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Vegetative cycle and bankruptcy predictors of agricultural firms

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Abstract: The characterisation of agricultural activity depends on what firms produce. In this article, we introduce the importance of the vegetative cycle in the prediction of bankruptcy of agricultural firms, analysing the financial ratios proposed by the classical models of Altman (1983), Ohlson (1980) and Zmijewski (1984). We consider a total of 2 228 Portuguese firms, with 83 failing between 2015 and 2019. The findings confirm that the differences between healthy and bankrupt firms depend on their vegetative cycle. Although predictors based on liquidity are helpful only in predicting the bankruptcy of non-perennial crop firms, activity predictors are better in identifying healthy perennial crop firms. In addition, we show substantial statistical differences in terms of liquidity and profitability, but only in healthy firms. The results encourage the topic of the vegetative cycle to be more present in the construction of more accurate bankruptcy prediction models.

Keywords: agriculture; bankruptcy prediction; financial ratios; non-perennial; perennial

In an agricultural project, different investment needs and risks depend on the longevity of the crops. The vegetative cycle is related to the risk of exposure to natural phenomena, specific cultivation practices, and threats transversal to other activity sectors. Alone or together, they can affect the survivability of the business.

Agricultural activity is going through challenging times. Even though Malthusian predictions have been belied by agricultural productivity increases, food shortages remain a severe threat because of the finitude of available arable land (Lanz et al. 2017). Also, climate change is now dominating the concerns and agendas of world leaders. Results from one study of the effects of the climate crisis, using latest-generation crop and climate models, suggest significant effects on the production of different crops, with 24% decreases in corn, but 17% increases in wheat (Jägermeyr et al. 2021). Although farmers recognize the negative effect of these climate changes on the productivity of some crops, the predictions are that if they cannot adapt to land use, there will be substantial losses in various economic outcomes (Burke and Emerik 2016).

However, the need for agriculture to adapt to a sustainable development model and thus avoid global biodiversity loss is very much on the political agenda, particularly in the European Union (EU). Citizens are pressing for the Common Agricultural Policy to focus

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more on sustainable production methods. The European Commission established a European Green Deal, with a target of at least 25% of the EU's agricultural land under organic farming (European Commission 2021).

Agriculture is an activity of diversified practices with different investment needs depending on the crops. Agricultural firms rely on indebtedness to acquire land, machinery, and technology or manage working capital needs. Some of them, in this modernisation effort, succumb and go bankrupt. Also, for world governments to define better policies, particularly how support to the agricultural sector should be structured, it is necessary to deepen the knowledge of its characteristics.

It is essential to understand that certain decisions related to the vegetative cycle of crops may be associated with some financial fragility. Some farmers prefer annual crops because they generate income in their first year, whereas non-perennial crops may require several years before the first harvest. Farmers making these choices demonstrate different risk behaviours (Özerol and Bressers 2017).

Identifying bankruptcy predictors is essential for creditors to categorise borrowers' risk of default. Agricultural firms also depend on their vegetative cycle, which affects the investment cycle and, thus, their capital requirements. For example, the investment needed to plant a vineyard is significant, and the first harvest is obtained only years later. The same goes for a producer of olives or oranges. These perennial crops are characterised by a vegetative cycle that does not necessarily end with the death of the plant as soon as crops are harvested. Firms dedicated to these crops typically have high planting costs and lower maintenance investments in subsequent years.

Conversely, farmers who grow wheat, rice, or vegetables need to renew their investment at the end of the season. Therefore, these non-perennial crops require a shorter asset turnover than do perennial crops. We illustrate the vegetative cycle of crops in Figure 1.

Dorohan-Pysarenko et al. (2021) state that a long production cycle of some agricultural products can be a severe threat, as it makes the firm unable to react quickly to changes in market conditions. Supposing there is a considerable time gap between investment and its associated return, inflationary conditions or rising interest rates can cause a firm to go bankrupt. Despite this possibility, most agricultural credit score models tend not to differentiate firms according to their growing cycle and understand them as having similar financial structures in terms of liquidity, solvency, leverage, activity, and profitability. Here, we show that this can be dangerous, as the values of classical bankruptcy predictors vary with the vegetative cycle.

