Journal of Wine Economics (2023), **18**, 245–265
doi:10.1017/jwe.2023.17

ARTICLE

Spatial integration and hierarchy in Old-World wine markets: The role of the 2013 CAP reform

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Abstract

We explore the impact of the 2013 Common Agricultural Policy (CAP) reform on spatial price co-movements between the main European Union (EU) wine producer markets (i.e., Spain, France, and Italy). We consider monthly prices from January 2005 to January 2020 and R-Vine copula models, splitting the time period considered in December 2012 to track the changes in (1) the degree of integration, (2) the central markets, and (3) the potential asymmetries after the 2013 CAP reform. The results indicate an increasing overall price dependence from one sub-period to another, with Spain succeeding Italy as the central EU market. We also show asymmetry between Italy and France in the upper tail before 2013 and between Spain and France in the lower tail after 2013.

Keywords: agricultural commodities; R-Vine copulas; wine markets

JEL classifications: C10; Q2; Q13

I. Introduction

Associations between market integration and spatial price relations have been studied for a long time. They are based on acknowledging that the patterns and intensity of price linkages reflect whether relevant but geographically separated markets are integrated or segmented. Goodwin and Schroeder (1991) note that two markets exhibit a high degree of spatial integration if price variations in one are transferred to the other or segmented if there are no connections between their prices. Thus, for integrated markets, price variations in one market are related to price variations in the other, that is, prices move synchronized rather than independently (Monke and Petzel, 1984). Several studies, including those of Serra, Gil, and Goodwin (2006) and Fousekis and Trachanas (2016), argue that in segmented markets, profit opportunities are not fully exploited, which results in a loss of economic efficiency.

The EU has around 43% of the world's vineyards and leads the world in wine production, consumption, and exports, with 61%, 50%, and 67%, respectively. Approximately 15% of its domestic production is exported to non-EU countries, and about 30% is traded with the EU (European Commission, 2020). Spain, Italy, and France are the "big three" countries in the global wine market. Their domestic wine markets have mature consumption patterns. Germany, Portugal, and Greece are further important EU producer markets, entailing their own distinct characteristics, such as varieties, geographical traits, oenological culture, consumption preferences, and laws. Thus, the EU wine sector is rich and diversified, explaining the complex structure of its wine policy and often raising criticism from academics and market actors.

In Common Agricultural Policy (CAP) history, wine market policy has been on a different pathway, starting later and building upon existing regulations in France and Italy (Meloni and Swinnen, 2013). Vineyard registers and planting rights were enacted in response to declining consumption patterns in Europe's main production countries, causing a huge surplus and stockholding, together with imports outgrowing exports due to trade liberalization efforts in the 1990s (European Parliament, 2006).

Prior to 2008, the need for a new wine policy became evident, tackling non-competitive surpluses and ineffective policies (e.g., planting bans, crisis distillation). Subsequently, the 2008 wine policy reform was set up to improve the competitiveness of EU wine producers, balance wine markets in a sustainable way, and preserve European wine growing traditions (Corsinovi and Gaeta, 2019). Over time, the policy direction has shifted from removing and restricting supply toward raising wine quality, increasing exports, and promoting sustainable vineyard practices (Pomarici and Sardone, 2020). Implemented over time, the 2008 wine market reform introduced national support programs (NSPs), a phase-out of distillation measures, and a new vineyard removal program. However, wine remains the only sector in the CAP maintaining production controls (new planting authorizations). With the 2013 CAP reform, wine was integrated into the common market organization (CMO), which kept the fundamentals of the 2008 wine market reform coherent with the principal CAP policy guidelines (European Parliament, 2015).

Pomarici and Sardone (2020) provide a detailed discussion of the post-2013 CAP affecting the wine sector (pp. 9–18). They differentiate structural and conjectural measures within NSPs, show a differential uptake of the various policy measures, and derive relations between CAP goals and wine policy measures. Moreover, they stress that the main beneficiaries of support measures often spread beyond individual wine growers to include producer organizations and their associations as well as professional organizations. Thus, we conclude that the 2013 CAP reform policies at least aim toward increasing market integration within the EU and beyond.

In the policy context related to our analysis, the role of alcohol taxation in the formation of intra-EU and international wine trade flows is important (including excise, import, and value-added taxes). Anderson (2019, 2020) discusses the evolution of tax rates for various countries (including France, Italy, and Spain) and shows that wine is taxed only slightly lower than beer and considerably lower than spirits.

To assess how the 2013 CAP reform may have impacted market integration in the EU wine sector, the general review paper by Kabbiri et al. (2016) provides some useful insights. They analyze 65 studies identifying the following important factors impacting agricultural market integration: physical infrastructure, market institutions, information, competition, market power, trade, social capital, public/government intervention, as well as export restrictions or bans. They also identify a wide research agenda and conclude that, so far, no conclusive answer is available as to how certain factors and related policies impact market integration. In this context, our study will be able to answer if the policy reform has supported market integration, and we draw some conclusions about whether individual reform policies, as discussed by Pomarici and Sardone (2020), may have worked in favor of or against it.

The global wine trade has experienced substantial changes during the last few decades. Creating an integrated market involving traditional EU wine-producing countries has been a strategic objective of the European Commission. Integration has been pursued through common regulations and objectives that provide strategic benefits against non-EU competitors, such as Chile, the United States, Australia, New Zealand, Argentina, and South Africa. Castillo-Valero and García-Cortijo (2015) argue that a common and synchronized EU wine market represents a substantial advantage against competitors.

