Can wine growing cause rural development? Evidence from Early Modern Baden-Württemberg*

Thilo R. Huning† and Fabian Wahl‡

Abstract

Historical wine growing shaped modern rural development, even in areas in which its cultivation stopped after the early modern period. We provide evidence from municipality-level data on Southwestern German viticulture over the last 1,300 years, and find a significant link between historical wine growing and modern development. We rely on cross-sectional regressions and on an instrumental variable strategy using precipitation seasonality. Our findings indicate that a more egalitarian inheritance norm explains parts of the effect historical viticulture had on regional development.

JEL Codes: *D02 · D31 · N09 · N05 · O18 · Z01*

Keywords: *regional economic development · viticulture · Germany · labor intensity · agricultural inheritance · Baden-Württemberg*

There is a long-standing debate among economic historians on the role of specific crops in economic development. The appearance of new crops, often of New World origin, has certainly shaped European development during the Industrial Revolution in many ways (Nunn and Qian 2011; Dall Schmidt, Jensen, and Naz 2018; Berger 2019). Local geographic conditions that determine crop choice have been connected to the most fundamental differences between modern societies (Alesina, Giuliano, and Nunn 2013; Mayshar et al. 2022). In this paper, we show that wine growing has had a significant economic impact.

We provide the first evidence for the effect of wine growing on regional development.

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Our case study is Baden-Württemberg, the state in the most Southwestern corner of Germany. With over 10,000 vineyards, the state possesses a 30% share of all German vines. Wine has often been highlighted as essential for the understanding of Germany's Southwest, which is populated by over 11 million people and generates a gross regional product comparable to Sweden. This effect goes beyond the 28,000 hectares of viticulture, and beyond the produce with a market value of around 350 million euros (amounting to 15% of all plant production in the state). The contribution of wine to the emergence of a common Baden-Württembergian identity after WWII cannot be overstated, given the severity and longevity of conflicts between the predecessors of this "hyphenated" state.[1]

Our argument runs as follows. The specific geographic requirements of wine growing, in combination with its tendency to encourage and sustain a structure of small-scale family-run farms, has altered local economies to the present day. The legacy of viticulture can also be found in areas which stopped growing wine hundreds of years ago. We provide an overview of the historical and theoretical literature on why viticulture has these properties, and then establish empirically the degree to which regions that have once grown wine are better developed today. A specific channel we investigate is the effect of viticulture on cultural traits, specifically agricultural inheritance. Wine, due to its high ratio of labor intensity per unit of land relative to other crops, stabilized the inheritance norm of equal partition, because overfragmentation of land was a less significant issue if wine could be grown (Huning and Wahl 2021a).

The empirical strategy of this paper relies on data on 3,382 municipalities in Baden-Württemberg in 1953. First, we elaborate upon geographic information relating to the spread of historical wine growing from Nüske (1977). This provides us with detail about which municipalities cultivated wine in which period between the years 799 and 1624. We extend the data sets presented in Huning and Wahl (2021a) and Huning and Wahl (2021b) by collecting additional variables on geography, historical developments, and indicators for municipal economic development in 1950. We first study the determinants of wine growing in different past periods until 1624. We find that, in line with the oenological literature, geographical factors like elevation, terrain ruggedness, and soil suitability are important for wine growing in all periods. The proximity to Roman roads is significant for earliest wine growing in the 8$^{\text{th}}$ century and during the early Middle Ages (800–1000). The proximity to monasteries, consistent with historiography, is also relevant. These

[1] Significant historical territories in the area were Baden, Württemberg, different Hohenzollern territories, and several cities which used to be independent for most of their history.

results confirm the conjectures of historians regarding the role of the Romans as well as the Church in the spread of early wine growing in Germany. Surprisingly, the geographic variables of seasonality of precipitation, and the share of Trias rock strata (which are relevant for viticulture on steep hills that provide a high exposure to solar radiation), predict wine growing in a statistically significant way only during the Middle Ages. This is also in line with the rapid spread of wine growing into the most suitable areas in this period, following technological discoveries that first made viticulture on precipices possible.

In a second step, we investigate the relationship between historical wine growing and equal partition. Confirming our theoretical priors, we find a statistically significant and positive relationship between wine growing before 1624 and the historical predominance of equal partition. This relationship is much less pronounced and disappears for today's wine growing locations if controlling for historical wine growing. This suggests that historical rather than contemporary wine growing is responsible for the association of viticulture and equal partition. Historical wine growing set some municipalities on a different developmental path due to its impact on the emergence and persistence of equal partition even after wine growing had disappeared from some regions because of climatic changes, and the increasing importance of quality considerations. These results reveal a novel direct effect on wine growing on the state's regional economy that goes far back into history, as early as medieval times.

Finally, we consider the relationship between equal partition and local economic development in Baden-Württemberg. To establish a causal relationship between both variables, we focus on a sample of municipalities within 50 kilometers of the state's capital, Stuttgart. We then run an instrumental variable (IV) strategy via which we instrument equal partition with a variable motivated from our analysis of the determinants of historical wine growing and its relation to equal partition: seasonality of precipitation. This way, we establish a statistically and economically significant causal link between this specific condition for wine growing, via historical wine growing, to modern development. We establish the unique importance for seasonality of precipitation for viticulture but not for the growing of other staple crops. We run ample robustness checks, including a placebo test around other German state capitals located in areas in which wine has been grown and equal partition is not prevalent today. To conclude, our findings suggest that intensive agriculture, in the form of historic wine growing, had a specific—and hitherto unexplained—influence on modern regional development, that runs in part via its influence on inheritance traditions.

I. Literature Review

Our findings continue the debate on the role of agricultural inheritance traditions on regional development (Hager and Hilbig 2019; Huning and Wahl 2021a; Huning and Wahl 2021b), while shedding light on a specific channel: the role of crops with a high labor to land ratio. The identification strategy in this paper can also provide more causal evidence for the effect of agriculture on development. More generally, our study is motivated by the preposition of David (1985) that historical circumstances (in our case the suitability for growing wine to a medieval standard) have a persistent effect on the modern economy, even though the circumstances have themselves faded. This adds to an influential literature on economic geography and path dependence in Germany (see Redding, Sturm, and Wolf 2011; Voigtländer and Voth 2012; Ahlfeldt et al. 2015, for example).

Our results highlight the role of specific crops for economic development, in the tradition of Nunn and Qian (2011). There is also a vivid debate on the role of alcohol in human society. An overview of this literature is provided in Slingerland (2021), who argues that the production of alcohol has coincided with collaborative societies, and has shaped culture (even the human brain) for thousands of years. Wine is also a central subject for economic historians (see Simpson (2011) and more recently Federico and Martinelli (2018)). Since wine is ubiquitous in Southwestern German geography, culture, and everyday life, this paper adds a new economic narrative to the understanding of this region, and the cultural heterogeneity of Germany and Europe, not the least because wine is also a part of the Southwest's Roman inheritance (see Wahl 2017).

We contribute not only to the literature on the effect of specific crops, but also on specific types of agriculture, namely labor-intensive agriculture. Within this literature, Vollrath (2011) shows that population growth, output per capita, population density, and industrialization within a Malthusian world depend on the labor intensity of agricultural production. Recently, Fiszbein, Jung, and Vollrath (2022) have shown empirically that labor-intensive agriculture is linked to lower levels of individualism and therefore higher social capital among US counties. They reason that higher returns to cooperation in geographic circumstances allow a high labor-intensity, and that a higher division of labor translates into higher population densities and closer social ties. They also argue that non-marginal reductions in labor input result in considerable social losses, thereby supporting the emergence of a sense of equality and community among the inhabitants of wine growing areas. We contribute to this literature by postulating a relationship between intensive agriculture and the social norm according to which people transfer their property to the next generation, namely equal partition. We also show that this is another channel through which labor-intensive agriculture could have influenced regional economic development in the long-run.

By studying the link between viticulture and inheritance traditions, this paper extends a literature on persistence of cultural traits (Bisin and Verdier 2001). Specifically on the subject of inheritance traditions, Hager and Hilbig (2019) find that equal partition areas are more egalitarian today. In Huning and Wahl (2021b), we trace these traditions through history and study their origins in Baden-Württemberg. Our results highlight the role of geography and settlement history. In areas with favorable agricultural traditions, equal partition is more likely to be prevalent. Areas that have been settled later are more likely to rely on primogeniture. We also find that the political economy of feudalism had a significant effect. Our findings indicate that feudal lords could impose primogeniture in areas that were deforested during the Middle Ages, and this tradition persists there to this day. Since primogeniture facilitated the collection of taxes, the nobility enforced this norm wherever it had the means to do so. In a second paper, Huning and Wahl (2021a), we show that regions with equal partition are today more industrialized. We propose a neoclassical model featuring equal partition and primogeniture. This model explains how urban entrepreneurs in search of laborers turn to equal partition regions. Since equal partition led to more fragmented and smaller plots than primogeniture, inhabitants of equal partition areas were more willing to work in proto-industry alongside the work on their own farm. As shown in the empirical section, our model explains the early industrialization of the countryside in Baden-Württemberg well.

In this paper, we provide more evidence for a link between small-scale farming and development, and focus on the suitability for wine growing, a specific mechanism. The historical literature has long noted the correlation between wine growing areas and their reliance on equal partition. It is particularly interesting to analyze the effect of historic wine growing conditions on modern development, considering how the production and consumption of wine has changed over the centuries.

