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## Abstract

Historical German migration to Central Europe made a persistent impact on local economic development. After prolonged warfare between the Habsburg and Ottoman Empires, German speaking agricultural settlers helped repopulate newly conquered parts of Hungary during the 18th century. Exploiting spatial variation across more than 5,000 towns and villages in areas affected by German immigration, and instrumenting immigrants' settlement locations with exogenously determined migration routes, we find that geographical proximity to 18th-century German settlements increased farm productivity until the early 20th century. This effect is persistent over time and robust to controlling for initial conditions, geography, religion, and other potential confounding factors. Consistent with historical accounts, we show empirically that areas of German settlement had higher land productivity because of stronger specialization in crop farming and viniculture and more intensive farming. Even a century after immigration, we find limited diffusion of agricultural knowledge from German settlement areas.



JEL Classification: N13, N54, N93, O13, O15

Keywords: Immigration, Development, agriculture, Persistence, Habsburg empire



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# Immigration and Development: German-Speaking Agricultural Settlers in the Kingdom of Hungary

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September 21, 2022

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Historical German migration to Central Europe made a persistent impact on local economic development. After prolonged warfare between the Habsburg and Ottoman Empires, German speaking agricultural settlers helped repopulate newly conquered parts of Hungary during the 18th century. Exploiting spatial variation across more than 5,000 towns and villages in areas affected by German immigration, and instrumenting immigrants' settlement locations with exogenously determined migration routes, we find that geographical proximity to 18th-century German settlements increased farm productivity until the early 20th century. This effect is persistent over time and robust to controlling for initial conditions, geography, religion, and other potential confounding factors. Consistent with historical accounts, we show empirically that areas of German settlement had higher land productivity because of stronger specialization in crop farming and viniculture and more intensive farming. Even a century after immigration, we find limited diffusion of agricultural knowledge from German settlement areas.

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# 1 Introduction

International migration has long been an important topic in economics (Giersch, 1994; Hatton and Williamson, 2005; Hatton, 2010; Abramitzky and Boustan, 2017). An extensive literature discusses the short-term impact of immigration on local economic outcomes.[1] Building on a large body of scholarship on historical persistence (Mokyr, 1992; Nunn, 2009, 2014, 2020; Spolaore and Wacziarg, 2013), a growing number of studies document that immigration can have persistent economic effects.[2] For example, European colonizers profoundly influenced development outcomes in their former dependencies by establishing either growth-enhancing or growth-inhibiting institutions (Acemoglu *et al.*, 2001, 2014) and by transferring human capital and technology (Glaeser *et al.*, 2004; Putterman and Weil, 2010; Easterly and Levine, 2016). Mass migration between Europe and the Americas in the late 19th century was instrumental in expanding the frontier of the global economy and in forging an international labor market (Hatton and Williamson, 1998; O'Rourke and Williamson, 1999; Sánchez-Alonso, 2019). The bulk of this literature, however, has focused on industrial economies and overseas migration. We have comparatively limited understanding of how international migration affected pre-industrial development. This is critical given the recent scholarship on the cultural and economic legacies of pre-modern agricultural development (Vollrath, 2011; Alesina *et al.*, 2013; Talhelm *et al.*, 2014; Chen and Kung, 2016; Galor and Özak, 2016; Ang, 2019).

We aim to fill this knowledge gap. From the Middle Ages and throughout the early modern period, one of the main dimensions of transnational migration within Europe was the eastward movement of German settlers, often termed 'colonists'. Historians have acknowledged their role in the social and economic history of the Baltic region, Poland, the Habsburg and Romanov Empires (Koch, 1977; Ingrao and Szabo, 2008; Plakans, 2011). We examine the persistent development effects of 18th-century immigration of

[1] Recent empirical studies include Card (2009), Peri and Sparber (2009), Peri (2012), Ottaviano and Peri (2012), Foged and Peri (2016), and Dustmann *et al.* (2017). Bauer *et al.* (2013), Braun and Mahmoud (2014), Braun and Kvasnicka (2014), and Braun and Dwenger (2020) examined the local labor-market effects of historical immigration in particular.

[2] Recent empirical contributions include Moser *et al.* (2014), Hornung (2014), Waldinger (2017), Rocha *et al.* (2017), Droller (2018), Valencia Caicedo (2019), Burchardi *et al.* (2019), Sequeira *et al.* (2020), Tabellini (2020), Malein (2021), and Fouka *et al.* (2022).

German speaking agricultural settlers to the Kingdom of Hungary. Following two centuries of Habsburg-Ottoman wars and a national uprising in the early 1700s, the Habsburg Empire conducted settlement campaigns to repopulate the newly conquered Hungarian wasteland. Agricultural settlers from Austria and southern Germany played an important role. Compared to Hungarians and other ethnic groups native to the country, German settlers seem to have had more human capital (Blum and Krauss, 2018; Blum *et al.*, 2022) and more advanced agricultural knowledge (Kaposi, 2010; Kurucz, 2010). From rich historical demographic data, we can derive that they were relatively more likely to engage in more skill intensive agricultural trades already in the 18th century and that this difference did not owe to better land quality, religion, or the regional concentration of German immigrants. Exploiting detailed agricultural and population statistics from Hungarian censuses between 1865 and 1910, we document that geographical proximity to 18th century German settlements still correlated significantly with higher farm productivity in the mid-19th and early 20th century.[3]

This historical setting allows us to identify how immigration may have affected economic development in predominantly agrarian societies independent of alternative channels. First, by focusing on a single country with uniform political institutions, we rule out the impact of heterogeneous institutional treatment. This is a common problem in studying European emigration in the colonial context, since western settlers were subject to different institutions than those governing the indigenous populations (Fourie and Von Fintel, 2014). German agricultural settlers were affected by the same feudal institutions in Hungary in the 18th century and by the abolition of serfdom in the 19th century as ethnically different farming communities. Second, since the settlement campaigns preceded the Industrial Revolution in continental Europe (Crafts, 1996), they could not have affected economic development through the transfer of manufacturing skills and technologies. Third, self-selection is a common feature in empirical studies of immigration, where migrants are often weakly representative of their source populations

[3]Valencia Caicedo (2019) recently found that geographical proximity to seventeenth and eighteenth century Jesuit missionary activities has long-term positive effects on modern-day literacy rates in Argentina, Brazil, and Paraguay.

in important socio-economic characteristics. The best documented transfers of advance human capital through immigration are French Huguenots in Prussia (Hornung, 2014) and Dutch South Africa (Fourie and Von Fintel, 2014) and Jewish émigrés from Europe to the USA before the Holocaust (Moser *et al.*, 2014; Blum and Rei, 2018). These episodes all reflect on immigration of select groups prosecuted for their religion and known for their relatively high human. By contrast, German settlers were not forced to emigrate to 18th century Hungary and were representative of their source population in terms of basic human capital (Blum and Krauss, 2018), meaning that the Habsburg authorities did not select immigrants based on their level of education.[4] They came from an essentially still Malthusian society, where the majority of the population had a similar close-to-subsistence standard of living. Fourth, these settlement campaigns ended before the implementation of universal elementary public education either in the German lands or in Austria (Cvrček, 2020), which could have affected human-capital transfers over time. Finally, having access to rich demographic data for the Kingdom of Hungary at the time of settlement and detailed agricultural and population statistics from a century later, we can document both the initial conditions and persistent development effects at the local level. This gives us a very large dataset of approximately five thousand observations and the ability to control for many potential co-determinants.

We utilize three sets of historical data. Using Geographic Information System (GIS) techniques, we first identify the location of German settlements in the 18th century from ethnographic maps produced by statistical demographers. We crosscheck and validate this cartographic information with a voluminous historical encyclopedia of the towns and villages in the Kingdom of Hungary. This unique source allows us to compare homogeneous German and other settlements in terms of religious affiliation, the identity of landowners, land quality, and the agricultural or proto-industrial trades that they were noted for at the time. Second, we assemble detailed agricultural and population statistics from Hungarian censuses between 1865 and 1910. In this article, we examine only settlements within the

[4]This is in contrast, for example, to the positive selection of immigrants in terms of education in case of state-sponsored settlement policy in late 19th and early twentieth century Brazil studied by Rocha *et al.* (2017). Self-selection has a strong impact on immigrant incomes (Borjas, 1987).

counties where German immigrants first arrived in the 18th century to rule out legacies of late-medieval German settlement in other parts of Hungary. While German colonists before 1500 were often artisans, lived in the more developed regions, spatially concentrated and often in cities, their 18th-century counterparts were predominantly farmers in small rural communities scattered across the country. Therefore, one could expect that different episodes of German immigration into Hungary may have had different developmental consequences. Third, we complement these data with settlement-level statistics controlling for geographic, cultural, and other confounding factors.

We exploit this large database to examine empirically the persistent impact of 18th-century German settlement on local agricultural development. Conditional on a range of geographical controls, our OLS estimates indicate that towns and villages nearer 18th-century German settlements had higher farm productivity in the mid-19th century and even at the start of the 20th century. We utilize agricultural census data on land use and income per farmed area to examine potential mechanisms behind this persistent impact of German immigration. The results suggest that both greater specialization in crop farming and winemaking as well as more intensive farming in these types of cultivation played a role. We localize these development effects by including county fixed effects in our regression specifications, demonstrating that German farmers remained more productive and more likely to cultivate croplands and vineyards within the specific regions where they had settled. This corresponds with qualitative historical evidence suggesting that 18th-century German settlers expanded the area under cultivation and brought new agricultural techniques that intensified farming (Seewann, 2012).

The principal identification concern is that Habsburg authorities may have directed German settlers to areas with unobserved characteristics that may have subsequently affected economic development. The historical encyclopedia of Hungarian towns and villages that we digitized rules out differences in land quality and the spatial concentration of German immigrants as sources of bias. Religion did matter, as Protestant towns and villages were more frequently noted for specialized agricultural and proto-industrial trades, but this 'worked against' Germans who were predominantly Roman Catholic.

We account for any remaining omitted-variable bias with instrumental variables. Our identification strategy is similar in spirit to that of Sequeira *et al.* (2020). We instrument our treatment variable, the distance of a town or village to the nearest 18th-century German settlement, with historically documented but geographically determined migration routes: the least-cost distance from Vienna to a given settlement via navigable rivers and over land. On their way to Hungary, travelling in primitive barges down the Danube, German settlers passed through Vienna, the capital of the Habsburg Empire. At the end of their long journey, they settled in proximity of navigable rivers, as travelling over land was costly, but outside of the extensive flood areas. Fewer immigrants made their way further East and South as greater travel distance increased both cost and uncertainty. We calculate migration routes accounting for the physical geography, including river navigability, terrain slope, and flood lands, that existed in Hungary in the 18th century, using historical cartographic data. The two-stage least squares (2SLS) estimates are consistent with the OLS results. Proximity to 18th-century German settlements predicts significantly higher farm productivity even a century after the period of German immigration. We consider the exclusion restrictions justified. The geographical determinants of our instrumental variable cannot independently explain differences in agricultural outcomes, which we observe locally.

We implement a series of robustness tests. First, we show that the persistent impact of German immigration on agricultural development is independent from the location of historical flood zones. Second, we control for religious affiliation and ethnic fractionalization, and we show that they do not affect the results. Third, we control for both population and railway density. Fourth, we show that the baseline results remain robust to controlling for historical institutions that could have had a differential impact at the settlement level: the presence of German city law, free royal cities, and the legacy of the Habsburg Military Frontier. Since these pre-existing institutions affected only a small subset of settlements in our database, they do not change our main findings.

The robust persistent effect of German immigration on local agricultural development may be a surprise finding. Intensive crop farming and crop rotations, the use of fertilizer and heavy plowing gradually diffused in Hungarian as in European agriculture throughout the 19th century and were responsible for a significant increase in farm output and productivity that economic historians have documented (Katus, 1970; Schulze, 2000). However, this diffusion was slow and, therefore, German settlements remained more developed. We argue that two factors limited the spread of agricultural knowledge that the immigrants had brought with them. First, before the construction of modern communication networks and the achievement of mass literacy, information travelled slowly over long distance. Agricultural knowledge could only diffuse geographically if people migrated.[5] Second, we show that the location of German settlement in Hungary changed little over time; German farmers did disperse from their initial settlements but remained near them. Accordingly, we find that until 1910 agricultural knowledge diffused within the close vicinity of 18th-century German settlements but that distance remained an obstacle for knowledge transfer.

## 2 Historical background

From the 14th century, the Ottoman Empire continuously expanded in Southeastern Europe. After the fall of Belgrade in 1521, the Battle of Mohács in 1526, and the conquest of Buda in 1541, the medieval kingdom of Hungary fell apart. The central and southern regions became Ottoman subjects; Transylvania turned into a vassal state; the north and west of the country were domains of the Habsburg emperors, who were also Hungarian kings. During the 16th and 17th centuries, the rival empires engaged in constant warfare over territory and influence in Central Europe (Kann, 1974; Bérenger and Simpson, 2014). The unsuccessful siege of Vienna in 1683 represented a turning point, after which the Habsburgs swiftly pushed the Ottomans out of Hungary. In the Treaty of Karlowitz (1699), concluding the fifteen-year Great Turkish War, they acquired most

[5] Kantor and Whalley (2019) recently demonstrated significant spatial frictions in the diffusion of agricultural research even in the United States in the late 1800s, which disappeared only with advanced transport and communication technology (e.g. automobiles and telephones).

of Hungary, Transylvania and Slavonia, as well as parts of Croatia. After conquering the Banat and defeating the Ottomans in the Austro-Turkish War (1716–1718), the Habsburg Empire extended its reign to the entire Pannonian Basin between the Alps and the Carpathians.[6] The sheer frequency and long periods of warfare resulted in severe and permanent population losses. In addition, a national uprising of Hungarians against Habsburg rule (1703-1711) led by Francis Rákóczi II, the Prince of Transylvania, devastated large parts of the country. Farm estates decayed and disease spread. Forests, marshlands, and wastelands dominated the landscape.

Even though the richness of Hungarian soil and the vastness of the land were known in Germany, German colonists were not the first to arrive. From 1689 until the Peace of Szatmár in 1711, Serbs and Croats flooded into southern Hungary. Once Habsburg rule had consolidated, the authorities in Vienna began to promote, regulate, and conduct immigration campaigns to bring the newly conquered land back to life (Seewann, 2012). The main objective of the new rulers was to enhance the agricultural population and, therefore, their tax base in the country. Colonization in early 18th century was managed by local landlords and by their agents in Vienna. The incentives they offered varied depending on the degree of devastation and, therefore, shortage of labor in the region, and typically included exemptions from taxation and labor service (robot) for the initial years of settlement. Early colonists received more generous incentives than settlers who arrived later during the 18th century. From the 1740s, under the reign of Maria Theresa and her son Joseph II, the state coordinated the settlement campaigns. Immigration into Hungary required increasing subsidies due to growing Prussian and Russian competition for settlers.[7] In principle, colonists had to be married and to bring sufficient starting capital to finance livestock, work tools, the construction of farmhouses, and subsistence until the first harvest. However, poorer couples and penniless single men were admitted, too, and settled as landless cottagers for work in the vineyards, as household servants, as well as craftsmen and day labourers (Seewann, 2012).

[6] Today, Transylvania is part of Romania. Slavonia is part of Croatia, while the Banat is divided between Hungary, Romania, and Serbia.

[7] Benefits included travel subsidies, land via ground rent, and exemption from state and other taxes for a limited number of years.

Throughout the long 18th century, at least 150 thousand German-speaking immigrants settled in Hungary, but historical sources cited even higher estimates. Settlers came predominantly from German territorial states of the Holy Roman Empire and Habsburg domains in modern-day Switzerland (Seewann, 2012). Push factors included land scarcity, high prices for arable land, increased living costs, and high taxes. Landless existence was an inevitable destiny for the majority living in territories that practiced 'Anerbenrecht', the inheritance law where farms passed on undivided to a single heir. Emigration offered a way out for the landless. Land abundance and low prices of agricultural land attracted the settlers to Hungary. With modest finances, they could acquire land and achieve social advancement in their settlement area much quicker than it would have been possible in their region of origin. However, living conditions for the pioneers were dreadful and the historical records suggests that mortality among them was extreme. One of the earliest campaigns brought 36 German colonists to the settlement Pári in the southwestern county of Tolna. A survey conducted in December 1734 found only four of them alive (Spannanberger and Spannanberger, 2018). Later in the 18th century, circumstances had vastly improved, not least thanks to increased state investment in new settlement construction, canals, roads, and bridges (Seewann, 2012). The draining of flood land and marshlands enhanced and improved the cultivable area (Kaposi, 2010). Settlements became more consolidated thanks in part to significant transmigration, meaning the movement of settlers between Hungarian territories, and in part to landowners aiming at ethnically and religiously more homogeneous settlements to reduce tensions between different communities. These movements were most significant in the southwestern counties, where both German and Croatian settlers had strong presence (Szita, 1993).

