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RESEARCH ARTICLE

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Survival analysis of orange tree varieties in Spain

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Abstract

The fundamental basis of Spanish citriculture is its varietal composition, which contributes to the existence of a marketing calendar that extends to almost the entire year. As time goes by, the supply of varieties is continuously renewed, requiring significant investments by growers. The guarantee of a quality supply to the markets, on one hand, and the optimal result of the investments made, on the other, require that, in managing the sector, the characteristics determining the survival of the varieties be taken into account. The main purpose of this study was therefore to assess the influence of the attributes affecting the longevity of orange plantations from a technical and commercial point of view. The duration analysis technique applied to the different varieties has been used. The main attributes determining the elimination of a variety were the presence of seeds in the fruit and the tendency towards a decrease in surface size. Permanence- or survival-friendly attributes included the calibre (large size of the variety, within its group) and the price received by farmers. Precocity, frost resistance, commercial quality and resistance to fruit fly did not have the expected level of significance.

Additional keywords: longevity; duration analysis; attributes; varietal composition; introduction of varieties.

Abbreviations used: AIC (Akaike information criterion); BIC (Bayesian information criterion); EU (European Union); LR (likelihood ratio).

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Introduction

Spanish citriculture occupies a significant place worldwide not only because of its production, but also because it ranks first among the exporting countries of fruit for fresh consumption, maintaining this global leadership in oranges, mandarin oranges and lemons, with an average of 33%, 55% and 28% respectively in the 1994-2013 period (FAO, 2018). In the 2016-17 season, the Spanish cultivated area amounted to 295,331 ha, of which 48% accounts for sweet oranges, 37% for mandarin oranges and 14% for to lemons. The remaining area is divided between grapefruit, bitter oranges and other citrus fruits (MAPA, 2018). National citrus fruit production in the 2016-17 season amounted to 7,085,819 tonnes (tn), with oranges accounting for 51.7% of production, followed by mandarin oranges with 33.4%, while lemon production is 13.5% and that of grapefruit only 1.02%.

Taking all varieties as a whole, or groups of orange varieties, the navel group stands out which, with a production of 2,705,332 tn in the aforementioned season, accounts for 73.86% of the total for oranges. This is followed by the late varieties, which account for 13.88%; select white varieties for 10.97% and the rest of the groups (common whites and blood oranges) for only 1.29%. Orange cultivation mainly covers the area between the Region of Valencia and Andalusia, with respectively 49.31% and 41.45% of the national orange tree area; the Region of Murcia is the third-largest region in orange production, with 7,952 hectares, *i.e.* 5.61%.

In Spanish citriculture, the varietal composition, the qualities obtained in production, and the marketing calendar coinciding with peak demand periods in the main markets are the characteristics that contribute the most to placing Spain in the top position among the exporting countries for fresh consumption. Although the exported proportion varies between different

seasons, over the years, competitiveness determined by the degree of specialization and dependence, trade balance, analysis of market share, quality, national efforts and product differentiation (Ben-Amor *et al*., 2015), presents a growing trend among Mediterranean countries, where Spain has not lost its primacy as the main orange exporter to the European Union (EU), positioning itself ahead of its traditional competitors (Ben-Amor & de-Miguel, 2018).

The success of the competitiveness and stability of Spanish citriculture is due to: (i) the geographical situation, close to the main importing countries of fruit and vegetables; the climate, which varies from region to region and production area and is highly suitable for the production of quality citrus fruit; the range of varieties, which is very broad and comprehensive, with a marketing calendar running from September with the early clementines to June, and which even extends to the summer, with sales to the domestic market and exports of the 'Valencia' variety drawn from cold storage, or the 'Verna' lemon; (ii) the abundant availability of well-equipped packing and degreening warehouses, and an efficient logistics network; (iii) the existence of an ensemble of plant nurseries with a good technical standard, regulated by legislation that ensures the production and supply of healthy plants and the availability of technological research and dissemination to facilitate obtaining new varieties and rootstocks, improvements in cultivation techniques and the optimal use of natural resources such as water among producers.

However, against these characteristics that favour competitiveness, we should also point out shortcomings in the productive structure and difficulties in marketing. With regard to the productive structure, the division of the property has fewer drawbacks in Andalusia and Murcia than in the Valencian Region, where the greater proportion of smallholdings leads to an unfavourable situation (Fernández-Zamudio *et al*., 2006). However, in order to maintain the sector's professionalisation, actions promoting associated or collective management are increasing in a quest to encourage larger and more viable management units both in the technical and commercial aspects (Cajamar, 2018; BOE, 2018; UPA, 2018).

