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ORCID

SF: 0000-0002-7533-7412
JR: 0000-0003-3564-7771
AG: 0000-0003-2019-3535
SG: 0000-0001-9680-0114

Fractional responses with spatial dependence of Portuguese wineries' domestic market sales to an exogenous shock (Covid-19)

SAMUEL FARIA¹, JOÃO REBELO², ALEXANDRE GUEDES^{2,*}, SOFIA GOUVEIA²

¹ Department of Economics, Sociology and Management (DESG), University of Trás-os-Montes and Alto Douro (UTAD), Quinta de Prados, 5001-801 Vila Real, Portugal

² Department of Economics, Sociology and Management (DESG), Centre for Transdisciplinary Development Studies (CETRAD), University of Trás-os-Montes and Alto Douro (UTAD), Quinta de Prados, 5001-801 Vila Real, Portugal

E-mail: samuelf@utad.pt; jrebelo@utad.pt; aguedes@utad.pt; sgouveia@utad.pt

*Corresponding author

Abstract. This paper uses firm-level data to investigate the resilience of the Portuguese wine sector's domestic market in the aftermath of the exogenous shock arising from Covid-19. To address this objective, this article applies a fractional response model. The results allow us to confirm that the impact of the pandemic crisis depends on firm structure and behaviour reflected by variables such as firm size, age, export intensity, market channel as well as on the geographic location of firms. This suggests the need for the development of innovative regional clusters and calls for managers and policy-makers to consider the heterogeneity of wineries and dissimilar effects of contingency measures at the municipal level during an exogenous shock.

Keywords: wine, fractional response model, spatial dependence, exogenous shock, firm performance.

JEL classification: C31, C34, D22, L22, Q12.

1. INTRODUCTION

Based on business and consumer surveys, recent studies show that containment measures established at the onset of the pandemic determined either temporary or permanent closure of businesses, mobility restrictions, and losses in income, which led to an increase in economic uncertainty, affecting worldwide wine consumption [1]. The perception of an economic crisis caused a change in purchasing behaviours, namely in spending [2] and preference towards non-premium and mid-range wines [3]. Moreover, the pervasive effect of the pandemic, which sprawled geographically almost without limitations, varied between countries, and among companies, according to different lockdown measures, demand elasticities, and reliance on sales channels [4].

Overall, the repercussions of the pandemic caused significant losses for wine-producer countries, especially in domestic market sales and exports [5] with effects that are likely to last throughout the coming years [6]. Depending on the business model adopted by each country, wine industries may differ in the impacts on and perceptions of the extent of the crisis [7]. Therefore, the level of resilience and ability to adapt to a disrupted business environment impacted by an exogenous shock depends on the structure and behaviour of firms in their location.

At the firm level, the impacts of the pandemic varied according to its market sales focus [8]. Smaller wineries were particularly affected by the pandemic's impact on the on-trade channel, mostly sustained by tourist activities (e.g., bars, hotels, and restaurants) as well as those more dependent on selling directly to consumers at the winery [9]. All this led to a sharp decline in points of sale and local wine consumption in various wine-growing destinations [4].

Regarding the location of wineries, the pandemic had differentiated regional impacts at the national level because of both higher production volumes and collective recognition mechanisms (e.g., the tradition of high quality). The discrepancies at regional levels also affected the resilience of firms, due to the influence of location on performance [10]. Wineries tend to cluster in the same geographic area which affects their production capabilities [11]. Therefore, while some regions have shown stronger resilience, others have struggled more during the pandemic also due to different levels of local constraints, suggesting that a firm's location might have influenced its economic resilience.

Some agglomeration externalities develop naturally due to spatial proximity between wine producers. For instance, the performance of neighbouring wineries can encourage the diffusion of marketing-related externalities for the entire region [12,13] This poses additional considerations with implications for managers and, even more so, for regulating bodies. Geographical clusters in the Portuguese wine industry are highly directed to collective promotion in third countries and exploring regional tourism activities.

Whilst such strategies have improved the position of the industry at an international level, there are a few more opportunities that this paper highlights, which, if taken, would make firms more resilient. These are particularly relevant during a crisis caused by an exogenous shock. In this context, researchers have highlighted the importance of a firm's resilience in mitigating the impacts caused by an exogenous shock such as a financial crisis, natural disaster, or pandemic. Previous research has informed that those firms that resist retaining busi-

ness stability, particularly, throughout a disruption tend to sustain sales losses, reduced market share, and diminished revenue [14]. In particular, small businesses, which represent most of the Portuguese wine industry, are deficient in several critical factors (e.g., knowledge, resources, or liquidity) that ensure business resiliency to implement the required adjustments necessary to endure, following a considerable economic shock [15].