German inheritance law assured that emigration to Hungary remained profitable, even as land became scarcer. As land and farmhouses passed to the oldest male heir, children of German farmers had to take up other occupations in craft trades, as village priests and teachers, or migrate to urban areas, where they would become an important part of the Hungarian bourgeoisie by the 19th century (Seewann, 2012). German immigrants had already shaped Hungarian cities in the late Middle Ages, but their share in the urban population grew further during the 18th century (Kaposi, 2010). Yet, the settlement campaigns came to an abrupt end in the late 1700s. The three main factors were the increased cost of attracting new settlers, growing competition from territories in the Russian Empire, and extensive warfare in Europe after the French Revolution. The rich historiography on the economic impact of German settlement in 18th century Hungary highlighted three main channels.

First, the repopulation of central and southern Hungary greatly extended the area under cultivation. From 1683 until 1800, arable land increased fourfold. Even though crop yields were modest by western standards, the 18th century witnessed a dramatic increase in farm output and exports. In the 1770s, approximately 60% of Hungarian exports were farm products, with cattle making up the majority but the share of crops growing over time. Germans were instrumental in expanding grain production as well as horticulture and viniculture, while Serbs in southern Hungary remained dominant in the cattle trade (Kurucz, 2010, pp. 92-4). Second, German immigrants brought advanced agricultural knowledge: the three-field system, crop rotation, weed control, fertilization, the use of granaries, and the cultivation of new crops like cabbage, potato, or clover. The share of Hungarian land farmed under the three-field system tripled between 1723 and 1823 (Seewann, 2012). Winemaking had a long tradition in Hungary and tobacco had already been cultivated in the 16th century, but German settlers helped to maintain these labor intensive activities and brought them to new regions of the country. They had perhaps the greatest impact on the adoption of heavy iron plows, for which they used horses rather than oxen as draft power (Kaposi, 2010, pp. 113-4). Historical sources indicate that German settlers did not receive preferential treatment in taxation or settlement conditions compared to other ethnicities; nor did they have access to better land (Seewann, 2012).

Third, Germans had significantly higher human capital than the ethnic groups that were native to Hungary (Blum and Krauss, 2018). Figure 1 reports numeracy in Central and South-Eastern Europe in the period from 1710 to 1840. Numeracy is a basic form of human capital, which historians can reconstruct with the age-heaping method (A'Hearn *et al.*, 2009, 2022; Baten *et al.*, 2022). Historical censuses, land surveys, or conscription campaigns documented the self-reporting of age by the surveyed individuals. Too frequent self-reporting of 'rounded' years that end with five or zero is evidence for lack of basic numeracy. The measure of numeracy is the share of the population able to report their age accurately, by comparing the survey reports with an age distribution that would have been typical for the population at the time. Accordingly, around 94% of German settlers in the Kingdom of Hungary born in the 1750s were numerate. Hungarians reached numeracy levels of 84% and 88% in the 1750s and 1760s respectively. Romanians lagged behind both Germans and Hungarians consistently over the period. Even as late as the 1790s, numeracy among Serbs was very modest at only 19%, although it increased to 59% by the 1830s. There is no evidence for migrant (self-) selection. German settlers were representative of their source populations. Blum *et al.* (2022) studied the human capital transfer that German settlement brought to Eastern Europe. They showed that the numeracy of German settlers to the Kingdom of Hungary was virtually identical to numeracy levels in Germany, different from German colonists in the Russian Empire who were somewhat more numerate.

In sum, German agricultural settlers in Hungary were likely to be more productive, engage more frequently in skill-intensive agricultural and proto-industrial activities, and be better educated. This article aims to test the significance and persistence of these economic consequences of German immigration based on a large database of agricultural and population statistics collected at the settlement level.

# 3 Data

This section describes our data on both the location and initial conditions of 18th century German settlements in Hungary and reports descriptive statistics. We also explain the measures we constructed for agricultural outcomes based on Hungarian censuses from the 19th and early 20th century.

### 3.1 German settlements in the 18th century

We combine cartographic information and historical demographic sources to identify the location of German settlements. Kocsis and Tátrai (2015) reconstructed the long-term ethnic composition of the Pannonian Basin. They used historical censuses to construct ethnographic maps for 1495 and 1784, which document the absolute or relative majority of different ethnicities at the settlement level.[8] Using GIS software, we geo-coded these maps and extracted the location of mainly German settlements. Since our focus is on 18th century German immigration, we distinguish German settlements formed after the Habsburg conquest of Hungary from those established in earlier migration episodes. Such distinction is not only a matter for identification. Late-medieval German communities in Hungary differed substantively from colonists in the 18th century. The westernmost counties of Hungary were historically German speaking. Germans settled into north-central Slovakia as well as southern and northeastern Transylvania from the 14th century to develop rich mineral deposits and build new cities. They became urban dwellers and enjoyed considerable autonomy in free royal cities or in the Transylvanian Saxon Seats. By contrast, the new German settlements in central and southern Hungary in the 18th century were predominantly rural and agricultural. They did not differ initially from adjacent Hungarian and other communities in occupational structure, the legal forms of land tenure, political institutions and degree of autonomy (Ingrao and Szabo, 2008).

Figure 2 illustrates Hungarian counties within their 1910 borders, mapping two types of German settlements: those established by 1495 and those that formed later until 1784. The shaded area includes the 25 counties that, according to historical sources, German immigration affected in the 18th century, but not earlier. We limit our analysis to this part of Hungary. We exclude both counties with no German presence and counties where German communities were the legacy of earlier migration. The spatial concentration of recent German settlement confirms that the 18th century colonization campaigns aimed at repopulating the parts of the country most directly affected by the Turkish wars (central and southern Hungary) and by the wars between the Habsburg kings of Hungary and

[8] Original maps are available at: `http://www.mtafki.hu/konyvtar/karpat-pannon2015/en/supplementary_maps.html`.

Transylvania, including the Rákóczi uprising after 1703 (mainly the northeast). The 1910 census enumerated 5,262 towns and villages in these 25 counties.[9]

We validated this cartographic information with a unique historical demographic source. András Vályi, a pioneer of Hungarian demography, compiled a monumental encyclopedia of all communities in the Kingdom of Hungary published in three volumes between 1796 and 1799. His *Description of Hungary* conveyed short accounts of towns and villages, specifying their main ethnicities and religious orders (ranked in importance), their historical county, and in most cases the landowners whose feudal domain the settlement comprised. It also informs about the quality of farmland, following the classification established in the Urbariaum of Maria Theresa in 1767, which reflected broader conditions besides soil quality.[10] It documents the specialized agricultural trades, other than grain cultivation, and crafts that the settlements were noted for at the time. The matching of towns and villages described by Vályi's *Description* and settlements listed in the 1910 census required tedious work due to the frequent changes in names during the 19th century. Appendix A catalogs the cartographic and historical demographic sources that we used in the matching process and the limitations we had to accept. Of the 5,262 settlements enumerated in 1910, we could match 4,787 in 1796. Of the matched settlements, only 255 were towns or cities; the vast majority were villages.

Table 1 reports the number of settlements in 1796 by ethnicity and religion. One century of immigration had made Hungary a culturally diverse landscape, hence the many settlements where a dominant ethnicity or religion could not be determined. These include many small villages and communities with more than two ethnicities or religious orders. In mixed communities with two main ethnic groups or religions, we report the majority ranked first. German settlements represented a small proportion of towns and villages even in the 25 counties affected by German immigration in the 18th century. Not only Hungarian but also Romanian, Ruthenian (Ukrainian), and Slovakian settlements

[9] These towns and villages had approximately 9.7 million people and covered 137 thousand square kilometers accounting for 53% of Hungarian population and 49% of surface area in 1910.

[10] The Urbarium of 1767 was an extensive land registry conducted with the aim of enumerating the peasant population and standardizing the size of peasant landholdings as well as the rights and obligations of landlords and serfs across the Empire. The classification of land quality served the purpose of creating equally taxable peasant land holdings in different regions (Fónagy, 2013).

were more numerous. Early-modern Hungary was famous for its religious diversity. Even though Habsburg counter-reformation made Roman Catholicism dominant, the share of protestant and Greek orthodox communities remained significant. However, this religious diversity was not true for German colonists, who were almost exclusively Roman Catholic. Table 1 corroborates the information on German settlement location mapped in Figure 2, with 91% of German villages and towns in 1796 falling within 10km of German settlements in 1784. The strong match confirms that ethnic settlement patterns in Hungary had consolidated by the end of the 18th century.

Figure 3 reports the percentage of villages of different ethnicity noted for the four specialized agricultural trades that the *Description* mentioned most frequently. Serbian and to a lesser extent Croatian and Romanian villages dominated the cattle trade. Serbian, Croatian and Hungarian villages were the most active in fishing, whereas Germans villages engaged in the skill intensive trades of winemaking and tobacco more strongly than any other ethnicity. We cannot explain this difference in specialization with any factor other than human capital. The *Description* classified agricultural land into three classes, with the first class corresponding to the best and the third class to the most mediocre farmland. The average score for all settlements was 2.1, German villages having the identical mean score 2.0 with their Hungarian, Serbian, and Romanian counterparts. In theory, German settlements could have specialized differently from other communities if their landowners had had a stronger preference for the cultivation of more skill intensive crops or better access to western agricultural knowledge. We find no evidence for this mechanism. German settlers were no more common on the domains of German or French as opposed to Hungarian landowners. They were slightly overrepresented on royal domains, which were scattered across regions with different farming conditions. By contrast, German villages were underrepresented in church domains, which were traditionally seen as most progressive in viniculture and horticulture. The spatial concentration of German settlement within Hungary cannot explain specialization patterns either. In the three counties with the highest German population share (Baranya, Tolna and Veszprém), villages had access to better land than in other parts of the country, with an average score of 1.8. However, German villages had virtually identical mean scores with villages of any other ethnicity in these counties. As elsewhere, they were much less frequently noted for their cattle trade and fishing than Croatian and Serbian villages, but stood out in tobacco and winemaking.

By contrast, religion did matter. As shown in Figure 4, Protestant and Orthodox towns and villages were more prevalent in specialized agricultural trades than Roman Catholic settlements were. The *Description* mentioned craft trades much less frequently, which makes the data less reliable in this regard, especially as the low frequency does not allow us to differentiate between crafts. To the extent that we can trust the information, Protestant communities seem to have engaged more in proto-industrial activity than other, especially Catholic, towns and villages. This is not surprising given the role of Protestantism in the economic development of pre-industrial Europe (Baten and Van Zanden, 2008). However, religion 'worked against' Germans in Hungary, since they were more predominantly Roman Catholic than any other ethnic group. Their relatively high human capital and more advanced agricultural knowledge and trade skills made them engage more frequently in more skill intensive activities not because but despite their religion.

## 3.2 Agricultural development, 1865-1910

With data from agricultural censuses, we can measure systematically outcomes in Hungarian settlements in the mid-19th and early 20th century. We exploit two detailed land surveys performed in 1865 and during the years from 1909 and 1911 to assess land use and farm productivity shortly before two critical junctures in Hungarian history.[11] The Compromise of 1867 established the constitutional monarchy of Austria-Hungary, which created an autonomous Hungarian government and gave a major impetus to industrialization, infrastructural development, and the expansion of public education in the country. This golden age of economic development lasted until World War I, which ended with the defeat and disintegration of the Habsburg Empire and within that the Kingdom of Hungary. Therefore, 1910, the year of the last imperial census, is the natural end date of

[11] *Magyarország művelési ágak szerinti területe és földjövedelme.* Buda, 1865. *A 63 vármegye adóközségeinek területe és kataszteri tisztajövedelme mívelési áganként és osztályonként az 1909. évi V. t.-c. alapján* (az összes magyarországi vármegyére).

our study. We cannot extend any territorially consistent analysis beyond this period. The land surveys document the distribution of land across different types of cultivation (e.g. crop farming, winemaking, or pasture) and the estimated income from the land farmed by each settlement. The surveys around 1910 reported farm income obtained from different forms of cultivation. We calculate consistent measures of land use and farm productivity. We assemble data for the 5,262 settlements located within the 25 counties that received German immigrants in the 18th century, highlighted in Figure 2.

To construct control variables, we collected additional information at the settlement level on population size and its composition by both ethnicity (first spoken language) and religious affiliation from the population census of Hungary in 1910.[12] We use these data to identify cities with more than 20 thousand inhabitants, which could provide sizeable markets for agricultural products, to calculate population density and religious shares, and to construct an ethnic fractionalization index. We derive the area of each settlement and any distance measure used in the subsequent analysis using the GIS shape files from the digital map of Hungary in 1910.[13] To calculate railway density, we use data on railways around 1910 from the same source. Finally, to measure the legacy of preexisting historical institutions, we identify towns that had German city law, former free royal cities, and settlements within the boundaries of the Habsburg Military Frontier until its dissolution from the historical atlas of Magocsi (2002).

Table 2 reports the summary statistics by splitting the database at the median of the main treatment variable, geographical proximity to the nearest 18th century German settlement. The raw data suggest that towns and villages closer to these German settlements had more developed agriculture in 1865 and that this difference persisted until 1910. Settlements within the median distance recorded approximately 50% higher land productivity than those beyond. Productivity by type of cultivation, which we observe in 1910 only, reveals that cropland, vineyards, and pastures were all more productive within median distance. Lastly, the descriptive statistics demonstrate that in proximity

[12] Magyar Királyi Központi Statisztikai Hivatal (1912). *A Magyar Szent Korona országainak 1910. évi népszámlálása. Part I: A népesség főbb adatai községek és népesebb puszták, telepek szerint.* Budapest.

[13] GIS shape files from GISta Hungarorum project: `https://www.gistory.hu/g/en/gistory/otka`.

of German settlements land use was skewed towards more productive farming activities: crop farming and winemaking, instead of pastures.

## 4 Empirical strategy and results

In this section, we empirically investigate persistent effects of German immigration on local agricultural development. We examine how German settlement in the 18th century affected land use and farm productivity in Hungary in the middle of the 19th century and in the early 20th century.