Spanish citriculture is characterised by high-quality production, although its costs are also higher than other competitors, which requires proper management and economic planning of production (Caballero *et al*., 2001).

As for marketing, the main difficulties faced by the citrus sector are the result of market liberalisation. There is a decrease in trade protection, especially through tariffs. The measures adopted by the EU lead to the increased openness of EU markets, with a significant reduction in export aid and the questionable effectiveness of control mechanisms, as there are insufficient measures to prevent the penetration of new pests and diseases. Fresh fruit and vegetable markets are well supplied, are demanding in terms of quality, with little response to novelty and prone to price collapse if oversaturation is reached.

There is no seasonality in prices due to the ease with which Southern Hemisphere productions can access the European market, and the positive effect that used to occur at the end and beginning of each season has diminished. In recent years, too, the quality has been established in the calibre, colour and a blemish-free skin, with the market not clearly appreciating organoleptic quality. This prevents the real value of the fruit from being recognised, which could otherwise favour growth in consumption (Hagenmaier & Baker, 2004). In the commercial stage, the concentration and dominance of mass distribution has led to very marked change. Trade relations between wholesaler and customer are usually reached through prior agreements, with product and service security guarantees. Sale prices in superstores are not always fairly related to production costs in the field and often do not take sufficient remuneration for the farmer into account. In some cases, abusive behaviour has even been detected, especially towards the source link in the chain (Caballero, 2009). In addition, increased consumer awareness of product health and pesticide residue levels requires traceability throughout the production and marketing process, which mass distribution does not compensate for.

Given the commercial perspectives of Spanish citriculture, exports are expected to increase, as the latest countries to have joined the EU offer possibilities of increasing their consumption and shipments to third countries continue to grow. In addition, there will be an increase in demand for quality fresh juice, which will result in a higher proportion of industrialised fruit.

Lastly, it is essential for Spanish citriculture to maintain varietal restructuring. This strategy has been implemented in every era and is one of the foundations underpinning current and future competitiveness, by improving existing varieties and introducing new ones. The adoption of new varieties offers advantages by filling the gaps that the season commercially accepts. However, there is no need to modify varietal supply-demand because there is no phase difference.

In this context, and based on the dynamic structure of varietal composition, the objective of this study was to explain the survival of different orange varieties on the market, identifying the attributes inherent to the variety or environmental factors that affect the survival period of the varieties over time. Survival refers to the length of the variety's commercial life, which may

adopt two types of cycles: (i) long cycle, corresponding to the accumulation of one or more useful life periods with their corresponding plantations; in this case we could say that introducing the variety was a success; (ii) short cycle, shorter than normal biological duration; the introduction of the variety is then unfavourable and does not cover the businessperson's expectations. In both situations, in the former case commercial obsolescence usually occurs in the last plantation period and, in the latter, in the first and only period (Caballero *et al*., 1992).

Knowing the survival of varieties on the market and identifying which factors affect them will help improve decision-taking for both growers and breeders of new varieties, thus allowing for an increase in economic efficiency.

Material and methods

Situation and characteristics of orange varieties

In the last 40 years, most of Spanish production tonnage comes from the range of sweet orange varieties which, given their common characteristics with regards to morphology, ripening time and fruit properties, are made up of the following groups: navel, mid-season white, blood and late white. The number of varieties with commercial importance grown and introduced on the market since the mid-20th century is 33, with representatives of the four groups among them (Table 1). In addition, Table 1 shows whether the characteristics of the variety have allowed for a commercial life with a duration equal to or longer than a useful biological life, whether or not the variety is currently extinct and the current situation of the varieties. Current situation categories, associated with the growing area, are: (i) fully extinct, when no product can be found in the market; (ii) starting cycle indicates the recent novelty of the variety; (iii) surface area refers to the growing area trend, that could be growing, decreasing or maintained.

In accordance with the start of ripening, the most precocious group is that of 'Navelina' and 'Newhall', both from the Navel group, identified by their navel, both of them very similar to each other, with medium-size or large trees of open and rounded growth (Soler, 2014). The fruits differ because the 'Navelina' ones adopt a more reddish and glossy hue. The 'Navelina' was introduced in Spain in 1933, the 'Newhall' in 1966, and both have a long harvesting period spanning from October 20 to January 20 (Soler & Soler, 2006). Both varieties are very widespread, accounting for 32% of Spanish orange production. In Spanish citriculture, except for 'Navelina' and 'Newhall', there have been no precocious varieties for marketing at the start of the season. Both sufficiently cover the first stage of the Spanish marketing calendar, and do so with quality.

