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Valuation of an innovative investment project using real options approach: A case study of a viticulture company in Spain

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Abstract: In Spain, the leader in pesticide sales in the European Union, a high-tech and innovative company provides services to the wine industry to optimise phytosanitary work, reduce crop losses and lower production costs. Although the nature of its business encourages the transition to a sustainable agri-food system, it also involves risks associated with uncertainty. The objective of this article was to perform the valuation of the company through the real options approach, including an expansion option, analysing whether this company will be able to increase the value of its project by expanding its activity to a larger number of vineyards. Results showed that the application of the real options approach projected a higher result than the traditional net present value method, so that if the company makes additional investments in its precision agriculture project, these will increase the value by a 15%.

Keywords: company valuation; efficient resource management; innovation processes; precision agriculture

The Green Deal is a holistic strategic plan of the European Union designed in 2019. This plan was presented by the European Commission as a new strategy to achieve competitiveness of the European economy through climate neutrality. It is composed of a governance framework made up of more than twenty strategic documents. This framework regulates *i*) the fight against climate change with scenarios foreseen for 2030 and 2050, *ii*) the change of the energy paradigm, *iii*) the abandonment of the linear economy for the circular economy, *iv*) the protection of biodiversity, *v*) sustainable mobility, and *vi*) making Europe the first climate-neutral continent.

Therefore, the policies related to the European Green Deal are aimed at combating climate change and environmental degradation. To achieve its aims, European

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countries must, among other actions, cut down the use of the most hazardous pesticides by 50% by 2030 (European Commission 2021). This policy has its precedent in the European Directive 2009/128/EC regarding the controlled use of pesticides, and is framed within the Sustainable Development Goals (United Nations 2021). However, the institutional framework for the transition to a sustainable agri-food system is not feasible through traditional practices based on the abusive use of plant protection products (PPP) (Taiwo 2019).

In 2020, Spain was the first country in PPP sales (66.41 t) in the European Union, followed by France (64.74 t) and Italy (56.37 t), and was the tenth largest consumer of pesticides in the world (Eurostat 2021). The Spanish agricultural area (24 million ha) includes the production of cereals, fruit trees and vineyards, all crops with a high level of PPP consumption (González et al. 2021). Even though the classes and doses of pesticides used in fruit orchards and vineyards have been legally reduced, spraying varies between 10 and 15 treatments per year, depending on climatic circumstances (Pertot et al. 2017; Román et al. 2022). The environmental consequences of these practices entail a dangerous increase in the toxins present in terrestrial and aquatic habitats for both wildlife and humans. Although a full elimination of pesticides in agriculture does not seem feasible, performance optimisation is achievable, especially in crops with increasing technification, as is the case of vineyards.

In 2021, 941 086 ha of Spanish land were dedicated to vineyards. This fact makes Spain the third largest producer of wine and must in the world. There has been a reduction in the area dedicated to vineyard exploitation but through restructuring and improvements in production techniques, the production did not fall (Lorenzo et al. 2018). In economic terms, the wine value chain accounts for 2.2% of the gross value added in Spain. The goal of streamlining and strengthening the sector encouraged the creation of the Wine Technology Platform in 2011. This association, made up of public and private collaborators, brings together the wine production and processing sector, the auxiliary sector and the scientific sector. (Plataforma Tecnológica del Vino 2021). Between 2011 and 2020, the platform has promoted 159 R&D&I projects, with an overall investment up to EUR 157.5 million. In addition, the International Organisation of Vine and Wine (OIV) was created in 2001 at the international level. The OIV is made up of 48 states, including Spain. The purpose of this intergovernmental association is to foster scientific and technical innovation, the dissemination of its results and the development of the international wine sector.

In addition, new formal rules have been incorporated into the current governance of the sector. One of them is the 2019–2024 Strategic Plan, included in the sustainable development goals of the United Nations 2030 Agenda. This way, the OIV creates a framework for meeting sustainability objectives at the environmental, socioeconomic and sociocultural levels, while also responding to the demands of its consumers, who are increasingly interested in the ecological aspects of the wine sector (Ferrer et al. 2022). With its compliance with the OIV, the sector seeks more sustainable production through the reduction of pesticides and fertilisers use (Golicic 2021).