On the most general level, our findings contribute to the debate on the role of small-scale farming for economic development. Has Europe undergone a phase in which family-farming—as the rural counterpart of urban developments—was crucial for the rise and fall of regions? Has Europe experienced a similar "Triumph of Gardening" to that which Studwell (2013) and others view as a cornerstone of the East Asian economic miracles?[2]

II. Historical Background: The expansion and contraction of Southwestern German viticulture

There is no evidence for wine cultivation East of the Rhine in Roman times, but historians are certain that wine was consumed across a significant geographic spectrum West of the Rhine in antiquity (Schröder 1953; Kohl 2017). The first evidence of wine growing in the region can be found in ecclesiastical archives: a gift deed of a vineyard dated to around 800. After the Romans, viticulture expanded into two distinct regions. First in the Southwest of Baden between the Rhine and the Black Forest and in the region around Freiburg, and second in the Northwest of the state in the Rhine-Neckar region around the cities of Heidelberg and Mannheim. From there, it spread eastwards into colder areas of higher elevation, which were less favorable for viticulture. From the region around Mannheim and Heidelberg it expanded in a southeastern direction, following the Rhine. It arrived in the region around Heilbronn before the end of the 10th century. It started in the region around Stuttgart during the high Middle Ages (1000–1299), and expanded from there until it hit the Swabian Jura first in a southern, and then also in a northern and a northeastern direction. Coming from the Southwest of Baden, wine-cultivation started to diffuse into the Southeast of the state and around the Lake Constance in the high Middle Ages. Viticulture there is made possible by an especially warm micro-climatic conditions that defend the plants against the cold influence of the adjacent Alps. There is no evidence to suggest the existence of wine growing in the Black Forest at any time, and also the north of the Lake Constance has never had substantial wine cultivation. This can mostly be explained by its pre-Alpine climate and prohibitively high altitudes.

The rapid diffusion of wine growing during this period in general can also be attributed to climatic change (Nüske 1977; Hirbodian and Wegner 2017). Between approximately 1000 to 1250, wine only yielded substantial grapes if the preceding winter months provided the soil with enough hydration, given a warm period. During the late Middle Ages and early modern period, viticulture expanded well into areas with relatively unfavorable natural conditions (like parts of the Swabian Jura's high plain, and some Upper Swabian villages). While it was predominantly an affair of monasteries and rural villages until around 1300, wine's consumption and trade became increasingly urban after the Black Death, when a lot of new vineyards were founded close to city walls (Hirbodian and Wegner 2017). The

[2]See also Huning and Wahl (2021a) for a discussion and a formal model.

growing area of wine expanded until the 17th century. A main driver of this expansion was the improved ability to grow on ever-steeper slopes (Schröder 1953), as well as the increasing demand originating from an exploding urban population in the prospering Imperial cities in the area.

Trade in Southwestern German wines was relatively absent during the Middle Ages. This was induced by the perceived low quality of the local wine compared to French, Italian, and especially Greek wines (Fritz 2017; Krämer 2017).[3] The colder and more volatile climatic conditions in German lands stood in the way of establishing a constant quality—which was mainly a question of reducing its bitterness (Krämer 2017). Consequently, the historiography indicates that the local wine was drunk by all social classes except for those who could afford imported wines (Krämer 2017, p. 141). Medieval lords encouraged local production to establish independence from foreign markets (Rösener 1992), however the growing city population continued to regard the local wine as a poor substitute for the imported wines.

Historians have attributed the following contraction of wine cultivation area to climate change, wars, and finally a shift in preferences. Quarthal (2017) argues that wine yields in the Neckar region plummeted since the 1560s due to less favorable climatic conditions. Jörg (2017) echoes this assessment for Southwest Germany and surrounding regions, and explains how vines froze due to climatic changes from the 16th to the 18th centuries. The Thirty Years War (1618–48) reached what is today Baden-Württemberg in 1620, and was closely followed by the Palatinate Wars of Succession (1688–1697).[4] Both conflicts led to a decline in population, and devastated whole villages. Quarthal (2017) argues that the lack of constant maintenance destroyed the vineyards, and contributed to the shift of drinking preferences towards beer. The 18th century was then already accompanied by a demand for higher quality. As explained by Fritz (2017), the Duke demanded uprooting of lower quality grapes (especially Tokajer), and first experiments with sparkling wines were also recorded. The renaissance of widespread wine drinking since the 18th century, parallel to the Industrial Revolution and an increase in incomes especially in cities, was already satisfied by more quality-oriented, and also more global supply (Krämer 2017; Schröder 1953). As such, many settlements which grew wine through the Middle Ages have given up viticulture.

[3]For example, a 16th century source from the Palatinate shows how "Malvasier", a wine named after the Italian name of the Peloponnese port of Malvasia, was regarded as the quintessence of luxury wine, and also explains techniques how to "create" such a Malvasia wine using local wines. (Krämer 2017)

[4]It is interesting to note that recent historical research following Parker (2017) has linked the Thirty Years War itself to climatic changes.

III. Theoretical considerations

In this section, we explain why viticulture was economically particular, to then discuss ecological and botanical considerations that also inspire our empirical approach.

1. Viticulture: an extreme case of labor intensity

The Church was an important producer of wine in the region. Wine has always been central in the Christian liturgy, and the historical sources indicate that its consumption has also been an essential part of a monks' everyday live in Southwestern German monasteries since the 8th century (Kohl 2017). Outside of ecclesiastical communities, wine was almost exclusively grown on small family owned and operated farms. This was because viticulture was peculiar in its ability to establish and maintain a structure of these small-scale farms. First, vineyards could thrive on otherwise relatively unsuitable land. As pointed out by Simpson (2011, p. xxxiv), "viticulture and wine production were generally family businesses. Vines were widely cultivated despite the considerable output volatility because grapes could be successfully produced on land that was marginal to most other crop and therefore cheap". Second, the specifically high labor intensity coupled with a low necessity to invest in physical capital made "small plots of wines [...] excellent vehicles for family producers with limited means to acquire a capital asset". Third, overcoming the limitations of family farming was also especially hard in the wine industry. Both rental agreements or wage labor were relatively scarce in the wine industry because "vines can be easily and permanently damaged if the pruning, plowing, and hoeing operations are badly carried out" (see Simpson 2011, p. 9). The link between wine cultivation and family farming draws our attention to family traditions, especially how the inter-generational transfer of the farm was organized.

2. Ecological and botanical considerations

Even more than today, historical wine growing depended on a multitude of specific factors. The required micro-climatic conditions are characterized by a complex interplay of terrain features like slope, elevation, and soil, but also climatic factors like temperature, humidity, solar radiation, and precipitation levels (e.g., Chen 2011; Fraga, De Cortazar Atauri, and Malheiro 2016; Irimia, Patriche, and Quenol 2011; Sommers 2008). As temperature and rainfall are known to vary systematically with elevation, altitude is among the most important determinants of wine growing. Consequently, wine is usually cultivated in modest elevation levels (in Germany typically below 500m). It is also known that locations close to rivers are favorable for growing wine as they reflect and bundle solar radiation, and lead to warmer and wetter winters. Similarly, hills orientated to the south with a slope of around 45° are most exposed to solar radiation and have a favorable micro-climate. Therefore, a south-oriented hill, with the correct steepness, located next to a river, and in an area with modest elevation levels (for example in the valleys of the German rivers of Mosel, Neckar, or Rhine) can be considered optimal for growing wine. These locations are often not favorable for general agriculture, as large slopes or hilly terrain make it difficult to grow most other crops.

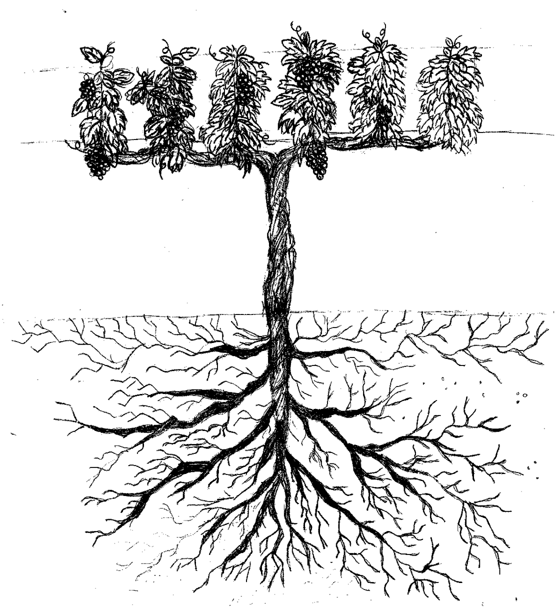


Figure 1: *The grapevine features a large network of creeping (horizontal) and plunging (vertical) roots. The implication of this botanical particularity for hydration throughout the year inspires our instrumental variable strategy.*[5]

The seasonality of climate is more significant for the growth of grapes than for any other agricultural crops. Wine is sensitive to rain in the growing season but highly adaptable to drought during the summer. Excessive summer rain leads to overshooting growth and early ripeness, and also makes grapes vulnerable to pests. As such, a highly seasonal precipitation pattern with a lot of rain during the winter and spring, but modest levels of rain in the summer is optimal (Sommers 2008). This makes wine's botanical properties

[5]Illustration by Isabelle Huning.

favorable from an empiricists' perspective. The reason for this peculiar dependence on seasonality of precipitation is the grapevine's root system. Smart et al. (2006) provide a review of this literature and calculate the ratio between width and depth of vine plant, concluding that "the depth distribution of grapevine roots in the vadose zone[6] among the deepest observed for plants worldwide" [p. 89].

Figure 1 provides an illustration of grapevine that shows how creeping roots allow the plant to access immediate rainfall before it evaporates. These roots are in depth levels compared to cereals and other plants which are re-seeded in any harvest season. More important for the grapevine however are the deeper so-called plunging roots which often reach ground water. These roots are not only well-protected from frost in colder periods, but also allow the vine to reach water stored underground in the seasons of lower precipitation. It is to this system that the grapevine owes the ability to take advantage of large rainfall differences between growing seasons. In summer and autumn, the grapes can mature in the sun while plunging roots guarantee photosynthesis and the hydration of the grape itself (grapes consist of around 80% water). In winter and spring, the plant can efficiently manage its soil hydration by reducing evaporation through its creeping root network, allowing excess water to resupply the hydration level of deeper layers. This botanical particularity of the grapevine inspires our rainfall instrument in the empirical part.

