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VULNERABILITY OF COFFEE PRODUCTION: AN ANALYSIS OF ECONOMIC PROFITABILITY

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ABSTRACT

Given the economic importance of domestic coffee production, it is essential to Brazilian coffee farmers to ensure a financially profitable activity. This study used a coffee farm in the Espírito Santo state as a proxy to investigated how coffee profitability respond to four variables: Brazilian coffee price, international coffee prices, oil price and exchange rate.This research implies the evaluation of the economic viability of coffee production in function of market conditions. Economic viability was then measured by conventional techniques such as the Internal Rate of Return (IRR) and the Net Present Value (NPV) in combination with other economic metrics. The study was developed in a baseline scenario, where demand elasticities were determined for each variable, using Granger causality and Johansen cointegration tests, as well as the Cholesky impulse response function. As a result, we found significant variables to determine the economic viability of coffee produced in the Espírito Santo state. Based on the results of the sensitivities, shocks were applied to the variants to simulate different alternative scenarios that allowed us to analyze in which market conditions coffee production was more profitable. It was observed through the elasticities of variables that the international price of coffee does not affect the price of domestic coffee. Approximately 70% of the simulated scenarios presented economic viability.

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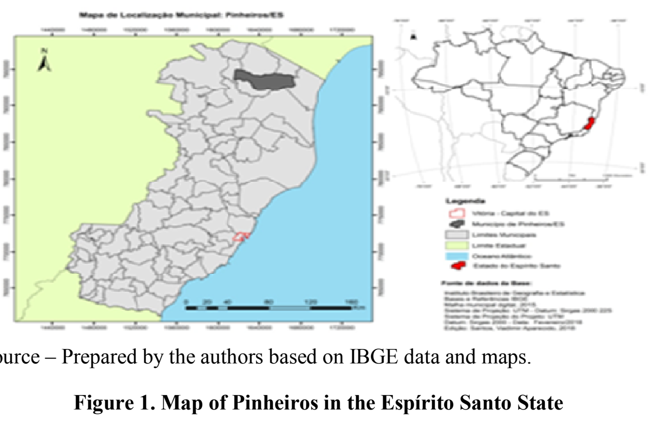
INTRODUCTION

In 2016, Brazil produced 51.4 million bags of coffee in 2,22 million hectares. There were 43.4 million bags of Arabica-type coffee and 8 million bags of Conillon-type coffee. In the same year, coffee production totaled US $ 5.47 billion for the Brazilian economy and accounted for 9.8% of Brazilian exports, totaling US $ 600.74 million. In this context, the coffee production chain generated more than eight million jobs for the country(CONAB, 2016). Brazil is the largest coffee producer in the world, accounting for 30.13% of world production, followed by Vietnam (19.18%) and Colombia (9.41%). Among the largest consumers, Brazil occupies the third position in the world ranking. The European Union and the United States represent the largest consumer markets and together import about two thirds of all the world's coffee(CECAFÉ, 2017; AGRIANUAL, 2016). The cultivation of *Arabica* and *Conillon* coffees is present in the Brazilian states of Minas Gerais, Espírito Santo, São Paulo, Bahia, Rondônia, Paraná and Goiás. Together they account for 98.65% of the national production.Minas Gerais produces almost 100% of Arabica-type coffee, with an average annual production of approximately 26 million bags. Espírito Santo is the largest Brazilian producer of Conillon-type coffee with an average annual production close to 5 million bags.(CONAB, 2016). Brazilian coffee growth, specially Conillon-type cultivation in Espírito Santo, is a result of increased investments in breeding, biotechnology, pest management, food security, optimization of the production system, integrated pest and disease management, irrigated coffee, climatic zoning, harvest and post-harvest techniques; in addition to improvements in processes and development of equipment that helped to obtain clonal varieties suitable for high yields and with differentiated maturation(MAPA, 2017, CETCAF, 2016). Coffee agro-industrial chain counts on the multidisciplinarity of several agents such as research laboratories, suppliers of inputs, machinery and equipment, cooperatives, processing companies, exporters, consulting and technical assistance, international buyers, domestic consumers and especially the rural producer(CHAIN et al., 2016).