The plan leads the companies of the sector to include new investments in their strategy that allow them to adapt to the new production paradigm. Therefore, the objective of this article is to carry out the financial valuation of a company whose activity is focused on innovation and digitalisation applied to viticulture with the aim of increasing the degree of sustainability of crops. The valuation of the company, based in Galicia (Spain), will be performed through the real options (RO) approach, which is appropriate in uncertain environments. This methodology includes an expansion option to analyse whether this company, which promotes the improvement of resource productivity and the reduction of agricultural resources, will be able to increase the value of its project by expanding its activity to a larger number of vineyards.

Although RO models have limitations [they are sometimes considered as a 'black box' (Horn et al. 2015)] and the decision-making process has been criticised because of the so-called subjectivity of the analysts (Ajak and Topal 2015; Driouchi et al. 2020; Alexander et al. 2021), they are a fast and commonly used method in a number of sectors such as wind power, gas and electricity, and can be applied to almost any process where prices have a stochastic behaviour. The novelty of this article lies in two factors. The first one is the analysis of the company's activity, which is aimed at the optimisation of phytosanitary treatments, the reduction of crop losses, and the reduction of production costs. The second factor lies in the inclusion of the RO methodology. This methodology has been applied in various sectors, but its first analysis was focused on the valuation of natural resources (Tourinho 1979). Since then, there has been a great deal of research focused on this area, although the RO methodology has been applied mainly to energy resources. In the case

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of the wine sector, there are a few examples (Viviani 2007; Cyr et al. 2010; Seyoum-Tegegn and Chan 2013), but they do not incorporate precision agriculture in their analysis. In particular, we consider a binomial model as in Henao et al. (2017), Rambaud and Pérez (2017) or Kamel et al. (2023).

MATERIAL AND METHODS

The company we analyse is focused on innovation and digitalisation applied to viticulture. It is a start-up created by research staff from a Spanish university in 2014. The company was established with a share capital of EUR 20 000, and in its seven years of existence, its growth was constant, because it has expanded its client portfolio to twenty wine-producing partners from ten different designations of origin (Figure 1). Such a gradual increase in the client portfolio is due, at least in part, to the fact that the company has diversified the services offered as a result of its participation in various research projects.

According to the company's record deposited in the Spanish Trade Register, its activity consisted of providing detailed information on the health status of the vineyards through a control process. This was achieved by studying the phenological state of the plants and the environmental parameters influencing the grape quality, such as wind direction, degree of humidity, or the level of rainfall, with subsequent analysis by experts in viticulture and meteorology. The obtained results can be checked on the company's website under a monthly subscription service. In addition, such a subscription provides access to two important services: a document processing system for vineyard managers to record agricultural processes or any anomalies in the crops, and a vegetation mapping tool which, through satellite, drone or light aircraft photographs, identifies fluctuations in vine growth. This allows for zoning the vineyard and characterising its vigour, chlorophyll and photosynthetic efficiency (Monet Viticultura 2022).

The main goal of this process is to optimise the number of phytosanitary treatments, which, in turn, lowers the grape production costs, and monitoring the crop through data interpretation helps the winemakers' decision-making process. Since the vineyards of the company's customers were located in the northern half of Spain, the company created different predictive models both for the main grape varieties in the area (Godello, Treixadura, Albariño and Tempranillo) and for the vine diseases associated with these grape varieties (oidium, mildew, botrytis or black-rot).

