Bongiolatti Elisa 950309094020
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**Department of Social Science - MSc Thesis in Business Economics**


# Cost-Benefit Analysis of three innovative projects in the wine sector in Northern Italy

Wageningen University

MSc Management, Economics and Consumer Studies

Registration number: 9503090940209

Supervisor: Dr Mariska van der Voort

Università Cattolica del Sacro Cuore

MSc Agricultural and Food Economics

Registration number: 4709740

Supervisor: Prof. Claudio Soregaroli

## Preface

This MSc Thesis is the final accomplishment of the Double Degree programs "Management, Economics and Consumer Studies" at Wageningen University and " MSc Agricultural and Food Economics" at Catholic University of Sacred Heart of Milan.

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I dedicate this MSc thesis to my grandparents Olimpia and Ottorino in memory of the good time spent together in the vineyards in Valtellina.

**Abstract**

The aim of this research is to assess whether three innovative projects in Valtellina wine sector can be economically sustainable. The three innovative projects are: the conversion to organic wine production in Valtellina, the implementation of a nursery of grafted vine plants in Valtellina and the drone spraying adoption in terraced vineyards in Valtellina. The data collection was firstly done through a literature review about the advantages and disadvantages of organic wine production, nursery for grafted vine plants and drone spraying in vineyards. Afterwards, sixteen small-scale wineries in Valtellina, two drone companies, a nursery for grafted wine plants in Valtellina were interviewed. The interviews were specifically structured for each of the three projects and consisted in closed-ended questions about production costs and revenues. Expert elicitation was used to check the correctness of the data collected through the interviews. Data about market price and quantities of grafted vine plants sold in the last 10 years in Valtellina were collected from nurseries outside Valtellina. The quantitative production data collected during the interviews were used in the data analysis which was based on a Cost-Benefit Analysis (CBA). The CBA included, for every project, the costs for the inputs and the revenues of the outputs. The calculated indicators are: the Net Present Value (NPV), the Cost Benefit Ratio (CBR) and the investment rate of return (IRR). Furthermore, one sensitivity analysis for each project was done. The findings show that for small-scale wineries in Valtellina it is economically sustainable to invest in the organic conversion. It is economically sustainable to implement a nursery for vine plants in Valtellina only when the selling prices of the grafted wine plants are higher than the marginal production costs for grafted vine plants. Despite the drone spraying being debated at legislative level in Europe, the drone leasing from a farm cooperative to a winery was investigated at economic level. The result of this simulation is that it generates a positive NPV only for the farm cooperative when the drone's rent price is 50 euro/ha. It could be of interest to investigate further the case of a winery which buys the drone itself and use internal workforce to program the drone flight and do the drone spraying and lease it to other wineries since it is expected to be economically sustainable. In this research the environmental impact is not included in the CBA therefore the suggestion for further research is to include the environmental impact costs in the CBA by using a multicriteria analysis.

**Key words**: small-scale winery, organic wine production, nursery for grafted vine plants, vineyards drone spraying, North Italian wine sector

**Table of abbreviations**

CAP Common Agricultural Policy
CBA Cost-Benefit Analysis
CBR Cost benefit Ratio
CRD Chemicals Regulation Directorate
IRR Investment Rate of Return
LRC Large Retail Chain
NPV Net Present Value
PV (B) Present Value of benefits
PV (C) Present Value of costs
RDP Rural Development Programme

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# 1 Introduction

## 1.1 Background and problem statement

The Common Agricultural Policy (CAP) incentivize agricultural production in the mountain areas also for vineyards and winemaking. The Rural Development Programme (RDP) measures, specifically the measure number 4 and 11 of the Second Pillar of the CAP, are targeting the young entrepreneurs. The RDP measures are supporting the startup of farms in mountain areas (European Commission, 2013), the landscape maintenance and the generational change (Đurić, Kuzman, & Prodanović, 2019). Since young farmers and small-size farms are more inclined to change, they are more likely to adopt sustainable practices in agriculture (Rooij, 2004).

Italy is the second-largest wine producer in the world, it produced over 51 hectoliters of wine in 2016 with a turnover of £10.5 bn and a market share of 16.4 per cent (Dainelli, Francesco ; Daddi, 2018). Due to its volumes, the socio-environmental impact of wine production has started to be included in the mission of the wineries and in their daily practices. Parameters to measure environmental-social impact and competitiveness are included in the company's sustainability reports (Banfi Winery, 2017). Moreover, consumers consciousness towards a more environmentally friendly production is increasing (Vermeir & Verbeke, 2006). Also, local communities, who live close to the wine production area, claim for more eco-friendly productions for the present and future generations. Northern Italy wine sector has landscape differences (e.g. hills, planes and mountains area) and this results in different vineyards' management and production costs. Therefore, environmental issues related to vineyards' management can rise across the different landscapes. In Valtellina, there are higher production costs for wine production compared to other flatter wine areas in Italy like Bolgheri (Tuscany) and Prosecco (Veneto) region. Moreover, the market price for wine grapes in Valtellina (ISMEA, 2008) is lower compared to their production costs (Garbellini, Zecca, 2008).

Valtellina wine sector as a part of mountain rural agricultural area of the Italian Alps is facing a pretty similar issue as the ones related to the whole EU agricultural system. Its wine sector produces on average 3 million wine bottles per year. Valtellina is located in the middle of the Italian Alps in Lombardy region (North of Italy), close to the Swiss border. It is characterized by 995 ha of terraced vineyards on the Rethic mountain side. Those terraced vineyards are sustained by dry stone walls. In this valley, there are 2,150 wineries and most of them are small-scale with less than thirteen employees (Consorzio Tutela Vini di Valtellina, n.d.). In Valtellina, the steepness of the mountainside does not allow complete mechanization. Therefore in the terraced vineyards, there is a high cost of labor (Torquati, Giacchè, & Venanzi, 2015) and maintenance costs (Murada, 2017) for the dry-stone walls. In this context, few big wineries can exploit the benefits of economies of scale. However, this system is not economically sustainable for the small-scale wineries and this is reflected in the increased number of abandoned vineyards in Valtellina (García, 2012) and the loss of rural landscape heritage in Valtellina (Puleo, 2012).

The overarching knowledge gap is the lack of societal awareness towards the economic impact of small-size farms in rural areas. This can be due to the lack of farmers' awareness of their knowledge capital towards sustainable innovation in agriculture (Stuiver, Leeuwis, & Van der Ploeg, 2004), or the little social recognition of the farmers in the modern society (Coolsaet, 2015). Moreover, the supply chain power distribution is concentrated on the large retail chains (LRC), leaving farmers with little or no decision making power (Assefa, Kuiper, & Meuwissen, 2011). This is one of the central issues for the future of the CAP from 2020 onwards (Azcárate & Terrile, 2015).To solve this problem a strategic and straightforward plan is needed at policy level (Erjavec, Lovec, Juvančič, Šumrada, & Rac, 2018).

There are many possible approaches to tackle this knowledge gap. One possible solution is raising awareness of the farmers' activity highlighting their economic impact in specific rural areas at the local level. The other option is sensitizing farmers towards sustainable innovation projects in those areas (López-García, Calvet-Mir, Di Masso, & Espluga, 2019). This MSc thesis focuses on the former approach by taking into account three innovative projects which could be an economic driver for mountain areas like Valtellina (Perlik & Membretti, 2018). The mountains are a physical constraint for the agricultural production, especially for the farm size and the field management practices. Mountain agriculture suffers from the above-stated issues in a more significative way, that is the reason why the CAP targets mountains areas with support-specific tools. Consequently, the factors that impact the economic sustainability of small-scale wineries in Valtellina the most were investigated.

Having insights about the economic impact of the three innovative projects, it could help small-scale wineries in Valtellina to make more objective choices when deciding to implement a project. The research objective is to determine the economic impact of three innovative projects in Valtellina wine sector especially focusing on the conversion to organic wine production in Valtellina, the implementation of a nursery for vine plants in Valtellina and the use of drones for spraying in terraced vineyards in Valtellina. Those three projects are selected because, to our knowledge, it is unclear whether they can have a positive economic impact on the Valtellina wine sector.

## 1.2 Research objective

**Main research question**

Can the adoption of innovative projects in Valtellina (North of Italy) wine sector be economically sustainable?

**Sub-questions**:

1. What is the economic benefit of organic production schemes when implemented in the small-scale wineries in Valtellina?
2. What is the economic benefit for a small-scale winery implementing a nursery of grafted vine plants in Valtellina?
3. What is the economic benefit of drones' spraying for the small-scale wineries in Valtellina?

## 1.3 Report Outline

After this brief introduction, the second chapter is about the research methodology design which entails a brief explanation of the three projects with the overarching theoretical framework. The third chapter is the literature review followed by research design, data collection and data analysis method. In the fourth chapter the results of three cost-benefit analysis (CBA) of the three projects are presented with the respective sensitivity analysis. It follows the discussion with limitations and the conclusion with suggestions for follow up research.

## 2 Research methodology design

### 2.1 Three innovative projects

In this study the economic impact of three innovative projects were analyzed: the conversion to organic wine production in Valtellina, the implementation of a nursery for vine plants in Valtellina and the use of drones for spraying in terraced vineyards in Valtellina. Those projects were selected together with Fondazione Fojanini, the local research agricultural institute in Valtellina.

The first project is about the conversion to organic production of small-scale wineries in Valtellina. Currently, 12 small-scale wineries in Valtellina are converting to organic production. Those companies were selected for the data collection since they are the only ones that to our knowledge have switched or are switching from conventional to organic production in Valtellina. The fact that customers led by environmental consciousness and curiosity are more willing to pay a higher price for labelled organic wine (D'Amico, Di Vita, & Monaco, 2016), may incentivize organic wine production in Valtellina.

The second project under investigation is the implementation of a nursery for grafted vine plants to satisfy the internal demand of Valtellina's wineries. The vine plants grafting has been existing in Valtellina since 1950. Despite the increased request from the market of certified-quality vine plants, Valtellina producers could not provide their grafted vines with that certification. Therefore, the vine plants were bought from the major grafted vines' producers in Rauscedo (Friuli Venezia Giulia region, Northern East Italy). Currently, the viticulture in Valtellina is growing and the quality of grafted vine plants influences the performance of farm investments (Borsellino, Galati, & Schimmenti, 2012). By outsourcing the production of grafted vine plants, there is the risk of introducing new vine plant diseases to Valtellina like the "Flavescence Dorée" which is present in France and Italy (Martini et al., 2002). Currently, in Valtellina, there is only one vine plants' producer who was interviewed, and he produces 15,000 grafted vine plants yearly.

The third project investigates the use of drones for spraying Valtellina's terraced vineyards. Due to the nature of the landscape and the increased average age of vineyards' owners in Valtellina, the spraying activity is a critical issue for managing the vineyards.

The underlying theory adopted for the theoretical framework, the data collection and analysis is agricultural production economics (Archibald & Debertin, 1987). Agricultural production economics theory is related to the production of crops and livestock. In production economics, the economic goal for a farmer is given by the difference of the sales revenues and the production costs.

Depending on the objective of the farmer the goal can change accordingly, so profit maximization can be one of the goals (Archibald & Debertin, 1987). Environmental sensitive farmers could consider as a goal to adopt innovations in their farms to efficiently use the resource or to implement a certification production scheme.

The choices of outputs to be produced and the allocation of the farm resources are of concern from an agricultural production economics point of view (Archibald & Debertin, 1987). The decision about producing on farm grafted vine plants depends on how much economic impact have the set-up of a nursery of vine plants.

The choice of setting up a nursery is also affected by uncertainty on the market price when the vine plants is ready to be sold. The uncertainty about the price and the climate and the production yields are considered in the agricultural production economics (Archibald & Debertin, 1987). The use of drone spraying in agriculture presents uncertainties the legislation, and the useful life of the drone

itself is still uncertain. Those are crucial information for a farmer, when deciding to allocate resources for the drone purchase. The agricultural production economics applies decision tools like present value of the cost and the revenues: a project can be adopted if the present value of revenues exceed its costs. Therefore, this theory is useful when making decision for project appraisal.

## 2.2 Materials and Methods

The first step of the data collection was the literature review. For the literature review were consulted 70 papers which were collected in the reference manager Mendeley. A literature review was performed to have more insights about the economic impact of the three innovative projects. The database used for the search are: Web of Science, Scopus, CAB Abstract, Google Scholar, WUR edepot to look for MSc thesis of fellow students and comparable studies, Wur Library Search. The key words used for the literature review are: "organic wine" AND "advantages" OR " disadvantages" OR "cost benefit analysis" OR "biodiversity"; "organic and conventional viticulture comparison"; "grafted vine plants" AND "nursery" OR "advantages" OR "disadvantages" OR "greenhouse" OR "experimental field"; "drone spraying" AND "terraced vineyards" OR "legislation" OR "field experiment".

Afterwards, three questionnaires (one for every project) were structured and summarized in excel tables, those were used during the interviews with: 16 small-scale wineries in Valtellina, 2 drones spraying companies and 1 nursery for vine-plants.

To check the correctness of the data collected through the questionnaires, mails exchanges and phone calls were done with wine experts. In order to get more detailed data, also other data sources were used such as specialized book (Bongiolatti, 2018) and archival records (Consorzio Tutela Vini di Valtellina, n.d.). Invoices of vine plants sold in Valtellina were collected over a range of the last ten years. All these data were collected in three binders (one binder for each project).

Finally, an excel file for all the three projects was created to organize the quantitative production data ready for the data analysis. The binders and the excel file are available for later access.