Relatively stable production and commercial patterns led to a concentration of wine production and dominant positions in international export markets for France, Italy, and Spain. As a result, these countries have acquired a strong wine industry employing traditional practices coupled with high amortizations (Castillo-Valero and García-Cortijo, 2015). Anderson and Pinilla (2018) argue that globalization in wine is impressive, with rapidly growing international trade, rising foreign direct investments, and declining demand in traditional European markets. Calderón and Blanco (2005) note that trends in global wine markets require leading actors to change strategies and restructure continuously.

Price transmission analysis is a common method to study market integration. From the corresponding literature, we reference Serra, Gil, and Goodwin (2006) using non-parametric regression and non-linear threshold models to analyze spatial integration in the EU pork markets; Ghoshray (2010) assessing price cointegration among four different coffee qualities based on exponential smooth transition autoregressive models; and Goodwin and Piggott (2001) employing threshold autoregression and cointegration models to evaluate spatial price linkages for corn and four soybean markets in North Carolina. Regarding wine, Bentzen and Smith (2002) apply vector autoregression models and causality tests to analyze the interactions among export quantities and prices for French, Italian, and Spanish red wines. Castillo-Valero and García-Cortijo (2015) use linear and threshold cointegration error correction models and find that export prices for Old-World countries are cointegrated but those for New World countries are not. Finally, Correia, Gouveia, and Martins (2019) analyze the cyclical synchronization of wine exports for ten European wine-producing countries and find a strong and growing degree of synchronization over six decades.

Copulas are gaining popularity within economics following pivotal research in finance, risk management, and engineering. For agricultural economics, studies applying copula models include Sriboonchitta et al. (2013) employing static as well as time-varying copula models to study the dependence between agricultural prices and the agricultural production indices of Thailand; Reboredo (2012) investigating the co-movements between oil prices and prices of corn, soybean, and wheat based on static and time-varying copula models; Shahzad et al. (2018) employing static and dynamic copulas to analyze the co-movement between oil and agricultural commodity prices (i.e., wheat, maize, soybeans, rice); and Emmanouilides, Fousekis, and Grigoriadis (2014) assessing the price dependence structures in the principal EU olive oil markets (Greece, Italy, and Spain). Moreover, Grigoriadis, Emmanouilides, and Fousekis (2016) apply mixed R-Vine copulas to investigate market integration for pig meat in seven EU countries. Fousekis and Grigoriadis (2017) use nonparametric copulas to explore price linkages between coffee varieties of different quality. Furthermore, time-varying nonparametric copulas are applied in Fousekis, Emmanouilides, and Grigoriadis (2017), exploring spatial price interrelations in the skim milk powder markets of Oceania, the EU, and the United States. Finally, studies employing copula models in a wine economics context include those of Cyr, Kwong, and Sun (2017), assessing the dependence structure between Parker's ratings and Bordeaux *en primeur* wine prices; Cyr, Kwong, and Sun (2019) investigating the relationship between the ratings of prominent *en primeur* wine critics and those of Parker; and Cyr, Kushner, and Zhang (2023) exploring the sensitivity of aggregate grape yields to various bioclimatic indices, which represent major viticulture risks, in order to hedge a weather-related risk and provide weather-derivative contracts for the association of Grape Growers of Ontario, Canada.

Applications of copula models in market integration or price transmission research have gained momentum recently. Fermanian and Scaillet (2004) note that copulas exhibit attractive features that allow them to effectively analyze the co-movement between stochastic processes. Specifically, copulas are effective in modeling the joint behavior of stochastic processes independently of their margins. Furthermore, copula models need not assume the same family of marginal distributions as they capture linear and non-linear co-movements and provide information regarding the structure and intensity of the co-movements. Regarding market integration, symmetric and strictly positive co-movement at the extremes of the joint distribution, combined with a high degree of price co-movement, indicates well-integrated markets (Grigoriadis, Emmanouilides, and Fousekis, 2016). In addition, R-Vine copula models can provide added information concerning central markets that standard bivariate copulas cannot capture. Central markets have direct connections with at least two other markets. On the other hand, R-Vines are multivariate models where prices in the separated (i.e., not directly connected) markets are linked with each other through a relationship that is conditioned on prices in the central markets. Finally, R-Vines indicate potential market clusters, which link markets directly connected with the same central market. Markets belonging to the same cluster display common attributes such as intensity and patterns of price co-movement. However, this trait is not relevant to our study as it considers only three markets.

We apply multivariate static copula models (i.e., R-Vines), which (i) assess the degree of integration in Old-World markets and its evolvement under the 2013 CAP Reform, (ii) identify central markets where the formation of prices is based on signals related to more than one other market, and (iii) identify potential asymmetries in the co-movement of prices between wine markets under consideration. Rezitis and Rokopanos (2019) follow a similar approach, considering the dairy markets of Europe, Oceania, and the United States. However, to the best of our knowledge, this is the first study applying copula models to study price dependencies in the European wine sector.

We organize the remaining paper as follows. Section II introduces the bivariate copula models, their multivariate extension static models, as well as the estimation and testing procedures. Section III presents the main characteristics of the data utilized, and Section IV discusses the empirical results of the marginal models, the R-Vines, and their implications concerning the wine market. Finally, Section V concludes the paper by summarizing its main findings.