In recent years, the company's business plan has been focused on 'precision agriculture'. The company collaborated on several research projects that entailed advances in the rationalisation of the use of phytosani-

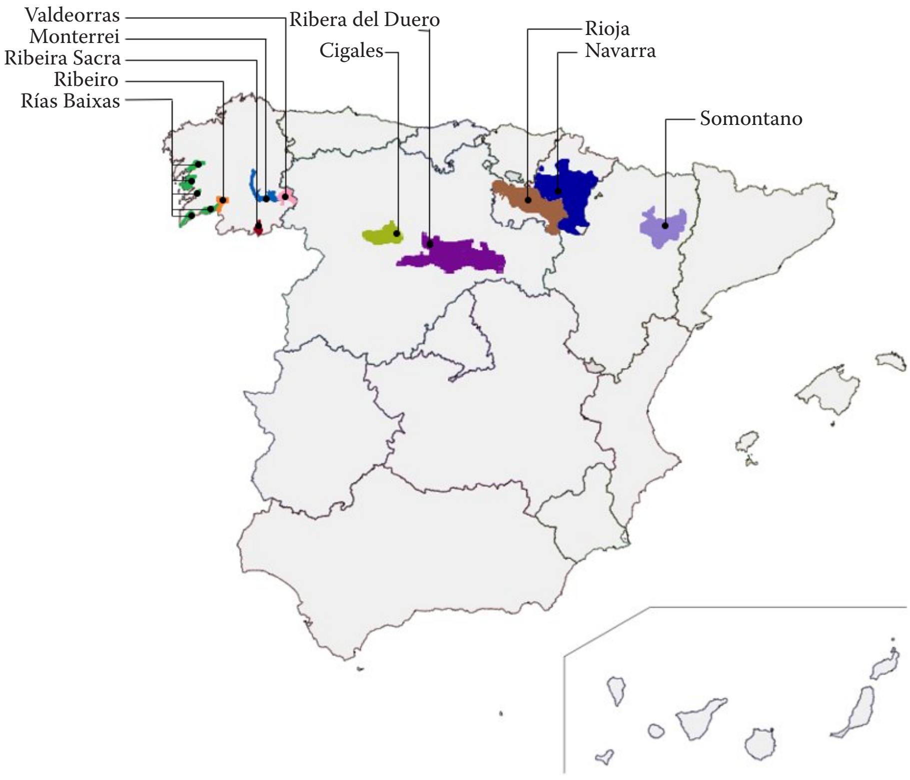

Figure 1. Protected Designations of Origin in this study

Source: Authors' own elaboration

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tary treatments and the reduction of chemical residues. Such streamlining not only increased the sustainability of the crops but also meant savings in costs. For example, phytosanitary treatments were reduced by 40%, which directly affected the production costs (Ministerio de Agricultura, Pesca y Alimentación 2018, 2021). The implementation of the results of the study of the microclimates' effect on the incidence of fungal diseases, the knowledge of wood diseases, and the concentration of fungal spores in the environment allowed for a reduction of uncertainty in the harvest outcome. At the same time, it also improved the sustainability and quality of wine crops. In addition, this information was channelled through digital tools to increase its availability and accuracy.

The shortcomings of the classic valuation models, together with the uncertainty inherent in an increasingly lobalized economy, paved the way for a new methodology for investment project valuation, the RO approach. This fact has led to a growing trend in academic research in this field (Cabrerizo et al. 2020). One of the most important shortcomings of classical valuation models, such as net present value (NPV) and internal rate of return (IRR), is that they neglect the value of investor management's flexibility (Lin and Tan 2021). The RO approach attempts to solve this deficiency by incorporating the valuation of the impact of uncertainty and flexibility inherent to investment projects. The RO approach is a tool that provides decision-makers with a valuation model capable of analysing several scenarios (Agaton et al. 2020; Cuervo et al. 2021). Such flexibility is of great use in environments where new information can be valued or where the uncertainty affecting the project is high. Hence, this constitutes a good approach for scenarios where the project's market conditions are very volatile and flexible (Agaton et al. 2020). By considering new factors such as uncertainty and flexibility that classical models do not take into account, the RO approach presents an added value in decision-making. In addition, the RO approach provides versatile decision-making (Cabrerizo et al. 2020; Ipsmiller et al. 2021; Li and Cao 2022), allowing for an adaptation to future changes caused by uncertainty affecting the project over time (Lin and Tan 2021).

The valuation of investment projects using the RO methodology is based on financial option valuation models. Myers (1977) applied the valuation of financial option models to the valuation of non-financial assets for the first time. The most important models for the valuation of financial options are the Black-Scholes model, the binomial model, and the Monte Carlo simulation.

