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# Economic Sustainability in Emerging Agro-Industrial Systems: The Case of Brazilian Olive Cultivation

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**Abstract:** The economic sustainability of agro-industrial systems expresses firms' competitive capacity and can be achieved with greater innovation, productivity and price management. The emerging olive oil agro-industrial systems in Brazil lack the information on economic and financial performance that they need to grow. The objective of this study is to evaluate the financial viability of an olive grove and the competitiveness and economic sustainability of the extra virgin olive oil using primary data collected and analyzed by the policy analysis matrix method. The main indicators considered with respect to current production and commercialization techniques are private and social profitability, added value, remuneration of domestic factors and total factor productivity. It is concluded that the emerging extra virgin olive oil agro-industrial system in Brazil has financially viable olive groves, significant competitiveness and presents economic sustainability.

**Keywords:** olive oil; policy analysis matrix (PAM); agrifood systems; competitiveness; sustainability



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## 1. Introduction

Olive farming is one of humanity's oldest production chains and covers 10.5 million hectares worldwide, with 97% in the Mediterranean Sea Basin (MSB) and 50% in Spain, Tunisia and Italy. World production reached 3197.000 tons of olive oil in 2021 [1–3]. The main olive oil importers are the USA (36%), the European Union (EU) (14%), Brazil (8%), Japan (7%) and Canada (5%), which together absorb 70% of imports [2,3]. Olive oil production will continue to feature the same pattern of heterogeneity in producer countries and increases in annual production of between 2.5% and 5% in Spain, Italy and Portugal [4]. Brazilian spending on olive oil imports [5] totaled USD 534,922.471 in 2020 on 135,463.056 kg of olives and 122,988.894 kg of olive oil in general, with 91,251.190 kg of the latter being extra virgin olive oil (EVOO).

The cultivated area in Brazil is 5986 ha, with 448.5 tons, and the largest producer (70%) is the state of Rio Grande do Sul (RS) [6,7]. The 2022 Flos Olei Guide highlighted that nine Brazilian EVOO producers appear among the top 500 from 56 countries and singled out the one that won the Emerging Farm Award [8].

This economic importance of olive oil in the Brazilian consumer market and the emergence of national production are the motivations behind this study; it also aims to advance knowledge about an agrifood system that is very prominent on the world stage, contributing to adjustments to performance indicators and to future studies. It is also worth noting the growing interest in EVOO due to its compatibility with healthier diets [9,10], in addition to the great influence of Mediterranean gastronomy, where olive oils are central elements usually associated with wine and breads.

The agro-industrial system (AGS) approach emerged in the 1990s, when competitiveness stood out in debates on industrial policy, revealing the assumptions and limitations of systems analysis [11] and emphasizing the connections of contracts and economic strategies in the various agribusiness approaches [12]. Several authors have addressed the concepts and relevance of the creation and development of agro-industrial clusters in sectoral policy [13], which define the purpose of constructing AGSs—the institutional, organizational, methodological and administrative bases for coordination and for the determination of factors of competitiveness as well as the generation of an analytical framework [14–17]. There are now models for analyzing both sectoral [18] and territorial [19] competitiveness.

The emergence and maturation of a new production cluster always presents many challenges [13,18,20]. It is significant that Brazilian olive cultivation was established in a humid mesothermal climate, classified as Cfb by Köppen [21], with an annual average rainfall of 1300 mm in the south of RS, where summers in particular differ from those in the arid territories of the south of the EU such as Seville, Spain, which receives 483 mm of annual rainfall. Even so, these MSB locations have served as technical and commercial references for the new producing regions in the Southern Hemisphere. Agile learning through benchmarking of a notably traditional sector is the fastest route to innovation in the flows or routes of research, development and innovation (RD&I) of new AGSs, as it rationalizes, reduces costs and accelerates the absorption of technologies [22]. This intense absorption of knowledge and the definition of key performance indexes [7,23] have been occurring in the Brazilian olive sector [24].

In this sense, the current productive clusters in Brazil lack knowledge about the adaptation of olive tree cultivars and modern inputs, efficient agronomic processes and agro-industrial technologies, and require better business organization and governance adjustments at both the sector level and the level of the three branches of government [7,25]. These technological and organizational innovations will allow AGS expansion and economic sustainability, which will also encourage entrepreneurs to stay in business and possibly attract new investors [26]. Therefore, approaches are required that emphasize the search for incremental knowledge derived from the market economy and that result from the aggregation of value, with the potential to subsidize decisions on sustainable productive investments and the creation of agricultural and trade defense policies.

The structure of the article is as follows: it initially analyzes, in the introduction, the general aspects of olive growing and the importance of socioeconomic assessments for the management of companies and sectoral governance, in addition to expressing the objective and research question analyzed, namely, whether the EVOO AGS in Brazil is economically sustainable. The article next presents the conceptual framework and theoretical considerations related to the application of feasibility and competitiveness analyses to agrifood systems, highlighting studies on the economic performance of EVOO production in other countries and the reference indices used for the comparisons of policy effects in the discussion of the results. The second part presents the methodology adopted (especially the robustness of the policy analysis matrix (PAM) method), the data collection procedure, the selection of indicators or coefficients to express economic performance and the meaning and usefulness of each index for interpreting AGS performance. Next, the results on investment feasibility and competitiveness are presented, the generated indices contextualized and the performance against the theories discussed. Finally, the implications for managerial measures and sectoral governance practices, including public policy recommendations, are prioritized in the study conclusions.

