A forecast of Cava wine sales applied to vine planting authorizations

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Abstract

Purpose – This paper aims to establish the determinants of production in the Spanish Designation of Origin (DO) area for Cava wine and forecasts sales to establish vineyard area variations that maintain market equilibrium.

Design/methodology/approach – By applying a vector autoregressive (VAR) model, the authors forecast demand and the consequent requirements for base wine production.

Findings – The results show that Cava sales determine the base wine supply. After forecasting demand and the consequent requirements for base wine, the authors' results show that, to avoid oversupply, the vineyard area for Cava wine should not be increased.

Practical implications – The paper develops a simple and effective method for DOs affected by the current European wine plantation regulations to forecast from a supply and demand perspective and their surface needs in response to market changes.

Originality/value – This study contributes to the literature because, to the best of the authors' knowledge, no other study has investigated the determinants of Cava supply and demand or defines a model to assess the effects of changes in growing areas. The model is applicable to other European protected designations of origin wines and would help policymakers to accurately establish vine planting authorizations.

Keywords Cava wine, VAR model, Vine planting authorizations, Designations of origin

Paper type Research paper

1. Introduction

Regulatory changes in the European Union (EU) Common Market Organization for wine have affected its production. In 2013, a new vine planting authorization system (Regulation (EU) No. 1308/2013) was approved and came into force for the period 2016–2030, replacing the old planting rights scheme. This has posed challenges for the Ministries of Agriculture, who must now set annual limits on the protected designation of origin (PDO) areas authorized for new vineyards. Cava is a popular Spanish sparkling wine protected by a designation of origin (DO), so this regulatory change is particularly relevant for its production. We highlight two issues specific to Cava. First, although Cava is deeply rooted in the Penedès region, its production has spread to other areas in Spain. In consequence, the DO area is neither connected nor homogeneous [1] and each territory has differing interests in the authorization of new vineyards. Second, it shares territory with 13 DOs, so grapes from its DOs are available either for base wine for Cava or for wines of any of the other 13 designations. Hence, some of its vineyards have double or triple registration in different and competing DOs.

In Spain, Cava is of great economic importance. According to the Cava Regulatory Council, in 2021, there were 6,284 farms and 38,133 hectares registered in the Cava DO

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(DO Cava, 2022). It is the second largest wine DO in Spain (surpassed only by Rioja): in 2021, 253 million bottles of Cava were placed on the market. More than two-thirds of these were exported (DO Cava, 2022). Despite its economic relevance, there is little academic literature on its production.

A wide number of scholars have dealt with the topic of forecasting as a tool to facilitate the decision-making of economic agents. Some recent examples are the study of Çuhadas (2020) for the tourism demand, Kolkhova (2020) for the service sectors, Maaonuane *et al.* (2021) for the energy demand and Lutoslawski *et al.* (2021) for food. In accordance with these authors, they confirm the importance of forecasts for the competitiveness of a company. Nevertheless there is no evidence of forecasting Cava demand. This paper aims to provide a useful method of predicting the changes in the future vineyard surface needed to respond to the changes in demand of Cava in the Spanish, the EU and third country markets. Applying a vector autoregressive (VAR) model, we forecast demand and consequent base wine production requirements. Our results show that with few observations related to both the supply and the demand for Cava, projections of demand are adequate to ensure the necessary supply of wine for Cava to meet the final demand.

To the best of our knowledge, European DO Regulatory Councils do not have useful and practical tools to robustly estimate the vineyard areas needed to respond to future market developments (without negatively affecting quality and prices). Our proposed method allows DO teams to annually adjust the surface forecast to critical situations such as global pandemics or armed conflicts.

Our main contribution here is to offer a simple and efficient method that facilitates to specialists forecasting the future needs of European DOs affected by the current European regulation of wine plantations. Forecast models have been useful when estimating changes in demand and the needs of cultivated area. In the literature, the use of a large amount of data is crucial (Elliott and Timmermann, 2016). This implies that one of the main limitations for policymakers is the difficulty in accessing the requisite volumes of information. This article demonstrates that a reduced set of variables can obtain accurate forecasts and provides a useful tool for making adjusted estimates from a limited volume of data. The issue is not so much about accessing a large number of variables but about having an adequate combination of information (Kourentzes *et al.*, 2019).

The article is organized as follows. Section 2 presents the changes in the EU Common Wine Policy (CWP), especially the most recent reform that has led to the emergence of planting authorizations. Section 3 reviews the literature on Cava sector. Section 4 analyses the determinants of supply and demand for Cava. Section 5 describes our econometric model. Sections 6 and 7 present the results of the determinants of Cava supply and demand. Section 8 shows the demand forecast. We end with a Conclusions section.