### 2.2.1 Insights about the organic conversion of the small- scale wineries in Valtellina: the closed ended questionnaire, the winery criterial selection winery size, the descriptive statistics

To collect the production cost data of the conventional and organic wineries a structured closed ended questionnaire was elaborated (see Appendix 1). The questions which was submitted to the small-scale wineries, were on the production costs of labor, capital, machinery and materials. More specifically were collected data about the inputs and outputs prices and quantities for producing conventional and organic wine. The questions of the closed-ended questionnaire were the same across all the interviewed wineries. Then the questionnaire was summarized in an Excel table which was filled in during the face-to-face meeting with the small-scale wineries' managers in Valtellina.

At this stage it was important which criteria to use to classify the wineries. There are different ways to measure the winery size: hectoliters of wine produced, average yearly bottles production, average yearly sales revenues, hectares of vineyards, number of employees (Cyr, Kushner, & Ogwang, 2012). The most suitable measure of the size for our study is hectares of vineyards (Lanfranchi, Pascale, & Giannetto, 2018) and number of employees. This is due to the fact that hectoliters of wine can also be purchased, and the annual sales of wine bottle was not suitable for the interviewed wineries since one of the interviewed wineries does not bottle. There are some cases in which the size range is

arbitrarily chosen as motioned by Nelson A. Barber (Barber, Donovan, & Dodd, 2008). As Lanfranchi (Lanfranchi et al., 2018) classified the small-scale wineries as the one having less than 15 ha of land. Therefore, our classification for the small-scale wineries is being of comparable size (less than 13 employees and less than 15 ha of vineyards) and being located in the Valtellina wine area.

In order to compare the production costs of organic with conventional also four conventional wineries were interviewed. Therefore, twelve small-scale organic wineries and four conventional small-scale wineries were selected and all of them accepted to be interviewed. The wineries are small-scale since they manage an average of 4.6 ha of vineyards, they have on average 3 employees, an average age of the workforce of 50 years. The average year of foundation of these companies is 1981 and the average starting year for the conversion to organic is 2012. The descriptive statistics of the conventional and organic wineries are presented in Table 1. and Table 2 respectively.

**Table 1**. *Descriptive statistics of the interviewed organic wineries in Valtellina*

| | |
|---|---|
| Average year of foundation of the winery (year) | 1987 |
| Average beginning year of the conversion (year) | 2012 |
| Average age of the workforce (year) | 48 |
| Average hectares of vineyards (ha) | 3.5 |
| Average number of employees | 3 |
| Average number of the head of the company | 1 |
| Average annual sales (euro/ha) | |
| Average annual soil management cost (euro/year) | 4,084 |
| Average annual cost for the workforce for spraying treatments (euro/year) | 5,298 |
| Average yearly number of spraying treatments (euro/year) | 10.2 |
| Average certification costs (euro/year) | 974 |

**Table 2.** *Descriptive statistics of the interviewed conventional wineries in Valtellina*

| | |
|---|---|
| Average year of foundation of the winery (year) | 1975 |
| Average age of the workforce (year) | 53 |
| Average hectares of vineyards (ha) | 5.7 |
| Average number of employees | 3 |
| Average number of the head of the company | 1 |
| Average annual sales (euro/ha) | |
| Average annual soil management cost (euro/year) | 6,192 |
| Average annual cost for the workforce for spraying treatments (euro/year) | 15,652 |
| Average yearly number of spraying treatments | 9.5 |

### 2.2.2 Insights about the nursery of grafted vine plants in Valtellina: the nursery selection criteria, the structured questionnaire and data sources

The nursery for vine plants was selected according to this parameter: producing grafted vine plants in Valtellina. One nursery was contacted. The nursery could freely choose to take part or not in the data collection. Only the contacted nursery for vine plants was interviewed since it was not possible to find a nursery of comparable (to the interviewed nursery) size in Valtellina. The interviewed nursery resulted to have a production of 15,000 grafted vine plants. The size of the nursery is classified depending on the number of grafted vine plants produced yearly. Depending on the nursery size the production costs can vary. It is expected that a small nursery with an average of 15,000

grafted vine produced per year has higher production costs than a nursery of 150,000 grafted vine plants. Therefore, it wouldn't have been meaningful to collect production costs from bigger size nurseries outside Valtellina.

A structured closed-ended questionnaire was elaborated (see Appendix 2) and it was summarized in an Excel table which included a list of voices related to the production costs and revenues. The excel table was presented to the manager of the nursery of grafted vine plants in Valtellina during a face-to-face meeting.

The experts of the Fojanini Foundation (the local research institute for Agriculture in Valtellina) and the farm cooperatives in Valtellina were contacted to get information about the total demand for grafted vine plants in Valtellina in the last 10 years. Secondary data were retrieved from the databases of the nurseries of vine plants in the North of Italy (which sell the grafted vine plants in Valtellina). Invoices of prices and quantities of grafted vine plants purchased (from nurseries outside region) were collected from farm cooperatives in Valtellina.

### 2.2.3 Insights about the data sources, the drone company criteria selection and closed ended questionnaire for the use of drone spraying in terraced vineyards in Valtellina

The experts from Fojanini Foundation were contacted to get information about the field experiment of the flight of drone for spraying held in terraced vineyards in Valtellina in 2017. The drone spraying company was selected according to those characteristics: having experimented drones spraying in terraced vineyards. Two drones spraying companies were contacted and to one it was requested to fill in the questionnaire via mail. That drone company was available for that and so we used the data collected to run the CBA. With the other drone company, we had only phone calls since we wanted to have confirmations on the data collected through the questionnaire.

The structured close ended questionnaire (see Appendix 3) was summarized in an Excel table which included a list of voices related to the purchase maintenance insurance costs and technical details of the drone for spraying. The company that experimented the drone spraying in the vineyards in Valtellina was contacted. The drone spraying company selected and interviewed is the only one in Italy, as far as it is known, that experimented drones spraying in terraced vineyards. The excel table was filled in by the manager of the drones spraying company, we received his reply by mail.

### 2.2.4 Data analysis

In this section, a general presentation of the data analysis procedure and the formulas used for the three innovative projects are presented. The data analysis method which is chosen for the three projects is the cost benefit analysis. As defined by the guide for the cost benefit analysis of the EC (European Commission, 2014) , the cost-benefit analysis (CBA) is an analytical tool that helps to make decision about an investment by assessing its costs and benefits. Applying this definition to our research, the CBA was used to evaluate the economic effect of investing in each of the three projects. A common structure was used for the excel data collection tables. The revenues and the cost are presented in the following sections: the cost of labor, machineries, material and analysis, capital. The program that was used to run the cost-benefit analysis (CBA) for the three projects is Excel. Moreover, the depreciation of machineries, building, equipment is disregarded since it doesn't correspond to actual inflows or outflows. This is valid except for the case of the drone purchase from a farm cooperative since the investment cost in the drone purchase entails an opportunity cost. The environmental costs of an investment (European Commission, 2014) are expected to be included in a CBA but this was over the scope of this research. Therefore, the environmental effects were identified in qualitative terms and presented in the discussion section.

The formula for analysis were the same for the three projects and the following:

$$NPV = PV(B) - PV(C)$$

PV(B)= Sum of the present Value of Benefits
PV(C)= Sum of the present Value of Costs

$$PV(B) = \sum_{t=0}^{n} \frac{B_t}{(1+r)^t}$$

$$PV(C) = \sum_{t=0}^{n} \frac{C_t}{(1+r)^t}$$

t = discount period
$C_t$ = Undiscounted Costs
$B_t$ = Undiscounted Benefit
r = discount rate

The discount rate for all the three innovative projects that was used for the projects is 5% since it is a standard value for projects in agricultural sector.

To determine the return of the investment over time. The cost benefit ratio (CBR) was calculated for each year and for sum of the years with the following formula:

$$CBR = \frac{PV\ (B)}{PV\ (C)}$$

The last ratio was be calculated for the CBA is the Internal Rate of Return (IRR), which is the discount rate that makes the NPV=0 The formula for the IRR is the following:

$$\sum_{t=0}^{n} \frac{B_t}{(1+IRR)^t} - \sum_{t=0}^{n} \frac{C_t}{(1+IRR)^t} = 0$$

The general rule followed for the sensitivity analysis in each of the three projects is based on the identification of the variables which impact most the project's economic performance. One variable at a time was varied and the effect of that change on the NPV was calculated.

The decision rules are the following:
If the NPV>0, the project is economically sustainable and the higher the NPV is, the better it is.
If CBR > 1 and the NPV>1 the project is economically viable. If there is a comparison between multiple projects the one having the highest CBR is the preferred one.
If the IRR is lower than the prefixed return rate set by the investor, then the project is not economically interesting since it doesn't give a good return for the investor. The comparability of the project is possible by looking at the NPV, the CBR and IRR together. The project having the highest NPV, the CBR greater than 1, and the IRR greater than the prefixed return rate established by the investor, will be the most economically sustainable.

**Table 3.** *Overview of the variables used in the cost benefit analysis of the three innovative projects*

| Innovative project | Variables used in the CBA | Data Source | Data collection methods |
|---|---|---|---|
| *The organic conversion of small-scale wineries in Valtellina* | - Cost of Labor (euro/year) | n. 16 interviewed small-scale wineries in Valtellina | Closed ended questions one wineries visit and specialized book (Bongiolatti, 2018) at page 74 |
| | - Cost of machineries (euro/year) | n. 16 interviewed small-scale wineries in Valtellina | Closed ended questions and wineries visit |
| | - Cost of capital (euro/year) | n. 16 interviewed small-scale wineries in Valtellina | Closed ended questions and winery visit |
| | - Cost of materials and analysis (euro/year) | Fojanini Foundation Local (Valtellina) Research Institute for Agriculture<br>n. 16 interviewed small-scale wineries in Valtellina | Closed ended questions and wineries visit |
| | - Sales revenues from wine bottles and wine grapes (euro/year) | n. 16 interviewed small-scale wineries in Valtellina | Closed ended questions and wineries visit |

| Innovative project | Variables used in the CBA | Data Source | Data collection Methods |
|---|---|---|---|
| *The implementation of a nursery for vine plants* | - Cost of Labour (euro/year) | n.1 interviewed local (Valtellina) nursery for grafted vine plants | Closed ended questions and winery visit |
| | - Cost of machineries (euro/year) | n.1 interviewed local (Valtellina) nursery of grafted vine plants | Closed ended questions and winery visit |
| | Cost of Capital (euro/year) | n.1 interviewed local (Valtellina) nursery of grafted vine plants | Closed ended questions and winery visit |
| | - Cost of materials (euro/year) | n.1 interviewed local (Valtellina) nursery of grafted vine plants | Closed ended questions and winery visit |
| | - Revenues from the selling of 1st and 2nd choice rootstock (euro/year) | n.1 interviewed local (Valtellina) nursery of grafted vine plants | Closed ended questions and winery visit |
| | - Annual total demand and average selling price for Nebbiolo and all the other varieties of grafted vine plants | • Fojanini Foundation ( Valtellina local research institute for Agriculture);<br>• Nurseries of grafted vine plants: “Giuliani Bruno s.n.c”, "Rauscedo", "Vivai cooperativi Padergnone", “Tutzer", | Email exchanges and phone calls and Agri-cooperatives’ visits in Valtellina |

| | | | |
|---|---|---|---|
| | | "Vivai Sommadossi", "Vivai Giumelli";<br>• Local Farm cooperative of Albosaggia-Caiolo-Faedo Berbenno-Montagna; | |
| | - Investment duration | n.1 interviewed local (Valtellina) nursery of grafted vine plants | Closed ended questions |

| Innovative project | Variables used in the CBA | Data Source | Data collection methods |
|---|---|---|---|
| *The drone spraying of terraced vineyards* | - Marginal costs for the workforce for drone spraying (euro/hour) | Aerialclick drone company | n. 2 phone calls |
| | - Number of hours for the drone flight planification | Aermatica 3D drone company | Closed ended questions |
| | - Number of workforces need for planification and drone flight | Aermatica 3D and Aerialclick drone companies | Closed ended questions and n.2 phone calls |
| | - Velocity of the drone spraying (ha/hour) | Aermatica 3D drone company and Fojanini Foundation | Closed ended questions and email exchange |
| | Total hectares to be treated with drones (ha) | n. 16 interviewed small-scale wineries in Valtellina | Closed ended questions |
| | - Average number of spraying treatments per year | n. 16 interviewed small-scale wineries in Valtellina | Closed ended questions |
| | - Number of people for phytosanitary treatment with drone | Aermatica 3D and Aerialclick drone companies | Closed ended questions and n.2 phone calls |
| | - Number of people for programming | Aermatica 3D and Aerialclick drone companies | Closed ended questions and n.2 phone calls |
| | - Number of times of programming in a year | Aermatica 3D drone company | Closed ended questions |
| | - Cost for the Labour (euro/year) | Aermatica 3D and Aerialclick drone companies | Closed ended questions and n.2 phone calls |
| | - Cost for the drone and traditional spraying machineries and materials | Aermatica 3D drone company<br>n. 16 interviewed small-scale wineries in Valtellina | Closed ended questions |
| | - Average lease price for agricultural machineries (euro/day) | Farm cooperative Albosaggia-Montagna (Valtellina) | On site visit |
| | - Average lease price for drones (euro/ha) | Aerialclick drone company | n.2 phone calls |
| | - Savings for the cost of the phytosanitary licence using a drone compared to traditional spraying (euro/year) | Aermatica 3D drone company and n.16 interviewed small-scale wineries in Valtellina | Closed ended questions |

| | | | |
|---|---|---|---|
| | - Savings in the costs of gasoil using a drone compared to traditional spraying (euro/year) | Aermatica 3D drone company and n.16 interviewed small-case wineries in Valtellina | Closed ended questions |
| | - Savings in the purchase cost of traditional spraying machineries compared to a drone purchase | Aermatica 3D drone company and n.16 interviewed small-scale wineries in Valtellina | Closed ended questions |
| | - Savings in the yearly maintenance costs for traditional spaying machineries compared to drone maintenance (euro/year) | Aermatica 3D drone company and n.16 interviewed small-scale wineries in Valtellina | Closed ended questions |
| | - Savings in the insurance costs for traditional machineries spraying compare to drone's insurance (euro/year) | Aermatica 3D drone company and n.16 interviewed small-scale wineries in Valtellina | Closed ended questions |
| | - Savings in insurance costs for the use of machineries for spraying compared to drone (civil responsibility) (euro/year) | Aermatica 3D drone company and n.16 interviewed small-scale wineries in Valtellina | Closed ended questions |
| | - Useful life of a drone (years) | Aermatica 3D & Aerialclick drone company | Closed ended questions and phone call |