## 2. Materials and Methods

The Food and Agricultural Organization (FAO) has published several recommendations for the analysis of sectoral and territorial competitiveness, including quantitative assessments of the impacts of socioeconomic policies on AGSs, such as a proposed methodology called EASYPol [27], which includes the PAM method [28]. Other authors have also highlighted the PAM method, and still others have expanded its applications [18,29]. Economic evaluations are used to formulate, evaluate and estimate policy impacts on AGSs [30–32]; to identify the efficiency of emerging enterprises; and to measure the effects of innovation, productivity and competitiveness [33].

When considering the heterogeneity in production systems and business management within the same AGS, many authors use case studies to obtain real and direct accounting data from the most representative company—to the detriment of the use of average cost and revenue estimates—obtained by consensus in open stakeholder panels [16,18]. In this regard, combining the procedures for selecting representative establishments (REs) of the AGS [18] and subsequently consolidating their data into databases managed by qualified market agents or even academic researchers [34] is the most appropriate quantitative method for assessing the socioeconomic impacts of technological and organizational policies in agribusiness studies [32]. In addition, the choice of the case study format for analyzing olive cultivation is aimed at supporting decision-making on investments in the AGS, the diagnosis of economic performance problems and quickly establishing a socioeconomic knowledge base on EVOO production in southern Brazil [35]. The information obtained for productive factor allocation and technical performance assessment coincides with the views of consulted experts and is in line with data from the literature [24,36,37].

The site from which the data and information were collected was considered representative of the AGS that could serve as a reference for researchers and technical assistants, as it has adopted the most efficient technologies and modern management processes in olive and oil production, with adult olive groves in production and a mill located next to the olive groves. Accounting data from this RE were obtained in August 2021; this large company manages 341 ha of olive trees, including a 40-hectare 10-year-old olive grove in Seival, Candiota municipality, Rio Grande do Sul, Brazil, which was selected to assess the financial viability of an olive grove and has 300 plants/ha. To facilitate the comparison of the results, prices in dollars are converted to euros (EUR) at the August 2021 exchange rate, when USD 1.00 corresponded to EUR 0.84409. In converting the prices collected in this study, the average quotation adopted is EUR 1.00 to BRL 6.00.

Data collection was carried out using the PAM method, with data registration spreadsheets and formulas for calculating the competitiveness indicators and coefficients [18]. The introduction of this international methodology to Brazil, among other benefits, has consolidated an analysis model that has already supported several commercial defenses of Brazilian agribusiness in international panels, in addition to other contributions to the internal policies of the federal government. This method was developed to measure the impact of public policies, such as taxes, tariffs, interest rates set by the monetary authorities, social levies, subsidies for inputs and products, and recovery of taxes paid internally and to support decisions on allocations of productive factors and evaluations of innovation impacts in agriculture [31]. Almost all of these policies can cause disruptions in an AGS, affecting its efficiency and competitiveness at each link [34,38]. In this context, the PAM method can facilitate the formation, implementation and evaluation of investment plans in companies, in sectoral organizations such as cooperatives and throughout the production chain [18,28].

Among the strengths of this quantitative analysis technique, according to [16], is the consolidation of real accounting data from the different stages of production and for the entire system, thus allowing evaluations of raw materials producers and integrated processors (Table 1). Additionally, the method considers the complete production cost, as it includes the opportunity cost of inputs and depreciation of productive assets, and considers physical yields and technical coefficients. Market or private prices are converted into social prices to verify how much levies and taxes interfere with or dissipate the comparative advantages of the AGS, as traditionally occurs with imports of subsidized products or taxation of exports, which are transactions to be avoided according to the most elementary rule of international economics. The method further generates essential information for market intelligence processes, emphasizing logistics, identifying price-making centers and revealing the dimensions of global value chains [18].

**Table 1.** Accounting structure of the policy analysis matrix and formulas for calculating profitability indices, competitiveness indicators and policy effect coefficients.

| Price | Revenue | General Input Costs | | Profit |
|---|---|---|---|---|
| | | Tradable | Domestics Factors | |
| Private | A | B | C | D [1] |
| Social | E | F | G | H [2] |
| Wedges | I [3] | J [4] | K [5] | L [6] |

(a) Profitability, Competitiveness and Wedge Indices:
(b) Performance indicators of agro-industrial systems and calculation formulas:
(1) Share of profits in revenue (SPR%): Private = (D/A) × 100; Social = (H/E) × 100
(2) Share of added value in the revenue (SAVR%): Private = [(A − B/A)] × 100; Social = [(E − F/E)] × 100
(3) Share of the domestic factors for the added value (SDFAV%): Private = [C/(A − B)] × 100; Social = [G/(E − F)] × 100
(4) Total factor productivity (TFP): Private = A/(B + C); Social = E/(F + G)
(5) Nominal protection coefficient of the product (NPCP): A/E
(6) Nominal protection coefficient of the input (NPCI): B/F
(7) Effective protection coefficient (EPC%): (A − B)/(E − F) × 100
(8) Vulnerability of the chain to policies (VCP%): [(H − D)/H] × 100
(9) Profitability coefficient (PC): D/H
(10) Level of taxation in the chain (LTC%): L/E × (−1) × 100

Source: [16,18,28]. [1] Private profit (D = A – B − C); [2] Social profit (H = E – F − G); [3] Outbound transfer (I = A − E); [4] Incoming transfer (J = B − F); [5] Factor transfer (K = C − G); [6] Net transfer (L = D − H or L = I – J − K).