2. Background: the EU common wine policy

The wine sector has always been tightly regulated in Europe, vineyard planting rights being widely used as a tool (Meloni *et al.*, 2019). The CWP came into force in 1970 in the early days of the European Economic Community. The CWP incorporated many instruments: minimum prices, tariffs on wine imports, public interventions in the wine market, financial support for private storage and for distilling wine surpluses, restrictions on the planting of new vineyards and grubbing aids (Meloni and Swinnen, 2013). However, problems quickly arose with large wine surpluses, and public support funding was eventually used to distill them.

In 1976, the CWP reform tightened the planting restrictions. It required a grower to have a “planting right” to plant a new vineyard. Such rights might be “replanting rights” because the grower had previously grubbed up his vineyard or because another grower did so and transferred his replanting rights. The alternative method was to acquire a “planting right” from the national (or regional) reserve of planting rights. Thus, planting rights were transferable although each Member State could establish restrictions on trade in such rights (Deconinck and Swinnen, 2014). Nevertheless, problems of surplus production in table wine remained, and from the 1980s on, the problem has applied to quality wines within the DO system (Alston and Gaeta, 2021).

In 2008, a new CWP reform (Council Regulation (EC) No. 479/2008) was approved which abolished planting rights in 2018. The European Commission defended the reform as a way of increasing European wine competitiveness, allowing the most efficient producers to increase their production. Reform opponents countered that suppression of planting rights would generate overproduction and a fall in price, especially damaging for small producers and DOs.

The CWP reform in 2013 reversed this liberalization. A scheme like that of planting rights, known as the authorization system, was approved and will run until 2030 (Regulation (EU) No. 1308/2013). The main innovations of the new system are as follows: first, it does not allow authorization transfers and second, new planting authorizations are limited to 1% of a Member State's vineyard area. However, in protected designation of origin or protected geographical indication areas, Member States should have the possibility of restricting the granting of authorizations for replantings on the basis of recommendations of representative professional organizations (i.e. Regulatory Councils of the DO).

Finally, the recent reform (Regulation (EU) 2021/2117) is extending the authorization system until 2045. As Pomarici and Sardone (2020, p. 14) point out, the persistence of planting rights is "*the most idiosyncratic characteristic of the wine policy*".

Recent events such as the Covid-19 pandemic are creating new challenges for European wine policies. According to Vergamini *et al.* (2021), the pandemic evidenced the need to increase cooperation and coordination between governments (national, regional) and actors in the supply chain, in planning stabilization measures as well as in facing disruptions in wine supply and demand.

3. Literature review

Despite its economic relevance, there is a paucity of Cava literature among economists, especially as compared to other sparkling wines such as Champagne (see, among others, Kunc *et al.*, 2019; Haight and Wenzel, 2018; Rokka, 2017; Ody-Brasier and Fernandez-Mateo, 2017; Velikova *et al.*, 2016; Charters *et al.*, 2013) or Prosecco (Galleto *et al.*, 2021; Trestini *et al.*, 2018; Dal Bianco *et al.*, 2018; Onofri *et al.*, 2015; Thiene *et al.*, 2013; Scarpa *et al.*, 2009).

Alonso's work (2017) using the resource-based view of the firm should be mentioned. His results show the importance of history, tradition, knowledge and accumulated experience as crucial resources for the Cava industry. The sector's main challenge is a consumption decrease in the domestic market, which leads producers to rely on foreign markets and diversification strategies (e.g. wine tourism, wine gastronomy, new products, etc.) and on quality improvement. Additionally, Valls-Junyent (2009) concluded that Cava is a successful sector due to the continuous growth of its production (which was higher than that of Champagne in 1970–2006) and export volumes close to those of Champagne. The most recent Cava success story is related to the consolidation of the cluster cantered in Sant Sadurní d'Anoia: high competition between local producers has resulted in their successful diversification into international markets.

There are some comparative analyses involving Cava producers. Saito and Takenaka (2004) compared three Spanish wine-producing regions (Jerez, Rioja and Penedès). For the last of these, they pointed out that most of the leading producers have a long tradition in wine, and specifically in Cava, production, and they continue to operate as family companies. In a recent paper, Alonso and Kiat (2021) analyse internationalization for micro-firms producing Cava and Prosecco. They highlight the significance of exports and wine tourism in small producers' strategies (for both wines, although more so for Prosecco, wine tourism constitutes a direct reason for them to internationalize).