II. Measuring dependence

A. Copulas

According to Sklar (1959) any multivariate distribution function can be decomposed into its univariate marginal distributions and a copula function defining the dependence structure between the variables. More formally, if F is the n-dimensional distribution function of a random vector $\boldsymbol{X} = (X_1, X_2, \ldots, X_n)^T$ with marginal distribution functions $F_1, F_2, \ldots, F_n$, then a copula C exists such that for all

$$\boldsymbol{x} = (x_1, \ldots, x_n)^T \in \mathbb{R}^n, \; F(x) = C(F_1(x_1), \; F_2(x_2), \ldots, F_n(x_n)), \tag{1}$$

where C is unambiguously defined and $F_1, F_2, \ldots, F_n$ are continuous distribution functions; C may be interpreted as the distribution function of an n-dimensional random variable on $[0, 1]^n$ with uniform margins. The corresponding densities are denoted as c and the random variables $X_1, X_2, \ldots, X_n$ are considered continuous. We use the pair copula constructions (PCCs) of Aas et al. (2009) to obtain elaborate multivariate graphical representations noted as vines. Specifically, in the case of a three-dimensional variable $\boldsymbol{X} = (X_1, X_2, X_3)^T \sim F$ with marginal distributions F_1, F_2, F_3 and marginal density functions f_1, f_2, f_3 the corresponding joint density function of $\boldsymbol{X}$ is given as:

$$f(x_1, x_2, x_3) = f_1(x_1) f(x_2|x_1) f(x_3|x_2, x_1) \,. \tag{2}$$

The conditional probability density functions of $x_2|x_1$ and $x_3|x_1, x_2$ are then obtained by applying the theorem of Sklar (1959) as:

$$\begin{aligned} f(x_2|x_1) &= \frac{f(x_1, x_2)}{f_1(x_1)} = \frac{c_{1,2}(F_1(x_1), F_2(x_2)) f_1(x_1) f_2(x_2)}{f_1(x_1)} \\ &= c_{1,2}(F_1(x_1), F_2(x_2)) f_2(x_2) \end{aligned} \tag{3}$$

and

$$\begin{aligned} f(x_3|x_1, x_2) &= \frac{f(x_2, \; x_3|x_1)}{f(x_2|x_1)} = \frac{c_{2,3|1}(F(x_2|x_1), F(x_3|x_1)) f(x_2|x_1) f(x_3|x_1)}{f(x_2|x_1)} \\ &= c_{2,3|1}(F(x_2|x_1), F(x_3|x_1)) f(x_3|x_1) \Rightarrow f(x_3|x_1, x_2) \\ &= c_{2,3|1}(F(x_2|x_1), F(x_3|x_1)) c_{1,3}(F_1(x_1), F_3(x_3)) f_3(x_3). \end{aligned} \tag{4}$$

Hence, the joint probability density function of Equation (2) can be written via the density functions $c_{1,2}$, $c_{1,3}$, and $c_{2,3|1}$ of the bivariate copulas $C_{1,2}$, $C_{1,3}$, *and* $C_{2,3|1}$. We note that the bivariate copulas are chosen independently of each other, which allows capturing different dependence structures. Furthermore, we note that the decomposition of Equation (2) is not unique and alternative PCCs can be produced.

Considering the three-dimensional process, an R-Vine copula is an arrangement of nested trees, where exclusively unconditional pair copulas (e.g., $c_{1,2}$, $c_{1,3}$) compose tree 1 and the bivariate copula conditioned on a single stochastic process that is drawn from tree 1 (i.e., $c_{2,3|1}$) is contained in tree 2 (Figure 1).

The joint density function of the three-dimensional process can be factorized as follows:

$$f(x) = f_1 \cdot f_2 \cdot f_3 \cdot (c_{1,2} \cdot c_{1,3}) \cdot c_{2,3|1} \quad (5)$$

We select the most suitable bivariate copulas for each copula pair in Equation (5) using the information criteria of Akaike (AIC) and Bayes (BIC). Thus, through R-Vine multivariate copulas, we can describe complex dependence structures, including asymmetries or extreme tail dependence. As discussed before, R-Vine structures allow us to obtain richer insight compared to the usual bivariate copulas.

In addition, we refer to intrinsic characteristics of the tree structure inherent in the R-Vine models. More precisely, bivariate copulas may provide a misleading picture when describing price linkages between markets that are not directly linked, but for which price co-movements exist given a conditioning market. Aguiar-Conraria and Soares (2014) show that through a third price, the co-movement between two prices may be distorted and appear either more intense or weaker. However, a positive association between price changes in separated markets usually leads to co-movements getting weaker after conditioning (Dissmann et al., 2013; Kellner

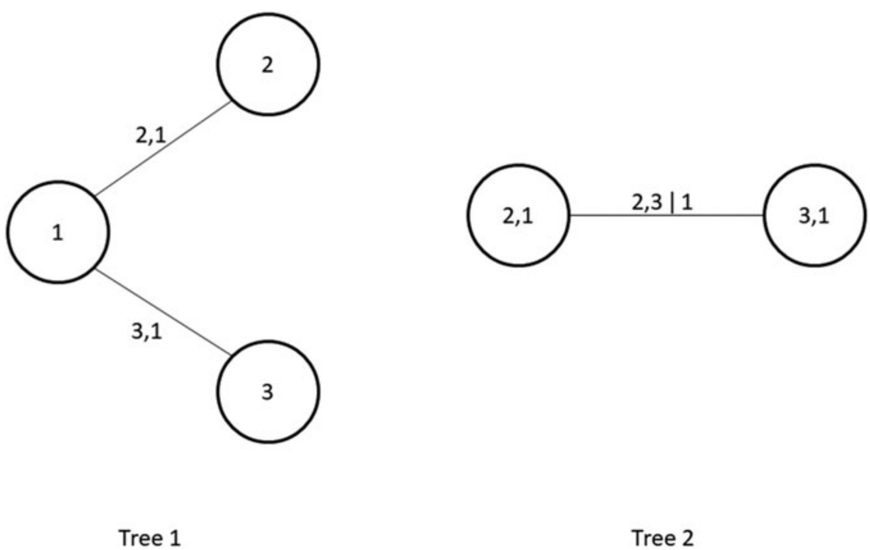

Figure 1. Example of a three-dimensional R-Vine.
Source: Authors' elaboration.