The PAM method consists of building matrices to analyze technological, environmental, labor and tax policies and other interventions in AGSs in developing countries, in addition to allowing calculation of efficiency measures and resource transfers due to the incidence of policies on prices [30,34]. The economic analyses cover three levels of policy: the microeconomic performance of producers; sectoral trade; and the macroeconomic linkages of prices paid and received under taxes and tariffs, exchange rates, interest and inflation, and market failures. The expenses and revenues recorded are those actually incurred, building the PAM with the prices paid and received at the EVOO pricing center in the corridor between the RE and the AGS located in Seival, RS, and the city of São Paulo, SP.

The formulas for calculating the competitiveness indicators used and other methodological procedures are detailed in Table 1 [30], which presents the general accounting potential of the PAM method, highlighting the effects of distorting policies expressed by social expenses, revenues and profits. The performance results can be expressed as percentages or as nominal values, and, to support interpretability, the results obtained are grouped into indicators of competitiveness, comparative advantage and subsidies, in addition to protection coefficients [18].

It is noteworthy that in the first link of the olive chain, the alternate bearing phenomenon (ABP) occurs, namely, the olive tree flowers and produces fruit on the branches only every other year. Reducing this fluctuation in the volumes produced is one of the main innovation challenges in the south Brazilian olive growing AGS. However, until now, the main solution has been to plant olive groves with different ABP cycles in different years. The demonstration of the financial impacts of this ABP have been calculated by an analysis of investments over a period of 20 years [38]. The total investment costs were EUR 80,000.00/40 ha, and the sum of the annual financing costs (expenditure on intermediate inputs and temporary work) was EUR 31,159.51/40 ha. Annual revenues were those collected up to the current age of the olive grove (10 years), added to the values estimated by experts for the following 10 years, with a minimum acceptable rate of return (MARR) of 10% per year.

## 3. Results

The production system adopted in the RE is irrigation intensive, using olive management techniques similar to those adopted in Uruguay considering the similar edaphoclimatic characteristics between the territories, which are both part of the South American

Pampa biome [21]. Other descriptions of the technical indices of the AGS of southern Brazil are described in some publications [24,26,36,37,39,40].

Table 2 presents the yield and oil extraction data of the cultivars collected in the 40 ha of the viability study with the cultivars Arbequina, Arbosana and Koroneiki [35], which adopts an irrigation-intensive and mechanized production system. Significant variations in yields were observed between the olive cultivars and in the percentages of EVOO extraction, with emphasis on the highest average yields of olives and oils by the cultivars Koroneiki and Arbequina.

**Table 2.** Olive yield and percentage of EVOO extraction by EVOO AGS cultivars in southern Brazil.

| Cultivars | Area—Ha | Productivity—kg· ha$^{-1}$ | Olive Oil Extraction—% | Olive Oil Production—kg·ha$^{-1}$ |
|---|---|---|---|---|
| Arbequina | 18 | 5919.94 | 10.95 | 648.06 |
| Arbosana | 6 | 4570.17 | 8.52 | 338.67 |
| Koroneiki | 12 | 6548.17 | 12.72 | 834.83 |
| Ripe olives | 2 | 2281.00 | 15.03 | 374.50 |
| Average | - | 5600.00 | 12.50 | 700.00 |

Source: Values collected from RE accounting data for this study.

Regarding the percentage of oil extraction, olives harvested while still green have an accentuated aroma and taste but a yield of only 12% of the weight of the olives; meanwhile, for those harvested in the full maturation phase, extraction reaches approximately 20% of the weight but the product has a less pronounced flavor and aroma. This trade-off is being faced by producers considering the national market price of local EVOO, which still has a small volume and is always fresher, as successive crops are marketed in the same year of production with late-harvested olives, which are more mature and accumulate more oil. However, simulations and sensitivity analyses can still reveal useful economic information.

### *3.1. Agricultural Costs of Olive Production in Brazil*

The average cost of olive production in Brazil was 2356.13 EUR/ha for the 2020/2021 harvest, according to Table 3. With a similar irrigation-intensive mechanized system [40], Spain presented a cost average of 2375.18 EUR/ha, while in the USA [41], with other differences accounted for, super-high-density olive groves (1917 trees/ha) with drip irrigation and complete mechanization have an average cost of 4041.73 EUR/ha. Note that these costs/ha are higher than those in Brazil but the production of olives and EVOO/ha are also higher. As with most fruit species, labor costs in olive cultivation in Brazil exceed 43% of the total cost, while fertilizers cost approximately 8% and irrigation management costs 7%. The costs of phytosanitary treatments consume approximately 5% of the total expenditures on the olive grove and have increased in recent years due to the higher incidence of diseases caused by the fungus *Colletotrichum sp*. and the greater adaptation of insect pests that damage yields, increase production costs and have the potential to cause environmental problems.

