PROFITABILITY RISK IN CONVENTIONAL AND ORGANIC DAIRY FARMS IN SÃO PAULO STATE, BRAZIL

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Juliana Cristina dos Santos[1]
Lucilio Rogerio Aparecido Alves[2]

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ABSTRACT

This study analyzed and compared the economic risks of conventional and organic milk production systems in the regions of São José do Rio Preto, Mococa, and Ribeirão Preto (SP), from January 2017 to September 2021, focusing on the probability of negative net margins. For conventional systems, panel data (typical farms) were used, while a case-study approach was adopted for organic systems. Costs were classified into Effective Operating Cost (EOC) and Total Operating Cost (TOC), and revenues included milk and animal sales, which together composed Gross Revenue (GR). Total Net Margin (TNM) and Net Margin considering only milk sales (MNM) were estimated using stochastic simulations to assess

[1] University of São Paulo (USP). Luiz de Queiroz College of Agriculture. Piracicaba/SP, Brazil. https://orcid.org/0009-0009-9998-4639

[2] University of São Paulo (USP). Luiz de Queiroz College of Agriculture. Piracicaba/SP, Brazil. https://orcid.org/0000-0002-9959-590X

risk. Results indicated a low probability of negative profitability when total GR was included. However, when only milk revenue was analyzed, high liquidity risks emerged, particularly for organic farms, with up to an 87.7% probability that milk revenue would not cover TOC. Despite presenting better zootechnical performance indicators, organic systems showed greater economic vulnerability, mainly due to high expenditures on externally purchased concentrates. Sensitivity analysis revealed that milk revenue and concentrate feed costs were the primary determinants of Net Margin. The findings support management strategies and policy design aimed at strengthening the economic sustainability of dairy farming by highlighting the central role of feed cost control and productive efficiency in mitigating liquidity and profitability risks.

Keywords: Organic milk. Production cost. Stochastic simulations. Typical farm.

RISCO DE RENTABILIDADE EM PROPRIEDADES LEITEIRAS CONVENCIONAIS E ORGÂNICAS NO ESTADO DE SÃO PAULO, BRASIL

RESUMO

Este estudo analisou e comparou os riscos econômicos em sistemas de produção de leite convencional e orgânico nas regiões de São José do Rio Preto, Mococa e Ribeirão Preto (SP), no período de janeiro de 2017 a setembro de 2021, com foco na probabilidade de margens líquidas negativas. Para os sistemas convencionais, utilizaram-se dados de painel (typical farm) e, para os orgânicos, estudo de caso. As despesas foram organizadas em Custo Operacional Efetivo (COE) e Custo Operacional Total (COT), enquanto as receitas incluíram as vendas de leite e de animais, compondo a Receita Bruta (RB). Foram estimadas a Margem Líquida Total (MLT) e a Margem Líquida considerando apenas a venda de leite (MLL), com aplicação de simulações estocásticas para mensuração dos riscos. Os resultados indicaram baixa probabilidade de rentabilidade negativa quando considerada a RB total. Entretanto, ao analisar apenas a receita do leite, observaram-se elevados riscos de liquidez, especialmente em propriedades orgânicas, com probabilidade de até 87,7% de a receita do leite não cobrir o COT. Apesar de apresentarem melhores índices zootécnicos, os sistemas orgânicos mostraram maior vulnerabilidade econômica, associada principalmente ao elevado custo com concentrados adquiridos externamente. A análise de sensibilidade evidenciou que a receita do leite e os gastos com alimentação concentrada foram os principais determinantes da Margem Líquida. Os achados contribuem para o delineamento de estratégias de gestão e para a formulação de políticas voltadas ao fortalecimento da sustentabilidade econômica da atividade leiteira, ao evidenciar a centralidade do controle de custos alimentares e da eficiência produtiva na mitigação dos riscos de liquidez e rentabilidade negativa.

Palavras-chave: Leite orgânico. Custo de produção. Simulações estocásticas. Fazenda típica.

1 Introduction

The international demand for organic products is increasing. Given the global context of the search for food security and healthier products, this trend should be maintained in the coming years with fewer negative social and environmental impacts (Lima et al., 2020). Studies indicate that companies dedicated to rebuilding a fairer and more sustainable world will gain a competitive advantage over other enterprises and social trust in the product brand (Westbrook; Angus, 2021). Therefore, the observed strategies have evolved from good positioning to social and environmental purpose-focused practices (Westbrook; Angus, 2021).

However, the adoption of new eating habits, increased purchasing power, and improvements in population welfare have contributed to the growth of *per capita* consumption of dairy products (Vilela et al., 2017). For Brazil, the projection of the Federation of Industries of the State of São Paulo (FIESP, 2020) indicates that the per capita consumption of liters of milk should increase from 161.6 liters/per inhabitant/per year in 2018 to 210.4 liters/per inhabitant/per year in 2029, that is, a 30% growth in demand.

Given the expected increase in demand, it is also relevant to analyze producers' profitability, risk, and economic attractiveness. It is common for producers to question the low profitability, at the same time that studies are seeking to evaluate the situation of organic production as an alternative, compared to conventional production, both for cattle and small animals, in Brazil and important producing countries (Acs; Berentsen; Huirne, 2007; Balestrin; Frandaloso; Bertoglio, 2020; Bassotto et al., 2022a; Berentsen; Kovacs; Van Asseldonk, 2012; Flaten et al., 2005; Gardebroek, 2006; Olini et al., 2020; Ramos et al., 2020; Salinas-Martínez et al., 2020; Schiavon et al., 2021; Stonehouse; Clark; Ogini, 2001; Tzouramani et al., 2011).

Several studies have examined dairy supply chains in Brazil (Acosta; Souza; Bankuti, 2018; Bassotto et al., 2022b; Silva Neto; Basso, 2005). However, studies that analyze and compare conventional and organic milk production systems, particularly with respect to economic risk and the probability of negative margins, remain scarce. Among the studies that characterize Brazilian milk production and discuss profitability aspects, one can mention (Alves et al., 2009; Balestrin; Frandaloso; Bertoglio, 2020; Bassotto et al., 2022a; Olini et al., 2020; Ramos et al., 2020; Schiavon et al., 2021; Vilela et al., 2017).

In light of this gap, the following research question emerges: Is organic milk production economically viable for Brazilian dairy farmers when compared to conventional systems, and which cost and revenue factors most strongly influence the risk and probability of negative net margins in each production model?

A detailed comparison at the farm level makes it possible to determine the differential causes of performance between activities using alternative production methods and to identify risk factors, especially in comparison with conventional milk production. Moreover, analyzing production risks, a tool used by market agents, helps evaluate uncertainties by measuring economic returns, enabling adjustments in the management of the enterprise (Hertz, 1979).

Given these aspects, this study aims to analyze and compare the financial and economic risks of conventional and organic milk production systems in the producing regions of the state of São Paulo, Brazil, including the microregions of São José do Rio Preto, Mococa, and Ribeirão Preto. Furthermore, it seeks to identify the main factors associated with the probability of negative profitability across two conventional production farms and three organic milk-producing farms.

To produce a product, a set of interdependent operations affects economic outcomes (Davis; Goldberg, 1957; Goldberg, 1968). The instability of agricultural income is one of the problems that most affects the production complex. Among the various problems facing commercial agriculture, pressure on production costs is the main factor hindering capital formation along the chain.

To better manage activities, it is paramount to understand cost variations, revenue variability, and the risks of negative margins that affect the activity's economic sustainability. Burton Junior et al. (1996) defined management as managing activities related to decision-making and farm administration. Osaki and Batalha (2014) suggested using an agricultural planning model under risk conditions to select the best products with higher returns and lower risk. Planning an activity as a tool in the administrative process helps decision-makers choose the best production strategies.

The decision-making process regarding investment is challenging, not because of the need for return projections, but because of the difficulty of measuring and quantifying its impacts. Each hypothesis involved a certain level of uncertainty and imminent risk. Risk assessment, a tool used by market agents, helps reduce uncertainty by measuring returns and informing management decisions (Hertz, 1964, 1979). Furthermore, the risk scenarios simulated by the Monte Carlo method enable improved decision-making within the production structure by adjusting production volume based on the expenditures generated by the activity (Barros et al., 2019; Osaki et al., 2019).

Haddade et al. (2005) identified the items with the greatest impact on the profitability of dairy cattle farmers located North of Rio de Janeiro: milk pricing, buying and selling animals, labor, and the use of concentrate for feeding adult animals. The authors applied the Monte Carlo simulation method to evaluate financial aspects. They found that the dairy farms analyzed had a 39% probability of profitability, which was lower than the 6% annual rate of return.

Rotz et al. (2007) evaluated the differences in economic performance between conventional and organic dairy production systems in Pennsylvania, USA, from 2004 to 2006. Data from four dairy farms indicated that organic farms had lower herd-maintenance costs, such as veterinary expenses, due to the animals' excellent health.

However, the production costs estimated by Rotz et al. (2007) did not vary much between organic and conventional farms in Pennsylvania, ranging from $32,700 to $61,900 on organic farms and from $53,100 to $63,800 on conventional farms. The recognized difference in the comparison between the farms was the return on variable costs, which showed relatively better values in organic production (from $2.6 thousand/cow to $3.8 thousand/cow) compared to the returns of conventional output (from $1.7 thousand/cow to $2.1 thousand/cow). In addition, income is higher when selling organic products, surpassing the unit sale value of regular milk (Rotz et al., 2007). They pointed out that the economic efficiency of an organic farm is sensitive to milk prices.

To understand the motivators for not converting from conventional to organic milk production in the Netherlands, Berentsen et al. (2012) evaluated and compared the risks between the two systems, considering the gross margin, price, and production variables. They obtained data from 2001 to 2007 using the panel method. The results indicated that the main risk variables were milk production per cow, gross forage per hectare, and veterinary costs per animal. They found that the gross margin risk per cow was significantly higher in organic farming due to higher milk and concentrate prices and production risks, resulting in greater per-cow volatility in the organic system.