Finally, the geology of the location plays a significant role in its wine growing potential, first because geology influences the soil type of an area, but also because Württemberg is characterized by steep slope viticulture since the late Middles Ages. Hills with slopes as steep as 45° here consist of rock strata from the Trias period (lacustrine limestone). Technical innovations during the high Middle Ages enabled the exploitation of these sunny spots, which were unsuitable for any other crop (Schröder 1953; Simpson 2011).

The relative absence of trade, as discussed in Section II, has two consequences for the interpretation of our study. First, we can assume a relatively closed market and can ignore demand shocks elsewhere. Second, we can hardly distinguish between the place of production and the place of consumption, instead we should assume they often coincided.

[6] This is the earth layer just above ground water.

IV. Data

Data on Inheritance Traditions. Data on the historical prevalence of equal partition in the 3,382 municipalities of Baden-Württemberg for the year 1953 is available from Röhm (1957). Röhm collected these data by sending a one-page questionnaire to each municipality's major. Based on this survey, Röhm drew a map showing the predominant inheritance tradition in each municipality in 1953. He also drew a division line that separated the areas in which equal partition was prevalent from the areas where primogeniture was applied, representing the state in 1800. To measure local prevalence of equal partition, we digitized the map and created a dummy variable equal to one if a municipality is located within the borders of the historical equal partition area. Figure 2 shows our digitized version of this map, augmented with the four largest cities for the reader's convenience. The main advantage of these data is their uniqueness in providing municipality-level information on historical agricultural inheritance traditions.[7]

Data on wine growing. We digitized municipality-level data on historical wine growing in Baden-Württemberg from a map on the spread of wine growing in Baden-Württemberg until 1624 by Nüske (1977). These data is depicted in Figure 3(a). This map shows the spread of wine growing in categories of five historical periods: before 700, between 800–900, 1000–1299, 1300–1624, and before 1624 (the last category captures the municipalities for which Nüske saw evidence for earlier wine cultivation, but lacked the data to provide a clear categorization into one of the four former categories). Nüske's explanation for these categories is logical and oriented among historical breakpoints and developments closely connected to wine growing, and consistent with our historical outline in Section II. The period from 800 to 900, for example, marked the period of the first significant expansion of wine growing during the reign of the Carolingians, 1000–1299 covers the high Middle Ages with its many city foundations and expansion of settlement spaces, and 1300–1624 marks the period up to the Thirty Years War in Southwestern Germany. The figure also shows the historical border of equal partition and primogeniture from Röhm (1957).

[7] A critical discussion of these data is provided in Huning and Wahl (2021a) and Huning and Wahl (2021b). The same data are used by Hager and Hilbig (2019) to study the long-term consequences of equal partition on economic and social inequality. The original map by Röhm (1957) is provided in Figure A.1 of the Online Appendix.

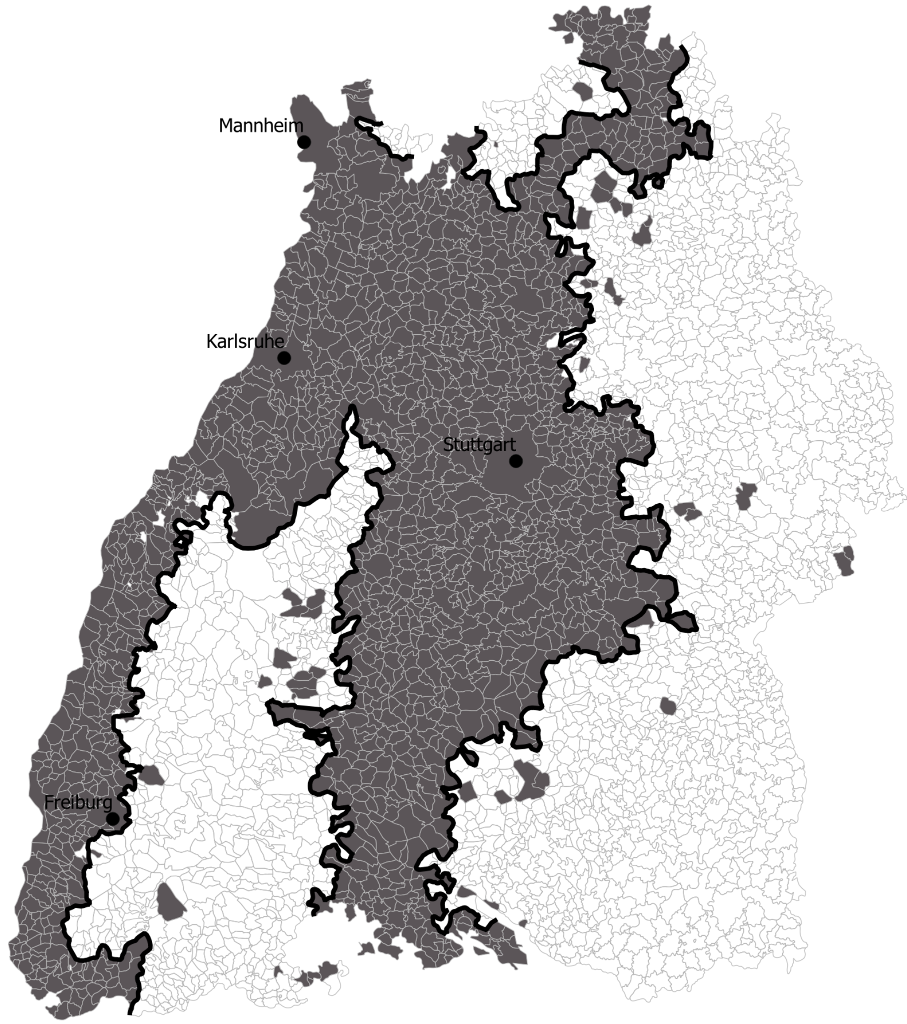


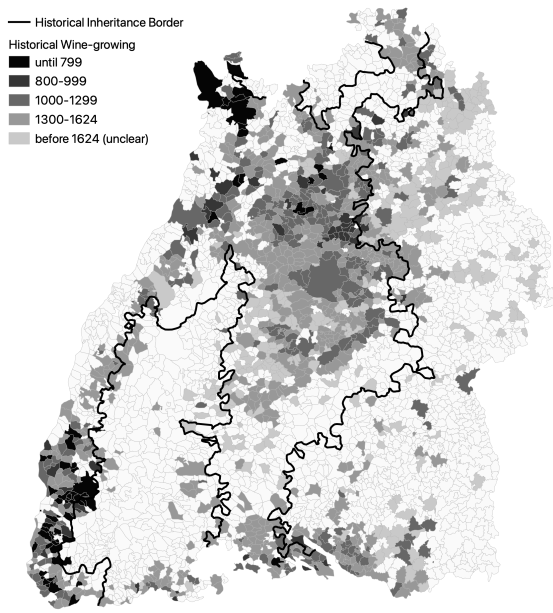
Figure 2: *The map on inheritance traditions in 1800 after Röhm (1957). Dark gray areas applied equal partition before 1800, light gray areas relied on primogeniture.*

Data on contemporary wine growing municipalities (as shown in Figure 3(b)) comes from the official agricultural statistics of Baden-Württemberg (Statistical Office of Baden-Württemberg 2018). These statistics report, by municipality, the acreage used to grow white and red wine in 2018. From these data we code a dummy variable equal to one if a municipality had grown any wine in 2018. Comparison of Panels (a) and (b) of Figure 3 shows that the wine cultivation area has reversed its expansion. Most of the areas south of Stuttgart (again with the exception of the area around Lake Constance) and in the East have abandoned viticulture. As hypothesized by (Nüske 1977), this contraction is likely caused by two factors. First, wine today is a luxury good and quality is today more important than historically. This has reduced the area suitable for wine growing. Second, climate change made some of the areas unsuitable to profitably grow wine of acceptable quality.

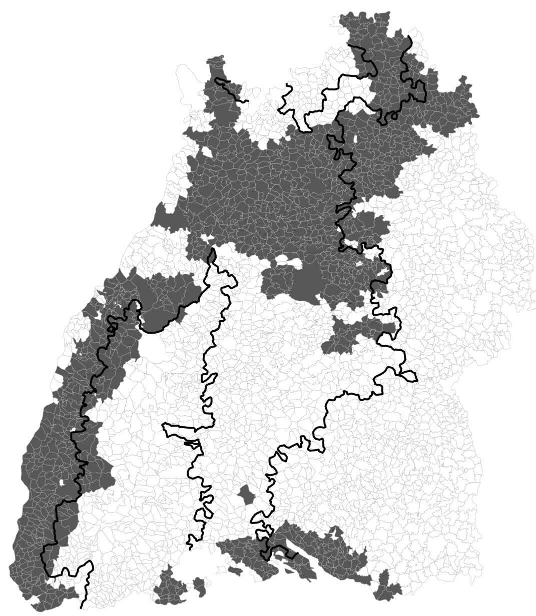
Data on Local Economic Development in 1950. We measure local economic development and industrialization levels with four variables: population, firm density, and industrial and agricultural employment shares. We obtain these from the official municipal and county statistics of Baden-Württemberg of 1950.[8] The year of 1950 is the closest match for the 1957 inheritance survey (Statistical Office of Baden-Württemberg 1952).

Control Variables and Predictors. The control variables and predictors of historical wine growing originate from various sources. The area of each municipality in km^2 stems from the municipal statistics of 1950 (Statistical Office of Baden-Württemberg 1952). Our measure of soil quality is the agricultural suitability index devised by Zabel, Putzenlechner, and Mauser (2014). Their closest measure is average agricultural suitability 1961–1990. They provide one data point for each geographic grid cell of 30 arc seconds $\times$ 30 arc seconds in size.[9] Their index considers climate (temperature, precipitation, solar radiation), soil (including pH value, texture, salinity, or organic carbon content), and topography (elevation and slope). The measure is calculated for 16 different crops and then averaged over all of them. We calculate the municipal averages of this measure by overlaying these raster data with the municipal borders.