Of the above-mentioned models, the binomial model through the decision tree tool is one of the most widely used ones for the valuation of investment projects in literature. This is due to its great versatility and adaptation to real assets (Cox et al. 1979). It also presents better applicability for complex options, and therefore is a suitable model for case studies where there are several sources of uncertainty or where volatility fluctuates over time (Loncar et al. 2017).

To apply the binomial model to the valuation of investment projects, we need to define the following variables:

– underlying asset value: corresponds to NPV value.

– exercise price (E): the value of the investment expected to be made by the company

– expansion factor (F): growth percentage projected by the company

– volatility (σ): standard deviation of the cash flows calculated to obtain the NPV. Its calculation is defined by the following Equation (1) (Loncar et al. 2017):

$$\sigma = \ln\left(\frac{\sum_{i=1}^{n} CF_i}{\sum_{i=0}^{n} CF_i}\right) \tag{1}$$

where: CF_i – value of the expected cash flows in each period.

– project duration (T): period to develop the project.

– stage duration (n): duration of development of each stage. In this case, each stage lasts one year.

– u represents the upward movement of the value of the underlying asset (NPV), is defined as:

$$u = e^{\sigma\sqrt{dt}} \tag{2}$$

where: $dt = T/n$.

– d represents the downward movement in the NPV, is defined as:

$$d = e^{-\sigma\sqrt{dt}} = \frac{1}{u} \tag{3}$$

– p_u: risk-neutral probability of an increase in the underlying asset value.

$$p_u = \frac{e^{r_f dt} - d}{u - d} \tag{4}$$

where: r_f – interest risk free rate.

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– p_d: neutral risk probability linked to the decrease of the underlying asset.

$$p_d = 1 - p_u \quad (5)$$

– r_f: risk-free discount rate.

The company valuation process, which includes the expansion option, has four stages (Fernández-González et al. 2021, 2022; Pérez-Vas et al. 2021).

1) Projection of financial statements (profit and loss statement, and balance sheet).

2) Cash flow estimation based on stage 1 projections.

3) Net present value calculation

$$NPV = -I + \sum_{t=1}^{T} \frac{CF_t}{(1+i)^t} \quad (6)$$

where: I – investment made by the company; i – the average cost of capital ($WACC$).

4) Application of the RO methodology. This stage is divided into three sub-steps:

4.1) Creation of the binomial tree corresponding to the underlying asset without flexibility.

Generally, every node in the binomial tree represents the expected value of cash flows and is given by:

$$CF_{i,j} = u^i d^{|i-j|} CF_{0,0} \quad (7)$$

4.2) Estimation of the investment project with flexibility [NPV expanded, as in Liao and Ho (2010)]. ROV represents the value of the project incorporating flexibility. The process of creating the structure that forms the value of the investment project with the incorporation of options consists of two steps. Firstly, the value of the terminal nodes is calculated and secondly, the value of the intermediate nodes is calculated through the process called backward induction. The valuation of the nodes is carried out through a maximisation rule in which the values of the project with and without options are compared. In this case, the valuation of an expansion option was carried out, and its value was defined by the following Equation (8):

4.3) Option value calculation

As in Rambaud and Pérez (2017), we obtained the value by subtracting the values not including the option from the ones including it.

RESULTS AND DISCUSSION

The four stages described in the previous section were applied for evaluating the project. During the first stage, the projection of the financial statements was carried out. Subsequently, in stage 2, the cash flows necessary to estimate the NPV were calculated by estimating this accounting statement (Table 1).

