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**Do denominations of origin provide useful quality signals?  
The case of Bordeaux wines<sup>1</sup>**

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**Abstract:**

This paper investigates whether the existing Denominations of Origin (DOs) provide useful quality signals for wine consumers. To test our conjecture that the large number of existing DOs is too many for the typical consumer, we investigate the patterns of co-movement among average monthly wholesale prices for red wines from the 11 main DOs in Bordeaux over 16 years, 1999–2014. Our results indicate that consumers substitute among these wines according to the similarity of semantic elements in the names of DOs on the labels, and not according to prices or terroir that could reflect intrinsic quality where the names as such cannot. This finding suggests that the current DOs are too numerous and complex to provide helpful quality signals to consumers. A substantial reduction of the number of DOs might be warranted to better address the broader informational issue in wine markets.

**Key words:** quality signal, wine, denomination of origin, cointegration, substitution, price

**JEL codes:** C32, D83, Q11, Q18

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## 1. Introduction

While much of our empirical understanding of markets for consumer goods is based on assumptions of perfect markets and homogeneous products, in many cases consumer goods are highly differentiated and the industry attributes are such that models of monopolistic competition seem more appropriate. Along with product differentiation comes the potential for information asymmetries, especially with respect to quality attributes that might not be readily apparent to the buyer, even after purchase. We are dealing with markets that might not work well for differentiated products that may be close but not perfect substitutes. These aspects of markets, which are central to much of the empirical industrial organization literature, make empirical work challenging; likewise, the design of mechanisms to improve market efficiency. In this paper we explore issues of this nature that arise in the market for wine, and the effectiveness of quality signaling mechanisms introduced at least in part to mitigate the consequences of hidden quality variation. We find that the existing Denominations of Origin (DOs) do not provide useful quality signals for wine consumers because there are too many (57 in Bordeaux alone) and they are too complex. As a practical matter and for policy, these findings suggest a substantial reduction of the number of DOs may be warranted to better address the broader informational issue in wine markets.

Wine is one of the most highly differentiated of all consumer goods. Wines are differentiated and labeled according to vintage and variety of grapes used; alcohol content; country of origin, region within country, sub-region, and other geographical identifiers (down to the level of specific vineyards); the winery and in some cases even the winemaker; and for particular winery-specific products—individual wineries might produce a dozen or more distinct wines in a given vintage. While these characteristics are for the most part objective and precise, they do not refer to the characteristics of the wine as such. The wine itself is an “experience” good for which the drinking quality (i.e., sensory characteristics) is unknown to the consumer until after purchase and consumption; and is not something that can be conveyed so clearly or simply as its place of origin,

grape varietal composition, or alcohol content. This is so partly because wine is a horizontally differentiated product in the sense that, as wine consumers, we do not all like the same things, and we do not all agree completely about the ranking of wines or our willingness to pay for particular attributes of wines.

One solution to this information problem is for producers to provide information on the label about how the wine was produced, which consumers can use to try to infer whether they will like it and how much they should pay for it; and this can be supplemented by employing experts to provide independent advice (such as Parker points and commentary) about the wine itself. For this approach to be useful, consumers have to be able to understand enough about the information that producers (and wine raters) do provide on the labels such that they can draw inferences about the wine relative to their personal preferences. In counterpoint to this information problem from the point of view of the consumers is the problem of producers in seeking to earn an appropriate premium from creating a high-quality wine, in a context with asymmetric information. They want to differentiate their products from those of their competitors in the eye of consumers, and earn a premium from doing so, but they also want to claim credit for particular attributes and thus be able to enjoy the benefits from collective reputation associated with their region of production. Wine DOs capture these attributes that wine producers aim to use to differentiate their products. In today's wine market as many as 1,239 different wine DOs exist (International Organisation for Vine and Wine),<sup>1</sup> and information about DOs is included with other information on wine labels.

Wine is highly diverse, in ways that matter to consumers and are reflected on wine labels, whether is it because of *terroir* (referring to characteristics of the soil, terrain, climate and other natural factors associated with the geographic location where the grapes were grown); the varieties (and even the clones within varieties) of grapes grown; the weather pattern during a particular vintage; or the result of a vigneron's style and skill (exercised through management of the vineyard and the winemaking process). But even if every wine was unique, all wines compete with one

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<sup>1</sup> See <http://www.oiv.int/en/databases-and-statistics/database>

another—wines, as horizontally and vertically differentiated products, share some common characteristics, and can satisfy similar wants—, though they may be imperfect substitutes. The aim of this paper, using a time-series econometrics approach applied to Bordeaux wine prices, is to identify which (denominations of) wines are (imperfect) substitutes and the information that serves as the basis of substitution among them in the minds of consumers.

A key point is that wines are both vertically and horizontally differentiated and wine is an experience good, creating information problems. Vertical differentiation of wines has been widely studied by economists, using the hedonic pricing method (related to the Bordeaux case, see for instance Combris et al. 1997, or Cardebat and Figuet, 2004). Horizontal differentiation of wines has received much less attention.<sup>2</sup> If vertical differentiation refers to objective quality, horizontal differentiation has some subjective dimensions. Objective quality can be distinguished from subjective quality (Grunert, 2005). The production process, managed by engineers and food technologists (or in the case of wine, vigneron and wine makers), builds physical characteristics into the product and this set of characteristics can be seen as objective quality. Subjective quality is perceived by the consumer and “can be seen as *mediating* between supply and demand, as it is the perception of the supply of goods that leads to the demand for these goods” (Grunert, 2005, p. 371). Inferring quality from characteristics of the product and from other information has been widely studied in economics and in marketing, in the market signal framework (see Kirmani and Rao, 2000, for a review and a typology of quality signals).<sup>3</sup>

According to the “Sorting Rule Model” developed by Cox (1967), consumers prefer signals that they believe to be predictive of the quality of interest for themselves, and that they feel confident in using (i.e., when they know they make the right inference). Hence, Grunert (2005, p. 377) reminds us that “just giving consumers more information will not reduce asymmetry when consumers do not feel confident about using the information.” It will depend on how consumers use

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<sup>2</sup> Livat (2008), in the case of Bordeaux bulk wines, is an exception.

<sup>3</sup> Research in marketing often employs the term quality cues.

this information.<sup>4</sup> In this article, we consider the wine market, where much information is provided, and the way consumers use quality signals to assess substitutes in an information costs framework.

The wine market employs several different types of quality signals on wine labels: individual and collective, private and public. A denomination of origin is typically used to denote specific production practices and/or specific natural endowments that are understood to have an effect on wine quality (whether taste or some other attribute) as perceived by the consumer.<sup>5</sup> When this origin is certified by the government in the form of an “appellation of origin” (AO, mostly used in Europe) or a denomination of origin (DO), it becomes a public collective quality signal. For instance, the European Commission has introduced legislation that allows producers to market their products with a label stating 'Protected Designation of Origin' (PDO), certified as such by a public agency for products produced in the specified region (throughout this paper we use DO and PDO somewhat interchangeably).<sup>6</sup> This certification of origin can be associated with a brand (Lockshin et al., 2006), sometimes with a medal (Orth and Krška, 2001), a back label (Mueller et al., 2010), or some other attribute used to signal wine product quality. The consumer can also use other sources of information, including ratings and comments published by experts (Dubois and Nauges, 2010),<sup>7</sup> public opinion (Ashenfelter et al., 2007), specific press, and even movies (Cuellar et al., 2009).<sup>8</sup>

This proliferation (and even redundancy) of information, labels and appellations can produce distortions, including consumers' lack of trust (Casini et al., 2008) or misunderstanding (Anania and Nistico, 2004; Marette, 2005). While the economic literature recommends using quality signals as

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<sup>4</sup> For instance, Selnes and Troye (1989) have shown that depending on their own expertise, consumers will use more or less information and different types of information.

<sup>5</sup> For a review of the country-of-origin effect on perceived quality, see Verlegh and Steenkamp (1999). For an analysis of the region-of-origin effect, see Van Ittersum et al. (2003). Armington restrictions have been used extensively to characterize trade in products differentiated by country of origin, a feature incorporated in many CGE models of entire economies, as well as commodity-specific trade models.

<sup>6</sup> In France the agency is the Institut National de l'Origine et de la Qualité (see <http://www.inao.gouv.fr/eng/>).

<sup>7</sup> The role of expert opinion is a much-studied topic in wine economics (Cardebat and Livat, 2016). Wine experts have a significant influence on prices of individual wines (Ali et al., 2008), the calculation of wine price indexes (Masset and Weisskopf, 2018) and the behavior of investors (Aytaç et al., 2018).

<sup>8</sup> The American consumers' boycott of French wines in 2003 is an example of the role of public opinion, and the “sideways effect” is an example of the effect of movies.

instruments for mitigating information asymmetry, the proliferation of such signals generates information costs for consumers: they have to search for the signals, process them, and use them to make decisions, all of which can be costly. As a consequence, on the demand side of the market, it is rational for the consumer to remain at least somewhat uninformed because of the costs of information, primarily opportunity costs of information processing, especially in the food industry (McCluskey and Swinnen, 2004; Swinnen et al., 2005).<sup>9</sup>

This paper seeks to assess whether wine consumers understand and use the information conveyed by PDOs. The approach consists in seeking to identify which wines are perceived as substitutes by consumers, and the roles of PDOs in product differentiation: if wines from two different denominations of origin are perceived as perfectly substitutable by consumers, then they have missed their target of differentiation; alternatively if the system of PDOs conveys complete (relevant and useful) information to consumers then each PDO would be seen as distinct, and different PDOs would be complementary to one another in differentiating wines. A time-series econometrics approach is applied to an exhaustive and unique database on Bordeaux wine prices obtained from the CIVB (Conseil Interprofessionnel du Vin de Bordeaux), to analyze substitution relationships among Bordeaux PDOs over the period 1999–2013.