and Rösch, 2016). Hence, higher-numbered trees could potentially include the Independence copula and become redundant. Thus, R-Vine models outperform their standard counterparts, capturing aspects of co-movement well beyond the scope of bivariate copulas.

B. Bivariate copula families

The tree structure of R-Vines necessitates using bivariate copula models for the pair connections. Hence, we consider both elliptical and Archimedean bivariate copulas. The elliptical copula models are Gaussian and Student's t copulas, obtained by inverting Equation (1). The single-parameter Archimedean families of Clayton, Gumbel, Frank, and Joe are considered together with the two-parameter Archimedean copula families of Clayton-Gumbel (BB1), Joe-Gumbel (BB6), Joe-Clayton (BB7), and Joe-Frank (BB8). These copulas provide various structures with sufficient flexibility to effectively capture diverse non-zero lower- and upper-tail dependence relationships. Furthermore, we consider the rotated Clayton, Gumbel, Joe, BB1, BB6, BB7, and BB8 copulas. The 180-degree rotated version of a copula corresponds to the respective survival copula, whereas the 90- and 270-degree rotated versions allow modeling negative dependence linkages, which is not possible otherwise.

We measure the intensity of the dependence in the upper- and lower-tail based on Kendall's τ, which takes values from –1, indicating perfect dis-concordance, to +1, indicating perfect concordance. It is calculated as:

$$\tau = 1 - 4\int_0^1\int_0^1 \frac{\partial C}{\partial u_1}\frac{\partial C}{\partial u_2} du_1 du_2 \tag{6}$$

The lower- and upper-tail coefficients are defined in Equations (7) and (8), respectively.

$$\lambda_L = \lim_{u \to 0^+} \Pr(U_1 < u | U_2 < u) = \lim_{u \to 0^+} \frac{C(u,u)}{u} \tag{7}$$

$$\lambda_U = \lim_{u \to 1^-} \Pr(U_1 > u | U_2 > u) = \lim_{u \to 1^-} \frac{1 - 2u + C(u,u)}{1 - u} \tag{8}$$

C. Marginal distribution models and testing procedure

We follow the semi-parametric approach of Chen and Fan (2006a, 2006b), which includes three steps: (1) specifying a GARCH model fitting the price series; (2) converting the standardized residuals into copula data, that is, data taking values in (0,1); and (3) estimating the copula model using the maximum-likelihood method. Thus, we apply ARMA(p,q)-GARCH(1,1) models, selecting among them based on the information criteria of Akaike, Bayes, Shibata, and Hannan-Quinn. Moreover, we perform the constancy tests of Busetti and Harvey (2011) to explore tail dependence relationships and decide if a static or time-varying structure is more suitable for the R-Vines.

III. Data

We analyze monthly price indices for wine in Spain, France, and Italy from January 2005 to January 2020. The data source is the food price monitoring tool of Eurostat (2021), and we are using the agricultural commodity price index for the product *Wine from grapes* (COICOP CP02121). We consider Spain, France, and Italy as the major EU wine producers and exporters to study price interdependence within the European wine market. Substantial wine trade exists between these three markets, which in 2018 accounted for almost 78% of the total EU wine trade in quantity terms and about 80% in value terms (European Commission, 2019). Therefore, the formation of prices takes place both through direct trade relationships and through indirect competition in international markets.

Table 1 presents data regarding the exports and imports of wine for Spain, France, and Italy in terms of quantity (in HL) and value (in Mio EURO). Spain leads wine exports in quantity terms for 2018, accounting for 30.68% of the EU total. Italy is the second-largest exporter with 27.67%, and France accounts for 19.63% of the EU total. In terms of value, the ranking differs, with French exports leading (39.85%), followed by Italy (26.92%) and Spain (13.35%). For wine imports, the ranking is the same in quantity and value terms, with France in the lead, followed by Italy and Spain. France has held a leading role in exports in value terms since 1964 (Anderson et al., 2016). Agostino and Trivieri (2014) show that French wines are associated with higher increases in value and export volume compared to those from Spain and Italy.

Figure 2 shows a long-term trend in wine price indices, which is increasing for all three countries. Specifically, the price index of Spanish wine is consistently higher than that of French and Italian wine, except for two short periods around 2015. It is worth noting that Spain exhibits higher variability compared to France and Italy. Therefore, the series in France and Italy are smoother than the one in Spain. Moreover, the plot patterns indicate specific elements of circularity and seasonality for all three countries.

Table 2 presents the descriptive statistics for the wine price indices, indicating a range of variation in the results for the three countries. In particular, the average price index for Spanish wine (0.0023) for the period from January 2005 to January 2020 is slightly higher than the average price index for French wine (0.0022), which in turn is higher than the average price index for Italian wine (0.0018). Note that Spain exhibits the highest maximum price index and that it has the largest standard deviation (0.0668) (also confirmed graphically in Figure 2).