We measure these persistent effects at the settlement level, using a cross-section of more than five thousand towns and villages as outlined in Section 3. We apply ordinary least squares (OLS) to estimate models of the form:

$$Y_i = \alpha_1 + \beta_1 DistanceGermanSettlement_i + X_i\gamma_1 + \delta_{1j} + \varepsilon_{1i} \tag{1}$$

where $Y_i$ represents an agricultural outcome in settlement $i$. The main treatement variable, $DistanceGermanSettlement_i$, is the geodesic distance in kilometers from town or village $i$ to the nearest 18th century German settlement. $\beta_1$ is the main coefficient of interest. $X_i$ represents a vector of covariates, with a corresponding vector of coefficients $\gamma_1$. The coefficient $\delta_1$ captures county $j$ fixed-effects, controlling for unobserved characteristics specific to each of the 25 counties affected by 18th-century German immigration; $\alpha_1$ is a generic constant, and $\varepsilon_1$ is an error term. In every specification, we use the county fixed-effects to make sure that we measure local development effects not biased by regional differences in farming conditions and cluster standard errors across districts (járás), which were the smaller unit of local governance within counties in Hungary.[14]

Settlement-level covariates control for a range of geographical factors that may have independently determined agricultural outcomes, including area, altitude, latitude and longitude, terrain ruggedness, soil suitability, historically observed land quality, and

[14]The 25 immigrant-receiving counties were divided into 255 local districts. Applying instead Conley spatial standard errors, with a cut-off distance of 17 kilometers at which each settlement has at least one neighboring town or village, only marginally increases the estimated standard errors and hence does not change our findings.

distance to the nearest urban market. The size of the land area belonging to a settlement controls for potential returns to scale (Combes and Gobillon, 2015). Latitude and longitude are standard controls in empirical studies in economic geography, as they can influence market access (Redding, 2010). Economic historians have observed a strong development gradient in the Habsburg Empire (Pollard, 1981; Klein *et al.*, 2017), with the regions of Alpine Austria and the Czech lands demonstrating consistently higher levels of the development than eastern and southern parts of the empire. Therefore, northwestern counties of Hungary may have achieved relatively higher agricultural productivity because of relatively better access to the most advanced imperial markets. Altitude affects the type of cultivation. Following Nunn and Puga (2012) and Nunn and Qian (2011), we control for terrain ruggedness and soil suitability with modern data. In addition, we identify historically observed land quality from the data introduced in Section 3. Lastly, we measure distance to large urban markets (towns with more than 20,000 inhabitants), using data from the 1910 population census and GIS estimation. The importance of urban markets for agricultural development is an old notion. Johann von Thünen published a theory in 1826, according to which farms close to cities would produce high-value goods for the urban market that are costly to transport over distance, such as meat and dairy, whereas cheaper and less perishable goods such as grains would be cultivated elsewhere. Allen (2009) demonstrated this dynamic in the English agricultural revolution, Kopsidis and Wolf (2012) in the period of German industrialization. We, therefore, expect income per hectare of farmland to decrease with distance from urban markets.

Robustness checks in Section 5 control for alternative drivers of development including religion, ethnic fractionalization, and the legacy of preexisting historical institutions that had a differential impact across Hungarian settlements. We account for local agglomeration effects and market access with population density and the density of the railway network in 1910. Our main findings are consistently robust to the inclusion of these controls.

## 4.1 Baseline results

**Main effect.** Figure 5 provides suggestive evidence that German immigration had a positive and persistent impact on agricultural development in Hungary. The figure plots distance to the nearest German settlement in the 18th century against farm productivity in 1865 and 1910. Farm productivity increased with proximity to German settlements. The bivariate relationship is highly significant and persistent. The fitted lines in both binned scatter plots have practically the same slope, suggesting that the size of the effect that German immigration had on agricultural development did not change between 1865 and 1910. This is truly remarkable given that the period witnessed an industrial revolution in Hungary combined with the building of a modern transport network, rapid population growth, and a massive expansion of land under cultivation.

The regression results reported in Table 3 confirm this suggestive evidence. Towns and villages in proximity to 18th century German settlements had higher agricultural income per hectare in both 1865 and 1910. Specifications using the full set of controls (3 and 6) demonstrate that being 16.5 kilometers, the median distance, closer to the nearest German settlement increased farm income per hectare by 0.5 crowns in 1865 and 0.6 crowns in 1910. In both years, these figures corresponded to 5% of the mean. The size of the coefficient on the main treatment variable relative to the dependent-variable mean remains the same between 1865 and 1910 in all specifications. Not only did the localized effect of German immigration on local farm productivity persist; the magnitude of the effect was also persistent.

The statistically significant relationship between German immigration and farm productivity is robust to the inclusion of settlement-level geographical controls. Models 2 and 5 control for land area, altitude, latitude, longitude, ruggedness, and soil suitability. Models 3 and 6, additionally, account for historically observed land quality and distance to the nearest urban market. The number of observations is slightly smaller because of the limitations we had to accept when matching historical demographic sources with 1910 census data, as explained in Appendix A. The coefficients have the expected sign for all covariates. Conditions for arable farming worsened with altitude and ruggedness, which reduced farm productivity. The significant negative coefficients for latitude and longitude confirm that the level of agricultural development declined from northwest to southeast. The insignificant result for land area per settlement shows that there were no increasing returns to scale in pre-modern agriculture before the introduction of farm machinery. Interestingly, we find that the historical classification of farmland, which assigned higher numerical value to land that was more mediocre, is a more reliable predictor of farm productivity than modern data of soil suitability. Lastly, farm productivity did increase significantly with proximity to urban markets. The magnitude of this effect declined between 1865 and 1910, which is not surprising since the development of railways reduced transport costs, but the effect is still significant.

**Mechanisms.** Data reported in the agricultural censuses enable us to examine potential mechanisms that may explain the baseline result of a consistent and persistent productivity gap between German and non-German settlements.

Table 4 suggests that different specialization in land use, and the more intensified use of land in certain types of cultivation both mattered. We estimate all specifications with OLS and include both county fixed-effects and the full set of settlement-level controls. We first examine differences in land use. In both 1865 (models 1-3) and 1910 (models 4-6), proximity to 18th century German settlements increased the share of land used for crop farming and winemaking. By contrast, areas of German settlement seemed to have specialized away from pasture. For 1910, when data on income per hectare of farmland for different types of cultivation become available, proximity to 18th century German settlements predicts higher farm productivity for both cropland and vineyards, but not for pastures (models 7-9). These findings are consistent with the historical narrative discussed in Section 2 that German colonists were instrumental in expanding grain cultivation and viniculture in Hungary, contrary to extensive grazing traditionally performed since the Ottoman period. German immigrants were crop farmers and winemakers, not herdsman like other immigrant groups, especially the Serbs. We also find consistently that the magnitude of the immigration effect on both land use and land productivity was highest in winemaking. In 1910, being nearer to German settlements by the median distance of 16.5

kilometers increased income per hectare of cropland by 0.6 crowns and income per hectare of vineyard by 3.2 crowns, 3.9% and 10% of the dependent-variable mean respectively. This concurs with the argument that the superior human capital and advanced agricultural knowledge brought by German colonists mattered the most in the most skill intensive agricultural trades, which German villages were relatively more likely to be noted for already in the 18th century, as shown in Figure 3.

**Comparison with other literature.** Our empirical results are in line with Sequeira *et al.* (2020), who find that European immigrants in the United States during the Age of Mass Migration have had a positive effect on present-day economic prosperity through, among other things, agricultural know-how and higher agricultural productivity. Interestingly, drawing on historical sources, Sequeira *et al.* (2020, p. 6) single out the positive contribution of German immigrants especially: 'the most notable group of immigrant farmers were the Germans [...]. German immigrants have been credited with adopting, perfecting, and popularizing new crops and better livestock'. We also find that German immigrants fostered economic development through the advancement of farming. That immigrant farmers had a particularly important role in winemaking is also not an unprecedented finding, for Fourie and Von Fintel (2014) argued the same for Huguenot settlers in the Dutch Cape colony.

## 4.2 2SLS estimates

As in other immigration studies, a potential identification concern is that immigrants may have selected locations based on unobserved characteristics that influenced agricultural development. Selection of marginal land would downward bias OLS estimates. By contrast, OLS estimates would be upward biased if areas of settlement had more favorable conditions for farming. The map in Figure 2 validates this concern. Even within the 25 counties affected by 18th century German immigration, the spatial concentration of German settlements was clearly not random. German presence was not uniform across Hungary; it was exceptionally high in the counties Baranya, Veszprém and Tolna, and relatively high along the Danube as well as in the northern Banat region. Both the theoretical and empirical literature on immigration would suggest chain migration as the most likely explanation for concentrated settlements. Subsequent waves of German colonists would have favored areas that had been settled by the pioneers. In the context of 18th century Hungary, this argument gains strength from the length of the migration period and the significant degree of transmigration, which according to historical accounts aimed at creating ethnically more homogeneous settlements.

Instrumental variables can be used to correct for any such bias. Following Card (2001), many studies have routinely relied on pre-existing settlement patterns to instrument subsequent immigration locations.[15] Since we can identify the location of German settlements only in the late 18th century and we cannot track actual migrant flows, this strategy is not feasible. As an alternative, recent empirical studies similar to ours have instead used the transport network available to migrants at the time of immigration to construct instrumental variables. Assuming rational choice, immigrants would favor settlement areas which they could reach faster and at lower cost and risk. Sequeira *et al.* (2020) utilized variation in railway access and the aggregate inflow of migrants as an instrument for European immigration in the United States during the Age of Mass Migration. Our instrumental variables strategy is similar in spirit.

We estimate the migration route immigrants would have travelled to reach any particular settlement area. German colonists migrated to Hungary before the railway age, at a time when waterways provided the cheapest means of transport. Historians have documented German settlers arriving on the Danube to Vienna in barges, from where they continued their voyage into Hungary downstream. They would use other rivers only after their confluence with the Danube, after which they would have to travel upstream. Longer voyage implied significant additional cost, risk, and time. Land transport was practically impossible over long distance.[16] Railway construction began in the middle of the 19th century, while the Habsburg-Ottoman wars had damaged whatever primitive road network had existed in Hungary. Immigrants settled relatively close to the main

[15] The paper by Tabellini (2020) is one recent example.

[16] Donaldson and Hornbeck (2016, pp. 811-812), following Fogel (1964), report that in late 19th century US wagon freight costs were nearly 50 times waterway freights. Estimates of 18th century transport costs in Hungary are hard to come by.

rivers. Distance to Vienna through the Danube and other navigable rivers was, therefore, the key determinant of early German settlement location, which in turn determined the settlement pattern of subsequent waves of German immigration. Figure 6 illustrates the main navigable rivers in Hungary, based on cartographic evidence of historical river flows.

We estimate with two-stage least squares (2SLS) models of the form:

$$\begin{aligned} DistanceGermanSettlement_i &= \alpha_2 + \beta_2 MigrationRoute_i + X_i\gamma_2 + \delta_{2j} + \varepsilon_{2i} \\ Y_i &= \alpha_3 + \beta_3 Distance\widehat{GermanSettlement}_i + X_i\gamma_3 + \delta_{3j} + \varepsilon_{3i} \end{aligned} \tag{2}$$

where our instrumental variable $MigrationRouteVienna_i$ measures the least-cost distance in kilometers from Vienna to settlement $i$ via navigable rivers and over land from the nearest river point. This identification strategy uses only the part of variation in the distance to German settlements that comes from historically documented but geographically determined migration routes from Vienna. The correlation coefficient between the instrument and the treatment variable is 0.44, which indicates that transport geography indeed mattered for immigrant settlement.

**Exclusion restriction.** One could be concerned that part of the migration route consists of the distance of a given settlement to the nearest river, and proximity to rivers may independently affect agricultural outcomes. Farmland close to rivers may have been more fertile, could be better irrigated, while rivers also provided cheap transport. Following Sequeira *et al.* (2020), we include several control variables and perform robustness checks to account for this possibility. Our measures of soil suitability and historically observed land quality already control for some benefits of river proximity, while county fixed effects capture regional variation in this regard.[17] We do not expect the instrument to be strongly biased for several reasons. First, proximity to the nearest river is a tiny portion of the total migration route for most settlements: on average, only 5%. The bulk of the variation in the instrumental variable comes from navigable river distance to Vienna. Second, our

[17] The correlation between these controls and our instrument is weak. The correlation coefficient with historically observed land quality is 0.16 and with modern soil suitability is 0.17.

instrument measures only the navigable portion of major rivers used by immigrants, not all waterways in Hungary that may have impacted agricultural development. Figure 6 highlights additional smaller rivers and lakes as well as the vast flood areas that covered the Hungarian Plains historically. Access to water was a common feature of many if not most regions, while the extensive flooding made proximity to major rivers a mixed blessing. Third, distance to the nearest 18th century German settlement, the variable we instrument, is not correlated with either modern soil suitability or historically observed land quality. German colonists were not assigned to more favorable land than other ethnic groups in the regions where they settled. In principle, river distance to Vienna may have indirectly affected agricultural development through market access. We already control for this in all regression specifications using latitude and longitude to capture the northwest-southeast development gradient and county fixed effects.

**2SLS baseline.** The first-stage estimates reported in Table 5, Panel B show that the length of the calculated migration route from Vienna strongly predicts distance to the nearest 18th-century German settlement. The large F-statistics rule out weak instrument bias in every specification. The second-stage estimates in Panel A are consistent with the baseline OLS results reported in Table 3. Proximity to the nearest German settlement significantly increased agricultural productivity. The estimated 2SLS coefficients are somewhat larger than OLS coefficients. A downward bias in OLS estimates suggests that immigrants moved to places that without them would have had lower land productivity. This counterfactual strengthens our main finding that German immigrants had a powerful, positive and persistent effect on local agricultural development.

**2SLS mechanisms.** Table 6 reports the second-stage results from the 2SLS estimation of the regression specifications testing for potential mechanisms that can explain the persistent effect of immigration of land productivity.[18] In all specifications, the F-statistic safely exceeds the benchmark value of 10. The 2SLS estimates are consistent with the OLS results reported in Table 4 and confirm that German agricultural settlers in Hungary specialized away from pasture and significantly increased productivity of both croplands

[18]First-stage results (not reported) vary slightly across estimations due to the varying number of observations, but are essentially the same to the first-stage results reported in Table 6.

and vineyards. Once controlling for omitted variable bias, German settlements do not seem to have used a significantly higher share of their area as cropland compared to ethnically different villages in their vicinity. This makes sense, since German colonists were crop farmers who were brought to Hungary with the primary aim of expanding grain cultivation, which means that they were probably directed to regions more suitable for crop farming. The consistent finding that German settlement areas were more likely to engage in winemaking and cultivated more productive vineyards remains robust.

# 5 Robustness checks

We conduct a battery of robustness checks. The first set of tests examines if and to what extent the extensive flood areas in Hungary affected the settlement of German immigrants. The second set of tests controls for alternative drivers of development including religion, ethnic diversity, historical institutions, and agglomeration effects.

## 5.1 Flood lands

Rivers in the pre-industrial world were a mixed blessing. They were means of cheap transportation but also of destruction. Areas permanently or frequently under flooding were not suitable for arable cultivation and, therefore, for the settlement of farming communities, including German colonists. The most attractive locations for German immigrants were, therefore, close to the Danube and other navigable rivers but outside the historical flood lands. These are very well documented in historical sources because of the extensive projects on river regulation, flood control, and land drainage undertaken first on the Danube and then on other rivers until the end of the 19th century. These were essential for railway construction, the use of steamships on rivers, and for the expansion of grain cultivation in Hungary that was driven by robust population growth and growing demand for wheat exports. We geocoded a detailed map produced by the Hydrographical Institute of the Hungarian Ministry of Agriculture in 1938, which shows precisely the areas that were under water either permanently or for significant periods every year before the rivers were regulated. We mark these flood zones in Figure 6. We exploit this information to conduct two robustness checks to validate our instrumental variable.

**Adjusted instrument.** We first adjust the instrument. For any settlement within a flooded area, we add to the measured migration route the distance from that town or village to the nearest settlement unaffected by frequent flooding. The adjustment lengthens the migration route to flooded areas, penalizing areas that were less likely to be settled. Tables B1 and B2 in Appendix B respectively report the results from estimating the main treatment effect and mechanisms with the adjusted instrument. The coefficients are indistinguishable from the main 2SLS estimates reported in Section 4.2.

**Restricted sample.** A more conservative approach to control for the impact of flood lands on immigrant settlement is to drop them from our sample. We repeat our estimations on a restricted sample of settlements outside the flood zones. We report the results in Tables B3-B6 in the appendix. Both the OLS and 2SLS estimates of the main treatment effect and the mechanisms are closely in line with our baseline results.

Flood lands, however geographically extensive, had a limited impact on the relationship between 18th century German immigration and subsequent agricultural development in Hungary. This can be explained in two ways. First, the largest historical flood lands along the river Tisa in central and northeastern Hungary as well as near the Danube in western Slovakia remain outside the scope of our analysis precisely because they were not suitable for German settlers, who were predominantly crop farmers. Second, we measure the impact of 18th century German immigration on land use and productivity until the beginning of the 20th century, when the risk of flooding had been removed and a modern railway network had been constructed. Access to river transport became much less important, and vast areas of new cultivation emerged on fertile soils that were even closer to the main rivers than 18th century German settlements had been. Yet, the effect of German colonists on local agricultural productivity remained persistent, and the magnitude of this effect did not change between 1865 and 1910, when the main river regulation and railway construction projects took place. The developmental impact of German immigration persisted even in the face of changing geography.