There are 16 grand vineyard areas in France, and 357 Protected Designations of Origin for French wines, including 57 just in the Bordeaux region (see Appendix 1 for a map). Our hypothesis is that such a large number of DOs represents too much information for most consumers and that, therefore, consumers will use characteristics other than DOs to distinguish between wines and will treat some wines coming from different DOs as (quasi) perfect substitutes. To test this conjecture, we investigate the cointegrating vectors among a set of price series for the 11 DOs that are the highest-traded producers of Bordeaux red wines. We test three alternative hypotheses about which

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<sup>9</sup> As Stigler (1967, p. 291) put it: “Information costs are the costs of transportation from ignorance to omniscience, and seldom can a trader afford to take the entire trip.”

information on the labels consumers use to compare and choose among wines, including (1) *terroir*, (2) prices, or (3) semantics (denominations and names).

The results suggest that consumers substitute among Bordeaux DOs primarily according to semantic elements (i.e., treating similar names as carriers of reputation). As such, substitution exists and there is a kind of competition among Bordeaux wines, but the tradeoffs among wines are driven by names more than *terroir* or price. This result confirms that the current DOs, which may well serve a small minority of cognoscenti among producers and consumers, are too complex to address the broader informational issue in wine markets. Therefore, the findings suggest that consumers and producers would benefit from a simplification of the PDO system in the Bordeaux region—perhaps modeled after the recent reform of the Prosecco DO. Such simplification might be based sensibly on the merger of some denominations that have similar names and produce similar wines. This finding could be extended to other wine regions or to other highly differentiated agricultural products, like cheese, both in France and in other countries (e.g., Spain, Italy). It might provide a basis for some policy reforms, such as a simplification of the PDO system in Europe to provide more useful information to consumers more economically.

The article is organized as follows: section 2 discusses the literature on PDOs and information costs; section 3 discusses the literature on substitution between goods and cointegration of prices; section 4 presents our data and empirical analysis; section 5 presents our results; and section 6 discusses the main findings and concludes.

## **2. Protected designation of origin and information costs**



Wine is a typical experience good and wine markets exhibit imperfect information. In many countries, the public sector provides certification of origin to address the information problem.<sup>10</sup> France created the first European label of origin system, the *appellation d'origine contrôlée* (AOC).<sup>11</sup> The AOC was conceived as a protected designation of origin (PDO), i.e. a geographic indication certified by the government: "Products covered by AOC labels are controlled by the state to ensure both their territorial origin and their conformity to precise rules for production and processing that guarantee their 'typicity,' or distinctive character" (Barham, 2003, p. 128). The aim of AOC labeling is to represent *terroir* (Barham, 2003), which refers to natural qualities of a geographic area (soil, microclimate, slope, exposure, and so on) blended with human factors (know-how or particular techniques confined to that area) and history (public knowledge of a product as originating in that area, recognition of the association between product and place).<sup>12</sup> Certification of origin has been applied to other agricultural products, in addition to wine (including cheese, meat, lavender, lentils, honey, ham, butter, and spirits), and the number of products benefiting from a protected designation of origin is increasing in Europe (Profeta et al., 2010).

In the case of wine, in addition to being produced in a defined geographic area, qualifying for an AOC may also require wine to conform to technological restrictions, such as the grape varieties used to produce it, the maximum yields per hectare, the alcohol percentage, or particular viticultural practices used. Since 2008, the system has been similar to that of taxes, where the winemaker must declare that the wine has been produced in accordance with AOC requirements, and producers are subject to random audits. A given brand can lose its AOC status for a given vintage.<sup>13</sup> Spain and Italy

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<sup>10</sup> While economists usually consider Geographic Indications as collective quality signals (Bramley and Kristen, 2009), Broude (2005) views them as a tool to protect cultural heritage and preserve traditional methods of production; to establish and preserve an identity.

<sup>11</sup> Laws passed in 1919, 1927 and 1935 allowed the creation of this system. Meloni and Swinnen (2013) discuss the political and policy context in which quality regulations were introduced, with their essential purpose at the time being to create a barrier to entry and restrict competition from surging imports, especially Algerian wine.

<sup>12</sup> Josling (2006) discusses trade issues between the United States and the EU associated with *terroir*.

<sup>13</sup> For instance "Les Hauts de Pontet-Canet" is usually awarded with a Pauillac appellation but did not get it for the 2012 vintage: <http://www.decanter.com/news/wine-news/587659/pontet-canet-second-wine-loses-aoc>

have developed similar systems, instituted in, 1932 and 1963: *denominación de origen* and *denominazione di origine controllata*. The system of American Viticultural Areas (AVAs), introduced in the United States in 1979, was inspired by the French AOC model.

Stanziani (2004), who studied the emergence of the AOC system in France, considers them as collective brands, which arise when neither the market alone nor the private individual quality signals provide efficient information on the quality of goods. For Meloni and Swinnen (2013), given that consumers have imperfect information and high ex ante costs of monitoring wine quality, regulations like the AOC system that promise a specific set of attributes or reduce information costs can improve welfare. Menapace and Moschini (2011) have shown that this kind of credible certification scheme reduces the cost of establishing reputation, compared with a situation in which only private brands are established, and improves the reputation mechanism of quality assurance.

Geographic Indications (GIs) are viewed as public (or collective) goods since they are used simultaneously by many firms that are free to enter and exit the market, provided they meet all requirements (Moschini et al., 2008). Rangnekar (2004) views them as "club goods," non-rival, congestible and excludable, where producers are free collectively to decide the size of the club. Binding a brand to a territory also generates a rent for some groups of producers who have access to key assets or skills required to qualify for the certification or the AOC, such as the land and vineyard, which may come to some extent at the expense of owners of land and vineyards in neighboring regions that do not qualify for the certification (Meloni and Swinnen, 2013).

Teil (2010) suggests that, since their creation, AOCs have been suspected of not conveying reliable information. Nevertheless, their use is expanding in the world and they coexist with many other strategies used for signaling quality. As a consequence, the wine market has become a complex one hosting hundreds of thousands of brands and other quality signals. We thus can consider that

information costs in the wine market have become partially processing costs in the (implicit) market for wine information.

To Barzel (1982, 1985), information costs are at the heart of transaction costs, especially when producers can cheat and manipulate product attributes. These information costs are associated with measurement of quality, and they increase with the accuracy of measurement. Wine exhibits severe quality measurement problems given that the relevant product characteristics are hard to observe before purchase (Barzel, 1982), and sometimes even after consumption in the case of confidence characteristics. In this view, informational issues are not exogenous, i.e. dependent only on the good's characteristics. The informational content of the characteristics of a particular wine may change or evolve according to the extent of knowledge or expertise, and the past experience of the potential buyers.

One can also argue that this measurement is the result of a perception process, as summarized by Lévy-Garboua in a theory of the formation of choice (1979, p. 101): "individuals are confronted with a collection of alternatives, e.g. goods, and [...] they attempt to make the best choice by basing their evaluation of these alternatives solely on perceived objects of choice (or characteristics or information)." Lévy-Garboua (1976, 1979) adds that this selection procedure is sequential and stops once the marginal cost of the search equals or exceeds the expected marginal returns. According to him, the consumer will incur costs of (i) prospecting (associated with visiting the markets and identifying the substitutes), (ii) assessment (associated with verifying the authenticity of quality signals), and (iii) perception (associated with the identification of relevant or decisive characteristics). Hence, the subjective assessment of quality depends on the relative costs of accessing and understanding the different signals. Similar reasoning was developed more recently by McCluskey and Swinnen (2004) in terms of the 'Rationally Ignorant Consumer' hypothesis under which consumers will choose to stay imperfectly informed despite the existence of quality signals if the increase in income from more information is less than the cost of information. Even when information is free, processing the information entails an opportunity cost that can be larger than the

marginal benefit. Lastly, differences in preferences for particular attributes may mean that the information conveyed by particular media or using particular signals that is useful for some consumers is irrelevant for others (or worse and can even generate disutility).

Quality signals developed by producers can also change the order in which signals are perceived and generate an illusion effect. On wine markets, given the high degree of vertical and horizontal differentiation, signals compete to get the consumer's attention. Some are private, others are public signals; some are individual, others are collective. Some also require specific skills, on the demand side, to be interpreted in the right way. As a consequence, it may be difficult to interpret information about origin or other attributes correctly (Grunert, 2005). In such a context, the consumer will not necessarily see as substitutes wines that are truly similar in their objective characteristics (i.e., wines with PDOs that guarantee similar characteristics of their production processes and promise consequentially similar intrinsic properties).

