Agricultural Roots of Industrial Success

How German Viticulture Shaped "Hidden Champions"

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This paper studies the long-term contribution of viticulture to regional development in Germany, focusing on Hidden Champions—little-known yet globally leading firms in niche markets that form a cornerstone of Germany's export-oriented industrial success. Using data on all German municipalities, and instrumenting viticulture with the Huglin Index—a climate-based measure of climatic suitability for wine growing—I find that the presence of viticulture increases the number of Hidden Champions in a municipality by 31%. I argue that, unlike staple crops, wine cultivation demanded a broader and more technically diverse skill set, fostering the emergence of technically oriented firms that ultimately evolved into Hidden Champions.

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1. Introduction

What are the long-term effects of specific agricultural crops on development? The existing literature largely examines how agricultural change shaped development in the aggregate (Gollin (2010); Hornbeck and Keskin (2015); Fiszbein (2022)), while the role of individual crops has only recently begun to receive attention (Vollrath (2011); Jung (2020); Carillo (2021)). This paper studies one such crop: it analyzes the role viticulture played in Germany's industrial success, particularly in the emergence of a group of firms known as Hidden Champions.

A striking feature of Germany's industrial structure is its decentralization. Take, for instance, the company Eirich, founded in 1863 in a rural town in southwestern Germany, originally focusing on the maintenance of local mills. It has since become a global leader in mixing and grinding technologies. Eirich serves as an exemplar of Hidden Champions (HC)—mostly medium-sized firms that, despite limited public brand awareness, dominate specialized and highly technical market segments globally. These firms play a pivotal role in positioning Germany as an export-oriented economy, centered on specialized, knowledge-intensive manufactured goods (Rammer and Spielkamp (2015)). This paper asks whether viticulture contributed to the establishment of these firms.

To identify a causal link between viticulture and the prevalence of Hidden Champions, this study links the geographical origins of present-day vineyards with Hidden Champions at the municipality level, incorporating a comprehensive sample of all 10,785 modern municipalities in Germany. Given the historical data constraints concerning viticulture, this research uses the Huglin Index (Huglin (1978))—a metric for assessing climatic suitability for viticulture—as an instrumental variable for wine cultivation.

The core result is that the presence of viticulture increases the number of Hidden Champions by 31% at the municipality level. This effect persists even when accounting for a range of local historical conditions, such as population density, size of municipalities, soil quality and crop suitability, geographical factors, and centrality considerations, along with state-level fixed effects. These controls are essential due to Germany's long-standing federalist tradition and the resulting regional economic development disparities. In addition to this direct effect, the

cultivation of wine in adjacent municipalities also exerts a substantial impact on the presence of Hidden Champions, signifying spillover effects. These findings indicate that viticulture areas shaped the emergence of Hidden Champions.

Why would wine growing matter for firm formation? I argue that viticulture, unlike staple crops such as wheat or barley, involved complex and technically demanding production. Its manufacturing-like character cultivated a broader and more technically skilled workforce, and production ran from grape to bottle within a single operation, whereas other crops outsourced most processing steps. Consistent with this, viticulture areas exhibit persistently higher population densities—likely reflecting the crop's high yield on otherwise unproductive land—and the municipality-level results confirm lasting effects on population and employment. The fragmentation of land ownership, especially in the southwest, sustained many part-time wine growers who also practiced other trades. Together, these conditions created a reservoir of technical expertise that fostered industrialization and, ultimately, the emergence of specialized manufacturing firms.

Related Literature

This study contributes to the expanding literature on Hidden Champions by documenting the geographical distribution of these companies within Germany (Rammer and Spielkamp (2015); Benz et al. (2021)). While the existing literature traces the origins of Hidden Champions to a blend of historical and institutional factors, such as Germany's vocational education system with apprenticeships (Schlepphorst et al. (2016)) or dualistic corporate boards and civil law system (Lehmann and Schenkenhofer (2023)), the historical roots in agricultural practices have remained unexplored.

Furthermore, this paper contributes to the understanding of how agriculture has shaped long-term development and the specific role played by certain crops. Related studies have examined the economic effects of introducing potatoes to Europe (Nunn and Qian (2011)) or cotton in the US South (Jung (2020)). What sets this paper apart is its focus on viticulture and its relationship with industrialization in Germany.

In a closely related contribution, Huning and Wahl (2025) argue that the long-standing

tradition of wine cultivation, dating back to the Middle Ages in a particular southern German state, has a lasting impact on development and industrialization. This paper, developed independently and concurrently, offers a complementary narrative. While they highlight the role of inheritance traditions and employ an alternative instrument for viticulture, my study sheds light on the pivotal effect of viticulture on the development of technical skills essential in the formation of Hidden Champions. This aspect is not fully accounted for by the inheritance traditions, as shown in subsequent sections.

This paper also contributes to understanding the decentralized configuration of economic activities in Germany, especially in the industrial sector. It fits in a literature that analyzes the effects of decentralization on long-term economic performance (Iimi (2005)), offering insights into the distinctive developmental trajectories influenced by varying degrees of centralization across countries.

This paper is structured as follows: Section 2 explores the historical background, Section 3 outlines the conceptual framework, Section 4 describes the data, Section 5 presents the empirical results, and Section 6 concludes.

2. Historical Background

I. Viticulture

The history of viticulture in Germany is deeply interwoven with the country's broader economic and regional development. Originating in Roman times, the cultivation of vineyards gradually found its stronghold in several regions, most notably along the Rhine and Mosel rivers. During the Middle Ages, monasteries played a pivotal role in advancing viticulture, both as a source of revenue and as a repository of viticultural expertise. The peak of viticulture in Germany was reached with approximately 300,000 hectares under cultivation in the 16th century (Woschek (1978)).

Since then, viticulture has experienced several shifts due to climate adaptations, grape specialization, and pests (Storchmann et al. (2018)). Land used for viticulture shrank from its mid-19th century peak of 100,000 hectares to roughly half this size following World War II.

Most notably, vineyards were severely affected by the Phylloxera epidemic, an insect infestation, from the 1870s onward, by changing climatic conditions in certain growing regions of East Germany, and by damage during both World Wars. Factors such as global competition and reduced demand led to a further decrease in viticulture post-WWI, with a recovery only occurring in the 1960s.

Despite significant fluctuations in land allocated to viticulture, the core production areas in southwestern Germany experienced only modest reductions in the past 150 years, primarily in less productive vineyards on the periphery. The primary growing regions have remained consistent—located in northern Bavaria, southern Hesse, along the Rhine and Mosel rivers in Rhineland-Palatinate, and in Baden-Württemberg—echoing the historical map of dominant agricultural crops in 1900, as seen in Figure A1 in the appendix.

II. Hidden Champions

The concept of Hidden Champions gained prominence through the scholarly work by Simon in the 1990s (Simon (1992b); Simon (1992a); Simon (1996)). Despite their low brand awareness, often due to their operation in B2B sectors, these companies display champion-like attributes: dominating niche sectors, frequently ranking in the top three globally within their specialized product or service categories. While they are limited in size, generating revenues below $5 billion, their economic impact is substantial (Simon (2009); Benz et al. (2021)). These Hidden Champions are highly innovative and employ a skilled, well-compensated workforce, thus contributing significantly to both regional and national economies.

Their resilience during economic downturns and adaptability to market shifts further underscore their importance (Rietmann (2022)). Consequently, Hidden Champions have become a topic in conversations about economic diversification, competitiveness, and the decentralization of economic activity—not just in Germany.

Hidden Champions are pivotal to Germany's economic landscape, serving as essential components of its modern economic backbone, which includes the Mittelstand—medium-sized companies—and family-owned firms. These entities collectively shape Germany's unique economic model. Analyzing Hidden Champions within the context of viticulture serves as an

insightful proxy for understanding the broader influence exerted by these other crucial types of companies.

