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Trade Uncorked: Genetic Resistance and Quality Heterogeneity in Wine Exports

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Abstract

A nascent literature explores the impact of taste differences on trade. In gravity model estimations, the coefficient on geographical distance is large because it tends to capture such (usually unobservable) preference-related frictions. A related stream of research also shows that the effect of distance decreases with quality. We bring both aspects together by asking how heterogeneity in tastes affect exports and how this effect may depend on good quality. We examine these questions in the context of French wine, i.e. a cultural good characterized by a great variety of types (accommodating a large heterogeneity in wine tastes) and of quality levels (from cheap table wine to the finest grands crus). A series of gravity models are estimated using very complete data on French wine exports by detailed appellation between 1998 and 2015. We use genetic distance as a proxy for taste differences explained mainly by biology and culture, while controlling for the other pathways through which culture affects trade (for instance the role of trust) and for other factors associated with genetic distance (e.g. micro-geography). We show that the 'taste' component of genetic distance has an independent effect on trade, explaining between 20% and 40% of the coefficient of physical distance. Heterogeneous effects of physical and genetic distances are estimated using alternative proxies of quality (namely the reputation of wine regions and experts' scores). We confirm that high-end wines tend to escape gravity but also the home bias due to tastes – possibly illustrating the fact that luxury goods have become global iconic products, less associated to national original preferences but rather to status and investment motives.

Keywords: wine trade, cultural/genetic distance, geographical distance, gravity model, PPML

JEL: F10, F14, L66, Q17

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1. Introduction

While freight costs have declined over time thanks to innovation, trade costs can remain high and persist if hidden frictions – related to cultural differences and the diversity of local tastes inherited from the past – are large and subject to slow changes (Disdier and Head, 2008).[4] These sources of resistance to trade, belonging to "dark trade costs" (Head and Mayer, 2013), have been detected in the estimation of standard gravity models and tend to explain a large share of the coefficients on borders and distance effects. Such hidden costs are implicitly or explicitly at the center of the discussion on the relationship between trade intensity and cultural diversity (Disdier et al., 2010, Felbermayr and Toubal, 2010). Another aspect of the role of distance is that quality sorting makes high-end products more geographically diversified and more able to meet their demand in distant markets (see Crozet et al., 2012, in the case of Champagne producers and Fontagné and Hatte, 2013, and Martin and Mayneris, 2015, for French luxury brands). If we bring both aspects together, the question then becomes whether hidden trade barriers, those pertaining to heterogeneity in tastes and culture, matter differently for products of different quality.

We examine these different questions in the context of a good that is consumed worldwide: French wine. This good presents several advantages for our investigation. First, while wine drinking has become particularly common in Western countries, Russia, Asia and many South American countries, it is now widely available in most countries. Second, as an experience good, wine is an interesting candidate for the exploration of 'dark trade' costs related to taste heterogeneity. Its consumption is intimately linked to local preferences shaped by cultural and biological diversity. The biological aspect is rarely explored in such a context but potentially matters a lot for the trade of food and beverage goods (e.g. Jäkel, 2019). Wine is also a cultural good whose quality is a priori unknown but often proxied by its reputation, a factor that may alter quality sorting based on taste heterogeneity only (Ali and Nauges, 2007). Third, focusing on French wines is useful for this investigation because these wines are exported in most parts of the world;[5] they also exhibit a great variety that can accommodate different types of tastes (through a large diversity of grapes, *terroir*, etc.) as well as a broad variation in terms of quality and reputation (from cheap table wine to the finest *grands crus*). Finally, wine is a good with a strong vertical differentiation and for which external measures of quality are available. We will rely on the reputation differences across French wine regions (which are correlated with prices) and in expert ratings (as in Crozet et al., 2012).[6]

Our empirical investigation relies on a dataset recently assembled by the French federation of exporters of wine and spirit. It contains wine shipments between 1998 and 2015 for 158 French wine 'appellations' (e.g. Chateauneuf-du-Pape, etc.) from the main wine regions (e.g. Bordeaux, Burgundy, Rhone Valley, etc.) to the main export destinations (51 countries). This represents around 95% of total French exports over the period and amounts to around 145,000 observations. We combine this dataset

[4] Distance matters also for digital goods consumed over the Internet that have no trading costs, as it appears to capture taste similarities between countries located closer to each other (Blum and Goldfarb, 2006). Two-third of the distance effect disappears with eBay trade, as information frictions are reduced by online technologies while taste differences may explain the rest (Lendle et al., 2015).

[5] France, Italy and Spain account for about 50% of world wine production. France is world leader in terms of export value and just behind the two other countries in terms of exported volumes.

[6] Reputational effects in the wine sector are analyzed by Costanigro et al. (2010), Castriota et al. (2015) or Oczkowski and Doucouliagos (2015) among others. The latter authors justify the use of reputation and rating rather than unit values, which are weakly correlated with quality (correlation of 30%).

with information on standard trade determinants that vary over time (annual GDP, real exchange rates, theoretically-funded measures of multilateral resistance, importing countries' own wine production) as well as geographic distance (representing transportation costs) and genetic distance (representing taste heterogeneity) following Spolaore and Wacziarg (2016). We estimate a one-exporter gravity model to disentangle the determinants of French wine exports (Anderson and Van Wincoop, 2003, 2004), using standard techniques to account for heteroskedasticity and the presence of zero trade flows (Santos Silva and Tenreyro, 2006). Quality is proxied by alternative measures including regional reputation and the scores given by the wine expert Robert Parker to sub-regions of France for most of the studied years.

Results are as follows. After verifying the role of standard correlates of trade (GDP, exchange rates, geographical distance), we show that genetic distance diminishes the effect of geographical distance by 20% to 40% (depending on the specification). It has an independent effect on trade, interpreted as differences in tastes due to cultural/biological diversity, once purged from alternative explanations such as the other cultural dimensions explaining trade intensity (for instance trust) or trade frictions associated with genetic distance (such as the micro-geography). Then, we confirm that high-end wine products defy gravity, using alternative proxies for wine quality. The coefficient of physical distance is markedly smaller for regions with the highest reputation (Bordeaux and especially Bourgogne), which also have the most expensive wines on average. It becomes even smaller in the case of wines that are both from reputed regions and scoring high on Parker's scale, becoming insignificant for the top red Burgundy wines (which include some of the most expensive wines in the world). Finally, in contrast with standard wines, high-end varieties also tend to escape the home bias due to cultural divergences (Trefler, 1995).[7] A likely interpretation of this result pertains to the fact that some luxury goods have become global iconic products, less associated to local original preferences but rather to conspicuous consumption or to investment motives.

2. Literature

2.1 Cultural and Biological Factors shaping Demand and Trade

The international trade literature usually highlights foreign demand (determined by country income and tastes) and price-competitiveness (determined by relative prices and nominal exchange rates) as key determinants of exports (e.g. Armington, 1969, Warner and Kreinin, 1983). The more recent literature adds other factors: non-price competitiveness, and particularly the quality of goods (Melitz, 2003, Hallak, 2006), as well as trade costs and frictions, which include transportation costs, tariffs and non-tariffs barriers. In standard gravity models of trade, the coefficients on borders and distance are usually too large to be explained by traditional tariffs or transportation costs related to freight costs or the geography (Grossman, 1998). Head and Mayer (2013) argue that behind the estimated coefficient associated with distance, hidden sources of resistance are of greater importance. These 'dark trade' costs (for the analogy to astrophysics) would account for 50%–85% of the effect of geographical distance on trade flows, according to their estimation based on the data of Feyrer (2009). These "new" sources of frictions could be linked to spatial decay of information, localized tastes, colonial legacies,

[7] There is increasing evidence of a home bias in consumption, for instance regarding the choice between oil and butter (Head and Mayer, 2013), cereals (Bronnenberg et al., 2012) or, closer to us, beer (Lopez and Matschke, 2012).

and long-run impacts of conflicts. They may especially relate to differences in tastes and preferences across nations, as explained by historical paths of cultural and biological evolutions.

The impact of bilateral cultural 'affinity' on trade patterns has been examined in three streams of the trade literature. The first one corresponds to the exploration of traditional gravity variables that pertain to cultural dimensions, such as sharing a common language (e.g. Boisso and Ferrantino 1997, or Melitz and Toubal, 2014), colonial ties (e.g. Rose, 2000, or Head et al., 2010), religion or the legal system (Glaeser and Shleifer, 2002, Mayer and Zignago, 2011). More recently, another branch of the literature has focused on variables that further explain affinity, notably the role of bilateral trust (Guiso et al., 2009, Yu et al. 2015, Spring and Grossman, 2016), homophily (Melitz and Toubal, 2019), bilateral opinions (Disdier and Mayer, 2007) or bilateral values (Ahern et al. 2015, Maystre et al. 2014). Finally, original indicators of taste proximity have also been suggested. Felbermayr and Toubal (2010) construct affinity measures based on an international song contest. Disdier et al. (2009) use trade in cultural goods as a proxy for countries' cultural proximity. Jäkel (2019) examines export performance of Danish chocolate producers depending on taste proximity based on information on the average ingredients of chocolate and confectionery sold in different countries.[8]

The present paper adds to this literature by extracting from genetic distance a measure of *biological and cultural diversity in taste*. Genetic variation has been investigated in a few studies on trade. In Giuliano et al. (2014), it essentially captures trade barriers due to the geography. In Guiso et al. (2009), it relates to frictions due to trust and values. We will check for the role of these other pathways in our empirical analysis. Note that genetic distance has rarely been used as a direct determinant of trade. Guiso et al. (2009) use it only as an instrument for trust. Quite inversely, we want to extract from genetic distance what is unrelated to either physical distance or common values and trust – rather what purely pertains to preference heterogeneity due to culture and biology. Closer to us, Melitz and Toubal (2019) test the direct role of somatic distance and co-ancestry, two different aspects of genetic distance, on trade. Focusing on a cultural interpretation, they find that both of them impact trade flows whether trust measures are controlled for or not. Bove and Gokmen (2017) also use gravity models and genetics to revisit Spolaore and Wacziarg (2009), suggesting trade as one of the possible channels through which cultural differences retard the diffusion of development. Gokmen (2017) also demonstrate the deterring effect of cultural gaps on trade, and how they have progressively replaced other barriers such as geopolitical divides.