Next, Equation (6) was applied to calculate the NPV (EUR 398 667.35). Finally, stage 4 was carried out, where the valuation of the company was performed using the RO methodology. Table 2 shows the necessary parameters for the application of RO through the binomial model.

$$WACC = E \times K_e + D \times K_d = 82.29\% \times 4.59\% + 17.71\% \times 1.5\% = 4.04\%$$

E: equity (82.29%)

K_e: cost of equity (4.59%)

D: debts (17.71%)

K_d: cost of debts (1.5%)

$$u = e^{0.3249\sqrt{1}} = 1.39$$

$$d = \frac{1}{1.39} = 0.72$$

$$p_u = \frac{e^{0.0078 \times 1} - 0.72}{1.39 - 0.72} = 0.43$$

$$p_d = 1 - 0.43 = 0.57$$

Considering that the net present value of the project was EUR 398 667.35, the investment project was feasible. However, this value did not consider management flexibility. To solve this issue, the valuation of the

$$ROV_{i,j} = \begin{cases} \max\left(CF_{i,j}; CF_{i,j} * F - E\right) & \text{if } j = n \\ \max\left(CF_{i,j} * F - E; CF_{i,j}; \dfrac{p_u ROV_{i+1,j+1} + p_d ROV_{i,j+1}}{\left(1+r_f\right)^{\Delta t}}\right) & \text{if } j \in \{0,1,2,\ldots,n-1\} \end{cases} \quad (8)$$

where: $i, j = 0, 1, 2, \ldots n$ and $j \geq i$

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Table 1. Cash flow estimation (EUR)

Year	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Revenue	59 855.00	59 855.00	62 847.75	65 990.14	69 289.64	72 754.13	76 391.83	80 211.42	84 222.00	88 433.10	92 854.75
Change in stocks	4 195.00	15 470.00	1 137.65	1 194.53	1 254.26	1 316.97	1 382.82	1 451.96	1 524.56	1 600.79	1 680.83
Cost of goods sold	−22 753.00	−22 753.00	−23 890.65	−25 085.18	−26 339.44	−27 656.41	−29 039.23	−30 491.20	−32 015.76	−33 616.54	−35 297.37
Tasks performed by the company for assets	28 776.00	28 776.00	30 214.80	31 725.54	33 311.82	34 977.41	36 726.28	38 562.59	40 490.72	42 515.26	44 641.02
Other operating income	53 322.00	53 322.00	55 988.10	58 787.51	61 726.88	64 813.22	68 053.89	71 456.58	75 029.41	78 780.88	82 719.92
Personnel expenses	−61 812.00	−61 812.00	−64 902.60	−68 147.73	−71 555.12	−75 132.87	−78 889.52	−82 833.99	−86 975.69	−91 324.48	−95 890.70
Other expenses	−9 443.00	−9 443.00	−9 915.15	−10 410.91	−10 931.45	−11 478.03	−12 051.93	−12 654.52	−13 287.25	−13 951.61	−14 649.19
Depreciation expense	−46 767.00	−46 767.00	−46 767.00	−46 767.00	−46 767.00	−46 767.00	−46 767.00	−46 767.00	−46 767.00	−46 767.00	−46 767.00
Grants	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Others results	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00
Operating profit/(Loss) EBIT	**5 377.00**	**16 652.00**	**4 716.90**	**7 290.89**	**9 993.59**	**12 831.42**	**15 811.14**	**18 939.85**	**22 224.99**	**25 674.39**	**29 296.26**
Depreciation expense	46 767.00	46 767.00	46 767.00	46 767.00	46 767.00	46 767.00	46 767.00	46 767.00	46 767.00	46 767.00	46 767.00
Change in stocks	5 991.00	−15 470.00	−1 137.65	−1 194.53	−1 254.26	−1 316.97	−1 382.82	−1 451.96	−1 524.56	−1 600.79	−1 680.83
Change in receivables	2 206.00	28.53	−100.52	−105.55	−110.83	−116.37	−122.19	−128.30	−134.71	−141.45	−148.52
Change in payables	0.00	−4 732.78	43.51	45.69	47.97	50.37	52.89	55.53	58.31	61.22	64.29
Cash flow	**60 341.00**	43 244.75	50 289.24	52 803.50	55 443.47	58 215.45	61 126.02	64 182.12	67 391.03	70 760.38	74 298.20