In this article, we analyse the financial variables traditionally used to predict corporate bankruptcy. Besides looking into the difference between healthy and bankrupt firms, we focus on how different these variables are according to their vegetative cycle. Concretely, for Portuguese agricultural firms, we distinguish between firms dedicated to growing non-perennial crops and firms dedicated to growing perennial crops. We use the European Community statistical classification of the Nomenclature of Economic Activities NACE (Nomenclature statistique des activités économiques dans la Communauté européenne) Rev. 2 (European Commission 2008), according to the vegetative cycle of crops.

Literature review. Because of its unique characteristics, agriculture has been widely studied in the credit risk literature. Focussed on understanding the predictors of the financial health of agricultural firms, researchers have been looking for more specific variables linked to the rural world.

Krause and Williams (1971) studied the behavioural personality of farmers. Limsombunchai et al. (2005) estimated a credit risk model for farm lending introducing dummy variables distinguishing regions as well as the farm type (horticulture, orchard/vegetable, livestock/aquaculture and others). Rusiana et al. (2017) looked into how experience, age of farmers, and farm size relate to firms' financial strength. In another approach, Dinterman et al. (2018) concluded that some macroeconomic factors are strong predictors of farm

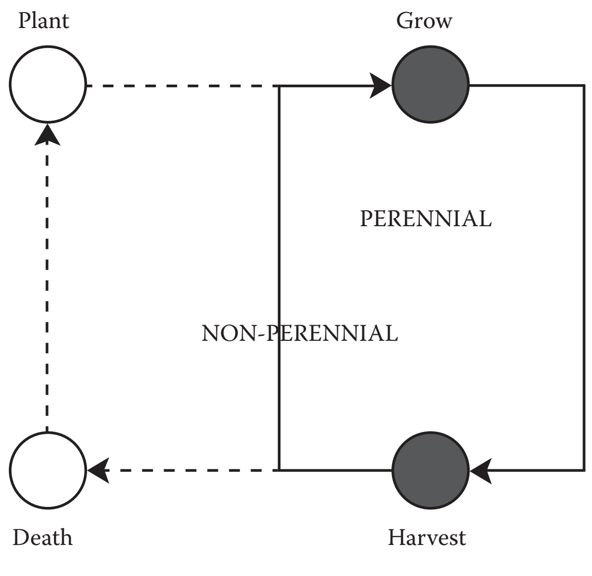

Figure 1. Vegetative cycle of crops

Source: Own elaboration

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bankruptcies. Investigators of some studies, such as Hardy and Weed (1980) and Zech and Pederson (2002), looked into both qualitative and quantitative variables but concluded that only the quantitative variables tended to be statistically significant. More recently, and aware of the influence of climate on agricultural productivity and consequently on the likely financial strength of agricultural firms, Römer and Mußhoff (2018) introduced a climate variable in a credit scoring model for the first time. Their main conclusion was that the variable did not improve the model's accuracy. However, it remains to be seen whether the conclusions would not have been different if this climate variable had been affected by the type of agriculture and the vegetative cycle.

Through time, however, investigators of most studies still focussed mainly on quantitative variables and, among them, on financial ratios. See, for instance, Johnson and Hagan (1973), Whittington (1980), Barry and Ellinger (1989), Laitinen (1993), De Jager and Swanepoel (1994), Lukason (2014), Klepáč and Hampel (2017), Valaskova et al. (2020), and Chen et al. (2021). 'Financial ratios provide important information about a firm's past performance, predicting a firm's future performance prospects, assessing management's decision-making, risk assessment, and are a critical tool employed in lending agreements to control a firm's activities' (Faello, 2015). Among particularly well-known studies in this category, Altman (1968) and Altman (1983) used multivariate discriminant analysis and considered both listed and non-listed firms, respectively; Ohlson (1980) used the logistic scoring model; Zmijewski (1984) used a probit model.