In Table 3, we examine the stationarity properties of the log-returns using the Augmented Dickey-Fuller (ADF) and the Phillips-Perron (PP) unit root tests. The null hypothesis of unit roots is rejected by ADF and PP at the 1% level, providing statistical evidence that the price series are stationary on the first differences.

IV. Empirical findings

A. Results for the marginal models

We begin our approach by acquiring the filtered rates of the price changes. Thus, we fit ARMA(p,q)-GARCH(1,1) models to each price series. We select among the

Table 1. Wine exports and imports (intra- and extra-EU28) in volume (in HL) and value (in Mio EURO) for 2018

	Exports				Imports			
2018	Volume	%	Value	%	Volume	%	Value	%
ES	23336064	30.68	3194.2	13.35	808737	1.20	243.2	1.62
FR	14931503	19.63	9530.4	39.85	7786959	11.53	1067.8	7.12
IT	21047559	27.67	6437.6	26.92	2137901	3.17	361.8	2.41
EU28	76072913		23917.7		67509158		15001.9	

Source: European Commission (2019).

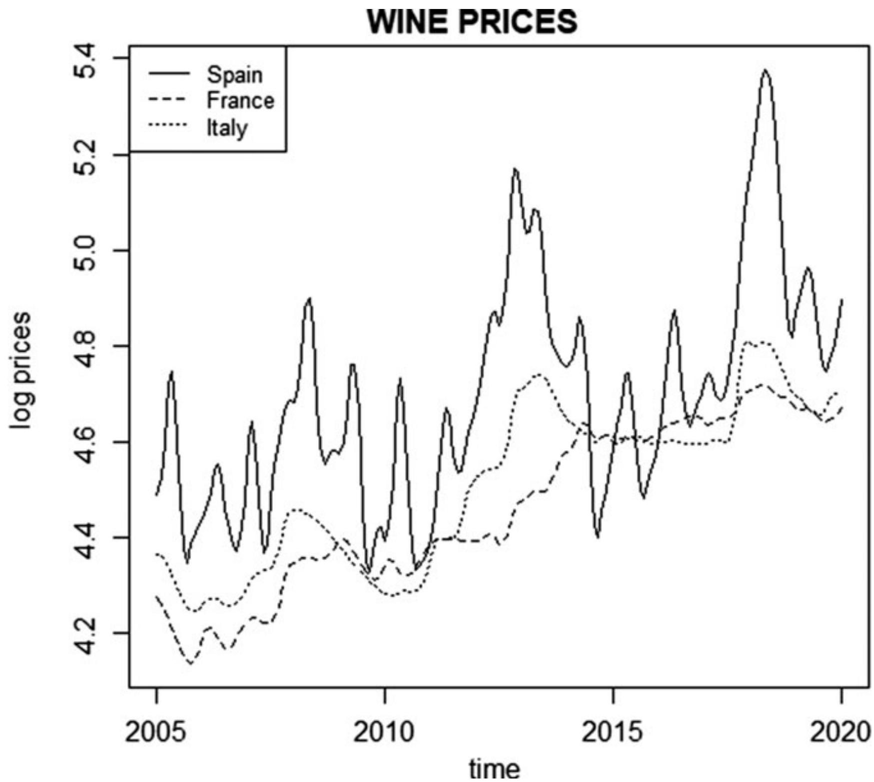

Figure 2. Development of log-price indices for wine.

Table 2. Descriptive statistics of price log-returns (raw price shocks)

	ES	FR	IT
Mean	0.0023	0.0022	0.0018
Standard deviation	0.0668	0.0101	0.0140
Maximum	0.1658	0.0388	0.0761
Minimum	−0.2063	−0.0229	−0.0234
Observations	180	180	180

Note: Monthly data, period is 01/2005 to 01/2020.

different models applying the usual information criteria (Akaike, Bayes, Shibata, and Hannan-Quinn). The selected models are ARMA(2,1)-GARCH (1,1) for Spain, ARMA(2,2)-GARCH(1,1) for France, and ARMA(1,1)-GARCH(1,1) for Italy.[1] The standardized residuals are subsequently used to calculate the respective empirical distribution functions, providing the copula data.

[1]More detailed results are not shown for the sake of brevity but are available on request.

Table 3. ADF and Phillips-Perron test results

	ES	FR	IT
Test statistic	−7.0195	−6.5823	−4.2308
Z(alpha)	−53.6760	−43.6850	−35.0060

Notes: Null hypothesis: the series has a unit root. Test critical values: 1% level −2.5758, 5% level −1.9600, and 10% level −1.6449.

Table 4. Empirical Kendall's τ for the Filtered Data

	First sub-period (i.e., 01.2005–12.2012)			Second sub-period (i.e., 01.2013–01.2020)		
Country	ES	IT	FR	ES	IT	FR
ES	1	0.1074	0.0215	1	0.3115	0.2438
IT		1	0.2246		1	0.1336
FR			1			1

Sources: Authors' calculations.

Table 4 lists the empirical Kendall's τ for filtered data and the sum $\sum_{i \neq j} |\tau_{i,j}|$, before and after the 2013 CAP Reform. The empirical Kendall's τ is calculated as $(P_n - Q_n)/\binom{n}{2}$ where n is the number of observations and $P_n(Q_n)$ is the number of concordant (dis-concordant) pairs and provides an initial measure of price association.

