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The Influence of Climate on Varietal Similarities Across Countries

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The influence of climate on varietal similarities across countries

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CORE IDEAS

- Wine-producing countries have become more similar and concentrated in their mix of winegrape varieties.
- This similarity extends particularly among countries sharing similar climatic conditions.
- In recent years, countries with similar climates have continued to converge in their winegrape varietal mixes.
- Nevertheless, vignerons have not necessarily been planting varieties that are better suited to their climates.

ABSTRACT

In recent decades, vignerons have focused more on the world's mainstream varieties than on differentiating their varietal mix. This has led countries to become more similar to each other in their mix of winegrape varieties, and more varietally concentrated. What are the drivers of those changes? In this study we focus on one

of those drivers, that is, climate similarities. We estimate statistical models to quantify the potential influence of sixteen climate variables on varietal similarities across countries, as well as on how their varietal mixes have become more or less similar since 2000. The results indicate not only that countries with more similar climates have more similar varietal mixes but also that in recent years countries with more similar climates have become even more similar in their mixes. This, however, does not necessarily mean that vignerons have been planting the varieties that are better adapted to their climates.

1 INTRODUCTION

Which winegrape varieties are grown where depends on multiple simultaneous forces. These include traditions, the demand of both domestic and export markets, the terroir of different regions, and sometimes government regulations. Anderson and Nelgen (2021a,b) argue that vignerons have focused more on well-known mainstream varieties than on differentiating their offer with lesser-known ones. This has led countries to become more similar and more concentrated in their varietal mix (Puga and Anderson, 2023).

Meanwhile, the relative importance of the drivers of these changes are less known. Figure 1 is a dendrogram in which the countries are grouped by similarities in their varietal mixes. This figure suggest some reasons why countries have more similar varietal mixes, such as geographical closeness, colonial ties (e.g., France and Algeria), and similar climates.

The present study focuses on the potential role of climate similarities and goes beyond this more basic graphical analysis. Its aim is to analyse the influence of these climate similarities across countries on the similarities in their mixes of winegrape varieties, and on how these mixes have become more or less similar.