In Brazil, organic milk production can be an economically viable alternative for cattle farmers, provided remuneration is higher than that of conventional production, as found by Alves et al. (2009) and similar to that identified by Rotz et al. (2007). A case study conducted between 2002 and 2004 on an organic dairy farm in the Federal District of Brazil indicated that between 34% and 56% of gross revenue came from organic milk and 44% to 66% from the sale of animals.

Alves et al. (2009) pointed out that premiums for organic milk, compared to conventional milk, are essential for the net income of organic dairy farms to be positive. Because milk prices fluctuate in the consumer market, a risk assessment of the financial efficiency of organic milk production is necessary to determine the viability of this activity.

For authors, such as Olini et al. (2020) and Schiavon et al. (2021), milk production in Brazil and its sustainability are influenced by the number of lactating cows in terms of the total herd, productive performance, productivity per area, milk quality, use of artificial insemination, and supplementation (concentrate and minerals). Profitability is inversely related to labor costs and productivity. There is also evidence that land productivity (milk production per area and the number of lactating cows per area used by the herd) has a more significant impact on the profitability of dairy cattle ranching than herd productivity indicators.

Overall, however, the literature on economic risks in organic dairy farms is still limited. Therefore, the present study aimed to assess the extent to which producers in the State of São Paulo, Brazil, produce organic milk.

In addition to this introduction, which presents the study's theoretical framework, the paper is organized into three sections. The second section describes the materials and methods, including data collection for conventional and organic systems, price series construction as well as the design of the stochastic simulations. The third section presents and discusses the results. The final section highlights the main findings and outlines managerial implications for dairy production.

2 Material and Methods

We conducted this research using a quantitative approach that enables numerical assessment and description of trends, attitudes, and opinions within a given sample (Creswell; Creswell, 2021). In the following sections, we describe the procedure adopted in the research, covering data collection; the construction of the price time series; the generation of distribution functions; the derivation and composition of gross revenue, production costs, and economic performance indicators; and, finally, the stochastic simulation.

2.1 Data Collection in Conventional and Organic Activities

We obtained databases on conventional milk production systems from the Center for Advanced Studies in Applied Economics and Brazil's Confederation of Agriculture and Livestock (CEPEA-Esalq/USP; CNA, 2021). They used a typical farm methodology to structure production costs (Chibanda et al., 2020; Plaxico; Tweeten, 1963). Therefore, the information collected pertains to production costs in conventional dairy farming in São José do Rio Preto/SP and Mococa/SP, with 2017 as the base year.

For the organic system, we applied the case-study method proposed by Yin (2015). The information survey was conducted through interviews with three milk producers in the Ribeirão Preto/SP region, using the same cost structure as conventional farms to standardize the data and facilitate subsequent comparisons. Organic production systems were characterized relative to 2020.

Typical farms were selected from the state of São Paulo's main milk-producing regions. For organic production, the case studies also sought to involve producers with similar production conditions in nearby regions. The study period, which ran from 2017 to 2021, was determined based on the most up-to-date technical coefficients available and on a sufficient number of years to allow for stochastic analyses. This type of study does not require ethics committee authorization, as it involves economic data on agricultural businesses.

The technical coefficients evaluated were milk revenue, revenue from animal sales, general expenses, bulk (silage + forage), concentrate + mineral supplementation, maintenance, milking material, hired labor, and depreciation. We use the general price index–domestic availability (IGP-DI) for September/21 to deflate actual prices. However, to hire labor and technical assistance (allocated to general expenses), we used the National Wide Consumer Price Index (IPCA) for September/21.

2.2 Price Series Constructions

Using the technical coefficient definitions for the two production structures (conventional and organic), input price variations were applied to each subgroup of production revenue and costs to derive the evolution of the monthly price time series from January 2017 to September 2021. First, we use the primary database made available by CEPEA-Esalq/USP (2021) to identify variations in quotations for agricultural inputs and other items used to track the evolution of the series, such as the prices of milk, corn, soybeans, calves, and fat cattle. We also considered variations in the Brazilian minimum wage and electricity values. We then obtain a monthly series of costs and revenues, assuming all inputs are purchased and all products are sold in the same month.

2.3 Gross Revenue, Cost of Production, and Economic Performance Indicators

We organized the conventional and organic production structures using the methodology proposed by Matsunaga et al. (1976) and Nachiluk and Oliveira (2012), grouping expenditures and revenues into three categories: Effective Operating Cost (EOC), Total Operating Cost (TOC), and Gross Revenue (GR). According to these authors, direct expenses can be classified as EOC, whereas indirect expenses can be classified as TOC (Table 1).

The GR incorporates remuneration from milk and animal sales. For the economic performance indices, we calculated Gross Margin (GM) as GR minus EOC and Net Margin (ML) as GR minus TOC (Table 1). We analyzed each farm's margins, considering only milk sales. From the original data, the distribution functions for each series (inputs) could be obtained. We then calculated revenue, cost, and margin subgroups by summing or differencing outputs.

Table 1. Structure of production costs, revenues, and margins by group

Classification	Group	Stochastic classification
(A)	Milk revenue	*Input*
(B)	Revenue from animal sales	*Input*
Sum (A;B)	Gross Revenue (GR)	*Output*
(C)	General Expenses	*Input*
(D)	Bulky (silage + forage)	*Input*
(E)	Concentrate + Mineral Supplementation	*Input*
(F)	Maintenance (inventory)	*Input*
(G)	Medications	*Input*
(H)	Milking material	*Input*
(I)	Hired labor	*Input*
Sum (C;I)	EOC	*Output*
(J)	Depreciation	*Input*
Sum (C;J)	TOC	*Output*
(A) – EOC	Gross Milk Margin (GMM)	*Output*
(A) – TOC	Net Milk Margin (NMM)	*Output*
GR – EOC	Total Gross Margin (TGM)	*Output*
GR – TOC	Total Net Margin (TNM)	*Output*

Source: elaborated by the author.

2.4 Stochastic Simulation

The economic risk analysis used a stochastic simulation based on the Monte Carlo method, as developed by Hertz (1964, 1979). We used @Risk, an Excel add-in developed by Palisade, to identify the probability distribution for each selected group (Table 1) based on the Akaike information criterion (Akaike, 1974). This test aims to evaluate the quality of the parametric model estimated using the maximum likelihood method by adjusting the data distribution to the theoretical models. In addition, we sought to work primarily with distribution functions that did not restrict the data range, such as the normal and extreme value distributions, while preserving the characteristics of the original data.

After defIn the distribution functions for each element, truncations with a minimum value of zero were added to avoid negative costs and revenues. Next, the correlation matrices among the distribution functions (inputs) were structured to preserve the original characteristics of the variables (Barros et al., 2019).

Using the @Risk program, 10,000 random interactions were simulated for each function across the ten selected groups, accounting for the data series' probabilistic distributions. The sums or subtractions of the *inputs* allowed for the calculation of the *outputs* are also listed in Table 1. These methodological procedures have been applied to both conventional and organic production systems.

The *outputs* related to the economic performance of the farms, defined as Gross Milk Margin (GMM), Net Milk Margin (NMM), Total Gross Margin (TGM), and Total Net Margin (TNM), were the most interesting in this study. Therefore, the data are presented in a frequency distribution, enabling probability analyses of negative margins, that is, liquidity and profitability risks, as per Barros et al. (2019). According to the authors, liquidity risk is treated as the probability of negative GMM and TGM, whereas the likelihood of negative NMM and TNM is profitability risk.

3 Results and Discussions

This section has five subsections. Initially, information on the probability distribution functions of each revenue and cost variable, as well as correlations between the variables, is presented, enabling them to analyze the risks of negative margins for conventional and organic production systems. The fourth section compares the economic risks of the systems and presents sensitivity analyses of the cost and revenue variables on the Net Margin.

3.1 Identification of Probability Distributions and Correlation Matrix of the Risk Variables

Initially, for each input cost item, the probability distribution function was determined to obtain its parameters. We then used this information to generate random numbers representing the original characteristics of each productive farm.

The results of the probability distribution functions for each variable are presented in Appendices 1 (two conventional farms) and 2 (three organic farms). Normal, extreme, and minimum extreme values, as defined by Akaike's test, were observed across the distribution functions.

The disbursements for maintenance, medication, milking material, and contracted labor in the dairy matrix in this study were distributed using minimum extreme values, except for the property in Mococa/SP, which showed a normal distribution for maintenance costs. Across all sampled matrices, the category of expenses for concentrate and mineral supplementation showed an extreme distribution.

For each productive farm, a correlation matrix of inputs was constructed, enabling the generation of random numbers while preserving the typical characteristics of the relationships among the variables (see Appendices 3 to 7). There was a strong positive correlation between revenue from animal sales and purchases of concentrate and mineral supplements across all dairy farms. In contrast, there was a strong and negative correlation between the groups of medicines and milking supplies and the purchase of concentrate and mineral supplementation. Specifically, there was a moderate, positive correlation between the bulk group and farm overhead on conventional farms, but not on organic farms.

3.2 Risk Analysis for Conventional Production Systems

The statistical results for the production structure of the Rio Preto/SP are presented (Table 2). The GR averaged USD 42.3 thousand, with revenue from milk sales accounting for 86% of total income and animal sales for 14%. The average verified value for TOC was USD 36.6 thousand, of which 75.5% was disbursed to the activity's EOC. The gross margin simulation for Rio Preto/SP showed an average positive value of USD 14.7 thousand, indicating no risk that Gross Revenue will not cover expenses with the EOC.

The TNM calculation for the region was positive during this period, with an average of USD 5.7 thousand. Therefore, the 5% confidence interval showed that TGM and TNM remained positive. However, the liquidity risk in the production structure of Rio Preto/SP is 3.7%, according to the accumulated relative frequency line in Figure 1.

