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Measuring the financial sustainability of vine landraces for better conservation programmes of Mediterranean agro-biodiversity

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ABSTRACT

The Apulia region, in southern Italy, has a long tradition of vine cultivation for winemaking. However, in the last decades, regional farmers substituted local landraces with more productive non-native varieties. Regional institutions introduced regulations aimed at preventing the extinction of the local and historic ecotypes in the form of financial subsidies to reduce planting and operating costs.

In this paper, we compared the financial sustainability of a non-autochthone, a typical and a landrace variety for wine production, in intensive and semi-extensive cultivation systems, with and without financial supports. The analysis referred to northern Apulia, considering a 26-year economic duration of vineyards. The results showed that the non-autochthone variety was more profitable due to its higher yields, while investments regarding landrace-based plants were characterized by lower economic convenience, despite financial aid.

These estimates shed light on the effectiveness and efficacy of the present regulations, as well as on the development of future strategies for a better restoration of vine landraces in Apulia. This new framework will help to increase farmers' profits, improve environmental conditions for the community and ensure higher quality, security and safety for consumers.

1. Introduction

Landraces play a prime role in agricultural biodiversity; these are local varieties of domesticated plant species that have adapted to the natural and cultural local environment (Pascual et al., 2013; Krasteva et al., 2009; Scholten et al., 2009), enabling food and forage production, yield stabilization and improved soil structure (Brussaard et al., 2007; Mahon et al., 2016; Sardaro et al., 2016). They also allow agricultural practices based on low levels of technology and inputs (Altieri, 2004; Jackson et al., 2013; Caldeira et al., 2001; Martin et al., 2009; Srivastava et al., 1996; Hammer and Diederichsen, 2009; Veteläinen et al., 2009; Xie et al., 2011; Sardaro et al., 2017). Over the last decades, agricultural ecosystems increasingly lost their biological diversity based on local landraces and modern intensive cropping systems are now based on monoculture farming in order to increase the global food supply by using genotypes with high yields, but also requiring high levels of inputs (Matson et al., 1997; Evenson and Gollen, 2003; MEA, 2005).

In Apulia, southern Italy, the market forces over the last fifty years gradually caused the replacement of the local vine landraces used for winemaking (e.g. Somarello rosso, Minutolo, Moscatello selvatico and Ottavianello) with more productive varieties, also imported from northern Italy (e.g. Trebbiano, Montepulciano and Sangiovese). Moreover, farmers widely replaced the traditional and extensive "alberello" and espalier plants with more intensive structures ("tendone"), which, being based on several vine-shoots per vine (even more than four), allowed yields to increase (even four/five-fold). These varietal and structural changes led to a modern approach to wine growing that uses higher levels of inputs (i.e. fertilizers, water, power and pesticides required because the new varieties are less disease-resistant), with a consequent reduction in production quality and the loss of local and historical traditions. To date, vine landraces are cultivated in just 300 farms on 150 ha; besides, a 66% reduction in area and a 47% drop in the number of farms was recorded between 2000 and 2010 (ISTAT, 2016).

In order to prevent the extinction of these local vine ecotypes, Apulia Regional Government introduced several regulations aimed at encouraging their restoration by reducing the planting and operating costs. However, the success of this strategy was rather uncertain and farmers in several areas of the region did not demand at all to the aids, but continued their intensive wine growing based on non-autochthone varieties, high yields and massive use of inputs. Moreover, in these areas, farmers produced only grapes, which they then sold to wholesalers for winemaking. Possible reasons could be the following: farmers'

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lack of awareness about the difference in costs and revenues among the several production systems; their lack of knowledge about the technical, economic and administrative aspects of wine-making; the high investment costs involved in the construction of new private wineries; the difficulties inherent in the social fabric, which does not allow the implementation of cooperative strategies in the stages of wine-making, so to reduce the aforesaid costs. Hence, along the entire supply chain, insufficient economic information was available concerning the regional vine landraces. This meant that there was a need for a financial analysis focusing on their cultivation, which would then enable evaluation of the outcomes of the regional strategies in the light of market dynamics and help farmers to be more effective and efficient in their decision-making.

In order to fill this gap, we compared the financial sustainability of the following varieties: a) a non-autochthone variety (Sangiovese) in an intensive system (tendone); b) a typical regional variety (Uva di Troia) in a semi-extensive system (espalier); c) a vine landrace listed in the regional regulations (Somarello rosso) in a semi-extensive plant (espalier). This approach was chosen in order to understand the market forces driving wine growing in the area and consequently to evaluate the existence of concrete economic possibilities to preserve the region's vine landraces.