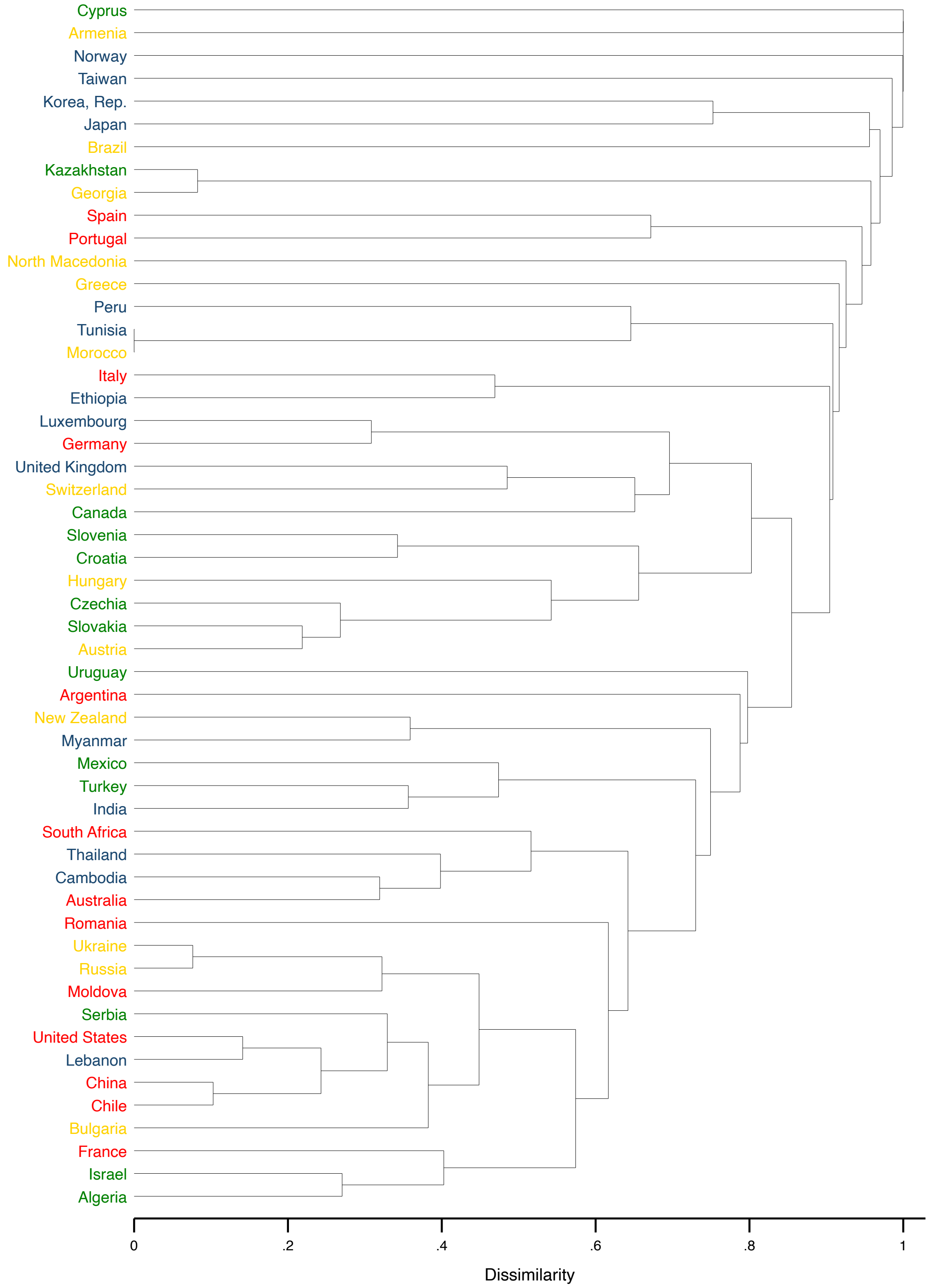

Figure 1. Dendrogram based on varietal similarities across countries.

Notes: Longer horizontal lines indicate higher levels of dissimilarity in the mix of winegrape varieties between countries or groups of countries. The countries are grouped together by the vertical lines based on the similarities in their mix of winegrape varieties. This is done using the varietal similarity index from Anderson (2010) as an input for an average linkage clustering method introduced by Puga and Anderson (2023). The top 13 countries by winegrape area (as for 2016) are shown in red, followed by the next 13 countries by winegrape area in yellow, the subsequent 13 countries in green, and then the 14 countries with the lowest vineyard area in this study in blue.

2 DATA

We use a database on bearing area by country and variety that covers 99% of the world's winegrape area (i.e., Anderson and Nelgen (2020a)). This database contains information for 53 countries in 2016, and for 38 of those 53 countries in 2000, including all major wine-producing countries. There is a total of 1,733 DNA-distinct varieties in this database, based on their prime names according to their perceived country of origin as provided in Robinson et al. (2012) or otherwise JKI (2019).

We also use climate data from Puga et al. (2022) for 813 wine regions, based on one representative location within or nearby each regions, using TerraClimate data for the 1989-2018 period. These data are available for 16 climate variables shown in the first two columns of Table 1. Those wine regions are included in Anderson and Nelgen (2020a). As such, we can estimate an area-weighted average across regions for each climate variable in each country.

3 METHODS

We use the varietal similarity index (VSI) for analysing similarities in the mix of winegrape varieties between two countries. This index was first introduced by Anderson (2010). For countries i and j, it takes the form:

$$VSI_{ij} = \frac{\sum_{v=1}^{V} f_{i,v} f_{j,v}}{\left(\sum_{v=1}^{V} f_{i,v}^2\right)^{1/2} \left(\sum_{v=1}^{V} f_{j,v}^2\right)^{1/2}}. \qquad \text{Eq. 1}$$

Here, $f_{i,v}$ ($f_{j,v}$) is the area of variety v in country i (j) as a proportion of the total winegrape bearing area in that country.

The VSI ranges between 0 and 1. The closer the index is to 1, the more similar is the mix of varieties between two countries. An index of 0 indicates a completely different mix of winegrape varieties, while an index of 1 means that both countries have the same varieties and the same proportional area for each of those varieties.

We use the VSI_{ij} as the dependent variable for estimating a set of models given by:

$$VSI_{ij} = \alpha + \beta ClimateVariableDifference_{ij} + \epsilon. \qquad \text{Eq. 2}$$

The independent variable is the absolute value of the difference in the value for a climate variable between two countries and β is the coefficient of interest. The intercept is denoted by α and ϵ is an error term. We estimate this model separately for the 16 climate variables in Table 1 using ordinary least squares (OLS). For calculating the average value for the climate of each country, we use the region-specific climate data of each country and use the winegrape bearing areas of the regions as the weights in our computation.