Table 5 presents the results of the Busetti and Harvey tests, which determine the most appropriate copula structure. The test indicates whether a static or time-varying structure is more appropriate to capture price dependence.

The Busetti-Harvey tests for the quantiles (i.e., 0.25, 0.5, and 0.75) of the bivariate empirical copulas highlight that in all cases the empirical values are below the 5% critical value (0.461). Thus, our results show that all the bivariate empirical copulas feature constant tail dependence. We conclude that there is insufficient statistical evidence indicating breaks and/or gradual but persistent shifts in the bivariate empirical copulas, and therefore, static copula structures are adequate to capture the price dependence among the EU wine markets.

B. Results for the copula models

The constancy tests highlight that static copula models are more appropriate than time-varying models for capturing the price dependence structures between the countries considered. We proceed to select the R-Vine copula models for the two sub-periods. The results for the first sub-period (i.e., January 2005 to December 2012) are reported in Table 6. It is worth noting that the Kendall's τ we obtain are remarkably close to the empirical Kendall's τ.

Table 5. Constancy tests on the quantiles of the empirical copulas for wine

	Quantiles		
Empirical copula	τ=0.25	τ=0.5	τ=0.75
ES–FR	0.1364	0.0798	0.1788
ES–IT	0.0747	0.1421	0.2717
FR–IT	0.0756	0.1173	0.0671

Note: Critical values: 0.743 at 1% level, 0.461 at 5% level, and 0.347 at 10% level.

These results indicate that prior to 2013, Italy acts as the central market for EU wine. Italy establishes unconditional pair-copulas, that is, direct connections with Spain and France (i.e., IT–ES and IT–FR). This finding seems somewhat unexpected, given that Italy has not exhibited the highest price index during the specific period. On the other hand, Italy has been the largest wine producer for about half of this period (OIV, 2011, 2014). Urso et al. (2018) report a fall in grape prices in Italy between 2005 and 2010, leading to higher efficiency in the Italian wine sector. Moreover, it is well documented that during the period 2006–2015, viticulture in Italy evolved substantially through effective policies and vineyard mechanization, leading to higher quality production, which made Italy one of the foremost, if not the leader, in the wine world (Urso et al., 2018; Di Vita et al., 2015; Cembalo, Caracciolo, and Pomarici, 2014; Caracciolo et al., 2016). Moreover, this outcome is supported by Bentzen and Smith (2002), who demonstrate that Italian wine exports are in most cases influenced by Spanish and French wine exports. Therefore, we come to observe a higher Kendall's τ between Italy and Spain, and between Italy and France than between Spain and France. These higher Kendall's τ indicate stronger price associations between the relevant countries and establish direct connections in the maximal spanning tree of the R-Vine.

Furthermore, our results show intermediate price dependence between Italy and Spain, with the Frank copula being selected based on AIC. The price dependence we observe here is moderate (Kendall's τ=0.1054). This type of price dependence is consistent with symmetric price transmission since it provides no evidence of upper-tail or lower-tail asymmetry.

On the other hand, the Survival Clayton copula, indicating upper-tail asymmetry, is selected between Italy and France based on AIC, with a much higher price dependence being observed (Kendall's τ=0.2214). The upper-tail or positive asymmetry indicates that extreme positive price shocks are transmitted from one region to the other but extreme negative price shocks are not. This finding may be attributed to consumer preferences in these Old-World countries. In more detail, consumption has continued to fall in traditional wine-producing countries (Italy and France), and consumers there are gradually moving to higher-quality wines (Menna and Walsh, 2019). Therefore, we see Italy and France competing in the upper-tail of the prices—associated with higher-quality wines—but not in the lower-tail.

Another possible explanation for the observed asymmetry is the export-partner portfolio. In more detail, Italy targets the markets of Japan, Mexico, and the United States, whereas France directs its wine exports mainly to China, Australia,

Table 6. The R-Vines for wine, first sub-period (i.e., 01.2005–12.2012)

	Copula	Par. 1	Std. error	λ	τ	AIC	BIC
IT–ES	Frank	0.9587	0.5837	λ=0.0000	0.1054	−0.7098	1.8545
IT–FR	Sur. Clayton	0.5687	0.1590	λ_U=0.2956	0.2214	−15.8992	−13.3348
ES|IT–FR|IT	Independence	0.0000	NA	λ=0.0000	0.0000	0.0000	0.0000

Hong Kong, Mexico, and the United States (Ferto and Balogh, 2016). Italy's orientation toward the Japanese market rather than China, Australia, and/or Hong Kong seems to provide a strategic advantage over France. It seems that during periods of price crashes, Italy can secure higher ground prices compared to France. The higher income of the average Japanese consumer, combined with a higher level of oenological sophistication in Japan, may provide sufficient grounds for the asymmetry we observe. Furthermore, the outcome of upper-tail asymmetry appears rather interesting, given the findings of Ferto and Balogh (2016) showing that Italian and French wines have not been competitive with regards to their extra-EU export markets during the specific period. Therefore, we complement the wine-trading profiles of the specific countries, as drawn from the latter study, by showing that France and Italy compete in the upper tail with regard to their bilateral trade, even though they may be price-discriminating with regards to their extra-EU export markets, suggesting monopolistic behavior, during the same period.