The present paper contributes to the literature in two ways. Firstly, no applied economic study investigated the financial results of typical vine landraces in the Mediterranean area in general, and in southern Italy in particular. Secondly, this study adds to the growing literature that takes a financial approach to estimating the sustainability of Mediterranean agricultural components. Our findings have implications for the debate concerning the conservation of Mediterranean plant species based on the related costs and benefits, allowing verification of the suitability of conservation strategies already in place, and enabling the design of future *ad hoc* cost-effective programmes.

2. Vine biodiversity in Apulia

World vine production is ca. 74.5 million tonnes yr^{-1} on 7.1 million hectares, of which about 45% of the area and 33% of production are in Europe. In turn, Italy is the third European country in terms of vineyard area (about 0.7 million hectares, i.e. 22.1%), following Spain and France, and is the leading producer (about 0.7 million tonnes, 28.4%), preceding the previous Countries (FAOSTAT, 2014). In Italy, Apulia accounts for 12.7% of the national vineyard area (86,000 ha, second to Sicily Region), 16.3% of the national grape production (1 million tonnes, second to Veneto Region) and 13.3% of the national wine production (5.6 million hectolitres, in third place behind Veneto and Emilia-Romagna Regions). Apulia plays a leading role in the Italian wine sector (ISTAT, 2016) and vine growing in the region is particularly adapted to the local climate. The region produces a large amount of high-quality wine, with approximately 20% of production labelled as Protected Designation of Origin (PDO), and 40% as Protected Geographical Indication (PGI), while the remaining 40% is table wine.

In the past, the large number of farmers and the limited availability of land led to a significant number of small-sized farms with an area of less than 1 ha (ISTAT, 2016), often based on family management. This structural characteristic, also common to other productive sectors such as olive and fruit growing, fostered vine production mainly based on local varieties and contributed to the maintenance of agro-biodiversity in Apulia. In the last decade, 50 regional vine landraces were recognized and a further 118 were cited in bibliographies but have not yet been identified (INEA, 2013).

The 2014–2020 Rural Development Programme of Apulia (RDP − Apulia Region, 2015) provided funds to farmers to incentivize on-farm conservation and reintroduction of the region's vine landraces (submeasure 10.1.4). These local varieties were inserted into a regional list (pp. 699) and were selected on the basis of their genetic erosion risk (two classes), concerning the speed of genomic variety loss, the greater difficulty in finding reproductive material and the lack of demand. The premium per hectare/year for farmers who undertook to cultivate the local varieties for at least five years was set at 397 € ha^{-1} for the ecotypes at the first risk level and 417 € ha^{-1} for the varieties with a high extinction risk (level 2). The payment considered the additional costs and income losses consequent to the cultivation of the local varieties with respect to the more widespread commercial varieties. In addition, Apulia Regional Government (BURP no. 5, 21/01/2016, Regulation EU no. 1308/2013) also provided funding to favour the restoration of specific local landraces with high oenological and commercial value (listed in BURP no. 16, 31/01/2013), cultivated in extensive or semi-extensive systems, i.e. guyot and espalier. For these investments, financial aid amounted to 75% of restoration costs, including compensation for income loss, up to 18.000 € ha^{-1}.

3. Materials and methods

3.1. Study area and data collection

The study focused on Barletta-Andria-Trani (BT) Province of northern Apulia, where replacement of vine landraces with more productive varieties was particularly intense in the last fifty years, leading to the almost complete extinction of the local ecotypes. Revenues were related to high yields rather than to the production of high quality wine. In particular, most farmers only produced grapes, which were then delivered to private wineries, so that farm income did not include any profit from wine-making.

Primary data concerned agronomic practices, quantities of productive factors (pesticides, fertilizers, irrigation water, etc.), yields, revenues and costs, which were collected through face-to-face based questionnaire interviews of approximately 50 min in eight farms (Table 1). The sampled farms were selected according to their classic agronomic and economic management, but also for the availability of their historical data (from the first year of planting up to the present). In addition, only small landrace-based vineyards were investigated in the study area, so that small farms were also selected for the other two grape varieties. This approach made it possible to compare farms with similar economic dynamics connected to farm size, i.e. economies of scale.