[8] "Gemeinde- und Kreisstatistik Baden-Württemberg".
[9] This is equivalent to 0.86 km^2 at the equator.



(a) *Wine growing in Different Historical Periods*



(b) *Wine growing in 2018*

Note: Figure (a) shows municipalities in which wine was growing in different historical periods between the early Middle Ages and 1624. Figure (b) shows municipalities which produced wine in 2018. The solid black line depicted in all sub-figures is the historical border of the equal partition area according to Röhm (1957).

Figure 3: *Historical and Contemporary wine growing in Baden-Württemberg*

The Digital Elevation Model (DEM) of the U.S. Geological Survey's Center for Earth

Resources Observation and Science (EROS), the GTOPO30 data set, provides us with elevation data above sea level. From these data, we calculate terrain ruggedness as outlined in Riley, DeGloria, and Elliot (1999). The distance to Rhine or Neckar is calculated using a shapefile with the location of rivers and lakes in Europe.[10] We consider these variables as proxies for the natural conditions for agriculture, but they may potentially also have determined the timing of when a certain area was first settled. Proximity to rivers also proxies for second-nature geography, via their effect on market access especially in premodern times. Data on average growing season solar radiation levels between 1970 and 2000 can be downloaded from the WorldClim database. The share of the municipalities' areas comprised of trias rock strata is provided by an official geological map of Baden-Württemberg.[11] Data on the precipitation seasonality is contained in the WorldClim database.

We digitized data on the location of areas that were first settled and deforested during the Middle Ages from a map by Ellenberg (1990). We also digitized data on the location of areas that were forested and hence mostly uninhabited in the 19$^{\text{th}}$ century from the same source.

Other historical variables stem from (and are discussed in) Huning and Wahl (2020). These are: distance to the closest Imperial city, the share of each municipality located within an Imperial city (both in 1556), historical political instability and fragmentation, the share of each municipality located in church territories in 1556, and a dummy equal to one if a municipality was located within the historical Duchy of Württemberg in 1789.

To account for the settlement history of a place (which may be of importance for the presence of equal partition, but potentially also connected to economic development), we have collected data on the location of Celtic graves, early medieval (Germanic) settlements, and Neolithic settlement areas. These stem from the "Historischer Atlas von Baden-Württemberg". We use these maps to compute a dummy variable equal to one if at least one Celtic grave was found in the area, and another variable equal to one if at least one early medieval village was within the municipality. We furthermore calculate the share of each municipality that was settled during the Neolithic period. Information on the location of monasteries in 800 AD stems from the map "Early Christendom" in the "Historischer Atlas von Baden-Württemberg" (Müller 1975).

[10]These data can be downloaded from the European Environment Agency (EEA), the 'WISE large rivers' shapefile.

[11]This is provided by the "Landesamt für Geologie, Rohstoff und Bergbau" (State Office of Geology, Raw Materials and Mining) of Baden-Württemberg.

To control for the possibly significant impact of Roman legacies on inheritance traditions and local economic development, we use the established Roman road network data from Talbert (2000). Here, we calculate the density of Roman roads for each municipality (km of certain Roman roads per km^2).

We consider the market size of a municipality's products by calculating domestic (inside Baden-Württemberg) market potential in 1500. We base this calculation on the data set of historical city population by Bairoch, Batou, and Chevre (1988) and follow the methodology of Crafts (2005).

The Online Appendix provides an descriptive overview of all variables used in the empirical analysis (Table A.1), and a more detailed description (section A.3).

V. Results

1. Determinants of Historical wine growing

We start our empirical analysis by investigating the determinants of historical wine growing. We estimate several cross-sectional probit models with dummy dependent variables equal to one if wine was grown in any of the historical periods. Following our discussion in Section III, we first run the following probit estimation to explain the determinants of viticulture in Baden-Württemberg:

$$\Pr(WINE_i|\mathbf{G}_i, ROMAN_i) = \Phi(\alpha + \beta'\mathbf{G}_i + \gamma ROMAN_i + \epsilon_i) \tag{1}$$

Here, $WINE_i$ is a dummy variable equal to one if wine is grown in a municipality i and in any of the historical periods under consideration. We discriminate between the seven different period categories (before 799, 800–999, 1000–1299, before 1300, 1300-1624, and before 1624) from our data. $\mathbf{G}_i$ is a set of geographical and geological predictors of wine growing which includes seasonality of precipitation, elevation, terrain ruggedness, distance to Rhine and Neckar (in km), soil suitability, the natural logarithm of growing season radiation, the share of each municipality's area consisting of Trias rock strata, and the distance to the closest monastery in 800 AD (in km). $ROMAN_i$ represents a variable measuring the average distance from the area of each municipality to the closest Roman road.

Table 1 shows the results. As expected, all the geographic and geological variables are significant.

Table 1: *Determinants of Historical wine growing in Baden-Württemberg*

Dependent Variable	Wine growing before 799	Wine growing 800-999	Wine growing before 999	Wine growing 1000-1299	Wine growing before 1300	Wine growing 1300-1624	Wine growing before 1624
	(1)	(2)	(3)	(4)	(6)	(5)	(7)
Seasonality of Precipitation	-0.0004	0.0004	0.0001	0.0218***	0.0130***	0.0093***	0.0252***
	(0.001)	(0.000)	(0.001)	(0.002)	(0.001)	(0.001)	(0.002)
Elevation	-0.0001***	-0.0001***	-0.0001***	-0.0008***	-0.0005***	-0.0006***	-0.0009***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Terrain Ruggedness	0.0001***	0.0001***	0.0002***	0.0014***	0.0008***	0.0008***	0.0015***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Distance to Rhine and Neckar	-0.0008**	-0.0007***	-0.0012***	-0.0040***	-0.0032***	-0.0015***	-0.0052***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Distance to Roman Road	-0.0036***	0.0005	-0.0009	0.0003	-0.0004	0.0008	0.0042***
	(0.001)	(0.000)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Soil Suitability	0.0005**	0.0009***	0.0015***	0.0065***	0.0042***	0.0037***	0.0115***
	(0.000)	(0.000)	(0.000)	(0.001)	(0.001)	(0.001)	(0.001)
ln(Growing Season Radiation)	0.7322***	0.1057	0.9074***	1.6678***	0.8765*	2.4663***	2.2059***
	(0.187)	(0.123)	(0.217)	(0.566)	(0.517)	(0.413)	(0.626)
Share Trias Rock Strata	-0.0100	-0.0009	-0.0080	0.2647***	0.1897***	0.0787***	0.3274***
	(0.008)	(0.006)	(0.010)	(0.024)	(0.023)	(0.019)	(0.026)
Distance to Closest Monastery	-0.0004**	-0.0003**	-0.0008***	-0.0011*	-0.0016***	-0.0001	-0.0010
	(0.000)	(0.000)	(0.000)	(0.001)	(0.001)	(0.000)	(0.001)
	(0.009)	(0.006)	(0.010)	(0.024)	(0.019)	(0.022)	(0.025)
Pseudo-R^2	0.303	0.166	0.244	0.213	0.132	0.203	0.226
Observations	3,378	3,378	3,378	3,378	3,378	3,378	3,378

Notes. Heteroskedasticity robust standard errors are in parentheses. Coefficient is statistically different from zero at the ***1 %, **5 %, and *10 % level. The table shows Probit estimates and the coefficients report average marginal effects. The unit of observation is a municipality in 1953. All regressions include a constant not reported.

Their coefficients also have the expected signs: It is more likely that wine is grown at low elevations, in rugged terrain, close to rivers, and in areas with a good soil quality, high growing season radiation levels, where seasonality of precipitation is high, and in municipalities with a high share of Trias rock strata.

In line with our discussion in Section III, the share of Trias rock strata is only significant after the year 1000. This provides evidence for the historical narrative that the technology to exploit the sunny (but steep) hills created in the geological period were only developed during the Middle Ages. The distances to Roman roads mattered most in the early Middle Ages (before 799). This is in line with the hypothesis that wine was introduced into the area by the Romans and then expanded from these early germ cells to other areas. Similarly, the results confirm the preposition that wine was first grown by monasteries. As shown by the negative and significant distance variable, viticulture was significantly more prevalent in areas close to 8$^{\text{th}}$ century monasteries, at least before 1300. Seasonality of precipitation also becomes more significant during the high Middle Ages, as suggested by the climatic changes throughout the Middle Ages, especially the 950–1250 warm period.

2. Wine growing and Equal Partition

In a second step, we investigate the explanatory power of wine growing in different historical periods, compare it to viticulture today, and explain the local prevalence of equal partition. We run probit models of the following form:

$$\begin{aligned} &\Pr(EP_i|WINE_i, \mathbf{G}_i, \mathbf{SETHIST}_i, \mathbf{X}_i) \\ &= \Phi(\alpha + \beta WINE_i + \gamma' \mathbf{G}_i + \delta' \mathbf{SETHIST}_i + \eta' \mathbf{X}_i + \epsilon_i) \end{aligned} \tag{2}$$

EP_i is a dummy variable that indicates whether a municipality i is located in the historical equal partition area (where it was dominant before 1850). $WINE_i$ is a dummy variable equal to one if wine was grown in a municipality. We separately introduce dummy variables for wine growing before 999, between 1000–1299, 1300–1624, before 1624 and in 2018. $\mathbf{G_i}$ is a set of variables measuring potentially relevant geographical factors (elevation and soil suitability). $\mathbf{SETHIST}_i$ are historical factors capturing the settlement history of a municipality. Consequently, these are dummy variables indicating whether archaeologists found at least one Celtic grave in the municipality, the share of a municipality's area located in the Neolithic settlement area, a dummy variable equal to one if a municipality was settled during the early medieval period (before 800) by a Germanic tribe, and the share of a municipality's area that was settled only during the early Middle Ages.