Other academic articles deal with Cava tangentially. Costa-Font *et al.* (2009) uses a Delphi panel method to analyse the wine sector in Catalonia to investigate why a fall in grape prices does not affect wine prices to the final consumer. The results indicate overproduction and imperfect price transmission along the value chain. However, some experts consider that overproduction is not as problematic for Cava as for other Catalan wines (Costa-Font *et al.*, 2009). Alonso *et al.* (2017) note that low grape prices make it difficult for the Penedès region to prevent urban sprawl encroachment by both Barcelona and Tarragona (the provincial capital city). They consider that stricter zoning of wine areas, based truly on *terroir*, would increase production of higher value-added wines and thus preserve rural land use.

Using data envelopment analysis, Aparicio *et al.* (2013) analyse the revenue efficiency of Spanish wine DOs. They conclude that Cava is one of the few Spanish DOs that can be considered efficient from this perspective. Ruiz-Fuentasanta *et al.* (2015) assessed the impact of industrial districts on wine sector efficiency in Spain. They conclude that being in industrial districts, such as Vilafranca del Penedès and Sant Sadurní, has significant positive effects on firm efficiency. Later, Esteban Rodríguez and Climent López (2017) reviewed Spanish wine DOs. Their results showed that Cava is "innovative" since it uses a specialized type of technology and competition between producers is based on knowledge and learning capacity. More generally, Martínez-Carrión and Medina-Albaladejo (2010) discussed the changes in the Spanish wine industry since 1950s. They highlighted the role of Cava in the internationalization process for Spanish wine and found that the outstanding export growth was largely due to the dynamism of Cava and Rioja.

On the consumption side, Angulo *et al.* (2001) analysed the determinants of Spanish alcoholic beverage consumption. Their results showed that the change in total Cava consumption is mainly due to a change in the number of consumers rather than changes in the individual consumption level of existing consumers. Seasonal consumption of Cava was confirmed, as well as higher consumption at home in households located in larger towns than in small villages (Angulo *et al.*, 2001). Bernabéu *et al.* (2012) showed that DOs are more important than brand name for Spanish consumers. Chamorro *et al.* (2015) pointed out how relevant it is that the Cava DO identifies the production location. For sparkling wines in the USA, Lerro *et al.* (2019) recently found that Cava is not widely known in USA markets (12% of their sample of sparkling wine consumer have never heard of, or tasted, a Cava wine).

Finally, Alonso and O'Neill (2011) conducted a survey of wineries in La Mancha, La Rioja and Penedès. They showed that 41.5% of grape growers see climate change as a real threat to their vineyards, and they are already changing their production practices accordingly.

4. The determinants of Cava supply and demand

4.1 Supply

The supply of Cava depends on the volume of the base wine available from each harvest. The production of base wine indirectly captures other factors, such as climatic conditions, pests and irrigation, which may impact on the grape harvest.

However, the base wine supply also depends on the growing surfaces registered in the DO and the variations in their yields. As previously mentioned, Cava has an additional particularity of double or triple registration. This may distort the supply of base wine since grape producers may choose the destination of the base wine according to the market price. Therefore, a determinant factor for Cava supply is the amount of DO land. The possibility of double or triple registration makes it easier for base wine producers to allocate their harvest to Cava or alternatives. This facilitates a more efficient distribution of the base wine as well as a great stability in prices.

Finally, the supply of Cava depends on the economic expectations. The past behaviour of the main markets will affect the current Cava production decisions. Hence, it is also necessary to include the changes in the three main markets (domestic, EU and Third countries) to capture the expectations of economic agents.

The domestic market represents 29% of total Cava sales (DO Cava, 2022). In Spain, Cava is a mature product with moderate sales growth (the cumulative growth rate of the domestic market is 1.259% over the period 2000–2019). Additionally, Cava consumption is characterized by high seasonality: more than half of annual sales (53%) are concentrated between December and January. Hence, the domestic market shows an extreme sluggishness, especially since the beginning of the economic crisis in 2008. Despite that, the consumption of high-quality Cava is increasing.

The stagnation of the domestic market has forced to Cava producers to branch out into external markets which have been the driver of sales growth. Currently, 46% of Cava production goes to the EU and 25% to Third countries. The share of exports to Third countries has been increasing since the beginning of XXI century. However, only 7.5% of exports are of high quality ("Reserva Cava," "Gran reserva Cava" and "Paraje calificado") (DO Cava, 2022).