Firms with lower debt ratios tend to be able to recover more quickly due to available resources to employ different strategies and control losses [16]. Therefore, the analysis of the economic performance of wineries is typically accomplished by examining the progress of financial indicators, such as the returns on assets (ROA) [17-19] or other operational indicators, such as earnings before interest, taxes, depreciation, and amortizations (EBITDA) [20].

Despite the earlier efforts to investigate the economic impact of Covid-19 on the firm's economic performance [21-23], there is a paucity of studies that analyze the real variation of sales during the pandemic, a gap this research seeks to fill by investigating the domestic wine sales of Portuguese wineries which have been particularly affected by the negative spike in sales in the on-trade sector comparing 2020 and 2021 to 2019, by as much as 45% and 53%, respectively [24]. Portugal (4.6 mhl, -0.6% / 2020) reduced its wine consumption levels in 2020 and 2021, not only compared to 2019 but also to its previous five-year averages [4]. Contrarily, the sale of wine through off-trade distribution channels (e.g., supermarkets) in 2020 rose 6.4%, up to approximately 12 million litres, and 9.4% in 2021 compared to 2019, amounting to more than 17 million litres. On average total domestic demand witnessed a sharper decrease in value rather than volume in 2020 and 2021 in comparison to 2019, with a difference of roughly 32 p.p. and 33 p.p., respectively. These indicators show that Portuguese wineries were deeply impacted by the effects of Covid-19, highlighting the importance of on-trade and direct-to-consumer channels which suffered the most during the pandemic, comparable to other Old World countries due to distancing measures and stringency of travel restrictions [25,26].

This study's results can be extrapolated to Old World countries given the overall average dimension of companies, mostly comprised of small-to-medium size business structures, and highly fragmented [7]. Also, the distribution system implemented by wineries to reach the market is associated with winery size and is highly correlated to geographic origin [3]. This posits limitations in market positioning which relate to export intensity but underlines the importance of wine tourism,

which has progressively become a significant revenue stream [27]. Moreover, Portugal embodies a typical market structure of monopolistic competition which tends to influence the level of differentiation of wineries, and business performance.

In the case of winery losses due to the Covid-19 pandemic, analyzing changes in domestic sales losses provides a vision of how a short-term exogenous shock impacted the ability of a firm to reach new customer demand. In this research, the percentage change of a winery's sales is the economic variable, which was estimated to capture two pandemic time frames, (2020-2019 and 2021-2019), and which occurs as a fraction and percentage, which from an econometric perspective, is not considered as a probabilistic outcome, but yet has 'both two-corner solution outcomes and continuous outcomes in the interval $[0, 1]$ ' [28]. Therefore, for the most part, traditional models are unsuitable for estimation. The method applied in this article offers a reliable estimator for the fractional response variable in the presence of a spatially lagged (explanatory) variable, that accounts for the interdependent relationships between neighbouring firms. According to [29], there is a lack of studies including spatial dependence in fractional models. As far as we are aware, no study of the wine industry has yet attempted to do so.

In summary, this paper uses firm-level data to investigate the Portuguese wine sector's economic resilience in the aftermath of the exogenous shock arising from Covid-19. To address the main aim of this research, two complementary issues have been dealt with: (a) to determine the economic characteristics of firms that influenced their resilience in the aftermath of the Covid-19 waves in 2020 and 2021 and reflected in the fall of sales in the domestic market; (b) to analyze the previous issue using a fractional response model that combines the spatial/geographic dependence factor of wineries.

Methodologically, this research applied a two-part fractional response model with spatial dependence, which allows overcoming, at the same time, two of the main drawbacks of the existing literature which are conditioning appropriate interpretations and policy recommendations. First, the relevance and advantages of using appropriate fractional response models over other regression models, which are unable to cope with values in the interval $[0, 1]$ and not with an excessive number of boundary values in the dependent variable. Second, the importance of including a spatially lagged term in the analysis to account for the role of the firm's geographical location in economic performance. The combination of these two issues constitutes a methodological advancement in achieving robust findings that allow a

better understanding of the firm's behaviour (specifically those in the wine sector), namely the propensity and intensity of firm-level economic resilience in the aftermath of an exogenous shock triggered by Covid-19.

This study provides important managerial implications for the resilience of wineries in facing a disrupted business environment impacted by an exogenous shock and improves management decision-making in a post-pandemic and recovery phase. Additionally, it provides new scientific background on the estimation and utility of fractional response models.