**Table 3.** Costs, agricultural income and feasibility analysis of olive production in Brazil, calculated in EUR/ha with full budgeting using the policy analysis matrix method.

| Cost in the Olive Grove (COG) | EUR/ha | Share% COG |
|---|---|---|
| **A. Intermediate inputs** | 419.93 | 18.04 |
| Fertilizers | 201.00 | 8.64 |
| Fungicides | 83.12 | 3.37 |
| Herbicides | 17.00 | 0.73 |

**Table 3.** *Cont.*

| Cost in the Olive Grove (COG) | EUR/ha | Share% COG |
|---|---|---|
| Diesel | 63.84 | 2.74 |
| Irrigation | 172.84 | 7.43 |
| Insecticides | 31.17 | 1.34 |
| B. Labor | 1020.99 | 43.87 |
| Permanent | 193.92 | 8.33 |
| Temporary | 769.21 | 33.05 |
| Technical assistance | 28.93 | 1.24 |
| C. Fixed costs | 915.21 | 39.32 |
| Land remuneration | 333.33 | 14.32 |
| Implantation of the olive grove | 160.00 | 6.87 |
| Depreciation of civil works | 35.20 | 1.51 |
| Depreciation of machines | 215.22 | 9.25 |
| Depreciation of equipment | 171.46 | 7.37 |
| Total olive grove cost = [A + B + C] | 2356.13 | 100.00 |
| Olives per hectare—kg | | 5600.00 |
| Cost of 1 ton olives—EUR | | 420.74 |
| EVOO per hectare—kg | | 700.00 |
| Revenue 1 ton EVOO | | 17,095.98 |

**Financial Feasibility of Olive Production with and without ABP**

| Indicator | Unit | with Alternate Bearing (A) | without Alternate Bearing (A) | Variation (A) – (B)% |
|---|---|---|---|---|
| Net Present Value—NPV | EUR/40 ha | 195,078.52 | 397,614.23 | −49.06 |
| Internal Rate of Return—IRR | % | 17.49 | 23.24 | −24.74 |
| Discounted Pay Back | Year | 7 | 5 | −28.57 |

Source: Values collected and analyzed for this study, based on [18,20,30,34].

### 3.2. Investment Feasibility Indicators and the Financial Impact of the ABP on Olive Groves

The net present value (NPV) obtained under the ABP was EUR 195,078.52/40 ha, and the internal rate of return (IRR) was 17.49%. The NPV without ABP was calculated considering the constant average production of 5600 kg·ha$^{-1}$ for all 20 years in the scenario with no reduction in productivity/ha, resulting in an NPV of EUR 397,614.23/40 ha with an IRR of 23.54%. Therefore, the percentage variation between the viability of investments with and without ABP (Table 3) show a revenue reduction of 49.06% with alternation in olive groves, a reduction in the time to recovery of the capital invested of 28.57% and a 24.74% increase in IRR. This result quantifies the financial impact of this phenomenon and reveals the severity of ABP damage, indicating the need for more innovations in olive production management to mitigate the effects on the productivity, competitiveness and economic sustainability of the Brazilian olive oil AGS.

### 3.3. Competitiveness of the EVOO Agro-Industrial System in Brazil

Table 4 shows the profit (private and social, in addition to the differences between them) and other competitiveness indicators for the Brazilian EVOO AGS, based on the framework in Table 1 and the expenses and revenues of the first link shown in Table 3, separated by the values before and after taxes to express the differences between prices.

These wedges indicate the impacts of policies on economic performance, in addition to possible market failures, and are quantified to allow analysis of possible adjustments to government supply, promotion and subsidy measures in negotiations between production chain agents. In addition to these aspects of measuring efficiency in the use of inputs and the comparative advantage of the AGS, they reflect aspects of equity in revenue distribution across production chain links and the sustainability of the production system.

**Table 4.** Competitiveness and comparative advantage indicators and policy impact coefficients for the EVOO AGS in Brazil.

| Links and Prices | Revenue—EUR/ton | General Inputs Costs—EUR/ton | | | Profit—EUR/ton |
|---|---|---|---|---|---|
| | | Tradable | Domestic Factors | | |
| | | | Labor | Land and Capital | |
| Private Price | | | | | |
| First Link [1] | 3736.15 | 391.13 | 1272.76 | 915.21 | 1175.05 |
| Second Link [2] | 6.67 | 3.47 | 0.97 | 0.58 | 1.65 |
| Third Link [3] | 13,333.33 | 2.893.82 | 2604.54 | 120.10 | 7714.87 |
| Fourth Link [4] | 19.83 | 10.32 | 2.88 | 1.73 | 4.90 |
| Chain [5] | 17,095.98 | 3298.73 | 3.881.15 | 1037.62 | 8878.48 |
| Social Price | | | | | |
| First Link | 3899.57 | 343.91 | 1704.15 | | 1851.51 |
| Second Link | 7.05 | 2.69 | 1.02 | | 3.35 |
| Third Link | 14,305.34 | 1877.95 | 1502.10 | | 10,925.29 |
| Fourth Link | 5.44 | 7.58 | 3.03 | | 5.17 |
| Chain | 18,217.40 | 2232.12 | 3210.30 | | 12,774.98 |
| Wedge (Private Price—Social Price) | | | | | |
| Wedge | (1121.42) | 6399.65 | 8740.15 | | (3644.72) [6] |