We also estimate VSIs using a modified version of Eq. 1 in which rather than using areas, we use area differences. For countries i and j, it takes the form:

$$VSI_{ij} = \frac{\sum_{v=1}^{V} \delta_{i,v}\delta_{j,v}}{\left(\sum_{v=1}^{V} \delta_{i,v}^2\right)^{1/2} \left(\sum_{v=1}^{V} \delta_{j,v}^2\right)^{1/2}}. \qquad \text{Eq. 3}$$

Here, $f_{i,v}$ ($f_{j,v}$) is the area difference of variety v in country i (j) as a proportion of the total winegrape bearing area difference in that country. The area difference is the winegrape bearing area planted to a variety in 2000 subtracted to the area planted to that variety in 2016.

Therefore, this modified index takes values between -1 and 1. An index of 1 means that the area of each variety has changed in exactly the same proportional direction, while an index of -1 means that the area of each variety has changed in exactly the same proportional but opposite direction. With this other dependent variable, we estimate the model given by Eq. 2, also separately using the 16 climate variable described in Table 1.

4 RESULTS

The third column of Table 1 show the estimation results of the models given by Eq. 2 when using the VSI as described in Eq. 1 as the dependent variable. Each of these models rely on 1,378 observations. The (not reported) coefficients of determination (R^2) are small, never higher than 0.08. The coefficients for all the climate variables are negative, and only the temperature range variables (GSDTR and RPDTR) are statistically insignificant. These negative coefficients are in line with what can be expected from a correlation analysis (results omitted) and indicate that the varietal mixes of a pair of countries is more similar, the more similar are their climates.

The last column of Table 1 report the estimation results for the model given by Eq. 2 but with the modified version of the VSI as the dependent variable, that is, with the VSIs calculated using area differences between 2016 and 2000 rather than the 2016 areas. Each of these models rely on 666 observations, which is less than for the models using 2016 data because only 38 countries have area data for both 2016 and 2000. The (not reported) coefficients of determination are again small, never higher than 0.05. The coefficients for all the variables are negative, and only the temperature range variables are statistically insignificant, same as when using 2016 areas as opposed to area differences between 2016 and 2000. However, the interpretation is different: countries with more similar climates have become more similar in their mixes of winegrape varieties.

Table 1. Variables description and estimation results.

Variable	Description	2016 areas	Area differences
GST (°C)	Growing season average temperature[a]	-0.0094 ***	-0.0096 ***
		(0.0013)	(0.0024)
GDD (°C units)	Growing degree days[a]	-0.0000 ***	-0.0000 ***
		(0.0000)	(0.0000)
AnnT (°C)	Annual average temperature	-0.0064 ***	-0.0091 ***
		(0.0000)	(0.0000)
RPT (°C)	Ripening period average temperature[b]	-0.0154 ***	-0.0093 ***
		(0.0001)	(0.0001)
GSDTR (°C)	Growing season diurnal temperature	-0.0001	-0.0029
	range[a]	(0.0000)	(0.0000)
RPDTR (°C)	Ripening period diurnal temperature	-0.0011	-0.0016
	range[b]	(0.0010)	(0.0020)
MJT (°C)	Mean January/July temperature	-0.0192 ***	-0.0083 ***
		(0.0016)	(0.0023)
CNI (°C)	Mean minimum March/September	-0.0088 ***	-0.0082 ***
	temperature	(0.0025)	(0.0029)
HI (°C units)	Huglin Index[c]	-0.0001 ***	-0.0000 ***
		(0.0022)	(0.0028)
AnnP (mm)	Annual precipitation	-0.0001 ***	-0.0000 ***
		(0.0018)	(0.0025)
GSP (mm)	Growing season precipitation[a]	-0.0001 ***	-0.0001 ***
		(0.0012)	(0.0019)
RIPEP (mm)	Ripening period precipitation[b]	-0.0004 ***	-0.0003 ***
		(0.0000)	(0.0000)
VPD_GS (kPa)	Growing season vapour pressure deficit[a]	-0.0101 ***	-0.0098 ***
		(0.0025)	(0.0031)
VPD_SU (kPa)	Summer vapour pressure deficit[d]	-0.0284 ***	-0.0208 ***
		(0.0046)	(0.0060)
SRAD_GS (W/m^2)	Growing season average day/night	-0.0002 ***	-0.0001 ***
	downward surface shortwave radiation[a]	(0.0000)	(0.0000)
SRAD_SU (W/m^2)	Summer average day/night downward	-0.0003 ***	-0.0003 ***
	surface shortwave radiation[d]	(0.0001)	(0.0001)