The revenue from milk sales alone was higher than that from the EOC, resulting in a positive average GMM of USD 8.8 thousand (Table 2). However, the GMM becomes negative by USD 238.8 when depreciation expenses are added. Furthermore, based on the 5% confidence interval, NMM showed a negative value of USD 5.0 thousand. These results indicate the need to sell animals to improve the farm's margin and maintain positive producer profitability.

When analyzing the NMM, the liquidity risk in the production system in São José do Rio Preto/SP is 53.7% (Figure 2); that is, the revenue from milk sales alone cannot cover more than half of the disbursements with TOC. Thus, the liquidity risk is 14.3% higher than when considering the farm's total revenue, including animal sales, which is typical for a dairy farm, but also indicates low profitability from milk sales.

Table 2. Statistical results of simulations in the typical farm of São José do Rio Preto/SP of conventional production

Items	Minimum	Average	Maximum	5% Coef.	95% Coef.	Standard Deviation	CV (%)	Share (%)
Milk revenue	24,533.55	36,409.79	48,253.81	31,434.40	41,380.02	3,023.25	8,3%	86,00%
Revenue from animal sales	3,496.40	5,925.06	14,166.76	4,480.09	7,988.25	1,106.68	18,7%	14,00%
Gross Revenue (GR)	**29,436.60**	**42,334.86**	**58,804.62**	**36,640.95**	**48,186.98**	**3,510.65**	**8,3%**	**100,00%**
General Expenses	4,217.79	4,701.20	6,383.65	4,412.27	5,113.79	221.30	4,7%	12,80%
Bulky (silage + forage)	3,961.00	5,452.68	10,152.15	4,576.58	6,703.90	670.84	12,3%	14,90%
Concentrate + Mineral Supplementation	3,050.17	4,796.58	11,295.93	3,793.23	6,229.67	768.88	16,0%	13,10%
Maintenance (inventory)	576.11	714.44	755.64	679.89	738.60	18.51	2,6%	1,90%
Medications	664.17	1,246.55	1,432.96	1,095.31	1,352.26	80.99	6,5%	3,40%
Milking material	235.60	735.32	888.11	605.19	826.33	69.72	9,5%	2,00%
Hired labor	8,510.39	10,008.83	10,383.08	9,697.79	10,226.41	166.86	1,7%	27,30%
EOC	**25,088.98**	**27,655.62**	**33,376.55**	**26,230.95**	**29,537.86**	**1,031.08**	**3,7%**	**75,50%**
Depreciation	8,177.21	8,993.02	9,791.71	8,643.42	9,342.27	212.43	2,4%	24,50%
TOC	**34,371.62**	**36,648.62**	**42,545.29**	**35,277.29**	**38,458.24**	**985.53**	**2,7%**	**100,00%**
GMM	**(1,323.38)**	**8,754.18**	**18,632.10**	**4,102.65**	**13,401.25**	**2,838.29**	**-**	**-**
NMM	**(10,770.38)**	**(238.84)**	**9,878.54**	**(4,955.96)**	**4,462.28**	**2,870.86**	**-**	**-**
TGM	**3,558.08**	**14,679.24**	**27,477.52**	**9,535.75**	**19,854.67**	**3,152.45**	**-**	**-**
TNM	**(5,890.70)**	**5,686.22**	**18,962.90**	**436.92**	**10,970.00**	**3,220.25**	**-**	**-**

Source: Research data. Obs.: Exchange rate 4.20 BRL / USD.

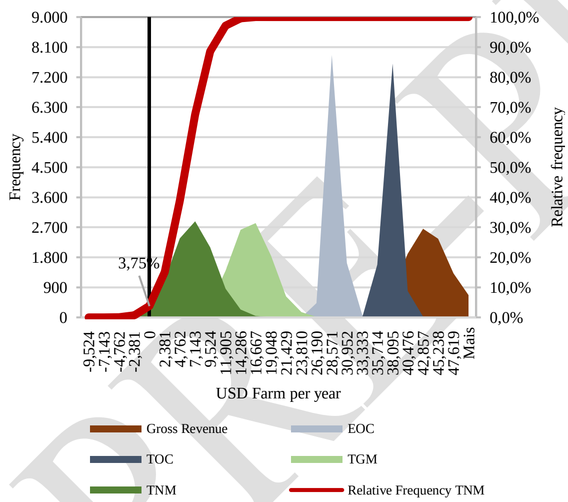

Figure 1. Frequency distributions of GR, EOC, TOC, TGM, and TNM and cumulative frequency of TNM in São José do Rio Preto/SP.
Source: Research data.

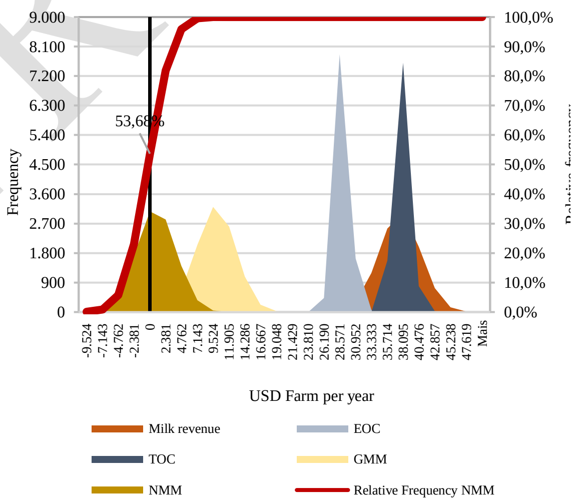

Figure 2. Frequency distributions of Milk Revenue, EOC, TOC, GMM, and NMM, and cumulative frequency of NMM in São José do Rio Preto/SP
Source: Research data.

For the second typical property under a conventional production system, Mococa/SP (Table 3), the average GR was USD 13.9 thousand. The gain from the sale of milk corresponded to 85.8% of the total, which was very similar to that recorded in the production structure of São José do Rio Preto/SP. Concerning the cost of milk production, the TOC totaled USD 100.7 thousand, with 86.2% of the EOC participating.

In the economic performance analysis, the TGM and TNM indicators showed positive simulated averages, resulting in USD 51.2 thousand and USD 37.2 thousand, respectively. Although the farm showed minimal negative TNM values, 95% of the values were above USD 21.8 thousand. According to Figure 3, the profitability risk is only 0.02%.

The average NMM was less than half of that recorded for TNM, at USD 17.7 thousand, and oscillated 90% of the time between a negative USD 26.0 thousand and a positive USD 49.4 thousand. The profitability risk for NMM is approximately 4% (Figure 4). Thus, the risk to this property was much lower than that recorded at the São José do Rio Preto/SP farm.

On the José do Rio Preto/SP farm, the modal property was 69 ha, of which 62 ha were for Brachiaria pasture. The herd consisted of 47 Girolando cows and had a lactation rate of 53% of the total cows in the activity, influenced by the long interval between calving (approximately 15 months) and the short lactation period (8 months). The farm's daily production was 200 L/day, with an average of 8 L/day per lactating cow.

On the modal farm in Mococa/SP, the production structure corresponded to 80 ha for livestock, of which 59 ha had Brachiaria pasture. In this production matrix, 89 cows in the herd had a predominantly Girolando genetic profile. The farm's lactation rate was 56% of the total number of cows in the activity, with a 16-month interval between calving and the start of the lactation period, and a nine-month lactation period. The farm's daily production record was 600 L/day, with an average production of 12 L/day per lactating cow.

Regarding the degree of dispersion among the distributions, the GR showed a coefficient of variation (CV) greater than 8% for both conventional properties analyzed (Tables 2 and 3). However, the lower variability in EOC and TOC for the São José do Rio Preto/SP farm, which has lower disbursement values, calls attention. Nevertheless, on both farms, the CVs of costs were lower than those of revenues. However, revenue from animal sales showed the highest variability (a CV of almost 19%).

Milk price fluctuations (milk revenue accounts for more than 85% of GR) directly affect producers' economic management on both small and large-scale farms. Jiang and Sharp (2014) cited this concept, which suggests that the potential for revenue control is limited, supporting an efficiency analysis based on cost minimization. Increased productivity and scaled production reduce TOC expenses (Lopes et al., 2009). Sabbag and Costa (2015) highlighted that milk pricing and the establishment's productivity are more salient determinants for minimizing risks of negative profitability.

Table 3. Statistical results of simulations in the typical farm of Mococa/SP of conventional production

Items	Minimum	Average	Maximum	5% Coef.	95% Coef.	Standard Deviation	CV (%)	Share (%)
Milk revenue	81,331.12	118,331.74	155,768.95	102,168.71	134,489.14	9,825.29	8,30%	85,80%
Revenue from animal sales	11,598.66	19,591.19	44,535.36	14,813.24	26,413.62	3,656.70	18,70%	14,20%
Gross Revenue (GR)	**96,840.36**	**137,922.93**	**184,135.02**	**119,532.81**	**156,856.88**	**11,354.08**	**8,20%**	**100%**
General Expenses	5,400.78	6,137.36	6,918.52	5,828.76	6,445.82	187.59	3,10%	6,10%
Bulky (silage + forage)	16,713.68	20,206.10	23,610.07	18,808.12	21,603.64	849.84	4,20%	20,10%
Concentrate + Mineral Supplementation	19,919.30	35,932.74	84,016.38	26,610.69	49,243.74	7,135.26	19,90%	35,70%
Maintenance (inventory)	1,211.21	1,428.44	1,646.93	1,333.64	1,523.20	57.62	4,00%	1,40%
Medications	2,863.66	5,773.05	6,706.78	5,049.69	6,278.85	387.58	6,70%	5,70%
Milking material	252.07	1,087.24	1,337.52	884.46	1,229.05	108.63	10,00%	1,10%
Hired labor	14,091.10	16,187.23	16,777.38	15,683.95	16,539.11	269.60	1,70%	16,10%
EOC	**72,169.69**	**86,752.17**	**130,447.52**	**78,015.24**	**99,216.95**	**6,670.94**	**7,70%**	**86,20%**
Depreciation	12,978.81	13,922.46	16,939.52	13,405.25	14,660.91	396.09	2,80%	13,80%
TOC	**85,894.12**	**100,674.62**	**144,263.79**	**92,018.62**	**113,014.86**	**6,598.35**	**6,60%**	**100%**
GMM	**(12,387.76)**	**31,579.57**	**62,991.31**	**14,934.88**	**47,459.86**	**9,936.60**	**-**	**-**
NMM	**(25,964.45)**	**17,657.12**	**49,403.36**	**1,087.05**	**33,567.26**	**9,898.18**	**-**	**-**
TGM	**12,950.55**	**51,170.76**	**81,427.69**	**35,747.02**	**66,575.19**	**9,388.10**	**-**	**-**
TNM	**(1,182.15)**	**37,248.31**	**67,572.00**	**21,815.51**	**52,706.21**	**9,372.78**	**-**	**-**

Source: Research data. Obs.: Exchange rate 4.20 BRL / USD.