[1] Agricultural or olive production; [2] transport from production to processing; [3] olive processing or mills; [4] transport from processing to retail; [5] total production chain in the Seival–Candiota–Rio Grande do Sul corridor to São Paulo; [6] profit reduction or transfer from the production chain to society from the 28.53% profit rate. Source: Values collected from the RE and analyzed for this study, based on [18,20,30,34].

Coefficients and Indicators of Competitiveness, Comparative Advantage and Policy Effects in the EVOO AGS in Southern Brazil

The ten indicators gathered in Table 5 present reference financial coefficients for the competitiveness of the EVOO AGS in Brazil. The coefficients that reveal the comparative advantage and competitive capacity, in addition to the protection or subsidy coefficients, can be understood as metrics capturing sectoral and systemic aspects of the competitiveness and sustainability of the Brazilian EVOO AGS. These coefficients, in general, are frequent in analyses of industry and economic sector performance, and in formulations or evaluations of regional or national development programs.

**Table 5.** Competitiveness coefficients and effects of policies on the EVOO AGS in southern Brazil.

| | | |
|---|---|---|
| (a) Share of profits in revenue (SPR) (%) | | |
| Private | $(D/A) \times 100$ | 51.93 |
| Social | $(H/E) \times 100$ | 70.13 |
| (b) Share of added value in revenue (SAVR) (%) | | |
| Private | $[(A - B)/A] \times 100$ | 80.70 |
| Social | $[G/(E - F)] \times 100$ | 87.75 |

**Table 5.** *Cont.*

| | | |
|---|---|---|
| (c) Share of domestic factors in added value (SDFAV) (%) | | |
| Private | $[C/(A-B)] \times 100$ | 33.83 |
| Social | $[G/(E-F)] \times 100$ | 20.01 |
| (d) Total factor productivity (TFP) | | |
| Private | $A/(B+C)$ | 2.15 |
| Social | $E/(F+G)$ | 3.35 |
| (e) Nominal protection coefficient of the product (NPCP) | | |
| | $A/E$ | 0.94 |
| (f) Nominal protection coefficient of the input (NPCI) | | |
| | $B/F$ | 1.48 |
| (g) Effective protection coefficient (EPC) (%) | | |
| | $(A-B)/(E-F) \times 100$ | 86.31 |
| (h) Vulnerability of the chain to policies (VCP) (%) | | |
| | $[(H-D)/H] \times 100$ | 28.53 |
| (i) Profitability coefficient (PC) | | |
| | $D/H$ | 0.71 |
| (j) Level of taxation in the chain (LTC) (%) | | |
| | $(L/E) \times (-1) \times 100$ | 20.01 |

Source: Values collected and consolidated for this study, based on [18,20,30,34].

The ten indicators in Table 5 present financial reference coefficients for the competitiveness of the EVOO AGS in Brazil, interpreted according to the theoretical framework [18] and the theory of free market and competition rules in open markets of the international economy [16,42]. The coefficients reveal that the Brazilian EVOO AGS does have a comparative advantage and competitive capacity, despite the high and complex incidence of taxes. The metrics used make it possible to identify sectoral and systemic aspects of competitiveness and economic sustainability, expressed in the performance coefficients of this industry; the indicators are also useful for the formulation or evaluation of development programs.

(a) Share of Profits in Revenue—SPR = $(D/A \times 100)$

The private net income of 8878.48 EUR/t from EVOO represents 51.93% of the AGS's gross revenue, which is 17,095.98 EUR/t in the corridor from Candiota, RS, to São Paulo, SP. This net revenue for each ton of EVOO is equivalent to the private profitability index called EBITDA, which can reach up to 70.13% in the complete absence of taxes and market failures—that is, the share of profit in social revenue can grow by 18.2%. These values indicate that producers will remain in the activity and, if this profit share is maintained, the chain will be able to attract new investments, as the yields are higher than those offered by the financial market; this confirms the financial viability of the olive grove, which has an IRR of 17.43%. Thus, if this situation is maintained, there will be economic and financial conditions for the growth and development of this AGS. In other words, with the current prices and business environment, this EVOO production and marketing system is competitive and economically sustainable.

(b) Share of Added Value in Revenue—SAVR = $[(A-B)/A] \times 100$

The share of added value in revenue is the most important indicator related to agricultural innovation, representing the effective contribution of tradable inputs in the domestic market to the generation of GDP. Added value in the olive chain was 80.70% for private prices and 87.75% for social prices. The indicator also reveals the contribution of all tradable inputs to the significant remuneration for work, fixed capital (machinery and equipment) and land. This result means that domestic factor allocation can be considered efficient and that there is no risk of these factors shifting to employment in another economic activity.