In the sampled farms, technical and economic management was

Table 1
Characteristics of the sampled farms.

n	Variety	Plant type	Management	Area (ha)	Vine spacing (m)	Age of vineyards (years)	Yield (ton ha^{-1})	Production value (€ ton^{-1})
1	Sangiovese	Tendone	Direct by farmer	2.2	2.3 × 2.2	4	38.4	208.3
2	Sangiovese	Tendone	Direct by farmer	2.7	2.2 × 2.1	11	41.1	208.3
3	Sangiovese	Tendone	Direct by farmer	2.1	2.2 × 2.1	24	25.3	208.3
4	Uva di Troia	Espalier	Direct by farmer	1.3	2.2 × 0.5	7	12.6	383.6
5	Uva di Troia	Espalier	Direct by farmer	1.1	2.2 × 0.4	15	16.2	383.6
6	Uva di Troia	Espalier	Direct by farmer	1.4	2.2 × 0.4	23	10.1	383.6
7	Somarello rosso	Espalier	Direct by farmer	1.2	2.2 × 0.4	17	11.4	431.1
8	Somarello rosso	Espalier	Direct by farmer	1.8	2.2 × 0.4	26	9.6	431.1

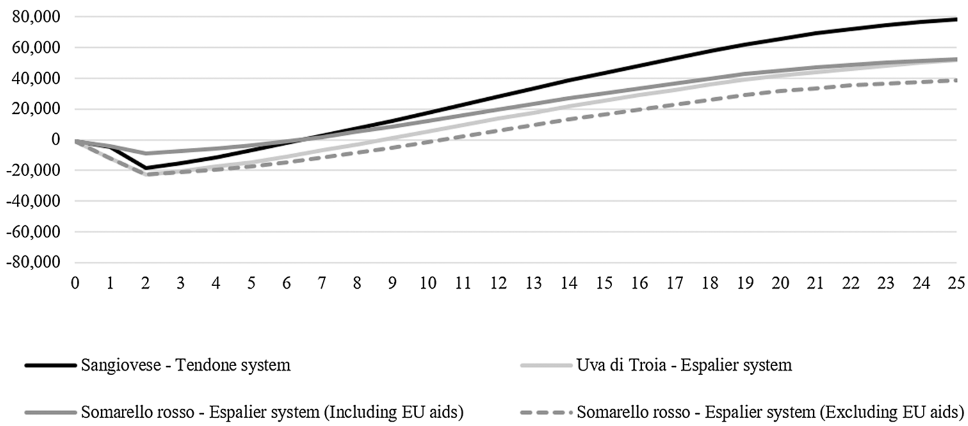

Fig. 1. Cumulative discounted cash flows of the wine-growing production systems.

Table 2
Result of the financial analysis.

Financial methods	Sangiovese – Tendone system	Uva di Troia – Espalier system	Somarello rosso – Espalier system	
			Excluding EU aids	Including EU aids
NPV (€)	78,249.23	52,192.37	38,583.35	52,233.03
IRR (%)	25.16	15.89	12.81	27.24
MIRR (%)	12.59	9.60	8.73	12.65
DBCR	2.83	2.40	2.08	3.38
DPBT (years)	7.4	9.7	11.4	7.3

carried out directly and exclusively by farmers, who held land and machinery capitals, and production was all sold to wholesalers. In the vineyards growing the non-autochthone variety (Sangiovese), just 2000 vines per hectare guaranteed sizeable yields (even 40 ton ha^{-1}), mainly used for to produce PGI wine. The unitary revenue was low (210 € ton^{-1}), which in any case generated a reasonable income (over 8000 € ha^{-1} at plant maturity). The typical variety (Uva di Troia) and the landrace (Somarello rosso) vineyards had a greater number of vines (more than 11,000 ha^{-1}), lower yields (9–16 ton ha^{-1}) and a higher production value (400 € ton^{-1}). Therefore, revenues (over 6000 € ha^{-1}) were mainly derived from the high production quality although, also in these cases, the grapes were not vinified on the farm.

Information concerning input quantities and yields was gathered from the past data and referred to 2016, whereas unitary costs and production value were calculated through the median in the period 2014–2016, in order to attenuate the yearly variations due to market trends, weather conditions and disease impact.

The analysis for the three plant configurations referred to an area of one hectare and a period of 26 years, which is equal to the average economic life of a vineyard in the study area with the considered characteristics. The productive cycle consisted of the following five phases:

1) planting, from the first to the third year, in which vines were not productive and the only economic item were planting costs;
2) a first increasing-production phase, from the fourth to the sixth year, in which vines and their production were growing, so that revenues increased more than proportionally compared to costs;
3) a second increasing-production phase, from the seventh to the eleventh year, in which vines and production were growing, so that revenues increased more than proportionally compared to costs, but more slowly than in the previous phase;
4) maturity, from the twelfth to the nineteenth year, in which vine growth was complete and production was stable, so that revenues and costs were constant;
5) decreasing-production phase, from the twentieth to the twenty-sixth year, in which vine aging reduced production, so that revenues decreased more than proportionally compared to costs.