### **3. Substitution of goods and cointegration of prices**

In the context of structural demand system models, goods that are substitutes have positive cross-price elasticities of demand, and for closer substitutes these elasticities are larger numbers. One approach for studying substitution relationships in consumer demand, then, would be to estimate these elasticities in a demand system model, such as the Rotterdam model, developed jointly by Theil (1965, 1975/1976) and Barten (1965), or the Almost Ideal Demand System (AIDS) proposed by Deaton and Muellbauer (1980). Several versions of these models have been applied to the demand for alcohol (for a survey in the case of beer, wine and spirits, see Fogarty, 2010; for a meta-analysis approach, see Fogarty, 2006). However, this approach requires access to detailed data on quantities and prices of the goods of interest, and it can be very challenging when the number of good to be studied is large. Indeed, although cross-price elasticities that can be derived from demand equations might seem to be the most natural measure of cross-price effects, the data necessary to

generate good estimates are usually difficult to obtain, even when good data are available on market prices (Asche et al., 2004). Another, more tractable approach for investigating substitution relationships is based on statistical characteristics of price series (Dronne and Tavéra, 1992).<sup>14</sup> In this article, we focus on analysis of price transmission relationships, a classical topic in agricultural economics, as a way of investigating the nature and extent of substitution among differentiated products.

Identifying substitutes allows a market to be defined, especially when the relative prices maintain a stable ratio (Stigler and Sherwin, 1985). In other words, prices of substitute commodities belonging to the same market should exhibit a stable long-run relationship or co-movement, i.e. they should be cointegrated. The degree of substitution between potentially competing products has been studied using analysis of cointegration of prices, especially in the case of seafood markets (see among others Hannesson, 1994; Bose and McIlgorm, 1996; Asche et al., 1997; Bada and Rahji, 2010; Jaffry et al., 2000). To motivate our price-based definition of a market, we develop the arguments presented by Bose and McIlgorm (1996, p. 145) and by Asche et al. (2004, pp. 198-199).

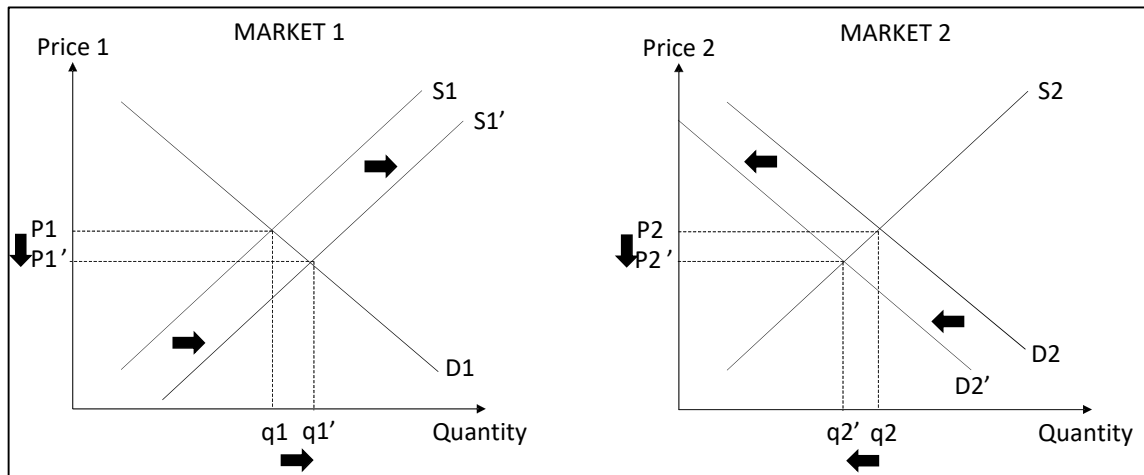
Let us consider the markets for two different goods in equilibrium at a price normalized at  $p_1 = p_2 = p$ , as in figure 1. The goods are related in consumption, as substitutes, but their supplies are mutually independent. Imagine a supply shock in the market for good 1 that shifts the supply curve from  $S_1$  to  $S_1'$  (i.e., supply increases). If nothing else changes, the new equilibrium is  $(p_1', q_1')$  with a lower price and larger quantity for good 1. But, assuming the two goods are substitutes, the decrease in price for good 1 causes a decrease in demand for good 2, with the extent of the shift being greater if the two goods are closer substitutes. This causes a fall in the price of good 2. In turn, the fall in price of good 2 feeds back into the demand for good 1. Eventually a new equilibrium is established, with prices of both goods lower than the initial price,  $p_1 = p_2 = p$ . If the two goods are perfect substitutes, the new equilibrium has both markets at the same (normalized) price. If the goods are

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<sup>14</sup> A cointegration approach can also be implemented to investigate substitution in a macroeconomic context. Auteri and Constantini (2010) apply it to investigate substitution between government and private consumption.

imperfect substitutes, as drawn in figure 1, the price for good 2 will have fallen somewhat, but not enough to equate prices across the two markets (the final prices are  $p_1''$ , between  $p_1$  and  $p_1'$  and  $p_2''$ , between  $p_2$  and  $p_2'$ ).

**Figure 1: Potential interaction between two markets**



As a result of this price feedback relationship, prices in the two markets exhibit cointegration; they should not diverge from one another to a great extent in the long run (Granger, 1986). The strength of this relationship will depend on how closely the two goods substitute for one another: if they are unrelated in consumption, then the relationship does not exist; if they are perfect substitutes, then we have the special case of the Law of One Price; more generally we will find ourselves somewhere in between these two extremes. The patterns of co-movement of prices will also depend to some extent on the sources of price variation—whether they derive from the supply side or the demand side of the market—along with the determinants of the elasticities that translate shocks into price changes, in the price transmission relationships, and the underlying elasticities themselves. In our particular application, the relevant elasticity of supply for any particular wine is zero. Specific results for this case are developed in Appendix 2.

We use a vector error correction model (VECM), as shown in equation (1), to examine the nature of cointegration (as an indicator of substitutability) among prices of wines in the Bordeaux region, as an example of PDOs for wine. A VECM model is appropriate if each variable is non-

stationary and integrated to degree 1 (written I(1)) and if the variables taken into account are cointegrated, meaning that their linear combination is stationary (Engle and Granger, 1987).

$$\Delta P_t = \sum_{j=1}^{k-1} \Gamma_j \Delta P_{t-j} + \Gamma_k P_{t-k} + \mu + \delta_t \quad (1)$$

$$\text{with } \Gamma_k = \alpha\beta' \quad (2)$$

where  $P_t$  is a vector of prices,  $\beta$  represents the cointegrating equations—i.e., the long-run equilibrium relationships between variables, and  $\alpha$  represents the error-correction adjustment—i.e., the short-run speed of adjustment following a deviation from the long-run equilibrium relationship (Johansen and Juselius, 1990). If the prices are expressed in logarithms, the  $\beta$  coefficients are the long-run elasticities of prices with respect to the price used to normalize the cointegrating equations. Said differently, the  $\beta$  coefficients are the long-run elasticities of price transmission. In the case of substitution between the goods, the expected value is positive, as described in figure 1 where both prices move together. The  $\Gamma_j$  matrix contains some autoregressive terms and the short-run price dynamics.

This kind of modeling is appropriate to detect substitution among differentiated products when supply is exogenous, which is reasonably the case for aggregate bulk wine at or close to vintage. In this case, price movements are mainly caused by demand-side factors. The  $\beta$  coefficients will signify whether Bordeaux wine consumers regard Bordeaux denominations as substitutes. If two DOs are close (or perfect) substitutes they could be merged because keeping them separate does not add anything in terms of information to the consumer, and in fact increases the costs of choice.

The main issue is identifying cointegrated prices—i.e., in our case, the wines that belong to the same long-term relationship or cointegrating vector. Wickens (1996) stresses the necessity to incorporate *a priori* information in order to identify cointegrating vectors and permit them to be given an economic interpretation. The same idea is noted by Lloyd et al. (2006, p. 24), for whom "in the absence of further restrictions, the long-run relations that have been detected are unidentified

and merely represent statistical rather than meaningful economic relationships." In the next section, we present our data and the different theoretical *a priori* restrictions that we impose and test empirically.

#### 4. Data and empirical strategy

We have data on average monthly real wholesale prices per barrel for every Bordeaux DO from August 1999 to October 2013 (171 observations), provided by the *Conseil Interprofessionnel du Vin de Bordeaux* (CIVB), a trade body that records all the transactions among wine producers and wine merchants. These prices come from the spot market and differ from the final consumer prices, which are usually higher with an average 15% mark-up plus the cost of the bottling. Prices are available for 57 DOs, including red, white and rosé sometimes for the same denomination name (i.e., the PDO rules treat Bordeaux red and Bordeaux white as two separate DOs). The Appendix presents some description about the locality of these 57 DOs and the volume traded per month on average over the period.

Because many of the price series exhibit a lot of missing observations (months without enough transactions or with no transactions at all), we decided to include only those DOs for which we observe at least 10 contracts (on average) per month. This average number of contracts guarantees a quasi-absence of missing data, as shown in Appendix 3, and ensures the representativeness of the average price.<sup>15</sup> We also chose, for *a priori* reasons, to study substitution among only red wines. However, as a robustness check, we also test for substitutability between different colors of wine. The resulting sample includes prices for wines with the following DOs: Bordeaux Rouge, Bordeaux Supérieur, Côtes de Bourg, Côtes de Blaye, Côtes de Castillon, Graves, Médoc, Haut-Médoc, Lussac Saint-Emilion, Montagne Saint-Emilion, Saint-Emilion (see figure 2).