Note. CBA=Cost Benefit Analysis

#### 2.2.4.1 Data analysis for the organic conversion of the small- scale wineries in Valtellina

The data for the comparison of organic and conventional production were categorized with alphanumeric codes in the following way to structure the data analysis and assure the privacy of the interviewed wineries:

- Unit 1 which includes the organic small-scale wineries in Valtellina which bottle their wine: W1, W2, W3, W4, W5, W6, W7, W8, W9, W10, W11, W12
- Unit 2 consisting of conventional small-scale wineries in Valtellina which bottle their wine: W13, W14, W15
- Unit 3 consisting of one conventional small-scale winery in Valtellina which doesn't bottle its wine: W16

The benefits include the revenues from the selling of wine bottles and wine grapes and the organic subsidy (if applicable). The costs include the production cost related to workforce, machineries, and material and analysis, capital both for organic and conventional production. Using the classification of the small-scale wineries (mentioned in the data collection Table 1 and Table 2) an average of the total revenues and total costs of all the organic and conventional wineries was made for the cost benefit analysis.

The net cash flow which is given by the total inflows (total revenues) and total outflows (see Table 3. for the variables involved) was calculated for every small-scale winery.

The time period selected for this case is 5 years. The first 3 years lasts the transition period from the conventional to the organic in which the winery is implementing the organic certification scheme, but still earning as conventional production. Only from the 4th year onwards the winery has revenues as organic. For the organic conversion the time span of 5 years is essential to evaluate the economic return. Of course, the first three years of the conversion are the one having the CBR lower than one therefore having a negative difference between the annual PV(B) and PV(C). The investment costs for the organic is the certification costs for a winery in Valtellina is 924 euro/year on average.

The discounted cash flow (DCF) of the benefits and costs of producing organic and conventional wine was used with a 5% discount rate. From the CBA were determined the Net Present Value (NPV), the CBR and the IRR for the adoption of the organic wine production.

The IRR normalized was calculated, by varying the discount rate until the NPV went to zero, through a financial formula (TIR.COST) present in Excel. The variables included in the matrix for the calculations of the IRR were the initial investment and the normalized net cash flow over five years. The initial investment for the conversion to organic production was the yearly average cost of the organic certification.
Two sensitivity analysis were performed on the interest rate in particular with a 2% and 10% interest rate. The 2% interest rate was chosen since the return over the first 5 years of organic conversion are expected to be lower compared to a longer time span like ten years. While the 10% discount rate was chosen since it reflects the increased risk in organic production for yield losses and change in soil management practices over 5 years.

#### 2.2.4.2 Data analysis for the implementation of a nursery of grafted vine plants in Valtellina

The benefits included the revenues derived from the sale of grafted vine plants and the savings in annual transport costs as if the grafted wine plants which are currently outsourced, were produced in Valtellina. The total revenues resulted from the sale of the grafted vine plants. The costs included the cost of labor, machineries, equipment, capital to produce the grafted vine plants.

The discounted cash flow (DCF) of the benefits and costs of implementing a nursery for vine plants was calculated with a 5% discount rate. The time period of 10 years is arbitrarily chosen since the production of grafted vine plants is not time dependent: a production cycle of grafted vine plants lasts one year.

The distinction between varieties is made since the Nebbiolo variety is the traditional variety planted in the vineyards Valtellina. The CBA allowed to calculate the Net Present Value (NPV) of the implementation of the nursery for vine plants differentiated by the varieties: Nebbiolo, other varieties (excluded Nebbiolo), all the varieties (included Nebbiolo).

Three IRR were calculated following the division of the varieties of grafted vine plants (only Nebbiolo, all the other varieties except Nebbiolo, all the varieties) were calculated. This was done by substitution of the 5% interest rate until the NPV gets to zero using a financial formula provided by Excel. The IRR for only Nebbiolo grafted vine plants was calculated as the matrix of the negative average annual investment costs over 10 years only for Nebbiolo grafted vine plants and the net cash flow only for Nebbiolo grafted vine plants. The average annual investment costs included all the costs sustained for producing only Nebbiolo grafted vine plants.
The IRR for all the other varieties except Nebbiolo grafted vine plants was calculated as the matrix of the negative average annual investment costs over 10 years only for all the other varieties of grafted vine plants (except Nebbiolo) and the net cash flow for all the other varieties of grafted vine plants.

The average annual investment costs included all the costs sustained for producing all the other varieties of grafted vine plants except Nebbiolo.
The IRR for all the varieties included Nebbiolo grafted vine plants was calculated as the matrix of the negative average annual investment costs over 10 years only for all the other varieties of grafted vine plants and the net cash flow for all the varieties of grafted vine plants. The average annual investment costs included all the costs sustained for producing all the varieties of grafted vine plants included Nebbiolo.

The sensitivity analysis was calculated on the (last 10 years market) average selling price of Nebbiolo (1.26 euro/ plant) and all the other varieties except Nebbiolo grafted vine plants (1.50 euro/plant) and the average of all the varieties of grafted vine plants which is 1.38 euro/plant.

#### 2.2.4.3 Data analysis for the drone spraying in terraced vineyards in Valtellina

The adoption of drones spraying in terraced vineyards was done through two CBA. One CBA was from the point of view a farm cooperative that leases one drone for spraying vineyards to a single winery (together with 2 specialized workers). The other CBA is from the point of view of a single winery which rents, from the farm cooperative, the drone for spraying 65.3 ha of vineyards. The 65.3 ha is the sum of the hectares of vineyards of the interviewed wineries.
The discounted cash flow is calculated with a 5% discount rate over a range of 15 year.

The IRR was calculated as a matrix of the total initial investment and the net cash flow over 15 years. The total initial investment is the sum of the annual costs for the workforce for phytosanitary treatments with the drone, the purchase of the drone, the yearly maintenance and insurance costs for one drone, the insurance for civil responsibility of the drone use and the annual cost for the license for drone spraying. The IRR from the point of a small-scale winery in Valtellina which rents a drone for spraying 65.3 ha of vineyards is calculated with the financial formula of excel using the total initial investment and the net cash flow over 15 years. The total initial investment is calculated as the sum of the annual cost for the annual cost for the workforce for phytosanitary treatments, the average annual cost of phytosanitary products and the annual cost for the drone lease.

As last step of the CBA two sensitivity analysis were made. One sensitivity analysis was done from the point of view of the farm cooperative which buys and leases for 50 euro/ha the drone for spraying to a winery in Valtellina. The other sensitivity analysis was done from the point of view of the winery which rents the drones for 50 euro/ha to spray 65.3 ha of vineyards.

# 3 Literature review: Advantages and disadvantages of the three innovative projects in the wine sector

In order to answers to the research question about the economic sustainability of three innovative projects in the wine sector in Valtellina a literature review was done. The advantage and disadvantage of producing organic wines production, implementing a nursery for grafted vine plants and adopting drones spraying in terraced vineyards were investigated. The main advantages and disadvantages were monetized and included in the CBA of the three projects. The literature review could partly answer the specific research questions that is why the following step was the CBA. In the following three sections are discussed the advantages and disadvantages of the three innovative projects in the wine sector.

## 3.1 Advantages and disadvantages of adopting organic certification schemes in wine production

The organic certification of agricultural products is a tool that could contribute to reduce environmental impact and increase farmers' and consumers' well-being. However, the decision to invest in certification should be based on economic and market fundamentals (Michiel & Yuca, 2014). According to Novaes Zilber et al., the organic production can be applied successfully when there are specific conditions as low labor costs and great availability of land that was not previously intensively cultivated with conventional systems. Indeed, many authors are pointing out that the organic production is more labor intensive than conventional production (Novaes Zilber, Friel, & Felipe Machado do Nascimento, 2010), (Dainelli, Francesco ; Daddi, 2018), (Wheeler & Crisp, 2011). A potential incentive to switch to organic production is that at consumer level there is higher willingness to pay for organic labelled products (Novaes Zilber et al., 2010)**.** Despite the higher initial investments costs related to the transition period from conventional to organic (Dainelli, Francesco ; Daddi, 2018)**,** the financial performance of wine companies which choose green strategy are promising in terms growth, solvency, profitability.

One disadvantage of the organic wine production is the one of reduced yields compared to the conventional production (Dabbert & Oberhofer, 1990), (Wheeler & Crisp, 2011). While other authors suggest that the biodiversity and soil management practices are important for the balanced growth and productivity of organic wine grapes (Provost & Pedneault, 2016). Merot & Wery (2017) mention that the conversion process from conventional to organic entails an increase in the complexity of the vineyard structure and management (Merot & Wery, 2017). However, the lower yields in organic production are compensated by the quality increase of the grapevines according to the German national law (Dabbert & Oberhofer, 1990). While other studies about organic viticulture presented some higher-quality production, although this is far from being conclusive for the available data (Wheeler & Crisp, 2011). Instead, it was found that organic management practices may result in higher soil fauna feeding activity (Reinecke, Albertus, Reinecke, & Larink, 2008).

In conclusion, for the economic analysis it is taken into account the higher costs for the workforce due the increased amount of labor for the soil management and wine grapes selection and the reduced wine grapes' yields. The economic benefit of organic wine production is that the wine grapes price (euro/kg) and the bottle price are expected to be higher compared to conventional production.

**Table 4.** *Advantages and disadvantages of the conversion from conventional to organic wine production*

| References on organic wine production | Advantages of adopting organic wine production | Disadvantages of adopting organic wine production |
|---|---|---|
| (Novaes Zilber et al., 2010) | Possible source of competitive advantage from a resource-based view<br>Reduced dependence on chemical and reduced soil depletion<br>Increased consumption of organic products<br>Higher willingness to pay for organic products from consumers<br>Higher prices for organic wines | Labor intensive the organic growing of grapes<br>Three-year transition period<br>Certifications costs and time-consuming auditing process<br>Higher production costs |
| (Dainelli, Francesco ; Daddi, 2018) | Higher market visibility<br>Strategy for quality diversification<br>Growing market appreciation for organic wines<br>Increased added value paid off by the customer<br>Costs savings on herbicide and fertilizers<br>Higher profitability<br>Higher solvency<br>Higher growth<br>Higher environmental sustainability | Higher start-up costs<br>Higher cost of labor<br>Lower volume of wine produced |
| (Provost & Pedneault, 2016) | | Copper accumulation in the soil |
| (Dabbert & Oberhofer, 1990) | Higher quality standards for the organic according to the German wine law | Lower yields |
| (Merot & Wery, 2017) | | Increased labor requirements<br>Increased complexity of vineyard structure and management |
| (Wheeler & Crisp, 2011) | | Lower yields<br>Higher labor costs |
| (Reinecke et al., 2008) | Organic management practices have a favorable influence on the soil biological activity | |

### 3.2 Advantages and disadvantages of implementing a nursery for grafted vine plants

The nursery of vine plants is a topic not deeply investigated in the literature, especially when it comes to the decision of outsourcing the production of vine plants. What is known from the literature is that the implementation of a nursery for vine plants can present opportunities and threads.

The major advantages of a local production of vine plants is that it can be based on customers' orders and it is less influenced by market trend forecasts. The Italian viticulture is characterized by native varieties of vine plants (Boselli, Tempesta, & Fiorilo, 2014). Those native varieties are more suitable for specific micro-climate since their genetic characters have adapted to the specific pedoclimatic conditions. Grafted vine plants certified organic can be a market opportunity for the nurseries. Indeed, in Valtellina the organic wine producers have to ask for a special permission to plant small-vine plants

which are not produced according to the organic production scheme. In this sense, there is research going on about the use of eco-friendlier substrates to grow plants in nurseries also according to the organic production principle of reduced use of chemical, fertilizers and pesticides (Pascual et al., 2018).

Even if the wine industry requires high quality planting materials, the market for vine plants wants the price of grafted vine plants to be low (Waite, Whitelaw-Weckert, & Torley, 2015)**.** In order to have high quality materials in a nursery, high investments costs (Zamanidis, Paschalidis, Maltabar, & Vasiliadis, 2013) and professionalized workforce are needed. A standardized guide on the Good Manufacturing Practices (GMP) for nurseries of vine plants is currently missing at EU level. This could be crucial from a safety perspective since at nursery level there is higher risk of grapevine trunk disease (GTD) contamination (Pintos, Redondo, Costas, Aguìn, & Mansilla, 2018) (Gramaje & Di Marco, 2015).

