

**MONTE CARLO SIMULATION APPLIED TO ECONOMIC AND FINANCIAL ANALYSIS OF AN AGRIBUSINESS PROJECT****SIMULAÇÃO DE MONTE CARLO APLICADA À ANÁLISE ECONÔMICO-FINANCEIRA DE UM PROJETO AGROINDUSTRIAL**Danilo Simões<sup>1</sup>, Lucas Raul Scherrer<sup>2</sup>**ABSTRACT**

In practice, all management decisions involving an organization, regardless of size, have uncertainties which lead to different levels of risk. Monte Carlo simulation allows risk analysis by designing probabilistic models. From a deterministic model of economic viability indicators, commonly used for decision investment projects, it was developed a probabilistic model with Monte Carlo method simulations in order to carry out economic and financial analysis of an agroindustrial project for orange juice processing. Results showed that the financial investment for orange processing is economically viable with low risk.

**Keywords:** Equivalent Uniform Annual. Modified Internal Rate of Return. Orange juice. Risk. Value Financial Investment.

**RESUMO**

Na prática, todas as decisões gerenciais que envolvem uma organização, independentemente do porte, possuem incertezas que conduzem a diferentes níveis de risco. A simulação de Monte Carlo permite analisar o risco por meio da construção de modelos probabilísticos. A partir de um modelo determinístico dos indicadores de viabilidade econômica, utilizados habitualmente para a decisão de projetos de investimentos, desenvolveu-se um modelo probabilístico, com simulações pelo método de Monte Carlo, para realizar a análise econômico-financeira de um projeto agroindustrial para o processamento de suco de laranja. Os resultados estatísticos demonstraram que o investimento financeiro para o processamento de laranja é economicamente viável e o risco associado pode ser considerado baixo.

**Palavras-chave:** Investimento financeiro. Taxa Interna de Retorno Modificada. Suco de laranja. Risco. Valor Anual Uniforme Equivalente.

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## 1. INTRODUCTION

Brazil is the world's largest orange producer and uses more than 70.0% of fruits for juice production. The amount of processed oranges has had a growing rate of 10% yearly confirming the trend of Brazilian citriculture for juice production (SANTOS et al., 2013).

Orange juice is a unique food due to its high level of C vitamin as well as great quantities of other essential nutrients as carotenoids, folate and potassium (CÉSAR et al., 2010). Within orange juice processing industry, juice production from the great variety of oranges in the market involves the analysis of great amount of information for optimizing the use of available resources (MUNHOZ; MORABITO, 2001).

Even with large amount of information the economic and financial analysis as the Net Present Value and Modified Internal Return Rate, among others, are performed in a deterministic way restricted to estimates which do not indicate the risk of financial return of an investment.

According to Silva and Marins (2014), usually in deterministic models it is proposed that collected data be reliable even if there might be information which may show uncertainty inherent to their nature such as raw material costs and demand or sale estimation.

Considering deterministic data, it is possible to make up probabilistic simulation models. Simon (1996) states that simulation is an essential technique for understanding complex systems, especially when the behavior of such systems can not easily be understood by means of characteristics of its compound parts.

The premise to perform probabilistic simulation is the necessity to identify the interest variables. Afterwards, the applicability will occur with generation of pseudorandom numbers, which may be accomplished by using Monte Carlo method, considering probabilistic events.

According to Bonifácio (2007), Monte Carlo method is a statistical method for numeric problem simulation using basically a random sequence of random numbers or pseudorandom numbers.

Summarizing, McNeil et al. (2005) describe Monte Carlo method as a general name for any risk measurement approach which involves simulation of a explicit parametric model for changes in risky factors. Simioni and Hoeflich (2006) add that risk

analysis using simulations by Monte Carlo method is an alternative used for estimation of economic results expected from projects.

Within this context this paper aimed to develop a probabilistic model, with simulations by Monte Carlo method to perform economic-financial analysis of an agroindustrial project for orange juice processing.

## **2. MATERIAL AND METHODS**

### **2.1 Characterization of the agroindustrial project**

It was used technical coefficient matrix from an agroindustrial project for the processing of pasteurized orange juice, with a production capacity of approximately 170 thousand liters by month to be installed in the Midwest region of São Paulo state.

Among the required equipment there are two extractors with processing capacity of 360 fresh fruits (oranges) per minute and a pasteurizer which will operate along with the extractors enabling an operational production of approximately 2.000 L h<sup>-1</sup> of pasteurized juice.