Finally, we find the Independence copula connecting the markets of Spain and France, given the market of Italy, which indicates a loose association of wine prices between the two countries. This finding is consistent with Smith and Mitry (2007), who find declining wine consumption in traditionally high-consuming countries like Spain and France, and to some extent with Bentzen and Smith (2002), who show that French wines are rarely influenced by Spanish wines. Moreover, our finding that France is a peripheral (i.e., non-central) market is in accordance with Castillo-Valero and García-Cortijo (2015), who conclude that France appears to be the "leader" of the Old-World countries. The latter study considers the term "leader" in the context of cointegration between prices, indicating a more independent market. On the other hand, the R-Vine trees highlight the central markets, that is, the markets establishing direct connections with more than one other market. In this sense, central markets are the most connected, interacting (i.e., affecting and being affected by) the most with other markets. Thus, the notion of a non-central or peripheral market, which is relevant for France, is associated with a market wherein price formation takes place to a lesser extent based on price signals from and to other markets.

Table 7 presents the results of the R-Vine copula models for the second sub-period (i.e., January 2013 to January 2020). We note again that the Kendall's τ are sufficiently close to their empirical values, except for the pair Italy-France.

The results for the copula models after 2013 indicate that Spain will become the central market for wine in the EU. This finding may reflect the fact that Spain exhibits the highest price indices among the three countries for the majority of the second sub-period. Furthermore, the status of Spain as the central market highlights that price signals between Spain and the other two markets (i.e., Italy and France) are more intense than those between France and Italy. This result is in accordance with Castillo-Valero and García-Cortijo (2015) finding that Spain is the most dependent market within the Old World, although referring to an earlier period. Moreover, our result is in line with Thach and Cuellar (2007), who find that prices for Spanish wine are sensitive to price changes for French and Italian wines.

Moreover, the Clayton copula is selected based on AIC for the price dependence between Spain and France. The specific copula indicates lower-tail or negative asymmetry with a considerable degree of price dependence (Kendall's τ=0.2456). This type

Table 7. The R-vines for wine, second sub-period (i.e., 01.2013–01.2020)

	Copula	Par. 1	Std. Error	λ	τ	AIC	BIC
ES–FR	Clayton	0.6511	0.1879	λ_L=0.3449	0.2456	−14.2039	−11.7731
ES–IT	Gaussian	0.5098	0.0768	λ=0.0000	0.3406	−18.7414	−16.3106
IT|ES–FR|ES	Independence	0.0000	NA	λ=0.0000	0.0000	0.0000	0.0000

of asymmetry shows that extreme negative price shocks are transmitted from one market to the other, but extreme positive shocks are not. The lower-tail asymmetry found may be explained, to some extent, by marketing trends in the retail sector, particularly related to wine. It has been well documented that wine is increasingly distributed via mass distribution channels, including discounters and food retailers. Schamel (2015) observes that this trend favors prices in the lower tail with regard to the German market. In addition, Kakkos, Trivellas, and Sdrolias (2015) observe that there has been a remarkable shift among consumers toward private labels or store brands, which are again associated with prices in the lower tail. Regarding food, there has been an increase in the market share of store brands in Europe, which are constantly gaining market share in terms of total sales (Kakkos, Trivellas, and Sdrolias, 2015). Therefore, we observe countries with large wine production, like Spain and France, increasingly competing on the lower tail of prices. Moreover, we observe that the degree of price dependence between the two countries increases considerably after 2013 (from τ=0.0000 to τ=0.2456). This outcome may be an impact of the EU policy measures regarding wine markets enacted from 2013 onward. Measures focusing on competitiveness and quality issues rather than production volume, seem to have strengthened price dependence between the main Old-World markets. Hence, the CAP reform measures within the promotion and information scheme, the restructuring/conversion schemes, the vine planting scheme, and those related to harvest insurance, investments, and by-product distillation, all seem to have played their role in facilitating the bilateral wine trade between Spain and France and thus resulted in more intense price competition.

Furthermore, the Gaussian copula is selected between Spain and Italy based on AIC, indicating intermediate price dependence but no upper-tail or lower-tail asymmetry. The intensity of price dependence between them in the second sub-period is relatively high (Kendall's τ=0.3406) and increases markedly compared to the first sub-period (from τ=0.1054 to τ=0.3406). We attribute this increase again to the effects of EU policies on the wine sector. Several schemes were regulated in 2013, and their measures took effect gradually between 2014 and 2020. More particularly, the expenditure for Spain and France under the restructuring and conversion scheme, covering the period 2014–2018, amounted to 46% of the total expenditure. During the same period, Italy and Spain ranked second and third, respectively, in receiving funds under the investment scheme. Moreover, several measures took place in Italy and Spain, which funded promotion and information schemes, harvest insurance, and by-product distillation (European Commission, 2020). Our results provide evidence that these policies may have led to stronger price dependence between Spain and Italy, thus boosting wine market integration in the EU.

Moreover, we find that the Independence copula better describes the price association between Italy and France in the second sub-period. This finding could be explained by substitution effects with beer, which take place both in Italy and in France. More particularly, both countries are considered mature wine markets where per capita wine consumption has been declining in recent decades (Kohr, Camanzi, and Malorgio, 2018). According to AssoBirra (2019), consumers in Italy are increasingly turning to beer, especially after 2013. A clear trend is shown through rising indices of total and per capita beer consumption. Furthermore, this substitution effect is confirmed in Villanueva, Castillo-Valero, and García-Cortijo (2017) finding that European consumers as well as producers reduce the wine consumption/production ratio while increasing their beer consumption/production ratio. Once again, our result regarding France acting as a peripheral market during the second sub-period is consistent with Castillo-Valero and García-Cortijo (2015), who find that France is the most independent Old-World market, even though their study period coincides mostly with our first sub-period.