Less widespread than the above ones is the 'Fukomoto' variety detected in Japan by spontaneous mutation of a tree bud from the 'Washington Navel', with a harvesting period similar to the 'Newhall' (Soler, 2014). In recent years, the company CGM Citrus has introduced 'Navelina M7', which is an ultra-early mutation of the 'Navelina 7.5' detected in Australia, from which it was imported. It is notable for the rounded shape of its fruits, and because it can be harvested over a long period of time.

The navel group also includes the 'Washington Navel' ('W. Navel'), introduced in Spain in 1910, which was one of the most representative varieties and in the 1970s accounted for as much as 36% of domestic production. A few years after the introduction of the 'W. Navel', the 'Thomson Navel' became widespread in Spain, with slightly earlier ripening and a smaller-sized fruit (Gonzalez-Sicilia, 1968). Its cultivation came to cover an appreciable area but was displaced by more precocious and better-quality varieties and has almost disappeared today. The 'Caracara' variety has identical morphological characteristics and harvesting calendar to the 'W. Navel'; it differs from the group by the red colour of the pulp (Soler, 1999).

Following the 'W. Navel' there appeared the 'Navelate' and the 'Lane Late', together with 'Ricalate' and other even less important ones because of the area they covered, such as the 'Powell Summer', 'Rohde Summer', 'Barnfield Late' and the 'Chislett', this last one with a later ripening date. This group has a harvesting period extending from January to May in ideal commercial conditions. The 'Navelate' became widespread in Spain from 1957 onwards, and the 'Lane Late' became known in the 1987/88 season. Plantations were started from 1990 onwards.

Also very important is the group of whites which, due to their time of ripening, are divided between mid-season and late-season. With regard to the mid-season ones, it should be noted that the 'Comuna' was the first variety introduced in Spain in the mid-15th century. It has many seeds; however, it continued to be cultivated for centuries thanks to its juice yield. It is currently deemed to be extinct. The 'Cadenera' is a variety known since 1870, virtually seedless and with high juice yield. Today, however, the most important mid-season orange is the 'Salustiana', which by 1960 already had an appreciable presence, with fruits that remained long on the tree and were high in juice content. Of lesser importance and now extinct were the 'Castellana' and 'Vicieda' varieties (seeded) and the 'Macetera' with few seeds, which was important in the mid-20th century.

Table 1. Characteristics and situation of the main varieties of Sweet Orange in Spanish citriculture.

Name	Long cycle[1]	Extinction[2]	Current situation
Navel group			
Navelina	X		Surface area is maintained
Newhall	X		Surface area is maintained
Varietal club (M-7)			Starting cycle
Washington Navel	X	O	Surface area on the decrease
Thomson Navel	X	O	Fully extinct
Navelate	X	O	Surface area on the decrease
Lane late	X		Surface area on the increase
Powell Summer			Surface area on the increase
Barnfield Late			Starting cycle
Chislett			Starting cycle
Ricalate		O	Surface area is maintained (abandonment)
Rohde Summer		O	Surface area is maintained (abandonment)
Caracara		O	Surface area is maintained (abandonment)
Fukumoto			Surface area is maintained (abandonment)
Blood orange group			
Doble fina	X	O	Fully extinct
Entrefina	X	O	Fully extinct
Murtera	X	O	Fully extinct
Sanguinelli	X		Surface area is maintained (residual)
Moro Catania	X	O	Fully extinct
Mid-season whites			
Comuna	X	O	Fully extinct
Cadenera	X	O	Fully extinct
Castellana	X	O	Fully extinct
Salustiana	X		Surface area is maintained
Macetera	X	O	Fully extinct
Vicieda	X	O	Fully extinct
Sucreña	X	O	Fully extinct
Late whites			
Valencia Late	X		Surface area is maintained
Berna	X	O	Fully extinct
Peret	X	O	Fully extinct
Delta seedless			Starting cycle
Midknight			Starting cycle
Late frost	X		Surface area is maintained
Barberina			Starting cycle

[1]X = Variety with a duration equal to or greater than a period of useful biological life. [2]O = Variety in extinction / abandonment.

For their part, late whites dominate the citrus fruit calendar in the last period of the season. The most relevant one is the 'Valencia Late', introduced in Spain by the Levante Orange Station and disseminated in the first half of the 20th century. Also in the group of late whites is the Valencia subgroup, which includes 'Barberina', 'Midknight', 'Late Frost' and 'Delta seedless'.

Virtually all the fruits are seedless and feature good conditions for conservation and transport. They are in demand by the juice industry. Late whites also include the 'Berna', of unknown origin, which is practically seedless.