The remainder of this paper is organized as follows: Section 2 develops the econometric approach to the research problem, section 3 presents the econometric function, the data, and the results, and Section 4 concludes.

2. ECONOMETRIC APPROACH

The study analyzes two estimations taking into account variations in domestic sales losses between 2019 and 2020 and between 2019 and 2021, to capture changes in the behaviour of companies along two different stages of the pandemic. In both models, the dependent variable is the relative loss of a firm's sales in the domestic market. It fills the condition , in which a value of represents wineries that showed no sales losses, and conversely a value of represents a loss of 100% of total sales. Therefore, since the main goal is to estimate , econometric models that assume a linear relationship between the explanatory and the dependent variable may produce predicted values that lie outside the meaningful boundaries $[0, 1]$, including the marginal effects.

To overcome such difficulty, alternative approaches are presented in the literature. Censored models, such as Tobit models may represent an alternative approach [30], [31]. However, they require piled-up observations in both limits of the interval, which is unlikely the case for our dependent variable. The most likely scenario for wineries is that the majority of firms experienced a drop in sales, even though a significant proportion did not report any loss (firms in this last category are represented by a '0' in the interval $[0, 1]$).

2.1 The fractional response model

An appropriate solution for the estimation approach is the use of fractional response models, as recommended by [32], to guarantee predictions in the meaningful interval that can be properly interpreted. They proposed a thorough answer to this issue, by considering the following expression:

$$E(y_i | x_i) = G(x_i\beta) \quad (1)$$

where $G(\cdot)$ is a known function satisfying $0 \leq G(z) \leq 1$ for all $z \in \mathbb{R}$. The dependent variable is represented by y_i , whereas x_i denotes the vector of explanatory variables. The use of this approach ensures that the predicted values of y lie in the $[0, 1]$ interval. In applied research, two main solutions for $G(\cdot)$, as a cumulative distribution function (cdf), are typically used, namely the logistic function, (fractional logit) and the standard normal distribution function, (fractional probit), which ought to be estimated through non-linear techniques.

Considering this, the fractional response models allow the estimation of sales losses, with predicted values inside the relevant boundaries, and are typically estimated through non-linear least-squares methods or quasi-maximum likelihood approaches.

A further issue that could occur when modelling firms' sales losses in the pandemic crisis might be the existence of sample selection bias, specifically since not all firms have reported losses. Since the value of total exports did not suffer a downturn [24], some firms might even have registered increased sales.

Despite the Heckman selection model offering a plausible solution to the expectable selection problem, it cannot cope with the previously identified issue of predicted values outside the meaningful interval $[0, 1]$. Furthermore, it requires the dependent variable to be normal for the assumptions to hold, and it does not account for neglected heterogeneity across the sample. Having this methodological scenario, [33] offers an appropriate solution, namely the use of two-part models. By using their proposed framework, the model is divided into two components: a binary and a continuous one. The binary component is used to estimate the occurrence of the event (0 for firms without domestic sales losses, and 1 for firms with registered domestic sales losses), and the extent of the domestic sales losses is estimated in the continuous part of the model, through a fractional regression model. Here, only firms who registered domestic sales losses are included, which solves the problem of selection. Furthermore, using a fractional response approach to model the continuous part also solves the issue of predicted values outside the meaningful interval.

Thus, following [33], the first part of this model is defined by a standard binary choice model, modelling the probability of observing a positive outcome,

$$y^* = \begin{cases} 0, & y = 0 \\ 1, & y \in (0, 1) \end{cases} \quad (2)$$

$$P(y^* = 1|x) = E(y^*|x) = F(x\beta_{1P}) \quad (3)$$

where $F(\cdot)$ is the distribution function, usually the logistic function or the standard normal, β_{1P} refers to the parameters of the first-part equation. Here, the propensity to have registered sales losses is modelled.

The second part of this model considers only the positive outcomes in equation 4 and models the magnitude of non-zero outcomes. When modelling for sales losses, this means considering only firms who registered losses and thus modelling the intensity of the loss. The second part may be defined by:

$$E[(y|x, y \in (0,1))] = M(x\beta_{2P}) \quad (4)$$

where β_{2P} refers to the parameters of the equation of the second part. Consequently, $M(x\beta_{2P})$ may be estimated through the QML method. Considering equations 3 and 4, and following [34], $E[(y|x)$ is then defined by:

$$E(y|x) = E[(y|x, y \in (0,1))] \cdot P[y \in (0,1)|x] = M(x\beta_{2P}) \cdot F(x\beta_{1P}) \quad (5)$$

Considering the fractional response nature of the variable of interest, the quantity of boundary observations, as well as the sample selection issues, this two-part model approach produces meaningful and consistent results.