In the present case, genetic proximity is not only interpreted as a proxy for cultural affinity in tastes. It may also directly relate to *biological explanations* for this proximity in tastes. For most food and beverage goods, the role of genetics in explaining tastes has been highlighted for years. In a review of the biological literature, Reed et al. (2006) describe the genes and molecular receptors responsible for taste preferences. Birch (1999) reveals how the interaction between environmental factors (culture) and the genetic predispositions produces food preferences. These genetics-based preferences have been analyzed in the context of different ethnic groups and nationalities, showing significant differences in food tastes in general (Bertino and Chan, 1986; Pirastu et al., 2012) and in tastes for

[8] Some of these factors are slow-moving and strongly associated with conventional transaction costs (Guiso et al., 2006). Yet, cultural ties may also allow resilience in trade during crises (Carrère and Masood, 2018) or benefit from a certain degree of convergence due to bilateral trade itself (Maystre et al., 2014) or more generally during the globalization process (Aizenman and Brooks, 2008).

alcoholic beverages in particular (Duffy et al., 2004). More specifically in the context of wine preferences, the current biological research is trying to understand the mechanisms that relate genetics and our taste/olfactory perceptions. In particular, Lanier et al. (2005) show that genes changing our perception of bitterness and sweetness also affect our alcohol consumption. Pirastu et al. (2015) reveal the genes responsible for white or red wine preferences on a large sample of three different populations from Italy, Central Asia and Netherlands. Muñoz-González et al. (2015) analyze how oral microbiota, i.e. the bacteria living in the human mouth, produce aromatic volatile compounds from grape and wine. They find that individual (and country) differences in oral microbial make-up have profound implications on how we understand wine tasting and the perception of aromas and flavors. Carrai et al. (2017) find a direct relationship between variability of taste receptors' genes and wine perception (namely sensations such as astringency and bitterness). They show that even small genetic variation matters. Focusing on Mediterranean versus Central European populations, which are similar in allelic frequencies for taste receptors, they find that the country of origin is an important factor, indicating that genetics alongside cultural factors (dietary habits) play a significant role in individual liking of wine and wine varieties. We will show how genetic proximity, possibly combining a culture of tastes and such biological factors, matters for wine trade.

2.2 Quality Sorting and Trade Patterns

Our work also pertains to the literature on quality sorting. Developed countries tend to specialize, within products, in the production of high-end varieties. The normative prescription that they should do so is also common in the literature (Schott, 2004) but actual implications of specializing in high-end varieties are rarely studied. Martin and Mayneris (2014) and Fontagné and Hatte (2013) show that exports of high-end products are less sensitive to distance – and more sensitive to destination country wealth – than other products.[9] This question is important in countries like France, whose economy crucially depends on a few export sectors, notably the luxury sector and the wine industry that generate trade surplus and create employment. As discussed in the introduction, France produces fine wines but also wines of lower quality, so the question of whether further specialization is a winning strategy is still pending. If the pattern found in the aforementioned studies applies to the wine sector, it means that high-end variety exporters are better equipped to meet demand in distant markets and notably in Eastern Asia, which remains the major source of global growth.[10]

The present study aims to verify this point using data on French wine exports. It completes the investigation of Crozet et al. (2012) who focus on the Champagne industry.[11] Using firm-level exports, these authors find that high-quality Champagne producers have a higher likelihood of exporting, export higher volumes and charge higher prices. Chen and Juvenal (2016) conduct a similar analysis on Argentinian wines using detailed firm information on wine types. As in both studies, we will use expert

[9] Martin and Mayneris use French firm-level data and focus on heterogeneity across firms in terms of variety-type within a country. Fontagné and Hatte use product-level data and focus on this heterogeneity across countries. To defined quality, both studies rely on information from the main French luxury brands, i.e. the Colbert group, and identify high-end variety exporters as firms selling the same product at least at the same price as Colbert firms.

[10] While several studies show that exporting firms are more likely to ship high-quality goods to more distant markets (Johnson, 2012, Crozet et al., 2012, Fontagné and Hatte, 2013, Martin and Mayneris, 2014), recent evidence also points to higher markups among firms that export to wealthier and more distant countries due to quality differentiation (Bellone et al., 2016).

[11] They assume that this industry conforms well to the assumption of heterogeneous firm monopolistic competition of Melitz (2003)'s model and focus on the quality interpretation of the latter.

rating as a direct measure of product quality.[12] Additionally, we will investigate whether cultural/biological distance also vary with wine quality – which should bring further information on the ability of high-end producers to conquer markets that are not only far away but also culturally different.

3. Empirical Approach

3.1 Gravity Model

To empirically analyze the impact of geographical and genetic distances on French wine exports, we rely on a theory-consistent estimation of the gravity model of trade. The theoretical foundations of the gravity model have been extensively documented in the literature (see for instance Anderson and Van Wincoop, 2003, 2004), as well as model specification and estimation approaches (see the survey of Head and Mayer, 2014, the practical guide of Yotov et al., 2016, or for applications to disaggregated data, such as sector-level data, Anderson and Yotov, 2016). Thus, we directly present the empirical model.

Model specification. The most frequent approach used in the empirical literature is the log-linearized form of the gravity equation. Given that there is only one exporter (France), the model is written:

$$\begin{aligned} ln(X_{irjt}) = \gamma_0 + \gamma_1\, ln(GDP_{jt}) + \gamma_2 ln(Pop_{jt}) + \gamma_3\, ln(RER_{jt}) + \gamma_4\, ln(AVE_{jt}) \\ + \gamma_5 \ln(Prod_{jt}) + \gamma_6 Language_j + \gamma_7\, ln(Geo_j) + \gamma_8\, ln(Gen_j) \\ + \gamma_9 MR_{Geo,j,t} + \gamma_{10} MR_{Gen,j,t} + \mu_t + \theta_{rt} + \lambda_i + \varepsilon_{irjt} \end{aligned} \quad (1)$$

where X_{irjt} represents French wine exports (in volume) of appellation *i* and region *r* to country *j* at time *t*. Trade determinants varying with trade partner and time include the log GDP of the partner, the log of its population size (it is equivalent, in logs, to use GDP and GDP per capita), the log bilateral real exchange rate (*RER*) between the French Franc or Euro and the partner's local currency, and the log of one plus the average tariff level with partner *j* in ad valorem equivalent (*AVE*). We also add factors pertaining to cultural dimensions, including the log of local wine production and a dummy for common language.[13] We will focus particularly on the geographical distance (*Geo*) and the genetic distance (*Gen*) between France and destination countries. We associate multilateral resistance (*MR*) terms that are theoretically funded, as described hereafter.

We control for several types of fixed effects. Year dummies μ_t account for a variety of common time factors: the overall quality of the new vintage (e.g. general weather conditions), the quantity and quality of (unsold) older vintages, exogenous factors affecting trade (business climate, trade policy, etc.) and factors affecting demand globally (such as the Great Recession years). Region x year dummies θ_{rt} proxy local climate conditions that may affect the production level and the average quality in one of the wine regions of France (8 regions x 18 years - 1 = 143 dummies). At the most disaggregated level,

[12] Recent evidence based on field experiment shows that consumers value expert opinion labels on wine as a form of reducing asymmetric information about product quality (Villas-Boas et al., 2020).

[13] Adding contiguity (or adjacency) as another trade determinant does not make any difference regarding the effect of physical and genetic distance (and the coefficient on contiguity) this variable is insignificant. Indeed, once French language is controlled for, it only adds information about three countries (Spain, Italy, Germany). Note that having a common boarder may be seen as an indication of genetic proximity – in the French case, this is not necessarily the case as seen in Figure 3.

appellation dummies λ_i reflect the long-term characteristics of each appellation.[14] Crozet et al. (2012) insist on the possibility to interpret firm heterogeneity in trade levels as due to variation in quality as much as in productivity (i.e. the original interpretation of the seminal paper of Melitz, 2003, linking firm heterogeneity and trade). In our setting, our disaggregation at the appellation level leads to a similar interpretation about appellation fixed effects (long-term heterogeneity in actual quality).

Estimation methods. Estimating the log-linearized form of the gravity model of trade by fixed effects ordinary least squares raises several issues. Heteroscedasticity derives from the log-linearization (Santos Silva and Tenreyro, 2006). Disaggregated data entail a large number of zero-value observations: if the latter are not randomly distributed, dropping them from the sample by log-linearizing the equation leads to a selection bias (Westerlund and Whilhelmsson, 2011). In the empirical literature of trade, several methods have been introduced to deal with these issues, including Tobit models (Eaton and Tamura, 2004), two-step Heckman models (Helpman et al., 2008) or Poisson family estimators (Santos Silva and Tenreyro, 2006; Martinez-Zarzoso, 2013). As recommended by Yotov et al. (2016), we rely on the Poisson Pseudo Maximum Likelihood (PPML) estimator proposed by Santos Silva and Tenreyro (2006) to estimate the structural gravity model of trade. This method has the advantage to deal with both issues and outperform OLS and Tobit in the presence of heteroskedasticity. The PPML remains consistent in case of over-dispersion in the data (Head and Mayer, 2014) and in case of a high frequency of zeros (Santos Silva and Tenreyro, 2011).[15]

3.2 Main Data Sources for Trade Variables

Export data. We exploit a dataset recently assembled by the French federation of exporters of wine and spirit (*Fédération des Exportateurs de Vins et Spiritueux de France*) on wine shipments in volume and value terms. We focus on bottled wine. With 158 different appellations exported to the 51 main importing countries, the dataset represents 95% of total French exports of wine. This information is available between 1998 and 2015, hence a total of 158 x 51 x 18 = 145,044 observations. French exports comprise a great diversity of wines, with different wine colors and grapes, different regions and *terroirs*, and wines with or without mention of origin (including fine wines from *appellations communales*).

On average over the period, 80% of the appellations export nonzero volumes abroad, to an average of 36 destinations. Figure A1 in the appendix presents the evolution of French wine exports by broad destination regions, both in volume and in value. EU countries (particularly the UK and Germany) represent the main export market of French wine, followed by Asia (mainly Japan and China) and North America (mainly the US). In value, we observe an almost continuous rise in all markets (with exceptions like the Great Recession). The progression is even smoother in volume, with a particularly fast increase in exports towards Asian countries but a slowdown in EU countries.