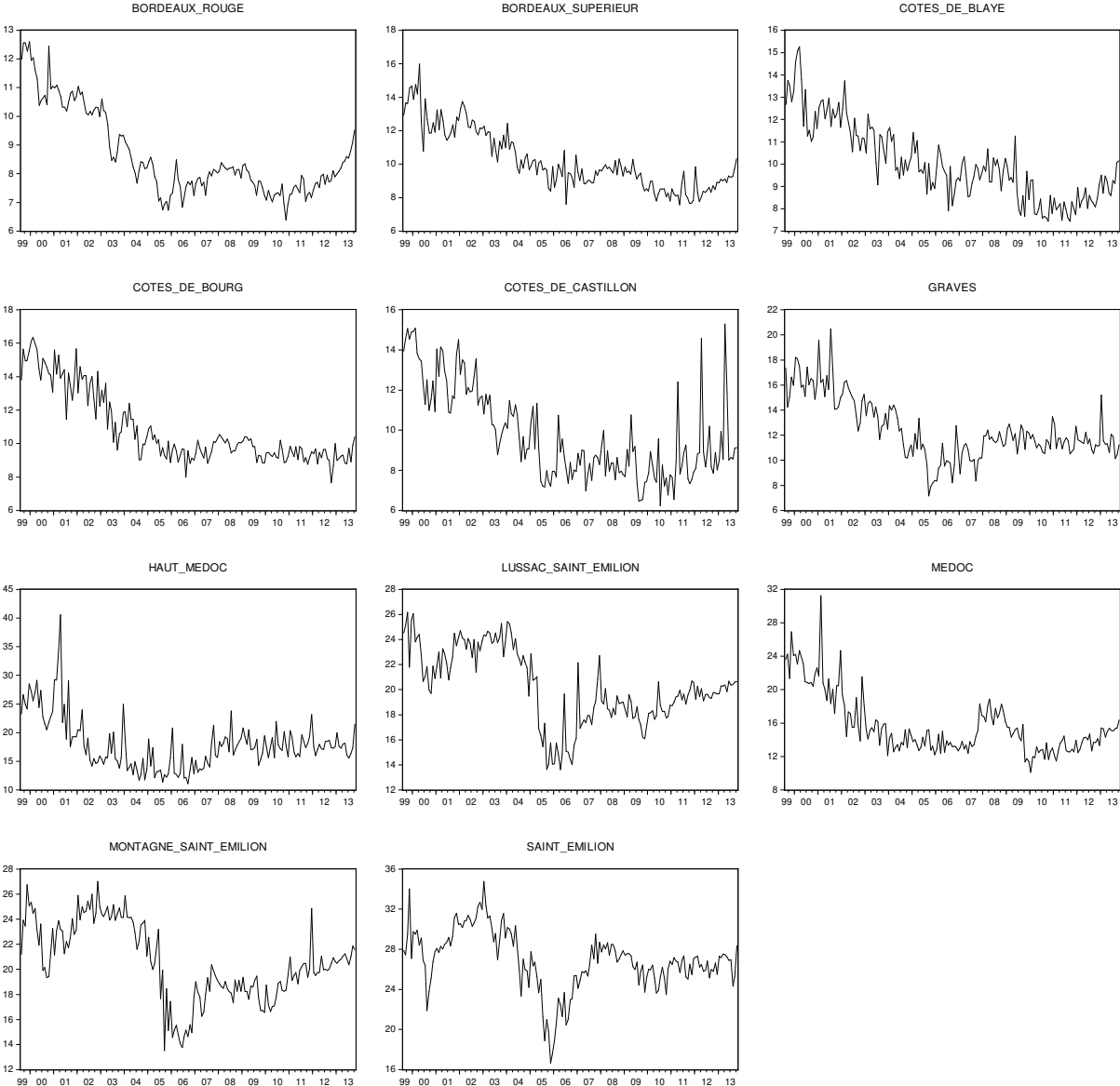
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<sup>15</sup> The CIVB publishes a monthly average price only for those months in which they observe at least four contracts, to ensure representativeness and preserve confidentiality. Appendix 3 shows the average number of contracts per month for each Bordeaux DO and presents a table that summarizes the trade-off between the number of DOs for red wines included in the analysis, and the extent of missing data.



Table 1 provides a description of the vineyard characteristics for these 11 denominations of origin, which all produce red wines and account for 80% of the entire production of Bordeaux wines on average over the past 10 years (including white and rosé wines). The total sample includes 171 monthly observations from each of these 11 DOs for red wines, plus 171 monthly observations for Bordeaux blanc (white wines).

**Figure 2: Real monthly wholesale prices of Bordeaux red wines, per DO, 1999–2013**



**Table 1: Vineyard characteristics for 11 DOs of red Bordeaux wines**

DO	Type of DO	Location	Average grape varietal mix for red wines (%)		
			Merlot	Cabernet Sauvignon	Cabernet Franc
Bordeaux rouge	Region	All vineyards	45	33	22
Bordeaux Supérieur	Region	All vineyards	45	33	22
Côtes de Castillon	Local	East Libourne	69	12	19
Côtes de Bourg	Local	Blaye	70	24	6
Côtes de Blaye	Local	Blaye	70	24	6
Graves	Sub-region	South West	60	15	25
Médoc	Sub-region	North West	40	54	6
Haut-Médoc	Sub-region	North West	35	55	10
Lussac	Local	East Libourne	65	10	25
Montagne	Local	East Libourne	75	5	20
Saint-Emilion	Local	East Libourne	60	10	30

The ADF test is used to test whether the variables are stationary or not. We then undertake a cointegration analysis using the procedure developed by Johansen (1995) to estimate the VECM. This procedure allows us first to find the number of groups, taking the view that wines belonging to the same cointegrating vector can be seen potentially as a single market. Then, it permits us to identify the specific groups (i.e., the cointegrating vectors) implied by alternative sets of *a priori* assumptions about which of the wines are seen by consumers as substitutes (see below). Lastly, the cointegrating vectors are estimated and the signs of coefficients indicate whether particular categories of wines are substitutes.

We propose three different sets of theoretical priors that will be tested to identify the cointegrating vectors. Specifically, under the hypothesis that consumers identify as substitutes groups of wines with similar features, we will test three alternative hypotheses about the basis for that grouping of wines: (1) similar *terroir*, (2) price proximity, and (3) semantic closeness. Different sets of restrictions are imposed on the cointegrating vectors to represent and thus test these hypotheses.

According to the *terroir* hypothesis (1), consumers regard as substitutes wines that have similar intrinsic properties. A wine's intrinsic characteristics depend on its *terroir* and the winemakers' technique. In the Bordeaux region (and more generally throughout the "old-world" wine industry), these aspects are to some extent summarized in the DO (see Barham, 2003; Spielman

and Gélinas-Chebat, 2012). Specifically, each DO is associated with a given *terroir* and regulations over its viticultural practices (e.g., maximum yield, grape varieties allowed in the area, distance between the rows of vines, allowable winemaking practices, and so on). In this way every DO seeks to ensure the wine's quality and its "typicity" or specific taste. Hence, we can postulate that consumers group together and perceive as substitutes denominations that use similar grape varietal mixes and are close geographically (i.e., with similar soil and weather conditions). This hypothesis presumes that consumers are well informed or that they are able to identify the quality signals conveyed by the DOs and to use them as intended. The *terroir* hypothesis relies on efficient signaling, associated with low information costs, but does not presume full information. We identify groups of denominations based on descriptions of their objective characteristics (location as a proxy for soil and climate, varieties, and average mixes, see table 1).

Hypothesis (2) proposes that consumers use price to compare wines. In other words, within the class of red wines from Bordeaux, wines that are similar in price will be considered as able to satisfy similar wants. Price is often the main source of information for ill-informed consumers, especially for experience goods like wine (Durham et al., 2004). The empirical marketing literature identifies price as a primary driver of wine purchase intention, especially for "low involvement" consumers (Hollebeck et al., 2007; Lockshin et al., 2006; Ritchie et al., 2010). This means indirectly that consumers do not use the other quality signals. The price proximity hypothesis relies on high information costs associated with wine market quality signals. We use a clustering of price series (k-means applied to mean price, see table 4 below) to identify groups of denominations.

Hypothesis (3) emphasizes reputation as a key variable in wine markets. The idea of names as carriers of reputation has been explored by Tadelis (1999). Many researchers have identified reputation, either individual or collective, as a relevant determinant of wine prices (see, among many others, Landon and Smith, 1998). This finding confirms that consumers lack specific information on wine quality and are willing to use quality signals. Here we suppose that, given the complexity of these signals, the consumer compares DOs according to their names. A regional brand name is

conceived as a support for collective reputation (Winfrey and McCluskey, 2005; Castriota and Delmastro, 2014). In our sample, several DOs share the same words—such as *Saint-Emilion*, *Médoc* and *Côtes*, which all refer to sub-regional areas in the Bordeaux vineyard—, even if the wines concerned are objectively or intrinsically dissimilar. Sharing a name appears to be a mechanism for informational leverage, as in the case of brand extension (Choi, 1998) or of umbrella branding (Hakenes and Peitz, 2008): consumers can be expected to draw inferences about the characteristics of one product from observations of the characteristics of others sold under the same umbrella brand, especially in the absence of other information. They might consider that two DOs sharing a common word should also share some quality characteristics. This hypothesis supposes that consumers are not well-informed by other signals and that they use something simpler and thus less costly in terms of information processing.