To conclude it is fundamental to invest in good quality grafted vine plants from the winery point of view since this will affect the life span of the vineyards itself and the quality of wine grapes. The economic benefit for a local nursery of vine plants is that the grafted vine plants get accustomed, already at the rooting stage, to the local microclimate conditions. Therefore, the young vine plant will adapt quicker when planted in the vineyards with a reduced risk of dry out. Of course, the investments for the implementation of the nursery in terms of machineries, equipment and infrastructure can be costly. However, this will be paid off by having control of the whole production cycle from the vine plant to the wine bottle.

**Table 5.** *Advantages and disadvantages of implementing a nursery for grafted vine plants*

| References on nursery for grafted plants | Advantages of a nursery for grafted vine plants mentioned in the literature | Disadvantages of a nursery for grafted vine plants mentioned in the literature |
|---|---|---|
| (Boselli et al., 2014) | Varieties can be planted on customers demand not on forecast<br>Italian viticulture stands on native varieties | Forecasts on wine grapes variety demand trends are not present on official channels.<br>The official databases are outdated |
| (Pisciotta, Fazio, Barbagallo, & Di Lorenzo, 2016) | Accurate plant material selection<br>Accurate vine plants replacement close to vineyard establishment | |
| (Pintos et al., 2018) | | Grapevines trunk diseases (GTD) are a significant threat for nursery plants |
| (Lewis, Kubota, Tronstad, & Son, 2014) | | The implementation of a nursery can have substantial capital investment in a risky endeavor |
| (Pascual et al., 2018) | The use of organic substrate for transplant production in organic nurseries can be beneficial for the plant and can comply with the reduced use of chemicals and fertilizers required by organic production | |
| (Waite et al., 2015) | The wine industry demands a higher quality for the planting material | The wine industry requires low price for the planting material |
| (Gramaje & Di Marco, 2015) | The propagation practices have an impact on the quality of the propagation material | The infection by GTD pathogens occurs during the grafting processes in nurseries |
| (Zamanidis et al., 2013) | The production of cuttings in heated greenhouses allows early production of grafted cuttings, reduces the need for land and water, and increases the output of cuttings up to 80% | |

### 3.3 Advantages and disadvantages of adopting drones spraying in vineyards

The literature review about drones spraying is mainly related to field experiments. Drones spraying in agriculture presents some advantages and disadvantage from a technical and a regulation point of view.
The main benefits in the use of drones for spraying is that they can cover difficult to reach areas and they can be remotely controlled (Hawkes, Farm, & Mar, 2017).

A disadvantage for the use of drones spraying is given by the restrictions in the regulation, which are country dependent. In the EU the use of aerial spraying is banned with some derogations for drones spraying of pesticides in difficult to reach areas, according to the Directive 2009/128/EC (Spackman, 2016) . While, in the USA, a remotely controlled helicopter for spraying pesticides has been approved by the Federal Aviation Administration (Gillespie, 2015). The pesticides to be used for drones spraying need to be approved by the drone manufacturer and by the Chemicals Regulation Directorate (CRD) and this can be a limitation since a few pesticides have been approved (Spackman, 2016).

Some technical issues related to the drones spraying are still to be solved, as concluded in the field simulation of drones spraying in steep terraced vineyards in Italy (Sarri et al., 2019). The drones spraying is bonded by safety issues: the optical sensors of the drones can be covered accidently by the spraying droplets and this could lead to accidental collision of the drone. This is caused by the misleaded height calculation by the drone's control system (Hawkes et al., 2017). Drones can be perceived as a danger for wildlife birds, it happened that drones were attacked by wild birds, like owls that is why drone could be a risk also for the wildlife (Gillespie, 2015) . Another technical issue is that the flight needs to be programmed according to the external weather conditions since the spraying performance of the drones can be affected (Kashkarov, Diordiiev, Sabo, & Novikov, 2018). On one hand, the actual technological limitations nowadays are expressed (Sarri et al., 2019) in the use of drones for spraying vineyards.

On the other hand there is increasing attention towards the Internet of Food & Farm 2020 (Hecker, 2019) which explores the potential of IoT-technologies for the European food and farming industry. Concluding, the economic benefit of drones spraying from the literature is given by the fact that drones can be used in difficult to reach areas by saving time, avoiding manual spraying. It needs to be considered that the drones spraying in the literature is not yet studied from an economic point of view but more from a technical one.

**Table 6.** *Advantages and disadvantages of adopting drones spraying in terraced vineyards*

| References on drones spraying | Advantages of drones spraying mentioned in the literature | Disadvantage of drones spraying mentioned in the literature |
|---|---|---|
| (Hawkes et al., 2017) | Drone spraying can be three times faster than traditional spraying | Ever-evolving regulation on the use of drones |
| | Drones can even cover the farm border and uneven geometries | Altitude sensing in a crop system can be challenging from a technical point of view |
| | Drones can be programmed to do the spraying without human intervention | The malfunction of the drone's sensors can lead to drone collision |
| (Gillespie, 2015) | The Federal Aviation Administration (FAA) approved the use of a remotely controlled helicopter for the spraying of pesticide in the USA | Drones are source of flying-wildlife disturbance |
| (Sarri et al., 2019) | Drones can be used for the spraying in granular forms for the biological control | The spraying performance needs to be improved |
| (Kashkarov et al., 2018) | Semi-autonomous drones can be used for the vineyards' spraying | Weather forecasts should be taken into account since they influence the effectiveness of the spraying |
| (Spackman, 2016) | Aerial spraying is not allowed in EU but regulation on pesticide spraying has some derogations | Use of the drones for spraying on remote or on difficult to access sites is allowed<br>A few pesticides are approved for drone spraying |

From the literature review about organic wine production, nursery for vine plants and drones spraying we conclude that organic wine production seems more promising from an economic point of view. For the nursery of vine plant, the economic estimates for the investment are projects specific, so no further generalization is possible. The drones spraying is not yet investigated in every aspect (economic, legislative) this because it is still an innovative niche market.

## 4. Results of the Cost Benefit Analysis

### 4.1 Results for the organic conversion of the small- scale wineries in Valtellina

The results of the Cost Benefit Analysis for the organic conversion of small-scale wineries in Valtellina are presented in Table 7. Looking at the NPV by ha of vineyards it can be noticed that it is quite high which means that the transition from conventional to organic production can generate in 5 years a wealth of 421,215 euro/ha. This positive results depends on the sum of the revenues (euro/ha). The sum of the revenues is given by the actual average bottle price of the interviewed conventional and organic wineries which is respectively 13 euro/bottle and 20 euro/bottle multiplied by the average yearly bottle production and divided by the ha of vineyards of each winery. The average yearly production costs, including labor, machineries and materials, for the interviewed conventional and organic wineries respectively is 89,760 euro/ha and 400,220 euro/ha. The difference in costs between organic and conventional is given by the higher costs for the soil management in organic wine production, the certification cost for organic which are in place form the first year of the conversion, and the increased number of spraying treatments ( on average 11 spraying treatments/year) in organic wine production compared to conventional wine production (on average 9 spraying treatments).

The "Year 0" represent an average (see Table 2. For the descriptive statistics of the interviewed conventional wineries) small-scale winery which produces conventional wine and bottles its wine has a net cash flow of 125,955 euro and a CBR greater than 1. This is economically better than the scenario for a winery (W16) in Valtellina which does conventional wine production without bottling its wine with a net cash flow of – 3,214 euro therefore this option in Valtellina is not economically viable. Indeed, when a winery in Valtellina produces conventional wine and bottles its wine then the CBR by ha of vineyards is 2.40. This means that the conventional wine production with bottling in Valtellina is an economic viable option. The total CBR given by the sum of the PV (B) divided the sum of the PV(C) is equal to 1.22 and this means that the conversion to organic wine production is an economic viable option over 5 years.

Looking at the first three years of the conversion to organic, the CBR by the ha of vineyards decreases by almost 5 times compared to the "Year 0" this is due to the fact that the cost for the workforce for soil management are higher since no herbicide can be used in the organic production. The average annual workforce costs for soil management in the conventional production are 4,084 euro (see Table 2.) while for organic is 6,192 euro (see Table 1.). Also the costs for the workforce treatments is higher due to the fact that the annual number of treatments increases it goes from an average of 9.5 in the conventional (see Table 1.) and it reaches 10.2 in the organic production (see Table 1.), plus there are the annual certification costs for the organic which are on average 974 euro (see Table 1.).

In the fourth and fifth year the CBR by hectares of vineyards is 2.24 and this is due to the annual sales revenues for organic wine by hectares of vineyards which are 896,858 euro/ha that includes the annual average organic subsidy which is 1,610 euro compared to the annual sales revenues from conventional production which is 215,715 euro/ha. The IRR over the 5 years is equal to 26% which is higher than the 5% (the prefixed return rate). So, this suggest that it is an economic rewarding investment for a small-scale winery.
The calculations presented in. Table 7. are considered as the base scenario the one which will be compared with the results of the sensitivity analysis in Table 8. Table 9.

**Table 7.** *Cost Benefit Results of the conversion to organic wine production of small-scale wineries in Valtellina*

| Year | Total revenues (euro/ha) | Total costs (euro/ha) | Net cash flow (euro/ha) | PV (B) (euro/ha) | PV (C) (euro/ha) | NPV (euro/ha) | Yearly CBR by ha of vineyards | Total CBR by ha of vineyards | IRR |
|---|---|---|---|---|---|---|---|---|---|
| 0 | 215,715 | 89,760 | 125,955 | 215,715 | 89,760 | 421,215 | 2.40 | 1.22 | 26% |
| 1 | 215,715 | 400,220 | -184,505 | 205,443 | 381,162 | | 0.54 | | |
| 2 | 215,715 | 400,220 | -184,505 | 195,660 | 363,012 | | 0.54 | | |
| 3 | 215,715 | 400,220 | -184,505 | 186,343 | 345,725 | | 0.54 | | |
| 4 | 896,858 | 400,220 | 496,637 | 737,847 | 329,262 | | 2.24 | | |
| 5 | 896,858 | 400,220 | 496,637 | 702,712 | 313,583 | | 2.24 | | |

Note. PV(B)= Present Value of Benefits. PV(C)=Present Value of Costs. CBR=Cost Benefit Ratio. IRR=Investment Rate of Return. NPV=Net Present Value.

The results from the sensitivity analysis with a 2% discount rate in Table 8. show that a decrease in the interest rate from 5% to 2% will lead to a negative change in the NPV of -81,285 euro over 5 years this means that having a 2% discount rate will lead to a higher NPV.
The CBR by ha of vineyard is slightly lower than the one of the 5% discount rate, but still greater than 1. The total CBR given by the sum of the PV (B) divided the sum of the PV(C) is equal to 1.22 and this means that the conversion to organic wine production is an economic viable option over 5 years.

The IRR is equal to the IRR of the base scenario of 5% discount rate this means that the discount rate does not affect the IRR and in a case of 2% interest rate it is still convenient for a winery to invest in organic production if the investor has a prefixed rate of return lower than 26%.

**Table 8.** *Cost benefit Analysis Results of the sensitivity analysis using a 2% discount rate of the conversion to organic wine production*

| Year | Total revenues (euro/ha) | Total costs (euro/ha) | Net cash flow (euro/ha) | PV (B) (euro/ha) | PV (C) (euro/ha) | NPV (euro/ha) | Yearly CBR by ha of vineyards | Total CBR by ha of vineyards | IRR |
|---|---|---|---|---|---|---|---|---|---|
| 0 | 215,715 | 89,760 | 125,955 | 215,715 | 89,760 | 502,500 | 2.40 | 1.25 | 26% |
| 1 | 215,715 | 400,221 | -184,505 | 211,485 | 392,373 | | 0.54 | | |
| 2 | 215,715 | 400,221 | -184,505 | 207,339 | 384,679 | | 0.54 | | |
| 3 | 215,715 | 400,221 | -184,505 | 203,273 | 377,136 | | 0.54 | | |
| 4 | 896,858 | 400,221 | 496,637 | 828,558 | 369,742 | | 2.24 | | |
| 5 | 896,858 | 400,221 | 496,637 | 812,312 | 362,492 | | 2.24 | | |

Note. PV(B)= Present Value of Benefits. PV(C)=Present Value of Costs. CBR=Cost Benefit Ratio. IRR=Investment Rate of Return. NPV=Net Present Value.

For the sensitivity analysis with 10% discount rate in Table 9. we can notice that the change from 5% to 10% discount result in a positive change of the NPV equals to 106,514 euro this means that the increased risk for the cost of capital leads to an increase in the wealth generated.
The CBR by ha of vineyard is still the same as the ones of the 5% discount rate. The total CBR given by the sum of the PV (B) divided the sum of the PV(C) is equal to 1.25 and this means that the conversion to organic wine production is an economic viable option over 5 years.

The IRR stay constant compared to the base scenario of 5% discount rate this means that the discount rate doesn't affect the IRR and in a case of 10% interest rate it is convenient for a winery to invest in

organic wine production if the investor has set its expected return rate at a value lower than 26%. The total CBR given by the sum of the PV (B) divided the sum of the PV(C) is equal to 1.19 and this means that the conversion to organic wine production is an economic viable option over 5 years.