EBIT – earnings before interest and taxes
Source: Authors' own elaboration

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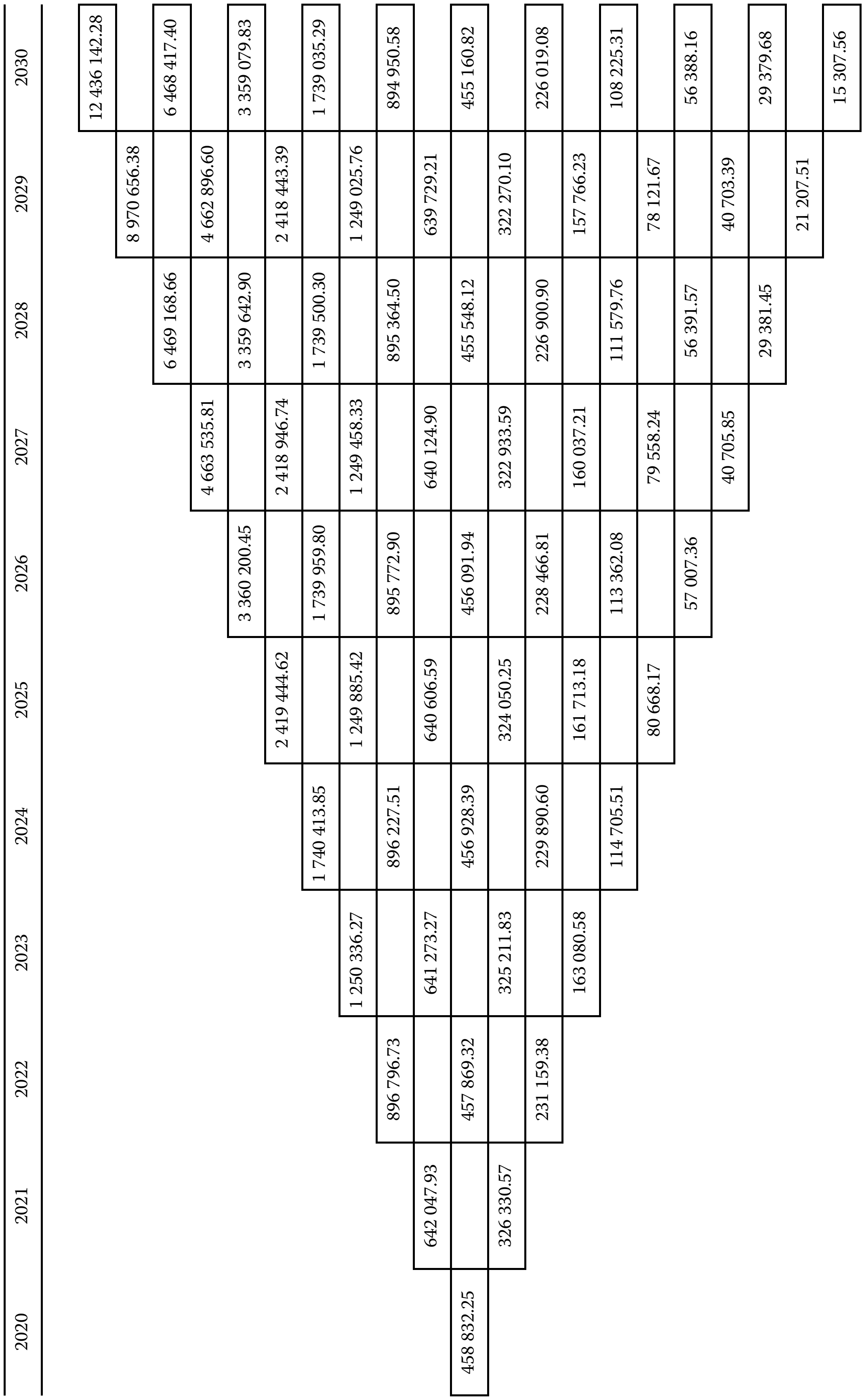

Figure 2. RO binomial tree (EUR)

RO – real options
Source: Authors' own elaboration

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Table 2. Parameters

Parameter	Value
NPV	398 667.35
σ (%)	32.60
u	1.39
d	0.72
p_u	0.43
p_d	0.57
dt	1.00
Expansion factor (*F*)	1.20
New investment (*E*) (EUR)	23 240.00
r_f (Spanish bond Feb 2, 2022) (%)	0.78
Discount rate (WACC) (%)	4.04