To illustrate this, I elaborate on the example of the company Eirich, founded in 1863 by Gustav Eirich in the town of Hardheim in the rural northern part of Baden-Württemberg. The company focused initially on the maintenance of mills in the region. Eirich transitioned to becoming a global leader in mixing and grinding technologies, particularly in intensive mixers. Figure A2 in the appendix depicts the high-tech transformation of a mixer, one of their core products. Their leadership in the field has led them to serve various industries, from ceramics to battery manufacturing. The company has expanded its footprint internationally, with a robust presence in the global market. Regionally, they have retained a strong presence in Baden-Württemberg with over 500 employees, contributing significantly to the local economy and knowledge base. Their success and innovation have been recognized through various awards, including the Gustav Eirich Award, named in honor of the founder.

Although most prevalent in Germany, Hidden Champions also constitute a global phenomenon, with over 300 such entities identified in the United States. Nonetheless, the per capita concentration is highest in German-speaking countries, including Switzerland and Austria, as emphasized by Simon (2009).

The origins of Germany's Hidden Champions are often traced to a blend of historical and institutional factors that have shaped the nation's complex history. Notably, Germany's robust vocational education system, featuring a dual system of apprenticeships and formal education, has been key in developing a highly skilled and specialized workforce (Schlepphorst et al. (2016)). This educational structure has roots in the historical particularism that marked various German states, encouraging specialized trades to thrive in autonomous regions (Tremblay and Le Bot (2000)). This particularism may have also been a catalyst for the regional emergence of Hidden Champions.

Post-World War II, the influx of skilled refugees contributed to Germany's economic reconstruction, creating a conducive environment for specialized industries (Peters (2022)). Institutional features such as lenient inheritance tax laws, dualistic corporate boards, and a civil law system have collectively encouraged niche entrepreneurship (Lehmann and Schenkenhofer

(2023)). Additionally, Germany's relatively underdeveloped capital markets have steered firms toward prioritizing organic growth and long-term stability over short-term profits, aligning well with the typical structure of Hidden Champions (Simon (2009)).

Many Hidden Champions were established after the unification of the German Reich in 1871 during the Gründerzeit period[1] when Germany became a leader in the fields of chemical, electrical, and mechanical industries that dominate its economic landscape to this day.

3. Conceptual Framework

The proposed mechanism operates through the skill-enhancing effect of viticulture on the local workforce. Unlike conventional agriculture, viticulture closely resembles manufacturing processes, requiring a broader, more specialized and technically advanced skill set. It is often an integrated process, from the plant to the bottle. In some regions, the special equipment was owned on a local scale, allowing for reduced capital intensity of the process. In contrast, traditional crops were primarily used directly as feed or their further production steps were outsourced. This is particularly evident in regions with highly fragmented land plots and many part-time viticulturists, often proficient in other trades such as blacksmithing. In addition, local farmhands were typically employed for tending in spring and harvesting in fall, creating a diverse and more competent labor pool that may subsequently facilitate the inception and growth of specialized, high-skill companies. The hypothesis centers on the period of industrialization, up to the 1950s, when agriculture was still a dominant source of employment and mechanization had not yet become widespread in viticulture. Figure A4 shows that more than 70% of HCs were already established by the end of the 1950s.

Another channel works through the local economic conditions viticulture creates: as viticulture exhibits an inherent advantage in land productivity relative to other forms of agriculture, yielding considerably higher output per unit of land area, this heightened yield allows for an elevated population density, effectively creating a labor market with larger agglomerations. This may serve as a necessary precondition for the establishment of Hidden Champions, as

[1] *Gründerzeit* translates to *Founder's Period* and refers to a time of rapid industrialization that saw the establishment of iconic German companies such as Deutsche Bank and Bosch.

Table 1: Summary statistics for municipalities and Hidden Champions

Level	Category	Variables	Values
Municipality	Administrative units	Number	10,785
		Number West Germany	8,376
		Mean Population 2019	7,712
		Mean Population 1871	2,712
	Viticulture	Number with viticulture	1,106
		Share with viticulture in %	10
		Mean hectares viticulture	10
	Hidden Champions	Number with HC	919
		Mean number of HC	0.156
Firm		Number	1,691
		Mean Employment	535
		Mean Revenue in Million Euro	162
		Share Manufacturing in %	82
		Stock market listing in %	4.3

Note: The table presents summary statistics for variables on the current (2019) administrative municipalities in Germany and the dataset on Hidden Champions (Venohr (2016)).

the application of technical skills is at the core of these companies and sufficient local labor supply is required.

4. Data

This paper uses contemporary German administrative units, primarily municipalities, districts, and states from official statistics, recognizing that historical administrative areas were smaller. Nonetheless, the design of current administrative zones considered regional interdependencies and was not arbitrary. Table 1 displays a summary of the main variables and averages at the municipality and district levels.

I. Viticulture and Climate Suitability for Wine

Modern viticulture data at the municipality level were collected from various sources, mostly from state-level administrative statistics, between 2017 and 2022, detailed in the Appendix. Figure 1b depicts the intensity (hectares) by municipality. While viticulture takes up only 0.6% of agriculturally used land in Germany, it has a substantially larger productivity compared to other agricultural crops. Modern cultivation data are, however, endogenous to local economic development. I therefore use a climatic suitability index for viticulture, the Huglin Index.

The Huglin Index is a widely recognized climatic index used to assess the suitability of regions for viticulture and is calculated based on the formula:

$$\text{Huglin Index} = K \sum_{i=1}^{n} (T_{\max,i} + T_{\min,i})/2 - 10$$

where $T_{\max,i}$ and $T_{\min,i}$ are the daily maximum and minimum temperatures during the growing season, from April to September, and K is the latitude adjustment (Huglin (1978)).

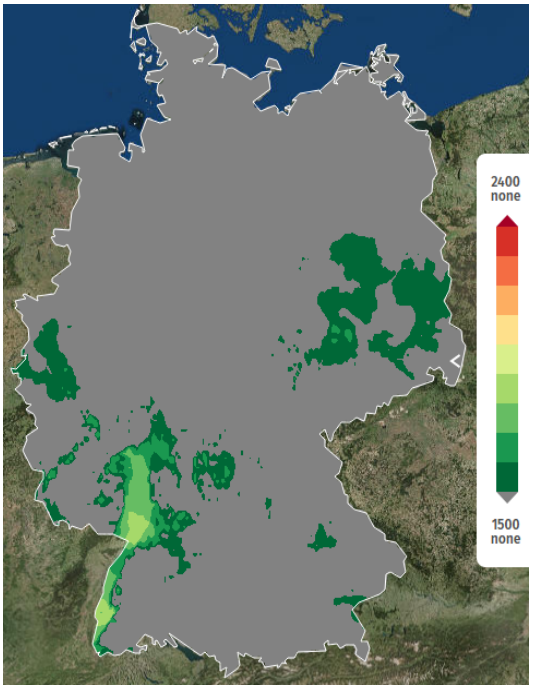
Over the years, climate change led to alterations in the index values across Germany, generally making the country more conducive for viticulture (Neumann and Matzarakis (2011)). It is worth noting that the Huglin Index, originally tailored for French viticulture, does not fully capture Germany's unique microclimate variations (Storchmann et al. (2018)), allowing for larger growing regions. Additionally, the index overlooks local variables like altitude and soil, key elements of the *terroir*[2] that contribute to regional wine complexities.

While the Huglin Index is available for periods since the early 20th century, it depicts a considerably smaller area suitable for viticulture. This contrasts with historical sources on wine-growing regions (Figure A1), which suggest that the microclimatic factors mentioned enabled a more expansive cultivation area. Additionally, vineyards were planted in less favorable regions due to a higher level of regionalization and limited trade. Therefore, the historical expanse seems more congruent with the Huglin map from the 2000s (Woschek (1978)), which was consequently used (Figure 1a).