## **5. Results and discussion**

We run the ADF test to verify if the price series have a unit-root (table 2). The Schwarz information criterion (SIC) is applied to determine the optimal lag length, which seems appropriate given the sample size and data frequency (Ivanov and Kilian, 2001; Liew, 2004). The test suggests that each of our price series has a unit-root and thus that the VECM is appropriate.

**Table 2: Unit Root test (ADF) applied to prices**

Denomination of Origin	ADF test (Log, intercept)		
	t-Statistic	p-value	Lags (SIC)
Bordeaux Rouge	-2.29	0.175	0
Bordeaux Supérieur	-1.98	0.293	2
C. de Castillon	-2.20	0.205	11
C. de Blaye	-2.66	0.084	1
C. de Bourg	-2.00	0.285	2
Graves	-2.28	0.179	2
Haut Médoc	-3.70*	0.005	1
Lussac	-2.40	0.142	2
Médoc	-2.20	0.207	2
Montagne	-1.98	0.297	1
Saint-Emilion	-3.49*	0.009	0

\* becomes I(1) when there the test equation is estimated without an intercept

We apply the Trace test and the Maximum Eigenvalue test (Johansen, 1995), which perform similarly (Lütkepohl et al., 2001), to determine the number of cointegrating relations or vectors. Given that identifying the true data-generating process is quite difficult (Dolado et al., 1990), several specifications are tested, depending on the kind of trend in the data and on the inclusion of an intercept and/or a trend in the cointegrating relation. The results, for two lags, are presented in table 3. The number of cointegrating relations varies from four to six, depending on the model specification. We consider that five cointegrating relations exist in our sample, given that this result occurs with the highest frequency.

**Table 3: Number of cointegrating relations**

<b>Model specification (lag length=2)</b>						
Data trend	none	none	linear	linear	quadratic	
Intercept in the cointegrating relation	no	yes	yes	yes	yes	
Trend in the cointegrating relation	no	no	no	yes	yes	
<b>Johansen cointegration test*</b>						
Trace test	5	5	6	5	5	
Maximum-eigenvalue	5	4	4	5	5	

\*critical values based on MacKinnon-Haug-Michelis (1999), 5% level.

As recommended by Wickens (1996) and Lloyd et al. (2006), we now test three sets of restrictions, associated with our three alternative hypotheses, to interpret economically the different cointegrating vectors and in particular to explore the nature of substitution relationships among Bordeaux wines. According to hypothesis 1, denominations with a similar *terroir* belong to the same market. In our sample, the four groups of DOs are: (i) Côtes de Castillon, Lussac Saint-Emilion, Montagne Saint-Emilion, and Saint-Emilion with a majority of merlot and a similar location, (ii) Haut-Médoc and Médoc with a majority of Cabernet Sauvignon and both located in the north-west of the Bordeaux region, (iii) Côtes de Blaye and Côtes de Bourg that both exhibit the same average grape variety mix and a location near the city of Blaye, and (iv) Bordeaux rouge and Bordeaux Supérieur, which share similar characteristics (see table 1). To obtain a specification with five cointegrating relationships, we add a vector, which is a linear combination of the others and does not have any actual economic meaning. This technical device is commonly used (see for instance Vogelvang, 1992, pp. 199-200).

To define a set of priors associated with the price hypothesis (hypothesis 2), we conduct a k-means clustering based on mean for five groups, as suggested by the Trace and Maximum-eigenvalue tests (see above). The results, as well as some descriptive statistics, are presented in table 4. The clustering highlights four groups of several DOs and a fifth one with Saint-Emilion, which is single (as such, it is not considered as a cointegrating vector). As before, we add a fifth vector, which is a linear combination of some others.

**Table 4: k-means applied to prices**

DO	Mean	Median	Maximum	Minimum	Std. Dev.	Cluster (kmeans)
<b>Bordeaux Rouge</b>	2.14	2.10	2.53	1.85	0.16	1
<b>Bordeaux Supérieur</b>	2.31	2.27	2.77	2.02	0.17	1
<b>C. de Castillon</b>	2.26	2.20	2.73	1.83	0.22	1
<b>C. de Blaye</b>	2.29	2.28	2.73	2.01	0.17	1
<b>C. de Bourg</b>	2.37	2.30	2.79	2.04	0.18	2
<b>Graves</b>	2.51	2.46	3.02	1.97	0.19	2
<b>Haut Médoc</b>	2.86	2.86	3.70	2.41	0.23	3
<b>Lussac</b>	3	2.99	3.26	2.61	0.15	4
<b>Médoc</b>	2.73	2.69	3.44	2.31	0.21	3
<b>Montagne</b>	3.01	3.01	3.30	2.60	0.15	4
<b>Saint-Emilion</b>	3.29	3.29	3.55	2.81	0.12	5

According to the semantic hypothesis (3), consumers might consider wines to be similar if they come from denominations sharing a word in the name. In our sample, groups of denominations based on semantic similarities include: (i) Bordeaux rouge and Bordeaux Supérieur sharing the word “Bordeaux,” (ii) Côtes de Castillon, Côtes de Blaye and Côtes de Bourg sharing the word “Côtes,” (iii) Lussac Saint-Emilion, Montagne Saint-Emilion and Saint-Emilion sharing the words “Saint-Emilion,” and (iv) Haut-Médoc and Médoc sharing the word “Médoc.” A fifth vector is a linear combination of two groups.

Our three hypotheses and the corresponding test results are summarized in table 5 (the added fifth vectors are not normalized given that they do not have any economic meaning). The semantic hypothesis is accepted while both the *terroir* hypothesis and the price hypothesis are rejected. It seems, therefore, that consumers assess (and choose) wines according to the names of their denominations —i.e., reputation. To reach more specific conclusions regarding substitution relationships among DOs with similar names, the cointegrating vectors have to be estimated. The results from estimating the normalized cointegrating vectors are presented in table 6 (the full estimation results, including the autoregressive part of the VECM, are available from the authors upon request).

**Table 5: Test of the cointegrating vectors**

	Terroir hypothesis					Price hypothesis					Semantic hypothesis				
	Vector 1	Vector 2	Vector 3	Vector 4	Vector 5	Vector 1	Vector 2	Vector 3	Vector 4	Vector 5	Vector 1	Vector 2	Vector 3	Vector 4	Vector 5
<b>DO</b>	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
Bordeaux Rouge	0	0	0	1	0	1	0	0	0	0	1	0	0	0	$\beta_{51}$
Bordeaux Supérieur	0	0	0	$\beta_{43}$	0	$\beta_{12}$	0	0	0	0	$\beta_{12}$	0	0	0	$\beta_{52}$
Côtes de Castillon	$\beta_{13}$	0	0	0	0	$\beta_{13}$	0	0	0	0	0	1	0	0	$\beta_{53}$
Côtes de Blaye	0	0	1	0	$\beta_{54}$	$\beta_{14}$	0	0	0	0	0	$\beta_{24}$	0	0	$\beta_{54}$
Côtes de Bourg	0	0	$\beta_{35}$	0	$\beta_{55}$	0	1	0	0	$\beta_{55}$	0	$\beta_{25}$	0	0	$\beta_{55}$
Graves rouge	0	0	0	0	0	0	$\beta_{26}$	0	0	$\beta_{56}$	0	0	0	0	0
Haut-Médoc	0	$\beta_{27}$	0	0	$\beta_{57}$	0	0	1	0	$\beta_{57}$	0	0	$\beta_{37}$	0	$\beta_{57}$
Médoc	0	1	0	0	$\beta_{58}$	0	0	$\beta_{38}$	0	$\beta_{58}$	0	0	1	0	$\beta_{58}$
Lussac	$\beta_{19}$	0	0	0	0	0	0	0	1	0	0	0	0	1	$\beta_{59}$
Montagne	$\beta_{110}$	0	0	0	0	0	0	0	$\beta_{410}$	0	0	0	$\beta_{410}$	0	$\beta_{510}$
Saint Emilion	1	0	0	0	0	0	0	0	0	0	0	0	$\beta_{411}$	0	$\beta_{511}$
Intercept	$c_1$	$c_2$	$c_3$	$c_4$	$c_5$	$c_1$	$c_2$	$c_3$	$c_4$	$c_5$	$c_1$	$c_2$	$c_3$	$c_4$	$c_5$
Chi-square(2)	111.36**					114.28*					85.64				
Probability	0.014					0.008					0.188				
	H0 is rejected					H0 is rejected					H0 is accepted				

\*, \*\* Significant at, respectively, 1 and 5% (the restrictions are rejected and do not allow to identify the cointegrating vectors).