The interpretations of the obtained estimations should consider the conditional expectation of the dependent variable, i.e., $E(y|x)$. Thus, the computation of the average marginal effects (AME) of each model is required [20]. In the two-part FRM modelling, following [33], the AMEs are given by:

$$AME_{X_k} = \frac{\delta E(y_i|x_i)}{\delta X_k} = \frac{\delta M(x_i\beta_{2P})}{\delta X_k} F(x_i\beta_{1P}) = \frac{\delta F(x_i\beta_{1P})}{\delta X_k} M(x_i\beta_{2P}) \quad (6)$$

In the case of dichotomous explanatory variables, the AMEs are given by the trivial difference of the adjusted predictions, i.e., the difference in the probability when that variable is observed and when it is not observed.

2.2 The fractional response model with spatial dependence

The role of the firm's location is typically studied within the framework of spatial econometrics by including a spatially weighted matrix that accounts for the distance between firms in a regression [35-37]. The main rationale is that the output of a firm depends on (and influences) the activities of neighbouring firms. This may occur due to the existence of spatial spillovers

generated by proximity [38], such as innovative regional clusters or transfer of knowledge between neighbouring producers.

Despite its relevance, the integration of spatial dependence into fractional response models is a rare phenomenon in the literature, with a handful of contributions extending the existing framework of fractional regression models. Specifically, [39] proposes considering additive errors as a way to include the spatial lagged term in the function. More recently, in the framework proposed by [29], spatial dependence is introduced through a spatial lag of the fractional dependent variable, inside a nonlinear function, as an extension to the [32] approach. This is the Fractional Response Spatial Lag Model (FRSLM) and may be defined as:

$$Y_i = G(\alpha \sum_{j \neq i} w_{ij} Y_j + X_i \beta) + u_i \quad (7)$$

In this specification, a link function $G(\cdot)$ is defined so that predicted $E(Y_i)$ values are bounded to the meaningful $[0, 1]$ interval. Spatial dependence is included within the defined function, where $w_{ij} Y_j$ represents the spatially lagged variable, provided from a row-standardized spatial weight matrix w_{ij} , ($W \cdot W$) in which all values are non-negative and represent the weight of the distance between each pair of firms i and j . Moreover, $X_i \beta$ is the matrix of the explanatory variable multiplied by the respective regression parameters.

The FRSLM approach is relevant in our case, as wine is an industry in which geographic location plays a crucial role in determining the behaviour and strategic decisions of a firm [30,32].

3. ECONOMETRIC FUNCTION, DATA, AND RESULTS

3.1 Econometric function

The market characteristics of the Portuguese wine industry allow us to define an econometric production function that represents the technology of all firms, due to technological homogeneity, which should be dependent on a set of intrinsic characteristics and interaction with neighbours, i.e., spatial dependence [12].

The explained variable is the domestic market sales losses of wineries, measured through the loss in 2020 and 2021 in comparison with 2019 (a fraction between 0 and 1). For the selection of the explanatory variables, the wine literature employing the resource-based view (RBV) of the firm framework usually considers factors such as size, which can be either measured as the number of paid employees [40] or the value of total assets [41]. Size is typically identified as a positive driver of performance,

since wineries can benefit from reaching economies of scale, due to higher availability of resources.

The age of a firm is also a relevant factor as it serves as a proxy for experience ([41-43]. The impact of age is not clear in the literature, as it could boost performance by the benefits of reputation or hamper it through the rigidity of strategies employed and lack of innovative dynamism [44].

Among other relevant factors affecting the performance of wineries, [45,46] the marketing budget is likely to impact the ability of firms to engage in innovative strategies, such as communication or promotion in third countries.

Export intensity, typically measured as the share of exports to total sales, refers to the strategic positioning of a firm in the international market. It is intrinsically linked with performance [31,43,47], as most successful exporting firms are generically associated with higher value.

Furthermore, the dependence on the on-trade channel affected losses, through the closure of most wine tourism activities during the lockdown [9,7]. To control for such phenomena, a dummy variable is included, taking a value of 1 if a firm has any form of tourism activity (tasting room, restaurant, wine store, or accommodation facilities) and 0 otherwise.

Finally, the inputs required for a firm's operations are considered as control variables, by including the value of the supplies and services as a proxy [10,48].

As mentioned by [29], there is a lack of studies that include spatial dependence in fractional response frameworks. The present paper includes the spatially lagged variable in the econometric function. A positive signal of such a variable indicates that firms that are located near their competitors struggled more than those who are isolated. Conversely, a negative sign suggests that regional clustering is a positive driver of resilience.