4.2 Demand

The total demand of Cava has three components: domestic demand, exports to the EU and exports to Third countries. Domestic demand has experienced a moderate downward trend and has high annual variability. Both the EU and Third country exports are growing but EU exports show a high interannual variability while sales to Third countries have a more stable trend. These different trends reflect the fact that the home market is a mature one with an increasing preference for high-quality Cava.

Several economic characteristics, such as income level, may affect demand in each country. For instance, the main European importers of Cava are Germany (17% of total exports), Belgium (13%) and the United Kingdom (12%), while the USA (14%) and Japan (6%) are the main non-European countries (DO Cava, 2022). All these countries are high-income countries with a significant purchase capacity.

Longer-term economic conditions, such as growth, may affect exports in a market. Shocks, such as the Covid-19 crisis or the Ukrainian conflict, may also affect Cava exports and consumption.

Finally, demand depends on trade openness in each market. Trade barriers, such as tariffs or trade regulations, affect exports in specific markets.

5. Econometric methodology

5.1 Econometrics

As a preliminary step, analysis of the Breusch–Godfrey test [2] (and alternatively the test of Durbin–Watson) confirmed no serial correlation between the residuals (Appendix Table A2) [3]. The analysis of the increased Dickey–Fuller test [4] (Appendix Table A3) confirms the existence of autoregression relations of each variable with the lagged ones. Therefore, it is convenient to estimate the supply and demand for Cava using a VAR model (Sims, 1980) [5]. VAR models are defined as follows:

$$y_t = \alpha + \beta_1 y_{t-1} + \cdots + \beta_p y_{t-p} + \varepsilon_t \tag{1}$$

where y_t is the dependent variable introduced with "p" lags, and ε_t is a random error term. The error term represents the part of y_t unexplained by past values [6].

VAR models have clear advantages. First, they allow forecasting a time series from a time window to a later one. Second, they design the trend of the variables under study according to the characteristics of the analytical model-time lags and linkages between variables and determinants of the variables to be estimated. Hence, VAR models allow estimating future values based on how period "t" values related to past values.

Following Subsection 4.1, our equation for the supply of Cava is as follows:

$$\begin{aligned} Q_t = {} & \alpha_1 + \beta_{11}Q_{t-1} + \beta_{12}Q_{t-2} + \beta_{13}Q_{t-3} + \beta_{14}\text{Sales\_dom}_{t-1} + \beta_{15}\text{Sales\_EU}_{t-1} \\ & + \beta_{16}\text{Sales\_Third}_{t-1} + \beta_{17}\text{Price\_wine}_{t-1} + \beta_{18}\text{Quality}_t + \beta_{19}\Delta\text{Export\_EU}_{t/-2} \\ & + \beta_{110}\Delta\text{Export\_Third}_{t/-2} + \beta_{111}\text{Surface}_t + \beta_{112}\Delta\text{Surface}_{t/-1} + \mu_{1t} \end{aligned} \tag{2}$$

where $Q_{t,}$ is the production of base wine devoted to Cava (in logs) and the lagged values capture the persistence trend in the production of wine. Sales_dom_{t-1}, Sales_EU_{t-1} and Sales_Third_{t-1} are sales in Spain, EU and Third countries (in logs); Price_wine is the price of white wine DO in terms of €/Hectograde (in logs); Quality is the evaluation of the quality of Cava ($0 =$ good, $1 =$ very good, $2 =$ excellent); $\Delta\text{Export\_EU}_{t/-2}$ and $\Delta\text{Export\_Third}_{t/-2}$ is the ratio of variation of exports of Cava to EU countries and Third countries, respectively, between year t and year $t-2$ (in percentage). Finally, Surface is the registered area (hectares in logs), and $\Delta\text{Surface}_{t/-1}$ is the variation in the registered area between years t and $t-1$ (as a proportion).

Following Subsection 4.2, our equation for the demand of Cava in each market (domestic market, EU and Third countries) takes the following linear form:

$$C_{it} = \alpha + \beta_1 C_{it-1} + \beta_2\text{Income}_{it-1} + \beta_3\Delta\text{GDP}_{it/-1} + \beta_4\text{Openness}_{it-1} + \varepsilon_{it} \tag{3}$$

where C_{it} is the Cava consumption in period t (in logs) for each market "i" [7], Income is the income per capita (dollars in logs); $\Delta\text{GDP}_{t/-1}$ is the annual GDP growth (share) between year t and $t-1$ and Openness is the ratio of exports over GDP (proportion) and represents the degree of openness.