## 5.2 Confounding factors

A common identification concern in studies of migration is that immigrant settlement may correlate with spatial variation in other drivers of development. German immigration may have changed the religious composition of the affected settlements, may have made them ethnically more diverse, and more densely populated. German colonists may have also settled more than ethnic groups native to the country in areas that were more or less affected by historical institutions that had a differential impact on development.

**Religion.** Religion has been found an important factor in economic development (Iannaccone, 1998; Iyer, 2016). Human capital formation has been associated with Protestantism (Becker and Woessmann, 2009) in Western Europe and Jews in Eastern Europe (Botticini and Eckstein, 2012, 2005, 2007). By contrast, Catholicism has been considered an impediment to knowledge diffusion and growth (Squicciarini, 2020). Economic historians have emphasized the positive role of religious migrants in particular (Fourie and Von Fintel, 2014; Hornung, 2014). We control for potential differences between the majority population that was Roman Catholic and religious minorities by including the share of Jews, Orthodox-Christians, and Protestants in the population of each settlement according to the 1910 census.

Tables 7 and 8 show that the baseline estimates are robust to controlling for religion. Compared to baseline results, coefficients on the distance to the nearest German settlement are marginally smaller. Protestantism did not bias the effect of German settlement since the majority of German immigrants were Catholic. Settlements with a higher share of Jews had significantly higher agricultural productivity compared to Catholic towns and villages. By contrast, settlements with more Christian-Orthodox inhabitants performed relatively poorly. This is due in part to the correlation between religion and ethnicity. Most orthodox Christians in Hungary were Romanian, Ruthenian (Ukrainian) or Serbian, nationalities that – as shown in Figure 1 – had consistently lower basic human capital than Germans, Hungarians and Slovaks, who were predominantly Catholic or Protestant. Historically, Jews had a very small presence in Hungary. This changed dramatically in the late 19th century, when Jews from Austrian Galicia and Bukovina stormed into other regions of the empire escaping population pressure and pogroms. Since in parts of Galicia, they were the majority population, many of them engaged in farming as well as other trades. Hence, Jewish migrants to late-imperial Hungary played an important role in both urban and rural development. Jewish farmers could acquire farmland in northeastern Hungary, which was sparsely populated but was witnessing a vast expansion of cultivation in former flood zones. In this region, Jews accounted for up to a third of the population by 1910. However, their positive impact on local agricultural development did not bias the effect of earlier German immigration because the settlement patterns of the two groups are weakly and, if at all, negatively correlated within our sample.

**Ethnic fractionalization.** Ethnic diversity has an important role in economic development. Easterly and Levine (1997) introduced the concept of ethnic fractionalization and established empirically that more ethnically fragmented countries grow less. Alesina *et al.* (2003) improved the measurement of fractionalization and differentiated between ethnic, linguistic, and religious heterogeneity. A large cross-country literature has since found a negative or insignificant relationship between ethnic heterogeneity and growth. In the Habsburg Empire, Schulze and Wolf (2009, 2012) showed that ethno-linguistic heterogeneity limited market integration, when ethnic nationalism became politically more prevalent. Montalvo and Reynal-Querol (2021), however, recently highlighted that at city level diversity has a significant positive effect on wages and productivity. Following this literature, we calculate ethnic fractionalization in Hungary at settlement level in 1910, accounting for all ethnicities reported in the census.[19] Although in our sample ethnic fractionalization varies from 0 to 0.76 (0 is perfect homogeneity), the mean score of 0.16 is well below the sample mean of 0.435 reported by Alesina *et al.* (2003). While Hungary was an ethnically diverse land, most villages were relatively homogeneous. The correlation between ethnic fractionalization and agricultural productivity is 0.05. Tables B7 and B8 document that controlling for ethnic fractionalization does not change any of our main findings. The coefficient is almost always insignificant both in OLS or 2SLS estimates.

[19]The census reported the following eight ethnic categories: Croat, Hungarian, German, Ruthenian, Serbian, Slovak, Vlach, and other.

**Density.** Through immigration, settlements may have become more densely populated and may have subsequently grown faster due to agglomeration effects. Densely populated areas, in turn, may have achieved higher land productivity simply with more intensive use of labor on relatively scarce land. Agglomeration effects would have increased in the late 19th century, a period of strong population growth and railway building. The density of population or railways could potentially affect agricultural development via local agglomeration effects or through facilitating market access (Donaldson and Hornbeck, 2016). We can control for both population density and railway density at the settlement level in 1910. Tables B9-B12 in the appendix report both OLS and 2SLS estimates using both controls. Railway density was a significant predictor of land productivity, but it does not bias the main treatment effect of German settlement location. The effect of population density is close to zero and insignificant in all specifications.

**Historical institutions.** Counties in the Kingdom of Hungary were governed by uniform institutions, and there was no difference between ethnic groups in institutional treatment. Yet, some historical institutions had differential impact at the settlement level, which may have affected local economic development. We georeferenced a series of maps from the historical atlas of Magocsi (2002), based on which we coded indicator variables that control for the presence of German city law, free royal cities, and being part of the Habsburg Military Frontier. German city law originated in the early 13th century and allowed Germans settling in towns outside Germany to establish a parallel legal system that provided legal and economic privileges (Magocsi, 2002, p. 37). Even though we excluded counties from our analysis, where late-medieval German immigration into Hungary concentrated, a few towns in our sample shared this legacy. Free royal cities (*libera regiae civitas*) were the exclusive domains of the kings of Hungary and were exempt from most feudal obligations. They enjoyed economic privileges and exercised a high degree of self-government from the Middle Ages until 1848, when they lost their special status following the abolition of serfdom.[20] The Habsburg (or Austrian) Military Frontier straddled the southern border from the 16th century and provided a *cordon*

[20]Economists have demonstrated the legacy of medieval institutions for development in a western context (Cantoni and Yuchtman, 2014).

*sanitaire* against incursions from the Ottoman Empire. It was under direct military rule from Vienna and was subject to different institutions than the other Habsburg lands. For the purpose of our analysis, the main difference was that feudal domains did not exist in the military frontier. The population belonged to peasant communities that were subject to military service but did not pay feudal dues and were masters of their land. Communal land tenure had persistent legacies even after the abrogation of the military frontier (1857 in the Banat, 1881 in the Croatian and Serbian borderlands) and its integration into the civilian administration of Hungary and Croatia (Ernst, 1982; Kaser, 1997).[21]

Tables B13 and B14 in the appendix show that the German immigration effect is robust to controlling for these historical institutions. They did have a differential legacy in Hungary at settlement level and do seem to correlate significantly with some agricultural development outcomes, but they do not alter the estimated coefficients for the distance to the nearest German settlement compared to baseline estimates. They affected a very small subset of Hungarian settlements, especially in the counties that were affected by German immigration in the 18th century. German colonists settled into an area with essentially uniform political and economic institutions.

## 6 Diffusion

We consistently find a persistent impact of German immigration on local agricultural development in Hungary, which begs a critical question that we examine last. If, in accord with historical accounts, German immigrants brought advance agricultural knowledge and practiced more efficient farming, then why did their knowledge not diffuse? Proximity to German settlements still mattered for land use and land productivity more than a century after the end of the settlement campaigns, and the magnitude of this effect seem to have changed little over time. A simple way to test for the diffusion of agricultural knowledge and practices between settlements is to perform our baseline estimation of the main treatment effect after we split our sample by median distance to the nearest German

[21]Economists found persistent development effects observed across borders separating areas subject to different historical institutions (inter alia Dell (2010) and Oto-Peralías and Romero-Ávila (2017)).

settlement. If there was significant diffusion between German settlements and neighboring communities, then we would expect to see a significant difference in the treatment effect between the two samples. Table 9 shows the results for the baseline OLS specifications using the full set of control variables that we reported in Table 3.

In 1865, we observe a significant correlation between proximity to 18th century German settlements and income per hectare of farmland both within and beyond median distance, suggesting no diffusion of agricultural knowledge. The size of the coefficient is much bigger relative to the dependent variable mean within median distance. The probable explanation for this finding is that, in proximity of German settlement areas, German farmers owed their productivity advantage both to more efficient land use and their specialization in crop farming and winemaking. Far away from German settlements, other ethnic groups pursued these types of cultivation too, even if less efficiently. By 1910, however, the size of the coefficient within median distance to German settlements is reduced by half relative to the dependent variable mean and turns insignificant. Throughout the late 19th century, farming communities in close proximity of German settlements seemed to have gained access to better agricultural techniques and practices pioneered by their neighbors. However, distance remained a powerful obstacle to knowledge diffusion, as the significant coefficient observed in the sample beyond median distance demonstrates.

The choice of median distance to split the two samples may seem arbitrary, but in the historical context we examine, it carried a specific and relevant meaning. The distance of close to 17 km was the average distance between the geodesic centers of two neighboring local districts, or járás, which in Hungarian means walking. Settlements within a district were meant to be within a day's walk. Settlements within this distance were, thus, more likely to develop close connections socially and economically, which may have supported stronger knowledge transfer between them than between more distant communities.

As outlined in the Introduction, our explanation for this localized diffusion is that in a society with limited human capital and before the construction of modern communication networks, useful knowledge between rural communities could only diffuse if people migrated. Figure 7 highlights areas of Hungary with relatively high German population share in 1910.

With few exceptions, they were near 18th century German settlements. Throughout the 19th century, Germans did disperse and mixed with other ethnic groups but only in close proximity of their initial settlement. Their advantage in farm productivity could persist so long because of their limited geographical mobility. Figure 8 provides further evidence for this observation. Towns and villages with a relatively high German population share in 1910 were located within no more than a few kilometers of the settlements that had already had a relative or absolute German majority at the end of the 18th century.

## 7 Conclusion

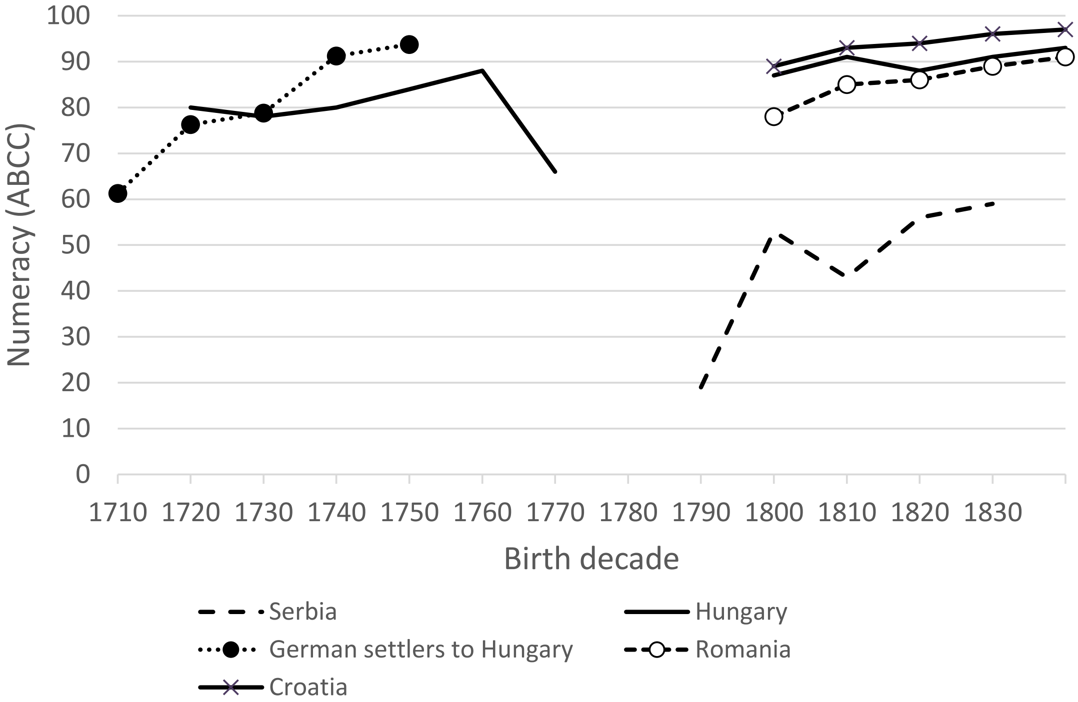
This article highlights persistent effects of immigration on economic development by examining the impact of 18th-century immigration of German-speaking settlers to the Kingdom of Hungary on local agricultural development until the early 20th century.

We find that German agricultural settlers had a significant, positive, and persistent impact on land use and farm productivity. Rich data from agricultural censuses in 1865 and 1910 helped us demonstrate that towns and villages nearer 18th-century German settlements had higher agricultural productivity. This immigration effect was supported by two mechanisms. Farmers closer to German settlement areas were more engaged in more intensive types of cultivation and achieved higher productivity in these types of cultivation. Our empirical findings are consistent with historical accounts that German immigrants improved agricultural practices in Hungary thanks to their advance knowledge in farming techniques and higher basic human capital compared to the rest of the population. We demonstrate that this powerful persistent development effect is independent from geographical characteristics and confounding factors including ethnic and religious diversity or historical institutions. We also highlight, however, that the development gains from German immigration diffused slowly and only locally because of the limited geographical mobility of rural populations in Hungary before the First World War.

Our research indicates that transnational migration may have played an important role in premodern, predominantly agrarian, development but economic effects remained localized in the absence of effective knowledge transfer.

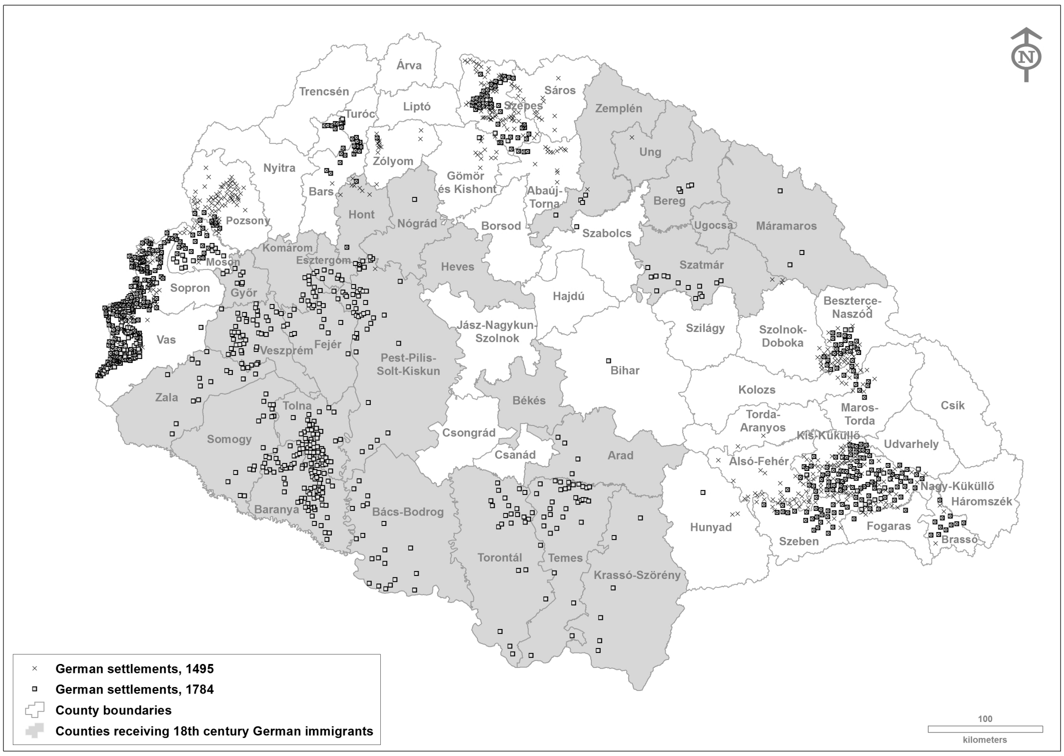
# Figures and Tables

**Figure 1:** *Numeracy in Central and South-Eastern Europe, 1710-1840*



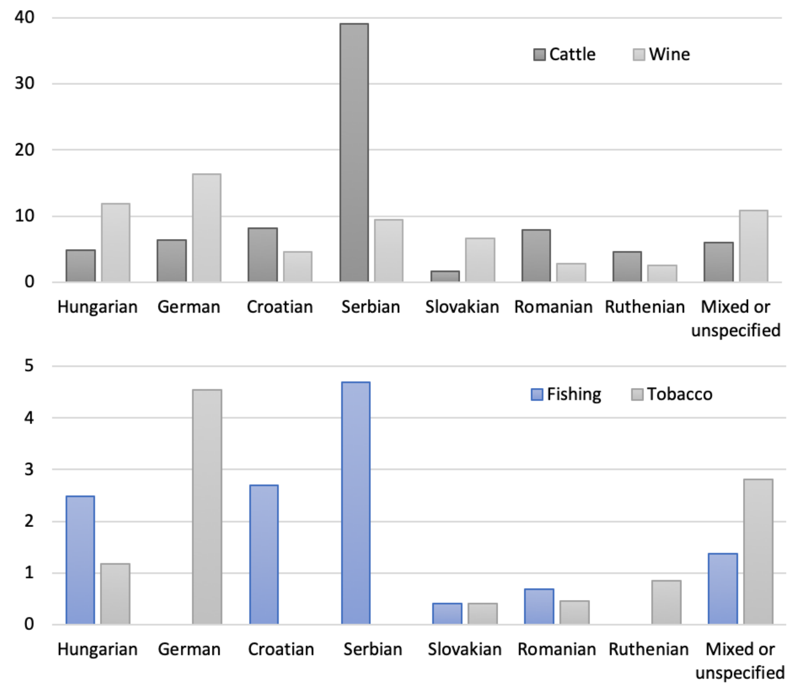

*Notes:* ABCC index of basic numeracy estimates the share of people in a population which are able to accurately report their age.
*Sources*: Blum and Krauss (2018) for German settlers and Clio Infra database for rest.