Following equation (7) and the set of characteristics presented above, the function that explains sales losses in Portuguese wineries is given by:

$$\begin{aligned} SalesLoss_i = & G(\alpha \sum_{j \neq i} w_{ij} SalesLoss_j + \beta_1 Ln(Employees)_i \\ & + \beta_2 Age_i + \beta_3 Ln(Marketing)_i + \beta_4 ExportIntensity_i + \\ & \beta_5 WineTourism_i + \beta_6 Ln(SuppliesServices)) + u_i \end{aligned} \quad (8)$$

3.2 Data

The dataset for this study is composed of Portuguese firms within the 11021 NACE code to ensure technological homogeneity (the same production function applies to all included firms). Data is retrieved from the official fiscal reports of wineries for the years 2019, 2020 and

2021 to monitor the extent of losses during the pandemic. Careful screening of the data available for all variables for both years provided a final sample of 290 wineries in 2019 and 2020 and 270 in 2021 covering mainland Portugal.

Figure 1 shows the distribution of the dependent variable (sales losses) and it highlights the methodological relevance of analyzing the phenomena with the use of fractional response models as well as the superiority of two-part models and provides key insights into the overall situation during 2020 and 2021.

Figure 1 displays the histograms of losses for the years 2020 and 2021. First, the figure shows a high prevalence of zero-observations, which means firms that did not report any domestic sales losses. In 2020, 31.14% of the total sample, whereas in 2021 the number was 48.88%.

Second, a quick look shows that the effects of the pandemic were much larger in the year 2020. The average drop in domestic sales in 2020 was 16.34%, whereas, in 2021, the drop was significantly lower, 11.86%. Additionally, the histogram provides a further reading. In 2021, the concentration of firms near the left margin, i.e., reporting zero loss, is much larger than in 2020. Of the 290 firms that were active in this period, we see that 121 reported domestic sales losses lower than 10% in 2020. This means 41.72% of the firms. In 2021, the number of firms that registered domestic sales losses lower than 10% was 181, a whopping 67.04 % of the total of firms This shows that the resilience of Portuguese wineries was a fact, alongside the speed of recovery.

Table 1 presents the descriptive statistics of the dependent and explanatory variables of the estimated econometric function.

At first glance, both pandemic years, 2020 and 2021, exhibited an average drop in domestic sales in compari-

Table 1. Descriptive statistics.

Variable	Mean	Std. Dev.	Min.	Max.
Sales Loss (2020/2019)	0.1634	0.1896	0	1
Sales Loss (2021/2019)	0.1186	0.1857	0	1
Turnover 2019 (euro)	3,282,168	1,12E+07	147	1.46E+08
Turnover 2020 (euro)	3,145,864	1.08E+07	768	1.37E+08
Turnover 2021 (euro)	3,766,341	1.25E+07	84	1.56E+08
Employees (#)	16.8581	44.7994	1	638
Age (years)	24.9273	18.4095	8	104
Marketing expenditures (euro)	204,937	1,265,488	0	2.02E+07
Export intensity	0.1956	0.2622	0	0.9978
Wine Tourism	0.2768	0.4482	0	1
Supplies and services (euro)	611,562	2,594,145	2,538	3.85E+07
Spatial Lag (2020/2019)	0.1654	0.0435	0.0281	0.2787
Spatial Lag (2021/2019)	0.1951	0.1036	0.0122	0.4851

son to 2019 of, approximately, 16% and 12%, respectively. Yet, the average annual turnover exhibited a different behaviour, first decreasing from 2019 to 2020 but stepping up in 2021 in comparison to 2019, which suggests an increase in sales value. This sets the generic scenario for domestic sales losses caused by the pandemic crisis.

In terms of firm characteristics, the heterogeneity of Portuguese wineries is observed with the size of firms ranging from just 1 employee to 638 of the largest producer. Similarly, disparities in age are also visible, with ages ranging from 8 to 104 years old (averaging 24 years). The mean expenditure per firm on promotion (marketing) was € 204,937. Exports are an important driver of wineries' growth. 64.71% of the firms are exporters. In terms of value, exports account for