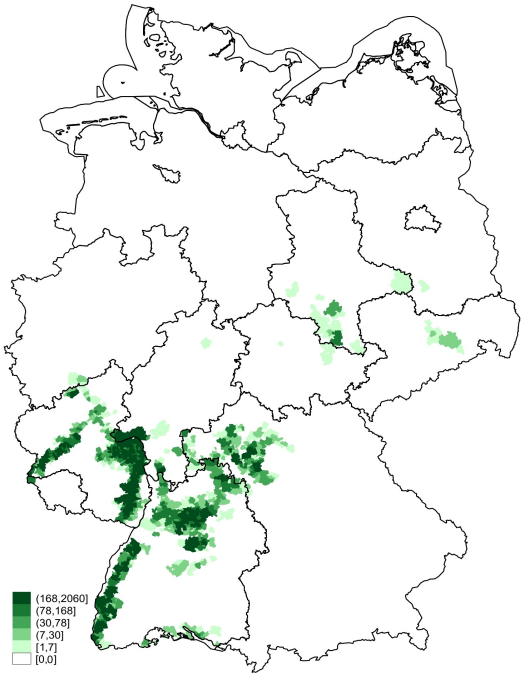
[2]Terroir describes the core elements of environmental conditions, namely soil, climate, topography, and geographical features (Van Leeuwen and Seguin (2006)).

Figure 1: Huglin Index 2000 and current viticulture intensity on municipality level

(a) Huglin Index 2000



(b) Current viticulture on municipality level



Note: Figure 1a shows the Huglin Index, dark green areas with Huglin Index numbers above 1500. Figure taken from the Potsdam Institute for Climate Impact Research, Stock et al. (2004). Figure 1b displays viticulture cultivation at the municipality level in 2022.

II. Hidden Champions

In the absence of a standardized dataset for Hidden Champions, scholarly research often relies on various sources for identification (Schenkenhofer (2022)). For this study, I use data from Venohr (2016), widely considered the most comprehensive dataset available. It was assembled through an initial broad screening of companies, followed by a case-by-case assessment. The criteria include: 1) low brand recognition; 2) market leadership, defined as ranking within the global top three in at least one product segment; and 3) being a small to medium-sized company, with revenues below $5 billion (Venohr and Meyer (2009)).

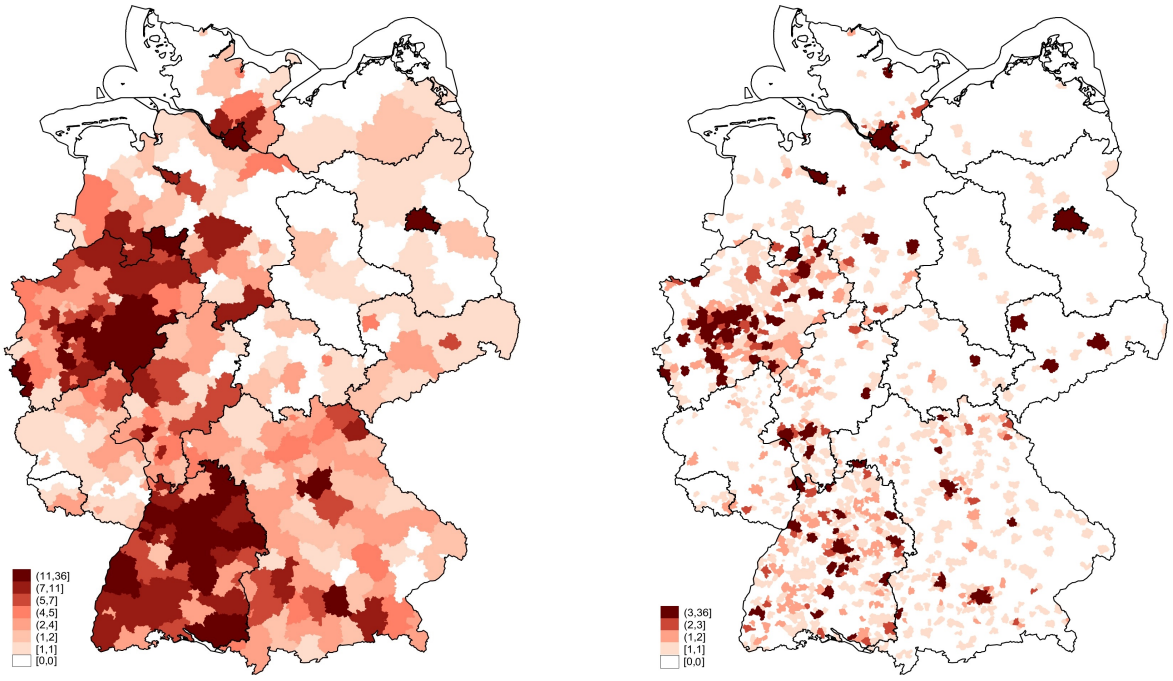
The Hidden Champions dataset comprises 1,691 firms. After mapping these based on their headquarters or founding locations, they are distributed at the district and municipality levels, as illustrated in Figure 2.

The cumulative distribution by founding year of Hidden Champions (Figure A4) shows that only a few companies were already established around 1800; this number climbed to 600

Figure 2: Number of Hidden Champions on district and municipality level

(a) Number HC on district level

(b) Number HC on municipality level



Note: The figures show the number of Hidden Champions at the district (2a) and municipality (2b) levels, taken from Venohr (2016).

companies by 1900 and subsequently doubled by the end of the 1950s. Overall, the number of HCs rose gradually, accelerating in the 1870s, with only a handful established after 1990.

III. Additional Variables

Municipality-level population data are taken from Roesel (2023), who compiles a comprehensive dataset spanning from 1871 to 2019. However, due to data limitations, comprehensive population data for all municipalities before 1930 are only available for the year 1871. Figure A3 presents the 1871 population densities on modern municipality borders. Modern population data by municipality were obtained from official statistics as outlined in the data appendix.

To approximate local agricultural productivity, I use crop suitability indices, following Zabel et al. (2014), which are averaged at the municipality level and included for the seven most relevant crops before 1900. These crops are summer and winter wheat, barley, rye, potatoes,

maize, and millet. Furthermore, I use a high-resolution dataset on plowland soil quality across Germany from the Reichsbodenschätzung of 1938. This comprehensive land evaluation survey, conducted by the German government (Van Diepen et al. (1991)), provides a reliable proxy for plowland productivity, especially given the exceptionally strong correlation between yield and the soil quality index prior to 1950. The data are indexed on a scale from 1 to 100, where 100 indicates plowland with the highest natural agricultural productivity. For this study, soil quality data are aggregated, and a mean value for each municipality is generated.[3]

Geographic controls include average elevation, longitude, latitude, and terrain ruggedness at the municipality level, calculated according to Riley et al. (1999).

Distance-related controls for each municipality are also incorporated, primarily focusing on the distance to the nearest of the 20 state capitals in 1871, as defined in Killingray (1979) following the formation of the German Reich. Additionally, distances to 19 major universities in the year 1900, derived from Rüegg (2004), are included. I also include a measure of the distance to major rivers.

5. Empirical Results

I begin by estimating the impact of viticulture on the emergence of Hidden Champions and other outcomes with Ordinary Least Squares (OLS) regressions of the following form:

$$y_i = \alpha + \beta \text{ viticulture}_i + \delta_s + \gamma' \mathbf{X}_i + \epsilon_i$$

where y_i stands for the outcome, most notably the log number of HC in unit i, at the municipality level. Viticulture is, unless otherwise specified, a dummy variable for current viticulture in a given unit i (viticulture in municipality = 1). δ_s is a state fixed effect for the 16 modern German states. $\mathbf{X}_i$ is a vector of control variables, and ϵ_i is an error term.