**Figure 2:** *Areas of German settlement in the Kingdom of Hungary*



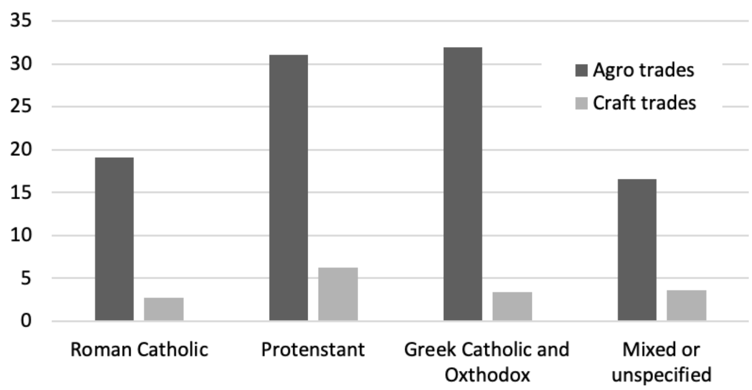

*Notes:* Boundaries represent counties in the Kingdom of Hungary in 1910. Counties first affected by German immigration in the 18th century are highlighted in grey. Boxes mark German settlements in 1784. German settlements that existed in 1495 are marked with an *x*.
*Source*: Own cartographic illustration based on Kocsis and Tátrai (2015).

**Figure 3:** *Share of villages (%) noted for specialized agricultural trades by ethnicity in 1796 (%)*



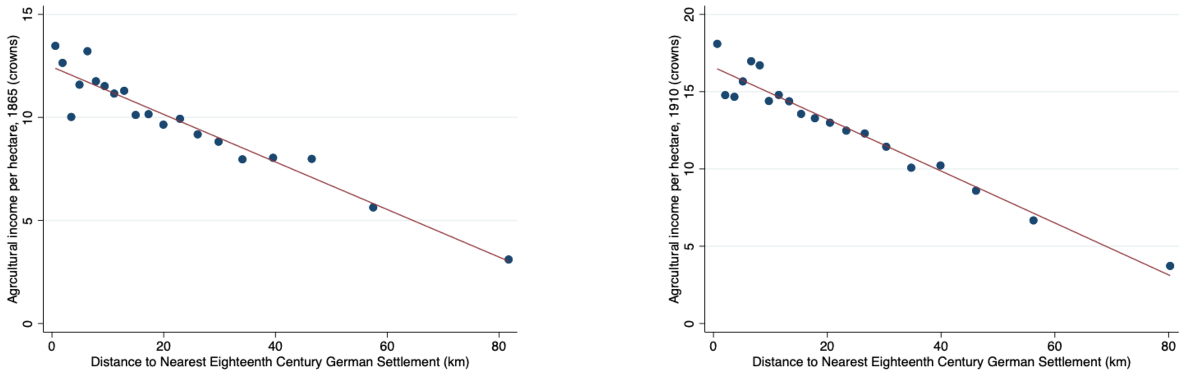

*Sources:* Own computation computations based on information collected from Vàlyi (1796-9) and the classification of settlements by ethnicity reported in Table 1.

**Figure 4:** *Share of towns and villages (%) noted for at least one specialized agricultural or craft trade by religion in 1796 (%)*



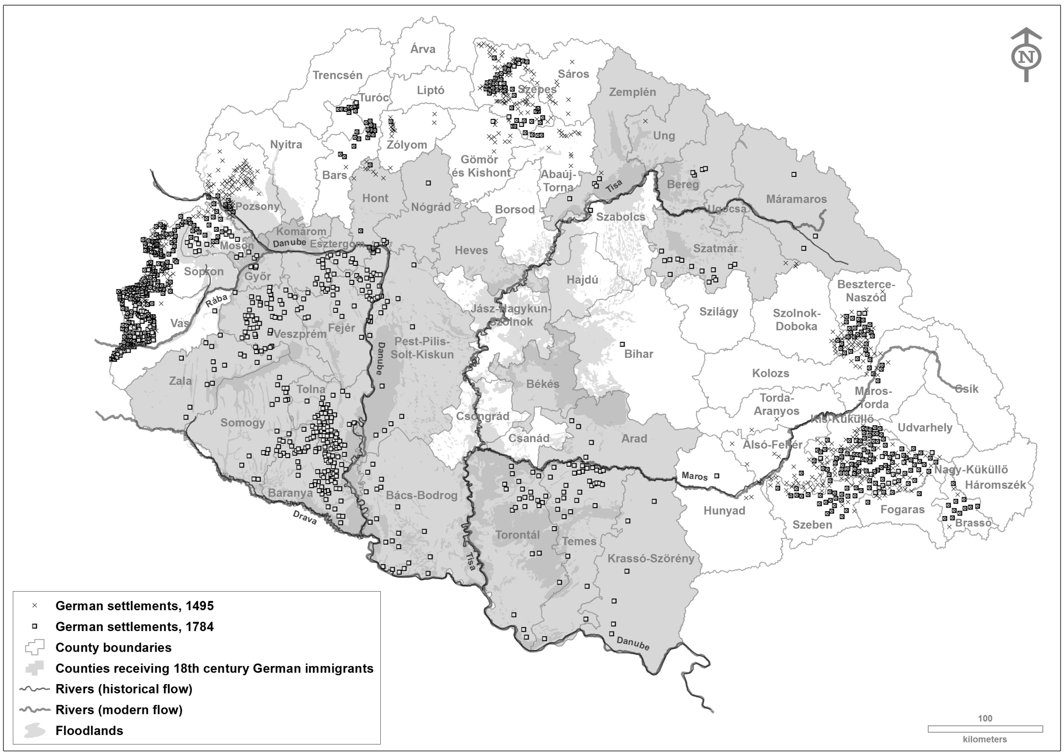

*Sources:* Own computation computations based on information collected from Vàlyi (1796-9) and the classification of settlements by religion reported in Table 1.

**Figure 5:** *Land productivity and distance to nearest German settlement*



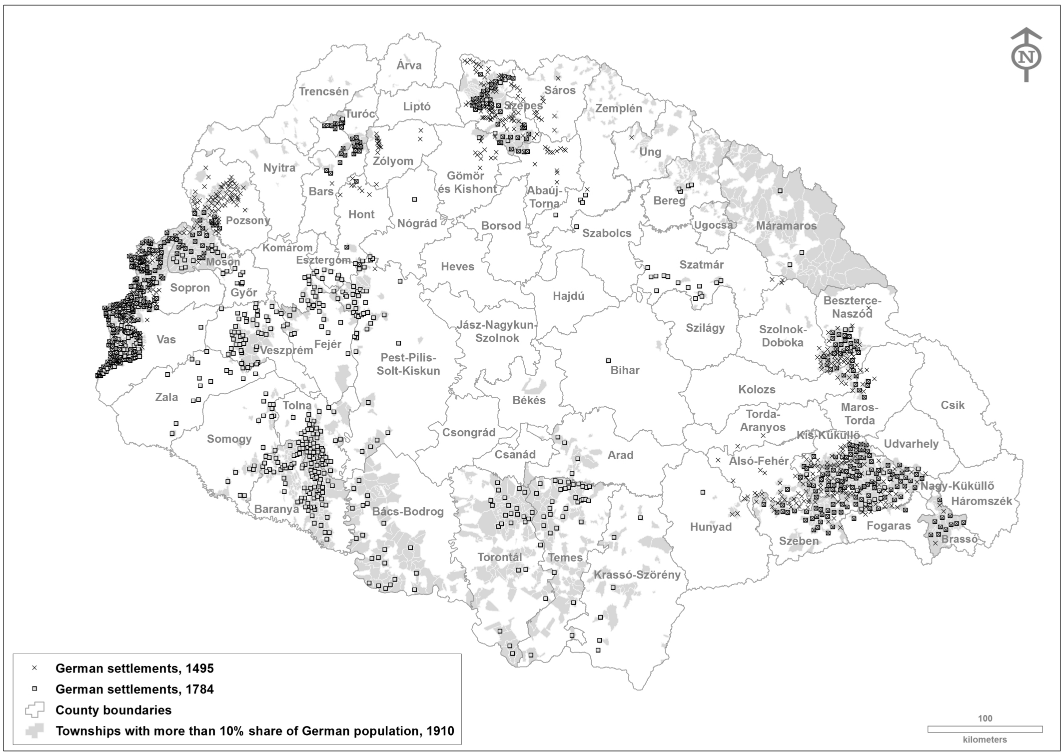

*Notes:* Unconditional binned scatter plots of distance to nearest 18th century German settlement in kilometers and agricultural income (in crowns) per hectare in 1865 (left) and 1910 (right). The figures illustrate that agricultural productivity decreases with distance and increases with proximity to German settlements.

**Figure 6:** *Areas of German settlement and waterways in the Kingdom of Hungary*



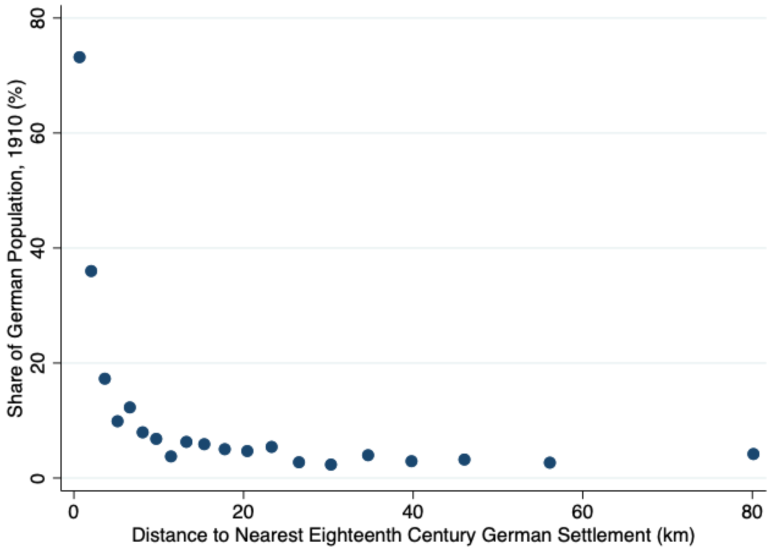

*Notes:* Boundaries represent counties in the Kingdom of Hungary in 1910. Flood lands and lakes are highlighted in dark gray. Historical river flows of the main navigable rivers are drawn in black.
*Sources*: Own cartographic illustration based on Figure 2 and map of Hydrographical Institute of the Hungarian Ministry of Agriculture (1938) available at `https://maps.hungaricana.hu/hu/HTITerkeptar/2206/`.

**Figure 7:** *German settlements and share of German population*




*Notes:* Boundaries represent counties in the Kingdom of Hungary in 1910. Areas of settlement with a German population share of more than 10% in 1910 are highlighted in grey. Boxes mark German settlements in 1784. German settlements that existed in 1495 are marked with an *x*.
*Sources*: Own cartographic illustration based on Figure 2 and information from the population census of Hungary in 1910.

**Figure 8:** *Distance to nearest German settlement and German population share*




*Notes:* Unconditional binned scatter plot of distance to nearest 18th century German settlement in kilometers and the share of Germans in the local population in 1910. The figure illustrates that most Germans in Hungary remained concentrated in close proximity to their 18th century settlements.

**Table 1:** *Villages and towns in Hungarian counties affected by 18th century German immigration by ethnicity and religion in 1796*

| | Religion | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Ethnicity | Roman Catholic | Protestant | | Greek | | Mixed with majority | | | Mixed or unknown | Total |
| | | Calvinist | Lutheran | Catholic | Orthodox | Catholic | Protestant | Orthodox | | |
| Hungarian | 863 | 254 | 10 | 0 | 1 | 340 | 6 | 5 | 206 | 1685 |
| German | 190 | 0 | 3 | 0 | 0 | 7 | 2 | 0 | 26 | 228 |
| Croatian | 104 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 8 | 114 |
| Serbian | 18 | 0 | 0 | 0 | 37 | 4 | 0 | 0 | 5 | 64 |
| Slovakian | 217 | 0 | 21 | 7 | 56 | 108 | 0 | 1 | 94 | 504 |
| Romanian | 3 | 0 | 0 | 19 | 325 | 37 | 1 | 4 | 55 | 444 |
| Ruthenian | 4 | 0 | 0 | 50 | 232 | 17 | 0 | 3 | 47 | 353 |
| Mixed with majority | 136 | 0 | 1 | 2 | 17 | 138 | 26 | 25 | 30 | 375 |
| Hungarian | 97 | 0 | 0 | 0 | 0 | 92 | 24 | 15 | 24 | 252 |
| German | 14 | 0 | 1 | 0 | 1 | 21 | 0 | 0 | 2 | 39 |
| Croatian | 9 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 10 |
| Serbian | 0 | 0 | 0 | 0 | 9 | 12 | 0 | 8 | 0 | 29 |
| Slovakian | 16 | 0 | 0 | 1 | 0 | 7 | 1 | 0 | 2 | 27 |
| Romanian | 0 | 0 | 0 | 0 | 4 | 5 | 1 | 2 | 1 | 13 |
| Ruthenian | 0 | 0 | 0 | 1 | 3 | 1 | 0 | 0 | 0 | 5 |
| Mixed or unknown | 307 | 8 | 6 | 7 | 21 | 142 | 1 | 3 | 525 | 1020 |
| All settlements | 1842 | 262 | 41 | 85 | 689 | 795 | 36 | 41 | 996 | 4787 |

*Notes:* Settlements whose ethnic and religious composition is either not specified in the source or is specified as mixed with no indication of the majority ethnic group or religion.
*Source:* Our own aggregation based on information collected from Vályi (1796-9).