3.2. *The capital budgeting methods*

Capital budgeting concerns analysis of investment opportunities involving long-term assets, which are expected to produce benefits for several years (Peterson and Fabozzi, 2002). In particular, it predicts the effects of investments, projects or programmes by verifying whether their realization can generate benefits for investors. Therefore, this is a widely accepted economic tool used in rational and systematic management in the primary sector (Sgroi et al., 2015a; Sgroi et al., 2015b; Bhattacharya and Ninan, 2011; Poot-López et al., 2014; Shamshak, 2011), and it is often requested by government planners for decision-making (Andrieu et al., 2017). In this connection, if an EU policy aims to favour the spread of local vine landraces into a specific area through targeted investments, capital budgeting is able to verify their economic performance by appropriate financial indicators calculated on a farm scale. Hence, it can indicate the suitability of the policy by explaining the present behaviour of investors in their own firms, suggest their future trends and provide crucial advice for policy makers in order to make any adjustments to the strategy.

In operative terms, investments have several financial characteristics, i.e. cash flows, time value of money, risk, return and maximization of profits (Anson et al., 2011), which influence their suitability and implementation. Capital budgeting makes use of several methods for the assessment of these aspects, each of which explores one or more financial characteristic, although each method is not always a dominant option and points out weaknesses (de Souza and Lunkes, 2016; Kalhoefer, 2010; Kengatharan, 2016). However, the synergic use of these tools is a common practice in the economic literature (de Souza and Lunkes, 2016; Kengatharan, 2016) since it is a complete approach for evaluation of the effectiveness and efficacy of investments. In this study, five capital budgeting methods were used for financial analysis: Net Present Value (NPV), Internal Rate of Return (IRR), Modified Internal Rate of Return (MIRR), Discounted Benefit-Cost Rate (DBCR) and Discounted Pay-Back Time (DPBT).

NPV (Bennouna et al., 2010; Adusumilli et al., 2016) is a long-term financial tool which assesses the magnitude of investments, makes it possible to understand the implications of one or more future investments and allows the selection of the best one under given market and cyclical conditions (Wetekamp, 2011). In formal terms, NPV is calculated as the difference between the discounted annual revenues (cash inflows) and the discounted annual costs (cash outflows), using the following formula:

$$NPV = \sum_{t=0}^{n} \frac{R_t - C_t}{(1+r)^t} \quad [1]$$

Table 3
Cash flows of the considered varieties and vineyard systems.

Items (€ ha^{-1})	Years				
	0 – 2	3–5	6–10	11–18	19–25
	Sangiovese – Tendone system				
Revenues	**0.00**	**5558.00**	**7329.00**	**8872.50**	**6360.00**
Deep tillage	266.67	0.00	0.00	0.00	0.00
Plants and plant setting	4400.00	0.00	0.00	0.00	0.00
Irrigation equipment	1113.33	0.00	0.00	0.00	0.00
Fertilizers	119.23	124.80	134.60	160.06	119.77
Pesticides	38.77	173.87	194.20	256.40	162.27
Irrigation water	24.50	111.10	145.66	246.70	217.43
Fuel and lubricant	163.43	237.20	251.96	274.10	244.46
Labour	197.73	460.00	620.30	660.20	589.20
Maintenance and repair	73.63	75.30	77.92	88.40	81.91
Costs	**6397.30**	**1182.27**	**1424.64**	**1685.86**	**1415.04**
Cash flow	**−6397.30**	**4375.73**	**5904.36**	**7186.64**	**4944.96**
	Uva di Troia – Espalier system				
Revenues	**0.00**	**3762.00**	**5829.20**	**6436.25**	**4755.43**
Deep tillage	183.33	0.00	0.00	0.00	0.00
Plants and plant setting	6283.33	0.00	0.00	0.00	0.00
Irrigation equipment	880.00	0.00	0.00	0.00	0.00
Fertilizers	80.77	70.34	86.60	96.56	80.21
Pesticides	62.00	143.80	200.74	217.09	169.69
Irrigation water	29.16	132.21	151.18	175.65	120.01
Fuel and lubricant	107.43	125.07	130.75	139.26	121.42
Labour	150.98	226.50	257.65	278.41	228.00
Maintenance and repair	70.46	78.31	80.06	87.05	82.50
Costs	**7847.46**	**776.23**	**906.97**	**994.01**	**801.83**
Cash flow	**−7847.46**	**2985.77**	**4922.23**	**5442.24**	**3953.60**
	Somarello rosso – Espalier system – Excluding EU aids				
Revenues	**0.00**	**2723.33**	**4661.20**	**5810.38**	**3685.71**
Deep tillage	183.33	0.00	0.00	0.00	0.00
Plants and plant setting	6283.33	0.00	0.00	0.00	0.00
Irrigation equipment	880.00	0.00	0.00	0.00	0.00
Fertilizers	70.23	61.17	75.30	83.96	69.20
Pesticides	58.67	130.33	168.88	188.83	136.66
Irrigation water	24.50	111.10	125.04	138.34	94.53
Fuel and lubricant	97.67	113.70	118.86	126.60	110.39
Labour	141.10	210.60	240.36	260.20	213.09
Maintenance and repair	67.75	75.30	76.98	83.70	79.33
Costs	**7806.58**	**702.20**	**805.42**	**881.63**	**703.19**
Cash flow	**−7806.58**	**2021.13**	**3855.78**	**4928.74**	**2982.52**
	Somarello rosso – Espalier system – Including EU aids				
Revenues	139.00	2862.33	4744.60	5862.50	3745.29
Deep tillage	183.33	0.00	0.00	0.00	0.00
Plants and plant setting	6283.33	0.00	0.00	0.00	0.00
Irrigation equipment	880.00	0.00	0.00	0.00	0.00
Fertilizers	70.23	61.17	75.30	83.96	69.20
Pesticides	58.67	130.33	168.88	188.83	136.66
Irrigation water	24.50	111.10	125.04	138.34	94.53
Fuel and lubricant	97.67	113.70	118.86	126.60	110.39
Labour	141.10	210.60	240.36	260.20	213.09
Maintenance and repair	67.75	75.30	76.98	83.70	79.33
EU aids	75% of plant costs	417	417	417	417
Costs	**3094.08**	**702.20**	**805.42**	**881.63**	**703.19**
Cash flow	**−2955.08**	**2160.13**	**3939.18**	**4980.87**	**3042.09**