(c) Share of Domestic Factors in Value Added—SDFAV = $[C/(A-B)] \times 100$

The allocation efficiency logic that governs competitiveness analyses indicates that the greater the expenditure on intermediate inputs in relation to production factors (labor, land and capital), the greater the productivity of the productive and commercial system under study [16]. This is because the use of modern inputs is a desirable signal of high technification and, thus, results in greater innovation and high competitiveness. In the same sense, the smaller the share of domestic factors in revenue, the more competitive the system under study. The value of 35.65% for private prices means that domestic factors have a relatively high weight in subtracting resources that could be used on intermediate inputs. In view of the values in Table 4, it appears that this high share is due to labor costs, whose weight of 43.87% in the total cost of olive production is shown in Table 3. This high labor cost share also occurs in milling, with a value of EUR 2604.54 for each ton of oil produced in the agro-industry.

The implications for production management are related to the need to evaluate alternatives to increase mechanization in the olive grove and in milling, both aimed at reducing labor costs and changing how employees are hired, shifting from recruitment of individuals toward links with legal entities, as the incidence of social levies on the latter is lower. This possibility is confirmed by the scenario without the burden on domestic factors and on total revenue, as the social price share is reduced to 20.08% in Table 4.

(d) Total Factor Productivity—TFP = A/(B + C)

This is the second most important coefficient to measure the efficiency of an agro-industrial system, as it estimates the rate of return on investments according to the AGS's technological and organizational innovation standard. The factors associated with the growth of TFP are improvements in product quality; increments in human capital; higher technological levels; and adequate RD&I services and financing, logistics and other aspects related to productive performance. Low TFP is correlated with the survival of the AGS because when the calculated value is zero, net revenue is null because the gross revenue pays only the total costs of production and commercialization. In Table 4, the TFP value for Brazil's EVOO AGS is 2.08 in the presence of taxes. In terms of social prices—that is, in the absence of policies that distort competitiveness—TFP is 3.35. The TFP values observed in this study are similar to the average for Brazilian agriculture [18]. Therefore, EVOO production in Brazil can have consistent growth, and the evolution can be even faster with adjustments to labor expenses. These results corroborate other studies in Brazilian agribusiness and are similar to the TFP of 1.49% found for North American agribusiness between 1948 and 2011 [41].

(e) Nominal Protection Coefficient of the Product—NPCP = A/E

The value of 0.94 of the nominal protection coefficient of the product indicates that there is taxation on AGS revenue from EVOO in Brazil; it is similar to the value of 0.90 observed for oilseeds for biodiesel in Brazil [34]. According to Table 2, this result means that Brazilian EVOO is taxed higher than the international average; however, this distortion also occurs in countries that have already carried out tax reforms, and any changes must be preceded by a breakdown of the incidence of the tax on income or gross revenue. Taxes on net income are constitutional and, therefore, are more difficult to change than those dependent on the administrative spheres of government. Hence, the implications of this result of nominal protection of the Brazilian EVOO are related to possible governmental incentives and programs to promote production that may affect sustainability and reduce the competitiveness of the national product vis-à-vis imported products.

(f) Nominal Protection Coefficient of Inputs—NPCI = B/F

The nominal protection coefficient of inputs is estimated at 1.48 and reveals the existence of high protection via taxes on the inputs used in the EVOO chain in southern Brazil, since the real expenditure (private prices) with annual inputs per ton of EVOO is EUR 8217.50. According to the results in Table 4, with taxes and other charges discounted, the cost would be 5442.42 EUR/t. Thus, the chain is taxed both on the EVOO sold and on the inputs used, with a greater nominal weight on labor than on the acquisition of intermediate inputs. Intermediate inputs are sources of innovation, increased productivity and added value in the AGS; however, the incidence of taxes on the prices paid increases the amounts disbursed by producers by 147.78%. This taxation then interferes negatively with RD&I promotion policies since the greater the adoption of new technologies or organizational processes, the greater the nominal value to be paid. This situation reinforces the need to reassess the amounts paid obligatorily to the state.

(g) Effective Protection Coefficient—EPC = $(A - B)/(E - F) \times 100$

The effective protection coefficient is the ratio of the differences in private revenues minus the cost of tradable inputs to social revenues minus the social cost of inputs. Thus, it is a coefficient between the value added at private prices and the value added at social prices, bringing together in the same formula the impacts of policies that distort the prices received by the EVOO and those that change the prices paid for the inputs used, allowing the identification and quantification of the weight of all fiscal policies in just one coefficient. Therefore, it is more complete than the last two coefficients above. The result of 86.31% expresses the amount of total revenue generated in the AGS that is withdrawn by taxes and tributary charges on intermediate inputs and on total revenue, causing a decrease in profitability (Table 4). It allows simulation of the new levels of competitiveness with a reduction in these charges, especially with respect to avoiding this double taxation.

(h) Vulnerability of the Chain to Policies—VPC = $[(H - D)/H] \times 100$

The coefficient for the vulnerability of the chain to policies is 28.53%, which means that there is a negative impact of all the policies considered in this study on AGS profitability in Brazil; the coefficient expresses the weight of the difference between private and social profits that would occur with the complete removal of the items that reduce profitability. The competitiveness and, ultimately, economic sustainability of the system are important. This vulnerability coefficient matters for the governance of the AGS because the more efficient the technology in the links, the lower their vulnerability to public policies, taxes and other market failures or inefficiencies.