**Table 9.** *Cost Benefit Analysis Results of the sensitivity analysis with 10% discount rate of the conversion to organic wine production*

| Year | Total revenues (euro/ha) | Total costs (euro/ha) | Net cash flow (euro/ha) | PV (B) (euro/ha) | PV (C) (euro/ha) | NPV (euro/ha) | Yearly CBR by ha of vineyards | Total CBR by ha of vineyards | IRR |
|---|---|---|---|---|---|---|---|---|---|
| 0 | 215,715 | 89,760 | 125,955 | 215,715 | 89,760 | 314,701 | 2.40 | 1.19 | 26% |
| 1 | 215,715 | 400,220 | -184,505 | 196,105 | 363,837 | | 0.53 | | |
| 2 | 215,715 | 400,220 | -184,505 | 178,277 | 330,760 | | 0.53 | | |
| 3 | 215,715 | 400,220 | -184,505 | 162,070 | 300,691 | | 0.53 | | |
| 4 | 896,858 | 400,220 | 496,637 | 612,566 | 273,356 | | 2.24 | | |
| 5 | 896,858 | 400,220 | 496,637 | 556,878 | 248,505 | | 2.24 | | |

Note. PV(B)= Present Value of Benefits. PV(C)=Present Value of Costs. CBR=Cost Benefit Ratio. IRR=Investment Rate of Return. NPV=Net Present Value.

Concluding, despite the initial investment the organic production for small-scale wineries in Valtellina is an economic viable option since the total CBR given by the sum of the PV ( B) divided the sum of the PV( C) is greater than 1 and this means that the conversion to organic wine production is an economic viable option over 5 years.

### 4.2 Results for the implementation of nursery of grafted vine plants in Valtellina

The local production of grafted vines was investigated to assess whether this could be a differentiated source of income for an average interviewed small-scale winery in Valtellina. The NPV for producing only Nebbiolo grafted vine plants over 10 years is 285,262 euro. This value is given by the difference between the sum of the PV (B) and the sum of PV (C) over 10 years. The yearly PV(B) is calculated as the discounted yearly revenues. The revenues is simulated over an actual average quantity demanded for Nebbiolo grafted vine plants outsourced yearly from grafted vine plants nurseries outside region. The previous quantity is multiplied by the selling price for Nebbiolo grafted vine plants (1.98 euro/plant) (suggested by the interviewed nursery in Valtellina). The yearly PV (C) is given by the marginal cost for producing a grafted vine plant of 1.62 euro/plant (calculated through data provided by the interviewed nursery in Valtellina), multiplied by the average annual demand for Nebbiolo grafted vine plants outsourced outside Valtellina. Therefore, it can be an economic viable investment for an average small-scale winery in Valtellina to produce in a nursery, grafted vine plants of Nebbiolo variety. The NPV over 10 years for all the other varieties (except Nebbiolo) is 10 times less the NPV of Nebbiolo grafted vine plants. On average, the outsourced demand for other varieties (except Nebbiolo) of grafted vine plants is 7,789 annually compared to the outsourced demand for Nebbiolo variety which is 100,786 plants annually. The NPV for producing all the varieties of grafted vine plants in Valtellina over 10 years is 307,148 euro.

The annual CBR and the total CBR over 6 years is 1.23 for all the varieties which means that the implementation of a nursery is an economic viable project independently from the varieties. However, we need to consider that to get to this result it has been used an equal (across the last 10 years) average marginal production cost which is 1.62 euro/plant and an equal (over the last 10 years) average selling price for the grafted vine plants of 1.98 euro/plant.

The IRR for all the varieties of grafted vine plants is 15%, which is higher than the prefixed return of 5%, so this means that investing in a nursery for only Nebbiolo grafted vine plants can be economically for a small-scale winery in Valtellina if the investors prefixed return rate is lower than 15%. The calculations presented in Table 10. Table 11 Table 12. are considered as the base scenario that can be compared with the results of the sensitivity analysis in Table 13. Table 14. and Table 15.

**Table 10.** *Cost Benefit Analysis Results of the implementation of a nursery for grafted vine plants in Valtellina only for Nebbiolo variety grafted vine plants*

| Year | Total revenues (euro) | Total costs (euro) | PV (B) (euro) | PV (C) (euro) | NPV (euro) | CBR | Total CBR | Annual total demand outsourced (plants) | IRR |
|---|---|---|---|---|---|---|---|---|---|
| 2009 | 147,205 | 120,166 | 147,205 | 120,166 | 285,262 | 1.23 | 1.23 | 74,403 | 15% |
| 2010 | 161,771 | 132,056 | 154,068 | 125,768 | | 1.23 | | 81,765 | |
| 2011 | 166,053 | 135,551 | 150,615 | 122,949 | | 1.23 | | 83,929 | |
| 2012 | 169,657 | 138,494 | 146,556 | 119,636 | | 1.23 | | 85,751 | |
| 2013 | 162,458 | 132,617 | 133,654 | 109,104 | | 1.23 | | 82,112 | |
| 2014 | 168,815 | 137,806 | 132,271 | 107,974 | | 1.23 | | 85,325 | |
| 2015 | 180,335 | 147,211 | 134,569 | 109,851 | | 1.23 | | 91,148 | |
| 2016 | 201,082 | 164,146 | 142,905 | 116,656 | | 1.23 | | 101,634 | |
| 2017 | 211,912 | 172,987 | 143,430 | 117,084 | | 1.23 | | 107,108 | |
| 2018 | 227,127 | 185,407 | 146,408 | 119,515 | | 1.23 | | 114,798 | |
| 2019 | 197,623 | 161,323 | 121,323 | 99,038 | | 1.23 | | 99,886 | |

Note. PV(B)= Present Value of Benefits. PV(C)=Present Value of Costs. CBR=Cost Benefit Ratio. IRR=Investment Rate of Return. NPV=Net Present Value.

**Table 11.** *Cost Benefit Analysis Results of the implementation of a nursery for grafted vine plants in Valtellina for all the other varieties of grafted vine plants (except Nebbiolo variety)*

| Year | Total revenues (euro) | Total Costs (euro) | PV(B) (euro) | PV(C) (euro) | NPV (euro) | CBR | Total CBR | Annual total demand outsourced (plants) | IRR |
|---|---|---|---|---|---|---|---|---|---|
| 2009 | 12,880 | 10,514 | 12,880 | 10,514 | 21,885 | 1.23 | 1.23 | 6,510 | 15% |
| 2010 | 10,598 | 8,651 | 10,094 | 8,239 | | 1.23 | | 5,357 | |
| 2011 | 10,743 | 8,769 | 9,744 | 7,954 | | 1.23 | | 5,430 | |
| 2012 | 9,797 | 7,997 | 8,463 | 6,908 | | 1.23 | | 4952 | |
| 2013 | 13,928 | 11,370 | 11,459 | 9,354 | | 1.23 | | 7,040 | |
| 2014 | 11,218 | 9,157 | 8,789 | 7,175 | | 1.23 | | 5,670 | |
| 2015 | 12,573 | 10,263 | 9,382 | 7,659 | | 1.23 | | 6,355 | |
| 2016 | 23,427 | 19,124 | 16,649 | 13,591 | | 1.23 | | 11,841 | |
| 2017 | 16,006 | 13,065 | 10,833 | 8,843 | | 1.23 | | 8,090 | |
| 2018 | 20,820 | 16,996 | 13,421 | 10,955 | | 1.23 | | 10,524 | |
| 2019 | 12,103 | 9,880 | 7,430 | 6,065 | | 1.23 | | 6,118 | |

Note. PV(B)= Present Value of Benefits. PV(C)=Present Value of Costs. CBR=Cost Benefit Ratio. IRR=Investment Rate of Return. NPV=Net Present Value

**Table 12.** *Cost Benefit analysis results of the implementation of a nursery for grafted vine plants in Valtellina for all the varieties of grafted vine plants (included Nebbiolo variety)*

| Year | Total revenues (euro) | Total costs (euro) | PV(B) (euro) | PV(C) (euro) | NPV (euro) | CBR | Total CBR | Annual total demand outsourced (plants) | IRR |
|---|---|---|---|---|---|---|---|---|---|
| 2009 | 160,085 | 130,680 | 160.085 | 130,680 | 307,148 | 1.23 | 1.23 | 80,913 | 15% |
| 2010 | 172,370 | 140,708 | 164,162 | 134,008 | | 1.23 | | 87,122 | |
| 2011 | 176,796 | 144,321 | 160,359 | 130,904 | | 1.23 | | 89,359 | |
| 2012 | 179,455 | 146,492 | 155,020 | 126,545 | | 1.23 | | 90,703 | |
| 2013 | 176,386 | 143,987 | 145,113 | 118,458 | | 1.23 | | 89,152 | |
| 2014 | 180,033 | 146,963 | 141,060 | 115,150 | | 1.23 | | 90,995 | |
| 2015 | 192,909 | 157,474 | 143,951 | 117,510 | | 1.23 | | 97,503 | |
| 2016 | 224,509 | 183,270 | 159,554 | 130,247 | | 1.23 | | 113,475 | |
| 2017 | 227,918 | 186,053 | 154,264 | 125,928 | | 1.23 | | 115,198 | |
| 2018 | 247,947 | 202,403 | 159,829 | 130,471 | | 1.23 | | 125,322 | |
| 2019 | 209,727 | 171,203 | 128,754 | 105,104 | | 1.23 | | 106,004 | |

Note. PV(B)= Present Value of Benefits. PV(C)=Present Value of Costs. CBR=Cost Benefit Ratio. IRR=Investment Rate of Return. NPV=Net Present Value.

The sensitivity analysis, using the average (over the last 10 years) market selling prices for Nebbiolo (1.26 euro/plant) and all other varieties of grafted vine plants (1.50 euro/plant), resulted in a negative NPV for all the varieties of grafted vine plants. This could be foreseen since the marginal production cost (1.62 euro/plant) for producing a grafted vine plant from the interviewed nursery in Valtellina is higher than the average last ten years market selling price (1.38 euro/ plant) for grafted vine plants from nurseries outside region. This means that in order to produce profitably the grafted vine plants in Valtellina the marginal cost should be lower than the average market selling price of grafted vine plants, this could be achieved maybe with higher degree of mechanization of the grafting process.
The interviewed nursery in Valtellina said it sells, to local wineries, its 1st quality grafted vine plants at 2 euro/ plant and the 2nd quality grafted vine plants are sold 1.70 euro/plant (10% VAT included). This means that wineries in Valtellina can pay a higher price for the local grafted vine plants compared to the Italian market price for grafted vine plants.
In the last 10 years, the market selling price for Nebbiolo grafted vine plants was around 0.90 euro/plant, but this was quantity purchased dependent. The price mechanism for grafted vine plants is complex several factors affects it: the demand for grafted vine plants, the supply of grafted vine plant varieties, the annual market trends for the different varieties, and the quantity dependent sales.

The annual CBR and the total CBR over 10 years for all the varieties ranges from 0.78 and 0.93 but it always lower than 1. The IRR for only Nebbiolo grafted vine plants is the same as the one of the base scenario while the IRR of all the other varieties of grafted vine plants is -5% since the demand for those varieties is small and the production costs are the same of the Nebbiolo variety.

The IRR of all the varieties is 14% this means that investing in a nursery of all the varieties of grafted vine plants can be interesting for a winery in Valtellina if the prefixed return for the investor s lower than 14%. But the preferred option will be the Only Nebbiolo Nursery since it has a higher IRR. The results are shown in Table 13. Table 14. Table 15. respectively for Nebbiolo variety, all the other varieties (except Nebbiolo) and the varieties of grafted vine plants (included Nebbiolo).

**Table 13.** *Cost benefit analysis results of the sensitivity analysis using the average (2009-2019) market selling price for Nebbiolo (1.26 euro/plant) for the implementation of a nursery in Valtellina for grafted vine plants only for Nebbiolo variety*

| Year | Total Revenues (euro) | Total costs (euro) | PV (B) (euro) | PV (C) (euro) | NPV (euro) | CBR | Total CBR | Annual total demand | IRR |
|---|---|---|---|---|---|---|---|---|---|
| 2009 | 93,793 | 120,166 | 93,793 | 120,166 | -278,230 | 0.78 | 0.78 | 74,403 | 15% |
| 2010 | 103,074 | 132,056 | 98,166 | 125,768 | | 0.78 | | 81,765 | |
| 2011 | 105,802 | 135,551 | 95,965 | 122,949 | | 0.78 | | 83,929 | |
| 2012 | 108,099 | 138,494 | 93,380 | 119,636 | | 0.78 | | 85,751 | |
| 2013 | 103,511 | 132,617 | 85,159 | 109,104 | | 0.78 | | 82,112 | |
| 2014 | 107,562 | 137,806 | 84,277 | 107,974 | | 0.78 | | 85,325 | |
| 2015 | 114,902 | 147,211 | 85,742 | 109,851 | | 0.78 | | 91,148 | |
| 2016 | 128,121 | 164,146 | 91,053 | 116,656 | | 0.78 | | 101,634 | |
| 2017 | 135,022 | 172,987 | 91,388 | 117,084 | | 0.78 | | 107,108 | |
| 2018 | 144,716 | 185,407 | 93,285 | 119,515 | | 0.78 | | 114,798 | |
| 2019 | 125,918 | 16,132 | 77,302 | 99,038 | | 0.78 | | 99,886 | |

Note. PV(B)= Present Value of Benefits. PV(C)=Present Value of Costs. CBR=Cost Benefit Ratio. IRR=Investment Rate of Return. NPV=Net Present Value.