### **2.2 Processing cost estimation**

Economic analysis consisted from estimates of total processing cost (TPC). Used cost methodology was proposed by Matsunaga et al. (1976), from the Institute of Agricultural Economics (IEA) and classified as effective operational cost (EOC); total operational cost (TOC); total processing cost (TPC) and result of addition of EOC and TOC.

These costs were expressed in American trade dollars for its use as reference international currency, according to Simões et al. (2012) and used as a parameter for the financial market (COELHO JUNIOR et al., 2008). It was considered as exchange rate the price of the official foreign currency at Brazilian Central Bank (PTAX 800) for selling price measured in fractions and units of the national currency, which was BRL 1,9749 on March, 17, 2013 (BANCO CENTRAL DO BRASIL, 2013).

### **2.3 Indicators of economic and financial profitability**

Considered economical profitability indicators were gross revenue (GR) and operational profit according to Martins et al. (2010) as well as gross margin (GM) according to Furlaneto and Esperancini (2010).

## **2.4 Economical and financial risk of investment project**

Risk incorporation to project on financial investment was drawn up from generating pseudorandom numbers, having quantity determined by optimal convergence of simulated values through the stochastic Monte Carlo method with stratified probability distribution. Used random number generator was Mersenne Twister for being approved by the major randomness tests according to Souza and Alves Junior (2011).

Simulations, data descriptive statistics and non-parametric Spearman's correlation coefficients used for checking intercorrelation of input variables were performed using @Risk 6.3.0 software Copyright © 2014 Palisade Corporation.

Autoregressive model was used along with movable averages (ARIMA) proposed by Bayer and Souza (2010) through criteria selection of Bayes Information Criterion (BIC) according to Barossi-Filho et al. (2010) for inflation rate projection and historical aspects of Total Savings Account.

Data from economic and financial periodical series were used, considering the National Consumer Price Index (NCPI) provided by Brazilian Central Bank (2014), observed from January 2004 to May 2014 in order to perform future predictions on inflation rate aiming at updating depreciation values as well as income taxes paid during cash flow series.

In order to determine hurdle rate and plan discount and reinvestment rate of intermediate flows it was used the historical time series of interests credited to Savings Account from January 1<sup>st</sup>, 2004 to June 23<sup>rd</sup>, 2014 considering that the entrepreneurs will not raise funds in the financial market but will use their own capital. For estimates on capital opportunity cost it was also used interests from Saving Accounts for its the investment alternative which has higher liquidity and lower risk in the financial market.

In this probabilistic model nine input variables were considered which have relation among each other and directly influence the formation of the variable dependent on Gross Revenue (GR) such as: invested capital (USD); quantity of fresh oranges (Kg month<sup>-1</sup>); orange juice production (L fruit<sup>-1</sup>); citrus pulp residue (Kg month<sup>-1</sup>); total

processing cost (USD month<sup>-1</sup>); orange juice marketing cost (USD L<sup>-1</sup>); citrus pulp marketing cost (USD Kg<sup>-1</sup>); NCPI (%) and yield on Savings Account (%).

Modal value of orange juice yield was determined from three varieties of oranges (*Citrus sinensis* Osbeck), Pêra, Valência e Natal, from a farm supplying fresh fruits for processing agribusiness. For citrus pulp residue it was considered 47.5% of mass of each fresh fruit. Modal marketing value was estimated according to that of marketing (reference value).

For not knowing the distribution of each variable (input) which has a great bearing on the financial results of the project, it was used triangular distribution. For defining minimum, modal and maximum input values, a variable was delimited from -15.0% to +15.0% of deterministic values except of NCPI for Savings Account yields which were planned by moving averages.

It was considered for cash flow analysis a period of 10 years due to equipment lifespan used for orange processing. Economic viability indicators considered as output variables were:

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

where:

NPV – Net Present Value (USD);

n – financial investment lifespan;

B – flow of benefits;

C – cost flows;

t – time counting;

r – discount rate.

$$MIRR = \left[ \frac{\sum_{t=0}^n R_t (1+r)^{n-t}}{\sum_{t=0}^n \frac{|C_t|}{(1+r)^t}} \right]^{\frac{1}{n}} - 1 \quad (2)$$

where:

MIRR – Modified Internal Rate of Return (%);

R – revenue (positive net values at each "t" time of cash flow);

C – costs (negative net values at each "t" time of cash flow).

$$EUAV = \frac{NPV [(1+r)^t - 1](1+r)^{nt}}{(1+r)^{nt} - 1} \quad (3)$$

where:

EUAV – Equivalent Uniform Annual Value.

$$PBD = \sum_{t=0}^n \frac{R}{(1+r)^t} = 0 \quad (4)$$

where:

PBD – discounted payback (years).

$$PI = \sum_{t=0}^n \frac{\frac{R}{(1+r)^t}}{IO} \quad (5)$$

where:

PI – profitability index;

IO – initial outlay.