(i) Profitability Coefficient—PC = $D/H$

The calculated probability coefficient of 0.71 results from the wedge between private profit and social profit, and confirms that the AGS private sector receives only approximately two-thirds of the total added value due to taxes paid on the purchase and use of inputs in general and on revenue. This value expresses that the chain is being taxed net, as values lower than unity proxy for a reduction in profit due to the transfer of net revenue to other AGSs or outside agriculture due to market distortions. Note also that this coefficient is more aggregated than that of the vulnerability of the system to policies, as it includes the impacts of policies on domestic production factors. The comparison of this indicator with the ones for other agribusinesses indicates greater profitability for the EVOO AGS, probably due to the high prices obtained by national EVOO in relation to imported products.

(j) Level of Taxation in the Chain—LTC = $(L/E) \times (-1) \times 100$

The level of taxation in the chain coefficient results from dividing the difference between private and social profitability by social profit, expressing how much profitability the AGS loses, in percentage terms, due to excessive taxation, since taxes, high interest rates on financing and charges can be reduced. Thus, the higher the result is, the higher the taxation. In Table 4, the result of 20.01% can be interpreted as the sum of all public policies that are excessively burdensome and, therefore, reduce competitiveness. This level of EVOO taxation in Brazil is similar to the findings of studies on agribusiness in RS [33], albeit slightly lower. These results indicate the importance and need for further studies to support reviews of economic freedom and adjustments to competitiveness in view of future scenarios and trends of increased competition.

## 4. Discussion

Brazil's emerging olive oil production system is mainly concentrated in Rio Grande do Sul and some areas in the high mountains of Southeast Brazil, with production of approximately 0.5% of national consumption. Total import volumes of olive oils and olives in 2020 were USD 472,774,818.00, and commercial production initiatives prove that the industry is characterized by technical feasibility in Brazil, despite the few experimental findings on climate and soil conditions for current production clusters.

From a marketing point of view, the International Olive Council sets quality standards for olive oils, but Brazil has not yet gained access. Current standards for EVOO are not widely applied and allow a wide range of olive oil qualities to be marketed as extra virgin. This situation allows adulterations and mislabeling, thus affecting the competitiveness of high-quality products. Consumers, not distinguishing the differences in standards, gravitate toward less expensive oils, giving an advantage to large bottlers who sell low-cost, imported products. A similar situation occurs in the USA, where this lack of enforcement has resulted in a long history of fraudulent practices [42].

These considerations justify the need to analyze national performance with economic evaluations that allow estimation of the returns and remuneration of the productive factors employed in addition to the impacts of the use of current technologies and taxes, and other market failures. These results also contribute to the advancement of knowledge and can support future investment decisions.

### 4.1. The Microeconomic Dimension

The results come from a case study based on 10-year-old olive groves composed of 18 ha of Arbequina that produce an average of 648 kg/ha of EVOO, 12 ha of Koroneiki that produce an average of 835 kg/ha and 6 ha of Arbosana that produce an average of 339 kg/ha. On the other dimensions, data were collected for the entire property. These results indicate the lower adaptation of the cultivar Arbosana (4570 kg/ha and 8.52% extraction), in contrast to the yield and percentage of oil extraction of the cultivars Koroneiki (6548 kg/ha and 12.72% extraction) and Arbequina (5920 kg/ha and 10.95% extraction), as shown in Table 2. These three cultivars are the most used worldwide for crops with high plant density per hectare; however, this system does not seem to be suitable for the soil and climate conditions of the current production territories in Brazil. High humidity predominates and favors phytopathogenic diseases that increase the cost of production and can, thus, generate problems in the sustainability of olive farming.

The cost of producing olives in this adult olive grove is 2356.13 EUR/ha, and the largest items of expenditure are labor, fuel, fertilizers and phytosanitary products, generating 5600 kg/ha of olives and an overall average of the extra virgin olive oil obtained with the three cultivars of 700 L of EVOO/ha. This technical performance expresses an average cost of 420.00 EUR/ton of olives produced, as shown in Table 3. The average yields of extra virgin olive oil are due to the average extraction percentage of 12%, obtained with olives considered still green but with a higher content of desirable components to increase the characteristic aroma, bitterness and spiciness of this type of oil. When ripe, olives can generate approximately 20% extraction; however, the intensity of these components, which are appreciated by haute cuisine and the demanding palate, is lower.

Generally, the technical performance of olive groves in Brazil can be considered low when compared with that of Spain, which has similar production patterns but yields of approximately 10,000 kg of olives/ha and 2000 kg of olive oil/ha, with 20% extraction [41]. However, current wholesale prices in Brazil are 17,095.98 EUR/ton of EVOO. This price can be considered high and, thus, compensates for the low physical yield. These favorable price conditions are confirmed by the profitability of the olive groves, which is 1175.05 EUR/ha, averaged across all other areas of the property.