NPV – net present value; σ – volatility; *u* – upward movement of the value os the underlying asset (NPV); *d* – downward movement in the NPV; p_u – risk-neutral probability of an increase in the underlying asset value; p_d – neutral risk probability linked to the decrease of the underlying asset; *dt* – *T*/*n* (*T* – project duration, *n* – stage duration); r_f – interest risk free rate; WACC – average cost of capital
Source: Authors' own elaboration

project with the possibility of an expansion option was considered, the results of which are shown in Figure 2. Once developed, the project's value taking into account the management flexibility amounted to EUR 458 832.25 (an EUR 60 164.90 value increase that represented 15% of the *NPV*).

$NPV = 398\ 667.35 < ROV = 458\ 832.25$

Table 3. Sensitivity analysis of *WACC*

WACC (%)	RO methodology (EUR)
2.50	516 525.31
2.75	506 604.07
3.00	496 894.32
3.25	487 390.71
3.50	478 088.02
3.75	469 050.60
4.04	458 832.25
4.50	443 370.16
4.75	435 162.75
5.00	427 124.43
5.25	419 251.02
5.50	411 538.48
5.75	403 982.86

WACC – average cost of capital; RO – real options
Source: Authors' own elaboration

Table 4. Sensitivity analysis of volatility

Volatility (%)	RO methodology (EUR)
50	463 238.17
45	462 038.03
40	460 782.15
35	459 475.45
30	458 255.77
25	457 679.40
20	457 166.31
15	457 049.11
10	457 042.94
5	457 042.94

RO – real options
Source: Authors' own elaboration

In this study, the effect of certain variables, such as volatility or WACC, had a direct impact on the valuation through RO. Therefore, these two variables were analysed in a sensitivity analysis (Tables 3 and 4). The range of dispersion in both cases was limited, which reinforces the valuation using the RO methodology.

CONCLUSION

Spain, as a member of the European Union, is also committed to joining efforts to achieve climate neutrality through active policies in agriculture. This commitment includes reducing the use of pesticides and fertilisers, which is widespread in the wine sector, among others. Therefore, the activity carried out by the company under study represented an encouraging initiative for sustainability and creating synergies that seek to reduce production costs while reducing the ecological footprint of the crop.

The services offered by the analysed company reduced the risk of fungal disease in vineyards and identified crop water stress, all through measurements at weather stations, satellite image processing and vegetation mapping. This innovative approach entailed certain risks, since there is a relative irreversibility and inflexibility associated with the decision to carry out this activity. Therefore, the analysis through the RO methodology was very useful in this case.

Over the last few years, there has been a growing trend of research conducted on new investment project valuation models as a way of adapting to the current business dynamics. The increase in uncertainty due to COVID-19 (Baig et al. 2020; Bakas and Triantafayllou 2020; Shruthi and Ramani 2021), the need for greater

https://doi.org/10.17221/299/2023-AGRICECON

flexibility in decision-making, as well as the limitations of discounted cash flow (DCF) models (Hu and Zhang 2015; Locatelli et al. 2020; Zuluaga and Sánchez-Silva 2020), lead to focus research in the field of RO.

Thus, the article proposes the application of the binomial model to the valuation of an investment project related to sustainable innovation in the agricultural sector. Through this application, it was possible to show that this model confers management flexibility not provided by classical models, developed through an expansion option. In this work, the application of the RO approach projected a greater value than the NPV method. This means that if the company makes additional investments in its precision agriculture project, it will generate a value of EUR 60 164.90.

Despite the advantages provided by the valuation of RO, it is necessary to highlight that the binomial model depends on certain assumptions that are carried out for the calculation of the underlying asset value (NPV). Therefore, the impact of WACC and volatility on the valuation of the company was analysed. As a result, it was concluded that the values obtained through these analyses did not differ from the initial value calculated. Another limitation of this study was the scarcity of similar studies in the same sector that would allow for an interesting comparison of results. Future research ideas include improving the model by incorporating compound options, and using other models of RO valuations, such as Black-Scholes or Monte Carlo simulations, in order to study the possible divergence of results.

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