To identify the causal effect of viticulture on Hidden Champions and other contemporary outcomes, I use the Huglin Index from the 2000s as an instrumental variable for present-day viticulture. Since the index derives exclusively from cumulative growing-season temperatures (April–September), the exclusion restriction is plausible. It is further supported by a placebo

[3]When data are missing—typically for areas classified solely as grassland or forest—a default value of 1 is imputed to indicate unproductive soil.

test shown in Table A6: regressing the number of Hidden Champions on the Huglin Index instrument shows no effect in regions without viticulture, as exemplified by areas around several major cities within a 50 km radius.

While temperature could in principle affect economic activity through channels other than viticulture—most plausibly through general agricultural productivity—the small temperature variation within Germany makes this concern minor, and the crop suitability controls for the seven main staple crops absorb the principal alternative agricultural channel. The instrument is highly relevant, as shown by Figure 1 and by the large first-stage F-statistics reported in Table A1. Additionally, for robustness, part of the analysis is restricted to West Germany, since East Germany became a socialist state after World War II.

The instrumental variable approach is formulated as:

$$y_i = \alpha + \beta_{IV} \left[\text{viticulture}_i | \text{Huglin Index 2000}_i\right] + \delta_s + \gamma' \mathbf{X}_i + \epsilon_i$$

where the variables are defined analogously to the previous equation, with the only difference being that viticulture is instrumented by the Huglin Index dummy. Using present-day viticulture as the treatment is justified by the pronounced persistence of growing regions documented in Section 2: the core production areas have remained essentially unchanged over the past 150 years, and the results using historical viticulture in 1900 (Table 3) confirm this.

I. Viticulture and Hidden Champions Results

Table 2 summarizes the core empirical findings at the municipality level, incorporating control variables such as population density in 1871 and land area per municipality, with further controls for geographic and distance factors as well as crop suitability. The key result is that the presence of viticulture increases the average number of Hidden Champions in a municipality by 31% in the main IV specification (5), which includes state fixed effects and the full set of controls.

The coefficient of interest for the IV results (4)–(6) with state fixed effects remains significant and increases substantially when additional controls are used. In contrast, the OLS coefficients with state fixed effects and additional controls are relatively close to zero. Focusing solely

Table 2: Viticulture effect on Log Number of Hidden Champions

	(1) OLS	(2) OLS	(3) OLS	(4) IV	(5) IV	(6) IV
Dependent variable: log(Number of Hidden Champions)						
Viticulture	0.0543***	-0.0045	-0.0088	0.0536*	0.316***	0.315***
	(0.0114)	(0.0330)	(0.0315)	(0.0300)	(0.1212)	(0.1150)
Pop density 1871		0.0013***	0.00126***	0.0012***	0.0011***	0.0015***
		(0.0004)	(0.000380)	(0.0001)	(0.0001)	(0.0002)
Soil quality		0.0001	0.000261	-0.0000	0.0001	-0.0000
		(0.0003)	(0.000193)	(0.0001)	(0.0002)	(0.0002)
Land area		0.0018***	0.00180***	0.0018***	0.0017***	0.0027***
		(0.0006)	(0.000582)	(0.0001)	(0.0001)	(0.0002)
Observations	10,785	10,785	10,784	10,773	10,772	8,363
R-squared	0.003	0.152	0.156	0.283	0.211	0.229
State FE		Y	Y	Y	Y	Y
Add. Controls: Geography, Crop Suitability, Distance Factors			Y		Y	Y
Only West GER						Y

Note: This table presents the results of the impact of viticulture on the number of Hidden Champions at the municipality level, using both OLS and IV regression, with state fixed effects and only West Germany as indicated. Robust standard errors shown in parentheses. Significance levels indicated by: *** p<0.01, ** p<0.05, * p<0.1. Constant term not displayed.

on West Germany leaves the coefficient in the instrumental variable model (6) unchanged, indicating a robust result.

The first-stage F-statistic exceeds 56 in the main specification with the full set of controls (Table A1), well above conventional weak-instrument thresholds, confirming the relevance of the instrument; at the same time, temperature differences across Germany are plausibly exogenous and unlikely to be correlated with HC formation through other channels.

Most control variables carry significant explanatory power. A higher historical population density in 1871 is positively associated with the current number of Hidden Champions, emphasizing the critical role of population density in fostering entrepreneurial activity and the emergence of these specialized firms. Larger municipalities generally host more of these firms. The analysis relies on modern municipality boundaries; as argued above, however, border modifications typically merged adjacent municipalities with pre-existing strong ties.

Table 3: Additional Viticulture effects on Hidden Champions

	(1) OLS	(2) IV	(3) OLS	(4) IV	(5) OLS	(6) IV
Dependent variable: log(Number of Hidden Champions)						
log(Viticulture hectares)	-0.00353	0.0882***				
	(0.00757)	(0.0341)				
Viticulture in adjacent municipality			0.000939	0.0869***		
			(0.0176)	(0.0327)		
Viticulture			-0.00851	0.268***		
			(0.0357)	(0.101)		
Viticulture 1900					-0.0353**	0.3894**
					(0.0145)	(0.1571)
Pop density 1871	0.0013***	0.0011***	0.0013***	0.0012***	0.0013***	0.0011***
	(0.0004)	(0.0001)	(0.0004)	(0.0001)	(0.0004)	(0.0001)
Soil quality	0.0003	0.0001	0.0003	0.0001	0.0003	0.0002
	(0.0002)	(0.0002)	(0.0002)	(0.0002)	(0.0002)	(0.0002)
Land area	0.0018***	0.0017***	0.0018***	0.0017***	0.0018***	0.0018***
	(0.0006)	(0.0001)	(0.0006)	(0.0001)	(0.0006)	(0.0001)
Observations	10,784	10,772	10,784	10,772	10,784	10,772
R-squared	0.156	0.195	0.156	0.239	0.157	0.153

Note: This table presents the results of the impact of viticulture intensity (in hectares), viticulture in adjacent municipalities, and historical viticulture on the number of Hidden Champions at the municipality level, using both OLS and IV regression. State fixed effects and controls for geography, crop suitability, and distance factors are included in each regression. Robust standard errors shown in parentheses. Significance levels indicated by: *** p<0.01, ** p<0.05, * p<0.1. Constant term not displayed.

Table 3 presents supplementary results using alternative measures of viticulture. The first two columns report results for the intensity of viticulture, measured as the log area under cultivation in hectares. These findings reveal a positive and statistically significant impact, consistent with the hypothesis that increased viticulture acreage boosts the average number of Hidden Champions in a municipality.

Columns (3) and (4) examine the influence of viticulture presence exclusively in neighboring municipalities, assessing its impact beyond the baseline effect of the viticulture dummy. The observed effect is positive and significant, indicating that local labor markets extend beyond municipal borders and that viticulture generates regional spillovers benefiting adjacent areas.