**Table 14.** *Cost Benefit Analysis results of the sensitivity analysis using the average (2009-2019) market selling price of all the varieties of grafted vine plants (1.50 euro/plant) excluded Nebbiolo variety for the implementation of a nursery in Valtellina*

| Year | Total revenues (euro) | Total costs (euro) | PV (B) (euro) | PV (C) (euro) | NPV (euro) | CBR | Total CBR | Annual total demand | IRR |
|---|---|---|---|---|---|---|---|---|---|
| 2009 | 9,746 | 10,514 | 9,746 | 10,514 | -7,101 | 0.93 | 0.93 | 6,510 | -5% |
| 2010 | 8,020 | 8,651 | 7,638 | 8,239 | | 0.93 | | 5,357 | |
| 2011 | 8,129 | 8,769 | 7,373 | 7,954 | | 0.93 | | 5,430 | |
| 2012 | 7,413 | 7,997 | 6,404 | 6,908 | | 0.93 | | 4,952 | |
| 2013 | 10,540 | 11,370 | 8,671 | 9,354 | | 0.93 | | 7,040 | |
| 2014 | 8,488 | 9,157 | 6,651 | 7,175 | | 0.93 | | 5,670 | |
| 2015 | 9,514 | 10,263 | 7,099 | 7,659 | | 0.93 | | 6,355 | |
| 2016 | 17,727 | 19,124 | 12,598 | 13,591 | | 0.93 | | 11,841 | |
| 2017 | 12,112 | 13,065 | 8,197 | 8,843 | | 0.93 | | 8,090 | |
| 2018 | 15,755 | 16,996 | 10,156 | 10,955 | | 0.93 | | 10,524 | |
| 2019 | 9,158 | 9,880 | 5,622 | 6,065 | | 0.93 | | 6,118 | |

Note. PV(B)= Present Value of Benefits. PV(C)=Present Value of Costs. CBR=Cost Benefit Ratio. IRR=Investment Rate of Return. NPV=Net Present Value.

**Table 15.** *Cost Benefit analysis results of the sensitivity analysis using the average (2009-2019) market selling price of all the varieties of grafted vine plants (1.38 euro/plant) included Nebbiolo variety for a nursery of grafted vine plants in Valtellina*

| Year | Total revenues (euro) | Total costs (euro) | PV(B) (euro) | PV (C) (euro) | NPV (euro) | CBR | Total CBR | Annual total demand | IRR |
|---|---|---|---|---|---|---|---|---|---|
| 2009 | 103,540 | 130,680 | 103,540 | 130,680 | -285,331 | 0.79 | 0.79 | 80,913 | 14% |
| 2010 | 111,094 | 140,708 | 105,804 | 134,008 | | 0.79 | | 87,122 | |
| 2011 | 113,932 | 144,321 | 103,339 | 130,904 | | 0.79 | | 89,359 | |
| 2012 | 115,513 | 146,492 | 99,784 | 126,545 | | 0.79 | | 90,703 | |
| 2013 | 114,051 | 143,987 | 93,830 | 118,458 | | 0.79 | | 89,152 | |
| 2014 | 116,051 | 146,963 | 90,929 | 115,150 | | 0.79 | | 90,995 | |
| 2015 | 124,417 | 157,474 | 92,842 | 117,510 | | 0.79 | | 97,503 | |
| 2016 | 145,849 | 183,270 | 103,652 | 130,247 | | 0.79 | | 113,475 | |
| 2017 | 147,134 | 186,053 | 99,586 | 125,928 | | 0.79 | | 115,198 | |
| 2018 | 160,471 | 202,403 | 103,441 | 130,471 | | 0.79 | | 125,322 | |
| 2019 | 135,077 | 171,203 | 82,925 | 105,104 | | 0.79 | | 106,004 | |

Note. PV(B)= Present Value of Benefits. PV(C)=Present Value of Costs. CBR=Cost Benefit Ratio. IRR=Investment Rate of Return. NPV=Net Present Value.

### 4.3 Results for the adoption of drones spraying in the terraced vineyards in Valtellina

The results of the CBA from the point of view of a farm cooperative in Valtellina which purchases a drone for spraying and leases it (together with two specialized workers) to a winery in Valtellina are presented in Table 16. The NPV calculated over 15 years is negative and it amounts to -131,168 euro.

The total CBR is below one since it is lower than 0.60 so from an economic point of view the drone purchasing from the farm cooperative is not a viable option. The IRR is 45% which means that is a valuable investment for a farm cooperative to invest in a drone for spraying if the investor rate of return is lower than 45%. The calculations presented in Table 16. And Table 17. are considered as the base scenario that can be compared with the results of the sensitivity analysis in Table 18. And Table 19.

**Table 16.** *Cost-benefit analysis results from the point of view of a farm cooperative in Valtellina which purchases a drone for. spraying and leases it (together with two specialized workers) to a winery in Valtellina*

| Year | Total revenues (euro) | Total costs (euro) | PV (B) (euro) | PV (C) (euro) | NPV (euro) | CBR | Total CBR | IRR |
|---|---|---|---|---|---|---|---|---|
| 0 | 17,982 | 38,097 | 17,982 | 38,097 | -131,168 | 0.47 | 0.60 | 45% |
| 1 | 17,982 | 36,772 | 17,126 | 35,020 | | 0.49 | | |
| 2 | 17,982 | 35,444 | 16,311 | 32,149 | | 0.51 | | |
| 3 | 17,982 | 34,117 | 15,534 | 29,472 | | 0.53 | | |
| 4 | 17,982 | 32,791 | 14,794 | 26,977 | | 0.55 | | |
| 5 | 17,982 | 31,464 | 14,090 | 24,653 | | 0.57 | | |
| 6 | 17,982 | 30,137 | 13,419 | 22,489 | | 0.60 | | |
| 7 | 17,982 | 28,811 | 12,780 | 20,475 | | 0.62 | | |
| 8 | 17,982 | 27,484 | 12,171 | 18,602 | | 0.65 | | |
| 9 | 17,982 | 26,157 | 11,591 | 16,861 | | 0.69 | | |
| 10 | 17,982 | 24,831 | 11,039 | 15,244 | | 0.72 | | |
| 11 | 17,982 | 23,504 | 10,514 | 13,742 | | 0.77 | | |
| 12 | 17,982 | 22,177 | 10,013 | 12,349 | | 0.81 | | |
| 13 | 17,982 | 20,851 | 9,536 | 11,057 | | 0.86 | | |
| 14 | 17,982 | 19,524 | 9,082 | 9,861 | | 0.92 | | |
| 15 | 17,982 | 18,197 | 8,650 | 8,753 | | 0.99 | | |

Note. PV(B)= Present Value of Benefits. PV(C)=Present Value of Costs. CBR=Cost Benefit Ratio. IRR=Investment Rate of Return. NPV=Net Present Value.

In Table 17. are presented the results of the CBA for a small-scale winery in Valtellina which rents a drone for spraying 65.3 ha of terraced vineyards. The NPV is a negative and it amounts to -140,325 euro.
The CBR is smaller than 1 it is equal to 0.31. Therefore, renting a drone for spraying with a rent price of 40 euro/day (excluded the workforce) is not an economic viable option in 10 years for a small-scale winery in Valtellina.

A consideration which needs to be done is that by outsourcing the spraying the cost for external workforce is 30 euro/hour instead of 12 euro/hours, it would be more convenient for the small-scale winery.
The IRR is 69% which could suggest that rent a drone for spraying vineyards in Valtellina could be economically viable if the prefixed return for the investor is lower than 69%, but it is uncertain how much should be the investor return for this project.

**Table 17.** *Cost benefit analysis results from the point of view of a small-scale winery in Valtellina which rents a drone for spraying 65.3 ha*

| Year | Total revenues (euro) | Total costs (euro) | PV (B) (euro) | PV (C) (euro) | NPV (euro) | CBR | Total CBR | IRR | Net cash flow (euro) |
|---|---|---|---|---|---|---|---|---|---|
| 0 | 5,651 | 17,983 | 5,652 | 17,983 | -140,325 | 0.31 | 0.31 | 69% | -12,331 |
| 1 | 5,651 | 17,983 | 5,382 | 17,126 | | 0.31 | | | -12,331 |
| 2 | 5,651 | 17,983 | 5,126 | 16,311 | | 0.31 | | | -12,331 |
| 3 | 5,651 | 17,983 | 4,882 | 15,534 | | 0.31 | | | -12,331 |
| 4 | 5,651 | 17,983 | 4,649 | 14,794 | | 0.31 | | | -12,331 |
| 5 | 5,651 | 17,983 | 4,428 | 14,090 | | 0.31 | | | -12,331 |
| 6 | 5,651 | 17,983 | 4,217 | 13,419 | | 0.31 | | | -12,331 |
| 7 | 5,651 | 17,983 | 4,016 | 12,780 | | 0.31 | | | -12,331 |
| 8 | 5,651 | 17,983 | 3,825 | 12,171 | | 0.31 | | | -12,331 |
| 9 | 5,651 | 17,983 | 3,643 | 11,591 | | 0.31 | | | -12,331 |
| 10 | 5,651 | 17,983 | 3,469 | 11,039 | | 0.31 | | | -12,331 |
| 11 | 5,651 | 17,983 | 3,304 | 10,514 | | 0.31 | | | -12,331 |
| 12 | 5,651 | 17,983 | 3,147 | 10,013 | | 0.31 | | | -12,331 |
| 13 | 5,651 | 17,983 | 2,997 | 9,536 | | 0.31 | | | -12,331 |
| 14 | 5,651 | 17,983 | 2,854 | 9,082 | | 0.31 | | | -12,331 |
| 15 | 5,651 | 17,983 | 2,718 | 8,650 | | 0.31 | | | -12,331 |

Note. PV(B)= Present Value of Benefits. PV(C)=Present Value of Costs. CBR=Cost Benefit Ratio. IRR=Investment Rate of Return. NPV=Net Present Value.

Table 18. shows the sensitivity analysis using a lease price (suggested by the drone company Aerialclick) of 50 euro/ha from the point of view of the farm cooperative resulted in a positive NPV of 241,162 euro over 15 years. The IRR is 47% and the CBR is always greater than 1. Therefore, investing in a drone spraying for a farm cooperative which leases the drone for 50 euro/ha it is economically viable.

**Table 18.** *CBA results of the sensitivity analysis using a leasing price of 50 euro/ha from the point of view of a farm cooperative in Valtellina which purchases a drone for spraying and leases it (together with 2 specialized workers) to a winery in Valtellina*

| Year | Total revenues (euro) | Total costs (euro) | PV (B) (euro) | PV(C) (euro) | NPV (euro) | CBR | Total CBR | IRR | Net cash flow (euro) |
|---|---|---|---|---|---|---|---|---|---|
| 0 | 45,132 | 32,528 | 45,132 | 32,528 | 241,162 | 1.39 | 1.88 | 47% | 12,604 |
| 1 | 45,132 | 31,201 | 42,983 | 29,716 | | 1.45 | | | 13,930 |
| 2 | 45,132 | 29,875 | 40,936 | 27,097 | | 1.51 | | | 15,257 |
| 3 | 45,132 | 28,548 | 38,987 | 24,661 | | 1.58 | | | 16,584 |
| 4 | 45,132 | 27,221 | 37,130 | 23,486 | | 1.66 | | | 17,910 |
| 5 | 45,132 | 25,895 | 35,362 | 21,329 | | 1.74 | | | 19,237 |
| 6 | 45,132 | 24,568 | 33,678 | 19,323 | | 1.84 | | | 20,564 |
| 7 | 45,132 | 23,241 | 32,074 | 17,460 | | 1.94 | | | 21,890 |
| 8 | 45,132 | 21,915 | 30,547 | 15,730 | | 2.06 | | | 23,217 |
| 9 | 45,132 | 20,588 | 29,092 | 14,126 | | 2.19 | | | 24,544 |
| 10 | 45,132 | 19,261 | 27,707 | 12,639 | | 2.34 | | | 25,870 |
| 11 | 45,132 | 17,935 | 26,388 | 11,262 | | 2.52 | | | 27,197 |
| 12 | 45,132 | 16,608 | 25,131 | 9,986 | | 2.72 | | | 28,524 |
| 13 | 45,132 | 15,281 | 23,934 | 8,807 | | 2.95 | | | 29,850 |
| 14 | 45,132 | 13,955 | 22,795 | 7,718 | | 3.2 | | | 31,177 |
| 15 | 45,132 | 12,628 | 21,709 | 6,712 | | 3.57 | | | 32,504 |

Note. PV(B)= Present Value of Benefits. PV(C)=Present Value of Costs. CBR=Cost Benefit Ratio. IRR=Investment Rate of Return. NPV=Net Present Value.

While, Table 19. Shows that the sensitivity analysis using a rent price for the drone lease (50 euro/ha) from the point of view of a winery. In this case we have a negative NPV of -365,847 euro. The IRR is 58% and the total CBR of 1.88 so it can be concluded that, from a winery perspective, using the drone for spraying at a price of 50 euro/ha to spray 65.3 ha of vineyards in Valtellina it is not an economically viable option.