The literature on credit risk in the agricultural sector deserves a deeper understanding of the unique characteristics of its bankruptcy predictors. In particular, we aim to understand better how the vegetative cycle of plantations is a factor to be considered in determining the survival of the non-listed agricultural business. Our analysis is based on a Portuguese data set. To our knowledge, it is also the first study on Portuguese agricultural bankruptcy predictors.

We test the following hypotheses:

H_1: The distribution of financial ratios between bankrupt and healthy firms is the same.

H_2: In the subsample of non-perennial crop firms, the distribution of financial ratios between bankrupt and healthy firms is the same.

H_3: In the subsample of perennial crop firms, the distribution of financial ratios between bankrupt and healthy firms is the same.

H_4: The distribution of financial ratios between non-perennial and perennial crop firms is the same.

H_5: In the subsample of healthy firms, the distribution of financial ratios between non-perennial and perennial crop firms is the same.

H_6: In the subsample of bankrupt firms, the distribution of financial ratios between non-perennial and perennial crop firms is the same.

We consider the predictors used in the key references of Altman (1983), Ohlson (1980) and Zmijewski (1984) and categorise the financial ratios used into five groups: *i*) liquidity ratios show the ability of firms to use short-term assets to pay their short-term obligations, *ii*) solvency ratios refer to a firm's ability to honour long-term obligations and continue operating in the future, *iii*) leverage ratios measure debt levels, *iv*) activity ratios measure how well a firm can turn its resources into sales, and *v*) profitability ratios measure the ability to generate gains through efficient resource management.

MATERIAL AND METHODS

Data sources. In this study, we focussed on financial predictors for Portuguese agricultural firms. We considered a firm bankrupt if one of three occurrences happened: *i*) bankruptcy at the firm's request, with a court decision, *ii*) bankruptcy at the lender's request, with a court decision, and *iii*) bankruptcy at the firm's request or the lender's request but without a court decision. The electronic supplementary material (ESM) provides Table S1 with the distribution of firms according to the type of bankruptcy (for ESM, see the electronic version).

The data source is the Amadeus database, provided by Bureau van Dijk (2021). To identify which firms were bankrupt from 2015 to 2019, we consulted Iberinform (a subsidiary of Crédito y Caución, a leading global credit insurance operator).

We considered as healthy all Portuguese agricultural firms with complete financial sheets and income statements from 2014 to 2018. We excluded firms that did not comply with their reporting obligations during that period. We selected the last financial statements available before the bankruptcy for bankrupt firms and the 2018 financial statements for healthy firms. Of the total of 2 228 firms, 83 were considered bankrupt. Also, 1 039 were classified as growing non-perennial crops and 1 189 were classified as growing perennial crops, according to the statistical classification of economic activities in the European Community (NACE Rev. 2). Table 1 pre-

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Table 1. Distribution of samples

Classification	Healthy	Bankrupt	Total
Non-perennial crop firms	985	54	1 039
Perennial crop firms	1 160	29	1 189
Total	2 145	83	2 228

Source: Own elaboration

sents the the firms' distributions according to these classifications.

In terms of bankruptcy predictors, we analysed the ratios proposed by Altman (1983), Ohlson (1980) and Zmijewski (1984) listed in Table 2.

For descriptive statistics, see Table S2 in the ESM (for ESM, see the electronic version).

Methodology. The emphasis of the analysis is not on obtaining a bankruptcy estimation model. Empirically the tests were performed to analyse the differences between financial ratios according to financial health (bankrupt versus non-bankrupt firms) and the vegetative cycle (non-perennial crop versus perennial crop firms). Our main goal was to test differences in bankruptcy predictors.