where *NPV* is the net present value, *R* and *C* represent the annual discounted revenues and costs, respectively, *t* is the cash flow time, *n* is the investment duration and *r* is the discount rate. The investment is convenient if NPV is positive and, given two or more options, the highest NPV value indicates the most opportune investment. The discount rate reflects the opportunity cost of the capital used and increases with the level of opportunity risk. Since riskier projects are expected to provide higher returns, this approach is risk-adjusted, unlike other indicators such as ROI or IRR (Gailly, 2011). In this study, the discount rate was set to 3.5% considering alternative but similar investments in terms of type, market conditions, duration and risk (Hartman and Schafrick, 2004).

Table 4
Results of the Monte Carlo analysis.

Financial methods	Sangiovese – Tendone system	Uva di Troia – Espalier system	Somarello rosso – Espalier system	
			excluding EU aids	including EU aids
NPV (€)	82,140.61	50,367.04	39,006.80	51,285.76
IRR (%)	26.18	14.70	13.16	26.09
MIRR (%)	13.86	11.28	8.71	13.39
DBCR	3.18	2.34	2.11	3.21
DPBT (years)	6.9	10.1	11.0	7.4

Table 5
Parameters of the Monte Carlo analysis.

Parameters	Years				
	0–2	3–5	6–10	11–18	19–25
Sangiovese – Tendone system					
Mean	−4732.03	7210.91	9037.5	13920.67	7926.41
Standard deviation	31.74	54.9	48.02	55.38	83.61
Coefficient of variation	−0.0067	0.0076	0.0053	0.0040	0.0105
Uva di Troia – Espalier system					
Mean	−7847.46	2985.77	4922.23	5442.24	3953.6
Standard deviation	37.03	32.03	44.81	38.19	33.55
Coefficient of variation	−0.0047	0.0107	0.0091	0.0070	0.0085
Somarello rosso – Espalier system – Excluding EU aids					
Mean	−8479.72	3729.69	4829.06	6201.88	4092.82
Standard deviation	47.19	23.91	26.00	45.43	40.13
Coefficient of variation	−0.0056	0.0064	0.0054	0.0073	0.0098
Somarello rosso – Espalier system – Including EU aids					
Mean	−1840.75	4075.25	6338.93	7920.8	5229.69
Standard deviation	10.08	41.67	38.49	72.25	43.17
Coefficient of variation	−0.0055	0.0102	0.0061	0.0091	0.0083

For the three production systems considered, annual revenues included the value of gross production, while annual costs comprised specific costs (fertilizers, pesticides, irrigation water, fuel and lubricants) and some other non-specific operating costs (machinery upkeep and labour), excluding taxes. All this information regarding each year of the vineyard was obtained from the data collected in the interviews. Annual inflows and outflows were calculated assuming constant financial conditions over the whole period of 26 years (Testa et al., 2015; Gasol et al., 2010).

IRR (Jackson and Sawyers, 2008) measures and compares the profitability of investments. In formal terms, IRR is the discount rate *r* that zeroes the NPV by the following equation (Bonazzi and Iotti, 2014):

$$\sum_{t=0}^{n} \frac{R_t - C_t}{(1+r)^t} = 0 \qquad [2]$$

An investment is profitable if the IRR is at least higher than the predetermined reference rate (Kelleher and MacCormack, 2014) and the best of several investments is the one with the highest IRR. Hence, it is an indicator of efficiency or investment yield, unlike NPV, which measures investment value or magnitude.