### 3. RESULTS AND DISCUSSION

#### 3.1 Financial investment analysis

Financial uncertainty on financial projects come from associated variables which usually modify along time thus showing different behaviors which may lead to project economic infeasibility. One possible understanding for the behaviour of such variables is the distribution of occurrence probability obtained from statistical techniques.

From probability distribution it was possible to get the most probable value for implementing the project of USD 597,988.04. From this amount, 28.6% will be used on building and 71.4% are destined to acquisition of equipments to supply the demand proposed by the project. Among the equipments two extractors and pasteurizer machines made up 39.5% of costs.

#### 3.2 Economic and financial profitability analysis

According to Oaigen et al. (2008) knowing production costs by means of cost generator centers allows the entrepreneur to understand the impact that some processes

or technologies may cause to the system especially at product final cost. However the effective operational cost (EOC) was of approximately 37.8% of the total processing cost (TPC). Return on invested capital which was considered as financial expenses within costs was the most affected (45.0%) in the total processing cost, estimated at a discount rate of 6.0% under time series based on ARIMA model. It is important to mention that financial expenditures aimed at immobilized capital for this activity are high what may influence economic profitability indexes for agribusiness.

According to processing modal value estimated at 347,250 kilograms of oranges per month which results in 169,284 liters of pasteurized juice, will result on a probable processing cost of 0.5932 USD L<sup>-1</sup>. Probable commercial cost of juice will be of 0.70 USD L<sup>-1</sup>.

Revenues from the commercialization of citrus pulp, considered as waste, will be approximately USD 8,300.00 per month, resulting in 165,400 kilograms of pulp. Such amount makes it possible to increase monthly operational profit of 0.3% (Table 1). Gross margin confirms total processing cost coverage, that is, direct and indirect costs will be refunded which shows the economical aspect of the agroindustrial project.

Table 1. Monthly profitability indicators of orange processing

Items	Values
Gross revenue (USD)	126,855.03
Gross margin (%)	26,33
Operating profit (USD)	26,435.95

### 3.3 Financial and economic risk analysis

Simulation through Monte Carlo method created pseudorandom numbers eliminating the biased probability due to great convergence of probabilistic model which occurred with 37,300 repetitions making the estimated results even more reliable.

Exit variables considered in the sensibility analysis were NPV and MIRR for they are the most expressive economic viability indicators within decision taking in a financial investment.

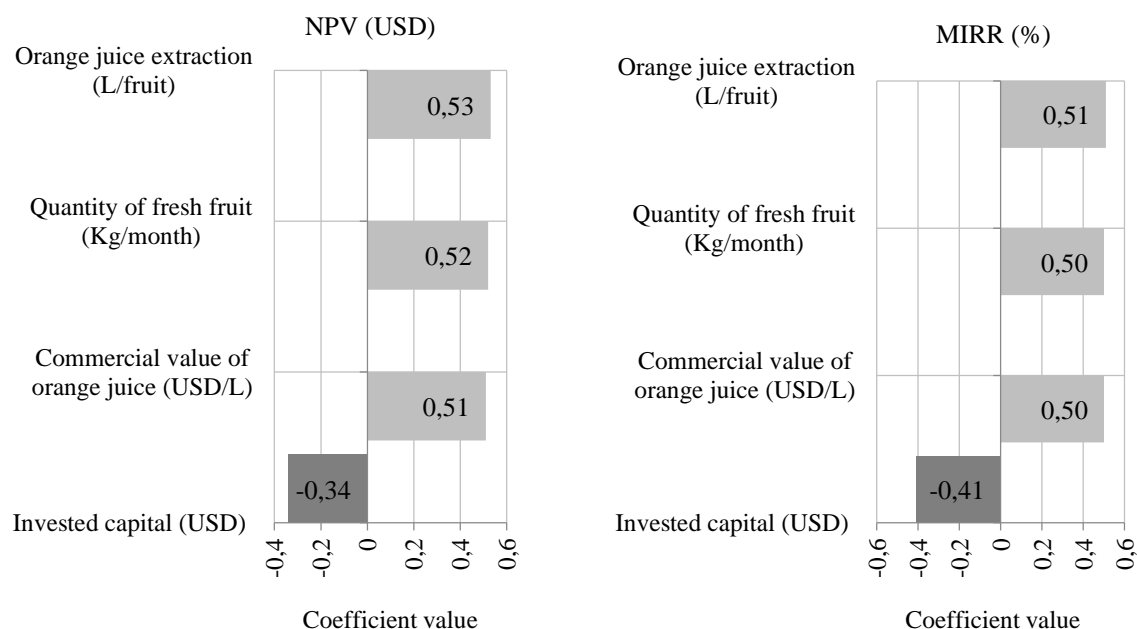
Sensibility analysis may be understood as an auxiliary tool for decision taking because it is from this analysis that it is possible to estimate the impact of each associated variable (input) over economic and financial viability of the studied project.