## **Table 2:** *Summary statistics*

| Distance to nearest German settlement: | Within median (<16.5 km) | | | | | Beyond median (>16.5 km) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Mean | Std. dev. | Min. | Max. | N | Mean | Std. dev. | Min. | Max. | N |
| *Outcomes* | | | | | | | | | | |
| Agricultural income per ha of arable land (1865) | 11.7 | 7.5 | 0.5 | 94.7 | 2384 | 8 | 5.8 | 0.3 | 38.5 | 2292 |
| % cropland (1865) | 41.8 | 18.7 | 0 | 98.6 | 2385 | 35.8 | 19.2 | 0 | 95.5 | 2292 |
| % vineyards (1865) | 3.3 | 5.5 | 0 | 83.5 | 2385 | 1.1 | 3 | 0 | 54.3 | 2292 |
| % pastures (1865) | 14.3 | 10.9 | 0 | 79.1 | 2385 | 14.9 | 11.9 | 0 | 77.6 | 2292 |
| Agricultural income per ha of arable land (1910) | 15.4 | 8.8 | 0.2 | 84.3 | 2614 | 10.2 | 8.5 | 0.1 | 46.7 | 2622 |
| Agricultural income per ha of cropland (1910) | 17.4 | 8.6 | 0.5 | 48.9 | 2608 | 12.5 | 8.7 | 0.8 | 51.7 | 2616 |
| Agricultural income per ha of vineyards (1910) | 34.9 | 15 | 0.7 | 102.1 | 1998 | 28.8 | 15.5 | 0.8 | 97.3 | 1096 |
| Agricultural income per ha of pastures (1910) | 6 | 4.4 | 0.3 | 26.1 | 2576 | 4.3 | 4 | 0.3 | 23.7 | 2557 |
| % cropland (1910) | 56.1 | 21.3 | 0 | 95.5 | 2614 | 47.1 | 24.6 | 0 | 96 | 2623 |
| % vineyards (1910) | 2.4 | 4.1 | 0 | 46.5 | 2614 | 0.7 | 2.1 | 0 | 27.8 | 2623 |
| % pastures (1910) | 10.1 | 8.2 | 0 | 59.8 | 2614 | 12.6 | 9.3 | 0 | 56.2 | 2623 |
| *Treatment and instrument* | | | | | | | | | | |
| Distance to nearest German settlement (km) | 7.6 | 4.6 | 0 | 16.4 | 2631 | 37.5 | 18.7 | 16.4 | 112.6 | 2631 |
| Migration router from Vienna (km) | 710.1 | 377.3 | 114.6 | 1527 | 2631 | 1010.3 | 412.2 | 119.8 | 1571 | 2631 |
| *Controls* | | | | | | | | | | |
| Area (km2) | 25.1 | 27.7 | 0.1 | 336.7 | 2631 | 27.2 | 47.2 | 0.4 | 973.7 | 2631 |
| Altitude | 170.9 | 103.9 | 65 | 1353 | 2631 | 237.5 | 183.6 | 35 | 1826 | 2631 |
| Latitude | 46.7 | 0.9 | 44.7 | 48.6 | 2631 | 47.5 | 1.2 | 44.5 | 49.4 | 2631 |
| Longitude | 19.4 | 1.9 | 16.6 | 24.3 | 2631 | 20.8 | 2.1 | 16.2 | 24.8 | 2631 |
| Ruggedness | 5.3 | 5.5 | 0 | 55.7 | 2631 | 7.4 | 7.7 | 0 | 60.9 | 2631 |
| Soil suitability | 71 | 41.8 | 0 | 100 | 2631 | 60.6 | 45.5 | 0 | 100 | 2631 |
| Land quality (Ványi, 1796-9) | 2 | 0.7 | 1 | 3 | 2206 | 2.2 | 0.7 | 1 | 3 | 2176 |
| Distance to nearest urban market | 32.5 | 18.5 | 0 | 92.7 | 2631 | 51.9 | 25.1 | 0 | 124.7 | 2631 |
| % Jewish (1910) | 1.9 | 3.6 | 0 | 52.8 | 2631 | 4 | 5.6 | 0 | 47.6 | 2631 |
| % Christian-Orthodox (1910) | 13.2 | 29.9 | 0 | 100 | 2631 | 13.9 | 32.4 | 0 | 100 | 2631 |
| % Protestant (1910) | 17.59 | 27.71 | 0 | 99.3 | 2631 | 17.7 | 28.9 | 0 | 98.8 | 2631 |
| Ethnic fractionalization (1910) | 0.17 | 0.19 | 0 | 0.76 | 2631 | 0.14 | 0.16 | 0 | 0.71 | 2631 |
| Population density (1910) | 101.5 | 353 | 2.2 | 8176.6 | 2631 | 66.6 | 72.4 | 2.7 | 2064 | 2631 |
| Railway density (1910) | 0.1 | 0.38 | 0 | 14.22 | 2631 | 0.07 | 0.37 | 0 | 18.1 | 2631 |
| German city law (0/1) | 0 | 0.05 | 0 | 1 | 2631 | 0 | 0.04 | 0 | 1 | 2631 |
| Free royal cities (0/1) | 0 | 0.06 | 0 | 1 | 2631 | 0 | 0.05 | 0 | 1 | 2631 |
| Military Frontier (0/1) | 0.03 | 0.17 | 0 | 1 | 2631 | 0.1 | 0.3 | 0 | 1 | 2631 |

*Notes:* See Section 3.2 for variable definitions and sources of data.

**Table 3:** *Agricultural productivity and distance to nearest German settlement (OLS)*

| Dependent variable: | Agricultural income per hectare of arable land | | | | | |
|---|---|---|---|---|---|---|
| | 1865 | | | 1910 | | |
| | (1) | (2) | (3) | (4) | (5) | (6) |
| Distance to nearest German settlement | -0.086*** | -0.049*** | -0.029** | -0.112*** | -0.057*** | -0.039*** |
| | (0.014) | (0.012) | (0.012) | (0.017) | (0.013) | (0.015) |
| Area | | -0.001 | -0.005 | | 0.005 | 0.001 |
| | | (0.003) | (0.003) | | (0.004) | (0.004) |
| Altitude | | -0.011*** | -0.009*** | | -0.014*** | -0.014*** |
| | | (0.002) | (0.002) | | (0.002) | (0.002) |
| Latitude | | -2.086** | -1.704* | | -1.645* | -1.818* |
| | | (0.901) | (0.970) | | (0.933) | (1.080) |
| Longitude | | -1.564** | -0.542 | | -1.546** | -0.370 |
| | | (0.642) | (0.629) | | (0.785) | (0.791) |
| Ruggedness | | -0.076*** | -0.077*** | | -0.177*** | -0.174*** |
| | | (0.016) | (0.015) | | (0.020) | (0.020) |
| Soil suitability | | -0.002 | -0.002 | | -0.005 | -0.002 |
| | | (0.004) | (0.004) | | (0.005) | (0.005) |
| Land quality | | | -0.638*** | | | -1.026*** |
| | | | (0.121) | | | (0.144) |
| Distance to nearest urban market | | | -0.045*** | | | -0.033** |
| | | | (0.013) | | | (0.016) |
| County fixed effects | Yes | Yes | Yes | Yes | Yes | Yes |
| Observations | 4676 | 4676 | 4091 | 5236 | 5236 | 4366 |
| R-squared | 0.498 | 0.566 | 0.555 | 0.527 | 0.616 | 0.612 |
| Dependent variable mean | 9.86 | 9.86 | 9.73 | 12.79 | 12.79 | 12.74 |

*Notes:* Table reports results of OLS estimation of equation 1. Distance is measured in kilometers. Standard errors, clustered at the district level, are given in parentheses. ***, **, and * refer to p<0.01, p<0.05, and p<0.10, respectively.

**Table 4:** *Mechanisms: type and intensity of land use (OLS)*

| | 1865 | | | 1910 | | | 1910 | | |
|---|---|---|---|---|---|---|---|---|---|
| Dependent variable: | | | | | | | agricultural income per hectare of | | |
| | % cropland | % vineyards | % pastures | % cropland | % vineyards | % pastures | cropland | vineyards | pastures |
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) |
| Distance to nearest German settlement | -0.076** | -0.047*** | 0.149*** | -0.039 | -0.032*** | 0.078*** | -0.035** | -0.193*** | -0.001 |
| | (0.037) | (0.009) | (0.024) | (0.043) | (0.007) | (0.024) | (0.015) | (0.040) | (0.008) |
| Area | -0.032** | -0.002 | 0.006 | -0.034** | 0.002 | 0.005 | 0.007 | 0.012* | 0.004 |
| | (0.013) | (0.002) | (0.005) | (0.013) | (0.001) | (0.005) | (0.005) | (0.007) | (0.003) |
| Altitude | -0.024*** | -0.001 | -0.007** | -0.048*** | -0.002** | -0.000 | -0.014*** | -0.027*** | -0.006*** |
| | (0.006) | (0.001) | (0.003) | (0.008) | (0.001) | (0.002) | (0.002) | (0.006) | (0.001) |
| Latitude | 6.595*** | 1.213* | -2.129* | 4.344* | -0.064 | -0.925 | -2.944** | -2.761 | -1.493** |
| | (2.385) | (0.641) | (1.285) | (2.620) | (0.509) | (1.182) | (1.236) | (2.089) | (0.605) |
| Longitude | -3.365 | 1.154* | 0.723 | -4.454* | 0.644 | 0.416 | -1.001 | 0.203 | -1.126*** |
| | (2.217) | (0.675) | (0.886) | (2.701) | (0.425) | (0.862) | (0.839) | (1.636) | (0.406) |
| Ruggedness | -0.525*** | 0.060*** | -0.108*** | -0.719*** | 0.033*** | 0.005 | -0.141*** | 0.028 | -0.077*** |
| | (0.064) | (0.018) | (0.036) | (0.067) | (0.011) | (0.036) | (0.021) | (0.067) | (0.009) |
| Soil suitability | -0.013 | 0.009*** | 0.009 | -0.015 | 0.004** | -0.003 | 0.000 | 0.024*** | -0.009*** |
| | (0.016) | (0.003) | (0.007) | (0.016) | (0.002) | (0.009) | (0.005) | (0.009) | (0.003) |
| Land quality | -0.662 | -0.463*** | 0.136 | -0.946** | -0.164* | 0.701*** | -1.219*** | -1.748*** | -0.251*** |
| | (0.434) | (0.116) | (0.258) | (0.419) | (0.084) | (0.193) | (0.150) | (0.381) | (0.081) |
| Distance to nearest urban market | -0.089** | -0.035*** | 0.029 | -0.171*** | -0.006 | 0.029 | -0.019 | -0.154*** | -0.001 |
| | (0.041) | (0.009) | (0.020) | (0.045) | (0.006) | (0.020) | (0.017) | (0.039) | (0.008) |
| County fixed effects | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Observations | 4092 | 4092 | 4092 | 4367 | 4367 | 4367 | 4357 | 2601 | 4281 |
| R-squared | 0.333 | 0.187 | 0.198 | 0.480 | 0.211 | 0.139 | 0.619 | 0.362 | 0.448 |
| Dependent variable mean | 38.82 | 2.27 | 14.53 | 51.99 | 1.62 | 11.36 | 14.79 | 31.86 | 5.1 |

*Notes:* Table reports results of OLS estimation of equation 1. Standard errors, clustered at the district level, are given in parentheses. ***, **, and * refer to $p<0.01$, $p<0.05$, and $p<0.10$, respectively.

**Table 5:** *Agricultural productivity and distance to nearest German settlement (2SLS)*

| | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|
| Panel A. Second-stage. | Agricultural income per hectare of arable land | | | | | |
| | 1865 | | | 1910 | | |
| Distance to nearest German settlement | -0.152*** | -0.100*** | -0.079*** | -0.160*** | -0.094** | -0.072* |
| | (0.033) | (0.027) | (0.024) | (0.049) | (0.044) | (0.041) |
| R-squared | 0.480 | 0.557 | 0.546 | 0.521 | 0.613 | 0.610 |
| Dependent variable mean | 9.86 | 9.86 | 9.73 | 12.79 | 12.79 | 12.74 |
| Panel B. First-stage. | | | | | | |
| | Distance to nearest German settlement | | | | | |
| Migration route | 0.040*** | 0.040*** | 0.040*** | 0.041*** | 0.039*** | 0.040*** |
| | (0.006) | (0.005) | (0.005) | (0.006) | (0.005) | (0.005) |
| Dependent variable mean | 22.44 | 22.44 | 22.68 | 22.6 | 22.6 | 22.7 |
| County fixed effects | Yes | Yes | Yes | Yes | Yes | Yes |
| Geographical controls | No | Yes | Yes | No | Yes | Yes |
| Observations | 4676 | 4676 | 4091 | 5236 | 5236 | 4366 |
| K-P Wald F-statistic | 45.231 | 47.503 | 48.793 | 45.866 | 45.039 | 50.902 |

*Notes:* Table reports results of 2SLS estimation of equation 2. The instrument is the migration route from Vienna, measured as least-cost distance via navigable rivers and over land. Distance is measured in kilometers. Control variables are the same as in Table 3. Standard errors, clustered at the district level, are given in parentheses. ***, **, and * refer to $p<0.01$, $p<0.05$, and $p<0.10$, respectively.

**Table 6:** *Mechanisms: type and intensity of land use (2SLS)*

| Dependent variable: | 1865 | | | 1910 | | | 1910 agricultural income per hectare of | | |
|---|---|---|---|---|---|---|---|---|---|
| | % cropland | % vineyards | % pastures | % cropland | % vineyards | % pastures | cropland | vineyards | pastures |
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) |
| Distance to nearest German settlement | -0.008 | -0.100*** | 0.149*** | -0.137 | -0.039** | 0.170*** | -0.095** | -0.324*** | 0.029 |
| | (0.090) | (0.039) | (0.045) | (0.130) | (0.019) | (0.042) | (0.045) | (0.120) | (0.019) |
| County fixed effects | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Geographical controls | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Observations | 4092 | 4092 | 4092 | 4367 | 4367 | 4367 | 4357 | 2601 | 4281 |
| R-squared | 0.331 | 0.167 | 0.198 | 0.477 | 0.211 | 0.121 | 0.611 | 0.355 | 0.439 |
| K-P Wald F-statistic | 48.796 | 48.796 | 48.796 | 50.877 | 50.877 | 50.877 | 50.796 | 47.245 | 51.700 |
| Dependent variable mean | 38.82 | 2.27 | 14.53 | 51.99 | 1.62 | 11.36 | 14.79 | 31.86 | 5.1 |

*Notes:* Table reports second-stage results of 2SLS estimation of equation 2. The instrument is the migration route from Vienna, measured as least-cost distance via navigable rivers and over land. Distance is measured in kilometers. Geographical control variables are the same as in Table 3, models 3 and 6 for 1865 and 1910 respectively. Standard errors, clustered at the district level, are given in parentheses. ***, **, and * refer to $p<0.01$, $p<0.05$, and $p<0.10$, respectively.

## **Table 7:** *Controlling for religious composition in 1910 (OLS)*

| Dependent variable: | agricultural income per hectare of | | | | | | |
|---|---|---|---|---|---|---|---|
| | arable land | cropland | vineyards | pastures | % cropland | % vineyards | % pastures |
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) |
| Distance to nearest German settlement | -0.037** | -0.034** | -0.186*** | 0.001 | -0.033 | -0.031*** | 0.078*** |
| | (0.014) | (0.015) | (0.040) | (0.008) | (0.043) | (0.007) | (0.024) |
| % Jewish | 0.068*** | 0.055** | 0.291*** | -0.010 | 0.157 | 0.057*** | -0.031 |
| | (0.024) | (0.023) | (0.074) | (0.012) | (0.105) | (0.018) | (0.045) |
| % Christian-Orthodox | -0.033** | -0.016 | -0.021 | -0.013* | -0.054* | -0.016*** | 0.013 |
| | (0.014) | (0.014) | (0.017) | (0.007) | (0.030) | (0.005) | (0.012) |
| % Protestant | 0.008 | 0.001 | -0.018* | 0.007** | 0.048*** | -0.001 | 0.008 |
| | (0.006) | (0.006) | (0.010) | (0.003) | (0.016) | (0.002) | (0.009) |
| Geographical controls | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| County fixed effects | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Observations | 4366 | 4357 | 2601 | 4281 | 4367 | 4367 | 4367 |
| R-squared | 0.616 | 0.620 | 0.366 | 0.452 | 0.485 | 0.218 | 0.140 |
| Dependent variable mean | 12.74 | 14.79 | 31.86 | 5.1 | 51.99 | 1.62 | 11.36 |

*Notes:* Table reports results of OLS estimation of equation 1. Additional controls include share of Jewish population, share of Christian-Orthodox population, and share of Protestant population. Share of Roman Catholic population is the omitted reference category. Other control variables are the same as in Table 3, model 6. Standard errors, clustered at the district level, are given in parentheses. ***, **, and * refer to $p<0.01$, $p<0.05$, and $p<0.10$, respectively.

