.

Given the prevalence of return migration in the Brazilian context, it is important to consider its potential impact on the validity and interpretation of our results. If migrants systematically remained in more productive areas and left less productive ones, this would create an artificial correlation between the 1920 immigrant share and agricultural outcomes.[39] The historical evidence provides little support for such an effect: return migration appears to have been planned rather than a response to local economic conditions (Sánchez-Alonso, 2019), and return rates were higher among immigrants in industry and commerce than in agriculture (Cinel, 1991). Moreover, our instrumental-variables strategy directly addresses this concern, since return migration does not affect the relationship of the timing of rail linkage and the immigration cycle.

Return migration does, however, affect the interpretation of our estimates. Our data enable us to study the effect of a higher share of immigrants in population in 1920. Return migration could lead this share to fail to represent total immigration to a municipality over the duration of the Age of Mass Migration, the effect of which is of interest as well. The difference between these two objects depends on where immigrants were more likely to return from and on the characteristics of those who returned. If, as the limited existing evidence suggests (Sánchez-Alonso, 2019), return migrants were positively selected, then municipalities from which they departed would have had a lower immigrant share in 1920 despite having benefited from the presence of these more productive immigrants while they resided there. But those same municipalities would also have lost the ongoing contributions of their most productive immigrants. The net effect on our estimates is therefore ambiguous. Ultimately, the lack of any systematic data on return migration does not allow us to do more than note this potential issue of interpretation.

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. Our results are also insensitive to the inclusion of state fixed effects (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.

[38] This implies that, even if areas with greater potential for economic or agricultural development were linked earlier, our identification would not be jeopardized unless this timing was also influenced by the cyclicality of the immigration cycle.

[39] The same would be true of systematic internal migration, insofar as internal migration out of a location is, for our purposes, equivalent to a return to the country of origin in that it removes an immigrant from a municipality.

Table 1
Balance test for observables: rail connection just before immigration boom years and lull years.

	Full sample	Boom	Lull	Difference	Cond. Diff. Regions	Cond. Diff. States
	(1)	(2)	(3)	(4)	(5)	(6)
Euro share 1872	0.01	0.02	0.02	−0.00	−0.00	−0.00
Population 1872 (1,000s)	16.41	20.05	19.67	−0.38	0.23	0.21
Agricultural employment 1872	0.31	0.31	0.31	−0.00	−0.00	−0.00
Justice work. 1872	0.24	0.24	0.28	0.04	0.05	−0.03
Slave share 1872	0.14	0.17	0.15	−0.02	−0.00	−0.01
White share 1872	0.38	0.42	0.41	−0.01	−0.01	0.00
Literacy 1872	0.15	0.16	0.14	−0.02	−0.02**	−0.02*
School attendance 1872	0.13	0.13	0.14	0.01	0.01	−0.00
Distance (port/custom house)	249.70	224.13	176.08	−48.05**	−41.67**	−11.44
Distance (city)	50.15	43.83	31.16	−12.67**	−14.36***	−4.93
Ruggedness	100.95	108.42	130.68	22.27**	28.25***	32.27***
Altitude	401.77	482.36	439.08	−43.28	−10.11	11.51
Latitude	−14.25	−17.99	−17.62	0.37	0.05	−0.10
Longitude	−43.58	−44.39	−42.83	1.56**	1.22***	0.48**
Land quality	−0.01	−0.37	−0.23	0.14	0.22	0.02
Observations	605	171	71	242	242	242

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 just before a boom year in aggregate immigration and those connected just before a lull year. Booms and lulls are defined and illustrated in Fig. 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 Fig. 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***
	(0.057)	(0.058)	(0.057)	(0.067)	(0.066)	(0.066)	(0.055)
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
1st 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.

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 (Stock and Yogo, 2005; Bound et al., 1995).[40] Our IV estimates corroborate the OLS estimates 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.

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

In columns (1)–(4) of Online Appendix Table A.5, we extend 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.