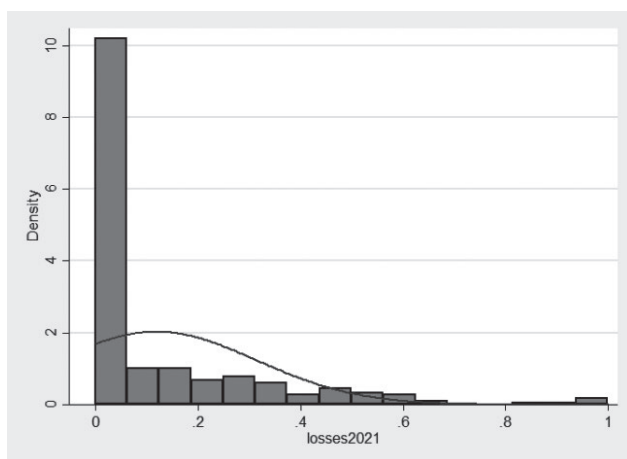
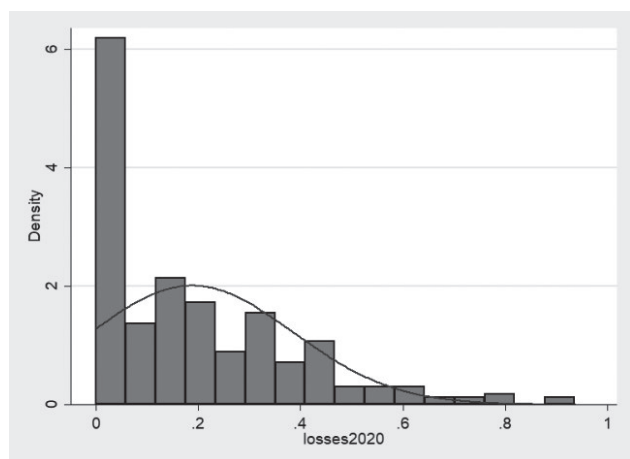


Figure 1. Histogram of sales losses (0-100%): 2020; 2021.

an average of 19.56% of the firm's total turnover, and 27.68% of the wineries have some sort of wine tourism activity (wine shop, tasting room, guided tours, etc.). The mean value of supplies and services (water supply, electricity, oil, etc.) was € 611,562.70.

Additionally, we estimated the Variance Inflation Factor (VIF) to detect the existence of multicollinearity in our datasets. By the rule of thumb, 10 takes on a critical value for the presence of multicollinearity. This hypothesis is dismissed since the mean VIF is 1.62 in 2020 and 2.11 in 2021 in which the maximum value is 2.98 (for the variable "employees") in 2020 and 4.04 (for the variable "supplies and services") in 2021.

3.3 Results

Considering that more than 31% and 49% of all the firms analyzed in 2020 and 2021, respectively, did not report any loss at all, the possibility of sample selection bias ought to be tested and accounted for. The rationale is that the intrinsic reality of those firms that did not suffer any losses might be substantially different from those that did report losses during the period.

Table 2 provides the results of the econometric estimations referring to the two-part fractional model¹ as it provides superior results in terms of statistical robustness [20,33].

Both estimated periods (2020-2019 and 2021-2019) share similar results in terms of signal and significance in the main equation (which models the intensity of sales losses), except for the size of the firm and age. It is noticeable, however, that there are interesting differences among both selection equations (i.e., probability/proneness of having a loss in sales). Among these, the size of a firm (measured through the number of employees), marketing budgets and services supplies are deemed significant determinants of having a loss between 2020 and 2019, whereas, in the second period, which represents the subsequent pandemic time frame, these variables did not significantly affect sales losses in the domestic market. This suggests different phenomena: (i) larger firms were more prone to having registered sales losses during the first year of the pandemic; (ii) among the firms who did register losses, larger firms were less affected (i.e., the level of loss was lower for larger firms); and (iii) 2021, on-trade sales increased independently of size, age, and marketing budgets.

¹ To check for divergences in results in the Two-part fractional model we compared its estimations with two other models: the fractional logit, and the Two-step Heckman. In Appendix 1 – Table A we present the first two models and report in the text the results of the Two-part fractional model.

Table 2. Econometric estimations of the Two-part fractional model.