For Hazell and Norton (1986) stability of sensibility analysis solution is evaluated under *ceteris paribus* condition through which the effect of alteration in only one income parameter (or only one income variable) is considered while the others are constant.

Such analysis showed that among input variables analysed by triangular distribution the production of orange juice (L fruit<sup>-1</sup>); the quantity of fresh fruit Kg month<sup>-1</sup>) and commercial value of orange juice (USD L<sup>-1</sup>) are the variables which have the highest positive correlation with NPV and MIRR which showed coefficients higher than 0.50 for both indicators. Thus, such variables are directly proportional to those economic variability indicators.

Invested capital is the input variable which shows the highest negative correlation with NPV and with MIRR with Spearman's correlation coefficients of -0.34 and -0.41 respectively. Therefore the degree of technological improvement used in this agroindustrial project expresses high sensibility due to the amount spent for such purpose (Figure 1). The other input variables do not show significative influence over economic viability of the project for they show linear coefficient below 0.01.

Figure 1. Spearman's correlation coefficients of input variables of probabilistic model in relation to NPV and MIRR for orange juice processing



Through NPV and MIRR simulations it is possible to observe, in Table 2, the results of descriptive statistics which may allow considering that skewness and kurtosis indicators of economic viability have approximately normal distribution with standard



patterns, respectively near 0 and 3. The proximity of median NPV (USD 125,681.11) and MIRR (8.14%) with obtained mean and modal values confirm data normality.

Descriptive statistical results allow the consideration that the agroindustrial project has a low financial risk according to standard deviation and variance of analysed economic viability indicators. Risk is defined by Bruni (2008) when the variables are under probable distribution which can be calculated with a certain precision, that is, it represents uncertainty which can be measured.

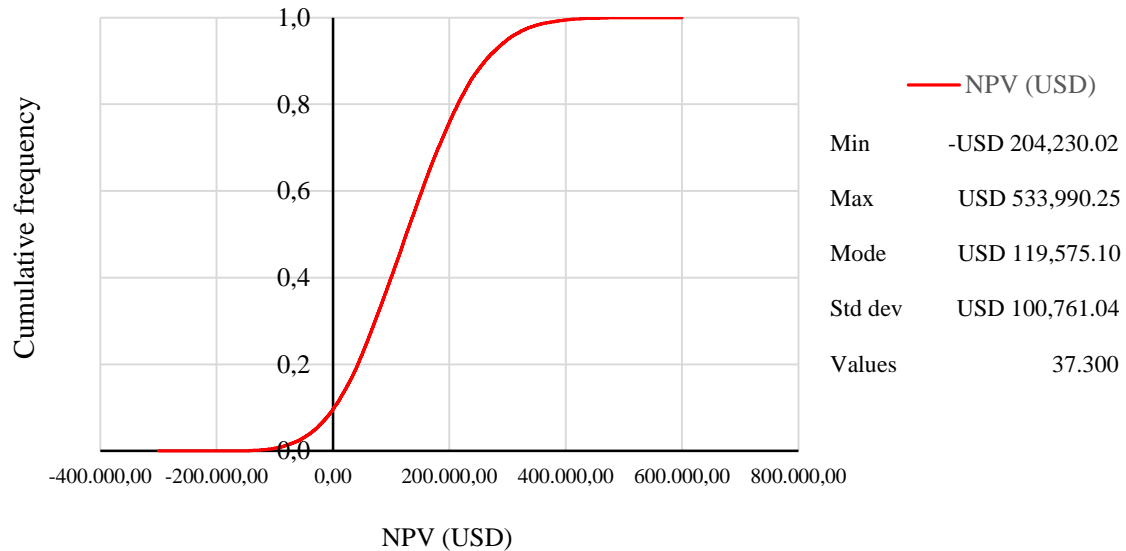
Table 2. Descriptive statistics of NPV and MIRR for orange juice processing