Table 6
Sensitivity analysis.

Financial methods	Sales price					Costs				
	−20%	−10%	Baseline	10%	20%	−20%	−10%	Baseline	10%	20%
Sangiovese − Tendone system										
NPV (€)	54,060.23	66,154.73	78,249.23	90,343.72	102,438.22	86,788.38	82,518.80	78,249.23	73,979.65	69,710.08
IRR (%)	19.45	22.26	25.16	27.48	29.94	31.14	27.75	25.16	22.51	20.41
MIRR (%)	9.34	11.21	12.59	13.67	15.09	14.43	13.46	12.59	11.61	10.79
DBCR	2.27	2.55	2.83	3.12	3.4	3.54	3.15	2.83	2.58	2.36
DPBT (yrs.)	8.7	7.9	7.4	6.9	6.6	6.4	6.9	7.4	7.9	8.3
Uva di Troia − Espalier system										
NPV (€)	34,273.74	43,233.05	52,192.37	61,151.68	70,111.00	59,672.53	55,932.45	52,192.37	48,452.29	44,712.21
IRR (%)	12.14	14.08	15.89	17.6	19.23	20.02	17.79	15.89	14.25	12.81
MIRR (%)	8.23	8.86	9.6	10.18	11.03	11.16	10.53	9.6	8.64	7.79
DBCR	1.92	2.16	2.4	2.64	2.87	2.99	2.66	2.4	2.18	2
DPBT (yrs.)	11.4	10.4	9.7	9.1	8.6	8.4	9	9.7	10.4	11
Somarello rosso − Espalier system (Including EU aid)										
NPV (€)	37,389.68	44,811.35	52,233.03	59,654.70	67,076.38	56,629.77	54,431.40	52,233.03	50,034.65	47,836.28
IRR (%)	22.07	24.73	27.24	29.63	31.91	33.02	29.89	27.24	24.97	22.97
MIRR (%)	9.77	10.93	12.65	13.94	15.15	13.91	13.18	12.65	11.93	11.05
DBCR	2.7	3.04	3.38	3.71	4.05	4.22	3.75	3.38	3.07	2.81
DPBT (yrs.)	8.4	7.8	7.3	7	6.6	6.5	6.9	7.3	7.7	8.2
Somarello rosso − Espalier system (Excluding EU aid)										
NPV (€)	23,740.00	31,161.67	38,583.35	46,005.02	53,426.70	47,710.03	42,146.69	38,583.35	35,020.01	31,456.67
IRR (%)	9.5	11.22	12.81	14.29	15.69	16.36	14.45	12.81	11.37	10.1
MIRR (%)	7.26	8.15	8.73	9.38	10.11	9.76	9.12	8.73	8.31	7.25
DBCR	1.65	1.87	2.08	2.29	2.5	2.6	2.31	2.08	1.89	1.74
DPBT (yrs.)	13.4	12.2	11.4	10.7	10.1	9.9	10.6	11.4	12.1	12.9

However, IRR assumes an unrealistic scenario, i.e. that cash flows are reinvested at the same rate of return of the project that generated them, giving an optimistic results of the considered projects. On the contrary, MIRR (Lin, 1976) assumes a more likely situation, i.e. that the positive interim cash flows are reinvested at the firm's cost of capital and compounded to the end of the project's life, while the negative interim cash flows are financed at the firm's financing cost and discounted to the beginning of the project's life. MIRR also makes it possible to obviate the multiple solutions that can be found for a project. Moreover, for mutually exclusive projects, MIRR could solve the potential NPV-IRR ranking conflict that arises due to the different cash flow distribution of investments. MIRR is calculated as follows:

$$MIRR = \sqrt[n]{\frac{FV}{-PV}} - 1 \quad [3]$$

where n is the number of periods, PV is the present value of the negative cash flows at the financing cost of the firm and FV is the future value of the positive cash flows at the firm's cost of capital. For MIRR calculation, the financing cost was set to 5% and the firm's cost of capital to 7.5%, also in this case considering alternative but similar investments, in terms of type, market conditions, duration and risk.

DBCR is the ratio between the discounted annual revenues generated during the investment life and the corresponding costs (Daneshvar and Kaleibar, 2010). It was calculated according to the following formula:

$$DBCR = \frac{\sum_{t=0}^{n} R_t/(1+r)^t}{\sum_{t=0}^{n} C_t/(1+r)^t} \quad [4]$$

Through this method, the investment is deemed convenient if the ratio is greater than the unit; given multiple investments, the one with the highest ratio is preferable (Zunino et al., 2012).