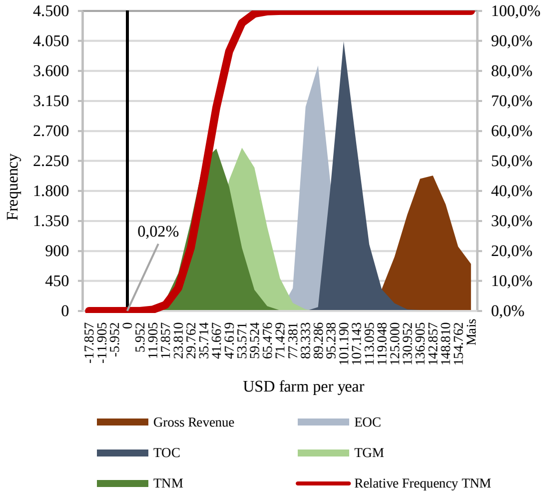

Figure 3. Frequency distributions of GR, EOC, TOC, TGM, and TNM and the cumulative frequency of TNM in Mococa/SP

Source: Research data.

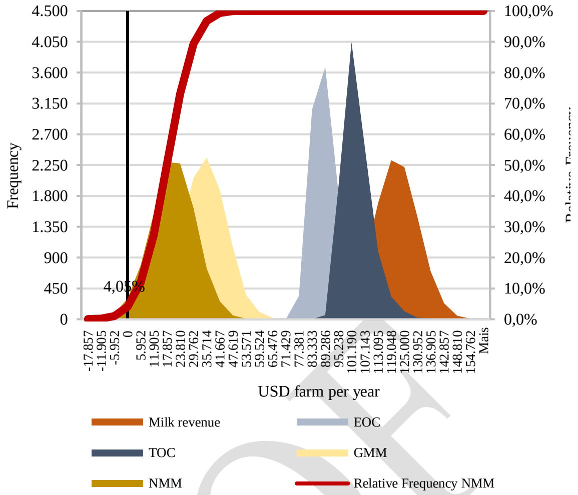

Figure 4. Frequency distributions of Milk Revenue, EOC, TOC, GMM, and NMM, and cumulative frequency of NMM in Mococa/SP

Source: Research data.

3.3 Risk Analysis for Organic Production Systems

Next, we describe the results of the organic production systems. The GR for the productive organic farm 1 averaged USD 1.1 million, with 95.7% of total revenue coming from milk sales (Table 4). This farm has 80 hectares designated for cattle raising, of which 10 hectares are mombaça pasture and 30 are for perennial forage, such as grass. This farm has 130 cows with a hybrid genetic profile of Jersey, Jersolando, and Holstein breeds. The farm's lactation rate accounted for 86% of the total number of cows in the activity, with approximately 111 cows in lactation. The calving interval was 14 months, and the lactation period was 12 months. The farm's daily milk production averaged 2,000 L/day, with 18 L/day per lactating cow.

The TOC averaged USD 808.4 thousand, of which 92.5% was attributable to the activity's operational costs. According to the simulation results, TGM averaged USD 323.3 thousand, and TNM USD 263.0 thousand (Table 4). Therefore, in this productive matrix for farm 1, the profitability risk was estimated at 1.1% using the TNM distribution (Figure 5).

In this property, when considering only revenue from milk sales, the values do not change significantly, given their importance to total revenue. The GMM averaged USD 276.7 thousand, and the NMM USD 216.5 thousand. When considering NMM, the liquidity risk was 2.9% (Figure 6).

Table 4. Statistical results of simulations in the organic matrix 1 in Ribeirão Preto/SP

Items	Minimum	Average	Maximum	5% Coef.	95% Coef.	Standard Deviation	CV (%)	Share (%)
Milk revenue	673,985.71	1,024,892.14	1,359,764.76	884,869.52	1,164,819.76	85,114.50	8,30%	95,70%
Revenue from animal sales	24,933.71	46,589.55	106,494.14	35,228.31	62,825.50	8,697.66	18,70%	4,30%
Gross Revenue (GR)	**710,070.71**	**1,071,481.90**	**1,412,372.86**	**927,101.43**	**1,215,596.90**	**87,931.22**	**8,20%**	**100,00%**
General Expenses	47,102.24	65,839.60	70,639.14	61,791.79	68,669.33	2,169.93	3,30%	8,10%
Bulky (silage + forage)	26,187.62	43,884.24	60,742.62	36,806.79	50,957.71	4,302.21	9,80%	5,40%
Concentrate + Mineral Supplementation	299,414.29	548,516.19	1,349,328.10	409,059.76	747,770.24	106,823.99	19,50%	67,80%
Maintenance (inventory)	5,553.51	6,693.46	7,061.10	6,397.17	6,900.74	158.78	2,40%	0,80%
Medications	1,103.23	9,708.16	12,491.37	7,335.00	11,368.19	1,270.34	13,10%	1,20%
Milking material	1,257.51	4,230.47	5,226.57	3,476.42	4,757.76	404.06	9,60%	0,50%
Hired labor	59,689.55	69,273.07	71,955.62	67,119.21	70,778.52	1,154.35	1,70%	8,60%
EOC	**496,187.86**	**748,145.24**	**1,544,879.76**	**608,618.33**	**945,654.05**	**106,004.95**	**14,20%**	**92,50%**
Depreciation	53,894.36	60,300.10	65,836.86	57,971.67	62,627.67	1,415.50	2,30%	7,50%
TOC	**562,024.76**	**808,445.24**	**1,602,203.81**	**670,509.52**	**1,004,667.14**	**105,192.07**	**13,00%**	**100,00%**
GMM	**(379,022.86)**	**276,746.90**	**632,838.81**	**95,201.81**	**432,696.43**	**104,544.45**	**-**	**-**
NMM	**(436,346.90)**	**216,446.86**	**568,224.29**	**36,424.14**	**372,091.90**	**103,905.84**	**-**	**-**
TGM	**(272,528.81)**	**323,336.43**	**667,555.24**	**152,623.00**	**472,036.19**	**98,712.63**	**-**	**-**
TNM	**(329,852.86)**	**263,036.43**	**602,940.71**	**93,155.79**	**411,158.81**	**98,107.56**	**-**	**-**

Source: Research data. Obs.: Exchange rate 4.20 BRL / USD.

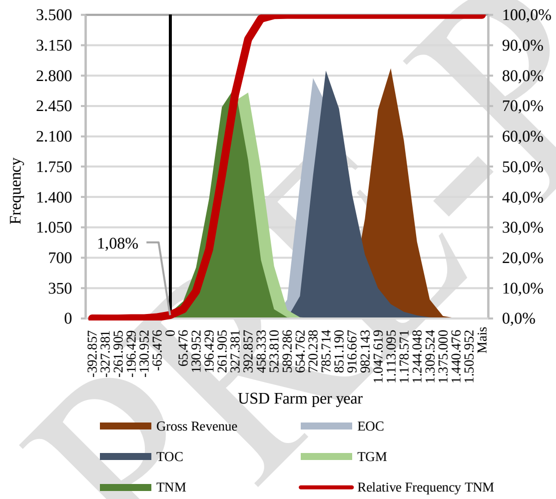

Figure 5. Frequency distributions of GR, EOC, TOC, TGM, and TNM and cumulative frequency of TNM at organic farm 1 in Ribeirão Preto/SP
Source: Research data.

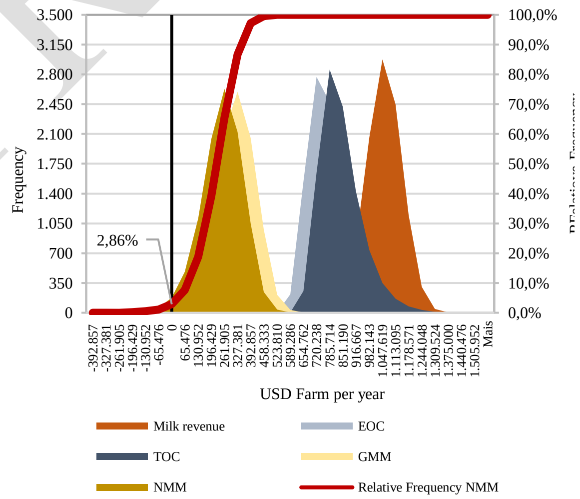

Figure 6. Frequency distributions of Milk Revenue, EOC, TOC, GMM, and NMM, and cumulative frequency of NMM on organic farm 1 in Ribeirão Preto/SP
Source: Research data.

This risk is much lower than that of two typical conventional dairy farms. However, compared with that observed on traditional farms, the CV for EOC and TOC warrants attention. Furthermore, this result was affected by the higher CV of the concentrate + mineral supplementation item, which, although similar to that calculated for conventional farms, represented more than 2/3 of the TOC.

For organic production matrix 2, the simulations yielded an average GR of USD 229.6 thousand, of which 71.7% came from milk sales (Table 5). It had the lowest share of milk revenue among the farms studied, with a greater dependence on animal sales revenue for the property's financial and economic sustainability. Thus, the dispersion of GR, represented by CV, exceeded that of other farms.