**Table 8:** *Controlling for religious composition in 1910 (2SLS)*

| Dependent variable: | agricultural income per hectare of | | | | | | |
|---|---|---|---|---|---|---|---|
| | arable land | cropland | vineyards | pastures | % cropland | % vineyards | % pastures |
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) |
| Distance to nearest German settlement | -0.069* | -0.094** | -0.319*** | 0.031 | -0.118 | -0.039** | 0.172*** |
| | (0.041) | (0.044) | (0.117) | (0.019) | (0.130) | (0.019) | (0.043) |
| % Jewish | 0.073*** | 0.063*** | 0.296*** | -0.014 | 0.169 | 0.058*** | -0.044 |
| | (0.024) | (0.024) | (0.074) | (0.013) | (0.106) | (0.018) | (0.046) |
| % Christian-Orthodox | -0.030** | -0.011 | -0.013 | -0.016** | -0.047 | -0.016*** | 0.005 |
| | (0.015) | (0.015) | (0.020) | (0.008) | (0.031) | (0.005) | (0.012) |
| % Protestant | 0.007 | 0.001 | -0.012 | 0.008** | 0.047*** | -0.001 | 0.009 |
| | (0.006) | (0.007) | (0.012) | (0.003) | (0.016) | (0.002) | (0.010) |
| Geographical controls | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| County fixed effects | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Observations | 4366 | 4357 | 2601 | 4281 | 4367 | 4367 | 4367 |
| R-squared | 0.613 | 0.612 | 0.359 | 0.443 | 0.482 | 0.218 | 0.121 |
| K-P Wald F-statistic | 51.751 | 51.702 | 50.649 | 52.446 | 51.724 | 51.724 | 51.724 |
| Dependent variable mean | 12.74 | 14.79 | 31.86 | 5.1 | 51.99 | 1.62 | 11.36 |

*Notes:* Table reports second-stage results of 2SLS estimation of equation 2. The instrument is the migration route from Vienna, measured as least-cost distance via navigable rivers and over land. Additional controls include share of Jewish population, share of Christian-Orthodox population, and share of Protestant population. Share of Roman Catholic population is the omitted reference category. Other control variables are the same as in Table 3, model 6. Standard errors, clustered at the district level, are given in parentheses. ***, **, and * refer to p<0.01, p<0.05, and p<0.10, respectively.

## **Table 9:** *Spatial diffusion*

| Dependent variable: | Agricultural income per hectare of arable land | | | |
|---|---|---|---|---|
| | 1865 | | 1910 | |
| | (1) | (2) | (3) | (4) |
| Distance to nearest German settlement | -0.148** | -0.036*** | -0.092 | -0.053*** |
| | (0.066) | (0.011) | (0.074) | (0.015) |
| Sample: Distance to nearest German settlement | Within median | Beyond median | Within median | Beyond median |
| County fixed effects | Yes | Yes | Yes | Yes |
| Geographical controls | Yes | Yes | Yes | Yes |
| Observations | 2045 | 2046 | 2183 | 2183 |
| R-squared | 0.285 | 0.459 | 0.391 | 0.541 |
| Dependent variable mean | 11.42 | 8.04 | 15.31 | 10.17 |

*Notes:* Table reports results of OLS estimation of equation 1. The sample is split by median distance to nearest German settlement (16.1 km in 1865; 16.3 km in 1910). Geographical control variables are the same as in Table 3, models 3 and 6 for 1865 and 1910 respectively. Standard errors, clustered at the district level, are given in parentheses. ***, **, and * refer to p<0.01, p<0.05, and p<0.10, respectively.

# Appendix A: Historical demographic sources in the Kingdom of Hungary

The *Description of Hungary* published by András Vályi in three volumes between 1796 and 1799 is the most extensive source of demographic data on 18th century Hungary. It comprises brief notes on each town, villages, or temporary settlement in the Kingdom of Hungary. In the area corresponding to the 25 counties that were affected by German immigration in the 18th century and that our study examines, the imperial census of 1910 enumerated 5262 settlements. We managed to match 4786 settlements in Vályi's Description. From historical records in the 19th century, we identified a further 186 settlements that were established after 1800 and 18 settlements that were mentioned in the Description but not independently. We could find no information on the history of 282 settlements listed in the 1910 census.

Despite the very high matching ratio (91%), we have several counties with a relatively high number of unmatched settlements, particularly Arad, Krassó-Szörény, Temes, and Torontál in the southern Banat region, Szatmár in the northwest, and Zala in the southwest. Particular 'white spots' are he lands of Kővár in county Szatmár and the Csajka district in the Serbian military frontier, later incorporated in county Bács.

The process of matching settlements between the *Description* and the 1910 population census was difficult because of the frequency of name changes for towns and villages, mergers and separations between villages, occasional printing errors and false classification of settlements by historical counties in the Description. Many settlements changed names several times or used alternative names interchangeably during the 19th century. We gathered the necessary information from the following list of historical sources.

Balpataki, K. (2014). Batta, Varjasbatta - legyen Százhalombatta. *Történeti Muzeológiai Szemle* 12, 185-192.

Borovszky, S. Ed. (1896-1914). *Magyarország vármegyéi és városai: A Magyar Korona országai történetének, földrajzi, képzőművészeti, néprajzi, hadügyi és természeti viszonyainak, közművelődési és közgazdasági állapotának encziklopédiája.* 26 volumes.

Budapest: Országos Monográfiai Társaság.

Demeter, Zs. (1998). Lajoskomárom, a "legelső rendes falu". *Honismeret* 26, 26–30.

Fridrik, T. (1878). *Bács-Bodrogh vármegye földrajzi, történelmi és statisztikai népszerű leírása.* Szeged: Endrényi Lajos és Társa.

Gaal, J. (1898). *Aradvármegye és Arad szabad királyi város monographiája.* 3 volumes. Vol 3, Part 2: Aradvármegye és Arad szabad királyi város közgazdasági, közigazgatási és közművelődési állapotának leírása. Arad: Monográphia-Bizottság.

Galgóczy, K. (1877). P*est, Pilis és Solt törvényesen egyesült megye monographiája.* Part 3: A megye részletes leírása. Budapest: Weiszmann Testvérek.

Gyalay, M. (1997). *Magyar igazgatástörténeti helységnévlexikon.* Vol. 2. Budapest: Engeler.

Központi Statisztikai Hivatal (1996). *Magyarország történeti statisztikai helységnévtára.* Vol. 7. Zala megye. Budapest: KSH.

Központi Statisztikai Hivatal (1996). *Magyarország történeti statisztikai helységnévtára.* Vol. 10: Tolna megye. Budapest: KSH.

Központi Statisztikai Hivatal (2000). *Magyarország történeti statisztikai helységnévtára.* Vol. 19. Győr megye. Budapest: KSH.

Ladányi, M. Ed. (1937). *Magyar városok monografiája.* Vol. 21: Kispest, Pestszentlőrinc, Pestszentimre. Budapest.

Mohai, M. (2002). Udvarszállás (Dobričevo), egy jugoszláviai magyar nyelvsziget. *Híd* 66, 349-372.

Pesty, F. (2019). *Baranya vármegye helységnévtára* 1864-1865. Pécs: Csorba Győző Könyvtár.

Sebestyén, Zs. (2010). *Bereg megye helységneveinek etimológiai szótára.* Nyíregyháza: Bessenyei Könyvkiadó.

Sebestyén, Zs. (2012). *Máramaros megye helységneveinek etimológiai szótára.* Nyíregyháza: Bessenyei Könyvkiadó.

Somogyi, Gy. Ed. (1913). *Aradvármegye és Arad szabad királyi város monographiája.* Vol. 3, Part 1: Aradvármegye és Arad szabad királyi város néprajzi leírása. Arad: Monográphia-Bizottság.

Véber, A. and Tauffer, J., Eds. (1895). *Természettudományi Füzetek.* A Délmagyarországi Természettudományi Társulat közlönye. Temesvár.

Vistai, A. J. *Tekintő: Erdélyi helynévkönyv.* 3 volumes. Online publication: https://web.archive.org/web/20110710231100/http://www.fatornyosfalunk.com/html/erdelyi_helynevkonyv.html

For cartographic checks, we used the detailed maps of the First Imperial Military Survey for Hungary, carried out in 1782-1795. Source: Össterreichisches Staatsarchiv, B IX a 527. https://maps.arcanum.com/hu/map/firstsurvey-hungary/?layers=147&bbox=2109136.4761014967%2C6019117.903762623%2C2134914.8638906726%2C6026761.60659114

# Appendix B: robustness checks

## Controlling for flood zones

**Table B1:** *Agricultural productivity and distance to nearest German settlement (2SLS, adjusted instrument)*

| | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|
| Panel A. Second-stage. | Agricultural income per hectare of arable land | | | | | |
| | 1865 | | | 1910 | | |
| Distance to nearest German settlement | -0.164*** | -0.119*** | -0.102*** | -0.150*** | -0.096** | -0.081* |
| | (0.034) | (0.027) | (0.024) | (0.048) | (0.043) | (0.041) |
| R-squared | 0.460 | 0.549 | 0.545 | 0.529 | 0.623 | 0.622 |
| Dependent variable mean | 9.86 | 9.86 | 9.73 | 12.79 | 12.79 | 12.74 |
| Panel B. First-stage. | | | | | | |
| | Distance to nearest German settlement | | | | | |
| Migration route (adjusted) | 0.040*** | 0.040*** | 0.040*** | 0.040*** | 0.038*** | 0.039*** |
| | (0.006) | (0.005) | (0.005) | (0.006) | (0.005) | (0.005) |
| Dependent variable mean | 22.44 | 22.44 | 22.68 | 22.6 | 22.6 | 22.7 |
| County fixed effects | Yes | Yes | Yes | Yes | Yes | Yes |
| Geographical controls | No | Yes | Yes | No | Yes | Yes |
| Observations | 4676 | 4676 | 4091 | 5236 | 5236 | 4366 |
| K-P Wald F-statistic | 45.342 | 46.480 | 47.843 | 45.880 | 44.248 | 50.544 |

*Notes:* Table reports results of 2SLS estimation of equation 2. The instrument is the migration route from Vienna, measured as least-cost distance via navigable rivers and over land, including the distance from any settlement in a flood area to the nearest settlement outside the flood zones. Distance is measured in kilometers. Control variables are the same as in Table 3, models 3 and 6 for 1865 and 1910 respectively. Standard errors, clustered at the district level, are given in parentheses. ***, **, and * refer to p<0.01, p<0.05, and p<0.10, respectively.

**Table B2:** *Mechanisms: type and intensity of land use (2SLS, adjusted instrument)*

| | 1865 | | | 1910 | | | 1910 | | |
|---|---|---|---|---|---|---|---|---|---|
| Dependent variable: | | | | | | | agricultural income per hectare of | | |
| | % cropland | % vineyards | % pastures | % cropland | % vineyards | % pastures | cropland | vineyards | pastures |
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) |
| Distance to nearest German settlement | -0.015 | -0.101*** | 0.150*** | -0.137 | -0.040** | 0.171*** | -0.096** | -0.327*** | 0.029 |
| | (0.090) | (0.039) | (0.045) | (0.131) | (0.019) | (0.042) | (0.045) | (0.120) | (0.019) |
| County fixed effects | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Geographical controls | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Observations | 4092 | 4092 | 4092 | 4367 | 4367 | 4367 | 4357 | 2601 | 4281 |
| R-squared | 0.331 | 0.166 | 0.198 | 0.477 | 0.211 | 0.121 | 0.611 | 0.355 | 0.439 |
| K-P Wald F-statistic | 48.786 | 48.786 | 48.786 | 50.898 | 50.898 | 50.898 | 50.808 | 47.315 | 51.709 |
| Dependent variable mean | 38.82 | 2.27 | 14.53 | 51.99 | 1.62 | 11.36 | 14.79 | 31.86 | 5.1 |

*Notes:* Table reports second-stage results of 2SLS estimation of equation 2. The instrument is the migration route from Vienna, measured as least-cost distance via navigable rivers and over land, including the distance from any settlement in a flood area to the nearest settlement outside the flood zones. Distance is measured in kilometers. Geographical control variables are the same as in Table 3, models 3 and 6 for 1865 and 1910 respectively. Standard errors, clustered at the district level, are given in parentheses. ***, **, and * refer to $p<0.01$, $p<0.05$, and $p<0.10$, respectively.

**Table B3:** *Agricultural productivity and distance to nearest German settlement (OLS, restricted sample)*

| Dependent variable: | Agricultural income per hectare of arable land | | | | | |
|---|---|---|---|---|---|---|
| | 1865 | | | 1910 | | |
| | (1) | (2) | (3) | (4) | (5) | (6) |
| Distance to nearest German settlement | -0.084*** | -0.045*** | -0.027** | -0.106*** | -0.052*** | -0.032** |
| | (0.015) | (0.012) | (0.012) | (0.017) | (0.013) | (0.015) |
| Geographical controls | Yes | Yes | Yes | Yes | Yes | Yes |
| County fixed effects | Yes | Yes | Yes | Yes | Yes | Yes |
| Observations | 3990 | 3990 | 3489 | 4486 | 4486 | 3730 |
| R-squared | 0.487 | 0.570 | 0.565 | 0.534 | 0.627 | 0.628 |
| Dependent variable mean | 9.37 | 9.37 | 9.29 | 11.97 | 11.97 | 11.98 |

*Notes:* Table reports results of OLS estimation of equation 1. Distance is measured in kilometers. The sample is restricted to settlements outside flood areas. Geographical control variables are the same as in Table 3, models 3 and 6 for 1865 and 1910 respectively. Standard errors, clustered at the district level, are given in parentheses. ***, **, and * refer to p<0.01, p<0.05, and p<0.10, respectively.

**Table B4:** *Mechanisms: type and intensity of land use (OLS, restricted sample)*

| Dependent variable: | 1865 | | | 1910 | | | 1910 agricultural income per hectare of | | |
|---|---|---|---|---|---|---|---|---|---|
| | % cropland | % vineyards | % pastures | % cropland | % vineyards | % pastures | cropland | vineyards | pastures |
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) |
| Distance to nearest German settlement | -0.073* | -0.050*** | 0.147*** | -0.027 | -0.033*** | 0.077*** | -0.029* | -0.207*** | 0.002 |
| | (0.038) | (0.010) | (0.024) | (0.048) | (0.007) | (0.025) | (0.015) | (0.041) | (0.008) |
| Geographical and historical controls | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| County fixed effects | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Observations | 3490 | 3490 | 3490 | 3730 | 3730 | 3730 | 3724 | 2169 | 3663 |
| R-squared | 0.374 | 0.195 | 0.192 | 0.497 | 0.222 | 0.154 | 0.616 | 0.373 | 0.444 |
| Dependent variable mean | 38.74 | 2.42 | 14.01 | 50.38 | 1.65 | 11.32 | 13.97 | 31.89 | 4.63 |

*Notes:* Table reports results of OLS estimation of equation 1. Distance is measured in kilometers. The sample is restricted to settlements outside flood areas. Geographical control variables are the same as in Table 3, models 3 and 6 for 1865 and 1910 respectively. Standard errors, clustered at the district level, are given in parentheses. ***, **, and * refer to p<0.01, p<0.05, and p<0.10, respectively.

**Table B5:** *Agricultural productivity and distance from German settlements (2SLS, restricted sample)*

| | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|
| Panel A. Second-stage. | Agricultural income per hectare of arable land | | | | | |
| | 1865 | | | 1910 | | |
| Distance to nearest German settlement | -0.164*** | -0.119*** | -0.102*** | -0.150*** | -0.096** | -0.081* |
| | (0.034) | (0.027) | (0.024) | (0.048) | (0.043) | (0.041) |
| R-squared | 0.460 | 0.549 | 0.545 | 0.529 | 0.623 | 0.622 |
| Dependent variable mean | 9.37 | 9.37 | 9.29 | 11.97 | 11.97 | 11.98 |
| Panel B. First-stage. | | | | | | |
| | German settlement distance | | | | | |
| Migration route | 0.041*** | 0.041*** | 0.040*** | 0.041*** | 0.039*** | 0.039*** |
| | (0.006) | (0.006) | (0.005) | (0.006) | (0.005) | (0.005) |
| Dependent variable mean | 23.12 | 23.12 | 23.33 | 23.31 | 23.31 | 23.36 |
| County fixed effects | Yes | Yes | Yes | Yes | Yes | Yes |
| Geographical controls | No | Yes | Yes | No | Yes | Yes |
| Observations | 3990 | 3990 | 3489 | 4486 | 4486 | 3730 |
| K-P Wald F-statistic | 45.342 | 46.480 | 47.843 | 45.880 | 44.248 | 50.544 |

*Notes:* Table reports results of 2SLS estimation of equation 2. The sample is restricted to settlements outside flood areas. The instrument is the migration route from Vienna, measured as least-cost distance via navigable rivers and over land. Distance is measured in kilometers. Control variables are the same as in Table 3, models 3 and 6 for 1865 and 1910 respectively. Standard errors, clustered at the district level, are given in parentheses. ***, **, and * refer to p<0.01, p<0.05, and p<0.10, respectively.