Table 2: *Historical wine growing and the Emergence of Equal Partition*

	(1)	(2)	(3)	(4)	(5)	(6)
Dep. Var.	Historical Equal Partition Area					
Wine growing before 999	0.1209					
	(0.090)					
Wine growing 1000-1299		0.1506***				
		(0.044)				
Wine growing 1300-1624			0.1268***			
			(0.042)			
Wine growing before 1624				0.1420***		0.1289***
				(0.038)		(0.036)
Wine growing in 2018					0.0968*	0.0605
					(0.050)	(0.046)
Elevation	-0.0007***	-0.0006***	-0.0007***	-0.0006***	-0.0006***	-0.0005***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Soil Suitability	0.0091***	0.0089***	0.0090***	0.0084***	0.0089***	0.0083***
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Celtic Grave	0.0509**	0.0434*	0.0474**	0.0455**	0.0543**	0.0485**
	(0.024)	(0.023)	(0.023)	(0.023)	(0.024)	(0.023)
Share Neolithic Settlement Area	0.3323**	0.2566**	0.3007**	0.2281*	0.3025**	0.2140*
	(0.139)	(0.124)	(0.131)	(0.124)	(0.132)	(0.122)
Early Medieval Settlement	0.0792***	0.0738***	0.0761***	0.0732***	0.0851***	0.0773***
	(0.025)	(0.025)	(0.025)	(0.025)	(0.024)	(0.024)
Share Medieval Settlement	-0.1632***	-0.1577***	-0.1629***	-0.1621***	-0.1573***	-0.1569***
	(0.058)	(0.057)	(0.058)	(0.057)	(0.057)	(0.056)
Roman Road Density	0.3739***	0.3796***	0.3774***	0.3871***	0.3921***	0.3975***
	(0.110)	(0.106)	(0.107)	(0.106)	(0.107)	(0.104)
Historical Political Fragmentation	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Historical Political Instability	-0.0029	-0.0015	-0.0017	-0.0026	-0.0006	-0.0012
	(0.010)	(0.010)	(0.010)	(0.010)	(0.009)	(0.009)
Share Ecclesiastical Territory	-0.0267	-0.0197	-0.0181	-0.0116	-0.0289	-0.0137
	(0.062)	(0.060)	(0.061)	(0.059)	(0.061)	(0.058)
Share Imperial City	-0.1202	-0.1118	-0.1127	-0.1182	-0.1142	-0.1133
	(0.109)	(0.109)	(0.110)	(0.110)	(0.109)	(0.109)
Württemberg 1789	0.1768***	0.1586***	0.1645***	0.1528***	0.1788***	0.1567***
	(0.047)	(0.047)	(0.046)	(0.047)	(0.047)	(0.047)
Distance to Imperial City	0.0082***	0.0089***	0.0088***	0.0090***	0.0080***	0.0087***
	(0.003)	(0.002)	(0.002)	(0.002)	(0.003)	(0.002)
Domestic Market Potential	0.2149**	0.2231**	0.2242**	0.2257**	0.2238**	0.2285**
	(0.097)	(0.091)	(0.093)	(0.090)	(0.093)	(0.089)
Pseudo-R^2	0.31	0.326	0.319	0.327	0.315	0.33
Observations	3,374	3,374	3,374	3,374	3,374	3,374

Notes. Standard errors clustered on county level are in parentheses. Coefficients are statistically different from zero at the ***1 %, **5 %, and *10 % level. The table shows Probit estimates and the coefficients report average marginal effects. The unit of observation is a municipality in 1953. All regressions include a constant not reported.

$\mathbf{X}_i$ is a set of ancient, late medieval, and early modern factors. We include Roman road density (km of Roman road per km^2 of municipal area). This is motivated by a literature that argues that Roman settlements left behind their culture of written wills and a generally more individual (but also egalitarian) inheritance (see, e.g. Huppertz 1939; Röhm 1957; Schröder 1980; Willenbacher 2003). We further include the share of a municipality's areas that were part of an ecclesiastical state or an Imperial city, a dummy equal to one if a municipality was located in the duchy of Württemberg in 1789, and distance to the closest Imperial city. This accounts for the fact that, according to the literature (see, e.g. Röhm 1957), ecclesiastical territories and Imperial cities had a tendency to enforce primogeniture, while the dukes of Württemberg enforced equal partition in their realm. As discussed in Huning and Wahl (2021b), the distance to the closest Imperial city is a measure for emigration pressure. Younger siblings who did not inherit land could migrate to a city only if it was proximate. This variable reflects second nature geography by accounting for the fact that land close to urban markets is more intensively cultured—an idea going back to von Thünen (1826).

Finally, we include measures of historical political fragmentation and historical political instability. These are designed to account more broadly for the effect of the political environment and the capacity of rulers to enforce one or the other practice in general. ϵ_i is the error term. We cluster the standard errors on county level and report average marginal effects in the regression tables.

Table 2 shows the estimation results. We see that very early wine growing before the 11$^{\text{th}}$ century does not significantly predict equal partition, which is not surprising as there are few municipalities with recorded wine growing in the early Middle Ages.

Wine growing in all other historical periods—especially between 1000 and 1299—is significantly and positively related to equal partition. This confirms the notion of the historical literature that wine growing was one of the most important factors for the emergence and persistence of equal partition. According to the estimated coefficients, equal partition is on average around 12 to 15% more likely in a municipality which grew wine compared to a municipality which did not. The dummy for wine growing in 2018 is much less significant, and the average marginal effect is only half as large as that of historical wine growing. Consequently, when we control for both historical wine growing before 1624 and contemporary wine growing, only historical wine growing remains significant.

3. Equal Partition and Local Economic Development: Using Seasonality of Precipitation as an Instrument

As the final step of our empirical analysis, we consider the causal effect of equal partition and municipal economic development in 1950. We identify causality by making use of the relationship between wine growing and equal partition. Specifically, we run 2SLS instrumental variables regressions using a peculiar and important determinant of wine growing as an instrument for the historical prevalence of equal partition: seasonality of precipitation. To reduce unobserved heterogeneity, we limit our data set to a 50km perimeter around Stuttgart. This avoids the potentially idiosyncratic mountainous areas of the Swabian Jura and the Black Forest, and leaves us with a relatively homogeneous area which is also balanced with respect to religion, and culture in general. The area around Stuttgart was also among the earliest to historically adopt viticulture in Baden-Württemberg. This leaves us with 892 municipalities of which 460 applied equal partition, a reasonably balanced sample.

Consider Table 3. Here, as a first step, we establish the validity of our instrumental variables strategy by predicting the cultivation of wine, important medieval crops (winter wheat and barley), and Columbian imports (maize and potatoes), with a set of geographic variables. This allows us to understand the determinants of farmers' decisions to grow a specific crop.[12] This regression is similar to the one in Table 1, but excludes factors that are constant (or hardly vary) across the smaller sample that we use for the IV estimations.[13]

We find seasonality of precipitation robustly and positively related to historical wine growing. Elevation and distance to rivers ae also important.[14] Reassuringly, the suitability for other crops (like winter wheat or potatoes) is not relevant, with the exception of barley suitability, which has a negative coefficient.[15]

[12] A descriptive overview of the data set used for these regressions and the later IV estimations can be found in the Online Appendix, Table A.2.

[13] Including them would not qualitatively change the conclusions drawn from the estimation results in any way.

[14] There is no reason to believe that contemporary seasonality in precipitation should have decisively changed compared to that in the 17th century. This is why we think it can act as a valid proxy. Predicting contemporary wine growing seems also not to be a preferable option, as nowadays through selective breeding and genetic manipulation most widely grown grapes are less sensitive to natural conditions than historical grapes. Today, wine is no longer produced in all areas which would be suitable; the quality bar has been raised since the early modern period. wine growing today is likely more endogenous to economic development than it was historically.

[15] Maize and potatoes arrived only after 1624. It is nevertheless useful to control for their suitability to grow these as proxy for "good natural conditions" independent of wine growing. Both maize and potatoes

Table 3: *Seasonality of Precipitation, Crop Suitability, and Historical wine growing*

Dependent Variable	Winter Wheat Suitability	Potato Suitability	Maize Suitability	Barley Suitability	Wine Growing before 1624
	(1)	(2)	(3)	(4)	(5)
Method			OLS		Probit
Seasonality of Precipitation	0.0811	-0.0662	0.00625	0.0418	0.0699***
	(0.131)	(0.0772)	(0.0339)	(0.193)	(0.0240)
Elevation	-0.0239**	0.00589	0.0280***	-0.000426	-0.00518***
	(0.0103)	(0.00481)	(0.00233)	(0.00926)	(0.00153)
Terrain Ruggedness	-0.0127**	-0.00704	-0.00653**	0.0183**	0.000802
	(0.00486)	(0.00430)	(0.00284)	(0.00804)	(0.000943)
Distance to Rhine and Neckar	0.135**	-0.0917**	-0.0581**	-0.110	-0.0238*
	(0.0620)	(0.0398)	(0.0238)	(0.0856)	(0.0129)
Distance to Closest Monastery	-0.111**	-0.0975***	0.0748***	0.0447	-0.00681
	(0.0490)	(0.0222)	(0.0155)	(0.0542)	(0.00937)
Distance to Roman Road	0.204***	-0.000354	-0.0950***	-0.239**	0.00742
	(0.0679)	(0.0606)	(0.0329)	(0.106)	(0.0245)
Suitability for Potato	0.350***		-0.0136	-0.0591	0.0112
	(0.0611)		(0.0326)	(0.0752)	(0.0143)
Suitability for Maize	1.111***	-0.0531		-0.454	-0.00935
	(0.352)	(0.136)		(0.316)	(0.0450)
Suitability for Barley	0.651***	-0.0260	-0.0511**		-0.0246**
	(0.0681)	(0.0352)	(0.0248)		(0.0122)
Suitability for Winter Wheat		0.253***	0.206***	1.071***	0.0268
		(0.0464)	(0.0249)	(0.0433)	(0.0172)
R^2 \Pseudo-R^2	0.934	0.615	0.853	0.901	0.355
Observations	890	890	890	890	890

Notes. Standard errors clustered on county (Landkreis) level are in parentheses. Coefficient is statistically different from zero at the ***1 %, **5 % and *10 % level. The unit of observation is a municipality in 1953. All regressions include a constant not reported. Column (5) reports average marginal effects.