**Table 19.** *Cost benefit analysis results of the sensitivity analysis using a leasing price of 50 euro/ha from the point of view of small-scale winery in Valtellina which rents a drone for spraying 65.3 ha of vineyards*

| Year | Total revenues (euro) | Total costs (euro) | PV (B) (euro) | PV(C) (euro) | CBR | Total CBR | IRR | NPV (euro) |
|---|---|---|---|---|---|---|---|---|
| 0 | 5,652 | 35,204 | 5,652 | 35,204 | 0.16 | 0.16 | 58% | -365,847 |
| 1 | 5,652 | 35,204 | 5,382 | 33,527 | 0.16 | | | |
| 2 | 5,652 | 35,204 | 5,126 | 31,931 | 0.16 | | | |
| 3 | 5,652 | 35,204 | 4,882 | 30,410 | 0.16 | | | |
| 4 | 5,652 | 35,204 | 4,649 | 28,962 | 0.16 | | | |
| 5 | 5,652 | 35,204 | 4,428 | 27,583 | 0.16 | | | |
| 6 | 5,652 | 35,204 | 4,217 | 26,269 | 0.16 | | | |
| 7 | 5,652 | 35,204 | 4,016 | 25,018 | 0.16 | | | |
| 8 | 5,652 | 35,204 | 3,825 | 23,827 | 0.16 | | | |
| 9 | 5,652 | 35,204 | 3,643 | 22,692 | 0.16 | | | |
| 10 | 5,652 | 35,204 | 3,469 | 21,612 | 0.16 | | | |
| 11 | 5,652 | 35,204 | 3,304 | 20,583 | 0.16 | | | |
| 12 | 5,652 | 35,204 | 3,147 | 19,602 | 0.16 | | | |
| 13 | 5,652 | 35,204 | 2,997 | 18,669 | 0.16 | | | |
| 14 | 5,652 | 35,204 | 2,854 | 17,780 | 0.16 | | | |
| 15 | 5,652 | 35,204 | 2,718 | 16,933 | 0.16 | | | |

Note. PV(B)= Present Value of Benefits. PV(C)=Present Value of Costs. CBR=Cost Benefit Ratio. IRR=Investment Rate of Return. NPV=Net Present Value.

## 5. Discussion

The research aim was to evaluate the economic sustainability of three innovative projects in the wine sector in Northern Italy (Valtellina) namely: the conversion to organic wine production, the implementation of a nursery for grafted vine plants and the use of drones for spraying terraced vineyards. The three innovative projects were assessed through the economic impact generated for a small-scale winery in Valtellina. Indeed, this was related to the theoretical framework thanks to the production cost economics theory.

The results of the CBA were in line with the findings of the literature. The organic production wine production resulted to have higher workforce costs for soil management 6192 euro/year compared to the one of conventional production amounted to 4913 euro/year due to the impossibility to use herbicides (Merot & Wery, 2017). The interviewed wineries in Valtellina for the organic and conventional wine production have respectively on average 10.2 and 9.5 spraying treatments per year. The price of organic wine is on average higher than the price of conventional ones (Novaes Zilber et al., 2010). This is present in the interviewed wineries in Valtellina since the bottle price for organic and conventional wine is on average 20 euro/bottle and 13 euro/bottle respectively.

The sensitivity analysis for the conversion to organic production was on the market price for grafted vine plants since it represented a realistic option to investigate the Valtellina wine sector. It resulted that there is no economic benefit since the market asks for high quality grafted vine plants with low selling price. Indeed this is in line with the conclusions of Waite (Waite et al., 2015). Of course, other options could have been used for sensitivity analysis like the ones to increase the volumes of grafted vines produced by 10%. But this was not meaningful to investigate since in the CBA we considered the average volumes of grafted vine plants produced outside region, which is stable in the last 10 years. For the CBA for the nursery of grafted vine plants was that were used the average last 10 years prices of grafted wine plants, without using the average yearly price from 2009-2019: Every year the market prices for grafted vine plants outsourced were different. Even though we had those data in our excel file, we preferred to have a general idea on the average market price just focusing on the traditional Nebbiolo variety and the other grafted vine plants compounded together.

Despite the restrictions the EU legislation for drone spraying there is room to simulate and be prepared in the case of legislative updates are put in place especially in the CAP 2020. Actually the drone spraying is restricted in the use by the legislation (Hawkes et al., 2017), indeed only drones which are less than 25 kg (full tank included) are allowed to fly. In Europe it is forbidden to spray products with aerial vehicle. Only in specific cases there are derogations: when there is no better option in terms of environmental impact or when the area to spray is difficult to reach (Spackman, 2016). However, the results of the CBA say that it is not economically viable for farm cooperative in Valtellina to purchase and lease the drone for only a single winery (which sprays with one drone 65.3 ha of terraced vineyards in Valtellina which are less than 20 km close to each other's). This can be explained by the fact that the drones could be leased to multiple wineries during the same period. The farm cooperative could program the schedule for leasing the drone. Moreover, the farm cooperative, could offer a prompt spraying treatment service which is essential, especially in the organic production. The advantage for the drone spraying in Valtellina is that it preserves the disposition of the rows in the vineyards which are traditionally oriented from North South, without the need of investing 100,000 euro/ha (Bongiolatti, 2018) to change the disposition of the rows in the vineyards. Another limitation for drone spraying, despite from the technical ones (Hawkes et al., 2017), is related to the fact that finding a fair leasing price for a drone to be used in terraced vineyards is case specific. The suggested leasing price (50 euro/ha) seams not economically viable for the Valtellina wine sector. There are different depreciation methods but from the literature it was not possible to retrieve information on which depreciation method fits better for a drone. For the CBA for the drone purchase

is given by the fact that it was chosen to amortize the drone in 15 years with a linear depreciation method. These choices were done according to the fact that the average size of the wineries is 4.6 ha of land and an investment of 20,000 euro cannot be amortized in only 3 years, but this is a supposition looking at the Valtellina context and it is not confirmed by experts or theory grounded.

The environmental effects play a role in every human action however in the three CBA the environmental impact is not included because it would have required a separate and deep study which was out of the scope of this report. The environmental impact for the conventional/ organic conversion could be monetized in the environmental cost of the conventional wine production on soil fertility, biodiversity, air quality. A multicriteria assessment could be considered since it used by researcher to monetize the ratio between inputs and outputs (bad outputs included). However, the main challenge would be how to determine scientifically, the conversion factors between $CO_2$ emission and bad outputs produced and shadow prices specifically for wine making production are difficult to calculate and to retrieve from the literature. This would be a target for a new research.

The internal validity is guaranteed by the sample since the data for the organic conversion are taken from a sample of small-scale organic and conventional wineries in Valtellina, with less than thirteen employees and an average of 4.6 ha of vineyards (Table 1). This allowed to have a group that is comparable. To boost the internal validity the three projects were set in the same specific context.

To ensure consistency the voices of the tables are the same for all the small-scale wineries the investigator was the same. Therefore, the investigator triangulation is not present since this is a MSc thesis from a single student, who is the only investigator. Having only one investigator could be a disadvantage since we needed to focus on only one aspect which is the economic effect. We couldn't consider other aspects as the environmental costs which are usually included in the CBA (European Commission, 2014). Maybe having more students investigating on these three projects would have led to different approaches for the CBA, which are present in the literature itself. An advantage of having one investigator is that the investigator had a progressed knowledge of the wine sector in Valtellina. This was helpful during the decision-making process especially for structuring and running the calculation for the CBA and sensitivity analysis.

The replicability of each the three-case study is guaranteed by the presence of structured quantitative tables. Every voice in the Excel tables is listed to highlight the revenues and the costs for the small-scale wineries, the drone company and the nursery of grafted vine plants in Valtellina. The triangulation of the methods of data collection was assessed comparing the data collected in the Excel tables with data from expert elicitation and literature review.
The theory triangulation is not present since the approach adopted pertains to the production cost theory.

In this MSc thesis no statistical generalization is possible due the small sample of interviewed companies in Valtellina (n.16 wineries, n.1 nursery for grafted vine plants, n. 2 drone companies). However, terraced wine area in Europe share the same destiny, having higher production costs and increased vineyards abandonment (Cervim, n.d.). Therefore the results of this study could be applied in other terraced wine region in Italy and outside Italy: "Cinque Terre" (Liguria), "Candia dei Colli Apuani" and "Colli di Luni" and "Elba" (Tuscany), "Morgex" (Valle d'Aosta), Lavaux (Switzerland) , Douro (Portugal), Ribeira Sacra Galicia (Spain), Mosel-Saar-Ruwer (Germany) , Wachau and Styria (Austria), Rhône-Alpes and Languedoc Roussillion (France) , Rehinland Pfalz (Germany).

The decision to leave out the taxes paid by the wineries intended as VAT and contribution for the employees' pension fund, can be a limitation. However, these data were not available from the

companies and the estimation would have been complex and unreliable. Actually, we can say that the three selected projects are investment project, therefore we would have taken into account actual taxes if they were upon the specific investment and not on the general management of the company. Moreover, the taxation system is country specific and we wanted to extend the applicability of those projects to other terraced wine area outside Italy, therefore we preferred not to include the taxes.

A point of discussion for the study is related to the discount rate adopted. The 5% discount rate is chosen as the usual discount rate adopted in investment projects in agricultural sector. This discount rate reflect the low returns in agricultural sector. However, further investigation could be done to see whether a different discount rate could better fit the Italian wine sector and each project. The discount rate entails the uncertainty of an investment so it is time dependent, the longer it is the investment the more uncertain and higher should be the discount rate. The discount rate can entail the difficulties in switching from the management practices of the conventional wine production to the organic wine production. The discount rate can refer to adverse weather condition related to climate change affecting the production yields. Therefore, every year should have its own discount rate for the project, since it is quite of an assumption that the discount rate stays the same for 5 or 15 years in agricultural sector. So, it could be interesting to investigate the economic effect of the three innovative projects with a variable discount rate. This could be a suggestion for further research.

The IRR needed to be calculated using the initial investment and the after taxes cash flow. Our IRR was calculated on the pre-taxes cash flow therefore in some cases the IRR have higher returns like the one ion Table 17. of 69%. Moreover, the benchmark to evaluate whether the IRR was good enough for an investor to invest, is really project and investor specific and we could not establish it. Indeed, further investigation should be done in follow up research. The IRR itself relies on the assumption that yearly PV is reinvested at IRR, which is not really representative of the agricultural sector, it is more plausible to have subsequent returns being reinvested at risk free rate (treasury bonds). However, complex decisions of investment are not to be taken depending only on the CBA results. Indicators can give an insight on which project is worth to invest, but they are not exhaustive, since they cannot take into account the multiples aspects in which the complexity of reality exists. Therefore, the outcomes of my investigation should be considered in this boundaries. The initial idea to use accountancy data from official databases could have been an option. However, official database like AIDA and ORBIS could not provide financial information about the investigated companies since those companies are too small and they are not obliged by the Italian law to publish the financial statements. The calculations are run on the primary collected data which are really context specific and they are not the result of the aggregation of the values as usually done for the financial statements. Since this thesis is based on production costs economics it was necessary to have the marginal production cost and revenues from the interviewed companies. This was helpful to decide on what to run the sensitivity analysis.

The recommendations, if companies decide to invest in organic production, they should find solutions on how to optimize the soil management and spraying treatments in order to reduce the yield losses (Wheeler & Crisp, 2011). The spraying treatments can be reduced by adopting fungi-resistant varieties of vine plants which need two spraying treatments a year (Tele Sondrio News, 2019). Therefore, when deciding to replant a vineyard or substitute died vine plants, they should take into account the resistant varieties of vine plants. The results show that, using different discount rate, when the discount rate decreases the NPV increases. Indeed, the discount rate includes the risk of investing in a project. The 2% discount rate is the risk-free rate of the treasury bonds, which is considered as a benchmark for the return on invested capital. While the 5% and 10% discount rate represent slightly more risky investments, since agricultural sector is characterized by possible adverse weather conditions and low margins.

The recommendation for the policy for the organic production in Valtellina is that policymakers should take into account the environmental impact of the agricultural production. This will give insights on which project to support not only according to market trends but also considering the environmental costs since every human action has an impact on the environment. There should be a technical consultants in Valtellina who can give advices on organic production in order to decrease the inefficiency in the organic production (e.g. yield losses). The policy makers should support the marketing of the organic products by networking also with other organic producers across the borders like the Swiss organic producers.

The recommendation for the business of drones spraying, in case of drone lease, is that it is crucial to establish a rent price which is economically convenient either for the company that leases the drone either for the company that borrows it. From the calculation we have seen that the rent price of 40 euro/day is not economically sustainable for the company that lease the drone, while the price of 50 euro/ha is not economically sustainable for the winery which uses the drone. The 40 euro/day was taken from a rent price for a machineries in the farm cooperative in Valtellina and the 50 euro/ha was suggested by Aerialclick drone company which does not operate in Valtellina. Therefore, the lease price of the drone is really context specific. Therefore, a convenient rent price should be established for the one who borrows and the one who rents the drones. The introduction of drones for spraying in Valtellina, should be investigated further maybe by including the scenario of a single winery which purchases the drones and leases it to other wineries since it is expected to be an economically viable option.

The recommendation for the policy for drone spraying is that the regulation should evolve with the development of the technology. The actual regulation bans the spraying of phytosanitary products with aerial vehicles, drones included. In that sense, there could be business opportunities with the drone spraying by which safeguarding the safety of the operators and the environment. There should be a distinction for drones which weight less than 25 kg and other bigger aerial vehicles. This will allow drones to avoid limitation for the no flying zone for the drone spraying. The regulation should provide a list of the phytosanitary products approved for the drone spraying as it is now in Switzerland. If the policy would implement the use of technology in agriculture like for drones, this will simplify the agronomic practices in terraced vineyards. A drone can spray 3 ha of terraced vineyards in 1 hour with two operators while for traditional spraying, 24 hours are need to spray 3 ha of vineyards.