The property has 18.5 hectares dedicated to livestock, of which 16.5 hectares are for pastures: mombaça (seven hectares), Zuri (four hectares), star grass (four hectares), and brachiaria (1.5 hectares). Over-seeding of oats and ryegrass in star grass and mombaça grass pastures during the off-season improved the nutritional composition of the herd.

On this farm, the herd consisted of 48 cows with a hybrid genetic profile of the Girolando and Jersolando breeds. The lactation rate was 71% of the total number of cows in the activity period, with approximately 34 cows in the lactation period. The average calving interval was 14 months, and the lactation period was 10 months. Daily production averaged 430 liters, with an average productivity of 12.5 liters/day per lactating cow.

The property expenditures totaled USD 175.7 thousand for the TOC, with a participation of 86.3% for the operating costs (EOC) (Table 5). Hired labor had a higher share on farm 2 than on organic farm 1, but it was still lower than on the two conventional farms. While disbursements for bulky and concentrated + mineral supplementation reached 73.2% of the EOC on organic farms 1 and 2, the average was 62.40%.

Table 5. Statistical results of simulations in the organic matrix 2 in Ribeirão Preto/SP

Items	Minimum	Average	Maximum	5% Coef.	95% Coef.	Standard Deviation	CV (%)	Share (%)
Milk revenue	112,800.86	164,566.88	218,823.17	142,080.05	187,033.19	13,665.52	8,30%	71,70%
Revenue from animal sales	37,418.57	65,010.05	153,973.17	49,153.33	87,655.12	12,140.63	18,70%	28,30%
Gross Revenue (GR)	**161,232.36**	**229,576.93**	**327,259.76**	**197,228.33**	**264,558.57**	**20,595.44**	**9,00%**	**100,00%**
General Expenses	9,918.24	10,306.71	11,617.05	10,085.45	10,622.76	169.45	1,60%	5,90%
Bulky (silage + forage)	11,863.73	15,689.20	19,183.83	14,155.35	17,221.91	932.20	5,90%	8,90%
Concentrate + Mineral Supplementation	64,955.90	94,057.31	185,107.17	76,745.64	118,780.62	13,251.19	14,10%	53,50%
Maintenance (inventory)	2,790.38	3,425.30	3,618.97	3,273.89	3,531.20	81.17	2,40%	1,90%
Medications	3,617.52	5,301.38	5,831.90	4,871.60	5,601.85	230.20	4,30%	3,00%
Milking material	681.53	2,015.74	2,435.67	1,658.84	2,265.22	191.04	9,50%	1,10%
Hired labor	18,578.48	20,934.21	21,718.84	20,283.79	21,389.17	348.47	1,70%	11,90%
EOC	**123,736.00**	**151,729.83**	**241,562.14**	**135,481.52**	**175,262.50**	**12,592.46**	**8,30%**	**86,30%**
Depreciation	22,482.33	24,000.67	25,527.26	23,379.95	24,621.00	377.22	1,60%	13,70%
TOC	**147,529.95**	**175,730.50**	**266,188.57**	**159,449.17**	**199,264.14**	**12,604.55**	**7,20%**	**100,00%**
GMM	**(59,819.79)**	**12,837.06**	**68,601.79**	**(10,850.96)**	**35,317.33**	**14,184.36**	**-**	**-**
NMM	**(84,446.02)**	**(11,163.60)**	**44,442.90**	**(34,877.90)**	**11,405.61**	**14,233.50**	**-**	**-**
TGM	**25,134.48**	**77,847.10**	**131,211.45**	**55,681.38**	**100,094.67**	**13,377.92**	**-**	**-**
TNM	**1,204.23**	**53,846.43**	**107,616.86**	**31,692.74**	**76,136.29**	**13,406.00**	**-**	**-**

Source: Research data. Obs.: Exchange rate 4.20 BRL / USD.

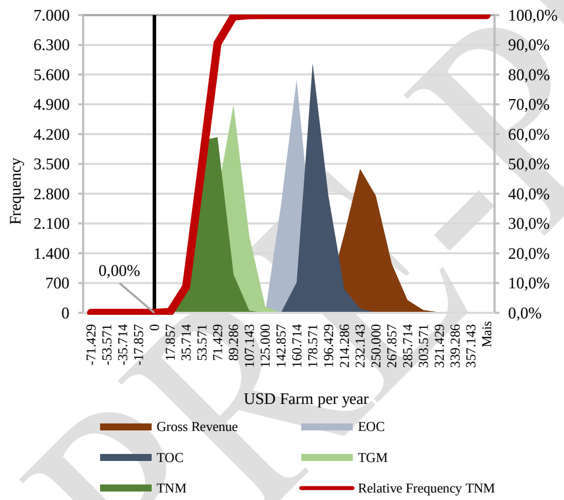

Figure 7. Frequency distributions of GR, EOC, TOC, TGM, and TNM and cumulative frequency of TNM at organic farm 2 in Ribeirão Preto/SP

Source: Research data.

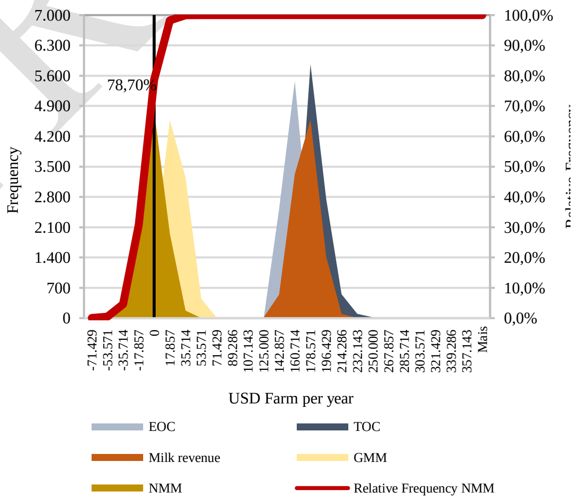

Figure 8. Frequency distributions of Milk Revenue, EOC, TOC, GMM, and NMM, and cumulative frequency of NMM on organic farm 2 in Ribeirão Preto/SP

Source: Research data.

For TNM, in 90% of cases, the values ranged from USD 31.7 thousand to USD 76.1 thousand per year, with an average of USD 53.8 thousand. Therefore, profitability risk was null. The results showed that this ownership structure consistently generated profit (Figure 7).

However, when only milk revenue covers the TOC (i.e., NMM), profitability risk is significant at 78.7%; in only 21.3% of years is milk revenue sufficient to cover the TOC (Figure 8). This was the worst result among the farms analyzed to date. When evaluating the GMM, the risk of a negative margin was 17.1%, which is considered high. However, with TGM, the risk remains zero because of revenue from animal sales.

The third organic matrix considered in this study covers 20 ha dedicated to livestock, of which nine hectares are for producing mombaça (4 ha), Zuri (3.5 ha), and brachiaria (1.5 ha) pastures. In addition, the farm cultivates annual forage crops during the off-season, sowing oats and ryegrass in the mombaça and Zuri pastures. The herd consisted of 34 cows with a genetic profile between the Jersey, Holstein, and Jersolando breeds. The lactation rate represented 83% of the total active cows, and the calving interval averaged 12 months, with a lactation period of 10 months. The average daily production was 450 liters, with an average productivity of 16 liters per lactating cow per day.

The calculations registered an average gross revenue of USD 221.2 thousand per year, with 77.9% coming from milk sales (Table 6). This share is higher than that of the second organic farm, but lower than that of the first and two conventional farms. Compared with other farms, there were no significant differences in gross revenue CV.

The TOC averaged USD 187.4 thousand, with 91% of disbursements allocated to operating costs (Table 6). Bulky and concentrated + mineral supplementation accounted for 56.3% of the TOC, well below that of the two other organic farms, similar to that of the conventional farm in Mococa/SP, but higher than that of the conventional farm in São José do Rio Preto/SP. The general expenses were in line with those of organic farm 1, but labor participation expenses were the second highest among the five farms analyzed.

According to the simulation results, the profitability risk of (negative TNM) is 0.7% (Figure 9), with an average of USD 33.8 thousand (90% of the time, the TNM is between USD 11.9 thousand and USD 55.5 thousand). When evaluating the NMM, the profitability risk increases to 87.7%, the highest among the analyzed farms (Figure 10). As with the second organic matrix, the dairy producer needs to generate additional revenue to cover the activity's TOC, such as by selling animals.

Table 6. Statistical results of simulations on organic matrix 3 in Ribeirão Preto/SP

Items	Minimum	Average	Maximum	5% Coef.	95% Coef.	Standard Deviation	CV (%)	Share (%)
Milk revenue	117,484.76	172,221.57	232,028.79	148,689.86	195,740.98	14,302.08	8,30%	77,90%
Revenue from animal sales	28,977.71	48,955.21	140,814.98	37,011.90	66,001.21	9,164.46	18,70%	22,10%
Gross Revenue (GR)	**154,696.19**	**221,176.79**	**329,385.24**	**191,286.83**	**253,240.48**	**19,002.88**	**8,60%**	**100,00%**
General Expenses	13,947.84	15,584.85	17,077.61	14,949.02	16,220.40	386.47	2,50%	8,30%
Bulky (silage + forage)	22,508.44	26,845.26	41,314.33	24,376.64	30,372.31	1,890.94	7,00%	14,30%
Concentrate + Mineral Supplementation	51,832.36	78,634.48	168,097.05	62,989.98	100,984.67	11,982.76	15,20%	42,00%
Maintenance (inventory)	2,451.84	3,018.75	3,197.93	2,868.37	3,123.95	80.57	2,70%	1,60%
Medications	2,006.24	5,136.21	5,820.99	4,583.10	5,523.09	297.20	5,80%	2,70%
Milking material	1,065.78	9,928.61	12,125.80	8,171.81	11,157.86	943.21	9,50%	5,30%
Hired labor	27,405.57	31,401.31	32,604.33	30,425.50	32,083.76	522.85	1,70%	16,80%
EOC	**145,962.74**	**170,549.48**	**252,740.48**	**156,796.29**	**189,800.45**	**10,457.15**	**6,10%**	**91,00%**
Depreciation	14,260.92	16,836.87	19,365.45	15,746.56	17,926.90	662.76	3,90%	9,00%
TOC	**164,947.71**	**187,386.33**	**267,001.43**	**174,563.55**	**205,774.60**	**9,943.63**	**5,30%**	**100,00%**
GMM	**(66,168.88)**	**1,672.10**	**61,933.69**	**(20,107.80)**	**23,670.61**	**13,379.28**	**-**	**-**
NMM	**(81,670.86)**	**(15,164.78)**	**45,011.60**	**(36,737.31)**	**6,764.94**	**13,234.73**	**-**	**-**
TGM	**1,551.79**	**50,627.33**	**110,883.40**	**29,121.50**	**72,030.40**	**13,145.95**	**-**	**-**
TNM	**(16,897.91)**	**33,790.45**	**93,961.31**	**11,949.66**	**55,503.88**	**13,346.96**	**-**	**-**

Source: Research data. Obs.: Exchange rate 4.20 BRL / USD.