Trade determinants. We combine this dataset with other sources on trade determinants. For standard gravity variables (geographic distance, common language, etc.) we use the database provided by the *Centre d'Etudes Prospectives et d'Information Internationales* (CEPII). Data on GDP, population size,

[14] They absorb regional effects so we need not include regional dummies in the model.

[15] Note also that export volumes appear in levels rather than in log with the PPML estimator but coefficients can still be interpreted as in the log specification of equation (1).

real exchange rate are taken from the World Bank's *World Development Indicators*. Bilateral exchange rates are expressed in real terms using the French and the foreign country's CPI. Tariffs are taken from the World Integrated Trade solution of the World Bank.[16] The different variables and the link to data sources are presented in Table A1.

Multilateral resistance. Anderson and Van Wincoop (2003, 2004) emphasize the role of multilateral resistance (MR) in determining trade flows. It is defined as the trade barrier of a country relative to the average trade barrier of each country with all its partners. It is often included as importer and exporter fixed effects in the gravity model (Baldwin and Taglioni, 2006; Yotov et al., 2016), which is not possible in our case. Indeed, we are interested by time invariant variables, such as geographical and genetic distances, which would be absorbed by importer fixed effects in the present setting. Moreover, even if slowly changing, MR may evolve over a period as long as 18 years. Hence, we rely on the methodology proposed by Baier and Bergstrand (2009) with the inclusion of extended GDP-weighted exogenous variables for the different trade cost variables (physical distance, genetic distance, common language) as MR controls. Note that Monte Carlo analyses by Baier and Bergstrand show that their theoretically-justified measures lead to very similar estimates of physical distance (and other trade costs variables such as border effects) compared to those obtained in a setting with fixed effects à la Anderson and Van Wincoop (2003).

3.3 Data for Genetic Distance, possible Confounders and Wine Quality

Genetic distance. While all people in the world share the same gene variants (alleles), the frequencies differ across populations. When populations split apart, genes start to change due to random drift or natural selection. Hence, genetic distance measured as the difference in the distribution of gene variants provides us with an approximate time since two populations have shared common ancestors (Spolaore and Wacziarg, 2009). We rely on a "coancestor coefficients" F_{ST}, first introduced by Cavalli-Sforza et al. (1996), and based on the difference in allele frequencies. We use the new database by Spolaore and Wacziarg (2016, 2018), which is deemed superior to previous ones as explained by Melitz and Toubal (2019). The older base of Cavalli-Sforza et al. (1996) provided bilateral genetic distances between 42 populations. Pemberton et al. (2013) have combined eight datasets appearing since then to construct a new measure of bilateral genetic distances covering a grid of 267 worldwide populations. These new measures have another advantage: they reflect DNA sequences at the molecular level (microsatellite variation), rather than using classic genetic markers, and hence provide finer distinctions – especially for Asian countries – on a much wider world scale. Spolaore and Wacziarg (2016, 2018) have adapted the dataset from Pemberton et al. (2013) – which pertains to ethnic pairs – to country pairs. Relying on ethnic composition by country from Alesina et al. (2003), they provide a comprehensive dataset for genetic distance at the country level. They emphasizes DNA measures of coancestry as an important factor in many economic contexts.[17]

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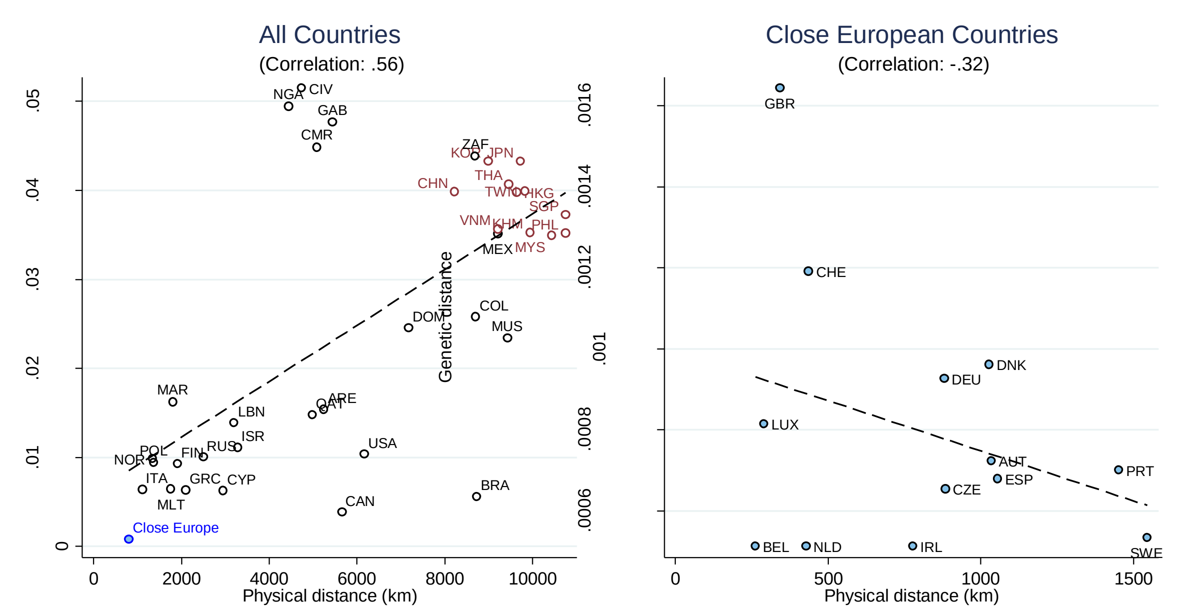
[16] Note that they correspond to MFN and that countries do not apply different tariffs to different types of wines, only by degree of alcoholic content across types of alcoholic drinks.

[17] We adopt their measure of weighted genetic distance, calculated as follows. Let $n = 1, \dots, N$, be the ethnic populations of country *i*, $l = 1, \dots, L$ those of country *j*, s_{in} the share of group n in country *i*, s_{jl} the share of group l in country *j*, and D_{nl} the genetic distance between groups n and l. The weighted F_{ST} genetic distance between the two countries could be expressed as:

One may argue that using genetic distance between only one exporter, France, and the 51 main export destination may provide only limited variation, or a variation that is highly collinear with geographical distance. In fact, the global correlation rate between physical and genetic distances is *only* 0.56.

This is depicted by the first graph of Figure 1. The graph shows that at the global level, the positive correlation is mainly due to Asian countries, whose coancestry, among all importing countries, is the farthest from the French, and which also happen to be far away from France. Apart from this, there is no systematic association between physical and genetic distance. If we zoom on European countries for instance, the second graph reports a correlation that is actually negative. In our empirical analysis, we will simply check how our results change when controlling for an "Asian countries" dummy.

Figure 1: Correlation between Genetic and Physical Distances



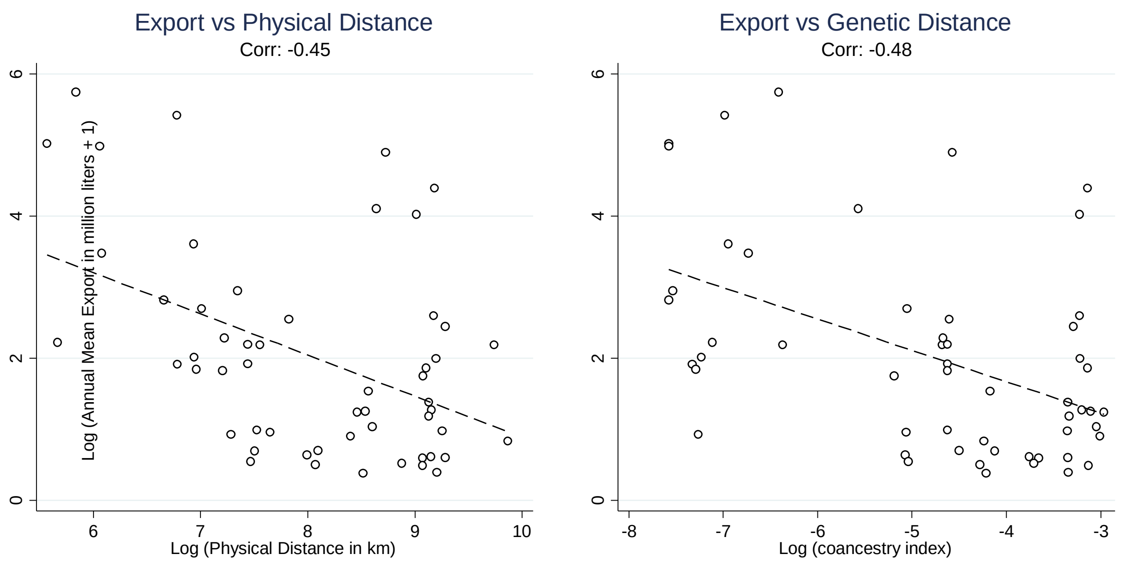
Note: authors' graphs based on geographic distance and genetic distance (coancestry measure from Spolaore and Wacziarg, 2016).

In Figure 2, we provide the basic intuition for our results. We observe the usual negative relationship between physical distance and trade flows (left-side graph). We also distinguish a similar relationship between genetic distance and trade (right-side graph). Estimations will account for both distances at once, together with standard trade determinants. They will also include possible confounders for the home-bias interpretation that we attach to genetic distance, including microgeography and cultural traits such as trust.

$$Gen_{ij} = \sum_{n=1}^{N} \sum_{l=1}^{L} [s_{in}\, s_{jl}\, D_{nl}]$$

This measure could be assimilated as the expected genetic distance between two randomly selected individuals, one from each country (Spolaore and Wacziarg, 2016).

Figure 2: Export Flows vs Physical and Genetic Distances



Note: authors' graphs based trade data from the French federation of exporters of wine and spirit, geographic distance (from CEPII) and genetic distance (coancestry measure from Spolaore and Wacziarg, 2016).

Microgeography. As Giuliano et al. (2014), we will control for the existence of a common sea/ocean between France and its trading partner as well as for topographical variability or *ruggedness*. Giuliano et al. explain that terrain variability can affect the construction and maintenance costs of surface transport networks, hence the costs to use these networks, while an increase in the road gradient also increases fuel consumption. The most frequent measure is the Terrain Ruggedness Index developed by Riley et al. (1999) and used for instance by Nunn and Puga (2012) to study slave trade. It is measured in hundreds of meters of elevation difference at very thin grid points and averaged at the country level. To capture the possibility that ruggedness may be more important in areas that are more densely populate, we will also use a population-weighted measure of ruggedness (see more details on the construction of both indices in Nunn and Puga, 2012). Not surprisingly, a very flat country like the Netherlands gets the lowest value for both indices in our data, namely 0.03 for the main ruggedness measure and 0.04 for the population-weighted measure. The highest level is reached by Switzerland for the former measure (4.76) and Lebanon for the latter (2.17).