Finally, DPBT represents the number of years in which the cumulative discounted cash flows are equal to the initial investment costs (Bedecarratz et al., 2011), so that an investment becomes more opportune as the indicator decreases.

However, uncertainty in the economic performance of the considered production systems could arise through the aforesaid financial methods. Medium- and long-term investments are subject to fluctuations due to currency values and technical innovation. Therefore, a Monte Carlo analysis was applied in order to avoid the determinism of the financial indicators, thus reflecting the logic of farmers' decision-making, which derives from rational choices based on appropriate information used to evaluate economic and technical risks (Daoyan, 2010; Clemen and Ulu, 2008). For the evaluation of investment risk by forecasting estimates of cash flows, the Monte Carlo analysis can estimate the probability distribution of the chosen output as an economic indicator of analysis (Lewy and Nielsen, 2003). In operative terms, the Monte Carlo analysis was applied by generating 1000 sets of cash flows using a normal distribution for each considered period (0–2, 3–5, 6–10, 11–18, 19–25 years), with mean and standard deviation obtained from the sample data. The distinction among the investment periods was justified by the heterogeneity of their respective cash flows (i.e. negative, positive, increasing, constant and decreasing), which prevented the interpretation of investment results by a single probability distribution. Finally, the averages for each production system were calculated from the 1000 sets generated for each period.

4. Results

The financial analysis in terms of cash flows showed a higher level of economic convenience for the non-native variety than for the typical one (Fig. 1). Moreover, without EU aid, Somarello rosso gave the worst economic performance, although this improved with EU support, so that the landrace became more profitable than the non-autochthone variety, but only for the first seven years. From the eighth year, its performance gradually decreased and, by the end of the vineyard life cycle, it gave the same level of profitability as the typical variety.

Concerning the financial methods (Table 2), Sangiovese produced a NPV of 78,250 € ha^{-1}, an IRR of 25.16%, a MIRR of 12.59%, a DBCR of 2.83 and a DPBT of 7.4 years. On the contrary, for the typical vineyard, the corresponding values for the first four financial indicators were respectively 33%, 37%, 24% and 15% lower, while the DPBT was 31% higher, thus showing a generally lower profitability of the investment.

Concerning the landrace, financial performance was even worse without EU payments, with a reduction of the same indicators, respectively of 51%, 49%, 31% and 27% compared with Sangiovese, and an increase of 54% in the DPBT. These findings explained why Apulian farmers decided to abandon the historical ecotypes and showed the importance of EU supports. Therefore, with EU supports, there was a moderate financial improvement for the landrace-based vineyard, with better IRR (+8%) and DBCR (+19%) than Sangiovese. However, landrace NPV was at the same level as the typical Uva di Troia (-33%), while the MIRR and DPBT were similar to those of the non-autochthone variety. Moreover, in the comparison between this last and the landrace, the results showed a slight NPV-IRR ranking conflict, despite a difference in MIRR of just 1%. However, NPV is theoretically more accurate because of its realistic reinvestment assumption in considering the cost of capital; therefore, the analysis indicated a generally better financial performance of the Sangiovese vineyard (Table 3). On the other hand, compared to the typical variety, costs of the non-native variety were greater, especially for labour (on average +55%), fuel and lubricants (+47%), fertilizers (+37%) and irrigation water (+18%), while plant expenses were lower due to the smaller number of vines used (-43%). These differences were more stressed in comparison with the landrace, so that the costs of the non-autochthone variety were higher respectively by 58%, 52%, 45% and 34%, in addition to pesticides (+17%). Hence, the typical and landrace varieties had lower costs and higher production value, but were not able to generate a better financial performance than the Sangiovese-based vineyard. In any case, their higher production value was guaranteed by a greater consumer willingness to pay for their respective wines, due to a generally better quality, local traditions, historical agricultural knowledge and positive impact on the environment.

To sum up, the results showed that in the study area, landrace and typical varieties had lower levels of sustainability than the non-autochthone variety, mainly due to lower yields and despite lower costs and higher production values. This entailed the progressive replacement of landrace-based plants and the spread of intensive wine growing, with negative impacts on the environment and on the general quality of production.

The Monte Carlo analysis gave a clearer indication of the greater economic profitability of the Sangiovese vineyard (Table 4). In conditions of uncertainty and risk, for the non-autochthone variety, the stochastic model showed indices of profitability between 19% and 46% better than for Uva di Troia and between 1% and 38% better than the landrace with EU supports. Moreover, the analysis made it possible to bypass the NPV-IRR ranking conflict, offering a clearer view of the economic convenience of the considered investments. In addition, the Monte Carlo analysis showed coefficients of variation close to zero for each production system (ranging from −0.0067 to 0.0110), highlighting the suitability of the means used for the model fitting, with a low level of difference between the systems (Table 5).