To validate the exclusion restriction, it is important to show that seasonality of precipitation is not a relevant predictor of growing winter wheat, potatoes, maize, or barley. To test this, we run OLS regressions in which we predict a municipality's suitability to grow either one of these crops using the same set of variables as for wine growing (columns (1) to (4)). We find that seasonality of precipitation does not play a role in the suitability to grow any of these crops. As such, precipitation seasonality is not another proxy for natural conditions in general.

Another test of the exogeneity of our instrument are placebo-like OLS regressions. Our control group consists of other German state capitals outside the wine growing areas and outside equal partition areas. If seasonality of precipitation is a valid instrument, the

are widely planted in Baden-Württemberg today. Another concern is that the insignificance of the different suitability measures is driven by huge correlations between those. This is, however, only the case for the suitability of winter wheat and barley (bivariate correlation is 0.93). The correlations between the other suitability measures are significant but less strong. We also checked what happens if we introduce the catch-all suitability variable we have used before. This variable represents the average suitability for 16 crops—including the ones considered separately here. This variable is also insignificant.

exclusion restriction holds and there is no direct effect of it on economic development over and above its effect on equal partition via wine growing. Therefore, seasonality of precipitation should not be significantly related to economic development in areas in which neither wine growing nor equal partition is applied. We utilize the data set of Hager and Hilbig (2019), who provide municipality-level information for equal partition and economic development measures for the whole of Western Germany in 2014. Based on these data, we run reduced-form regressions with seasonality of precipitation as the left-hand side variable and a municipality's average wage income in 2014 as the dependent variable. We consider the areas 50km around the state capitals of Bavaria (Munich), Bremen, Hamburg, Lower Saxony (Hanover), and Schleswig-Holstein (Kiel). This is a valid control group, as these cities neither have viticulture nor equal partition in their neighborhood. Table 4 shows the results.[16]

In all of these regressions, seasonality of precipitation shows a small and insignificant coefficient (leaning towards negative). This suggests that the exclusion restriction holds, and there is no channel through which seasonality of precipitation influences local economic development. We rely on these specific determinants of wine growing, measured by seasonality of precipitation as instrumental variable. Figure 4 visualizes the relationship between historical wine growing and equal partition on the one hand (Panel a), and seasonality of precipitation and equal partition (the first stage relationship) on the other hand. Both figures suggest a positive relationship between wine growing and equal partition, and seasonality of precipitation and equal partition, respectively.

This confirms that seasonality of precipitation is significantly and specifically related to wine growing, and is a valid instrument. We estimate 2SLS regressions of the following form:

$$EqualPartition_m = \alpha_1 + \beta_1 PRECVAR_m + \gamma_1' \mathbf{X_m} + \epsilon_m \tag{3a}$$

$$Outcome_m = \alpha_2 + \beta_2 \widehat{EqualPartition}_m + \gamma_2' \mathbf{X_m} + \eta_m, \tag{3b}$$

where $PRECVAR_m$ is the seasonality of precipitation in municipality m, and $Outcome_m$ are the same four measures of local industrialization as before. The vector of controls $\mathbf{X_{c,m}}$ comprises of geographical control variables (elevation, terrain ruggedness, and distance to Rhine or Neckar). The geographic variables are meant to account for the effect of geography on economic development and inheritance traditions. They are specifically

[16] A descriptive overview of the five data sets is provided in Table A.3

included to net out the variation in seasonality of precipitation that is caused by these factors. Historical control variables are the ratio of a municipality it shares with a historical ecclesiastical territory, distance to the next Imperial city or Roman road, historical political fragmentation, and the market potential in 1500. These account for factors that are likely related to wine growing, equal partition, and economic development alike. We also include suitability measures for barley, maize, potato, and winter wheat, and distance to Stuttgart (to consider the effect of the capital city and its agglomeration). Since the area studied is more homogeneous in most aspects (especially geography), our set of controls is smaller than before.

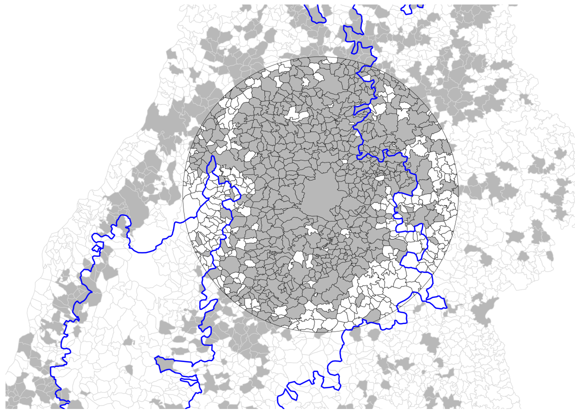
Table 5 reports the 2SLS results alongside the coefficient estimates of the reduced form estimated with OLS. Panel A shows the second stage, Panel B the first stage, and Panel C the reduced form results.

For each of the outcome variables, we first estimate bivariate regressions without any controls (columns with odd numbers), and then include the full set of controls (columns with even numbers). Panel B suggests that the seasonality of precipitation is a significant predictor of equal partition in all regressions. The F-value of the excluded instrument is above the common threshold of ten. In conclusion, the instrument is relevant and sufficiently strong.

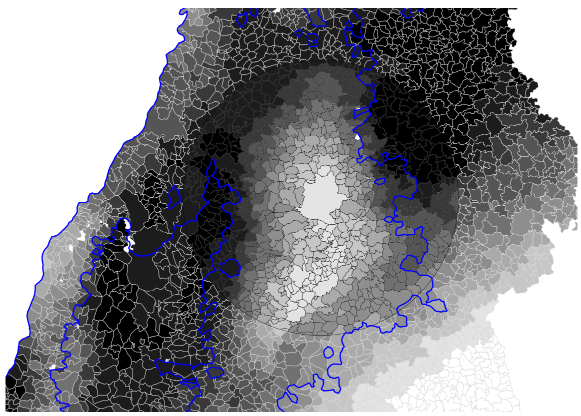
Table 4: *Seasonality of Precipitation and Economic Development in Primogeniture Regions Outside Wine Areas*

Dependent Variable	ln(Average Wage Income 2014)				
	(1)	(2)	(3)	(4)	(5)
Sampling Area 50km around	Munich	Bremen	Hamburg	Hanover	Kiel
Seasonality of Precipitation	0.0081	-0.0105	0.0167	0.0198	-0.0112
	(0.007)	(0.014)	(0.0184)	(0.016)	(0.008)
County Dummies	✓	✓	✓	✓	✓
Further Controls	✓	✓	✓	✓	✓
Distance to State Capital	✓	✓	✓	✓	✓
Observations	464	158	493	176	464
R^2	0.171	0.377	0.226	0.426	0.171

Notes. Heteroskedasticity robust standard errors are in parentheses. Coefficient is statistically different from zero at the ***1%, **5%, and *10% level. The unit of observation is a municipality in 2014. All regressions include a constant not reported. Controls include a municipality's distance to Wittenberg, average elevation, a variable reporting the intensity to which the county in which a municipality is located was involved in the Peasant Wars of 1522-1525, dummy variables for historical states of the German Empire of 1871, for municipalities located in the historically Roman part of Germany, and for municipalities in which the code civil was the prevailing civil code in 1894.



(a) *Wine Growing Before 1624 and Equal Partition*



(b) *Seasonality of Precipitation, and the Historical Inheritance Border*

Note: Figure (a) shows in gray the municipalities in which wine was already grown prior to 1299. The historical border of the equal partition area is depicted in blue. The circle marks the area 50km around Stuttgart. Figure (b) shows seasonality (the coefficient of variation) of monthly precipitation. The brighter the municipalities are shaded the larger is seasonality in precipitation. The historical border of the equal partition area is depicted in blue. The circle marks the area 50km around Stuttgart.

Figure 4: *Wine Growing, Variability of Precipitation, and Inheritance Traditions 50km around Stuttgart*

Table 5: *Equal Partition and Economic Development When Using Seasonality of Precipitation as Instrument*

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Panel A: 2SLS Second Stage							
Dependent Variable	ln(Population Density 1950)		ln(Firms per hectare 1950)		Employment Share Agriculture 1950		Employment Share Industry 1950	
Equal Partition	1.446***	1.164***	1.134**	0.887**	-0.234***	-0.264***	0.232***	0.238***
	(0.493)	(0.437)	(0.450)	(0.431)	(0.082)	(0.076)	(0.071)	(0.062)
	Panel B: First Stage (Dependent Variable: Equal Partition)							
Seasonality of Precipitation	0.0312***	0.0354***	0.311***	0.0304***	0.0312***	0.0304***	0.0312***	0.0304***
	(0.007)	(0.011)	(0.007)	(0.008)	(0.007)	(0.008)	(0.007)	(0.008)
F-Value of Excluded IV	19.48	13.43	19.31	13.43	19.48	13.43	19.48	13.43
	Panel C: Reduced Form							
Dependent Variable	ln(Population Density 1950)		ln(Firms per hectare 1950)		Employment Share Agriculture 1950		Employment Share Industry 1950	
	0.0451***	0.0354***	0.0352**	0.0270*	-0.0073***	-0.0080***	0.0072***	0.0072***
	(0.015)	(0.011)	(0.014)	(0.013)	(0.0026)	(0.002)	(0.002)	(0.002)
Geographic Controls	–	✓	–	✓	–	✓	–	✓
Soil Suitability Measures	–	✓	–	✓	–	✓	–	✓
Historical Controls	–	✓	–	✓	–	✓	–	✓
Distance to Stuttgart	–	✓	–	✓	–	✓	–	✓
Observations	887	887	887	887	887	887	887	887

Notes. Standard errors in parentheses are clustered on county level (Landkreisebene). Coefficient is statistically different from zero at the ***1 %, **5 %, and *10 % level. The unit of observation is a municipality in 1953. All regressions include a constant not reported. Geographic controls include elevation, terrain ruggedness, and distance to Rhine or Neckar. Historical controls encompass distance to the closest Imperial city, the next certain Roman road, historical political fragmentation, the share of a municipality's total area that is located in historically ecclesiastical territories, and market potential in 1500.