Trust. In the empirical literature, trust is mainly calculated on the basis of answers to particular questions that reflect the ability of individuals to trust each other. Most of empirical studies rely on the World Value Survey (WVS) and average the answers to obtain a country's level of trust in others (La Porta et al., 1997; Sapienza et al., 2007; Guiso et al., 2009; Ahern et al., 2015). This measure does not allow to produce interpretations on bilateral trust, for instance if French exporters are trusted by Italian importers. Giuso et al. (2009) have proposed a bilateral measure of trust based on the Eurobarometer survey. Conducted on a representative sample of total populations of age sixteen and over (around 1000 individuals per country), it asks the question on trust in people from various countries ("For each country, please tell me whether you have a lot of trust, some trust, not very much trust, or no trust at all"). Based on the answers, they provide a bilateral measure of trust for 15 European countries that ranges from 0 (no trust at all) to 4 (a lot of trust). We extract such a measure of bilateral trust between France and EU importing countries.

Cultural distance. Spolaore and Wacziarg (2016) rely on survey questions about individual values to measure cultural distance. In contrast to studies that focus on specific questions (Guiso et al., 2009), they use all the value-related questions from the World Value Survey 1981-2010 Integrated Questionnaire to avoid arbitrary choices. Their final dataset contains 98 questions for 74 countries. To obtain a distance in values between countries, they compute a simple Euclidian distance between the shares of respondents in the two countries who give a specific answer to a particular question. Then, they use a standardization procedure so that the distances computed for each specific question have a mean of zero and a standard deviation of one. For the global measure of cultural distance between countries, they sum all the indexes across all 98 questions. They also provide some disaggregated measures based on particular cultural topics such as life perception, work perception, family perception, politics and society religion and morale – which we shall also use hereafter.

Expert rating. We rely on the score given by the wine expert Robert Parker to French appellations for some of the years under study. Parker has been a leading US wine critic who assesses wines based on blind tastings and publishes his consumer advice and rankings in a bimonthly publication, the Wine Advocate. His evaluation is one of the largest coverage of wine rating that exists for French wines. The rating system employs a 50-100 point scale where wines are ranked according to their name, type, grape and vintage. In our investigation of quality sorting, we use annual scores for 18 sub-regions.[18] We obtain grades for 56% of the Bordeaux wines, 85% of the Burgundy wine, 33% of the wines from the Rhone valley, 55% of the Loire valley wines and 42% of the wines from Languedoc-Roussillon. Note that unrated wines within a region may be deemed of less interest for experts so we will use this information as an additional category when interacting distance with quality measures. Among rated wines, the lowest rate is 58 and the highest is 99. The distribution across wines is symmetric as the mean and the median are equal (at a value of 88.5).

4. Results

4.1 Standard Determinants and the Role of Genetic Distance

Estimation results for various specifications of the gravity model are presented in Table 1. In column (1), we start with a set of standard gravity variables. Geographic distance plays a significant and large effect. The coefficient of -0.716 is of a similar order of magnitude as the mean and median distance effects calculated by Head and Mayer (2013) over a large number of surveyed studies. In particular, it matches well with the distance coefficient found in the most recent studies based on PPML estimations (Head and Mayer’s figure 5). Other trade determinants of model (1) yield expected results. The income elasticity proxied by the coefficient on log GDP is close to 1. The coefficient of real exchange rates is positive (i.e. an appreciation of the foreign currency increases trade flows). Tariffs depress the flow of exports.

The following specifications introduce *culture-related variables* in a stepwise way. Model (2) adds a common language dummy: French speaking countries tend to significantly import French wine more

[18] This includes specific scores for Alsace, Barsac/ Sauternes (Bordeaux white), Graves / Pessac Léognan (Bordeaux), Margaux (Bordeaux), Pomerol (Bordeaux), StEmilion (Bordeaux), St Julien / Pauillac/ StEstèphe (Bordeaux), Burgundy white, Beaujolais, Côte de Beaune red (Burgundy), Côte de Nuits red (Burgundy), Champagne, Languedoc, Loire Valley Red, Loire Valley white, Chateauneuf du Pape (Rhone valley), Côte Rotie / Hermitage (Rhone valley), Languedoc, Roussillon.

than other regions of the world. Model (3) includes the log of local wine production: its coefficient potentially reflects opposing forces. Wine producing countries are characterized by higher preferences for wine consumption, which would make them more likely to import wine if they seek diversity. At the same time, their own wines are competitors/substitutes to imported wines, and national preferences do not necessarily include French wines in their demand for variety. The latter effect seems to prevail as the coefficient is negative.

Table 1: PPML Estimation of the Gravity Model: Baseline Results

	(1)	(2)	(3)	(4)	(5)	(6)
Log Geogr. Distance	-0.716***	-0.678***	-0.551***	**-0.395*** **	**-0.427*** **	**-0.348*** **
	(0.0427)	(0.0432)	(0.0455)	**(0.0486)**	**(0.0493)**	**(0.0482)**
Log GDP	0.932***	0.967***	1.081***	1.072***	1.041***	1.120***
	(0.0704)	(0.0699)	(0.0622)	(0.0628)	(0.0633)	(0.0537)
Log Pop.	-0.154**	-0.0514	0.0221	0.134*	0.184***	0.0738
	(0.0721)	(0.0740)	(0.0674)	(0.0709)	(0.0708)	(0.0606)
Log Real Exch. Rate	0.117***	0.180***	0.0560*	0.0971***	0.106***	-0.0360
	(0.0265)	(0.0268)	(0.0312)	(0.0339)	(0.0349)	(0.0392)
Log (Tariffs +1)	-0.0825***	-0.228***	-0.173***	-0.110***	-0.126***	-0.154***
	(0.0281)	(0.0292)	(0.0319)	(0.0349)	(0.0355)	(0.0348)
Common Language		0.831***	0.939***	0.890***	0.874***	1.038***
		(0.0931)	(0.0801)	(0.0869)	(0.0882)	(0.0905)
Log Local Production			-0.112***	-0.129***	-0.133***	-0.126***
			(0.0148)	(0.0133)	(0.0137)	(0.0130)
Log Genetic Distance				**-0.278*** **	**-0.288*** **	**-0.375*** **
				(0.0571)	**(0.0579)**	**(0.0540)**
Log (unit value + 1)					0.317***	
					(0.0271)	
Asia dummy						1.269***
						(0.207)
Constant	-16.50***	-18.26***	-18.88***	-22.82***	-22.86***	-22.86***
	(1.614)	(1.565)	(1.486)	(1.622)	(1.570)	(1.570)
Observations	145,044	145,044	145,044	145,044	145,044	145,044
Pseudo R-squared	0.627	0.622	0.621	0.636	0.637	0.664
Multilateral resistance variables	YES	YES	YES	YES	YES	YES
Year dummies	YES	YES	YES	YES	YES	YES
Region-Year dummies	YES	YES	YES	YES	YES	YES
Appellation FE	YES	YES	YES	YES	YES	YES

PPML estimations of export volume in level. Standard errors, clustered at country-appellation level, in parentheses. Significance levels: *** p<0.01, ** p<0.05, * p<0.1

Most importantly, model (4) adds the *log genetic distance* (and the associated multilateral resistance variable) to the other covariates. Its inclusion does not fundamentally affect the interpretation and magnitude of the coefficients on GDP, exchange rates, tariffs, common language or national wine production. As expected, it substantially diminishes the effect of geographical distance, namely by 28% compared to model (3). Nonetheless, genetic distance has a negative and significant coefficient, which happens to be relatively similar in magnitude to the coefficient on physical distance. These results, and robustness checks hereafter, suggest that genetic distance plays an independent role on trade flows, possibly related to cultural and biological determinants of wine preferences.[19]

[19] A regression of genetic distance on all the variables of the model including physical distance and multilateral resistance variables (resp. without multilateral resistance variables) gives a Variance Inflation Factor of 4.6 (resp. a VIF of 3.9), which is not extremely worrying regarding excessive multicollinearity.

The rest of Table 1 contains a few sensitivity checks. Model (5) shows that adding log unit values does not change the previous conclusions nor the magnitude of the coefficients on the key variables.[20] Also, we have seen that most of the international correlation between genetic and physical distances is driven by the cluster of Asian countries (cf. Figure 1). Hence, an interesting check consists of adding an Asian dummy in the model, which would capture much of the commonalities between physical and genetic distances. In model (6), we see that the results are qualitatively similar. The effect of genetic distance increases slightly and that on physical distance decreases a bit (i.e. a change of around a quarter in both cases).

Finally, note that our results are not dependent on the estimation method. We have experimented with several alternative approaches, which lead to the same conclusions, including basic Tobit estimations or a Heckman two-step procedure using religious prohibition of alcohol as an instrument.[21] In unreported estimations, we have also tried alternative specifications including hub dummies (to denote the particular role of re-exporter countries, including the Netherland, Belgium, Honk-Kong and Singapore), the per capital consumption of alcoholic drinks in destination country, or directly introducing the prohibition dummy (equal to 1 for a trade partner in which alcohol consumption is in principle forbidden due to religious motives, cf. Boüet et al., 2016). Adding these variables makes very little difference overall and, in particular, the coefficients on physical and genetic distances are barely affected.

4.2 Other Pathways

In what follows, the informational content of the genetic distance variable is filtered out from other gravitational influences. Precisely, our interpretation of genetic distance as a marker of taste heterogeneity of a biological and cultural nature is confronted to alternative pathways, including the other dimensions of culture that affect trade more generally (e.g. trust) or other correlates of genetic distance (e.g. micro-geographical factors).

Microgeography. Geographic factors possibly contributed to the genetic drift by having determined past migration routes or by having separated populations. For this reason, genetic distance could simply proxy how the micro-geography affects land/sea transportation and the related trade costs. This is the thesis of Giuliano et al. (2014). Following them, we check the impact of controlling for two additional variables in our estimations, namely the presence of a common sea/ocean and the measure of topographical variability or *ruggedness*. Giuliano et al. (2014) actually show that the effect of genetic distance on trade disappears when controlling for these types of factors. Their result is particularly strong in the case of bulky goods for which geographical barriers are more of an impediment to trade.