**Table 6: Estimated cointegrating vectors according to the semantic hypothesis**

DO	Vector 1	Vector 2	Vector 3	Vector 4	Vector 5
Bordeaux Rouge	1	0	0	0	-0.000
Bordeaux Supérieur	-1.138	0	0	0	0.000
Côtes de Castillon	0	1	0	0	-0.000
Côtes de Blaye	0	-1.02	0	0	0.000
Côtes de Bourg	0	-0.336	0	0	0.000
Graves rouge	0	0	0	0	0
Haut-Médoc	0	0	-1.099	0	-0.000
Médoc	0	0	1	0	-0.000
Lussac	0	0	0	1	-0.000
Montagne	0	0	0	-0.786	0.000
Saint Emilion	0	0	0	-0.32	-0.000
Intercept	0.485	0.876	0.418	0.426	-0.000

If consumers do perceive the denominations under consideration as substitutes, all but one of the estimated coefficients must take the same value, either negative or positive. For instance, considering vector 1, it can be written

$$\text{Bordeaux Rouge} - 1.138 \text{ Bordeaux Supérieur} + 0.485 = 0 \quad (3)$$

We can rearrange this equation to get a better understanding of the relationship between the price of Bordeaux Rouge and the price of Bordeaux Supérieur:

$$\text{Bordeaux Rouge} = 1.138 \text{ Bordeaux Supérieur} - 0.485 \quad (4)$$

This result means that when the price of Bordeaux Rouge increases, the price of Bordeaux Supérieur also increases as a result of increased demand for Bordeaux Supérieur, given that supply is exogenous.

For vectors 1 to 4 (vector 5 is not interpreted) in table 6, compared with the appellation chosen for normalization, all the estimated coefficients are negative: when the price of the appellation used to normalize increases, the price of the other denomination(s) that belong(s) to the same vector also increase(s). This result is consistent with the idea of substitution. The sensitivity of prices ranges from  $-0.32$  (for Saint-Emilion in vector 4) to  $-1.138$  (for Bordeaux Supérieur in vector 1), suggesting that the way consumers substitute between denominations is not uniform. Results presented in tables 5 and 6 confirm that consumers are not well informed about DOs, and in

particular that they do not use the denominations in the intended way. It seems easier or less costly for consumers to rely on the names of the denominations to group wines to be treated as substitutes than to obtain and use information about the intrinsic characteristics as conveyed by the organization of the DO.

### ***Robustness check***

To take the semantic hypothesis further, we can imagine a situation in which a white wine might be substitutable for a red one simply because they both come from denominations containing the same semantic content, in our case the word "Bordeaux." Verification of this "strong version" of the semantic hypothesis would reinforce our previous result. Therefore, as a robustness check, we introduce into the analysis a new type of wine, different in terms of color but semantically similar: Bordeaux blanc (white).<sup>16</sup>

The test is conducted after controlling for the statistical properties of the Bordeaux blanc price series, as required to run a cointegration analysis.<sup>17</sup> Applying the ADF test to Bordeaux blanc prices shows that there is a unit root when the test equation does not include an intercept. Regarding the number of cointegrating vectors, the Trace test systematically concludes that five relationships exist among the twelve price series. According to the Maximum-Eigenvalue test, the number of cointegrating relations varies from three to four.

Testing our semantic hypothesis implies the same restrictions as previously, with Bordeaux blanc being included in vector number 1, characterized by the word "Bordeaux." The results from

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<sup>16</sup> Appendix 3 suggests that the distribution of the transactions among the various DOs is highly skewed towards the "Bordeaux rouge" denomination (and to a lesser extent Bordeaux Supérieur). Probably for this reason, the price dynamics for this denomination appear to be much less erratic than for other applications. Even if this aspect of the data reflects mainly short-run dynamics, which are captured by the autoregressive part of the VECM, and if substitution refers to a long-run relationship, it might have an impact on the results and in particular on the significance of the various coefficients. So we ran the same analysis excluding the Bordeaux rouge prices. The results confirm that our semantic hypothesis allows to identify groups of prices exhibiting a positive interaction—i.e., a possible substitution. The details are available from the authors upon request.

<sup>17</sup> First, these series exceed the threshold of monthly average minimum numbers of contracts needed to allow a sufficient number of observations, and second, the series are integrated in the first order I(1).

testing the cointegrating vectors as well as their estimation are presented in table 7. The semantic hypothesis remains accepted. Vector 1 can be written as follows:

$$0.064 \textit{ Bordeaux Blanc} + \textit{ Bordeaux Rouge} - 1.241 \textit{ Bordeaux Supérieur} + 0.590 = 0 \quad (5)$$

We can rearrange this equation to show that prices in this group are positively related, suggesting that Bordeaux Blanc and Bordeaux Rouge are substitutes for Bordeaux Supérieur:

$$0.064 \textit{ Bordeaux Blanc} + \textit{ Bordeaux Rouge} + 0.590 = 1.241 \textit{ Bordeaux Supérieur} \quad (6)$$

or

$$0.052 \textit{ Bordeaux Blanc} + 0.806 \textit{ Bordeaux Rouge} + 0.475 = \textit{ Bordeaux Supérieur} \quad (7)$$

Overall, this outcome seems to confirm the semantic hypothesis, reconfirming the strong effect of the brand name (regional name in this case) compared with the intrinsic wine characteristics, including the color. Indeed, the power of the name is stronger than the color of the wine!

**Table 7: Test and estimation of the cointegrating vectors including Bordeaux Blanc**

DO	Semantic hypothesis including Bordeaux blanc prices					Estimated cointegrating vectors				
	Vector 1	Vector 2	Vector 3	Vector 4	Vector 5	Vector 1	Vector 2	Vector 3	Vector 4	Vector 5
Bordeaux Blanc	$\beta_{11}$	0	0	0	$\beta_{51}$	0.064	0	0	0	-0.000
Bordeaux Rouge	1	0	0	0	$\beta_{52}$	1	0	0	0	-0.000
Bordeaux Supérieur	$\beta_{13}$	0	0	0	$\beta_{53}$	-1.241	0	0	0	0.000
Côtes de Castillon	0	1	0	0	$\beta_{54}$	0	1	0	0	-0.000
Côtes de Blaye	0	$\beta_{25}$	0	0	$\beta_{55}$	0	-0.791	0	0	-0.000
Côtes de Bourg	0	$\beta_{26}$	0	0	$\beta_{56}$	0	-0.635	0	0	0.000
Graves rouge	0	0	0	0	0	0	0	0	0	0
Haut-Médoc	0	0	$\beta_{38}$	0	$\beta_{58}$	0	0	-0.938	0	-0.000
Médoc	0	0	1	0	$\beta_{59}$	0	0	1	0	0.000
Lussac St Emilion	0	0	0	1	$\beta_{510}$	0	0	0	1	-0.000
Montagne St Emilion	0	0	0	$\beta_{411}$	$\beta_{511}$	0	0	0	-0.761	0.000
Saint Emilion	0	0	0	$\beta_{412}$	$\beta_{512}$	0	0	0	-0.350	0.000
Intercept	$c_1$	$c_2$	$c_3$	$c_4$	$c_5$	0.590	1.061	-0.045	0.448	-0.000
Chi-square(2)						89.048				
Probability						0.332				
						H0 is accepted				

## 6. Discussion and conclusion

Competition exists among Bordeaux wines. Our results, based on a time-series econometric analysis of prices, show that some Bordeaux wines from different appellations are seen as substitutes by consumers, based on the existence of similar words in the names of the denominations—i.e., a reputation mechanism. Normally a reputation mechanism would permit perceived quality to converge to true or intrinsic quality, as shown by the premium quality reputation models (see Shapiro, 1983). However, an intriguing finding here is that intrinsic characteristics of wines, associated with *terroir* and represented by the denomination of origin, do not allow consumers to identify wines as substitutes. This suggests that quality signals associated with *terroir*, namely denominations of origin, do not convey information efficiently. To account for this finding, we suggest that, on the demand side, processing costs associated with these signals are too high to allow them to be used by most consumers to infer wine quality. As a consequence, it seems these signals are not being used by consumers in the ways intended by producers in devising the appellations. In such a context, the return on investing in the quality signals is not certain and incentives to leave the appellation can emerge.

Another relevant finding is that consumers compare wines according to their names and that competition occurs among denominations sharing some common words: Bordeaux, Côtes, Médoc or Saint-Emilion in our sample. Moreover, the interaction between prices is very intense in some cases, suggesting a high degree of substitutability: Bordeaux Rouge and Bordeaux Supérieur; Côtes de Castillon and Côtes de Blaye; Haut-Médoc and Médoc. On the supply side, this competition means that the rents associated with the certification of origin can be dissipated. A practical policy implication is that some DOs could merge and use more generic names, meaning less horizontal differentiation, making the full set of appellations easier to understand. On the demand side, a reduction in the number of DOs would decrease the costs to consumers associated with acquiring information and processing the signals.

The analysis in this paper could be extended to other sectors or products and countries. The results in the specific case of Bordeaux wines would have to be checked in a broader study of DOs before reaching any broader conclusion about a PDO reform. Even within the context of Bordeaux, one limitation of this analysis is that it considers only the main DOs, those with a sufficient number of contracts traded each month—just 11 DOs from a total of 57 (though to be sure, these 11 accounted for 80% of the total production in the region). There are probably other substitutions to find among the other appellations, and perhaps the semantic hypothesis does not hold for these other DOs. Nevertheless, our findings suggest at least something to think about for wine policymakers in the Bordeaux area, and potentially a basis for looking into significant reform of the DO system to better serve the interests of producers and consumers of Bordeaux wines. Meloni and Swinnen (2013) show that EU policies have caused some distortions in wine markets, rather than solving them. In a similar spirit, our study suggests that the current large number of DOs might create more information problems than it solves.