The second stage results show a significant relationship of instrumented equal partition on the outcome variables. The coefficients all have the expected sign. These results imply that population density is on average 220 % larger (column (2)) in an equal partition municipality.[17] Given the extraordinary variation in population density in our sample (it varies between 0.48 and 2,396), and the fact that all major agglomerations and most of the large cities in Baden-Württemberg are located in the equal partition area, this estimate is plausible. To put this in perspective, the coefficient implies that a primogeniture municipality with median population density (around 127 inhabitants per hectare) would become a third quantile population density municipality if it were an equal partition municipality. Panel C shows a significant positive influence of seasonality of precipitation on the outcome variables, which is overall economically sizable. The reduced form is estimated with OLS and is, provided the validity of our instrument, unbiased regardless of whether the 2SLS estimations suffer from a weak instrument. As such, the significant reduced form results are reassuring.

To conclude, these 2SLS estimations confirm that our empirical results are robust to alternative identification strategies.

VI. Conclusion

This paper provides evidence that historical viticulture can explain comparative development. Our proposed mechanism, along with the historical literature, is the outstanding land-labor ratio of wine cultivation. Following the argument of Simpson (2011), viticulture enabled agriculture on marginal and relatively small plots. This gave rise to the emergence and persistence of a particular inheritance practice: equal partition. Our causal identification strategy is inspired by specific botanical properties of the grapevine.

This study also investigates the role of agriculture for economic development. It highlights the role of wine—one of the most labor-intensive agricultural goods—in shaping modern Southwest Germany. As such, we provide support for several existing hypotheses on the determinants of economic development in the countryside, and establish new hypotheses of our own. of special relevance here are the role of viticulture for cooperative behavior, cultural traits other than inheritance traditions, and identity. Recent contributions such as Fiszbein, Jung, and Vollrath (2022) complement our own in guiding this research.

[17] In the case of a log-level model with a dummy variable as a regressor, the semi-elasticity of population density concerning equal partition can be calculated as $[(e^{1.164}) - 1] \cdot 100 \approx 220$.

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Appendix (For online publication only)

A.1. The Map of Inheritance practices of Röhm 1957

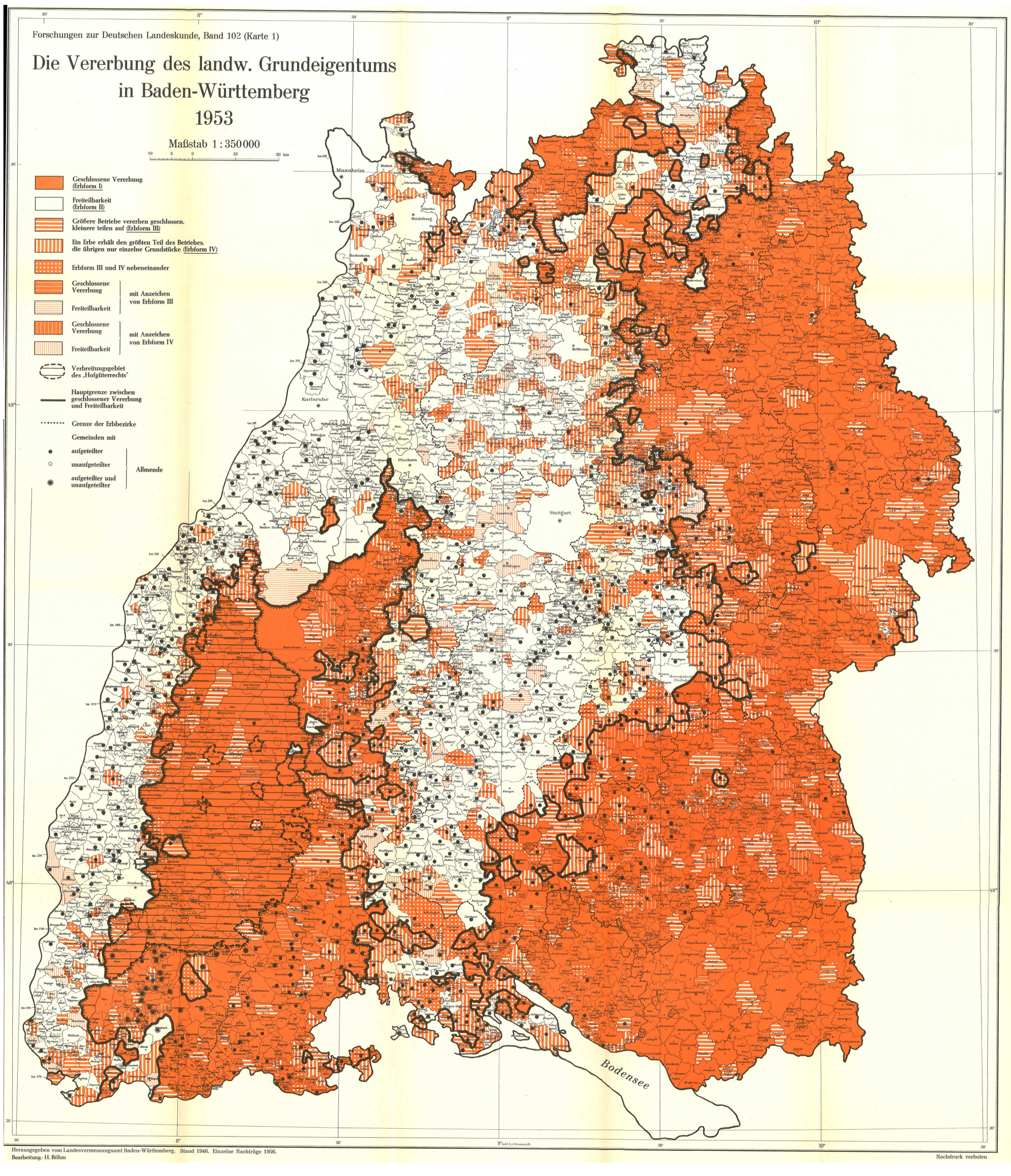

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Figure A.1: *Map of Inheritance Practices and Partitioned Common Land in 1953 according to Röhm (1957).*

A.2. Descriptive Overview of the Data Sets Used in the Study

Table A.1: *Descriptive Overview of the Data Set for Municipalities as of 1953*

Variable	Obs	Mean	Std. Dev.	Min	Max
Celtic Grave	3,374	0.241	0.428	0	1
Distance to Imperial City	3,382	11.331	9.843	0.000	51.745
Distance to Rhine or Neckar	3,380	23.572	20.47	0	88.010
Early Medieval Settlement	3,374	0.274	0.446	0	1
Elevation	3,380	474.774	200.677	96.333	1216.923
Employment Share Agriculture 1950	3,378	0.338	0.139	0.011	0.817
Employment Share Industry 1950	3,378	0.389	0.19	0.007	0.893
Historical Equal Partition Area	3,382	0.488	0.500	0.000	1.000
Historical Political Fragmentation	3,379	20075.080	27898.930	71.574	118850.000
Historical Political Instability	3,382	3.724	1.438	0.000	10.000
ln(Firms per hectare 1950)	3,373	1.542	0.901	-2.596	6.360
ln(Population Density)	3,370	4.436	0.779	0	7.986
Domestic Market Potential	1,912	11.879	0.238	11.631	15.48
Share Medieval Settlement	3,382	0.19	0.363	0.000	1.000
Share Ecclesiastical Territory	3,382	0.124	0.3	0.000	1.000
Share Imperial City	3,382	0.069	0.225	0.000	1.000
Share Neolithic Settlement	3,382	0.04	0.12	0	1
Roman Road Density	3,374	0.05	0.124	0	1.112
Soil Suitability	3,380	22.258	8.282	0.000	52.000
Terrain Ruggedness	3,380	100.496	71.543	2.367	460.234
Wine-growing before 999	3,382	0.032	0.177	0	1
Wine-growing 1000-1299	3,382	0.266	0.442	0	1
Wine-growing 1300-1624	3,382	0.182	0.386	0	1
Wine-growing before 1624	3,382	0.381	0.486	0	1
Wine-growing in 2018	3,382	0.37	0.483	0	1
Württemberg 1789	3,374	0.231	0.421	0.000	1.000