Notes: The area differences are between 2016 and 2000. *** denotes statistical significance at the 1% level. Standard errors are in brackets. [a] April to October in the Northern Hemisphere (NH) or October to April in the Southern Hemisphere (SH). [b] August to September in the NH or February to March in the SH. [c] April to September in the NH or October to March in the SH. [d] June to August in the NH or December to February in the SH. The base temperature for the GDD and HI calculations is 10 °C, with no upper cut-off value.

5 DISCUSSION

By comparing the coefficients for the different climate variables with the average VSIs values, which are shown in Table 2 along other summary statistics, one can get a rough idea of the size of the potential effects. For example, the first coefficient from the first row of Table 1 indicates that a GST difference of 1°C between two countries relates to a 0.009 lower VSI between those countries. Comparing that number with the VSI summary statistics for 2016 suggest that coefficient is of practical significance even though that variable does not explain much of the variation in VSI across countries. Similar conclusions can be reached when looking at many of the coefficients for the other variables, both for the results using 2016 areas and area differences between 2016 and 2000.

Table 2. Summary statistics for the VSI variables.

Variable	Mean	SD	Min.	Q1	Median	Q3	Max
VSI based on 2016 areas	0.14	0.18	0.00	0.00	0.07	0.21	1.00
VSI based on area differences	0.05	0.14	-0.56	0.00	0.00	0.05	0.89

Notes: The area differences are between 2016 and 2000. SD stands for standard deviation.

The fact that countries with more similar climates seem to be converging towards a more similar varietal mix raises a question: are these countries converging towards varieties that are appropriate for their climates? Figure 2 shows the 'optimal' GST ranges (according to Jones et al., (2012)) for producing high-quality wine for 21 varieties that accounted for 45% of the world's winegrape area in 2016. This figure also shows the shares of winegrape area planted under those ranges in 2000 and 2016. The area within these 'optimal' GST ranges has decreased between 2000 and 2016 for the majority of these varieties. That is the case for many of the most planted varieties such as Cabernet Sauvignon, Merlot, Tempranillo, and Chardonnay. This suggests that even though countries with more similar climates are becoming more similar in their mix of winegrape varieties, much of the new plantings may not necessarily be taking place in regions with ideal temperature ranges for producing premium wine of those varieties. This issue may become more concerning with climate change and with the global demand for wine shifting towards more premium products.

The main limitation of our statistical analysis is that our regressions do not allow us to uncover causal relationships. While we do not expect certain common statistical issues such as reverse causality, the simplicity of our models makes them very susceptible to other problems such as omitted variable bias. Since many climate variables are correlated, multiple regression models aiming at reducing the potential for omitted variable bias can end up with issues of multicollinearity. Even leaving the problem of omitted climate variables aside, there might be other non-climate variables that should be included in the models.

Despite this limitation, the results reveal an important insight: climate similarities positively influence both similarities in the varietal mixes and the way those mixes have converged in recent years. Unfortunately, the size of that potential effect is difficult to interpret from the results as the VSI takes values from 0 to 1, or from -1 to 1 when using area differences between 2016 and 2000. If the dependent variable was the natural logarithm of the VSI, then the interpretation would be more straightforward. However, that specification is not able to be used here because the VSI can take values of 0, and even negative values when calculated with area differences.