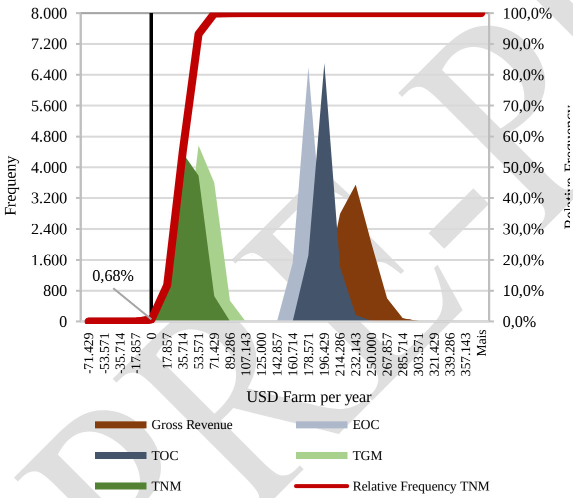

Figure 9. Frequency distributions of GR, EOC, TOC, TGM, and TNM and cumulative frequency of TNM at organic farm 3 in Ribeirão Preto/SP

Source: Research data.

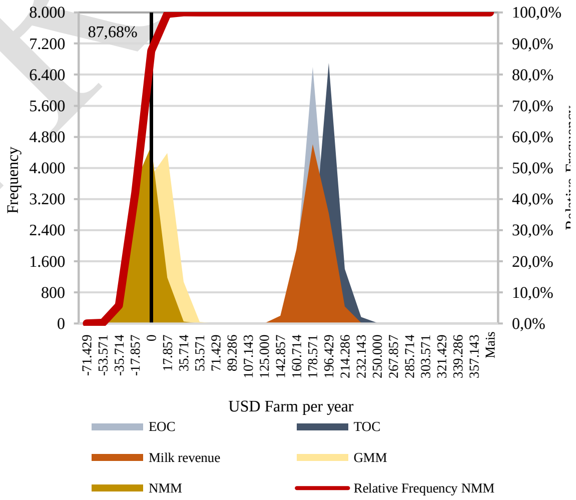

Figure 10. Frequency distributions of Milk Revenue, EOC, TOC, GMM, and NMM, and cumulative frequency of NMM on organic farm 3 in Ribeirão Preto/SP

Source: Research data.

3.4 Comparison of Economic Risk in Conventional and Organic Systems

In this subsection, we compare liquidity risk results across different production structures using NMM and TNM. When evaluating the frequency of negative TNM values in conventional and organic production structures (Figure 11), the property with the highest profitability risk was the conventional one in São José do Rio Preto/SP, at 3,75%. Next was organic matrix 3, but with a probability of 0.7%. This highlights the more concentrated probability distribution of the conventional properties compared to the organic ones (matrices 2 and 3), with higher frequency dispersion and net margin values per liter of milk.

The results change when considering NMM, that is, when analyzinpértog only the margins from milk sales. Organic matrices 2 and 3 presented higher profitability risks, reaching 78.7% and 87.7%, respectively (Figure 12), which aligns with the results obtained in the previous subsection. The risks for the conventional matrices were 4.1% for Mococa/SP and 53.87% for São José do Rio Preto/SP. Organic Matrix 1 continued to show a greater dispersion of values, with a low probability of negative margins.

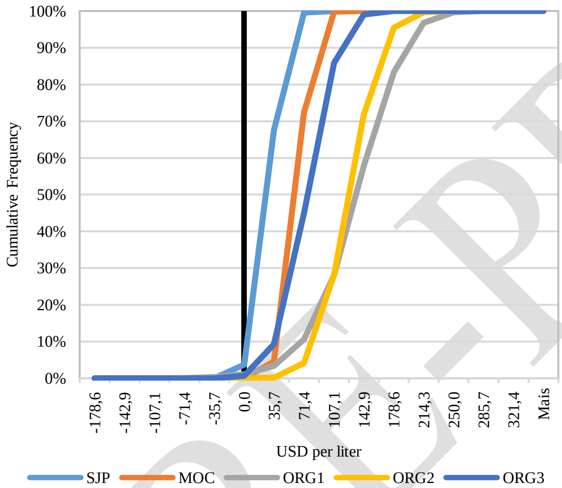

Figure 11. Cumulative frequency of TNM divided by annual milk production
Source: Research data.

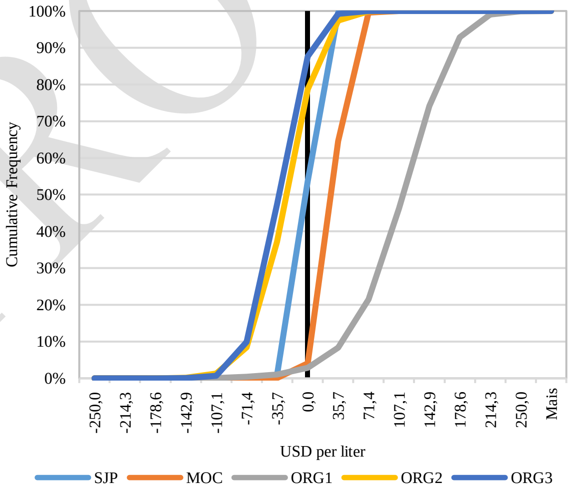

Figure 12. Cumulative frequency of NMM divided by the annual milk production
Source: Research data.

As discussed in the previous sections, the results show that animal sales are essential for covering dairy farms' total operating costs, as the systems face a high risk of negative liquidity due to NMM. High risk is associated with the herd's low productivity on the conventional farm and with high expenditures on both activities. In a conventional structure, 200 L/day of productivity is insufficient to cover operating costs and depreciation. In the organic system, a productivity of 450 L/day was also insufficient to cover the TOC's expenses, despite receiving additional value (premiums) for each liter of milk and having zootechnical indices considered satisfactory. Thus, cost management in both production systems is crucial for maintaining the economic sustainability of activities.

3.5 Sensitivity Analysis of Cost and Revenue Variables on Net Margin

Given the high risk, especially in the NMM analysis, one wonders which variables most affect the results. Thus, we present this information in the context of a regression analysis. The coefficients for each input variable were used to quantify how much each variable affected the TNM output (sensitivity). The higher the coefficients, the more representative the variables are in their impact on the net margin. Positive signs directly affect the NGM, whereas negative signs represent an impact in the opposite direction.

For the typical conventional farms in São José do Rio Preto/SP and Mococa, the items with the most significant influence on TNM were those related to income from the activity, especially the income from milk sales, with positive impacts, followed by the purchase of concentrates and mineral supplements (Figures 13 and 14). As expected, the EOC and TOC variables negatively affected TNM, with concentrate and bulk expenses being the most representative, changing only the order of importance across farms. Thus, cattle ranchers should pay more attention to factors that affect revenue, such as volume and prices, as well as to items related to animal feed, aiming to operate at a stage where costs grow less than revenue, thereby improving their margins.

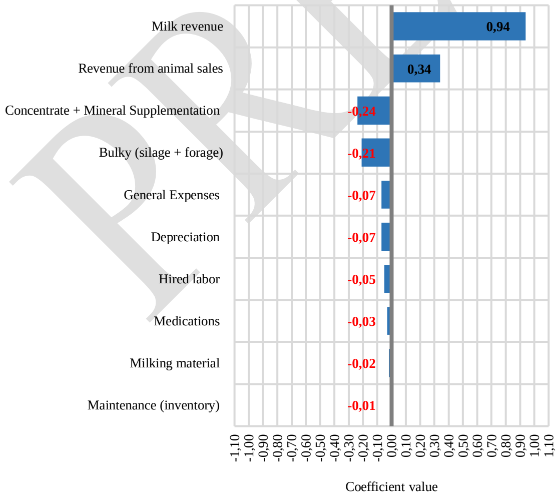

Figure 13. The regression coefficient of inputs on the TNM in São José do Rio Preto/SP
Source: Research data.

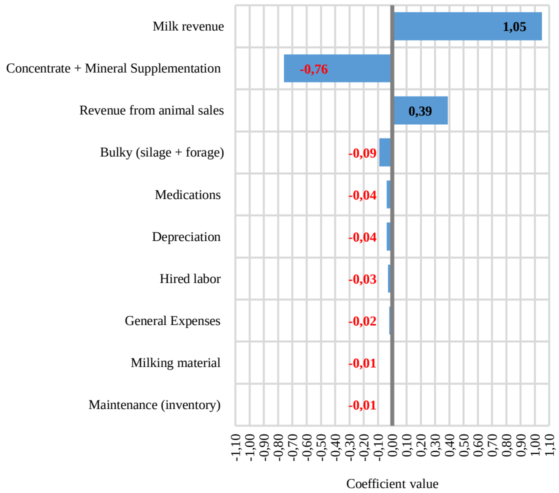

Figure 14. The regression coefficient of inputs on the TNM in Mococa/SP
Source: Research data.