Table A.2: *Descriptive Overview of the "50km around Stuttgart" data set*

Variable	Obs	Mean	Std. Dev.	Min	Max
Distance to Imperial City	892	7.013	6.679	0.000	27.183
Distance to Rhine or Neckar	892	13.852	9.641	0.000	39.972
Distance to Roman Road	892	4.023	4.307	0.000	18.448
Distance to Stuttgart	892	23.167	11.374	0.000	41.553
Elevation	890	419.025	152.293	169.625	820.800
Employment Share Agriculture 1950	889	0.309	0.162	0.011	0.710
Employment Share Industry 1950	889	0.418	0.121	0.098	0.817
Equal Partition	892	0.516	0.500	0.000	1.000
Historical Political Fragmentation	892	10818.090	17199.100	159.942	92386.520
ln(Firms per hectare 1950)	887	1.969	0.765	-2.596	5.005
ln(Population Density 1950)	889	4.994	0.761	-0.741	7.782
Domestic Market Potential	892	13.116	0.286	12.655	14.787
Suitability for Barley	892	60.214	18.677	3.000	85.000
Suitability for Maize	892	10.458	5.131	0.000	28.636
Suitability for Potato	892	38.885	6.269	18.704	48.000
Suitability for Winter Wheat	892	56.056	17.850	3.000	83.000
Seasonality of Precipitation	892	17.699	5.057	10.672	28.871
Share Ecclesiastical Territory	892	0.048	0.189	0.000	1.000
Terrain Ruggedness	892	151.060	80.694	24.203	494.897
Wine Growing before 1624	892	0.635	0.482	0	1

Table A.3: *Descriptive Overview of the Data Sets used for the Placebo IV Tests in Table 5*

	Obs	Mean	Std. Dev.	Min	Max
	Sample: 50km around Munich				
Distance to Munich	302	31.65	12.39	0	49.93
Distance to Wittenberg	302	422.7	25.71	369.7	481.5
Elevation	302	280.7	48.88	210.9	532.0
ln(Average Wage Income 2014)	290	10.38	0.186	9.703	11.41
Peasant Wars Dummy	302	0.055	0.131	0	0.907
Roman Dummy	302	0.997	0.058	0	1
Seasonality of Precipitation	302	32.37	2.428	26.80	38.26
	Sample: 50km around Bremen				
Distance to Bremen	158	32.81	12.49	0	49.87
Elevation	158	13.34	7.849	-0.074	31.04
ln(Average Wage Income 2014)	158	10.14	0.104	9.709	10.46
Roman Dummy	158	289.5	26.11	237.0	349.9
Seasonality of Precipitation	158	16.00	1.508	14.41	21.12
	Sample: 50 km around Hamburg				
Distance to Hamburg	496	34.76	10.02	0	49.93
Elevation	496	16.12	10.78	-2.464	63.43
ln(Average Wage Income 2014)	493	10.25	0.155	9.942	11.64
Roman Dummy	496	261.7	27.14	204.4	310.6
Seasonality of Precipitation	496	16.40	1.255	13.81	19.28
	Sample: 50km around Hanover				
Distance to Hanover	182	34.05	11.88	0	49.96
Elevation	182	48.07	32.16	11.63	173.3
ln(Average Wage Income 2014)	176	10.14	0.097	9.862	10.48
Roman Dummy	182	211.4	29.50	152.0	262.4
Seasonality of Precipitation	182	14.13	0.891	11.97	16.43
	Sample: 50km around Kiel				
Distance to Kiel	470	31.04	13.08	0	49.92
Elevation	470	14.25	7.771	-0.507	54.33
ln(Average Wage Income 2014)	465	10.15	0.160	8.619	11.10
Roman Dummy	470	323.2	26.84	270.1	375.0
Seasonality of Precipitation	469	18.76	1.594	15.42	23.18

A.3. Definitions and Sources of the Variables

The spatial data sets were each converted into ETRS89 UTM 32N projection. GIS computations were performed with the QGIS software. Variables from the official statistics of Baden-Württemberg are explained in detail in the main text and are not included in the list below.

Celtic Grave. Dummy variable equal to one if in a municipality archaeologists have found at least one Celtic grave. Variable calculated using a digitized version of the following map from Kommission für geschichtliche Landeskunde in Baden-Württemberg (1988): https://www.leo-bw.de/media/kgl_atlas/current/delivered/bilder/HABW_03_02.jpg (accessed latest on 27th March 2019).

Distance to Imperial City. Distance to city states is calculated as follows: Points with random location were generated until 1,000 points fell in into each municipality. In a second step, the Euclidean distance from each of the 1,000 points per municipality to the closest Imperial city was calculated. In a last step, these distances were aggregated by municipality. The location of city states follows the maps of territories of the HRE in 1556 by Wolff (1877) but we have corrected/ supplemented them—if necessary—with information from Köbler (1988), Keyser and Stoob (1939–1974) and Jacob (2010).

Elevation. Mean elevation of each municipality in meters. Data is based on the Digital Elevation Model (DEM) of the U.S. Geological Survey's Center for Earth Resources Observation and Science (EROS), namely the GTOPO30 dataset, which can be downloaded here https://lta.cr.usgs.gov/GTOPO30 (last accessed May, 30th 2016). The GTOPO30 has a spatial resolution of 30 arc seconds.

Early Medieval Settlement. Dummy variable equal to one if in a municipality there was at least one early medieval, Germanic settlement. Settlements are identified by a map of villages with the name endings "-ingen" "-heim" or "ingheim". These name endings indicate that the villages originates from an early medieval settlement. The variable is based on a digitized version of the map from Kommission für geschichtliche Landeskunde in Baden-Württemberg (1988): https://www.leo-bw.de/media/kgl_atlas/current/delivered/bilder/HABW_04_01.jpg (accessed latest on 27th March 2019)

Historical Political Fragmentation. Historical average state size of the states intersecting the municipality in km^2. Variable is calculated using digitized versions of the maps of the HRE printed in Wolff (1877).

Historical Political Instability. The variable reports the number of different historical states intersecting a municipality. Variable is calculated using digitized versions of the maps of the HRE printed in Wolff (1877).

Historical Wine-growing. Dummy variables equal to one if there was wine-growing in a municipality in different periods before 1624. The Variable is based on a digitized version of the following map from Nüske (1977): https://www.leo-bw.de/media/kgl_atlas/current/delivered/bilder/HABW_11_05.jpg (accessed latest on 24th June 2020).

Wine-growing in 2018. Dummy variables equal to one if there was wine-growing in a municipality in 2018. The Variable is based on the official agricultural statistics of the state of Baden-Württemberg (Statistical Office of Baden-Württemberg 2018). We consider a municipality to be a wine-growing one if it has more than zero hectare of area used for growing wine.

Domestic Market Potential. A municipality's market potential is calculated following the methodology of Crafts (2005). Unlike Crafts measure of regional economic potential, our measure is not based on the GDP of all other municipalities, but on the population size of the historical cities included in the database of Bairoch, Batou, and Chevre (1988) and including only cities located inside of Baden-Württemberg (domestic).

Roman Road Density. km of certain Roman Roads per km^2 of municipal area. Locations of Roman roads (minor and major) originate from a shapefile included in the "Digital Atlas of Roman and Medieval Civilizations" (McCormick et al. 2013). The shapefile is based on the map of Roman roads in the Barrington Atlas of the Greek and Roman World (Talbert 2000). It can be downloaded here: http://darmc.harvard.edu/icb/icb.do?keyword=k40248&pageid=icb.page601659 (last accessed September, 24th 2015).

Seasonality of Precipitation. Variable is the coefficient of variation of monthly precipitation in mm, averaged over the period from 1970 to 2000. It originates from the bioclimatic variables provided by the WorldClim database version 2.1 (https://www.worldclim.org/data/bioclim.html). We aggregated the 30*30 arc seconds raster data provided by WorldClim to the level of municipalities by averaging over all the pixels located within area of a municipality.

Share Ecclesiastical Territory. Variable is the share of a municipality's area that was located in an ecclesiastical state in 1556. The map of territories within the current state of Baden-Württemberg originates from Huning and Wahl (2020).

Share Imperial City. Variable is the share of a municipality's area that was located in the territory of an Imperial city in 1556. The map of territories within the current state of Baden-Württemberg originates from Huning and Wahl (2020).

Share Medieval Settlement. The share of each municipality's area that is located in area that was settled and partly deforested during the early Middle Ages. Variable is calculated based on a digitized version of a map by Ellenberg (1990).

Share Neolithic Settlement The share of each municipality's area that is located in Neolithic settlement area. Variable calculated using a digitized version of the following map from Kommission für geschichtliche Landeskunde in Baden-Württemberg (1988): https://www.leo-bw.de/media/kgl_atlas/current/delivered/bilder/HABW_03_01.jpg (accessed latest on 27$^{\text{th}}$ March 2019).

Soil Suitability. Soil Suitability is based on the agricultural suitability measure developed in Zabel, Putzenlechner, and Mauser (2014).[1] The measure used in the paper is average agricultural suitability in the period 1961–1990. Zabel, Putzenlechner, and Mauser (2014) measure agricultural suitability by considering climate (temperature, precipitation, solar radiation), soil (pH, texture, salinity, organic carbon content, etc.), and topography (elevation and slope) of a grid cell of 30 arc seconds*30 arc seconds (0.86 km^2 at the equator) size. They consider rain-fed conditions as well as irrigation (what could, among other things, give rise to endogeneity issues). To compute agricultural suitability, they contrast these factors with growing requirements of 16 plants (Barley, Cassava, Groundnut, Maize, Millet, Oilpalm, Potato, Rapeseed, Rice, Rye, Sorghum, Soy, Sugarcane, Sunflower, Summer wheat, Winter wheat).

1. The data set is described further here: http://geoportal-glues.ufz.de/stories/globalsuitability.html (last accessed on January 22, 2016), where it also can be downloaded.

Terrain Ruggedness. Following Riley, DeGloria, and Elliot (1999) average ruggedness of a municipality's territory is calculated as the negative value of the derivative of the ruggedness index of a digital elevation model. The calculations are based on the elevation raster of Nunn and Puga (2012) (see above).

Württemberg 1789. Dummy Variable equal to one if the majority of a municipality was located in the Duchy of Württemberg in 1789. Assignment of municipalities to the historical duchy is based on the map of territories in 1789 from Huning and Wahl (2020).

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