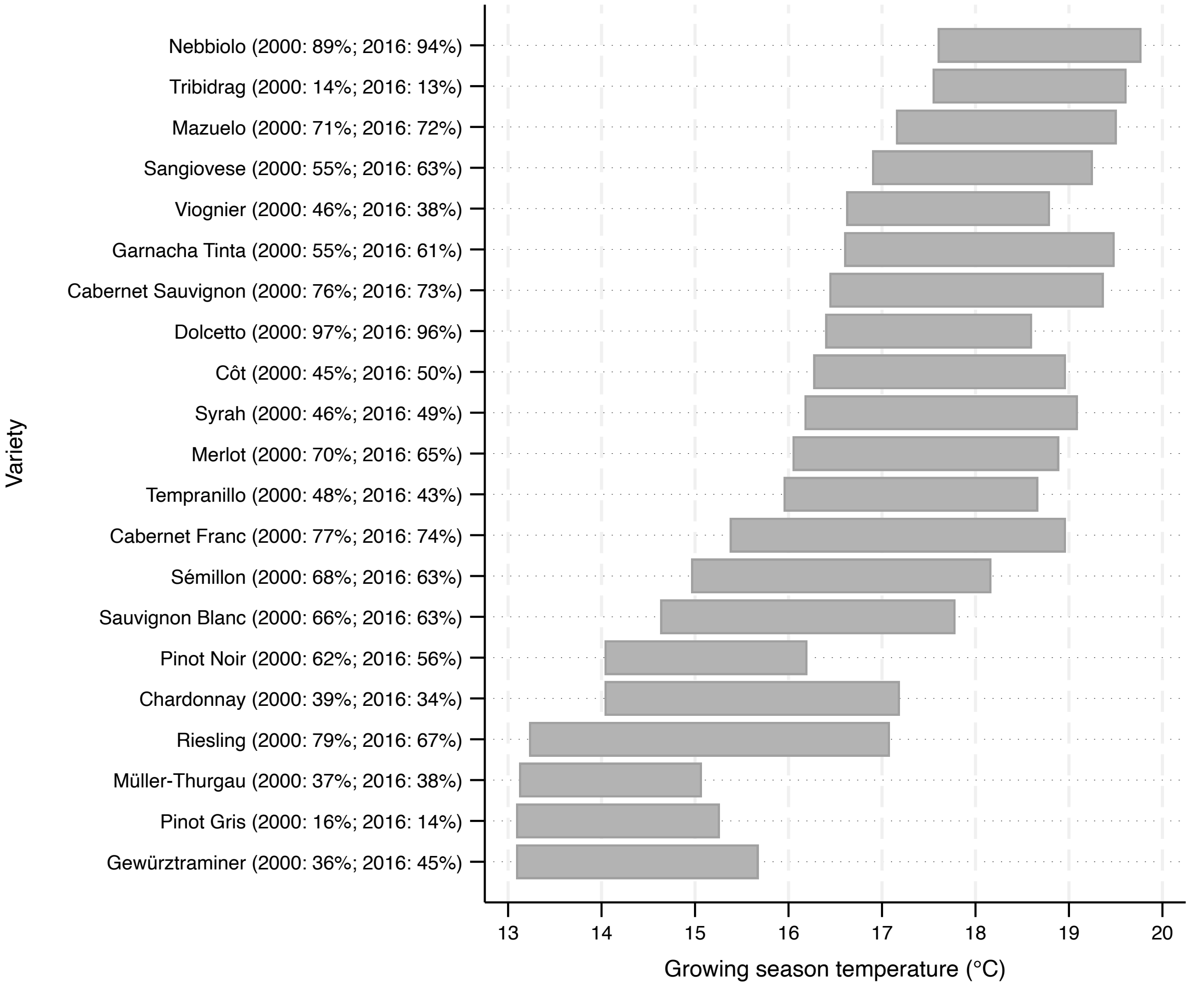

Figure 2. 'Optimal' growing season temperature (GST) ranges for high-quality winegrape production, with the shares of world winegrape area under these 'optimal' GST ranges shown in parentheses for the years 2000 and 2016.

Notes: The shares of world winegrape area under these 'optimal' GST ranges are based on data from Anderson and Nelgen (2020b). The 'optimal' GST ranges are defined by Jones et al. (2012). van Leeuwen et al. (2013) argue that the upper limits of many of these ideal temperature ranges may be higher.

6 CONCLUSION

We have analysed the influence of climate similarities on the mix of winegrape varieties by regressing the absolute value of differences in climate variables between countries on an index of similarity in their varietal mixes, as well as on an index summarising the extent to which those mixes have become more or less similar. The results suggest that countries with more similar climates have more similar mixes of winegrape varieties. As well, between 2000 and 2016, countries with more similar climates have become even more similar in their varietal mixes. The potential influence that climate similarities may have on varietal similarities and increases in varietal similarities seems substantial. That said, the fact that countries with more similar climates have become more similar in their varietal mixes does not necessarily imply that vignerons in these countries are planting more of varieties that do well in their climates. Further research should analyse this pressing issue in more detail.

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

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