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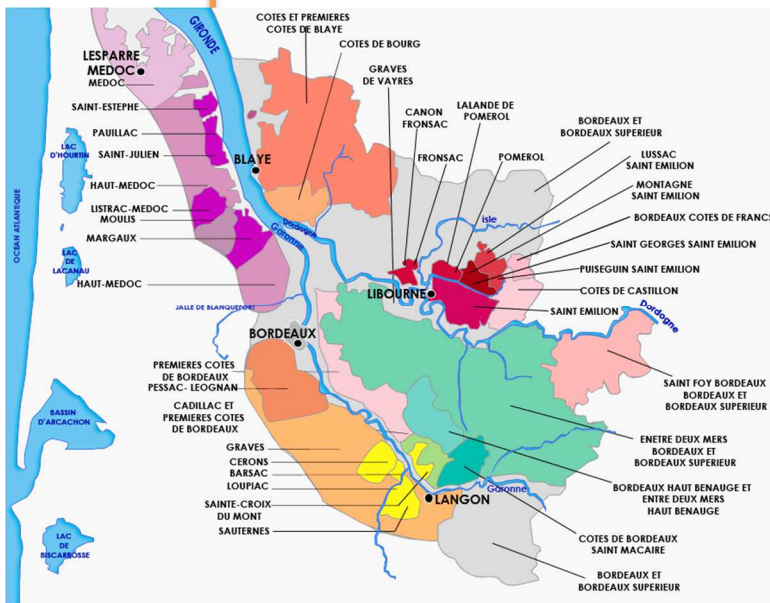
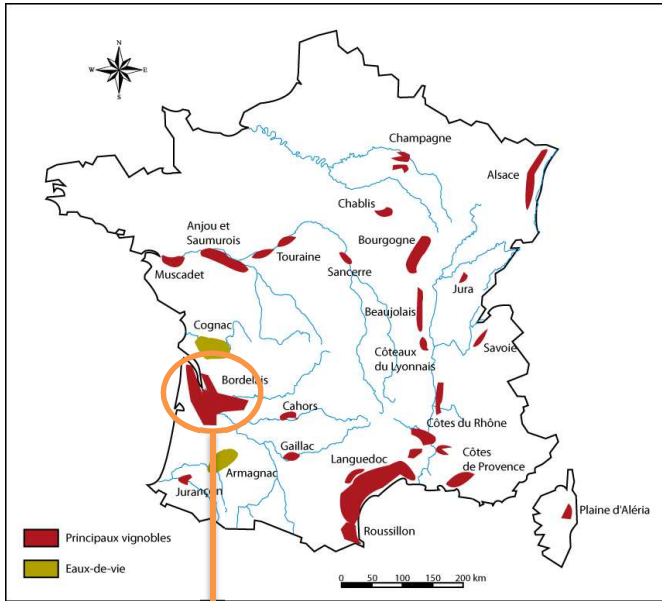
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## Appendix 1:

### Wine Regions in France and Bordeaux Wine Appellations



Source: Conseil Interprofessionnel du Vin de Bordeaux (CIVB)

## Appendix 2:

### Price Transmission in a Simple Model of Markets for Two Goods Related in Consumption

In this Appendix we present a simple but fairly general model of competitive market equilibrium in a case of two goods to illustrate the structural determinants of price transmission relationships among related goods such as Bordeaux wines. Consider two goods (or two qualities of the same good) related in demand and supply. Subscripts 1 and 2 are used to denote prices, quantities, and shifters in the markets for goods 1 and 2. The quantities demanded and supplied for each quality are functions of both prices, with demand shifters  $a_1$  and  $a_2$  and supply shifters  $b_1$  and  $b_2$ :

$$\text{Demand for Good 1: } Q_1^D = Q_1^D(P_1^D, P_2^D, a_1)$$

$$\text{Demand for Good 2: } Q_2^D = Q_2^D(P_1^D, P_2^D, a_2)$$

$$\text{Supply of Good 1: } Q_1^S = Q_1^S(P_1^S, P_2^S, b_1)$$

$$\text{Supply of Good 2: } Q_2^S = Q_2^S(P_1^S, P_2^S, b_2)$$

Totally differentiating, and expressing the results in logarithmic differential form, after some transformations we can relate the proportional changes in the endogenous variables to proportional changes in the exogenous supply and demand shift variables, conditioned by own-and cross-price elasticities of supply and demand:

$$d \ln Q_1^D = \eta_{11} d \ln P_1^D + \eta_{12} d \ln P_2^D + \alpha_1$$

$$d \ln Q_2^D = \eta_{21} d \ln P_1^D + \eta_{22} d \ln P_2^D + \alpha_2$$

$$d \ln Q_1^S = \epsilon_{11} d \ln P_1^S + \epsilon_{12} d \ln P_2^S + \beta_1$$

$$d \ln Q_2^S = \epsilon_{21} d \ln P_1^S + \epsilon_{22} d \ln P_2^S + \beta_2$$

where the exogenous demand and supply shifters are represented by

$$\alpha_i = \frac{\partial Q_i^D}{\partial a_i} \frac{a_i}{Q_i^D}, \text{ and } \beta_i = \frac{\partial Q_i^S}{\partial b_i} \frac{b_i}{Q_i^S}.$$

If we impose the market-clearing conditions reflecting the absence of any price wedges or quantitative restrictions:

$$P_i^D = P_i^S, \text{ and } Q_i^D = Q_i^S$$

then we can drop the D and S super-scripts. In matrix notation, we can write the above system of equations as  $\mathbf{A}\mathbf{y} = \mathbf{x}$  where  $\mathbf{A}$ ,  $\mathbf{y}$ , and  $\mathbf{x}$  represent (i) a 4 x 4 matrix of parameters, (ii) a 4 x 1 vector of endogenous quantities and prices, and (iii) a 4 x 1 vector of exogenous shocks to supply and demand:

$$\begin{bmatrix} 1 & 0 & -\eta_{11} & -\eta_{12} \\ 0 & 1 & -\eta_{21} & -\eta_{22} \\ 1 & 0 & -\epsilon_{11} & -\epsilon_{12} \\ 0 & 1 & -\epsilon_{21} & -\epsilon_{22} \end{bmatrix} \begin{bmatrix} d \ln Q_1 \\ d \ln Q_2 \\ d \ln P_1 \\ d \ln P_2 \end{bmatrix} = \begin{bmatrix} \alpha_1 \\ \alpha_2 \\ \beta_1 \\ \beta_2 \end{bmatrix}$$

The solution is found by pre-multiplying each side of the equality by the inverse of the matrix A:

$$\begin{bmatrix} d \ln Q_1 \\ d \ln Q_2 \\ d \ln P_1 \\ d \ln P_2 \end{bmatrix} = \begin{bmatrix} 1 & 0 & -\eta_{11} & -\eta_{12} \\ 0 & 1 & -\eta_{21} & -\eta_{22} \\ 1 & 0 & -\epsilon_{11} & -\epsilon_{12} \\ 0 & 1 & -\epsilon_{21} & -\epsilon_{22} \end{bmatrix}^{-1} \begin{bmatrix} \alpha_1 \\ \alpha_2 \\ \beta_1 \\ \beta_2 \end{bmatrix}$$

Thus, the solution is:

$$\begin{bmatrix} d \ln Q_1 \\ d \ln Q_2 \\ d \ln P_1 \\ d \ln P_2 \end{bmatrix} = \frac{1}{D} \begin{bmatrix} \epsilon_{21}(\eta_{21} - \epsilon_{21}) + \epsilon_{11}(\epsilon_{22} - \eta_{22}) & \eta_{21}\epsilon_{22} - \eta_{22}\epsilon_{21} & \epsilon_{21}(\eta_{12} - \epsilon_{12}) + \epsilon_{22}(\epsilon_{11} - \eta_{11}) \\ \eta_{21}\epsilon_{22} - \eta_{22}\epsilon_{21} & \epsilon_{22} - \eta_{22} & \eta_{12} - \epsilon_{12} \\ \epsilon_{22} - \eta_{22} & \eta_{21} - \epsilon_{21} & \epsilon_{11} - \eta_{11} \end{bmatrix} \begin{bmatrix} \alpha_1 \\ \alpha_2 \\ \beta_1 \end{bmatrix} \\ + \frac{1}{D} \begin{bmatrix} \eta_{12}(\epsilon_{21} - \eta_{21}) + \eta_{11}(\eta_{22} - \epsilon_{22}) & \eta_{11}\epsilon_{12} - \eta_{12}\epsilon_{11} & \eta_{22}(\eta_{11} - \epsilon_{11}) + \eta_{21}(\epsilon_{12} - \eta_{12}) \\ \eta_{22}\epsilon_{21} - \eta_{21}\epsilon_{21} & \eta_{22} - \epsilon_{22} & \epsilon_{12} - \eta_{12} \\ \eta_{22} - \epsilon_{22} & \epsilon_{21} - \eta_{21} & \eta_{11} - \epsilon_{11} \end{bmatrix} \begin{bmatrix} \beta_1 \\ \beta_2 \end{bmatrix}$$

where  $D = (\eta_{11} - \epsilon_{11})(\eta_{22} - \epsilon_{22}) - (\epsilon_{12} - \eta_{12})(\epsilon_{21} - \eta_{21})$ .