From a statistical point of view, removing outliers is an acceptable practice. 'The inclusion of a few outliers could result in the sample's mean and variance and regression's variable coefficients being significantly different from the results that are truly representative of the data set' (Faello, 2015). However, that is not the case for bankruptcy studies. Hossari et al. (2007) analysed 46 different studies on bankruptcy prediction and found that the outliers were not removed in 39 (85%). In this study, we also chose to maintain outliers. Financial ratios tend to present skewed distributions, although some have a shape similar to that of the normal distribution. Figure S1 in the ESM, showing distribution charts, and Table S3 in the ESM, showing standard Kolmogorov-Smirnov test results confirming our expectations about the non-normality of ratios are available in the ESM (for ESM, see the electronic version).

To compare financial ratios across subsamples and given the descriptive analysis described, we opted to perform a non-parametric test proposed by Mann and Whitney (1947). The Mann-Whitney *U* test can be considered the non-parametric version of the parametric *t*-test and tests the null hypothesis that a randomly selected value from one sample is likely to be significantly greater or less than

Table 2. Investigated predictors

Ratios	Description	Altman (1983)	Ohlson (1980)	Zmijewski (1984)
Liquidity				
WCTA	working capital : total assets	x	x	–
LIQ	current assets : current liabilities	–	–	x
CLCA	current liabilities : current assets	–	x	–
FUTL	funds provided by operations : total liabilities	–	x	–
Solvency				
RETA	retained earnings : total assets	x	–	–
BVEBVL	book value of equity : book value of total liabilities	x	–	–
Leverage				
TLTA (FINL)	total liabilities : total assets	–	x	x
OENEG	1 if total liabilities exceed total assets, 0 otherwise	–	x	–
Activity				
STA	sales : total assets	x	–	–
Profitability				
EBITTA	*EBIT* : total assets	x	–	–
ROA (NITA)	net income : total assets	–	x	x
INTWO	1 if net income negative last two years, 0 otherwise	–	x	–
CHIN	$(NI_t - NI_{t-1}) : (\lvert NI_t \rvert + \lvert NI_{t-1} \rvert)$	–	x	–
Dimension				
SIZE	log(total assets : GNP price-level index)	–	x	–

GNP – gross national product; *NI* – net income; *EBIT* – earnings before interest and taxes
Source: Own elaboration

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a randomly selected value from a second sample. For this purpose, the samples must be independent, which is the case. The U statistic is defined as follows:

$$U = n_1 n_2 + \frac{n_1(n_1 + 1)}{2} - R_1$$
$$U = n_1 n_2 + \frac{n_2(n_2 + 1)}{2} - R_2 \qquad (1)$$

where: n_1 – the number of observations available from the first population; n_2 – the number of observations from the second; R_1 and R_2 – the sum of the ranks of the observations from the first and second populations, respectively.

For variables *OENEG* (1 if total liabilities exceed total assets) and *INTWO* (1 if net income negative last two years), which assume a binomial distribution, we performed a χ^2 test, defined as follows:

$$\chi^2 = \sum_{i=1}^{k} \frac{(O_i - E_i)^2}{E_i} \qquad (2)$$

where: k – the number of classes; O_i – observed frequencies; E_i – expected frequencies; i – the total number of independent observations.

RESULTS AND DISCUSSION

One factor that assumes importance in interpreting the results is that the financial ratios are not evenly distributed around the mean. Thus, except for the *OENEG* and *CHIN* $[(NI_t - NI_{t-1}) : (|NI_t| + |NI_{t-1}|)]$ variables, we performed non-parametric tests to compare medians of subsamples.

Tables 3 and 4 summarise the Mann-Whitney U and χ^2 tests test results for the comparison of healthy and bankrupt firms.

Tables 5 and 6 summarise the Mann-Whitney U test and χ^2 test results for the vegetative cycle, considering whether the firms were bankrupt or healthy.

Table 7 summarises the results of the Mann-Whitney U and χ^2 tests in terms of significance. The left-hand side shows differences in predictors of healthy and bankrupt firms (in the full sample and for the different vegetative cycles). The right-hand side shows differences in predictors according to firms' vegetative cycle (in the full sample, just healthy or bankrupt firms).