We do not necessarily expect the same result here. First, we do not focus on bulk wine but on bottles. Second, Giuliano et al. focus on trade within Europe while we study the *global* trade of French wine. Third, and most importantly, their study relies on the older genetic data from Cavalli-Sforza et al. (1996). Recent evidence based on the new data from Spolaore and Wacziarg (2018) – which we use –

[20] If the dependent variable was in logs, adding log unit values among regressors would be equivalent to estimating (log) exports in value.

[21] Arguably, this is a very specific instrument to explain zero trade flows. Moreover, this approach requires the assumption that all random components of the model are homoskedastic (Santos Silva and Tenreyro, 2015; Helpman et al., 2008).

shows that coancestry measures are much more strongly associated with economic outcome than previously thought. This is particularly true with trade, as demonstrated by Melitz and Toubal (2019).

Table 2: PPML Estimation of the Gravity Model: Adding Geographic Controls

	(1)	(2)	(3)	(4)	(5)
Log Geogr. Distance	-0.348***	-0.515***	-0.511***	-0.454***	-0.449***
	(0.0482)	(0.0468)	(0.0473)	(0.0478)	(0.0483)
Log Genetic Distance	-0.375***	-0.187***	-0.191***	-0.285***	-0.290***
	(0.0540)	(0.0545)	(0.0558)	(0.0566)	(0.0580)
Ruggedness		-0.260***	-0.253***		
		(0.0401)	(0.0414)		
Pop-weighted ruggedness				-0.267***	-0.254***
				(0.0546)	(0.0570)
Common Sea			0.0852		0.156*
			(0.0881)		(0.0919)
Observations	145,044	145,044	145,044	145,044	145,044
R-squared	0.664	0.661	0.660	0.660	0.659
Standard trade determinants	YES	YES	YES	YES	YES
Multilateral resistance variables	YES	YES	YES	YES	YES
Year dummies	YES	YES	YES	YES	YES
Region-Year dummies	YES	YES	YES	YES	YES
Appellation FE	YES	YES	YES	YES	YES

PPML estimations of export volumes. Standard errors, clustered at country-appellation level, in parentheses. Significance levels: *** p<0.01, ** p<0.05, * p<0.1

Results are reported in Table 2. We see that compared to the baseline (column 1), our measure of genetic distance is reduced by a half when ruggedness is included (column 2). Adding the presence of shared seas/oceans barely change the estimates for gravity and genetics (column 3). Even if smaller, the effect of genetic distance remains significant at the 1% level. These results suggest that coancestry is a trade factor per se: while it cannot be subsumed by physical distance nor by geographical factors, it possibly reflects trade frictions that pertain to the existence of localized tastes inherited from cultural/biological diversity.

Our findings are different from Giuliano et al. (2014), and similar to Melitz and Toubal (2019), mainly because of the use of the new genetic data. The other reason discussed above is the fact that they focus on Europe. Hence, transportation costs are mainly associated with land routes in their case, so the presence of mountains chains may matter. This is less the case here: half of France's trading partners are located on a different continent; moreover, the global wine trade increasingly relies on sea and air transportation (Candau et al., 2017) while the containerization allows multiple modes of freight transport (Emlinger and Lamani, 2017). Nonetheless, in unreported estimations, we have also added the presence of mountains chains, which has virtually no impact on our results. In the same vein, ruggedness is not so much used to capture the topographical variability that lie between France and the destination country, but rather the implicit costs of transporting wine *within* the importing country. In that sense, a population-weighted measure of ruggedness seems to be an interesting variant. As shown in Table 2, it diminishes the coefficient on genetic distance but only by around a quarter (columns 4 and 5).[22] Finally, additional estimations convey that in the most complete

[22] Note that the correlation between the main ruggedness index and the population-weighted one is 0.78 (0.94 when weighted by exported volumes). Other measures are suggested by Nunn and Puga (2012) but they are even more correlated to the former index.

specifications, namely models 3 and 5, genetic distance reduces the effect of physical distance by 23% and 31% respectively.

Table 3: PPML Estimation of the Gravity Model: Adding Trust and Cultural Distance

	Trust (European sample, Guiso et al 2009)		Cultural distance (Spolaore and Wacziarg, 2016)			
	baseline (on sample with trust)	incl. **trust**	baseline (on sample with linguistic dist.)	incl. **linguistic dist.** (pop. weighted)	baseline (on sample with values distance)	incl. **total values distance**
	(1)	(2)	(3)	(4)	(5)	(6)
Log Geogr. Distance	-0.844***	-0.652***	-0.504***	-0.502***	-0.559***	-0.517***
	(0.172)	(0.175)	(0.0487)	(0.0508)	(0.0555)	(0.0591)
Log Genetic Distance	-0.461***	-0.283***	-0.171***	-0.171***	-0.376***	-0.352***
	(0.113)	(0.107)	(0.0514)	(0.0516)	(0.0668)	(0.0658)
Trust or Log (Cultural Distance)		2.366***		-0.265		-0.0792**
		(0.356)		(0.713)		(0.0360)
Observations	39,816	39,816	130,824	130,824	102,384	102,384
Pseudo R-squared	0.741	0.750	0.669	0.668	0.669	0.669
Standard trade determinants	YES	YES	YES	YES	YES	YES
Microgeography	YES	YES	YES	YES	YES	YES
Multilateral resistance variables	YES	YES	YES	YES	YES	YES
Year dummies	YES	YES	YES	YES	YES	YES
Region-Year dummies	YES	YES	YES	YES	YES	YES
Designation FE	YES	YES	YES	YES	YES	YES

PPML estimations of export volume in level. Standard errors, clustered at country-designation level, in parentheses.
Significance levels: *** p<0.01, ** p<0.05, * p<0.1

Trust, culture and values. Genetic distance has been used as a proxy of vertical transmission of cultural traits in many studies (see the discussion in Spolaore and Wacziarg, 2009, 2016, 2018). Hence, in our context, genetic distance may be seen as a proxy for pure cultural mechanisms associated to trust, homophily and common values, which tend to enhance the intensity of international trade in general, as shown by Guiso et al. (2009) and Melitz and Toubal (2019). Our point is that there is more to it: for a commodity like wine, genetic differences across nations must also convey cultural and biological dimensions associated to differences in taste, which also affect trade. We cannot perform a definite test of this hypothesis but provide suggestive evidence hereafter by simultaneously controlling for genetic distance and cultural variables such as trust. Note that all the models presented hereafter also control for ruggedness and common sea.

We start with trust, using the bilateral measure suggested by Guiso et al. (2009) and previously defined in the data section. Since it is collected for European countries only, our sample size is considerably reduced. To check the impact of using such a sample, we first replicate our baseline specification on this sample. Results are reported in model (1) of Table 3. Both geographical and genetic distances are still significant. Their magnitudes are larger here but the standard errors are also multiplied by 3.5. Then, we add trust in model (2). As expected, it has a strong positive effect on trade. Importantly, the coefficient on genetic distance is reduced by 38% but remains statistically significant. Note that the coefficient on physical distance also decreases. Given the very small sample used here, these results are only suggestive. Nonetheless, we share the views of Melitz and Toubal (2019) that genetic distance does not only measure the level of trust between nations. It possibly embodies other trade factors, such as local tastes in our context. Note that in this specification with trust and micro-geography together, the addition of genetic distance to the empirical model reduces the effect of physical distance by 40%, which is an upper bound for this statistic so far.

We move to linguistic and cultural distance using the data from Spolaore and Wacziarg (2016). We first report the estimation based on our usual specification – the only difference here is that 'common language' is taken out – using the sub-sample for which linguistic distance is available (model 3). Adding the log linguistic distance does not change the relative effects of physical and genetic distance (model 4): both remain highly significant. Very similar conclusions are obtained in models (5) and (6) where we add a measure of log cultural distance, calculated as the average distance over different types of values, namely perceptions about life, work, family, politics/society and religion/morale. In Table A2, we test each of these values separately. Two of them, the log distances in work values and in religion/morale, significantly reduce the intensity of wine trade with France. In all cases, adding these measures of cultural distance does not dramatically affect the impact of physical and genetic distances. These results are suggestive of the fact that genetic distance captures other types of cultural (and possibly biological) differences pertaining to consumer heterogeneity in tastes.