The importance of animal feed has been highlighted in organic systems. Therefore, when evaluating the regression coefficients for organic matrix 1, the coefficient for the acquisition of concentrate and animal supplementation was the most representative and the highest among the inputs across all matrices used in this study. This is the central aspect cattle breeders should focus on to improve their TNM (Figure 15). Next, milk revenue input stood out with a positive sign, whereas the other variables showed coefficients with much lower values.

For organic farms 2 and 3, revenue from milk sales was the most significant factor in determining the TNM of the activity, followed by the regression coefficients for expenditures on concentrate and mineral supplementation, with the latter considered expressive (Figures 16 and 17). In these two matrices, revenue from animal sales also significantly increases the TNM. Thus, on both farms, cattle ranchers should pay greater attention to income and animal feed. In addition, it is worth noting that organic production systems 2 and 3 presented the highest risk of negative margins among the analyzed farms.

The sensitivity analyses presented in this subsection show that revenue-related and animal feed factors had the greatest influence on each farm's TNM. Thus, producers should focus on productivity, increase output, reduce marginal costs, and improve TNM. Notably, inputs related to the purchase of concentrate were more representative of the impact on TNM for organic farms than for conventional farms.

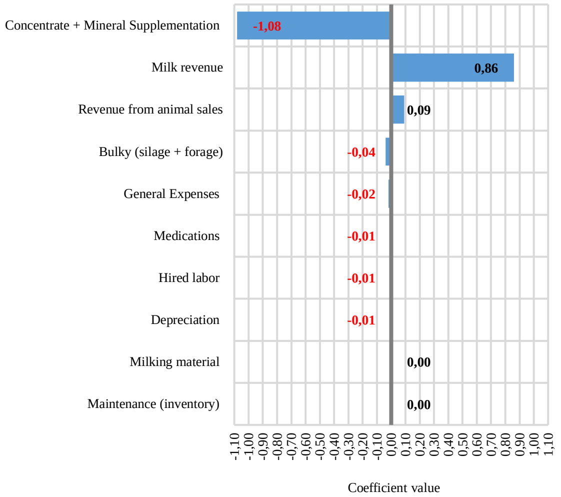

Figure 15. The regression coefficient of inputs on TNM in organic farm 1 in Ribeirão Preto/SP

Source: Research data.

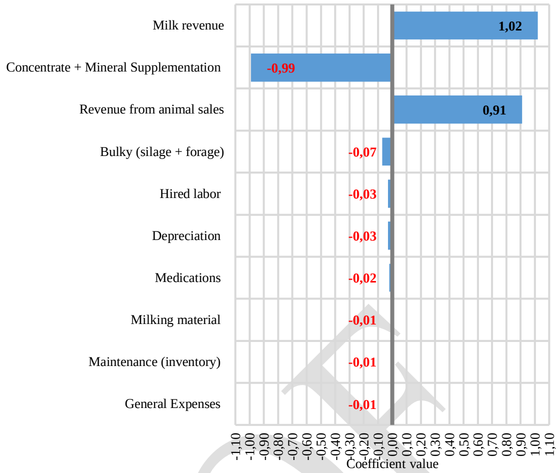

Figure 16. The regression coefficient of inputs on TNM in organic farm 2 in Ribeirão Preto/SP

Source: Research data.

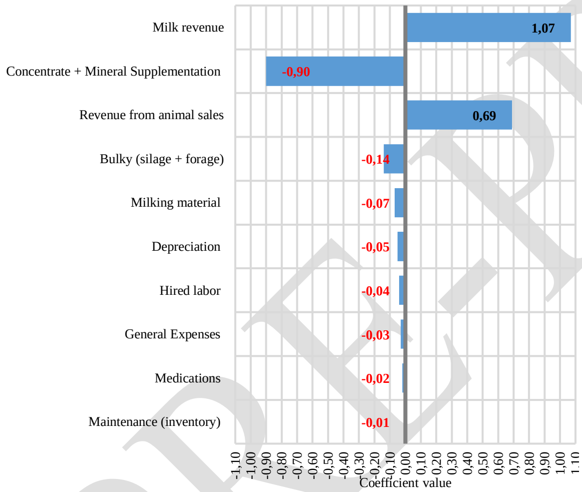

Figure 17. The regression coefficient of inputs on TNM in organic farm 3 in Ribeirão Preto/SP

Source: Research data (2021).

4 Concluding Remarks

This study analyzed and compared the financial and economic risks of conventional and organic milk production systems in São Paulo's milk-producing regions, Brazil. In addition, we sought to identify the main factors associated with the probability of negative profitability across two conventional and three organic milk-producing farms.

The simulations show that all properties have low liquidity risk when considering the Total Net Revenue (TNR) from the sale of milk and livestock. However, this study registered the highest risk in the conventional property of São José do Rio Preto/SP, at 3,75%, followed by the organic property 1 (1,08%) and the organic property 3 (0,68%), while the conventional properties of Mococa and the organic property 2 presented liquidity risk practically zero.

However, the risks increased when considering the possibility of covering the Total Operating Costs (TOC) solely with milk sales, which helps explain why cattle ranchers often point out the difficulty of maintaining the activity with the revenue obtained. The simulations indicated the highest liquidity risk for organic property 3, with an 87.7% probability that milk revenue would be insufficient to cover the TOC. The second property with the highest liquidity risk based on milk revenue alone was organic matrix 2 (78.7%), followed by conventional properties in Rio Preto/SP (53.7%). The second conventional property resulted in a risk of 4.1%, whereas Organic 1 had only 2.9%. Higher husbandry rates on these properties influenced the results.

Across all properties, the sensitivity analyses showed that factors related to milk sales revenue were important in raising the Total Net Margin (TNM). On organic farms 2 and 3, income from animal sales was also significantly associated with higher TNM. It is worth noting that both production systems are most susceptible to adverse liquidity risks.

Sensitivity analysis also identified the production cost factors that most negatively affected TNM, with the item related to purchasing animal feed concentrate being the most prominent variable. In organic matrix 1, this factor exceeded revenue from milk sales, underscoring the item's impact on the TNM and the importance of managing property costs. Thus, producers should focus more on production, decreasing marginal costs, and improving TNM.

We conclude that the risks associated with dairy farming in organic production systems are higher than those in conventional production systems due to the increased use of external concentrates as animal feed. Moreover, in organic matrices 2 and 3, revenue from animal sales is essential to maintaining a positive TNM. Thus, it is necessary to plan cost management using zootechnical and productive indices to reduce the risk of negative margins associated with high productivity levels in the activity.

This study contributes to the analysis of economic risks in milk production across conventional and organic systems in São Paulo State by characterizing properties and quantifying revenues and costs. This study identified the most critical factors for the economic sustainability of production, thereby reducing the risk of profitability losses in both conventional and organic systems. Revenue from milk sales, improved zootechnical indices, and reduced animal feed expenses are highlights of the property's longevity.

The heterogeneity of the sampled properties highlights the diversity of the milk production sector's characteristics and the main constraints that affect the profitability of dairy cattle ranchers. Analyzing the profiles of similar producers can also be an alternative for future studies aiming to understand the manager's role in economic results.

This study presents some methodological limitations that should be considered when interpreting the results. First, the analysis relied on a limited number of farms, combining typical farm panels for conventional systems with case studies for organic production, which may limit the generalizability of findings to other production contexts. In addition, the heterogeneity among the sampled farms, especially regarding scale, management practices, and productive structures, limits direct comparability between systems. Although stochastic simulations were employed to capture economic uncertainty, the results depend on the quality of the underlying price series and technical coefficients, which may vary over time and across regions. Future studies should expand the sample size, include producers with different characteristics, and replicate the analysis in other Brazilian states to improve external validity. Further research may also incorporate management-related variables to better understand the role of decision-making practices in shaping economic risk and profitability in dairy farming systems.

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PROFITABILITY RISK IN CONVENTIONAL AND ORGANIC DAIRY FARMS IN SÃO PAULO STATE, BRAZIL

Corresponding Author:
Lucilio Rogerio Aparecido Alves
University of São Paulo (USP). Luiz de Queiroz College of Agriculture
Av. Pádua Dias, 11 - Cx. Postal 9 – Piracicaba/SP, Brazil. Zip code 13418-900
lralves@usp.br

APPENDIX

Appendix 1. Probability distribution of cost and revenue variables in conventional production systems

Region	São José do Rio Preto/SP					Mococa/SP				
Items	**Distribution**	**Parameters and Values (USD)**				**Distribution**	**Parameters and Values (USD)**			
Milk revenue	Normal	$\mu =$	36,409.76	$\partial =$	3,023.33	Normal	$\mu =$	118,331.67	$\partial =$	9,826.19
Revenue from animal sales	Extreme Values	$\alpha =$	5,427.00	$\beta =$	862.83	Extreme Values	$\alpha =$	17,944.76	$\beta =$	2,852.86
Gross Revenue (GR)		*output*					*output*			
General Expenses	Extreme Values	$\alpha =$	4,601.60	$\beta =$	172.54	Normal	$\mu =$	6,137.35	$\partial =$	187.56
Bulky (silage + forage)	Extreme Values	$\alpha =$	5,150.69	$\beta =$	523.24	Normal	$\mu =$	20,206.12	$\partial =$	849.71
Concentrate + Mineral Supplementation	Extreme Values	$\alpha =$	4,450.74	$\beta =$	599.05	Extreme Values	$\alpha =$	32,720.24	$\beta =$	5,566.43
Maintenance (inventory)	Minimum Extreme Values	$\alpha =$	722.77	$\beta =$	14.43	Normal	$\mu =$	1,428.44	$\partial =$	57.62
Medications	Minimum Extreme Values	$\alpha =$	1,283.00	$\beta =$	63.15	Minimum Extreme Values	$\alpha =$	5,947.47	$\beta =$	302.17
Milking material	Minimum Extreme Values	$\alpha =$	766.70	$\beta =$	54.37	Minimum Extreme Values	$\alpha =$	1,136.13	$\beta =$	84.69
Hired labor	Minimum Extreme Values	$\alpha =$	10,083.86	$\beta =$	129.95	Minimum Extreme Values	$\alpha =$	16,308.55	$\beta =$	210.16
EOC		*output*					*output*			
Depreciation	Normal	$\mu =$	8,993.02	$\partial =$	212.43	Extreme Values	$\alpha =$	13,744.21	$\beta =$	308.81
TOC		*output*					*output*			
GMM		*output*					*output*			
NMM		*output*					*output*			
TGM		*output*					*output*			
TNM		*output*					*output*			

Source: Research data.
Legend: μ = mean for normal distribution and ∂ = standard deviation; α = location of extreme values and minimum extreme values, and β = scale.