Statistics	Economic viability indicators	
	NPV	MIRR
Minimum	-203,058.49	2.04%
Maximum	532,743.22	13.94%
Average	129,246.97	8.12%
Mode	121,953.12	8.61%
Standard Deviation	100,456.98	1.55%
Skewness	0.1776069	-0.06746797
Kurtosis	2.891791	2.860111
Errors	0	0
Percentiles		
5%	-30,119.36	5.53%
15%	24,649.14	6.50%
25%	58,229.66	7.06%
35%	86,362.34	7.52%
45%	113,188.27	7.93%
55%	139,319.40	8.34%
65%	166,252.86	8.76%
75%	196,995.80	9.21%
85%	234,164.12	9.75%
95%	299,964.72	10.64%

When NPV is observed, considering a pessimistic scenario, that is, obtaining a negative value, it is possible to have 9.7% (Figure 2). Probability of modal value occurrence (more probable) is 38.8%. According to Nardelli and Macedo (2011) NPV

refers to the difference, since the beginning of the project (present date), between the present value of future cash flows generated by the project and the investments made.

Figure 2. NPV accumulated frequency simulated for orange juice processing



MIRR accumulated frequency (Figure 3) has 51.9% of probability to be superior to that of attractiveness minimum rate (6.0% per year) and also to reach modal value. The advantage of using MIRR is the consideration of different rates to raise financial resources, and other fees that may be commonly used by financial markets for fixed-income investments for possible reinvestment of positive cash flows. Considering Ehrhardt and Brigham (2012) to overcome RIR deficiencies it is adopted the MIRR which uses calculus, investment rates for reapplication of intermediate cash flows which are more consistent to the market.

Figure 3. MIRR accumulated frequency simulated for orange juice processing

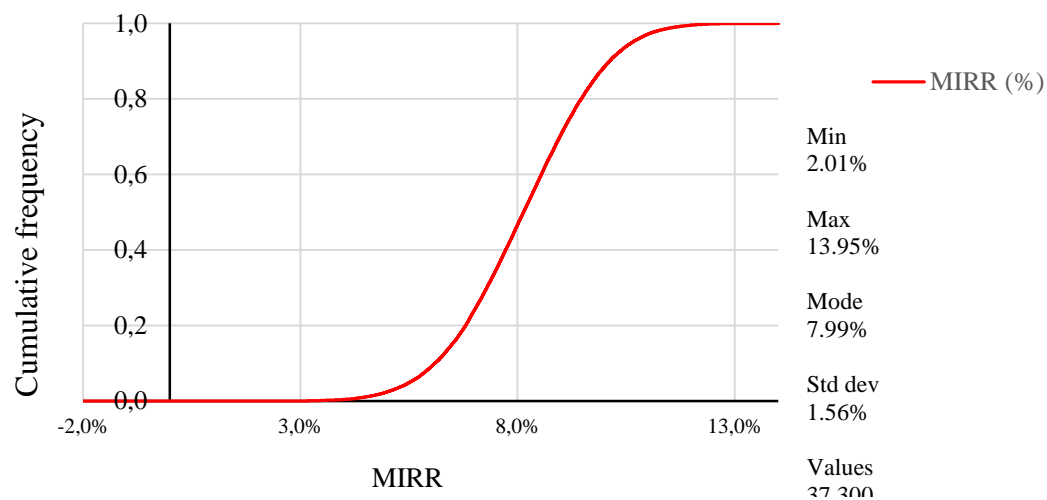


Table 3 shows that the EUAV enables a yearly average profit of USD 17,230.93. Silva et al (2014) assert that EUAV is a similar method to NPV but it consists in finding an annual standard series which is equivalent to investment costs and revenues using attractiveness minimum rate.

By analysing discounted payback, defined by Debastiani et al (2014) as responsible for calculating the investment payback time adjusting cash flows for an interest rate, the entrepreneur may have the return of invested capital within 7.7 years of investment acquiescence.

For Petinari et al. (2012), the profitability index (PI) is defined as equal to the proportion of gross income that constitutes an available resource after covering the COT. Therefore, obtained index for the analysed agroindustrial project will allow the entrepreneur to obtain USD 0.22 for each invested American commercial dollar.

Table 3. Economic viability indicators for orange juice processing

Economic viability indicators	Estimated results
EUAV (USD)	17,230.93
Discounted payback (years)	7.7
Profitability index (PI)	1.22

#### 4. CONCLUSIONS

Probabilistic model showed that input variables which most influenced agroindustry economic and financial viability in orange processing are the production of orange juice (L fruit<sup>-1</sup>), the quantity of processed fresh fruit and the commercial value of orange juice.

Financial invested showed economic viability for having a MIRR higher than 2.5% when compared to minimum attractiveness rate

Probabilistic model showed that the agroindustrial project can be considered of low risk for having a pessimistic scenario lower than 10.0%.

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