4.3 Quality Sorting and Heterogeneity

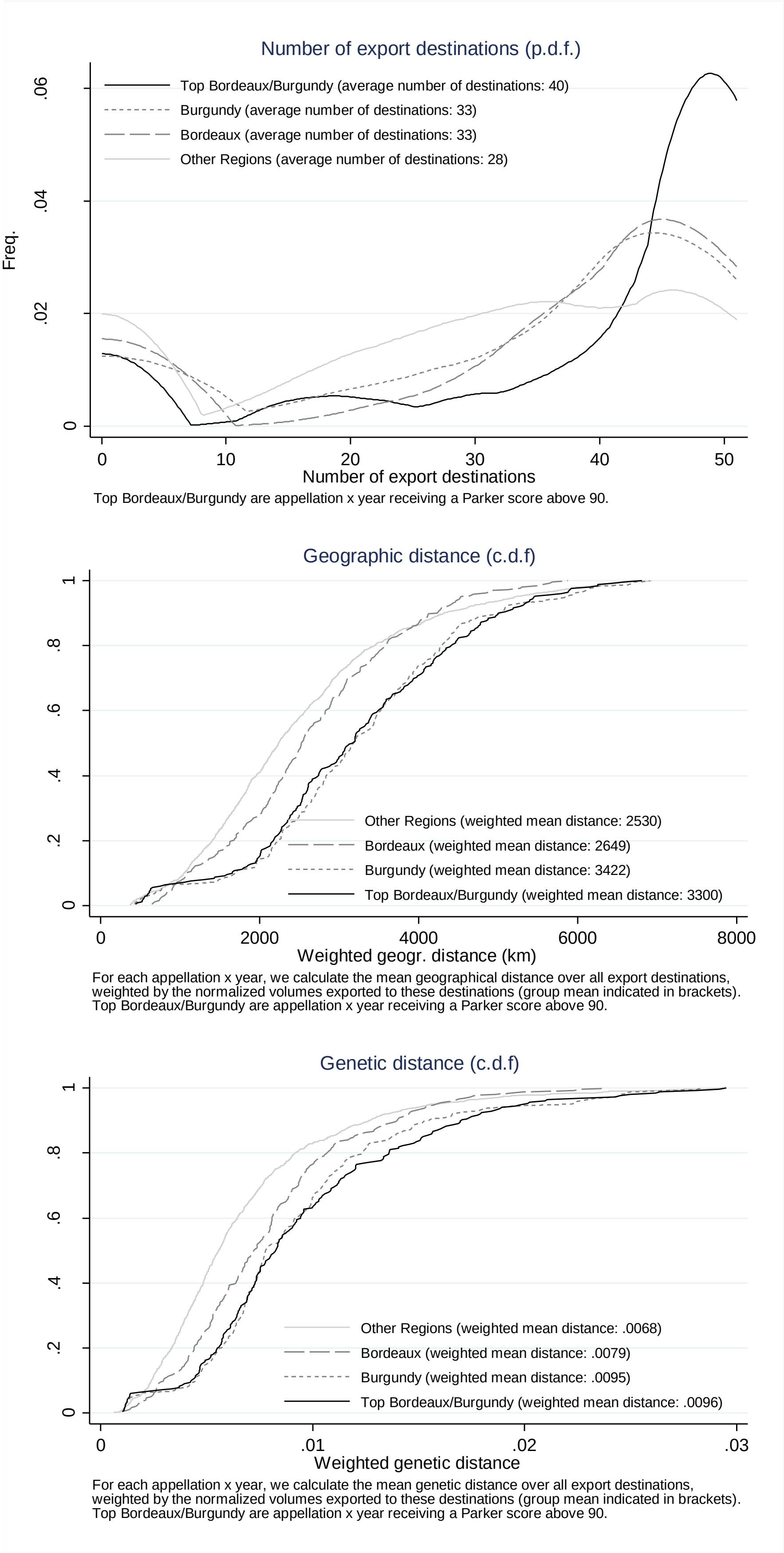
Previous results implicitly account for the diversity in wine types, and how it interacts with preference heterogeneity in explaining trade flows. We now exploit this diversity more explicitly by sorting wine types/regions according to different quality measures. Our aim is to test whether export flows of high-quality wines are less sensitive to transportation costs (as proxied by geographical distance, cf. Mayer and Mayneris, 2015) but also less dependent on local preferences (as proxied by genetic distance).[23]

Regional variation. We start using wine reputations as a broad proxy for quality. Consumers rely on the overall reputation of a wine's origin—the region it comes from—to indicate the wine's quality (see e.g. Stuart and Smith, 1998, Costanigro et al., 2010, Castriota and Delmastro, 2015, and the review by Lockshin and Corsi, 2012). In the case of French wines, two regions of world renown stand out: Bordeaux and Burgundy. Figure 3 shows that these two regions are exporting to a larger number of destination (first graph), the farthest geographically (second graph) but also to countries that are the most distant to France in genetic terms (third graph). The difference with other regions is even more marked when physical or genetic distances are weighted by export volumes.

The following results are consistent with these observations. Table 4 first presents estimates of the interaction of our log geographical distance with dummies for Bordeaux wines, Burgundy wines and the rest. The last rows report a test of equality between the coefficients. The negative effect of geographical distance is significantly dampened for the two famous wine regions (column 1). This difference with other regions is even more pronounced if we focus on red wine to address a more homogenous group (column 2). We find an insignificant effect of physical distance on Burgundy wines in this case.

[23] For the sake of comparability, we will extract detailed coefficients for regions producing both red and white wines. This means that we exclude Champagne (it receives much attention in Crozet et al., 2012) and Alsace (which produces essentially white wine).

Figure 3: Average Physical or Genetic Distance by Wine Region



Let us refine the interpretation of these results. The fact that reputed regions defy gravity appears to be more clear-cut in the case of Burgundy. Indeed, Bordeaux is a heterogeneous region that mixes both famous appellations and simpler wines. Burgundy is characterized by a much smaller area - hence a smaller production level - almost entirely dedicated to fine wines. These factors contribute to less variation in price and quality compared to Bordeaux. To illustrate this point, we use the distribution of unit values, taken as proxy for wine prices: when trimming the top 1% and excluding zeros, unit values show a larger standard deviation among Bordeaux wines (105) than among Burgundy wines (98).

Table 4: Physical and Genetic Distance Effects by Quality Levels: Reputed Regions vs the Rest

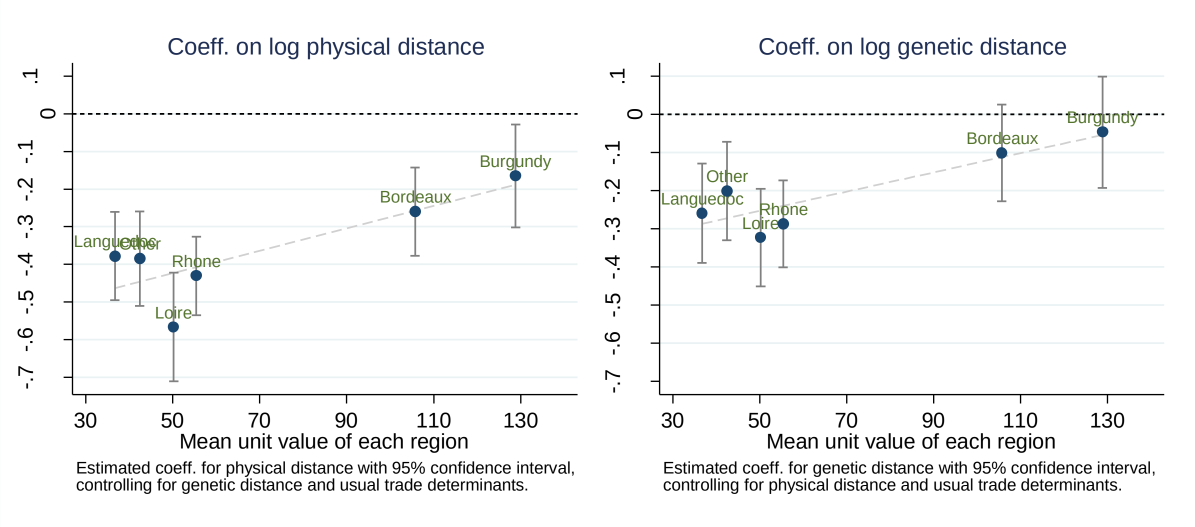
	Geographic distance		Genetic distance			
	All types	Red	All types		Red	
	(1)	(2)	(3)	(4)	(5)	(6)
Log Distance						
x Bordeaux	-0.260***	-0.190***	-0.283***	-0.102	-0.408***	-0.225***
	(0.0599)	(0.0602)	(0.0643)	(0.0651)	(0.0695)	(0.0659)
x Burgundy	-0.165**	-0.0147	-0.227***	-0.0472	-0.314***	-0.134
	(0.0698)	(0.0880)	(0.0716)	(0.0745)	(0.0930)	(0.0916)
x Others	-0.399***	-0.354***	-0.420***	-0.235***	-0.574***	-0.387***
	(0.0524)	(0.0556)	(0.0571)	(0.0596)	(0.0643)	(0.0594)
Observations	145,044	73,440	145,044	145,044	73,440	73,440
Standard trade determinants	YES	YES	YES	YES	YES	YES
Multilateral resistance variables	YES	YES	YES	YES	YES	YES
Microgeography variables	NO	NO	NO	**YES**	NO	**YES**
Year dummies	YES	YES	YES	YES	YES	YES
Region-Year dummies	YES	YES	YES	YES	YES	YES
Appellation FE	YES	YES	YES	YES	YES	YES
Test equality of heterogeneous effects (p-value):						
Bordeaux = Others	0.01	0.00	0.01	0.01	0.00	0.00
Burgundy = Others	0.00	0.00	0.00	0.00	0.00	0.00

PPML estimations of export volume in level. Region dummies (Bordeaux, Burgundy, others) are absorbed by designation dummies. Standard errors, clustered at country-appellation level, in parentheses. Significance levels: *** p<0.01, ** p<0.05, * p<0.1

Then, we suggest similar interacted effects using genetic distance. Table 4 shows that the coefficient is significantly smaller for renowned regions (column 3). As expected, additionally controlling for ruggedness and shared seas diminishes all the genetic-distance coefficients (column 4). Yet the same conclusion holds: wines from reputed regions tend not to be affected by country heterogeneity in taste, as proxied by genetic distance, while other regions are. Note that micro-geographic factors affect the distance coefficients by the same magnitude for Bordeaux, Burgundy and other regions. In other words, even if Bordeaux and Burgundy export further than other regions, the microgeography of their global trade is not fundamentally different and does not affect our interpretations.

To go a little further, Figure 4 plots the heterogeneous effects of physical distance (left) and genetic distance (right) for each region against the mean unit value of the wines exported by each region (mean values over all years). In this way, we confirm that whatever the 'other' region we compare them to (Rhone, Loire, etc.), Bordeaux and Burgundy produce wines that are (i) more expensive, (ii) less dependent on freight and transportation costs (proxied by physical distance), and (iii) not sensitive to preference heterogeneity (as captured by genetic distance).

Figure 4: Physical and Genetic Distance Effects by Quality Levels: Detailed Wine Regions



Among the other regions, there is no monotonic relationship in terms of price-distance coefficient, as these regions are bunched closely together. There is a ranking between Bordeaux and Burgundy as discussed above - Burgundy wines are slightly more expensive, more homogeneously of high quality, and hence less sensitive to physical and genetic distances than Bordeaux (yet the difference is not statistically significant). Note that controlling for micro-geographic factors does not affect these conclusions (see detailed estimates in Table A3).

Expert rating. Another way of sorting regions according to quality is to rely on expert judgement. As extensively described in the data section, Parker's scores are an international reference that helps individuals and professionals to assess the quality of all sorts of wine. In the case of French wine regions, we avail of Parker's grade for 18 sub-regions x 18 years, hence 324 points of observation for the heterogeneity analysis.[24] We create four categories: ungraded wines and terciles of Parker scores for graded wine. Note that Parker's scores for tercile 1 range from 58 to 86, those of tercile 2 from 87 to 90 and those of tercile 3 from 91 to 99. We interact distance measures with the four category dummies. Results are presented in Table A4 in the Appendix. While terciles 1 and 2 show no difference, an overall monotonic relationship appears. Ungraded wines turn out to be more sensitive to physical and genetic distances than terciles 1-2 while top tercile wines are less sensitive. As reported in the last rows, the difference is highly significant between ungraded and top wines. Again, these results tend to corroborate past studies showing that high-end products defy gravity.