Variables	Dependent variable: Sales Loss			
	2020/2019	2021/2019	2020/2019	2021/2019
	Main equation		Average marginal effects	
Ln(Employees)	-0.1800* (0.0978)	0.0704 (0.0711)	-0.0338* (0.0182)	0.0106 (0.0109)
Age	0.0097*** (0.0033)	-0.0004 (0.0039)	0.0018*** (0.0006)	-0.0006 (0.0006)
Ln(Marketing)	0.0912 (0.0645)	-0.0129 (0.0174)	0.0171 (0.0121)	-0.0019 (0.0126)
Export intensity	0.7894*** (0.2941)	1.1378*** (0.4225)	0.1418*** (0.0553)	0.1712*** (0.0653)
Wine Tourism	0.3557** (0.1517)	0.2971* (0.1574)	0.0667** (0.0284)	0.0447* (0.02341)
Ln(SuppliesServices)	-0.3089*** (0.1128)	-0.1860** (0.0932)	-0.0579*** (0.0212)	-0.0280** (0.1419)
Spatial Lag (LossW)	2.9411** (1.2854)	8.8978*** (1.2222)	0.5519** (0.2427)	1.3388*** (0.1343)
<i>Selection equation</i>				
Ln(Employees)	0.5579** (0.2256)	0.3338 (0.2110)		
Ln(Marketing)	0.2982** (0.1193)	-0.0060 (0.0444)		
Export intensity	-0.6992 (0.6522)	-0.3792 (0.5928)		
Ln(SuppliesServices)	-0.7587*** (0.2324)	-0.0824 (0.1723)		
Dummy Port wine	2.2375** (1.0718)	1.9565* (1.0635)		
<i>Model statistics</i>				
Log-likelihood	-83.3423	-45.5388		
Pseudo R ²	0.2297	0.6826		

Note: ***, ** and * denote significance at the 1%, 5% and 10% levels, respectively. Standard errors are reported in parentheses.

Furthermore, in both selection equations, the results suggest that larger firms, with higher marketing expenditure and heavier structure of operational costs, were struck harder in the first year of the pandemic, with a higher probability of having registered domestic sales losses than their smaller, more flexible counterparts. However, it is interesting when the interpretation goes to the continuous part of the model, which models not the probability to register domestic sales losses but the dimension of domestic losses. In the main equation, we see that larger firms were hit with lower impact. The same goes for the supplies and services variable, which reinforces the previous reading.

These results mean that larger firms have an overall stronger reaction and adaptation capability to a crisis,

which is in line with the findings by [49]. Moreover, our findings confirm [21] results, demonstrating that smaller firms are more likely to have registered higher losses during the pandemic than larger firms, which were capable of achieving economies of scale.

Results show that export intensity is positively linked with the size of the loss in sales (but has no significant effect on the probability of having sales losses). This happens since the response variable captures changes in domestic market sales, and the wineries that are more involved in export activities are also likely to be more dependent on the external markets' on-trade channel (generally higher value wines), which suffered more from the restrictions imposed during the pandemic, a behaviour similar to the domestic market. Consequently, the export intensity remains a strong driver for the dimension of sales losses in 2021, hinting that a dependence on the on-trade channel affects the recovery of wineries.

Wine tourism activities are identified as positive drivers of sales losses. This is explained by the traveling restrictions during the lockdowns. Since the sales of these firms are dependent on wine tourism sales (direct sales), their losses were stronger than those of the firms that did not have wine tourism activities, which is in line with [9] findings.

The two-part fractional response model requires the analysis of the AMEs for accurate interpretations of the true effects of the explanatory variables in the dependent variable. Overall, the results confirm the existing RBV framework literature in terms of determinants of performance. The overall effect of size (employees) is negative, which signals that achieving economies of scale in the Portuguese wine industry was a factor that determined greater resilience during the pandemic. This is in line with the previous findings regarding performance studies [15,16,43,50] but more relevantly, with the suggestion that smaller firms struggled more during the pandemic [4]. This can be explained by the lower exposure to the on-trade channel that larger firms could have when compared with smaller competitors.

Older firms showed higher intensity of domestic sales losses *Ceteris paribus*, a firm that is 10 years older than others suffered greater intensity of sales losses, being nearly 2% more. This confirms that older firms might show higher rigidity in processes and therefore display lower resilience than younger firms. Another explanation could be that the oldest firms in the sample are Port wine producers, who are also highly dependent on wine tourism activities, in the domestic market. This is most interesting given that in the selection model for companies' sales losses between 2021 and 2019, when the pandemic was still thriving but showing some signs

of receding, Port wine producers' sales losses were still significantly affected.

The industry-level scenario set for the Portuguese wine industry states that in 2020 and 2021, exports grew in both value and volume [24] despite the pandemic. However, in our sample, the intensity of exports shows a positive sign towards the intensity of domestic sales losses. Therefore, it is likely that wineries that are more dependent on the on-trade channels in the domestic market are dependent on the same channel in the international market.