Finally, α is a constant, and β are the parameters to be estimated. μ_t corresponds to a random error term. For Equation (1), the main source of our data is the Cava Regulating Council. The exception is Price_wine, which originates with the Catalan Department of Agriculture. Table A1 in Appendix shows the matrix correlation of the main magnitudes. For Equation (2), our main source of data is the World Bank, except for the consumption of Cava which comes from Cava Regulating Council and is available at country level for the period 2005–2019. The demand of EU countries and Third countries will be a weighted model according to each country's share of international trade. We must mention that the short number of periods causes that all explanatory variables are incorporated inside the model as exogeneous. After the VAR estimation, the test of stability shows that the modulus of each eigenvalue is strictly less than 1, the estimates satisfy the eigenvalue stability condition.

5.2 Forecast

Departing from equation (1), to forecast future values the general specification of the model assumes that variables "y" are observed until period T. We assume that the number of optimal lagged periods is $p = 1$, i.e. there is only one lag period. If we aim to forecast the values in $T+1$, $T+2$, etc. In $T+1$, our VAR model predicts the behaviour of y_{T+1}:

$$y_{T+1} = \alpha + \beta_1 y_T + \varepsilon_{T+1}$$

Taking expectations conditional on the available information and assuming that there is no serial correlation in the errors, our model is as follows:

$$E(y_{T+1}|y_T) = \alpha + \beta_1 y_T$$

Hence, future predicted values will depend on past values plus some corrections. Following this methodology, we iterate this procedure, and we estimate the predicted values of the predicted values until our time horizon (the year 2030).

6. Results

6.1 Determinants of supply

Based on the function of the production of base wine devoted to Cava, we follow a specific econometric strategy to estimate the coefficients of the supply function. Table 1 shows the corresponding estimated coefficients.

Our econometric strategy is as follows: first, we start from a model where the current crop depends on the three previous harvests, the lagged price of the wine and previous demand in the domestic market, the EU and Third countries (Column 1). Then, we sequentially introduce each of the other variables. In general, we observe a high stability for the coefficients. However, according to the Akaike information criterion (AIC) coefficient, the last estimation (Column 5) is the most robust model since it minimizes the estimated residuals.

Our results show that there is a negative relation between the volume of base wine of the current crop and the levels registered in previous harvests. This may indicate that Cava producers adjust their supply each year depending on their past acquisition of base wine.

The acquisition of base wine is highly sensitive to changes in the internal market and Third countries. Although the domestic market is about 35% of total sales, we observe that the impact of the domestic market is higher than that for sales to the EU and Third countries. However, the impact is significant only for sales to Third countries.

The estimated coefficient of the wine price is positive. In traditional markets, we expect that a fall in the price of wine would lead to an increase in production to maintain the incomes of farmers and producers (Costa-Font *et al.*, 2009). However, our result may be a consequence of the distortion caused by the double and triple registration: when the price of the base wine increases, there is a growth in the proportion of the crop devoted to Cava.

The relationship between the quality of wine and crop size is negative. This implies that the grape quality is closely related to the harvest size; in harvests with higher/lower quality, the amount of wine will be lower/higher. This will be conditioned by the base wine production volume.

The dynamics of EU market sales have a negative impact on our dependent variable, possibly because there is already a high market penetration in these countries. However, export growth to Third countries has a positive impact on wine production.

Finally, we observed a negative relationship between the growing surface and the volume of base wine.

6.2 Determinants of demand

Table 2 presents the estimated model of the determinants of the demand function. The model estimates the demand for the domestic, the EU and Third country markets. We observe that the model for Third countries minimizes the estimated residuals, followed by the estimation for the EU market.

Our results confirm a certain positive persistence of Cava consumption for both EU and Third countries. Conversely, the domestic market shows a non-significant persistence. This result confirms the stabilization of Cava consumption in Spain, while foreign sales have some degree of growth.

Income per capita has a positive influence on the level of Cava consumption in European countries. Growth in GDP exerts a positive significant impact on sales in both the EU and Third countries. Conversely, the domestic market has a non-significant impact, indicating

Table 1. VAR model. Determinants of the supply of base wine (2000–2019)