Although the sector is strongly grounded, farmers still face challenges in product marketing. They need to understand how prices respond to macroeconomic variables and find better prices for their products. Understanding the dynamics of prices is critical to manage production and protect it from market fluctuations.Just as in any commodity market, there is evidence of market power in the pricing of coffee - such as coffee bag prices, international coffee prices, oil barrel prices, and exchange rates (DUREVALL, 2007). Price variation of most commodities is related to supply and demand.Commodity price formation is directly affected by rising manufactured food prices, population growth, rising per capita income in developing countries, integration of global markets, climate shocks, falling global inventories, declining agricultural output, financial speculation, rising oil prices and expansion of biofuels.The price of coffee is also influenced by these factors, both domestically and internationally(FAOa, 2010; FAOb, 2012; MARTIN et al.,1995; JUNIOR et al*.,* 1996). Price is essential for the commercialization of Conillon-type coffee. It is less valued than the Arabica type in the foreign market and is mainly marketed to the soluble coffee segment (SAES et al., 2002). Like any agricultural crop, coffee production needs fertilizers to improve soil fertility and, consequently, increasethe yield. Most of fertilizers used to grow coffee is oil derivative, therefore, price variations in oil derivatives can affect the prices of fertilizers (OIC, 2015; BINI, DENARDIN, 2013). Macroeconomics variables can also explain the price variation of commodities. Inflation, aggregate demand, interest rates and especially the exchange rate can have effects on supply and demand dynamics, directly impacting coffee prices (PINDYCK, ROTEMBERG, 1990; ROSOLEN et al*.,* 2013; ENGEL, WEST; 2015). It is worth noting that the real exchange rate of any country dictates its competitiveness in the foreign market, significantly affecting the terms of trade and inflation (KARGBO, 2004; REICHSFELD; ROACHE, 2011). Given the importance of this commodity for Brazilian agriculture, and especially for Espírito Santo, it is fundamental for the farmer to produce coffee in a financially profitable way. Therefore, this study aimed at assessing the economic viability of Brazilian coffee production in different market conditions. Specifically, the study proposes to evaluate how the prices of coffee and oil in the domestic and foreign markets plus the exchange rate affect the economic profitability of the coffee producer. To prove the results, different scenarios were simulated for which the variables preponderant to the formation of the price of the coffee bag in Espírito Santo were found. The most frequent time of economic return in the simulated scenarios was also obtained. Finally, the scenarios where theanalyzed variables make coffee production economically feasible were presented.

METHODOLOGY

Localization and data: The study was conducted in the municipality of Pinheiros (974 km²), in the State of Espírito Santo, located in the mesoregion of the northern coast of the state.



Source – Prepared by the authors based on IBGE data and maps.

Figure 1. Map of Pinheiros in the Espírito Santo State

Agrianual (2017) data were used to construct the 2016-2017 crop cash flowfor the Conillon coffee planted in Pinheiros (ES), considering coffee production by one hectare. The time series of coffee's price variation in the domestic and foreign markets was obtained from the Center for Advanced Studies in Applied Economics (CEPEA / ESALQ). Information on oil barrel price time series was extracted from the World Bank database. TheBrazil Central Bank data were used to build the time series of national exchange rates.

Financial-economic viability: The fixed and variable production costs encompass all the inputs and services used during the coffee production cycle at a given time. Fixed cost changes do not occur in the short term (1 to 3 years after starting the activity), but in the long run (4 to 12 years after starting the activity).Recomposition of the variable cost occurs in the short term, at each coffee production cycle. A third production cost is still considered in the economic analysis – the opportunity cost. It refers to a normal retribution of capital ifthe farmer opts for another different activity or investment. Under these conditions, economic profit occurs if the financial return on coffee production outweighs the opportunity cost (EVANGELISTA *et al.*, 2011). The series were seasonally adjusted and deflated by calculating the linear growth trend of the time series estimated by linear regression. The cash flow considered the average projection of coffee prices in the last five years in the State of Espírito Santo.According to Bacha (1998), the average price of the last five years is related to the characteristics of the coffee market, which may have lagged reactions to the product supply, receiving price stimuli for up to five years. That is, even with negative prices in a time, supply may increase because of the production of new coffee plantations. From the projected prices, a cash flow is created (Table 1), which enables the coffee producer to analyze the profitability of its production, comparing the prices received for coffee and the average costs of production.