Columns (5) and (6) use historical viticulture areas, digitized from the map in Figure A1, sourced from the Statistisches Jahrbuch (1900), instead of a modern viticulture dummy variable. The findings align with current viticulture practices, with only a slight upward adjustment in the magnitude of the coefficients. Historical viticulture within a municipal-

Table 4: Viticulture effect on Population Density and Employment

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Dependent Var	log(Population Density 2019)			log(Num Employees 2019)		log(Unempl Rate 2019)	
Viticulture	-0.0266	0.5832*	1.1474***	-0.0260	0.6732**	-0.0305*	-0.9158***
	(0.0727)	(0.3459)	(0.3407)	(0.0719)	(0.3429)	(0.0166)	(0.1757)
Pop density 1871	0.0074***	0.0072***	0.0070***	0.0071***	0.0069***	0.0013***	0.0017***
	(0.0008)	(0.0006)	(0.0008)	(0.0008)	(0.0006)	(0.0002)	(0.0002)
Soil quality	-0.0012	-0.0015***	-0.0019***	-0.0015	-0.0018***	0.0004	0.0009***
	(0.0010)	(0.0005)	(0.0006)	(0.0010)	(0.0005)	(0.0004)	(0.0002)
Land area	-0.0009	-0.0011***	-0.0020***	-0.0010	-0.0013***	0.0016***	0.0020***
	(0.0008)	(0.0003)	(0.0004)	(0.0008)	(0.0003)	(0.0003)	(0.0001)
Observations	10,784	10,772	8,363	10,779	10,768	10,784	10,772
R-squared	0.423	0.549	0.439	0.466	0.700	0.148	0.097
IV Instrument: Huglin Index		Y	Y		Y		Y
Only West GER			Y				

Note: This table presents the results of the impact of viticulture on current outcomes for the population density, the number of employed and the unemployment rate in 2019 at the municipality level, using both OLS and IV regression. State fixed effects and controls for geography, crop suitability, and distance factors are included in each regression. Robust standard errors shown in parentheses. Significance levels indicated by: *** p<0.01, ** p<0.05, * p<0.1. Constant term not displayed.

ity is associated with a 38% increase in the number of Hidden Champions, thereby further reinforcing the previous results.

Table 4 concentrates on the long-term consequences, analyzing modern municipality-level outcomes from 2019. Viticulture has a significant and robust influence on contemporary population density; areas engaged in viticulture have seen marked increases in population density from 1871 to 2019. Moreover, the number of socially insured employees is substantially higher, and the unemployment rate is lower in municipalities with viticulture. Hence, viticulture yields positive effects on these vital economic indicators at the municipal level.

II. Robustness Results of Viticulture

The appendix provides additional robustness results addressing various concerns: Table A1 presents the first-stage regression from Table 2, which shows high F-statistics. Table A2 illustrates the regression model from Table 2 with all control variables and includes inheritance traditions. Table A3 examines fixed effects at the district level, a significant administrative unit with each state comprising 20 to 25 districts. Here, the coefficient of interest becomes insignificant. Moreover, this table incorporates the main results with standard error corrections as per Conley (1999) to account for spurious autocorrelation patterns, slightly lowering

the significance level. Table A4 explores the impact of viticulture on the revenue and employment of Hidden Champions (HCs), revealing positive effects. Table A5 dissects the number of Hidden Champions into research-intensive firms and engineering-focused firms[4]. Table A6 conducts placebo tests of the instrument on the number of Hidden Champions around four major cities in non-viticulture areas within a 50 km radius and finds no effect, thus supporting the exclusion restriction of the instrument, since a higher Huglin Index should not influence HC establishment in the absence of vineyards.

Additionally, Tables A7 and A8 in the appendix assess the effect of inheritance traditions[5] (equal partition vs. primogeniture), as highlighted by Huning and Wahl (2025), on the development of Hidden Champions and other current economic outcomes. Table A7 shows that the dominant inheritance tradition plays a minimal role: it is not a statistically significant factor in HC formation, which corroborates the proposed mechanism of the local skill-enhancing effect of viticulture and the resulting establishment of Hidden Champions. While the equal partition tradition positively influences other current outcomes, such as population density or the number of employees, the effect is smaller by a factor of at least three than that of viticulture.

6. Conclusion

This paper investigates the impact of viticulture on the emergence of Hidden Champions in Germany, revealing a significant positive effect at the municipality level with a magnitude of 31%. The results suggest that the historical presence of viticulture, characterized by its intensive, grape-to-bottle production processes—more demanding than those of other agricultural crops—has cultivated a skilled and diverse local workforce. This workforce, in turn, laid the groundwork for the development of highly specialized, globally dominant firms within Germany's characteristically decentralized industrial structure. To establish the validity of this mechanism, further research is necessary, which requires more detailed historical data than are available here.

[4]Engineering-focused firms in the three-digit industry classification include mechanical engineering, chemical engineering, electrical engineering, and vehicle construction (Fahrzeugbau).

[5]The inheritance status by municipality is sourced from Bartels et al. (2024).

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Appendix

I. Data Appendix

The data sources are listed as follows:

Administrative data

- Shapefiles Germany, www.govdata.de/dl-de/by-2-0 s, Year 2022, https://gdz.bkg.bund.de/index.php/default/digitale-geodaten/verwaltungsgebiete
- Municipality level data (2021): Gemeindeverzeichnis, Gebietsstand 2021, https://www.destatis.de/DE/Themen/Laender-Regionen/Regionales/Gemeindeverzeichnis

Hidden Champions data

- Prof. Dr. Bernd Venohr „Datenbank Deutscher Weltmarktführer“ 2016 & Weissmann-Gruppe für Familienunternehmen 2017, further research and supplements by Leibniz-Institute for Regional Geography/ SFB1199 2018, types of municipalities and spatial categories according to BBSR

Municipality level data for viticulture by state

- Baden-Wuerttemberg, Statistischer Bericht 3391-21001 https://www.statistik-bw.de/Service/Veroeff/Statistische_Berichte/339121001.pdf
- Bavaria, Bayerische Landesanstalt für Weinbau und Gartenbau (LWG) Veitshöchheim: Liste der Rebflächen der Weinorte, bestockte Rebflächen am Stichtag 31. Juli 2017.
- North Rhine-Westphalia, Statistisches Bundesamt (Destatis), Rebfläche 2022, Code: 41253-0010
- Hesse, Hessische Gemeindestatistik 2022, 2., korrigierte Auflage, https://statistik.hessen.de/publikationen/hessische-gemeindestatistik

- Saxony, Sachsen - Der Statistische Bericht Rebflächenerhebung C I 5 5-jährig zuletzt 2020
- Rhineland-Palatinate, Statistisches Landesamt Rheinland-Pfalz, 41252GJ010 Bestockte Rebfläche, www.statistik.rlp.de
- Saarland, https://www.saarland.de/mukmav/DE/portale/landwirtschaft/informationen/weinbau/weinbau_node.html
- Thuringia, Thüringen Landwirtschaftszählung 2020, https://statistik.thueringen.de
- Saxony-Anhalt, Landwirtschaftszählung Sachsen-Anhalt 2020, Statistisches Landesamt Sachsen-Anhalt

Other viticulture data

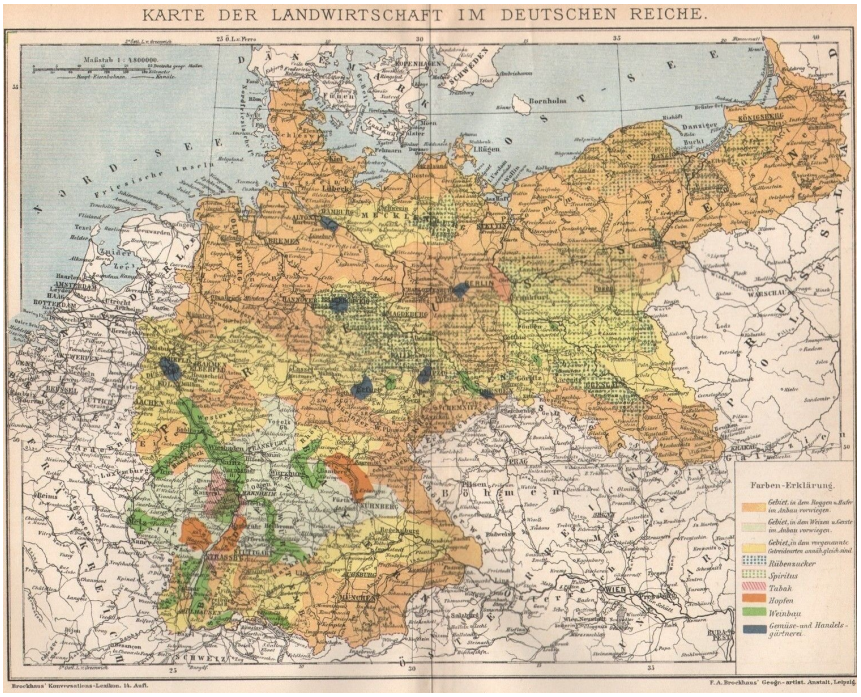
- Huglin Index maps: Potsdam Institute for Climate Impact Research, http://kfo.pik-potsdam.de
- Agriculture German Reich 1900: Statistisches Jahrbuch 1900, https://www.statistischebibliothek.de/mir/servlets/MCRFileNodeServlet/DEHeft_derivate_00070350/1900gesamt.pdf