Combining regional reputation and expert rating. We mix regional variation and expert rating. We use a threshold of 90 as a symbolically high score in Parker's scaling (it also corresponds to the cutoff of the upper tercile as used above). Therefore, it is supposed to capture wines of particularly high reputation and quality. Given the more detailed scoring for Burgundy and Bordeaux, we now estimate heterogeneous effects between 'top' Burgundy and Bordeaux (defined as those receiving a Parker

[24] In comparison, Crozet et al. (2012) use data on expert rating for 284 champagne firms. Chen and Juvenal (2016) use wine-specific rating from the *Wine Spectator* for Argentinian wines. For the export of French Cognac, Bouët et al. (2017) find lower distance effects for expensive brandies (they use unit values as a proxy for quality).

score above 90), other Burgundy and Bordeaux (i.e. unrated or with a score below 90), and other regions.

Results are reported in Figure 5 overall and in Figure 6 for red wines (estimates, including the coefficients for detailed regions, are reported in Table A5). Both for physical distance (left) and genetic distance (right), we obtain an expanded picture of the relationship between quality and distance effects. We see that 'top' Bordeaux and Burgundy wines – which are consistently the most expensive ones, with unit values around 140 euros on average – are the least sensitive to trade costs and to preference heterogeneity. They are followed by the 'other' Bordeaux and Burgundy, which represent an intermediary situation (their unit values are around 100 euros), and then by the cluster of other regions (which are all very similar to each other, see details in Table A5). There is no visible difference between high-score wines and other wines *within* Burgundy region, while both distance effects are reduced *within* Bordeaux when moving from standard to premium wines. This again reflects the fact that Bordeaux wines are more heterogeneous. Finally, note that these results are consistent with the descriptive statistics of Figure 3: top wines tend to export to more countries, more distant countries and more genetically differentiated countries compared to other wines ('other' Bordeaux stand in an intermediary position between top Bordeaux/Burgundy wines and other regions).

Interpretations. Regarding physical distance, our results complete firm-based evidence by Fontagné and Hatte (2013) and Martin and Mayneris (2015), who study luxury goods in general. Using variety in the quality of French wine, we confirm that high-end products suffer less from trade costs. We additionally find that contrary to standard wines, reputed/top wines are not affected by genetic distance, which possibly denotes a limited dependence on long-term local tastes. There are at least three possible explanations for this, which are not mutually exclusive and which may actually reinforce each other. *First*, cultural globalization may have pervaded local authentic preferences and facilitated the export of some of the luxury goods, which are now iconic and known by a large majority of people worldwide.[25] *Second*, luxury goods, and top wines in particular, are used by some people to achieve social status, signaling their wealth through conspicuous consumption (Bagwell and Bernheim, 1996). This type of Veblen effect is relevant today, at a global scale, as much as it was centuries ago among the bourgeois of Europe (Hori, 2009).[26] *Third*, luxury wines have also become an investment good (see for instance Masset and Henderson, 2010, or Dimson et al., 2015, as well as the survey by Storchmann, 2012).

[25] While this aspect has received little attention in the economic literature, a few studies look at cultural convergence during the globalization process (Aizenman and Brooks 2008) and how overall bilateral trade tends to reduce cultural distance (Maystre et al., 2014).

[26] Beyond concerns of social status, people may genuinely respond to higher prices: neuroscience experiments such as Plassmann et al. (2008) show that increasing the price of a wine can effectively change people's experiences with it, namely to increase subjective reports of flavor pleasantness.

Figure 5: Physical and Genetic Distance Effects by Quality Levels: Reputed Regions & Expert Rating

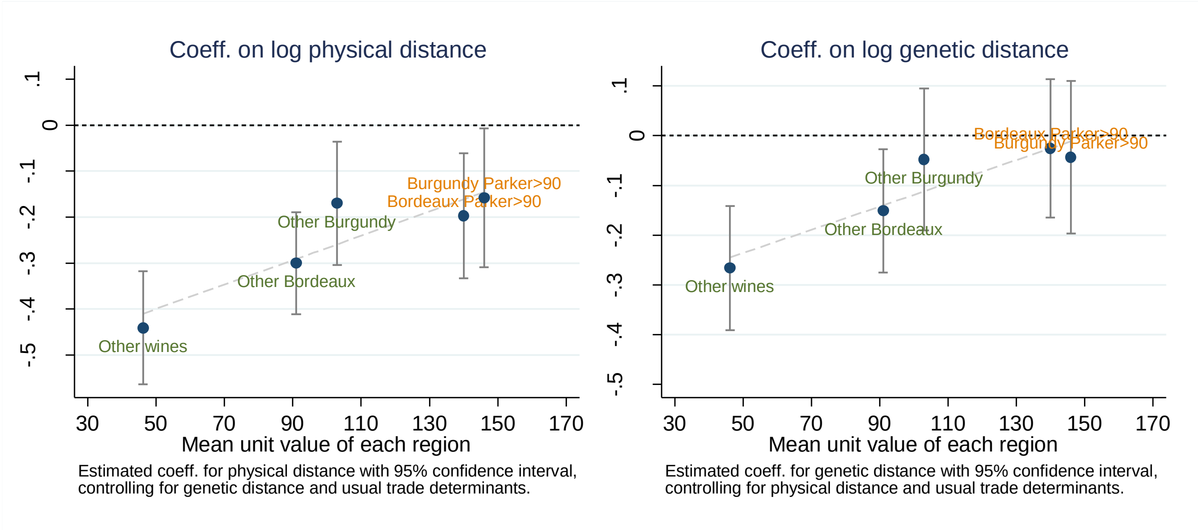
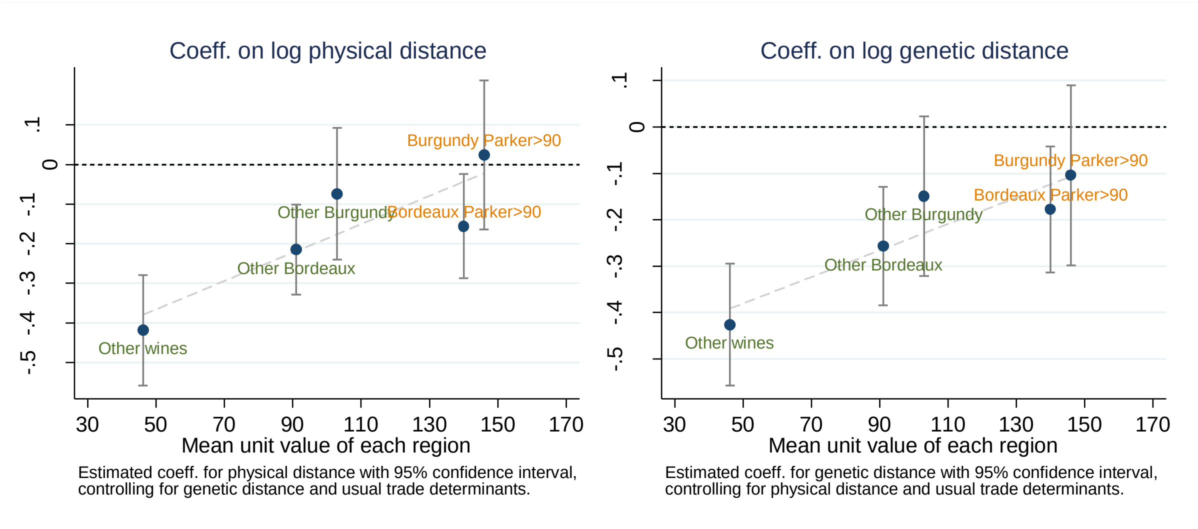


Figure 6: Physical and Genetic Distance Effects by Quality Levels: Reputed Regions & Expert Rating (Red wines)



Conclusion

We exploit a rich dataset on the appellation-level exports of French wine in the world over 1988-2015. The estimation of several gravity models allows disentangling the effects of physical distance and genetic distance. The latter cannot be subsumed by micro-geographic factors nor does it capture standard cultural factors that boost trade (trust, common language or linguistic proximity, similar values, etc.). Our favorite interpretation is that (i) a genuine effect of genetic distance exists and (ii) it possibly reflects trade frictions pertaining to cultural/biological differences, as shaped by history and which explain the existence of localized tastes (in particular the variation in gustatory and olfactory pleasures derived from French wines). Isolating this effect is important since preference heterogeneity is possibly long-lasting and hence a persistent source of trade barriers.

Interestingly, however, this pattern does not apply uniformly to all wines. Using regional reputation and expert rating, we find that top wines tend to escape gravity, but also show less sensitivity to genetic distance. This last point indicates that the global demand for luxury wines is less dependent on a country's average preferences, maybe because the high profile consumers have different preferences than the average, seek social status, or buy top wines as an investment. In any case, high-end variety exporters have the incentive to export to more distant markets and to more heterogeneous consumers, i.e. features that we consistently observe in our data. Specialization towards high-end varieties remains a strategy that allows reaping the benefits from globalization, notably from higher growth rates in emerging economies.

Related aspects are left for future research. First, further work could investigate the effects of genetic distance on different outputs including prices, as proxied by unit values, to test our interpretation in terms of reputational effect of high-quality wine against more classic mechanisms. In particular, theoretical channels through which genetic distance affect trade in wines can be explore starting with mechanisms as modelled in Chen and Juvenal (2016). Second, this would allow us to exploit country heterogeneity along other dimensions (such as endowments, GDP per capita, growth prospect and income inequality) to investigate how different types of wines are exported to different markets. In particular, it is possible that prices vary with the wealth of the importing country (Candau et al., 2017).[27] The quantity allocated to each market may also vary with country characteristics (such as the expected growth, for Asian markets for instance).[28] The French wine sector lends itself to this type of analysis because of a relatively fixed production (especially for regions characterized by small areas of production, such as Burgundy). Finally, one should also consider destination country's characteristics such as income inequality and how demand varies across social/income groups or with genetic diversity within a country. Addressing these questions would require better data, notably more disaggregated information about wine consumption within destination countries.