Finally, the blood orange group enjoyed an era of being of interest to farmers in the '60s. The 1970-

71 season accounted for 14% of Spanish citrus fruit production. This was followed by a dizzying decline and is currently only testimonially represented. The varieties 'Doblefina', 'Entrefina' and 'Moro Catania' were important in this group. Today, the scant surface area corresponds to the 'Sanguinelli', which originated from spontaneous mutation of the 'Doblefina' and was detected in 1929 (Bono, 1991).

Within the complex web existing between commercial varieties and the similarity some of them may present, it should be noted that not all are clearly reflected in the existing statistical series. In addition, the most important varietal groups tend not to have a single differentiated variety and, in some cases, statistics may group similar varieties together. Sometimes, not enough years may have elapsed for a new variety to become consolidated and consequently they do not have their corresponding section in the statistical information.

The estimated useful life of an orange tree is 40 to 45 years when grafted on a *bitter orange tree*, and 25 to 30 years if the rootstock is a *citrange*. Under this scenario, according to the information on plants marketed by nurseries, 22 of the varieties analysed have exceeded one or two periods of useful life, while 18 varieties have ceased to be in demand among farmers (Table 1).

However, the attributes of the varieties, and the environmental factors that lead to improving the competitiveness of productions, are behind the decision to adopt one or another variety.

One of the attributes that the farmer values is quality, in which there are different points of view in terms of appreciation since it is thought to play a decisive role in the introduction of new varieties. Firstly, health quality has been taken into account, which legislation enforces, especially in the case of pesticide residues. Secondly, the morphological quality of the fruit which consumers demand in terms of shape, colour, fine skin and calibre. Thirdly, organoleptic quality, which can include, in addition to taste, aroma, the proportion of juice, the sugar-acid ratio, pulp softness (Hagenmaier & Baker, 2004; López-Carmona, 2011; Bello, 2015).

The presence of seeds also affects quality. Harvest precocity has held considerable appeal for farmers because of higher prices obtained.

The location of the plantation may condition the adoption of one or another variety. This may be due, on one hand, to there being varieties that are more sensitive to frost than others, and on the other, to the varieties that are being grown in the area. The imitation effect has a strong influence on the adoption of innovations in agriculture (Alcon *et al*., 2011).

Duration analysis

The study was conducted on the main Spanish production regions, which are Andalusia, Valencia and Murcia.

The duration or survival analysis allows us to explore the fact that a certain event occurs (market entry or exit of a product or service, adoption of a technology, etc.) and the time elapsed until this event takes place (Fuentelsaz *et al*., 2004). Therefore, the interest lies in identifying the event as well as its causes, and the relationship between the causes and the timing of the event. Recently, works such as those of Alcon *et al*. (2010); Abebe & Menale (2015); Hina & Melinda (2016), and Robertson *et al*. (2018), have applied duration analysis to explain the attributes and factors influencing the adoption of innovations in agriculture.

In this regard, the likelihood that a variety will continue to be cultivated over time based on the variety's attributes and the environmental factors can be expressed as:

$$P_s = f\ (A, B) \qquad [1]$$

where P_s is the variety's survival, A are the variety's attributes, and B are the environmental factors that can influence the length of time the variety remains on the market but are common to all varieties.

Unlike other econometric methods which statically determine the conditioning factors of a particular event, without taking into account the time in which it occurs (*e.g.* Logit or Probit models), survival analysis explores the event through a dynamic approach based on a given observation period.

Formally, duration analysis explains the time period, T, between the start and end of a process in which a particular event occurs to learn the sign and magnitude of the effects exerted by the explanatory variables on T (Kiefer, 1988; Lancaster, 1990). In each case, survival, *i.e.* the likelihood of a variety of oranges surviving on the market over a period of time, dt after t, would be defined by a risk function.

If $F_{(t)}$ is the density function of the continuous probability of variable T and where t indicates the end of the period, cumulative function may be defined as:

$$F(t) = \int_0^t f(s)ds = P_r\ (T \leq t) \qquad [2]$$

Likewise, the distribution of T may be expressed by survival function $S_{(t)}$, which defines the probability of survival over time, in other words, that T is greater than or equal to t. This function offers the likelihood of surviving t, *i.e.* the probability that the variety has not disappeared in each period of t.

$$S(t) = 1 - F(t) = P_r\ (T > t) \qquad [3]$$

Therefore, the risk function h(t) defining survival to time t is defined as:

$$h(t) = \lim_{dt \to 0} \frac{P(t \leq T < t + dt / T \geq dt)}{dt} = \\ = \lim_{dt \to 0} \frac{F(t + dt) - F(t)}{dt\big(1 - F(t)\big)} = \frac{F(t)}{S(t)} \quad [4]$$