The results imply that we reject the null hypotheses (H_1, H_2 and H_3) for almost all financial ratios. Except for *STA* (sales : total assets), *SIZE* [log(total assets : GNP price-level index)] and *CHIN*, most financial ratios were statistically different when in the comparison

Table 3. Mann-Whitney U test according to the financial health

Ratios	Full sample (H_1)			Non-perennial crop firms (H_2)			Perennial crop firms (H_3)		
	Mann-Whitney U	z-score	P-value (2-tailed)	Mann-Whitney U	z-score	P-value (2-tailed)	Mann-Whitney U	z-score	P-value (2-tailed)
WCTA	63 158	−4.497	0.000***	17 320	−4.320	0.000***	13 269	−1.944	0.052
LIQ	58 875	−5.087	0.000***	16 647	−4.633	0.000***	12 027	−2.348	0.019**
CLCA	63 165	−4.496	0.000***	16 647	−4.633	0.000***	14 347	−1.354	0.176
FUTL	29 142	−7.855	0.000***	7 516	−6.995	0.000***	6 707	−3.816	0.000***
RETA	48 072	−7.120	0.000***	11 860	−6.863	0.000***	11 812	−2.742	0.006***
BVEBVL	47 973	−7.137	0.000***	12 839	−6.407	0.000***	10 876	−3.254	0.001***
TLTA	47 973	−7.137	0.000***	12 839	−6.407	0.000***	10 876	−3.254	0.001***
STA	63 692	−0.984	0.325	19 124	−0.575	0.565	10 089	−2.004	0.045**
EBITTA	41 283	−7.609	0.000***	11 179	−6.690	0.000***	8 885	−3.848	0.000***
ROA	38 793	−8.056	0.000***	10 513	−7.009	0.000***	8 497	−4.068	0.000***
CHIN	58 888	−1.541	0.123	15 977	−1.786	0.074*	12 580	−0.470	0.639
SIZE	84 605	−0.767	0.443	24 004	−1.207	0.228	16 141	−0.372	0.710

***, ** and * significance levels at 0.01, 0.05 and 0.10, respectively; *WCTA* – working capital : total assets; *LIQ* – current assets : current liabilities; *CLCA* – current liabilities : current assets; *FUTL* – funds provided by operations : total liabilities; *RETA* – retained earnings : total assets; *BVEBVL* – book value of equity : book value of total liabilities; *TLTA* – total liabilities : total assets; *STA* – sales : total assets; *EBITTA* – *EBIT* : total assets; *EBIT* – earnings before interest and taxes; *ROA* – net income : total assets; *CHIN* – $(NI_t - NI_{t-1}) : (|NI_t| + |NI_{t-1}|)$; *SIZE* – log(total assets : GNP price-level index); GNP – gross national product

Source: Own elaboration

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Table 4. χ^2 tests according to the financial health

Ratios	Full sample (H_1)				Non-perennial crop firms (H_2)				Perennial crop firms (H_3)			
	N	χ^2	d*f*	*P*-value (2-tailed)	N	χ^2	d*f*	*P*-value (2-tailed)	N	χ^2	d*f*	*P*-value (2-tailed)
OENEG	2 228	71.218	1	0.000***	1 039	68.867	1	0.000***	1 189	8.245	1	0.004***
INTWO	2 208	47.325	1	0.000***	1 025	41.267	1	0.000***	1 183	8.944	1	0.003***

*** significance level at 0.01; N – sample size; *OENEG* – 1 if total liabilities exceed total assets, 0 otherwise; *INTWO* – 1 if net income negative last two years

Source: Own elaboration

of healthy and bankrupt firms. The results obtained support the thesis that the bankruptcy predictors used by Altman (1983), Ohlson (1980) and Zmijewski (1984) usefully discriminate between bankrupt and non-bankrupt agricultural firms. The importance of financial ratios on the basis of liquidity, solvency, and leverage in differentiating between healthy and bankrupt firms was confirmed. Only the *CHIN* ratio does not reject the null hypothesis in profitability ratios. This ratio analyses the change in earnings in two consecutive years,