Online Appendix G presents the results of a number of tests of robustness of our main results. First, Online Appendix Tables G.1 and G.2 verifiy that our results are robust to the exclusion of certain groups of municipalities from the sample. Second, Online Appendix Table G.3 shows that randomly reassigning rail linkage years within the set of ever-linked municipalities fails to replicate our results. Finally, Online Appendix Table G.4 demonstrates that our results are robust to controlling for the 1872 characteristics listed in Table 1. We also find that 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.6, we divide the immigrant share into its constituent national origin components—Italians, Spanish, Portuguese, and others.[41] Interestingly, we find that, only Italian and Spanish immigrants appear to have had an impact on farm values. As discussed above, the Italian and Spanish immigrants were similar in terms of their propensity to enter agriculture, their reliance on immigration subsidies, and their propensity to return migration, whereas Portuguese immigrants were more likely to be unsubsidized and to enter the urban service sector. It is thus unsurprising that the Portuguese do not drive agricultural development.

In Table 3, 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.[42] 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.[43] 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.[44]

The 1920 census permits only the observation of the share of Europeans in a municipality's population. The 1904–1905 Agricultural Census of the State of São Paulo, however, enables us to explicitly separate native- and foreign-born agricultural workers. It 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, Commercio e Obras Publicas do Estado de São Paulo, 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. Column (3) of Table 3 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*.[45]

This finding is in 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 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.

7. Mechanism

We now examine the primary mechanism for the effect of European immigration on farm values per hectare. Our focus in this section is on what we identify as the most important mechanism—immigration leading to more intense cultivation of land. We also briefly discuss other potential mechanisms—developed more completely in Online Appendix H—which we find to either have not been present or to have been present but less important than the cultivation intensity mechanism. The tables discussed in this section present estimates both for the cultivation intensity mechanism and for the mechanisms discussed in the appendix.

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 or forest). Column (1) of Table 4 presents the results of our instrumental variables regression of the share of farm land cultivated on the European immigrant share of population. It shows that a one-standard deviation increase in the population share of European immigrants increased the share of farm land cultivated by 0.8 standard deviations.[46] Column (2) of Table 5 repeats our original IV regression

[41] Each column is a single regression. 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 Fig. A.4. Online Appendix Table A.7 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.

[42] Online Appendix Fig. A.10 presents the spatial distribution of foreign farm ownership.

[43] About 12 percent of nationwide agricultural establishments (Directoria Geral de Estatística, 1922, Volume III, 1ª Parte: Agricultura, p. XXVIII) and 8.6 percent in the average municipality (Online Appendix Table A.1) were foreign owned.

[44] 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.

[45] In Online Appendix Table A.8, 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.

[46] A natural concern is that, rather than being the product of immigration, increased cultivation intensity was a factor that attracted immigration. A related concern is that immigrants disproportionately moved to areas already on a path of agricultural expansion. While such sorting may have occurred, our identification strategy ensures that such issues do not drive our conclusions. In particular, the results of Table 4 are based on the use of our instrumental variables approach. If, as we have argued and demonstrated above, there was not a correlation between timing of rail linkage and the aggregate immigration cycle, then the results of this table indicate that there truly was an effect of immigration on cultivation intensity. Moreover, we show in Online Appendix Table A.9 that this finding is robust to adding 1872 controls. That said, we cannot rule out that there was also a degree of a relationship in the opposite direction, though the mere presence of such a relationship would not invalidate our results. However, the lack of an effect of immigration on population density or agricultural employment density, discussed below, suggests that a mechanism in which rising local demand spurred increased cultivation is unlikely to have been present.

Table 3
Farm values and foreign ownership.

	Municipality-level data		*Farm-level data*			
	Foreign-owned farms (1)	Farm value per hectare (2)		Land value per hectare (3)	(4)	(5)
Share Europeans	0.814***	0.890**	Share for. work.	0.159***		0.199***
	(0.069)	(0.355)		(0.024)		(0.025)
For.-owned farms		−0.292	For. owner		0.0656	−0.177***
		(0.268)			(0.053)	(0.061)
Observations	1,289	1,289		40,693	40,693	40,693
1st 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 4
Potential mechanisms and European immigration.