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[27] Price discrimination has been studied extensively at the domestic level but much less internationally (some exceptions concern the car and pharmaceutical sectors, cf. Malueg and Schwartz 1994).

[28] The rationing of supply as a factor of non-price discrimination is an original path to take since, to our knowledge, quantity discrimination has been rarely studied empirically (theoretically, see the early contribution of Bohm et al., 1983).

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APPENDIX

Figure A1: Evolution of Exports since 1998 (volume and value)

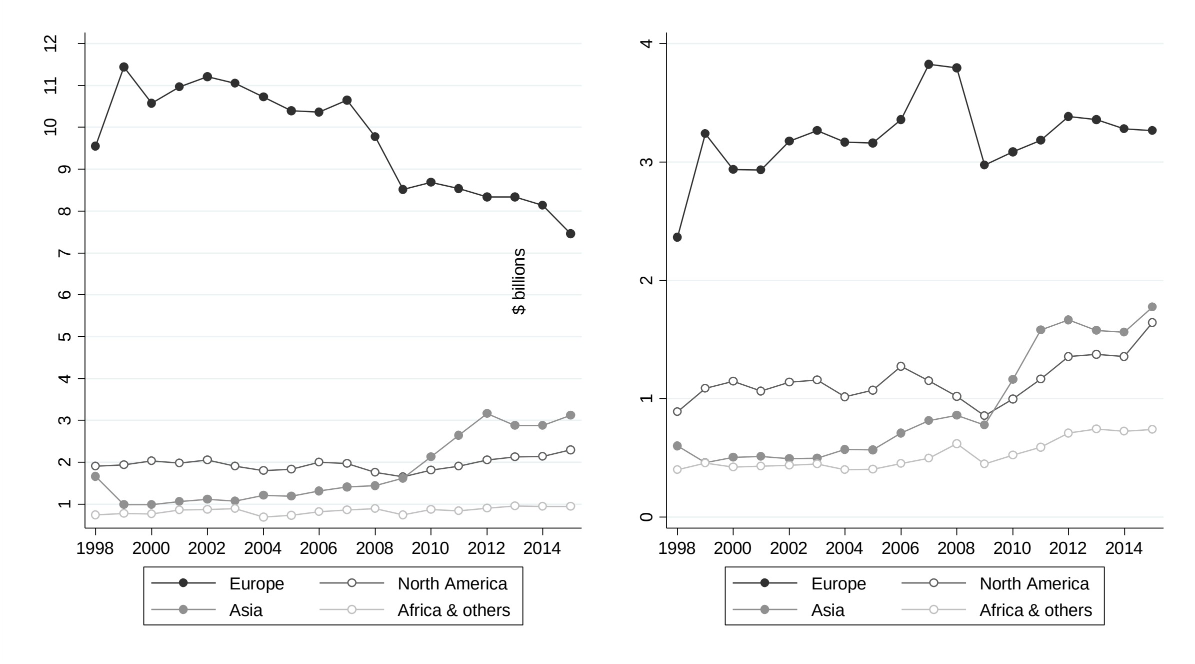

Table A1: Data Sources

Dep. Variable:	Unit / Variable Type	Source
Wine export (value & volume)	million liters	*Fédération des exportateurs de vins et spiritueux* (FEVS)
Explanatory Variables:	**Unit / Variable Type**	**Source**
GDP	2010 PPP$	World Bank indicators (a)
Population		World Bank indicators (a)
Real exchange rate	French franc or euro/LCU	World Bank indicators (a)
Tariffs	Ad Valorem Equivalent	World Bank, WITS (b)
Local wine production	1000 liters	International Org. of Vine and Wine (c)
Geographic distance	Km	CEPII (d)
Common language	dummy	CEPII (d)
Genetic distance	coancestor coefficient	Spolaore and Wacziarg (2016) (e)
Microgeography variables	ruggness, common sea	Nunn and Puga (2012) (f)
Trust	bilateral trust between France and importing countries (EU	Giuso et al. (2009)
Cultural distance		Spolaore and Wacziarg (2016) (e)

(a) databank.worldbank.org/data
(b) World Integrated Trade solution, https://wits.worldbank.org/
(c) http://www.oiv.int/en/
(d) French center for research and expertise on the world economy, www.cepii.fr/CEPII/en/bdd_modele/bdd.asp
(e) www.anderson.ucla.edu/faculty_pages/romain.wacziarg/papersum.html
(f) http://diegopuga.org/data/rugged

Table A2: PPML Estimation of the Gravity Model: Adding Specific Cultural Distances

	Cultural distance (Spolaore and Wacziarg, 2016):				
	life perception	work perception	family perception	politics and society	religion and morale
Log Geogr. Distance	-0.571***	-0.452***	-0.567***	-0.556***	-0.348***
	(0.0576)	(0.0658)	(0.0610)	(0.0565)	(0.0665)
Log Genetic Distance	-0.380***	-0.324***	-0.382***	-0.376***	-0.299***
	(0.0683)	(0.0619)	(0.0668)	(0.0670)	(0.0576)
Log Cultural Distance (values)	0.0316	-0.297***	0.0325	-0.00854	-0.669***
	(0.0462)	(0.0606)	(0.0828)	(0.0529)	(0.0912)
Observations	102,384	102,384	102,384	102,384	102,384
Pseudo R-squared	0.665	0.665	0.665	0.664	0.682
Standard trade determinants	YES	YES	YES	YES	YES
Microgeography	YES	YES	YES	YES	YES
Multilateral resistance variables	YES	YES	YES	YES	YES
Year dummies	YES	YES	YES	YES	YES
Region-Year dummies	YES	YES	YES	YES	YES
Appellation FE	YES	YES	YES	YES	YES

PPML estimations of export volume in level. Standard errors, clustered at country-appellation level, in parentheses. Significance levels: *** p<0.01, ** p<0.05, * p<0.1

Table A3: Physical and Genetic Distance Effects by Quality Levels: Regional Variation

	Geographic distance	Genetic distance	Genetic distance
Log Distance			
x Bordeaux	-0.260***	-0.283***	-0.101
	(0.0599)	(0.0642)	(0.0649)
x Burgundy	-0.165**	-0.226***	-0.0468
	(0.0699)	(0.0716)	(0.0744)
x Loire	-0.567***	-0.510***	-0.323***
	(0.0736)	(0.0625)	(0.0652)
x Languedoc	-0.378***	-0.444***	-0.259***
	(0.0596)	(0.0680)	(0.0665)
x Rhone	-0.431***	-0.473***	-0.287***
	(0.0534)	(0.0545)	(0.0582)
x Others	-0.385***	-0.384***	-0.201***
	(0.0640)	(0.0631)	(0.0661)
Observations	145,044	145,044	145,044
Standard trade determinants	YES	YES	YES
Multilateral resistance variables	YES	YES	YES
Microgeography variables	NO	NO	**YES**
Year dummies	YES	YES	YES
Region-Year dummies	YES	YES	YES
Appellation FE	YES	YES	YES

Note: PPML estimations of export volume in level. Region dummies are absorbed by appellation dummies. Standard errors, clustered at country-appellation level, in parentheses. Significance levels: *** p<0.01, ** p<0.05, * p<0.1

Table A4: Physical and Genetic Distance Effects by Quality Level: Expert Rating

	Geographic distance	Genetic distance	
Log Distance (interacted with information on Parker scores)			
x No grade	-0.398***	-0.423***	-0.238***
	(0.0549)	(0.0562)	(0.0577)
x 1st tercile	-0.311***	-0.342***	-0.159**
	(0.0531)	(0.0590)	(0.0627)
x 2nd tercile	-0.310***	-0.348***	-0.166***
	(0.0484)	(0.0561)	(0.0582)
x 3rd tercile	-0.273***	-0.288***	-0.104*
	(0.0522)	(0.0562)	(0.0582)
Observations	145,044	145,044	145,044
Standard trade determinants	YES	YES	YES
Multilateral resistance variables	YES	YES	YES
Microgeography variables	NO	NO	**YES**
Year dummies	YES	YES	YES
Region-Year dummies	YES	YES	YES
Appellation FE	YES	YES	YES
Test equality of heterogeneous effects (p-value):			
No grade = 3rd tercile	0.01	0.01	0.00
1st tercile = 3rd tercile	0.21	0.17	0.05

PPML estimations of export volume in level. Region dummies are absorbed by appellation dummies. Standard errors, clustered at country-appellation level, in parentheses. Significance levels: *** p<0.01, ** p<0.05, * p<0.1

Table A5: Physical and Genetic Distance Effects by Quality Levels: Regional Variation and Expert Rating

	Geographic distance	Genetic distance	Genetic distance
Log Distance			
x Top Bordeaux (Parker>90)	-0.197***	-0.208***	-0.0254
	(0.0693)	(0.0697)	(0.0709)
x Top Burgundy (Parker>90)	-0.158**	-0.224***	-0.0431
	(0.0772)	(0.0753)	(0.0783)
x Bordeaux (unrated or Parker<90)	-0.300***	-0.332***	-0.151**
	(0.0565)	(0.0630)	(0.0633)
x Burgundy (unrated or Parker<90)	-0.170**	-0.226***	-0.0475
	(0.0682)	(0.0702)	(0.0729)
x Loire	-0.568***	-0.509***	-0.322***
	(0.0736)	(0.0623)	(0.0650)
x Languedoc	-0.378***	-0.443***	-0.258***
	(0.0596)	(0.0678)	(0.0663)
x Rhone	-0.432***	-0.472***	-0.286***
	(0.0534)	(0.0543)	(0.0580)
x Others	-0.385***	-0.383***	-0.200***
	(0.0640)	(0.0629)	(0.0659)
Observations	145,044	145,044	145,044
Standard trade determinants	YES	YES	YES
Multilateral resistance variables	YES	YES	YES
Microgeography variables	NO	NO	**YES**
Year dummies	YES	YES	YES
Region-Year dummies	YES	YES	YES
Designation FE	YES	YES	YES
Test equality of heterogeneous effects (p-value):			
Bordeaux: Parker>90 = unrated or <90	0.01	0.00	0.00
Burgundy: Parker>90 = unrated or <90	0.72	0.93	0.85

Note: PPML estimations of export volume in level. Region dummies are absorbed by appellation dummies. Standard errors, clustered at country-appellation level, in parentheses. Significance levels: *** p<0.01, ** p<0.05, * p<0.1

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