The recommendation for the nursery of vine plants is that, of course, for a single small-scale winery satisfying the total demand for grafted vine plants in Valtellina it could be hard from an economic and technical point of view. However, through the cooperation with other wineries in the same area, is possible to set up a nursery for grafted vine plants in Valtellina as suggested by the wine expert of Fojanini Foundation. Currently it is not possible for Valtellina wineries to compete with the prices of nurseries outside region this can be noticed through the data collected from the nursery outside Valtellina which sell grafted vine plants to Farm cooperative in Valtellina at a market price lower than the local marginal production costs of grafted vine plants. The nursery activity is based on economies of scale and it is a competitive market. Indeed, from the results we can see that using the market price for all the varieties of grafted vine plants led to a negative NPV. The only option to make a nursery of grafted vine plants profitable in Valtellina is to sell the grafted vine plants at a higher price than the marginal production costs. This is already demonstrated to be possible by the interviewed nursery in Valtellina. The nursery in Valtellina could also produce the fungi-resistant vine plants for which at the moment there is an experimental field in Valtellina (Tele Sondrio News, 2019). It could be of interest for further research, to investigate how to reduce the marginal production costs of grafted vine plants in Valtellina. A possible option is to invest more in innovative machineries and use less labor. Another option is to assess the implementation of a nursery of vine plants owned

and run simultaneously by multiple wineries in Valtellina which want to close the production cycle from the small vine plant to the wine bottle.

The recommendation for the policy is that at nursery level, it should be created a guideline for Good Manufacturing Practices at EU level, in order to guarantee a safe common ground for the production and trading of grafted vine plants across Europe.

## 6. Conclusions

The aim of this study was to assess whether three innovative projects can be economically sustainable in Valtellina wine sector.

For what concern the economic benefits for the organic production schemes we can conclude that there is economic benefit since the NPV is positive. This is given by the fact that the raise in costs for organic production are compensated by the increased price for organic wine bottles. The organic wine bottles are paid more than conventional ones at least in our sample. The average bottle price for organic wine is 20.38 euro/bottle compared to the average bottle price for the conventional wine which is 13.47 euro/bottle. The organic wine production over 5 years has a positive NPV of 421.215 euro/ha. Also, in the case of increased risk in yield losses or difficulties in switching from conventional to organic wine production the NPV is still positive.

In the project for the implementation of the nursery of vine plants the economic benefit is given foremost by the production of Nebbiolo grafted vine plants since this variety is traditionally present in Valtellina. The nursery for grafted vine plants over 10 years has a positive NPV for Nebbiolo grafted vine plants of 285.262 euro.

The drone spraying simulation which include the purchase of a drone for spraying from a farm cooperative and a leasing of the drone to a single winery in Valtellina resulted in a negative NPV for both the farm cooperative and the winery. The drone rented by a winery from a farm cooperative for 15 years for spraying 65.3 ha of vineyards in an area of 20 km results in a negative NPV: equal to -140.325 euro and -365.847 euro respectively for a rent price of 40 euro/day and 50 euro/ha.

In conclusion, the adoption of innovative projects in Valtellina (North of Italy) wine sector can be economically sustainable especially for the conversion to organic wine production. While the drones spraying has a positive NPV for the farm cooperative with a rent price of 50 euro/ha. The nursery for vine plants has positive NPV only in the case where it is used the selling price and marginal cost for grafted vine plants suggested by the interviewed nursery in Valtellina.

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## Appendix

**Appendix 1**: *Structured questionnaire for the small-scale wineries with closed-ended questions about organic certification schemes in wine production*

| |
|---|
| What is the year of the foundation of the winery? |
| In what year did you start the conversion to organic? |
| What is the average age of the workforce in the winery? |
| How many hectares of vineyards do you cultivate (ha)? |
| What is the duration of the conversion to organic wine production (years)? |
| How much workforce do you have in your company? |
| How many company's owners are there in your company? |
| What is the average cost of the workforce in your vineyard (euro/hour)? |
| What is the average cost of the workforce in your wine cellar (euro/hour)? |
| What is the total amount of hours per year that are spent in the vineyards (hours/ha)? |
| What is the total amount of hours per year that are spent in the wine cellar? |
| What is the total amount of hours per year that is spent on bureaucracy practices? |
| What is the cost of the workforce for record-keeping (euro/year)? |
| What is the cost for the workforce for the phytosanitary treatments in the vineyard (euro/year/ha)? |
| How many hours are spent for the phytosanitary treatment in the vineyard per hectares (hours/ha)? |
| How many phytosanitary treatments are done in the vineyards per year? |
| How many hectares of organic vineyards are there in your winery? |
| What are the administrative/record keeping/bureaucracy costs? |
| What are the insurance costs for the vineyards (euro/year)? |
| What is the insurance cost for wine cellar's civil responsibility (euro/year)? |
| What is the average production yield (kg of wine grapes/ha)? |
| What is the price for wine grapes (euro/kg)? |
| How many hours do you spend on audits in a year (hours/year)? |
| How much are the updating costs for the workforce per year (euro/hour)? |
| How many hours do you spend on the workforce's updating sessions per year (hours/year)? |
| How much does the external consulting cost (euro/hour)? |
| What is the name of the winery? |
| How many external consulting hours are done in your company (hours/year)? |
| How much does your company spend yearly on phytosanitary products (euro/year)? |
| What is the value of your property (euro/$m^2$)? |
| How much organic subsidy do you get (euro/ha/year)? |
| Can you estimate the environmental impact costs (euro/ha)? |
| Do you analyse the biodiversity in your vineyards? |
| Do you analyse the soil fertility in your vineyards? |
| How much does it cost the soil fertility analysis (euro/una tantum)? |
| Do you analyse the water quality in the vineyards and the wine cellar? |
| Do you have data about the greenhouse gas emission of your production activity (from the vineyard to the cellar)? |
| How much sulphur dioxide do you use in the wine cellar (mg/hl)? |
| How much copper do you use in the vineyards (kg/ha/year)? |
| How much sulphur do you use in the vineyard? |
| Can you list the market in which you sell your bottles? |
| Can you list the sales channels that you use? |
| How many revenues do you have (euro/year)? |
| How many pesticides do you use (kg/ha/year)? |

How much mineral sulphur do you use (g/hl/year)?
How much is the employees' salary (euro/year)
How many hours does your workday last (hours/day)?
How many days do you spend in a year on work (workdays/year)?
Can you tell me the average bottle price (euro/bottle)?
How many of your bottles are labelled organic?
What is the total number of different labels in your wine production?
How many bottles do you produce in a year (number of bottles/year)?
How many kgs of grape do you produce in a year (kg of wine grapes/year)?
How much family labour do you have in your company?
How much machinery maintenance costs (euro/year) do you have per year?
How many grafted vines are planted per year in your vineyards?
How much do you pay for each grafted vine plant (euro/grafted vine plant)?
How much organic fertilizers. Do you use in the vineyards (kg/ha)?
How many litres of gasoil do you use in a year?
What is the price for the gasoil (euro/litre)?
What is the annual cost for the organic fertilisers?
What are the annual transport costs from the vineyards to the wine cellar or to the selling point (euro/year)?
How many days do you spend on pruning in a year (days/year)?
How many hours in a day do you spend for pruning (days/year)?
How many pruning costs do you have in a year (euro/year)?
How many days are spent on soil management in a year (days/year)?
How many hours in a day do you spend on soil management (hours/day)?
How much soil management costs does your company have (euro/year)?
What is the average price for the workforce for mowing (euro/hour)?
How many numbers of mowing session do you do per year (euro/year)?
How much is on average the water usage's bill for the wine cellar (euro/year)?
How much are on average the electric bill costs in the wine cellar (euro/year)?
How much is the processing cost from the wine grapes to the wine (euro/year)?
How much was the initial investment in the firm (euro)?
How much is on average the annual investment in the firm (euro/year)?
How much are the total taxation costs for your company (euro/year)?
How much is the cost of equity (euro)?
How much equity does your company have (euro)?
How much debt does your company have (euro)?
How much is on average your cost of debt (euro)?
How many suppliers of conventional and organic wine grapes do you have?
How many suppliers of ONLY organic wine grapes do you have?
How much does the harvesting workforce cost (euro/year)?
How much does the analysis of the residues in the wine cost (euro/year)?
How much does the Valoritalia’s counterfoil cost (euro/counterfoil)?
How much does the external bottler cost (euro/year)?
How many workforces do follow the updating sessions a year?

Can you list the vineyards machinery that you own?
Can you list the wine cellar machinery that you own?
When did you purchase each of these machineries (year)?
What was the purchase price of the machinery (euro)?
How many hours per year do you use those machinery?
What is the salvage value of each of those machinery (euro)?
How many years from the purchase do you expect those machinery will last (year)?

**Appendix 2:** *Structured questionnaire for the nursery of vine plants with closed-ended questions about the nursery for vine plants*

How many scions do you produce per year (number of scions/year)?
How many rooted grafts do you produce per year (number of rooted grafts/year)?
How many rootstocks do you produce per year (number of rootstocks/year)?
How many mother plants do you produce per year (number of mother plants/year)?
How much does the mechanical explant of rooted graft cost (euro/year)?
How much does the labelling of rooted grafts cost (euro/year)?
What is the average cost of the water bill (euro/year)?
How much does it cost to collect the rootstock (euro/year)?
How much does the cleaning of the rootstock cost (euro/year)?
What are the costs of the workforce for the anti-downy and powdery mildew fungicide spraying (euro/year)?
What is the purchase cost for the fungicide (euro/year)?
What is the cost for the anti-rot agent (euro/year)?
What is the cost of the workforce for the grafting (euro/year)?
What is the cost for the machinery maintenance (euro/year)?
What are the updating costs for the workforce (euro/year)?
What is the cost for the gasoil (euro/year)?
What is the cost for the first-choice rootstock price (euro/plant) VAT at 10% included?
What is the cost for the second-choice rootstock price (euro/plant) VAT at 10% included?
What is the cost for the red paraffin wax (euro/year)?
What is the cost for the hormonal rooting agent (euro/year)?
What is the cost for the sawdust (euro/year)?
What is the cost for “Agriperlite” (euro/year)?
What is the cost of the wood box(euro/year)?
What is the cost for the rooted graft cleaning (euro/year)?
What is the renting cost for the cellar (euro/year)?
What is the cost for the green wax (euro/year)?
What is the cost of the workforce for irrigation (euro/year)?
What is the cost for the mulching towel (euro/year)?
What are the soil management costs (euro/year)?
What are the costs for the workforce for spraying treatments (euro/year)?
What is the number of treatments/year?
What is the cost for the workforce for planting the cuttings (euro/year)?
What is the workforce cost per hour (euro/hour)?
What are the costs for the cleaning of the weeds (euro/year)?

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| What is the cost for the herbicide (euro/year)? |
| What are the costs for the lopping (euro/year)? |
| What is the cost for the clearance of the rooted graft (euro/year)? |
| What are the revenues of the nursery (euro/year)? |
| What is the cost for the tying of the rooted graft (euro/year)? |
| What are the workforce costs for dispensing sand filling in the wooden boxes (euro/year)? |
| What are the sand costs (euro/year)? |
| How many heads of the company do you have? |
| Which is the yield of the rootstocks (%)? |
| How much are the costs for the plastic bags for the scion (euro/year)? |
| How much are the bureaucracy costs (euro/year)? |

**Appendix 3**: Structured questionnaire for the drones spraying company with closed-ended questions about drones spraying

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| What is the purchase price for the drone BLY-C model (euro)? |
| What are the maintenance costs for the drone (euro/year)? |
| What are the costs for the nozzles substitution (euro/year)? |
| What is the cost of the substitution of the drone battery (euro)? |
| What is the average duration of the drone battery (number of recharges)? |
| What is the duration for the charging of the drone (hours)? |
| What is the battery life (minutes)? |
| What is the typology of the battery? |
| What is the maximum speed for the drone (km/h)? |
| What is the optimal velocity to have a balanced ratio of coverage and treatment duration (km/h)? |
| What is the manageable area to be treated in the terraced vineyard (hectares/day)? |
| What is the capacity of the fuel tank (litres)? |
| What is the weight of the drone BLY-C model with the empty fuel tank batteries included (kg)? |
| What is the cost of leasing the drone (euro/year)? |
| What is the cost of having a good quality GPS network (euro)? |
| What is the quality for the GPS network in Valtellina from a scale of 1 (really bad) to 5 (really good)? |
| What is the bureaucracy cost for a company that uses the drone for spraying? |
| What are the costs for the workforce who run the software before, during and after the spraying treatment? |
| How many hectares/day can be covered with a drone spraying treatment in a terraced vineyard in Valtellina (ha/day)? |
| Do you do the training for the personnel of other companies? |
| How much does the training for the drone spraying cost (euro)? |
| What is the insurance cost for the drone (euro/year)? |
| What is the cost for civil responsibility insurance for the use of the drone (euro/year)? |
| What is the cost for the phytosanitary licence (euro/year)? |
| What is the coverage efficacy of the drones spraying in terraced vineyards (litres/ha)? |
| What is the water-consumption concerning the use of manual spraying (litres/ha)? |
| What is the water-consumption concerning the air blast sprayer (litres/ha)? |

What is the minimum number of the workforce needed to run the drones (before/during/after) the spraying (number of workforce/ spraying)?
Can you mention how much is the phyto-sanitary products' saving from the drift of spraying products compared to air blast spraying (kg of products saved/year)?
Can you mention the saving in time of workforce compared to the traditional sprayings (hours of workforce/ year)
Can you tell the savings in term of the number of the workforce compared to the traditional spraying (saving in the number of workforce /year)?
What is the cost for the planning of the flights (euro/hour)?
How many hours do you spend on planning (hours/ha)?
How many hectares a day can be covered by the drone in terraced vineyards in a flying sessions (ha/day)?
Can you mention the strengths of the potential use of drones for spraying phytosanitary products on terraced vineyards?
Can you mention the weakness of the potential use of drones for spraying phytosanitary products on terraced vineyards?