	(1)	(2)	(3)	(4)	(5)
Q_{t-1}	−0.821*** (0.238)	−0.821*** (0.243)	−0.941*** (0.224)	−0.944*** (0.221)	−0.799*** (0.170)
Q_{t-2}	−0.753*** (0.237)	−0.752*** (0.242)	−0.703*** (0.218)	−0.711*** (0.215)	−0.767*** (0.158)
Q_{t-3}	−0.381* (0.199)	−0.380* (0.205)	−0.386** (0.183)	−0.364** (0.183)	−0.328** (0.134)
Sales_dom_{t-1}	−0.0338 (0.407)	−0.0326 (0.459)	0.189 (0.424)	0.0625 (0.453)	0.347 (0.353)
Sales_EU_{t-1}	−0.570 (0.466)	−0.570 (0.466)	−0.656 (0.419)	−0.714* (0.421)	−0.095 (0.386)
Sales_Third_{t-1}	0.814*** (0.254)	0.815*** (0.263)	0.921*** (0.240)	0.920*** (0.237)	0.735*** (0.181)
Price_wine_{t-1}	0.0548 (0.069)	0.0548 (0.069)	0.0135 (0.065)	0.026 (0.066)	0.058 (0.055)
Quality_t		−0.0002 (0.027)	−0.017 (0.026)	−0.018 (0.025)	0.0169 (0.026)
$\Delta\text{Export\_EU}_{t/-2}$			−0.006** (0.003)	−0.006** (0.003)	−0.004* (0.002)
$\Delta\text{Export\_Third}_{t/-2}$				0.002 (0.003)	0.003 (0.002)
Surface					0.377 (0.509)
$\Delta\text{Surface}_{t/-1}$					−2.081*** (0.529)
Constant_t	34.07*** (9.820)	34.05*** (10.43)	32.42*** (9.353)	34.39*** (9.616)	20.40* (11.33)
AIC	−1.777	−1.659	−1.767	−1.679	−2.119
HQIC	−1.738	−1.616	−1.718	−1.625	−2.056
SBIC	−1.385	−1.218	−1.277	−1.140	−1.482
Log likelihood ratio	21.106	23.106	25.02	25.27	31.01
Observations	17	17	17	17	17

Note(s): The standard errors are shown in brackets. *Significant at 1%, **Significant at 5% and ***Significant at 10%

	Domestic demand	European Union	Third countries
C_{it-1}	−0.272 (0.224)	0.491*** (0.170)	0.868*** (0.121)
$Income_{t-1}$	−9.506 (6.415)	0.623*** (0.229)	−0.0794 (0.316)
$\Delta\ GDP_{t/-1}$	0.186 (0.228)	0.0188** (0.00762)	0.0179*** (0.00655)
$Trade_{t-1}$	0.0209 (0.0691)	0.000247 (0.000882)	−0.00102 (0.00261)
Constant	110.7* (67.10)	−0.804 (2.583)	2.290 (2.434)
AIC	4.141	−2.842	−3.321
HQIC	4.120	−2.863	−3.366
SBIC	4.369	−2.614	−3.104
Observations	14	14	13

Note(s): Standard errors in brackets
*Significant at 1%, **Significant at 5% and ***Significant at 10%

Table 2.
VAR model. Determinants of Cava demand (2000–2019)

domestic market saturation. This result highlights the difficulty of introducing additional product in this market.

Finally, we observe that economic cycle is generally synchronized with the volume of Cava consumption and that the degree of openness is small and non-significant.

6.3 Supply versus demand model

Before presenting our forecast, we apply a Granger causality test between supply and demand of Cava. The aim is to analyse if supply fosters the demand or vice versa. The first hypothesis tests that demand fosters supply, while the second hypothesis tests the influence of supply on the demand of Cava. Our results (Table 3) confirm that demand of Cava has an impact on the supply of base wine.

7. Forecasting Cava demand, the base wine supply and the vineyard requirements

Given our previous results, it is crucial to analyse the demand prediction to see how it affects future surface requirements. By applying the properties of VAR models, we can forecast changes in our time series.

Table 4 presents two scenarios. Scenario I estimates the demand based on the model with three lags while Scenario II forecasts demand based on our model of the demand function. Scenario I shows a moderate growth rate of exports to Third countries, despite this being the area with the highest annual average growth rate (3.472%). On the other hand, there is stagnation in both the domestic and EU markets (the latter having a very slight fall).

Scenario II (VAR model of demand) showed slight but significant differences. According to the demand model, the Spanish market stabilizes in the medium term, with a moderate average annual growth of 0.680%. Conversely, exports to the EU fall annually at a rate of 0.012%, while those for Third countries grow at a rate of 2.473%.

The forecast of sales for the period 2020–2030 shows different features. First, the domestic market stabilizes at around 90 million bottles. Hence, we confirm the moderation of domestic

	χ^2	$Prob(X > \chi^2)$
Hypothesis (1) supply ← Demand	6.88	0.0087
Hypothesis (2) supply → Demand	0.73	0.3916

Note(s): The null hypothesis is the non-causal relation between the two variables

Table 3.
Test of Granger causality

sales observed in recent years. Second, we observe a slight decrease of sales growth in the main EU countries. Fourth, sales to Third countries are more dynamic, but with growth rates more moderate than previously seen.