Appendix 2. Probability distribution of cost and revenue variables in organic production systems

Region	Ribeirão Preto/SP - Orgânico1					Ribeirão Preto/SP - Orgânico2					Ribeirão Preto/SP - Orgânico3				
Items	**Distribution**	**Parameters and Values (USD)**				**Distribution**	**Parameters and Values (USD)**				**Distribution**	**Parameters and Values (USD)**			
Milk revenue	Normal	μ =	1,024,893.33	∂ =	85,107.62	Normal	μ =	164,566.67	∂ =	13,665.71	Normal	μ =	172,220.95	∂ =	14,301.19
Revenue from animal sales	Extreme Values	α =	42,674.29	β =	6,784.52	Extreme Values	α =	59,545.71	β =	9,466.90	Extreme Values	α =	44,837.86	β =	7,128.57
Gross Revenue (GR)	*output*					*output*					*output*				
General Expenses	Minimum Extreme Values	α =	66,815.60	β =	1,690.44	Extreme Values	α =	10,230.46	β =	132.10	Normal	μ =	15,584.86	∂ =	386.43
Bulky (silage + forage)	Normal	μ =	43,884.29	∂ =	4,302.14	Normal	μ =	15,689.24	∂ =	932.17	Extreme Values	α =	25,994.33	β =	1,474.19
Concentrate + Mineral Supplementation	Extreme Values	α =	500,444.05	β =	83,282.38	Extreme Values	α =	88,092.14	β =	10,335.24	Extreme Values	α =	73,241.90	β =	9,341.90
Maintenance (inventory)	Minimum Extreme Values	α =	6,764.93	β =	123.81	Minimum Extreme Values	α =	3,461.82	β =	63.27	Minimum Extreme Values	α =	3,055.02	β =	62.83
Medications	Minimum Extreme Values	α =	10,280.22	β =	991.66	Minimum Extreme Values	α =	5,404.99	β =	179.53	Minimum Extreme Values	α =	5,269.68	β =	231.08
Milking material	Minimum Extreme Values	α =	4,412.28	β =	314.98	Minimum Extreme Values	α =	2,101.75	β =	149.04	Minimum Extreme Values	α =	10,352.55	β =	734.13
Hired labor	Minimum Extreme Values	α =	69,792.31	β =	899.38	Minimum Extreme Values	α =	21,091.08	β =	271.79	Minimum Extreme Values	α =	31,636.63	β =	407.69
EOC	*output*					*output*					*output*				
Depreciation	Normal	μ =	60,300.19	∂ =	1,415.07	Normal	μ =	24,000.67	∂ =	377.17	Normal	μ =	16,836.88	∂ =	662.79
TOC	*output*					*output*					*output*				
GMM	*output*					*output*					*output*				
NMM	*output*					*output*					*output*				
TGM	*output*					*output*					*output*				
TNM	*output*					*output*					*output*				

Source: Research data.

Legend: μ = mean for normal distribution and ∂ = standard deviation; α = location of extreme values and minimum extreme values, and β = scale.

Appendix 3. Correlation matrix of the simulations in São José do Rio Preto/SP

@RISK Correlations	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)	(J)
(A) Milk revenue	1,0000									
(B) Revenue from animal sales	0,2743	1,0000								
(C) General Expenses	0,2161	-0,2443	1,0000							
(D) Bulky (silage + forage)	0,1824	0,0825	0,5767	1,0000						
(E) Concentrate + Mineral Supplementation	0,3735	0,8979	-0,1547	0,1424	1,0000					
(F) Maintenance (inventory)	-0,1359	-0,5855	0,0257	-0,0381	-0,4554	1,0000				
(G) Medications	-0,4569	-0,8858	0,1470	-0,2312	-0,9263	0,4524	1,0000			
(H) Milking material	-0,4093	-0,9125	0,1875	-0,0711	-0,9349	0,3947	0,9498	1,0000		
(I) Hired labor	-0,3192	0,1707	-0,4884	-0,2576	-0,0791	-0,3352	0,0634	0,0793	1,0000	
(J) Depreciation	-0,2064	-0,5273	0,1658	0,0288	-0,5535	0,6279	0,5129	0,4081	-0,1561	1,0000

Source: Research data (2021).

Appendix 4. Correlation matrix of the simulations in Mococa/SP

@RISK Correlations	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)	(J)
(A) Milk revenue	1,0000									
(B) Revenue from animal sales	0,2743	1,0000								
(C) General Expenses	-0,0882	-0,5987	1,0000							
(D) Bulky (silage + forage)	-0,0751	-0,0236	0,5295	1,0000						
(E) Concentrate + Mineral Supplementation	0,3644	0,9072	-0,4760	0,0613	1,0000					
(F) Maintenance (inventory)	-0,2618	-0,7259	0,2571	-0,1800	-0,6662	1,0000				
(G) Medications	-0,4362	-0,8884	0,5650	0,0793	-0,9138	0,5632	1,0000			
(H) Milking material	-0,4272	-0,9172	0,4903	0,0240	-0,9464	0,5893	0,9771	1,0000		
(I) Hired labor	-0,3192	0,1707	-0,5184	-0,1811	-0,0533	-0,2045	0,0480	0,0869	1,0000	
(J) Depreciation	-0,0283	-0,1601	0,0009	-0,1611	-0,1777	0,6235	-0,0121	-0,0017	-0,1716	1,0000

Source: Research data (2021).

Appendix 5. Correlation matrix of the simulations of organic matrix 1 in Ribeirão Preto/SP

@RISK Correlations	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)	(J)
(A) Milk revenue	1,0000									
(B) Revenue from animal sales	0,2743	1,0000								
(C) General Expenses	-0,2882	-0,7298	1,0000							
(D) Bulky (silage + forage)	0,2624	0,4175	0,0315	1,0000						
(E) Concentrate + Mineral Supplementation	0,4252	0,9128	-0,6480	0,4328	1,0000					
(F) Maintenance (inventory)	-0,0338	-0,4115	0,3681	-0,0072	-0,2737	1,0000				
(G) Medications	-0,1752	-0,7124	0,6364	0,0376	-0,6917	0,2620	1,0000			
(H) Milking material	-0,4093	-0,9125	0,6160	-0,4237	-0,9421	0,2274	0,8153	1,0000		
(I) Hired labor	-0,3192	0,1707	-0,4555	-0,2541	-0,0527	-0,3754	-0,0716	0,0793	1,0000	
(J) Depreciation	-0,1610	-0,5766	0,4463	-0,2335	-0,5872	0,6513	0,1588	0,4081	-0,2275	1,0000

Source: Research data (2021).

Appendix 6. Correlation matrix of simulations of organic matrix 2 in Ribeirão Preto/SP

@RISK Correlations	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)	(J)
(A) Milk revenue	1,0000									
(B) Revenue from animal sales	0,2743	1,0000								
(C) General Expenses	0,0341	-0,2358	1,0000							
(D) Bulky (silage + forage)	-0,0720	-0,5041	0,2719	1,0000						
(E) Concentrate + Mineral Supplementation	0,4264	0,8708	-0,1937	-0,3450	1,0000					
(F) Maintenance (inventory)	-0,0249	-0,3946	0,0493	0,5890	-0,1897	1,0000				
(G) Medications	0,0437	-0,4879	0,0043	0,1530	-0,5826	0,2538	1,0000			
(H) Milking material	-0,4093	-0,9125	0,1779	0,3856	-0,9347	0,2120	0,5406	1,0000		
(I) Hired labor	-0,3192	0,1707	-0,3623	-0,3029	-0,0808	-0,3770	-0,0015	0,0793	1,0000	
(J) Depreciation	-0,0837	0,0768	-0,0065	0,1262	0,0173	0,4601	0,0915	-0,1903	-0,1198	1,0000

Source: Research data (2021).

Appendix 7. Correlation matrix of simulations of organic matrix 3 in Ribeirão Preto/SP

@RISK Correlations	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)	(J)
(A) Milk revenue	1,0000									
(B) Revenue from animal sales	0,2743	1,0000								
(C) General Expenses	0,1328	-0,1866	1,0000							
(D) Bulky (silage + forage)	-0,0152	-0,3880	0,3627	1,0000						
(E) Concentrate + Mineral Supplementation	0,4446	0,8957	-0,1376	-0,2789	1,0000					
(F) Maintenance (inventory)	-0,1509	-0,6075	-0,0542	0,4773	-0,4771	1,0000				
(G) Medications	-0,1470	-0,7469	0,3086	0,3637	-0,7420	0,3731	1,0000			
(H) Milking material	-0,4093	-0,9125	0,1447	0,2944	-0,9409	0,4175	0,8511	1,0000		
(I) Hired labor	-0,3192	0,1707	-0,3680	-0,3226	-0,0836	-0,3255	-0,0320	0,0793	1,0000	
(J) Depreciation	-0,3359	-0,7800	-0,0350	0,2648	-0,8209	0,7502	0,4821	0,6994	-0,0456	1,0000

Source: Research data (2021).