Additional variables data

- Population density 1871, Roesel, Felix, The German Local Population Database (GPOP), 1871 to 2019 (2023)
- Soil quality index, Geoportal of the Federal Institute for Geosciences and Natural Resources, https://geoportal.bgr.de/mapapps/resources/apps/geoportal
- List of universities in Germany 1900, Walter Rüegg: Verzeichnis der wissenschaftlichen Hochschulen Europas 1800–1945, C. H. Beck, München 2004, S. 547–558.
- Distance to major rivers calculated on municipality level, taken from https://gdz.bkg.bund.de/index.php/default/digitale-geodaten
- Terrain Ruggedness, following Riley et al. (1999), calculated on the municipality level.
- Crop suitability index taken from Zabel et al. (2014) for the seven relevant crops.

II. Appendix Figures

Figure A1: Map of agricultural regions in Germany in 1900

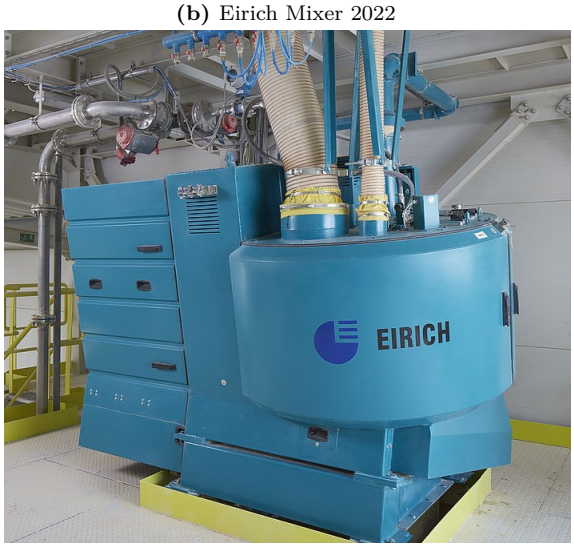


Note: Main agricultural crop by region, with viticulture highlighted in solid green, for the German Reich in 1900, taken from Statistisches Jahrbuch (1900).

Figure A2: Eirich products mechanical Mixer 1920 and 2022

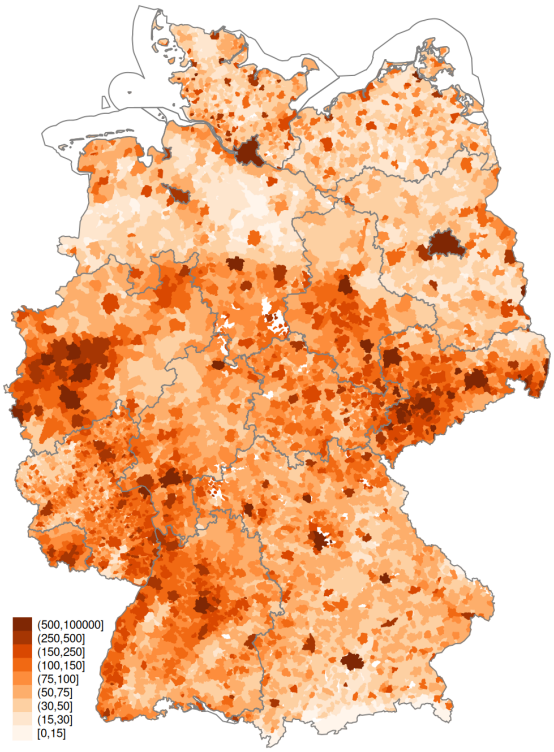
(a) Eirich Mixer 1920

(b) Eirich Mixer 2022



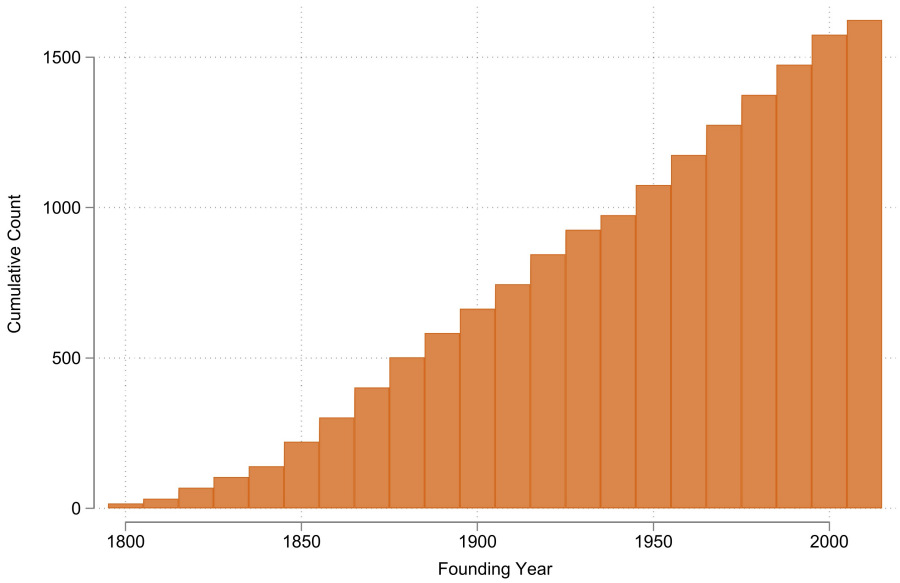
Note: Product line of Hidden Champion Eirich of a mechanical Mixer in 1920 and 2022. Source: www.eirich.com

Figure A3: Historical Population Germany in 1871 by Roesel (2023)



Note: Population on municipality level of Germany, taken from Roesel (2023).

Figure A4: Cumulative number of Hidden Champions by founding year



Note: The figure displays the cumulative number of Hidden Champions by founding year, binned every 10 years, N=1681, taken from Venohr (2016).

III. Appendix Robustness Results

This section collects the robustness analyses for the main results. Tables A1 through A7 probe the baseline specification of Table 2, the effect of viticulture on the number of Hidden Champions at the municipality level:

- Table A1 reports the first stage of the IV regressions, documenting the strength of the instrument across specifications.
- Table A2 displays the coefficients on the full set of control variables.
- Table A3 replaces state with district fixed effects and adjusts standard errors for spatial correlation following Conley (1999).
- Table A4 uses the employment and revenues of Hidden Champions as outcomes.
- Table A5 restricts the outcome to research-intensive and engineering-sector Hidden Champions.
- Table A6 provides a placebo test of the instrument in non-viticulture areas within a 50 km radius of four major cities.
- Table A7 accounts for the dominant inheritance tradition.

Table A8 complements the analysis of Table 4 on contemporary municipality outcomes by additionally controlling for the equal-partition inheritance tradition.