Table 5. Mann-Whitney *U* test according to the vegetative cycle of crops

Ratios	Full sample (H_4)			Healthy firms (H_5)			Bankrupt firms (H_6)		
	Mann-Whitney *U*	*z*-score	*P*-value (2-tailed)	Mann-Whitney *U*	*z*-score	*P*-value (2-tailed)	Mann-Whitney *U*	*z*-score	*P*-value (2-tailed)
WCTA	574 771	–2.833	0.005***	522 908	–3.385	0.001***	700	–0.793	0.428
LIQ	599 414	–1.173	0.241	561 321	–0.698	0.485	738	–0.176	0.860
CLCA	598 375	–1.275	0.202	561 321	–0.698	0.485	684	–0.946	0.344
FUTL	583 475	–1.570	0.116	539 029	–2.258	0.024**	363	–1.399	0.162
RETA	605 595	–0.798	0.425	547 516	–1.664	0.096*	5 930	–1.815	0.070*
BVEBVL	602 509	–1.002	0.316	567 645	–0.256	0.798	595	–1.796	0.073*
TLTA	602 509	–1.002	0.316	567 645	–0.256	0.798	595	–1.796	0.073*
STA	426 066	–12.094	0.000***	400 070	–11.979	0.000***	317	–2.162	0.031**
EBITTA	586 971	–1.848	0.065*	534 390	–2.582	0.010***	625	–0.667	0.505
ROA	599 079	–1.046	0.296	545 489	–1.806	0.071*	618	–0.740	0.459
CHIN	579 544	–1.755	0.079*	543 722	–1.933	0.053*	431	–0.256	0.798
SIZE	617 149	–0.035	0.972	568 579	–0.190	0.849	699	–0.802	0.422

***, ** and * significance levels at 0.01, 0.05 and 0.10, respectively; *WCTA* – working capital : total assets; *LIQ* – current assets : current liabilities; *CLCA* – current liabilities : current assets; *FUTL* – funds provided by operations : total liabilities; *RETA* – retained earnings : total assets; *BVEBVL* – book value of equity : book value of total liabilities; *TLTA*– total liabilities : total assets; STA – sales : total assets; *EBITTA* – *EBIT* : total assets; *EBIT* – earnings before interest and taxes; *ROA* – net income : total assets; *CHIN* – $(NI_t - NI_{t-1}) : (|NI_t| + |NI_{t-1}|)$; *SIZE* – log(total assets : GNP price-level index); GNP – gross national product

Source: Own elaboration

Table 6. χ^2 tests according to the vegetative cycle of crops

Ratios	Full sample (H_4)				Healthy firms (H_5)				Bankrupt firms (H_6)			
	N	χ^2	d*f*	*P*-value (2-tailed)	N	χ^2	d*f*	*P*-value (2-tailed)	N	χ^2	d*f*	*P*-value (2-tailed)
OENEG	2 228	0.204	1	0.652	2 145	0.476	1	0.490	83	3.309	1	0.069*
INTWO	2 208	0.040	1	0.841	2 145	0.746	1	0.380	63	1.046	1	0.306

* significance level at 0.10; N – sample size; *OENEG* – 1 if total liabilities exceed total assets, 0 otherwise; *INTWO* – 1 if net income negative last two years

Source: Own elaboration

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Table 7. Results summary table

Ratios	According to financial health			According to vegetative cycle		
	full sample	non-perennial crop firms	perennial crop firms	full sample	healthy firms	bankrupt firms
Liquidity						
WCTA	***	***	–	***	***	–
LIQ	***	***	**	–	–	–
CLCA	***	***	–	–	–	–
FUTL	***	***	***	–	**	–
Solvency						
RETA	***	***	***	–	*	*
BVEBVL	***	***	***	–	–	*
Leverage						
TLTA	***	***	***	–	–	*
OENEG	***	***	***	–	–	*
Activity						
STA	–	–	**	***	***	**
Profitability						
EBITTA	***	***	***	*	**	–
ROA	***	***	***	–	*	–
INTWO	***	***	***	–	–	–
CHIN	–	*	–	*	***	–
Dimension						
SIZE	–	–	–	–	–	–