The risk function reflects the effects of the explanatory variables (X) and the baseline. The risk function h_0, which can be semiparametric or follow a specific functional form $h_0(t)$ (Kiefer, 1988; Cleves *et al*., 2002), allows parameters to be estimated β, by maximum likelihood, assuming the observed durations t_i together with the right-censored observations, which last at least until the end of the observation period, which in this case corresponds to the survival of each variety of orange tree θ_j. Thus, the resulting risk function would be (Burton *et al*., 2003):

$$H(t, X, \theta, \beta) = h_0(t, \theta) q(X, \beta) \quad [5]$$

To ensure that the risk function is not negative, without imposing restrictions on parameters, proportional risk models use an exponential specification $q\ (X, B)$. Therefore, the estimated coefficients and their sign represent the impact on the risk function and should be interpreted as e^{β}. β values equal to 1 would have no impact on the risk function, higher (lower) values than 1 would indicate a positive (negative) impact on the risk function.

Data collection

The study period used ranged from 1972 to 2016. The time range analysed started, for each variety of orange tree, in the year when the sale of seedlings begun, or in the year in which the analysis period started if its sale was earlier, and ended in the year in which the sale of seedlings was completed. For cases where the variety remained on the market at the end of the analysis period, the length of the survival period was right-censored.

The collection of the information needed for measuring the attributes of varieties was set up in two phases. In the first one, the attributes of the varieties were identified through expert interviews and, in the second phase, assessed by a panel of 10 experts, who evaluated the existence of the attributes listed in Table 2 for 30 orange tree varieties. Despite other attributes that could affect the variety survival, were identified by experts in the first phase, they have not been considered due to their association with the variables included in Table 2, following Pearson's chi-squared criteria, whose values are shown in Table 2.

In the second phase, environmental factors (prices, productions, cultivation areas and sale of seedlings) were quantified from historical data series available from 1971 to 2016, for the different varieties of orange trees.

Most varieties ripen late within their group (only 17% are precocious), 50% of the varieties are large in calibre within their group, 47% are seedless, 83% are frost-sensitive, 90% have sufficient commercial quality, and 50% are not affected by fruit fly.

With regard to environmental factors, Figs. 1 and 2 show the evolution of prices[1] and cultivation areas for the most representative varieties within the four major groups of orange trees included in this study, namely: the navel group ('Navelina', 'Washington Navel' and 'Navelate'), whites ('Salustiana'), blood oranges ('Sanguinelli' and 'Entrefina') and late varieties ('Berna' and 'Valencia Late').

Results

Based on the evolution of the cultivated area for the different groups of varieties during the 1970-2016 period, the navel group is the most important one in Spanish citriculture today. In this group, some years ago there was a clear preponderance of the 'W. Navel', which in 1971 accounted for 38% of the total production of Spanish citriculture. From that year onwards, the growth of 'Navelina' plantations began, which continued until 1992, and at this time it partly remains free of major variations, a factor which must be attributed to its commercial quality and its ability to cover an extensive marketing period, comprising the entire fourth quarter of the year and extending until January. 1986 was when the area covered by both varieties equalised. Particular mention should be made of the stability of the 'Salustiana' and the growth of the 'Valencia Late', which completes the Spanish commercial calendar. The varietal group of blood oranges and the 'Berna' variety were significant in the early 1970s, but they practically disappeared from the 1980s onwards. The 'Thomson Navel', the 'Cadenera', and six more varieties of white mid-season varieties can also be deemed to have disappeared.

The analysis of the price series for oranges, constant 2017, indicates that there was considerable variability until 1985. There was subsequently some uniformity in the rates producers receive. These periods coincide with the weight achieved by major food distribution

[1]Prices perceived by farmers normalised to 2017 according to the prices perceived by farmer index (MAPA, 2018).

Table 2. Definition of explanatory variables.

Variable	Description	n	Mean	Std. Dev.	Min	Max	Chi square values[1]					
							Precocity	*Size*	*Frosty*	*Seeds*	*Quality*	*Ceratitis*
Precocity	0 = not early; 1 = early	30	0.17	0.38	0	1	30 (0.00)	30 (0.17)	1.2 (0.27)	5.25 (0.02)	0.67 (0.41)	0.24 (0.62)
Size	*(Referred to within its group)* 0 = not large; 1 = large	30	0.50	0.51	0	1		30 (0.00)	30 (0.5)	2.16 (0.14)	0.34 (0.54)	6.53 (0.01)
Frosty	0 = not sensitive; 1 = sensitive	30	0.83	0.38	0	1			30 (0.00)	0.11 (0.74)	0.66 (0.41)	0.24 (0.62)
Seeds	*(Presence of seeds)* 0 = no; 1 = yes	30	0.47	0.51	0	1				30 (0.00)	3.80 (0.05)	4.82 (0.03)
Quality	*(Commercial quality)* 0 = no; 1 = yes	30	0.90	0.31	0	1					30 (0.00)	0.37 (0.54)
Ceratitis	*(Sensitivity to fruit fly)* 0 = not sensitive; 1 = sensitive	30	0.50	0.51	0	1						30 (0.00)

[1]*p* value between brackets.