	Cultivated share of farms (1)	Coffee share (2)	Cash crops share (no coffee) (3)	Population density (4)	Agricultural emp. density (5)	Share farms with tools (6)	Share farms with machines (7)
Share Europeans 1920	0.824***	1.027***	0.024	−0.232	−0.094	0.701***	0.046
	(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
1st 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.

of farm value on the European share of population, but controls for the share of farmland cultivated.[47] 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 6, which shows that it was the cultivated share of farms that was responsible for the bulk of the reduction in the effect of the population share of European immigrants on farm values when controls are added.[48] 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 population share of European immigrants on the value of agricultural production per hectare, columns (5)–(8) reveal no effect (or perhaps even a slight negative effect) 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

The presence of a cultivation intensity mechanism is consistent with a number of aspects of Brazilian immigration, as discussed in Section 2, and with some of the potential mechanisms discussed in Section 3. In particular, the high rates of return migration and goal of accumulating savings to take back to the home country may have driven this increase. Efforts to accumulate savings in order to transition out of plantation work and into independent land ownership would have operated similarly.[49] Moreover, the unique features of the *colonato* contract also incentivized more intensive cultivation of the land, as discussed above.[50] The impacts of these factors would have been realized in the short term, before immigrants' returns to their home countries

[47] We do this while recognizing that potential endogeneity of the share of farmland cultivated is not addressed in this regression. However, having established a causal relationship between immigration and cultivation intensity in Table 4, we are not concerned that we are capturing a spurious relationship.

[48] 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.

[49] This interpretation can explain both the results from the cultivation intensity mechanism and are consistent with our findings in Table 3 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.

Table 5
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***
		(0.065)				(0.063)
Coffee share			0.236***			0.064**
			(0.046)			(0.033)
Other cash crops share			0.132***			0.090***
			(0.025)			(0.021)
Panel B: Labor force						
Pop density				0.138**		0.255***
				(0.060)		(0.069)
Agr. emp. density				0.150***		−0.047
				(0.046)		(0.040)
Panel C: Tools & Machines						
Share farms with tools					0.022	0.004
					(0.019)	(0.016)
Share farms with machines					0.189***	0.189***
					(0.050)	(0.042)
Observations	1,232	1,232	1,232	1,232	1,232	1,232
1st 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.

or transitions into land ownership. But the impacts would also have been persistent. For instance, land cleared to be brought into cultivation would have then been available for future production; indeed the new coffee trees planted there would continue to be productive for many years thereafter. We do not claim that these are the only ways in which immigration drove increases in cultivation intensity; other aspects of immigration may also have been responsible. Instead, these interpretations demonstrate that the mechanism that we propose is plausible in our context.[51]

7.3. Other mechanisms

In Online Appendix H, 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 associated with greater population density or agricultural employment density (Table 4, columns 4 and 5), ruling out a mechanism in which immigrants were uniquely responsible for the provision 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 increased the size of Brazil's aggregate labor force, they "crowded 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, in particular towards greater coffee production. While we do find that a greater immigrant share led to more coffee cultivation (Table 4, column 2), 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 6.

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 (Table 4, columns 6 and 7), of machine adoption on farm values (Table 5 columns 5 and 6), and of tool adoption on the coefficient on the population share of European immigrants (Table 6). But we also find that the magnitude of this mechanism was small relative to the cultivation intensity mechanism. In other contexts, such as the United States, there is evidence that immigrant labor was a substitute for mechanization

[50] Online Appendix Table A.10 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 3 and Online Appendix Table A.8, 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.

[51] This plausibility is enhanced by the fact that, as we have shown above, the bulk of the effects of immigration was the product of Italian immigrants, for whom the incentives described below were most salient.

in agriculture (e.g., Abramitzky et al., 2023). That we find no such effect in Brazil, and instead find an increase in the adoption of a complementary input—tools—is notable.