Table A1: First-Stage Regression for Table 2

	(1) OLS	(2) OLS	(3) OLS	(4) OLS
Dependent variable: Dummy Viticulture				
Huglin Index	0.000587***	0.000597***	0.000238**	0.000276**
	(1.86e-05)	(0.000190)	(9.46e-05)	(0.000103)
Pop density 1871		0.000596**	0.000391**	0.000370*
		(0.000244)	(0.000161)	(0.000201)
Soil quality		-0.000270	0.000353	0.000466
		(0.000467)	(0.000389)	(0.000425)
Land area		0.000400	0.000443*	0.000744
		(0.000240)	(0.000231)	(0.000413)
Observations	10,773	10,773	10,772	8,363
R-squared	0.124	0.165	0.258	0.305
F-statistic	992	885	56.12	63.62
State FE		Y	Y	Y
Add. Controls: Geography, Crop Suitability, Distance Factors			Y	Y
Only West GER				Y

Note: This table presents the results of the first-stage regression of Table 2 for the impact of viticulture on the number of Hidden Champions at the municipality level, with state fixed effects and only West Germany as indicated. Robust standard errors shown in parentheses. Significance levels indicated by: *** p<0.01, ** p<0.05, * p<0.1. Constant term not displayed.

Table A2: Viticulture effect on Log Number of Hidden Champions

	(1) OLS	(2) OLS	(3) OLS	(4) IV	(5) IV	(6) IV	(7) IV
Dependent variable: log(Number of Hidden Champions)							
Viticulture	-0.00194	-0.00532	-0.00881	0.3454***	0.2839***	0.3162***	0.3161***
	(0.0302)	(0.0310)	(0.0315)	(0.0880)	(0.1028)	(0.1212)	(0.1210)
Pop density 1871	0.00126***	0.00124***	0.00126***	0.0011***	0.0011***	0.0011***	0.0011***
	(0.000381)	(0.000381)	(0.000380)	(0.0001)	(0.0001)	(0.0001)	(0.0001)
Soil quality	5.17e-05	2.38e-05	0.000261	-0.0001	-0.0001	0.0001	0.0001
	(0.000148)	(0.000133)	(0.000193)	(0.0001)	(0.0001)	(0.0002)	(0.0002)
Land area	0.00183***	0.00183***	0.00180***	0.0017***	0.0017***	0.0017***	0.0017***
	(0.000574)	(0.000577)	(0.000582)	(0.0001)	(0.0001)	(0.0001)	(0.0001)
Geography							
Latitude	-0.0104	-0.00767	-0.00275	0.0241**	0.0191*	0.0303**	0.0303**
	(0.0119)	(0.0112)	(0.0111)	(0.0104)	(0.0110)	(0.0137)	(0.0138)
Longitude	1.07e-05	-0.00202	-0.00218	0.0025	0.0013	0.0008	0.0006
	(0.00619)	(0.00652)	(0.00706)	(0.0030)	(0.0031)	(0.0031)	(0.0030)
Elevation	1.65e-05	3.38e-05	4.47e-05	0.0004***	0.0003***	0.0004***	0.0004***
	(5.70e-05)	(4.96e-05)	(4.77e-05)	(0.0001)	(0.0001)	(0.0001)	(0.0001)
Ruggedness	-0.000407	-0.000406	-0.000386	-0.0022***	-0.0019***	-0.0019***	-0.0018***
	(0.000827)	(0.000771)	(0.000657)	(0.0006)	(0.0006)	(0.0006)	(0.0006)
Distance Factor							
Dist. nearest		-0.000283	-0.000290		-0.0001	-0.0001	-0.0001
		(0.000238)	(0.000233)		(0.0001)	(0.0001)	(0.0001)
Dist. Uni 1900		-1.80e-07	-2.18e-07		-0.0000**	-0.0000***	-0.0000***
		(1.09e-07)	(1.29e-07)		(0.0000)	(0.0000)	(0.0000)
Dist. major river		-1.24e-08	-4.62e-08		0.0000	0.0000	0.0000
		(3.00e-07)	(2.68e-07)		(0.0000)	(0.0000)	(0.0000)
Crop Suitability							
Summer Wheat			-0.000934			-0.0007	-0.0007
			(0.00264)			(0.0014)	(0.0014)
Winter Wheat			6.92e-05			0.0019	0.0019
			(0.00200)			(0.0015)	(0.0015)
Barley			0.000589			-0.0022*	-0.0022**
			(0.000709)			(0.0011)	(0.0011)
Rye			-0.000154			-0.0001	-0.0001
			(0.000772)			(0.0006)	(0.0006)
Potato			-0.000704			-0.0002	-0.0002
			(0.000660)			(0.0006)	(0.0006)
Maize			0.00128**			0.0008	0.0008
			(0.000581)			(0.0006)	(0.0006)
Millet			-0.000603			0.0010	0.0010
			(0.00106)			(0.0008)	(0.0008)
Inheritance Tradition							
Equal partition							-0.0019
							(0.0112)
Observations	10,785	10,784	10,784	10,773	10,772	10,772	10,772
R-squared	0.153	0.154	0.156	0.191	0.221	0.211	0.212

Note: This table presents the results of the impact of viticulture on the number of Hidden Champions at the municipality level, using both OLS and IV regression, with state fixed effects for every regression. Robust standard errors shown in parentheses. Significance levels indicated by: *** p<0.01, ** p<0.05, * p<0.1. Constant term not displayed.

Table A3: Robustness District Fixed Effects and Conley Standard Errors

	(1) OLS	(2) OLS	(3) OLS	(4) IV	(5) IV	(6) IV
Dependent variable: log(Number of Hidden Champions)						
Viticulture	0.0128	0.0897	0.0593	-0.00935	0.316*	0.315**
	(0.0142)	(0.123)	(0.120)	(0.0138)	(0.170)	(0.159)
Pop density 1871	0.000629***	0.000615***	0.000810***	0.00126***	0.00114***	0.00146***
	(0.000128)	(0.000111)	(0.000193)	(0.000163)	(0.000163)	(0.000241)
Soil quality	0.000353**	0.000331**	0.000276	0.000244	0.000114	-1.94e-05
	(0.000170)	(0.000154)	(0.000170)	(0.000174)	(0.000216)	(0.000248)
Land area	0.00133***	0.00131***	0.00245***	0.00180***	0.00167***	0.00272***
	(0.000164)	(0.000117)	(0.000204)	(0.000149)	(0.000163)	(0.000244)
Observations	10,784	10,772	8,363	10,772	10,772	8,363
R-squared	0.056	0.448	0.447	0.290	0.211	0.229
Kreis FE	Y	Y	Y			
State FE				Y	Y	Y
Only West GER			Y			Y

Note: This table presents the results of the impact of viticulture on the number of Hidden Champions at the municipality level, using both OLS and IV regression, with kreis and state fixed effects, only West Germany as indicated. Robustness check of the results regarding spurious autocorrelation patterns following Conley (1999) with a Bartlett kernel and a cutoff of 25 km. Controls for geography, crop suitability, and distance factors are included in each regression. Robust standard errors shown in parentheses. Significance levels indicated by: *** p<0.01, ** p<0.05, * p<0.1. Constant term not displayed.