The dependence on the on-trade channel is also evaluated through the wine tourism dummy, which shows, as expected, a positive relationship with the intensity of domestic sales losses. *Ceteris paribus*, having wine tourism activities meant that that firm experienced on average, a 6.67% higher loss than a firm that does not engage in tourism activities. This is explained by the fact that tourism was one of the most affected sectors, witnessing a disrupted environment that imposed mobility restrictions that drastically reduced flows of tourists as well as suffering temporary or permanent closure of businesses [9]. In 2021, that impact was not dissipated, but a reduction in both the coefficient and the significant level shows that the less stringent lockdown period, i.e., 2021, translated into less severe losses.

The supplies and services variable is a proxy for inputs that are required to carry out production (such as water, gas, electricity, etc.) and it is negatively related to the intensity of the losses, meaning that firms with larger structures reported lower domestic sales losses than smaller firms. In 2021, the impact was mitigated, with a reduction in both the coefficient and the significant level.

The spatially lagged variable reveals a positive relationship with the intensity of sales losses. This suggests that proximity relationships (usually envisioned as regional clusters) implied a domino effect during the crisis. Most agglomerations of firms comprise small-to-medium-size wineries with a high dependence on tourism, which determines performance-wise regional homogeneity in response to exogenous shocks. This underscores the importance of innovation and marketing efforts to enhance brand recognition, which have been shown to increase a winery's resilience to such a ubiquitous and destructive phenomenon [9]. In 2021 there was a reinforcement of the spatial component.

4. CONCLUSION

The Covid-19 crisis impacted most industries worldwide through the imposed restrictions that governments

took to contain the spread of the virus. This highly challenging environment triggered paradigm shifts in most industries, in response to demand and supply disruptions as well as future economic uncertainty. The wine industry is a good example of such an impact, with a negative spike in consumer demand and a quick shift in buying behaviour [3,51], which tended towards cheaper and lower quality wines, with a profound impact on domestic market sales, as this study illustrates.

Recent research in the wine literature has pointed out that the resilience of the wine industry is dependent on the strategies of government and regulatory bodies as well as firm-level capabilities in response to exogenous shocks [3]. Despite its relevance, no studies to date have analyzed the extent of the impacts of the pandemic on firm-level performance, through the analysis of financial indicators, which this study tried to accomplish.

The results of this study reveal two main trends that directly answer the research issues posed in the introduction. First, not all firms suffered from the impacts of the pandemic. While some firms lost their domestic sales almost entirely, some firms did not feel the impact of the pandemic.

Moreover, this paper identified several firm structure and behaviour variables that explain such discrepancies, such as firm size, age, export intensity, and dependence on the on-trade channel. As an illustration, this research demonstrates that in a context of crisis, increasing export intensity leads to a rise in the loss of sales in the domestic market, which is related to a substitution effect of the on-trade sales by exports due to contingency measures, which affect direct-to-consumer sales within the domestic market. Therefore, strong policy measures are needed to tackle this issue, namely through the development of digital platforms, both collective and individual, that allow increasing the direct sale of wines in national markets, namely in companies that are outside the large distribution system. This issue is interrelated with a broader requirement to develop and apply downstream business models that are not as developed in Portugal as well as in traditional Old World countries [3].

Second, this study's results exemplify the negative effect of the concentration of small average size firms that perform in a fragmented way and apparently without associative support. Public policies that strengthen associative relations and cooperation between firms would allow greater economic resilience of small businesses to external shocks such as a pandemic. So, it seems that agglomeration is not sufficient to promote entrepreneurial resilience and ultimately it can lead small businesses to compete for a direct-to-consumer

market that is contracting. The variable "wine tourism" reveals precisely this, i.e. that companies most exposed to direct sales, are those that suffer most through the reduction of sales in the domestic market, in the absence of alternative means of selling (e.g. online). Furthermore, the spatial effect can also be a consequence of other factors such as the heterogeneous impact of government contingency measures at the municipal level that affected wineries differently, particularly those serving local demand.

Therefore, this study indicates the need for the development of regional robust clusters. Such examples could involve the development of cooperative practices between neighbouring firms, such as knowledge sharing, in overcoming some obstacles that firms and regions might encounter as well as promotion. Expanding the geographical range of sales in the on-trade channel could improve resilience when a specific region is more affected than others by an exogenous factor.

Overall, this paper provides some practical insights that have the potential to be further developed, such as the study of regional differences, particularly in the behaviour of wineries within each wine region. Additionally, it reveals that firms should focus on sharing knowledge, research, development activities, and other innovative ventures, in line with [52]. Moreover, proper strategy design and market positioning could be key to ensuring resilience in challenging circumstances, as suggested by [53].

This paper is not without limitations. Future research could be improved by defining clear lines between wine regions since this paper showed that there are likely to be significant structural differences between different wine regions in Portugal.

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