5. Sensitivity analysis

A sensitivity analysis of variations of prices and costs was carried out in order to study the differences in financial parameters due to fluctuations in market conditions. The above economic items varied between −20% and +20%, below and above the baseline values (Table 6). This range was set taking into account the volatility of prices and production factors foreseeable in the market with current economic conditions (Di Trapani et al., 2014; Copeland et al., 2005).

Mainly, sensitivity analysis showed that sales price and cost variations greatly influenced the economic convenience of the investments. In particular, simulations indicated that, with a 20% reduction in sales price, the Sangiovese-based vineyard maintained a better performance than the typical variety at the baseline level. Compared to the landrace baseline, instead, the economic convenience of the non-native variety was lower for IRR, MIRR, DBCR and DPBT, but similar for NPV. Moreover, a 20% increase in sales price for the landrace without EU aid gave a low financial performance even as to the 20% decrease for the non-autochthone variety.

As regards costs, even with an increase of 20%, the Sangiovese vineyard still performed better. In addition, from a −20% to a +20% variation, landrace NPV performance was better than Uva di Troia.

6. Discussion and conclusions

The study indicated the better profitability of the non-native variety compared to the landrace. Moreover, the analyses highlighted the importance of EU aid, which made the landrace-based plant more profitable than the typical variety. However, the non-autochthone variety was more attractive for farmers, despite its higher operative costs. These situations were from the economic decisions of wine growers, who in the last few decades modified the level of on-farm agro-biodiversity based on assessment of their private net benefits (Pascual and Perrings, 2007; Smale et al., 2001 Smale et al., 2001), in response to market demands. Moreover, the market does not reward the social benefits of crop genetic diversity and farmers have no private incentives to encourage conservation (Perrings, 2001; Perrings et al., 2006; Meinard and Grill, 2011; Nunes and Van den Bergh, 2001). Therefore, they used more productive varieties and production systems giving high yields and needing a massive use of inputs, thus contributing to the near-extinction of the local ecotypes.

In general, the results reflected the weaknesses of the wine sector in several areas of Apulia. These concern fragmentation of the productive sector, intensive wine growing, high profitability from high yields, low wine quality, sales of grapes by farmers to wholesalers, lack of farmers' involvement in winemaking and sales, absence of a dedicated supply chain for the local varieties. In such a framework, where classic production is connected to highly productive non-autochthone varieties, and farmers are not involved in high-quality winemaking, the lower production levels of the local ecotypes mean that they are not profitable, despite their higher production value. Furthermore, it is difficult and complex to begin and to manage winemaking in the considered area, due to administrative issues and lack of technical knowledge by winegrowers. Although the regional RDP contains measures aimed at helping farmers in wine production, mainly with financial support for suitable structures and machinery, more assistance is needed in connection with technological, managerial, economic and administrative aspects of winegrowing and winemaking.

Changes in consumer preferences over recent decades require high-quality wines, and this means that structural innovations are needed in order to strengthen the sector in Apulia and start up a new supply chain exclusively devoted to vine landraces and their high-quality wines. Therefore, this requires more structured support and assistance to farmers concerning all stages of business management, from grape cultivation to wine sales. In particular, unitary and *ad hoc* measures encompassing the cultivation of landraces, the winemaking process and the wine-selling phase should be a crucial future objective for policy makers, who should firstly inform farmers of the economic, financial, environmental and social benefits of abandoning intensive production systems in favour of the local ecotypes. So that policy makers should guide winegrowers in terms of technical and administrative assistance.

The present financial analysis indicated an increased difference in NPV among native, typical and commercial varieties with the increasing of sale prices, showing that these last could be an indirect indicator of the suitability of incentives. In particular, we calculated the sale prices for the typical and native varieties able to obtain the same profitability of the Sangiovese investment. An average increase of 51%, 29% and 15% respectively in the sale price of landrace without EU aid, typical variety and landrace with EU supports can make their investments very similar to the Sangiovese one. This higher profitability could be achieved not necessarily by means of further subsides, but through a reorganization of the existing ones inside an innovative and unitary framework of supports comprising the entire supply chain of the Apulian landraces.

If these issue are addressed, the outcome could favour the preservation of Apulia's wine growing and a shift towards a more extensive approach, based on the promotion of local vine landraces and related high-quality wines produced by farmers themselves. This would lead to a consequent reduction in environmental impacts and favour the transmission of local cultural values to future generations. With a new approach to planning of subsidies, the benefits of avoiding genetic erosion will increase the welfare of all actors in the supply chain, generating higher profits for farmers, improving environmental conditions for the community and providing higher levels of quality, security and safety for consumers.

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