Table A4: Viticulture effect on Employment and Revenues of Hidden Champions

	(1)	(2)	(3)	(4)	(5)	(6)
Dependent variable:	log(Employment Hidden Champion)			log(Revenue Hidden Champion)		
Viticulture	0.341***	1.43e-05	1.403*	0.263***	-0.00366	0.999*
	(0.0678)	(0.161)	(0.761)	(0.0526)	(0.130)	(0.574)
Pop density 1871		0.00604***	0.00554***		0.00486***	0.00450***
		(0.00148)	(0.000691)		(0.00128)	(0.000557)
Soil quality		0.000971	0.000307		0.000698	0.000217
		(0.000962)	(0.00106)		(0.000637)	(0.000802)
Land area		0.00961***	0.00901***		0.00726***	0.00683***
		(0.00295)	(0.000737)		(0.00228)	(0.000581)
Observations	10,785	10,784	10,772	10,785	10,784	10,772
R-squared	0.004	0.105	0.184	0.004	0.108	0.191
Instr. Huglin Index			Y			Y
State FE		Y	Y		Y	Y
Add. Controls: Geography, Crop Suitability, Distance Factors		Y	Y		Y	Y

Note: This table presents the results of the impact of viticulture on the revenue and employment of Hidden Champions at the municipality level, using both OLS and IV regression, with state fixed effects and only West Germany as indicated. Robust standard errors shown in parentheses. Significance levels indicated by: *** p<0.01, ** p<0.05, * p<0.1. Constant term not displayed.

Table A5: Viticulture Effect by Hidden Champion Type

	(1)	(2)	(3)	(4)	(5)	(6)
Dependent variable:	log(Research Int. Hidden Champion)			log(Engineering Hidden Champion)		
Viticulture	0.0341***	-0.00645	0.254***	0.0312***	-0.000441	0.186**
	(0.00820)	(0.0207)	(0.0923)	(0.00733)	(0.0192)	(0.0827)
Pop density 1871		0.000758***	0.000661***		0.000618**	0.000550***
		(0.000256)	(0.000102)		(0.000222)	(8.93e-05)
Soil quality		0.000208	9.31e-05		0.000203*	0.000121
		(0.000158)	(0.000128)		(0.000111)	(0.000111)
Land area		0.00110**	0.000988***		0.000902**	0.000824***
		(0.000406)	(0.000114)		(0.000345)	(0.000101)
Observations	10,785	10,784	10,772	10,785	10,784	10,772
R-squared	0.003	0.104	0.120	0.003	0.085	0.127
Instr. Huglin Index			Y			Y
State FE		Y	Y		Y	Y
Add. Controls: Geography, Crop Suitability, Distance Factors		Y	Y		Y	Y

Note: This table presents the results of the impact of viticulture on the number of research intensive firms and the number of engineering focused Hidden Champions (mechanical, chemical and electrical engineering) at the municipality level, using both OLS and IV regression, with state fixed effects and only West Germany as indicated. Robust standard errors shown in parentheses. Significance levels indicated by: *** p<0.01, ** p<0.05, * p<0.1. Constant term not displayed.

Table A6: Placebo Test: Huglin Index for Cities Within a 50 km Vicinity

	(1)	(2)	(3)	(4)
	OLS	OLS	OLS	OLS
Dependent variable: log(Number of Hidden Champions)				
Huglin Index	-0.00082	0.00019	0.00027	0.00044
	(0.00078)	(0.00015)	(0.00058)	(0.00041)
Pop density 1871	-0.00014	0.00129**	0.00277*	0.00323***
	(0.00037)	(0.00052)	(0.00154)	(0.00075)
Soil quality	-0.00012	0.00081	-0.00447	0.00138
	(0.00065)	(0.00058)	(0.00353)	(0.00085)
Land area	0.00067*	0.00387***	0.00001	0.00056
	(0.00039)	(0.00145)	(0.00046)	(0.00104)
Observations	101	428	131	254
R-squared	0.132	0.236	0.266	0.263
State FE	Y	Y	Y	Y
City +50km Radius	Berlin	Hamburg	Bremen	Munich

Note: This table presents the results of a placebo test regression of the number of Hidden Champions on the Huglin Index at selected cities and neighboring municipalities within a 50km radius. State fixed effects and controls for geography, crop suitability, and distance factors are included in each regression. Robust standard errors shown in parentheses. Significance levels indicated by: *** p<0.01, ** p<0.05, * p<0.1. Constant term not displayed.

Table A7: Viticulture effect on Log Number of Hidden Champions

	(1) OLS	(2) OLS	(3) OLS	(4) IV	(5) IV	(6) IV
Dependent variable: log(Number of Hidden Champions)						
Viticulture		-0.0056	-0.00927	0.0534*	0.3161***	0.3146***
		(0.0322)	(0.0310)	(0.0303)	(0.1210)	(0.1151)
Equal partition	0.0199***	0.0072	0.00934	0.0007	-0.0019	0.0056
	(0.0058)	(0.0173)	(0.0140)	(0.0095)	(0.0112)	(0.0125)
Pop density 1871		0.0013***	0.00125***	0.0012***	0.0011***	0.0015***
		(0.0004)	(0.000380)	(0.0001)	(0.0001)	(0.0002)
Soil quality		0.0001	0.000255	-0.0000	0.0001	-0.0000
		(0.0003)	(0.000201)	(0.0001)	(0.0002)	(0.0002)
Land area		0.0018***	0.00181***	0.0018***	0.0017***	0.0027***
		(0.0006)	(0.000586)	(0.0001)	(0.0001)	(0.0002)
Observations	10,785	10,785	10,784	10,773	10,772	8,363
R-squared	0.001	0.152	0.156	0.283	0.212	0.229
State FE			Y	Y	Y	Y
Add. Controls: Geography, Crop Suitability, Distance Factors				Y	Y	Y
Only West GER						Y

Note: This table presents the results of the impact of viticulture on the number of Hidden Champions at the municipality level, using both OLS and IV regression, with state fixed effects and only West Germany as indicated, including the inheritance tradition (Equal partition Dummy). Robust standard errors shown in parentheses. Significance levels indicated by: *** p<0.01, ** p<0.05, * p<0.1. Constant term not displayed.

Table A8: Viticulture effect on Population Density and Employment

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Dependent Variable	log(Population Density 2019)			log(Num Employees 2019)		log(Unempl Rate 2019)	
Viticulture	-0.0349	0.5886*	1.1458***	-0.0339	0.6782**	-0.0353**	-0.9110***
	(0.0673)	(0.3443)	(0.3401)	(0.0672)	(0.3413)	(0.0163)	(0.1739)
Equal partition	0.1700**	0.1477***	0.1020***	0.1596**	0.1351***	0.0985***	0.1296***
	(0.0693)	(0.0261)	(0.0301)	(0.0631)	(0.0261)	(0.0156)	(0.0141)
Pop density 1871	0.0073***	0.0071***	0.0070***	0.0071***	0.0068***	0.0013***	0.0016***
	(0.0008)	(0.0006)	(0.0008)	(0.0008)	(0.0006)	(0.0001)	(0.0002)
Soil quality	-0.0013	-0.0017***	-0.0020***	-0.0016	-0.0019***	0.0004	0.0008***
	(0.0010)	(0.0005)	(0.0006)	(0.0010)	(0.0005)	(0.0003)	(0.0002)
Land area	-0.0008	-0.0010***	-0.0019***	-0.0009	-0.0012***	0.0017***	0.0021***
	(0.0008)	(0.0003)	(0.0004)	(0.0008)	(0.0003)	(0.0003)	(0.0001)
Observations	10,784	10,772	8,363	10,779	10,768	10,784	10,772
R-squared	0.426	0.551	0.441	0.430	0.549	0.156	0.159
IV Instrument: Huglin Index		Y	Y		Y		Y
Only West GER			Y				

Note: This table presents the results of the impact of viticulture on current outcomes for the population density, the number of employed and the unemployment rate in 2019 at the municipality level, using both OLS and IV regression. State fixed effects and controls for geography, crop suitability, and distance factors are included in each regression. Robust standard errors shown in parentheses. Significance levels indicated by: *** p<0.01, ** p<0.05, * p<0.1. Constant term not displayed.