***, ** and * significance levels at 0.01, 0.05 and 0.10, respectively; *WCTA* – working capital : total assets; *LIQ* – current assets : current liabilities; *CLCA* – current liabilities : current assets; *FUTL* – funds provided by operations : total liabilities; *RETA* – retained earnings : total assets; *BVEBVL* – book value of equity : book value of total liabilities; *TLTA* – total liabilities : total assets; *OENEG* – 1 if total liabilities exceed total assets, 0 otherwise; *STA* – sales : total assets; *EBITTA* – *EBIT* : total assets; *EBIT* – earnings before interest and taxes; *ROA* – net income : total assets; *INTWO* – 1 if net income negative last two years; *CHIN* – $(NI_t - NI_{t-1}) : (|NI_t| + |NI_{t-1}|)$; *SIZE* – log(total assets : GNP price-level index); GNP – gross national product

Source: Own elaboration

so a firm in financial difficulties would be expected to show a more significant negative change than would a healthy firm. We also noticed that the differences in the *SIZE* ratio between bankrupt and healthy firms was not statistically significant, regardless of whether they were perennial or non-perennial crop firms. In addition, the *WCTA* (working capital : total assets) and *CLCA* (current liabilities : current assets) financial ratios showed statistically significant differences at 1% in non-perennial crop firms. However, they did not show differences in the group of perennial crop firms. The *CLCA* ratio was strongly associated with liquidity, so it was a strong candidate for predicting bankruptcies for agricultural activities dedicated to crops with a shorter vegetative cycle. However, the *STA* ratio was statistically different at a significance level of 5% according to financial health in perennial crop firms, but it did not show any difference in non-perennial crop firms. In other words, the *STA* ratio did not seem to predict failure if agricultural firms were engaged in short-cycle plantations.

When we subdivided according to vegetative cycle (hypotheses H_4, H_5 and H_6), the *STA* ratio, which measures the relationship between sales and total assets, presented solid statistical evidence (at 1% significance) depending on the vegetative cycle. This finding is understandable, given the greater expression that this ratio assumed in firms engaged in non-perennial crops compared with those engaged in perennial crops. In other words, the transformation of assets into sales was higher in plantations with a shorter vegetative cycle. Interestingly, some financial ra-

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tios showed statistically significant differences when firms were healthy. However, they lost some significance when firms were bankrupt. This is the case the *WCTA*, *FUTL* (funds provided by operations : total liabilities), *STA*, *EBITTA* [earnings before interest and taxes (*EBIT*) : total assets], *ROA* (net income : total assets) and *CHIN*. We can infer that only when firms are in regular operation, without difficulties that affect their survival, can they show different financial structures according to the vegetative cycle of the plantations. The *WCTA* ratio, which in the group of healthy firms presented solid statistical evidence of the differences between firms with different vegetative cycles, lost all significance in the bankrupt ones. We can infer that when a firm is bankrupt, the vegetative cycle does not affect the short-term cash balance measured by this ratio that measures short-term financial health. This is an interesting finding, mainly because working capital measures a firm's ability to meet its current liability commitments by using current assets. Furthermore, *EBITTA*, which was strongly differentiated between the vegetative cycles of healthy firms, lost this differentiation in the bankrupt firms. This finding suggests that, for agricultural firms without financial difficulties, there are differences in this profitability ratio depending on the vegetative cycle, but that it shows no difference if the firms are bankrupt.

We found some similarities with other studies concerning the characterisation of plantations, but never specifically to the vegetative cycle. This similarity is the case of the study by Hardy and Weed (1980), who covered plantations and livestock, as well as Limsombunchai et al. (2005), who considered not only vegetables but even aquaculture.