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. The effects of immigration-driven agricultural development on these outcomes, in combination with immigration's direct effect, 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. To be clear, we are not aiming to determine the effect of agricultural development driven by immigration on structural transformation; instead, our goal is to measure the net effect of immigration.

An important caveat is that we can only answer this question in the relatively 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 et al., 2024).

In Table 7, we implement our IV strategy for 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 sex ratios (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). 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.

In Online Appendix Table A.11 we try to distinguish to some extent between the direct effects of immigration on structural transformation and the indirect effect, through agricultural development. In particular, we include the outcome of our main analysis (farm values) as a control in the structural transformation regressions of Table 7. The pattern that clearly emerges is that the effects of immigration on structural change and broader economic development are not mediated by 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 estimated effects of immigration on broader development remain qualitatively unchanged even after including farm values.[52] That is, immigration had parallel effects on agricultural development and structural transformation, but the effect on structural transformation did not depend on the effect on agriculture.

8.1. Human capital

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 7 that European immigration had a strong positive 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, and specifically on the share of the labor force employed in agriculture, in industry, and in services. These 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 et al., 2021). We operationalize these measures by using the share of the labor force employed in agriculture, industry, and services (excluding domestic service). These measures give an indication of the degree to which immigration aided or slowed down structural change.

We find in Panel B of Table 7 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, we classify certain areas 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). Indeed, many parts of Brazil were characterized by a large-plantation-based agricultural sector and connected oligarchic system known as *coronelismo*, in which

[52] Because our identification strategy does not provide instruments for both immigration and agricultural development, we are not able to rule out the possibility that immigration may have had an even stronger impact on structural transformation if it had not also driven agricultural development. This is an interesting area of exploration for future work.

Table 6
Gelbach decomposition for the European share coefficient.

	Outcome			
	Farm (1)	Land (2)	Infrastructure (3)	Tools & machines (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.

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). 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 et al., 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 ratios

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 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).

As expected, we find in Panel E of Table 7 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 significant change in the sex ratio in either overall employment or employment in agriculture and industry. Indeed, the point estimates suggest an *increase* in the female-to-male ratio in industrial employment as a result of immigration. These results indicate that women were not displaced from the labor force by the overwhelmingly male immigrant flow.

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

Table 7
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
1st 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		
1st 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**	0.082	0.305***	0.269***		
	(0.066)	(0.080)	(0.083)	(0.091)	(0.074)	(0.092)		
Observations	1,296	973	1,296	973	1,296	973		
1st stage F-stat	22.35	16.04	22.35	16.04	22.35	16.04		
Panel D: Political Economy								
	Rentiers		Pub. admin					
Share Europeans	0.096	−0.000	−0.177	−0.003				
	(0.174)	(0.221)	(0.168)	(0.174)				
Observations	1,296	973	1,296	973				
1st stage F-stat	22.35	16.04	22.35	16.04				
Panel E: Sex Ratios (female to male)								
	Population		Employed		Agriculture		Industry	
Share Europeans	−0.462***	−0.535***	−0.199	−0.061	−0.248	−0.033	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
1st 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.

human capital accumulation, reducing agricultural employment, increasing employment in industry and 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; US Congress, 1911; Goldin, 1994). 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; Zimran, 2022; Coulter, 1909). 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.

CRediT authorship contribution statement

David Escamilla-Guerrero: Writing – review & editing, Writing – original draft, Visualization, Validation, Supervision, Software, Resources, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization. **Andrea Papadia:** Writing – review & editing, Writing – original draft, Visualization, Validation, Supervision, Software, Resources, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization. **Ariell Zimran:** Writing – review & editing, Writing – original draft, Visualization, Validation, Supervision, Software, Resources, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization.

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Appendix A. Supplementary material

Supplementary material related to this article can be found online at https://doi.org/10.1016/j.jdeveco.2026.103861.

Data availability

Data and code to replicate the analysis described in this paper are available at https://data.mendeley.com/datasets/pzgkvp3mnk/1.

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