To sum up, the forecast for sales growth (2020–2030) is equal to 0.875% in Scenario I, while the value is 0.784% in Scenario II. Since sales of Cava did not grow during the period 2010–2019 (average annual growth rate was equal to 0.213%), the forecast predicts a clear moderation of total sales for the period 2020–2030.

Based on our sales forecast, our previous estimations allow us to estimate the requirements of land devoted to the production of Cava. The main objective is to avoid the risk of overproduction and product devaluation.

As we saw in Section 6.3, the dynamics of sales affect the strategies of purchases of base wine. The high concentration in the market means that, at each harvest, the large Cava producers establish the volume and prices of base wine. Hence, sales growth would result in an increase in the purchases of base wine in the following period. Consequently, the required surface would grow proportionally (under the hypothesis of same yield).

According to our sales forecast, it would not be appropriate to increase the DO area. In fact, the model estimates an excess production capacity of 66.8 Hectares.

8. Discussion and Conclusions

In Europe, restrictions on planting rights in wine markets have long been a tool of agricultural policy. The aim of these restrictions is to control wine production. This paper focuses on the case of the DO Cava. In the context of production restrictions under the common policy, some peculiarities of DO Cava require a more efficient allocation of production due to the impact on prices.

This article develops a model that allows policymakers to establish increases in planting area according to the market situation. The main purpose is to avoid, on the one hand, oversupply, and its consequent devaluation of the DO and, on the other hand, insufficient production and price increases that could harm demand. A VAR model with three lags was employed for both supply and demand modelling. It confirms that supply (represented by the production of base wine for Cava) depends on changes in past sales. Supply modelling shows the influence of large producers on the price paid for base wine.

The demand model considers the influence of the domestic, EU and Third country markets. For each of them, we considered determinants of demand: (1) the country's income level, (2) the GDP growth rate and (3) the degree of external openness. The results show a heterogeneous impact of these variables on each of the markets.

Using VAR models, we forecast the evolution of our time series. Empirical results offer two different scenarios. Scenario I estimates the demand based on three lags, while Scenario II

Table 4.
Forecast of Cava sales (2020–2030)

	Total sales	Domestic market	EU sales	Sales to third countries
Scenario I (VAR with 3 lags)				
AAGR 2020–2030	0.875%	0.333%	−0.148%	3.472%
Absolute 2020–2030 (thousands of bottles)	22.96	2.91	−1.66	21.71
Scenario II (VAR model of demand)				
AAGR 2020–2030	0.784%	0.680%	−0.012%	2.473%
Absolute 2020–2030 (thousands of bottles)	20.41	5.96	−0.14	14.59

forecasts the demand based on our demand function model. Scenario I shows a moderate growth rate of exports to Third countries (3.472%) and stagnation in both the domestic market and EU exports. Scenario II is slightly different: the domestic market and Third countries present a moderated average annual growth (0.680% for domestic, 2.473% for Third countries), but annual exports to the EU decrease at a rate of 0.012%.

The proposed supply versus demand model suggests future land requirements (supply) based on an analysis of demand predictions. This allows us to obtain projections that can support the decisions derived from the review of the land requirements for base wine production for Cava. Forecast models could be used to establish vineyard area increases according to the expected market changes. As shown, for Cava, demand is crucial for the supply of base wine, so it is necessary to temper supply to the variations in demand.

In the framework of the EU CWP, such an approach to the wine plantation authorization system has policy and market implications. Particularly, the main consequences are associated with the surface registered in the DO and quality of the wine that will have consequences on the income of farmers and producers. More specifically, this approach allows limiting the risk of over- or under-capacity and devaluation of wine production, as well as neutralizing risks associated with the existence of large Cava producers.

Our study has some limitations, which should be mentioned here. First, our results may present certain limitations due to the temporal horizon and because of the number of observations. However, our previous results with less data were similar which confirms certain stability in our results. Second, our results do not include the incidence of Covid-19. Covid-19 has been an unexpected, uncapturable, shock. Anyway, our results should be valid for a postpandemic world where borders are open and consumption patterns recover. Nevertheless, in future research lines, we may analyse the incidence of Covid-19 on the needs for planting rights. We hope that our work will contribute to an emerging evidence base that provides new ways of forecasting the demand evolution of different products such as other DO wines and agricultural products in general.