Structural, climatic and biophysical characteristics can be decisive in bankruptcy prediction. Exposure to uncertainty varies depending on the lifespan of the plantations. For example, the probability of a vineyard being affected by a climatic phenomenon during its long life is different from that of a rice plantation that lasts only one year. Also, the charges are different depending on the crop cycle. Thus, we must assess whether a model for predicting bankruptcy should not consider these differences, knowing that some financial ratios are also different.

Our findings suggest that the vegetative cycle can affect the differentiation between healthy and bankrupt firms, which motivates several reflections. Vegetative cycle considerations are pretty much absent from previous studies on bankruptcy in the agricultural sector. The analysis we presented here exposes that as a limitation. Indeed, model accuracy can be improved by considering different vegetative cycles. In terms of future studies, contextualised with the threat of climate change and its influence on farmers' preferences for different vegetative cycles of crops, it is essential to create credit risk models sensitive to cycles. Finally, although not always transversal between economic blocks or countries, the structures for classifying economic activities should allow for the identification of the vegetative cycle.

Agricultural firms, the healthy ones more than the bankrupt ones, presented statistically different ratios between vegetative states, mainly in terms of liquidity and profitability. These findings, extrapolated to other areas of economic study, open a great potential for new findings unrelated to bankruptcy prediction.

CONCLUSION

In this article, we empirically examined a large sample of firms in the Portuguese agricultural sector. We compared various financial ratios used in the original studies by Altman (1983), Ohlson (1980), and Zmijewski (1984) by doing a cross-analysis according to the financial health of firms and the vegetative cycle of plantations.

Our results identify how useful the classical predictors are for differentiating the financial health of agricultural firms dedicating themselves to crops with different vegetative cycles. Some ratios revealed the ability to differentiate between two categories (perennial crop and non-perennial crop firms). However, others revealed this ability in only one of the groups studied. Our findings indicate that the financial predictors of bankruptcy generally differed between groups of firms according to their category (liquidity, solvency, leverage, profitability, and dimension). In liquidity ratios, there was a lack of statistical evidence in differentiating healthy firms from bankrupt ones when they were dedicated to plantations with a vegetative cycle renewed annually (non-perennial crop firms). However, the activity ratio was different only in perennial crop firms. In the second group of findings, we obtained statistical evidence that some liquidity and profitability ratios were different in differentiating the vegetative cycles only when firms were healthy. In none of the tests performed did the size of the firms show any statistical ability to differentiate the financial condition of the firms.

Implications for theory, practice and policy makers. Stakeholders must understand agriculture

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as an activity full of specifics that react differently to exogenous factors. Economic policies also have a significant effect on farm profitability. Farmers, when faced with difficulties, adapt quickly to differentiated agronomic practices. However, the results depend on investment cycles, and the uncertainty increases the longer the vegetative cycle. In the future, the effect of climate change on farmers' investment decisions can be significant, including from a credit risk perspective. For economic survival, farmers can opt for crops with more resilient vegetative cycles. Understanding how the predictors of financial distress are revealed among different cycles is an essential tool for those who support agricultural activity, whether financial institutions, suppliers or policymakers, regardless of whether they are in economic blocks, as is the case of the EU.

Limitations. Some limitations should be considered when interpreting these results. The first limitation is that the variables studied are not necessarily those that could be the most significant in a statistical estimation context. We simply took the predictors from the previous literature. Another limitation is the fact that we focussed on Portugal alone. The national context and the potential mismatch of transnational realities owing to the heterogeneity of the agricultural sector require care when extrapolating to other situations.

In this article, we discussed the relevance of considering the vegetative cycle when predicting bankruptcy. Future bankruptcy models also may include this aspect. Furhermore, it would make sense to extend the empirical analysis to a transnational context. Finally, this analysis also opens the door to the possibility of considering the relevance of different crops and not just their vegetative cycle type.

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