The feasibility analysis of this investment in the olive grove over a period of 20 years under an MARR of 10% shows an internal rate of return of 17%, an NPV of 4876.96 EUR/ha and a payback period of 7 years. At the same time, the EBITDA calculated by the PAM method is 51.93% of the gross revenue of the AGS, as shown in Table 4. The ABP, which constitutes one of the main innovation challenges in the EVOO AGS in Brazil, impacts the financial viability of the olive grove, as it causes reductions of 24.74% in IRR and 49.06%

in NPV, and reduces the payback period from seven to five years (28.57%), as shown in Table 3. These estimates are useful to justify the orientation of new investments in the sector, in addition to being important for supporting new technological innovation projects in olive production in Brazil.

### *4.2. The Mesoeconomic Dimension*

In the mesoeconomic dimension, the results of Table 4 reveal the competitiveness of the EVOO AGS: the average profitability of the production chain taken as representative is EUR 8878.48 per ton produced. This economic performance is mainly due to the current average price of 13,333.33 EUR/t of EVOO received by the mill, which is 315% above the maximum prices (EUR 423.00/100 kg) identified for the producers in Jaén, Bari and Chania [2], which account for 60% of the global olive oil market. The high price received by the national product also confirms the average value of Brazilian imports of 4.85 USD/kg [4].

In addition, the positive economic performance of the AGS is confirmed by net income (share of profits in revenue (SPR)), which represents approximately half of the total revenue, also known as EBITDA [18]. The effective share of value added in revenue from production and commercialization of EVOO is 80.70%, indicating that there is an effective contribution of intermediate inputs to the detriment of domestic factors in the generation of profit. In this regard, according to Table 5, the degree of global performance of the oil sector in Brazil presents a TFP of 2.15% in terms of private prices, which is significant in comparison to the figures for other agro-industrial systems [43].

The current competitiveness of Brazil's EVOO AGS will change due to price volatility, fluctuations in exchange rates and inflation, increased competition and the effects of future agricultural, industrial, sectoral and systemic policies. Therefore, there is a trend toward a reduction in the prices received in the medium- to long-term, causing threats to economic sustainability. At this juncture, the solutions will involve increasing the productivity of olive groves, raising the price of EVOO through greater promotion and increased consumption, reducing costs by rationalizing production factors and improving production management, including technological intensification and mechanization to reduce high labor costs. Finally, greater production efficiency will be necessary, especially in olive groves, as will be further studies to estimate impacts.

### *4.3. The Macroeconomic Dimension*

In general, the policy impact coefficients (listed in Tables 1 and 2) confirm that the EVOO AGS in Brazil is competitive, that the continuity of the chain is viable and that there is the possibility of attracting new investments. On the other hand, there is high and complex taxation on AGS inputs and products in Brazil, resulting from the weak advance of tax exemptions for the Brazilian productive sector in general.

For example, the wedge between private revenue (prices with taxes and market failures) and social revenue (prices without taxes) in olive production is 167.42 EUR/t, while in olive oil agro-processing, it is 972.01 EUR/t. Together, they generate a tax collection of 1139.43 EUR/t on revenues from olive grove and mill sales alone, without considering the impact on transport revenues (the second and fourth links).

However, this transfer of revenues from the private sector to governments is greater in view of the encumbrances on inputs in general, which can be estimated by the difference between private and social profit, which is EUR 3644.72 for each EVOO producer in Brazil. These results indicate that the olive sector transfers 8.46% of its net income in taxes to the state while the olive oil agroindustry is taxed at 41.09%. Across the AGS, the reduction in private profit due to taxes and possible market failures is 30.34%.

In parallel with the adjustments to macroeconomic policies and taxes on intermediate inputs and, especially, on domestic production factors, it is recommended to evaluate the impacts of the European subsidy to olive oil producers, especially from the perspective of customs or economic integration of the European Union with Mercosur.

## 5. Conclusions

This article sought to generate useful information to support the economic sustainability of the emerging agro-industrial system of extra virgin olive oil in Brazil, analyzing productive and commercial performance indicators related to production costs and revenues, feasibility analysis and profitability coefficients of the production chain to characterize competitiveness. In these analyses of the current competitive dynamics, the technological and organizational capabilities of the system were considered in terms of productivity, efficiency and product quality.

In conclusion, it was observed that olive production in southern Brazil is viable despite the low oil yield per hectare (700 kg/ha), which is compensated by the high local wholesale price of extra virgin olive oil. The current total revenue is approximately three times that obtained by producers in the main pricing centers in Europe and, similarly, higher than the average FOB value of Brazilian imports in 2021.

The competitiveness indices indicate that the EVOO AGS in Brazil has comparative and competitive advantages, since all the accounting indicators of the productive and commercial system show efficiency and the performance coefficients of policies in general also characterize an economically stable olive growing system, despite the significant tax impacts. As the expected trend is for a reduction in national EVOO prices, due to increased production, price volatility, fluctuations in exchange rates and inflation, increased competition and the effects of future economic policies, it is recommended that aspects related to productive efficiency be monitored and taxation policies on intermediate inputs reoriented. Similarly, new agricultural technologies must be generated, and a reduction in direct taxes on labor, energy and logistics that most impact performance should be evaluated.

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