Given that the goods are substitutes we would expect all cross-price elasticities to be positive numbers, while all own-price elasticities are necessarily negative numbers. When the two goods are closer substitutes in consumption, we would expect both the own- and cross-price elasticities to assume larger magnitudes.

In the present application, we are interested in a special case of this model in which supply is exogenous (i.e.,  $\epsilon_{ij} = 0$  for all  $i$  and  $j$ ). In this case the above solution simplifies significantly to:

$$\begin{bmatrix} d \ln Q_1 \\ d \ln Q_2 \\ d \ln P_1 \\ d \ln P_2 \end{bmatrix} = \frac{1}{D'} \begin{bmatrix} 0 & 0 & \eta_{11}\eta_{22} - \eta_{12}\eta_{21} & 0 \\ 0 & 0 & 0 & \eta_{22}\eta_{11} - \eta_{12}\eta_{21} \\ -\eta_{22} & \eta_{12} & \eta_{22} & -\eta_{12} \\ \eta_{21} & -\eta_{11} & -\eta_{21} & \eta_{11} \end{bmatrix} \begin{bmatrix} \alpha_1 \\ \alpha_2 \\ \beta_1 \\ \beta_2 \end{bmatrix}$$

where  $D' = \eta_{11}\eta_{22} - \eta_{12}\eta_{21}$ . Focusing on the last two lines of this equation, the price equations, we have

$$d \ln P_1 = -\frac{\eta_{22}}{\eta_{11}\eta_{22} - \eta_{12}\eta_{21}}(\alpha_1 - \beta_1) + \frac{\eta_{12}}{\eta_{11}\eta_{22} - \eta_{12}\eta_{21}}(\alpha_2 - \beta_2)$$

$$d \ln P_2 = \frac{\eta_{21}}{\eta_{11}\eta_{22} - \eta_{12}\eta_{21}}(\alpha_1 - \beta_1) - \frac{\eta_{11}}{\eta_{11}\eta_{22} - \eta_{12}\eta_{21}}(\alpha_2 - \beta_2)$$

Notice that a decrease in supply has the same effect as an increase in demand for either good in this case of perfectly inelastic supply, and we can replace the exogenous “shift” term in each case with  $\delta_i = \alpha_i - \beta_i$  to represent the net effect of shocks to demand and supply. Taking the difference between these two equations yields an equation for the difference in proportional price changes or, equivalently, the proportional change in the price ratio:

$$d \ln \left( \frac{P_1}{P_2} \right) = -\left( \frac{\eta_{22} + \eta_{21}}{\eta_{11}\eta_{22} - \eta_{12}\eta_{21}} \right) \delta_1 + \left( \frac{\eta_{11} + \eta_{12}}{\eta_{11}\eta_{22} - \eta_{12}\eta_{21}} \right) \delta_2.$$

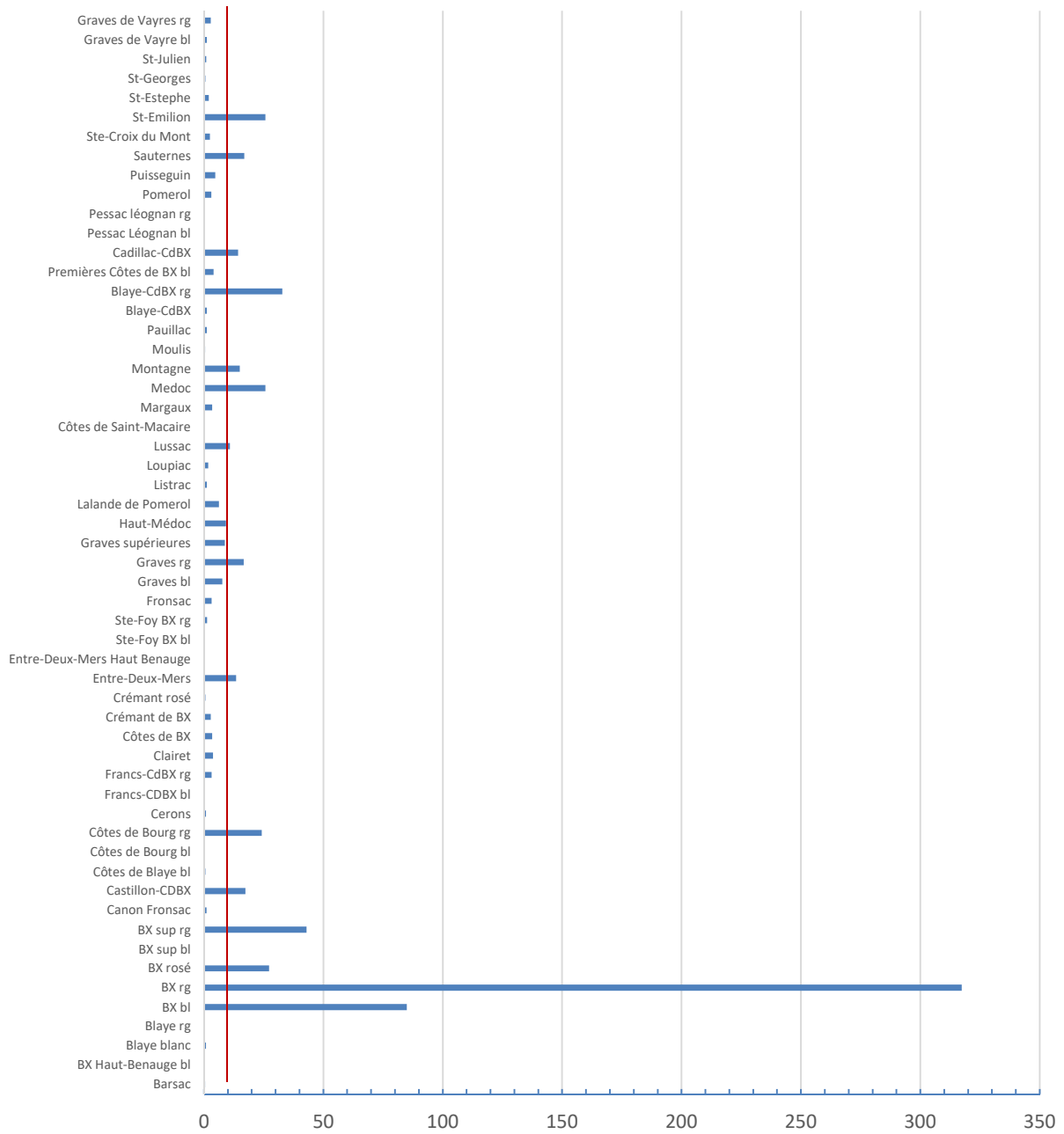
By inspection of this equation we can see that as the two goods become closer substitutes, in each of the multipliers in parentheses, the denominator becomes large relative to the numerator and the prices tend to move more closely together and the effect of any shock on relative price movements is diminished. In the limit of perfect substitutes, it converges to zero. The relative price movements also can depend on the source of the shock, whether it initiates in the market for good 1 or good 2. In some cases, we might expect external factors to induce related shocks to both markets. For instance, an increase in price of a third wine that is also a substitute for these two might cause an increase in demand for both; similarly, an exchange rate movement would have some effects in common across the two goods. Weather during the vintage might have positive or negative effects in common—albeit with different magnitudes—on production of wines from different parts of Bordeaux in terms of both yield (a supply shock) and quality of the wine (which could be represented as a demand shock). By inspection of the last equation it can be seen that if the supply and demand shifters are the same or very similar across the two goods, the relative price movements will be negligible.



The same kinds of relationships would be found if we were to extend this model to include a larger number of varieties. In a complete system (or a model of a weakly separable group), the own- and cross-price elasticities could be characterized, using the Slutsky equation, in terms of elasticities of substitution, expenditure shares, and an overall elasticity of demand. In some cases, the number of parameters could be further reduced by imposing further restrictions on the nature preferences—e.g., Armington restrictions.

### Appendix 3: Appellations, number of contracts and missing data

#### Monthly average number of contracts



Source: Authors' computation based on CIVB data.

Note: the appellation Bordeaux Moelleux has been excluded because it is an aggregation of several other appellations. So we retained 56 appellations in this graph and not 57, which is the official figure.

The following table presents some information about the distribution of the number of missing price data, depending on the number of contracts, applied as a threshold to select some appellations. A minimum of 10 contracts per month on average seems a good criterion to apply in selecting the appellations that will enter our sample: the number of missing data is manageable through linear interpolation and the set of 11 selected appellations accounts for 73% of the entire production of Bordeaux wines in 2012, and 86% of the reds.

Number of contracts on average per month	Number of AOs producing red wine	% of Bordeaux wine production (2012)	% of Bordeaux red wine production (2012)	Number of missing price data over the period (sample of red wines)
≥ 20	6	63%	74%	0
≥ 15	9	68%	80%	10
≥ 10	11	73%	86%	36
≥ 6	12	74%	87%	367
≥ 1	30	85%	100%	3079