**Table B6:** *Mechanisms: specialisation and intensive farming (2SLS, restricted sample)*

| Dependent variable: | 1865 | | | 1910 | | | 1910 agricultural income per hectare of | | |
|---|---|---|---|---|---|---|---|---|---|
| | % cropland | % vineyards | % pastures | % cropland | % vineyards | % pastures | cropland | vineyards | pastures |
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) |
| Distance to nearest German settlement | -0.074 | -0.110*** | 0.143*** | -0.136 | -0.041** | 0.169*** | -0.106** | -0.349*** | 0.028 |
| | (0.092) | (0.039) | (0.043) | (0.134) | (0.020) | (0.043) | (0.044) | (0.109) | (0.020) |
| County fixed effects | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Geographical controls | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Observations | 3490 | 3490 | 3490 | 3730 | 3730 | 3730 | 3724 | 2169 | 3663 |
| R-squared | 0.374 | 0.171 | 0.192 | 0.493 | 0.221 | 0.137 | 0.603 | 0.365 | 0.437 |
| K-P Wald F-statistic | 47.850 | 47.850 | 47.850 | 50.544 | 50.544 | 50.544 | 50.317 | 49.186 | 50.618 |
| Dependent variable mean | 38.74 | 2.42 | 14.01 | 50.38 | 1.65 | 11.32 | 13.97 | 31.89 | 4.63 |

*Notes:* Table reports second-stage results of 2SLS estimation of equation 2. The instrument is the migration route from Vienna, measured as least-cost distance via navigable rivers and over land. Distance is measured in kilometers. Geographical control variables are the same as in Table 3, models 3 and 6 for 1865 and 1910 respectively. Standard errors, clustered at the district level, are given in parentheses. ***, **, and * refer to $p<0.01$, $p<0.05$, and $p<0.10$, respectively.

## Confounding factors

**Table B7:** *Controlling for ethnic fractionalization in 1910 – (OLS)*

| Dependent variable: | agricultural income per hectare of | | | | | | |
|---|---|---|---|---|---|---|---|
| | arable land | cropland | vineyards | pastures | % cropland | % vineyards | % pastures |
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) |
| Distance to nearest German settlement | -0.040*** | -0.035** | -0.187*** | -0.001 | -0.040 | -0.032*** | 0.078*** |
| | (0.014) | (0.015) | (0.040) | (0.008) | (0.042) | (0.007) | (0.024) |
| Ethnic fractionalization | -1.441 | -0.745 | 2.352 | -1.466*** | -2.393 | -0.492 | -0.945 |
| | (0.982) | (1.026) | (1.540) | (0.475) | (2.465) | (0.370) | (1.112) |
| Geographical controls | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| County fixed effects | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Observations | 4366 | 4357 | 2601 | 4281 | 4367 | 4367 | 4367 |
| R-squared | 0.613 | 0.619 | 0.362 | 0.451 | 0.480 | 0.212 | 0.139 |
| Dependent variable mean | 12.74 | 14.79 | 31.86 | 5.1 | 51.99 | 1.62 | 11.36 |

*Notes:* Table reports results of OLS estimation of equation 1. The specification additionally controls for ethnic fractionalization. Other control variables are the same as in Table 3, model 6. Standard errors, clustered at the district level, are given in parentheses. ***, **, and * refer to p<0.01, p<0.05, and p<0.10, respectively.

**Table B8:** *Controlling for ethnic fractionalization in 1910 (2SLS)*

| Dependent variable: | agricultural income per hectare of | | | | | | |
|---|---|---|---|---|---|---|---|
| | arable land | cropland | vineyards | pastures | % cropland | % vineyards | % pastures |
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) |
| Distance to nearest German settlement | -0.076* | -0.098** | -0.318** | 0.026 | -0.144 | -0.041** | 0.168*** |
| | (0.041) | (0.045) | (0.125) | (0.019) | (0.131) | (0.020) | (0.042) |
| Ethnic fractionalization | -1.571 | -0.972 | 1.128 | -1.372*** | -2.760 | -0.522 | -0.626 |
| | (0.980) | (1.024) | (1.805) | (0.478) | (2.468) | (0.371) | (1.136) |
| Geographical controls | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| County fixed effects | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Observations | 4366 | 4357 | 2601 | 4281 | 4367 | 4367 | 4367 |
| R-squared | 0.610 | 0.610 | 0.356 | 0.444 | 0.477 | 0.211 | 0.122 |
| K-P Wald F-statistic | 48.328 | 48.297 | 44.564 | 49.067 | 48.307 | 48.307 | 48.307 |
| Dependent variable mean | 12.74 | 14.79 | 31.86 | 5.1 | 51.99 | 1.62 | 11.36 |

*Notes:* Table reports second-stage results of 2SLS estimation of equation 2. The instrument is the migration route from Vienna, measured as least-cost distance via navigable rivers and over land. The specification additionally controls for ethnic fractionalization. Other control variables are the same as in Table 3, model 6. Standard errors, clustered at the district level, are given in parentheses. ***, **, and * refer to p<0.01, p<0.05, and p<0.10, respectively.

## **Table B9:** *Controlling for population density in 1910 (OLS)*

| Dependent variable: | agricultural income per hectare of | | | | | | |
|---|---|---|---|---|---|---|---|
| | arable land | cropland | vineyards | pastures | % cropland | % vineyards | % pastures |
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) |
| Distance to nearest German settlement | -0.037*** | -0.032** | -0.178*** | 0.001 | -0.048 | -0.031*** | 0.079*** |
| | (0.014) | (0.015) | (0.039) | (0.008) | (0.042) | (0.007) | (0.024) |
| Population density | 0.003 | 0.002 | 0.010*** | 0.001 | -0.003 | 0.001 | -0.002** |
| | (0.003) | (0.002) | (0.003) | (0.001) | (0.003) | (0.001) | (0.001) |
| Geographical controls | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| County fixed effects | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Observations | 4366 | 4357 | 2601 | 4281 | 4367 | 4367 | 4367 |
| R-squared | 0.615 | 0.619 | 0.367 | 0.448 | 0.478 | 0.214 | 0.139 |
| Dependent variable mean | 12.74 | 14.79 | 31.86 | 5.1 | 51.99 | 1.62 | 11.36 |

*Notes:* Table reports results of OLS estimation of equation 1. Population density is included instead of settlement area. Other control variables are the same as in Table 3, model 6. Standard errors, clustered at the district level, are given in parentheses. ***, **, and * refer to $p<0.01$, $p<0.05$, and $p<0.10$, respectively.

**Table B10:** *Controlling for population density in 1910 (2SLS)*

| Dependent variable: | agricultural income per hectare of arable land | cropland | vineyards | pastures | % cropland | % vineyards | % pastures |
|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) |
| Distance to nearest German settlement | -0.068* | -0.085** | -0.282** | 0.033* | -0.168 | -0.036* | 0.171*** |
| | (0.039) | (0.043) | (0.112) | (0.019) | (0.126) | (0.019) | (0.041) |
| Population density | 0.003 | 0.002 | 0.010*** | 0.001 | -0.003 | 0.001 | -0.001** |
| | (0.003) | (0.002) | (0.003) | (0.001) | (0.003) | (0.001) | (0.001) |
| Geographical controls | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| County fixed effects | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Observations | 4366 | 4357 | 2601 | 4281 | 4367 | 4367 | 4367 |
| R-squared | 0.613 | 0.613 | 0.362 | 0.438 | 0.473 | 0.214 | 0.121 |
| K-P Wald F-statistic | 52.481 | 52.445 | 54.386 | 53.299 | 52.453 | 52.453 | 52.453 |
| Dependent variable mean | 12.74 | 14.79 | 31.86 | 5.1 | 51.99 | 1.62 | 11.36 |

*Notes:* Table reports results of 2SLS estimation of equation 2. The instrument is the migration route from Vienna, measured as least-cost distance via navigable rivers and over land. Population density is included instead of settlement area. Other control variables are the same as in Table 3, model 6. Standard errors, clustered at the district level, are given in parentheses. ***, **, and * refer to p<0.01, p<0.05, and p<0.10, respectively.

**Table B11:** *Controlling for railway density in 1910 (OLS)*

| Dependent variable: | agricultural income per hectare of | | | | | | |
|---|---|---|---|---|---|---|---|
| | arable land | cropland | vineyards | pastures | % cropland | % vineyards | % pastures |
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) |
| Distance to nearest German settlement | -0.037*** | -0.032** | -0.182*** | 0.001 | -0.048 | -0.031*** | 0.079*** |
| | (0.014) | (0.015) | (0.039) | (0.008) | (0.042) | (0.007) | (0.023) |
| Railway density | 2.475*** | 1.631*** | 1.944** | 1.241*** | -1.380 | 1.047*** | -0.765 |
| | (0.485) | (0.590) | (0.872) | (0.435) | (1.693) | (0.293) | (0.545) |
| Geographical controls | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| County fixed effects | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Observations | 4366 | 4357 | 2601 | 4281 | 4367 | 4367 | 4367 |
| R-squared | 0.616 | 0.620 | 0.362 | 0.449 | 0.478 | 0.215 | 0.139 |
| Dependent variable mean | 12.74 | 14.79 | 31.86 | 5.1 | 51.99 | 1.62 | 11.36 |

*Notes:* Table reports results of OLS estimation of equation 1. Railway density is included instead of settlement area. Other control variables are the same as in Table 3, model 6. Standard errors, clustered at the district level, are given in parentheses. ***, **, and * refer to p<0.01, p<0.05, and p<0.10, respectively.

**Table B12:** *Controlling for railway density in 1910 (2SLS)*

| Dependent variable: | agricultural income per hectare of | | | | | | |
|---|---|---|---|---|---|---|---|
| | arable land | cropland | vineyards | pastures | % cropland | % vineyards | % pastures |
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) |
| Distance to nearest German settlement | -0.071* | -0.087** | -0.292*** | 0.032* | -0.165 | -0.037** | 0.172*** |
| | (0.039) | (0.043) | (0.112) | (0.019) | (0.126) | (0.019) | (0.041) |
| Railway density | 2.392*** | 1.492*** | 1.732** | 1.392*** | -1.672 | 1.031*** | -0.535 |
| | (0.478) | (0.561) | (0.869) | (0.472) | (1.677) | (0.310) | (0.575) |
| Geographical controls | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| County fixed effects | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Observations | 4366 | 4357 | 2601 | 4281 | 4367 | 4367 | 4367 |
| R-squared | 0.613 | 0.613 | 0.357 | 0.440 | 0.473 | 0.215 | 0.120 |
| K-P Wald F-statistic | 52.781 | 52.756 | 54.838 | 53.683 | 52.757 | 52.757 | 52.757 |
| Dependent variable mean | 12.74 | 14.79 | 31.86 | 5.1 | 51.99 | 1.62 | 11.36 |

*Notes:* Table reports results of 2SLS estimation of equation 2. The instrument is the migration route from Vienna, measured as least-cost distance via navigable rivers and over land. Railway density is included instead of settlement area. Other control variables are the same as in Table 3, model 6. Standard errors, clustered at the district level, are given in parentheses. ***, **, and * refer to $p<0.01$, $p<0.05$, and $p<0.10$, respectively.

**Table B13:** *Controlling for the legacy of historical institutions in 1910 (OLS)*

| Dependent variable: | agricultural income per hectare of arable land | cropland | vineyards | pastures | % cropland | % vineyards | % pastures |
|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) |
| Distance to nearest German settlement | -0.040*** | -0.036** | -0.198*** | 0.000 | -0.035 | -0.033*** | 0.079*** |
| | (0.015) | (0.015) | (0.041) | (0.008) | (0.043) | (0.007) | (0.024) |
| German city law | 0.343 | 1.125 | 4.986 | -1.319 | -15.555*** | 2.350 | 0.895 |
| | (1.690) | (1.865) | (4.394) | (0.881) | (3.813) | (1.851) | (1.949) |
| Free royal cities | 3.071** | 3.382** | 3.894 | 1.445 | -7.047 | -0.269 | -1.130 |
| | (1.558) | (1.571) | (4.438) | (1.031) | (4.304) | (0.938) | (1.721) |
| Military Frontier | 0.554 | 1.156 | 4.526** | -0.964 | -3.766 | 1.031* | -0.619 |
| | (0.982) | (0.922) | (2.115) | (0.627) | (2.677) | (0.615) | (1.526) |
| Geographical controls | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| County fixed effects | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Observations | 4366 | 4357 | 2601 | 4281 | 4367 | 4367 | 4367 |
| R-squared | 0.613 | 0.620 | 0.364 | 0.449 | 0.482 | 0.214 | 0.139 |
| Dependent variable mean | 12.74 | 14.79 | 31.86 | 5.1 | 51.99 | 1.62 | 11.36 |

*Notes:* Table reports results of OLS estimation of equation 1. Specifications additionally include dummy variables controlling for the historical presence of German city law, free royal cities, and the Habsburg Military Frontier. Other control variables are the same as in Table 3, model 6. Standard errors, clustered at the district level, are given in parentheses. ***, **, and * refer to p<0.01, p<0.05, and p<0.10, respectively.

**Table B14:** *Controlling for the legacy of historical institutions in 1910 (2SLS)*

| Dependent variable: | agricultural income per hectare of | | | | | | |
|---|---|---|---|---|---|---|---|
| | arable land | cropland | vineyards | pastures | % cropland | % vineyards | % pastures |
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) |
| Distance to nearest German settlement | -0.070* | -0.093** | -0.304*** | 0.028 | -0.143 | -0.038** | 0.168*** |
| | (0.040) | (0.044) | (0.117) | (0.019) | (0.128) | (0.019) | (0.042) |
| German city law | 0.397 | 1.225 | 5.163 | -1.368 | -15.363*** | 2.358 | 0.737 |
| | (1.778) | (2.049) | (4.453) | (0.875) | (3.564) | (1.860) | (2.094) |
| Free royal cities | 3.027* | 3.297** | 3.493 | 1.483 | -7.203* | -0.275 | -1.002 |
| | (1.564) | (1.597) | (4.574) | (1.047) | (4.240) | (0.944) | (1.751) |
| Military Frontier | 0.900 | 1.804* | 5.417** | -1.269* | -2.548 | 1.083* | -1.616 |
| | (1.038) | (0.999) | (2.421) | (0.655) | (3.058) | (0.653) | (1.541) |
| Geographical controls | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| County fixed effects | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Observations | 4366 | 4357 | 2601 | 4281 | 4367 | 4367 | 4367 |
| R-squared | 0.611 | 0.613 | 0.360 | 0.442 | 0.479 | 0.214 | 0.122 |
| K-P Wald F-statistic | 52.071 | 51.853 | 51.127 | 52.812 | 52.045 | 52.045 | 52.045 |
| Dependent variable mean | 12.74 | 14.79 | 31.86 | 5.1 | 51.99 | 1.62 | 11.36 |

*Notes:* Table reports second-stage results of 2SLS estimation of equation 2. The instrument is the migration route from Vienna, measured as least-cost distance via navigable rivers and over land. Specifications additionally include dummy variables controlling for the historical presence of German city law, free royal cities, and the Habsburg Military Frontier. Other control variables are the same as in Table 3, model 6. Standard errors, clustered at the district level, are given in parentheses. ***, **, and * refer to p<0.01, p<0.05, and p<0.10, respectively.

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