Finally, we observe that the overall price dependence, measured as $\sum_{i \neq j} |\tau_{i,j}|$, increases markedly from 0.3268 to 0.5862. Thus, we provide statistical evidence that the EU policy changes of the 2013 CAP reform have boosted the integration of the main EU wine markets. According to the European Commission (2020), a series of measures under different schemes regarding viticulture and wine markets in general have been introduced since 2013 or later. More precisely, the authorization scheme for vine plantings replaced planting rights in 2015 and enabled competitive producers to increase their production within certain limits. Measures regarding the promotion of European wines and the labeling of relevant oenological and location information have been included in the NSPs of EU member states. Beneficiaries from Spain, France, and Italy accounted for 85% of the total during the period 2014–2018. Furthermore, the restructuring and conversion scheme assigned 16% of the total expenditures to Spain, 21% to France, and 30% to Italy, whereas under the investments scheme, Spain received 19% of the total, France 45%, and Italy 24% during the 2014–2018 period (European Commission, 2020). Other measures applicable during this period include the harvest insurance scheme, included in the rural development policy for France and the NSP for Spain, those relating to by-product distillation, and finally, innovation measures also applicable in Spain. The specific policies seem to have created an impetus for wine trade between Old World markets, strengthening intra-EU wine market integration. Our result regarding the increasing overall price dependence between the three wine markets is consistent with the converging EU wine consumption patterns found by Smith, Soolgard, and Beckmann (1999) and Smith and Mitry (2007). Moreover, it is consistent with the considerable trade surpluses for 2000–2013 found by Balogh and Jambor (2017), underscoring their competitiveness.

V. Concluding remarks

The EU has historically made substantial efforts to regulate its wine sector through measures affecting the agricultural sector horizontally and through measures encompassing the entire wine supply chain vertically. The goal of a more competitive agricultural sector targets the balance between supply and demand and resilience against market fluctuations. The environmental and social objectives focus on sustainable production systems, the development of innovative products, processes, and technologies, and the reuse of by-products, as well as measures seeking to raise consumer awareness and safeguard producer incomes.

This study utilizes price indices covering the period January 2005 to January 2020 and applies multivariate, static copula models to investigate (i) the degree of integration in the EU wine sector, (ii) the potential of the main Old-World producers (i.e., Spain, France, and Italy) to act as central markets in the intra-EU wine trade, and (iii) the price asymmetries regarding their bilateral trade. We split the time period to track changes resulting from the 2013 CAP reform regarding central markets and price asymmetries between the countries under investigation. Our analysis shows that Spain succeeds Italy as the central market from the first sub-period to the second, and it reveals upper-tail asymmetry between Italy and France before 2013 and lower-tail asymmetry between Spain and France after 2013. Furthermore, we show increasing overall price dependence between the countries from the first sub-period to the second, which signals that wine sector policies have been effective in facilitating a more integrated EU wine market.

The EU wine market policies adopted under the CMO and NSPs seem to have created momentum toward their declared objective of reaching a more competitive wine sector. Wine-specific measures include a new authorization scheme allowing for new vine plantings up to 1% per year; the extension of the restructuring and conversion scheme to replant vineyards; the support for innovative wine products, processes, and technologies and investments in physical assets; the promotion of designations of origin and geographical indications; and responsible wine consumption. Other non-wine-specific measures target improvements in sustainability and overall performance of agricultural holdings, mainly through the income stabilization tool (IST) and crop insurance schemes (Agrosynergie, 2018). A thorough examination assessing the role of these measures in market integration is beyond the scope of this study and needs further research.

The main contribution of our study is an assessment of the 2013 CAP reform regarding the integration of wine markets within the EU. Our research adds to the body of literature supporting the notion that policy measures pertaining to the oenological sector employed in the EU have facilitated market integration and have progressively created a more unified wine market. To the best of our knowledge, this is the first study employing copula-based models to assess market integration within the European wine markets.

A limitation of our research is that it focuses on the three main Old-World markets (i.e., Spain, France, and Italy). However, global wine markets have developed considerably during the past decades and nowadays involve additional actors. Wine production and trade are continuously evolving in the Old World (Portugal, Greece) as well as in the New World (Chile, Argentina, the United States, Australia) and Asia (China). Considering all these actors in detail is beyond the scope of this study. Moreover, we do not account for macroeconomic factors, such as the impact of the 2008 financial crisis on changing price relationships between wine trading countries. Nevertheless, as noted in Esposti and Listorti (2013), macroeconomic factors such as economic bubbles bear only slight effects on the price spreads, which supports our claim that EU policy changes have affected the price interrelationships markedly.

Finally, we acknowledge the importance of technological developments and their role in contemporary agri-food supply chains. Strategically designed supply chains incorporate appropriate IT goals and objectives, which yield increases in terms of efficiency, productivity, and profitability (Marinagi, Trivellas, and Sakas, 2014). Therefore, technological development allows supply chain actors to establish competitive advantages, which provide additional flexibility in setting prices.

Acknowledgments. The authors are extremely grateful to the editor and an anonymous referee for their valuable comments and suggestions, which have helped improve the quality of the paper.

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Cite this article: Rokopanos, A., Bersimis, F., Schamel, G., and Lallos, C. (2023). Spatial integration and hierarchy in Old-World wine markets: The role of the 2013 CAP reform. *Journal of Wine Economics*, 18(3), 245–265. https://doi.org/10.1017/jwe.2023.17