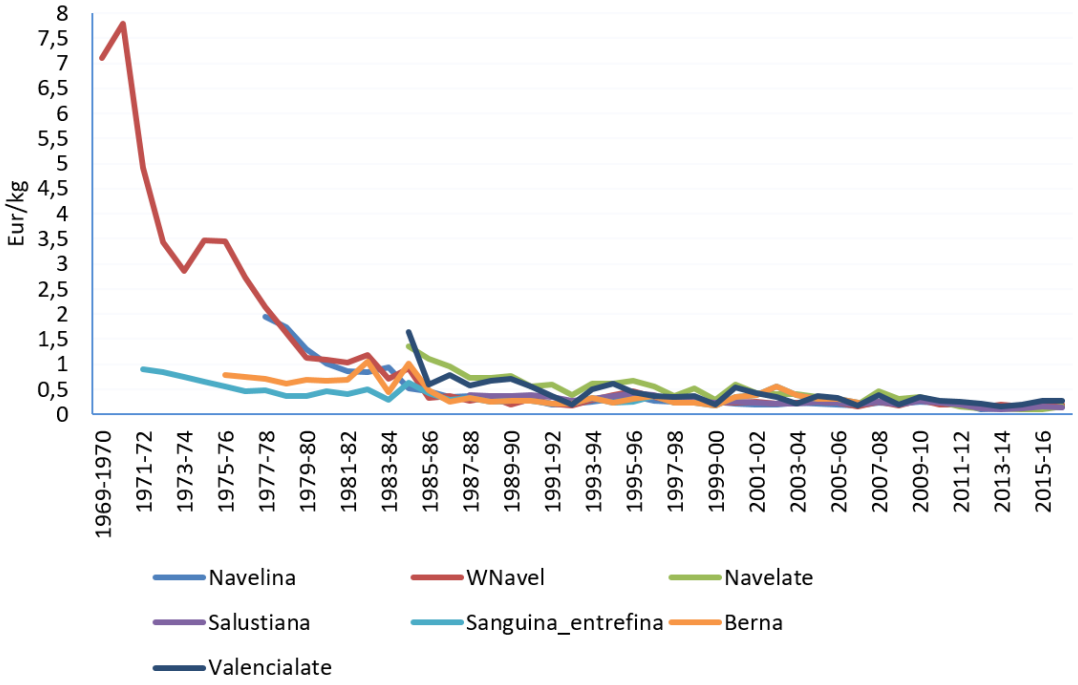

Figure 1. Price evolution ($€_{2017}$/kg) of the main varieties of orange trees in Spain from the 1969/70 season to the 2016/17 season. *Source:* Own compilation based on data from MAPA (2018), CAPA (2018), CARM (2018) and Junta de Andalucía (2018).

chains and the frequent reverse price formation policy (from retail to farmer). Also, the higher prices paid for oranges before 1985 are also associated with the relative high price of oranges in these dates.

The estimation of the risk function, which represents the likelihood of a variety of orange tree disappearing from the market at any given time, subject to its existence in the previous year, is set out in Table 3 for two specifications of the model. Model 1 lists all the variables that may impact on the length of survival of varieties. Model 2, the significant explanatory variables in Model 1 to 90% obtained by a stepwise procedure.

The information criteria for the goodness of fit of the restricted model, Akaike information criterion (AIC) and Bayesian information criterion (BIC), showed that they improve those of model-1 or general model. Furthermore, when performing the calculations for the likelihood ratio (LR) test [LR=2(llr-llg)] it was found to fail, which means rejecting the null hypothesis that the general one was better (LR=5.44; $\chi^2_{0.05,4}$=**9.54**), with the specifications of the restricted model (Model-2) being the ones that showed the best fits and those used in interpreting the survival of Spanish orange varieties in recent decades.