Notes

1. The DO Cava territory covers 159 municipalities, located in ten different provinces, belonging to seven autonomous communities. However, 84% of the registered area is in Catalonia.
2. The Breusch–Godfrey test can detect autocorrelation in the errors in a regression model up to any predesignated order (Breusch, 1978; Godfrey, 1978). Alternatively, the Durbin–Watson test was also used to find the serial correlation of residuals (Durbin and Watson, 1950).
3. This analysis was estimated after an OLS regression and as a preliminary step before applying the VAR model.
4. The Dickey–Fuller test analyses the existence of a unit root in an autoregressive time series model (Dickey and Fuller, 1979).
5. Finally, we apply the Akaike information criterion (AIC) and the log likelihood ratio (LR) to estimate the number of optimal lags. The AIC sets the number of optimal delays in 4 according, while the LR test establishes the number of lags as 3 (Appendix Table A4).
6. As explained in Lütkepohl (2005), performing linear regression on each equation produces the maximum likelihood estimates of the coefficients. The estimated coefficients can then calculate the residuals, which in turn are used to estimate the cross-equation error variance–covariance matrix.
7. For EU and Third countries, we included countries that consumed more than half a million bottles of Cava in 2015. The countries included in each group are: Domestic market (Spain); EU (Germany, United Kingdom, Belgium, France, Netherlands, Finland, Sweden, Austria, Denmark, Poland and Lithuania); Third countries (USA, Japan, Switzerland, Canada, Norway, Brazil, Israel, Australia, Russia and China).

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Appendix

Table A1.
Matrix of correlations of main magnitudes of supply and demand (2000–2019)

	Base wine	Total sales	Domestic market	EU exports	Exports to third parties	Stock of wine
Base wine	1.0000					
Total sales	0.5302	1.0000				
Domestic market	−0.3293	−0.6911	1.0000			
EU	0.4011	0.9481	−0.8210	1.0000		
Third countries	0.5874	0.9337	−0.8008	0.8740	1.0000	
Stock of wine (30 June)	−0.7338	−0.5323	0.3145	−0.4586	−0.4965	1.0000
Prices	0.4908	0.5672	−0.5429	−0.4489	0.7556	−0.2221

	Number of lags	Test of Breusch-Godfrey χ^2	Prob>χ^2	Test of Durbin–Watson F	Prob > F
Q	1st lag	0.665	0.4148	3.509	0.0794
	2nd lag	3.299	0.1922	3.557	0.0544
	3rd lag	4.171	0.2436	3.650	0.0392
Sales_dom	1st lag	1.363	0.2429	0.778	0.3908
	2nd lag	1.427	0.4899	1.821	0.1959
	3rd lag	4.502	0.2122	1.134	0.3693
Sales_EU	1st lag	2.571	0.1088	2.504	0.1331
	2nd lag	2.601	0.2724	1.190	0.3315
	3rd lag	2.942	0.4006	0.855	0.4870
Sales_Third	1st lag	0.000	0.9893	0.000	0.9904
	2nd lag	0.059	0.9709	0.023	0.9769
	3rd lag	0.325	0.9552	0.081	0.9691

Note(s): The null hypothesis is the absence of serial correlation
The test of Durbin–Watson uses the option of small

Table A2.
Test of Breusch-Godfrey and Durbin–Watson (2000–2019)

	Number of lags	Test ADF	p-value
Sales_dom	1st lag	−1.249	0.6520
	2nd lag	−0.802	0.8186
Sales_EU	1st lag	−2.556	0.1023
	2nd lag	−2.018	0.2789
Sales_Third	1st lag	−0.960	0.7676
	2nd lag	−1.967	0.3011

Note(s): The null hypothesis is the lack of unit roots

Table A3.
Augmented Dickey-Fuller test (2000–2019)

	2 lags		3 lags		4 lags		5 lags	
	LR	AIC	LR	AIC	LR	AIC	LR	AIC
0		−6.61		−6.92		−7.04		−7.14
1	82.09	−10.17	76.69	−10.37	93.08	−10.46	63.84	−10.20
2	29.66*	−10.82*	21.34	−10.57	22.37	−10.76	24.14	−10.61
3			19.16*	−10.64*	29.36	−11.47	35.37	−11.77
4					67.54*	−14.57*	572.25	−48.74
5							1885.7*	−173.63*

Note(s): *Statistically significant at 5%
LR corresponds to the log likelihood ratio and AIC corresponds to the Akaike information criterion

Table A4.
Tests AIC and LR. Simultaneous model of variables

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