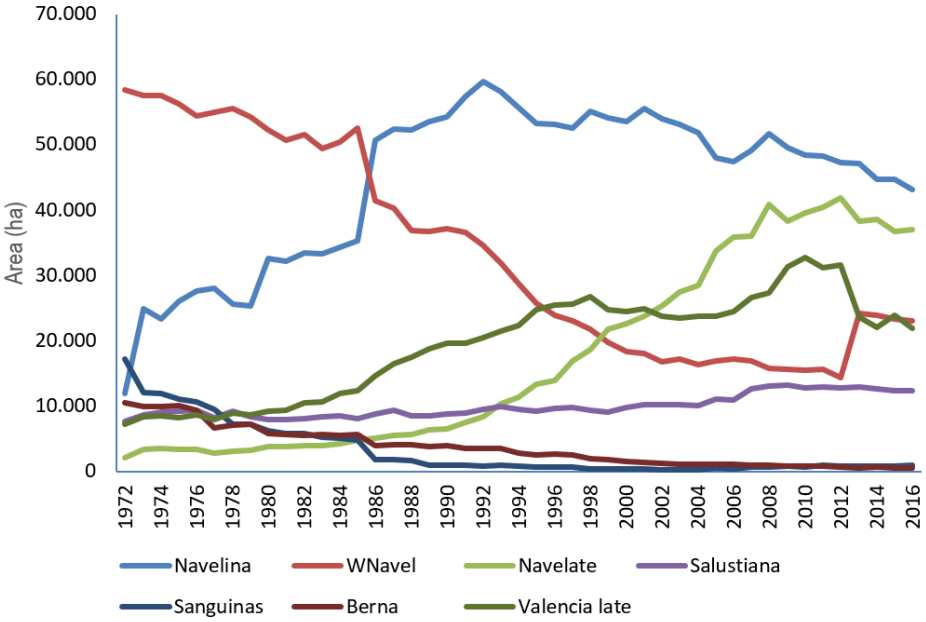

Figure 2. Evolution of the cultivated area for the main orange tree varieties in Spain for the 1972-2016 period (in hectares). *Source:* Own compilation from MAPA (2018).

Table 3. Specifications of the estimated models

	Model 1			Model 2		
	Coefficient	**SE**		**Coefficient**	**SE**	
Precocity	3.68	2.84				
Size	-4.70	2.77	*	-2.80	1.10	**
Frosty	0.42	0.86				
Seeds	2.63	1.21	**	2.49	0.92	***
Quality	-0.84	0.89				
Ceratitis	-0.53	0.85				
$Price_t$	-1.99	0.89	**	-1.90	0.86	**
$Area_{t-1}$	4.84e-50	2.37e-5	**	5.48e-5	1.95e-5	***
Constant	-3.93	1.80	**	-4.49	0.88	**
Log likelihood	-43.03			-44.94		
AIC	0.21			0.20		
BIC	-2874.52			-2900.02		
Number of observ.	488			488		

t = time-varying variable. Significance levels at *$p < 0.1$, **$p < 0.05$ ***$p < 0.01$.

The restricted model included four variables that clearly explained the survival of different varieties on the market: (1) the calibre, large size of the variety, within its group ('*Size*'); (2) the fruits may have seeds present ('*Seeds*'); (3) the price at which the crop is paid to the producer ('$Price_t$'); and finally (4) the area occupied by that same variety in the year prior to the reference ('$Area_{t-1}$'). Of these four variables, two are statistically significant to 99% and two to 95%.

The positive sign of the estimated coefficients for the variables '*Seeds*' and '$Area_{t-1}$', indicated that the likelihood of disappearing from the market increased over time, thus having a negative impact on the survival of a variety. In this regard, the coefficient exponential, which indicates the change in the conditional probability of survival for each explanatory variable, showed, for the '*Seeds*' variable, that the likelihood of seedlings of a seeded variety ceasing to be sold were 12 times higher than for seedless varieties. This reflects that the presence

of seeds in fruits, an attribute not desired by consumers, negatively influenced the survival of a variety over time. Likewise, if the planted area of a variety of orange tree decreased over time, it is reasonable to assume that its survival cannot be guaranteed.

On the other hand, the negative coefficients of the '*Size*' (-2.80) and '$Price_t$' (-1.90) variables indicate that attributes such as the large size of the variety within its group, and factors such as the price received by the farmer in each season, positively affected the survival of the varieties. This evinces that the likelihood of disappearing for a variety featuring a large fruit size is 16 times less than if the fruit is small, indicating that size is an aspect valued by distributors and consequently by consumers. Moreover, the exponential of the coefficient associated with the price indicated that an increase of 0.10 €/kg in the average price of a variety will increase by 60% the likelihood of this variety surviving over time, indicating that the rate received by the producer will modify his/her attitude when considering a varietal change in the plantation. Also, it should be noted that productivity also has a positive effect on the probability of survival over time. However, it has not been included in the model due to the collinearity problem. It is well known in the sector that higher production seasons are always associated with low orange prices.

Other attributes that were expected to have an effect on the survival of varieties have ultimately not done so in a significant manner. In this regard, the results indicated that attributes such as precocity (*Precocity*), frost resistance (*Frosty*), commercial quality (*Quality*) and resistance to fruit fly (*Ceratitis*), did not significantly affect the survival of varieties. This may be due to the fact that, in orange trees, precocity was not in itself an influential characteristic, unlike in mandarin trees, which is a species in which being able to bring forward (or delay) its arrival on the markets does impact its commercial interest.

Regarding frost sensitivity, experts state that in the last 20 years the risk of frost has decreased as a result of climate change and is therefore not a variable that has had a bearing. Moreover, in the survival of a variety, commercial quality did not seem to be as decisive as the expected price. The farmer, who decides on the renewal of plantations, is very directly impacted by the price, while commercial quality is a feature that has more influence on wholesalers and retailers. Regarding sensitivity to *Ceratitis capitata* (Mediterranean fruit fly) variable, the explanation for non-significance was based on the fact that this pest may cause damage, according to areas, in the initial months of the season in which the 'Navelina' is marketed and in the final months, when it coincides with the delayed harvest of the 'Valencia'. The producer accepts or overcomes this drawback given that both varieties are the ones with most years of survival.

Discussion

The incorporation of new orange varieties into citriculture is a process that producers have continuously undertaken and is the most direct response for seeking an improvement in the profitability of their plantation. Currently, there are barely any publications on the conditioning factors that influence the survival of a variety, so the information is of great interest to the entire citrus industry, and this paper also represents an important contribution to the generation of scientific knowledge.

The results suggest that the likelihood of survival for the different varieties of orange tree is positively dependent on the expected price and the calibre of the variety. On the other hand, this likelihood is negatively affected by the presence of seeds and by farmers observing that the cultivated area is decreasing annually. It should be remembered that, historically, when a variety starts to commercially decline for one or more of the aforementioned characteristics, it does not recover again (Caballero, 1992).

Greater perfection in cultivation techniques and in the marketing of the different varieties, with an increase in diversification and quality, help to extend survival while maintaining prices and avoiding deteriorations in the production process that leads to the ageing of plantations. Varietal wealth generates not only more options for fruit on a visual level (size, shape, colour, etc.) and on an organoleptic level (flavour, acidity, etc.); it also allows for a longer marketing calendar and other increasingly valued aptitudes such as resistance to disease or adaptation for the juice industry.

Until the emergence of superstores, there had been horizontal competition, so marketing companies used to compete against each other. At present the pressure of the major distribution chains has consolidated vertical competition, which demands actions in the different links of the value chain. On the other hand, the requirements of the retail trade, especially those of the major distribution chains, are right now the ones with the greatest control over the relationship between supply and demand. As well as requiring timely and reliable service, they have an impact on the quality/price ratio and on continued commercial quality during the stages of transport and display for sale. The role they play in the value chain is so important that their business requirements have had a decisive impact on the predominance of certain varieties and the jettisoning of others.

Apart from this, for the large commercial chains themselves, the supply of new varieties may represent an identification and differentiation value, and sometimes this is an asset that acts in their favour.

There has been an increase in investment in obtaining new varieties, but this has mainly been in those that are regulated through patents, which understandably have a more limited dissemination and normally lead to forming closed varietal clubs.

Moreover, in the opinion of the sector as a whole, the importance of the role played by retail is recognised. The problem is that at this time in Spain this role is performed especially by the major distribution chains, and they now hold very considerable power when it comes to controlling supply and demand. The producer is being required to provide good service, punctuality and reliability and to supply fruit that maintains its saleability during the stages of transport and display for sale. Meanwhile, except for varieties with controlled supply due to forming part of a production club, the current prices which characterise the Spanish season do not always meet expectations. The farmer's perception is that even if he/she achieves a quality production and applies good business management practices, this is not rewarded. His/her inability to influence higher rates always makes him/her the weakest link in the whole value chain.

Indeed, modern and competitive citriculture in a global market will require a suitable varietal map and this demands continuous changes to it, with the predominance of certain varieties and the jettisoning of others. Something that is worth remembering as being useful for the major chains, it is that many efforts are being made in the research, development and innovation of new varieties, and this well-managed varietal wealth could bring value to them, sign of identification and differentiation vis-à-vis of other competitors as well as considerable appeal for consumers. Also, further research should be developed for other citruses, such as mandarin, with similar cropping systems but different commercial characteristics.

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