In addition to cash flow, a financial-economic viability analysis can be addressed to the project using Net Present Value (NPV); Internal Rate of Return (IRR); Modified Internal Rate of Return (MIRR); Updated Payback; and Equivalent Uniform Annual Worth (EUAW) (EVANGELISTA et al., 2011; POSSAMAI, 2017). Coffee cultivation is riskier than the financial market itself, therefore it is important to consider this vulnerability. The Capital Asset Price Model considers it through a linear relation between risk and return of investment projects, which allows to verify the level of risk assumed by the project and the risk premium (MARKOWITZ, 1959; SHARPE, 1964; LINTNER, 1965; MOSSIN, 1966). According to Pereiro (2002), the CAPM model has limitations in emerging countries such as Brazil (small and concentrated stock markets and few publicly traded companies), so the Adjusted Hybrid CAPM-based model (AH-CAPM) is the most appropriate alternative:

$$Ke=Rf_g+R_c+\beta C_{LG}[\beta_{GG}(R_{MG}-Rf_g)](1-R^2) \quad (7)$$

Where:

Ke is the cost of equity. Rfg is the global risk-free rate. The US Treasury bonds (T-bonds) with a 30-year redemption period have been used as (Rf) and the rate was quoted at 2.88%. Rc is the country risk premium, represented in this study by the Emerging Markets Bond Index + Brazil index (EMBI + Brazil index), calculated by JP Morgan Chase: every 100 points expressed by EMBI + Brazil a surcharge of 2.58% is paid p.a., corresponding to a risk premium on US Treasury securities[1]. βCLG is the country Beta that adjust the global market premium to the Brazilian market. This adjustment mitigates the effects of emerging market volatility. βCLG = 1.1172 was obtained by the regression between the local stock market index (IBOVESPA Index) and the All Country World Index (MSCI ACWI), from September 2012 to September 2017[2]. The MSCI ACWI is disclosed by Morgan Stanley Capital International and measures the stock market performance of 46 countries grouped in 23 developed countries and 23 emerging countries (TEIXEIRA; CUNHA, 2017).

[1]http://ipeadata.gov.br
[2]http://br.investing.com

Table 1. Cash flow with economic variables for coffee production, considering 1 hectare

Cash Flow Variables	Description of variables
(1) Gross Operating Revenue (GOR): *GOR=Pp ×Pa*	Where: *GOR*=gross operating revenue; *Pp*= Price projection and *Pa*= Produced amount
(2) Tax on Revenue *TR=Al x GOR*	Where: *TR*= tax on revenue; *Al*=aliquot and *GOR*=gross operating revenue
(3) Net Operating Revenue *NOR=GOR-TR*	Where: *ROL*=net operating revenue; *ROB*= gross operating revenue and *TR*= tax revenue
(4) Production costs: *PC=OP+IM*	Where: *PC*= production cost; *OC*=operating costand *IM*= inputs and materials
(5) Gross profit[1]: *GP= NOR –PC*	Where: *GP*= gross profit; *NOR*= net operating revenue and *PC*=production cost
(6) Administrative costs: *Admc= T+ Techas + Mng + ME*	Where: *Admc*= administrative costs; *T*= travels; *Techas*=technical assistance; *Mng*= managementand *ME*=marketable expenses
(7) Gross Operating Profit: *GOP=GP-Admc*	Where: *GOP*= gross operating profit; *GP*=gross profit and *Admc*= administrative costs
(8) Tax on Revenue *TR=(Al IT+Al CSLL)*GP*	Where: *TR*=tax on revenue; *Al TR*= aliquot*TR; Al CSLL*= aliquot *CSLL* and *GP*=gross profit
(9) Net Operating Profit: *NOP= GOP – TR*	Where: *NOP*=net operating profit; *GOP*=gross operating profit and *TR*=tax on revenue
(10) Depreciation: *D=MD+CPD*	Where: *D*= depreciation; *MD*= machines and equipment depreciation and *CPD*= central pivot depreciation
(11) Operating Cash Flow: *OCF=NOP + D*	Where: *OCF*=operating cash flow; *NOP*= net operating profit and *D*= depreciation
(12) Financial expenses: *FE=PC x RxFI*	Where: *FE*= financial expenses; *PC*= production costs and *RxFI*=Financing Interest Rate
(13) Farmer Cash Flow: *FCF= OCF – FE*	Where: *FCF*=Farmer Cash Flow; *OCF*=Operating Cash Flowand *FE*= financial expenses

Source: Prepared by the authors

Table 2. Economic and financial indicators of coffee production in Pinheiros (MS)

Economic and financial indicators	Description of variables
$NPV = \sum_{t=1}^{n} \frac{CF_t}{(1+K)t} - I_0 + \sum_{t=1}^{n} \frac{I_t}{(1+K)t}$	Where: *FCt*= cash flow (benefit) during a single period *t;* *K*= project's discount rate or return represented by the minimum profitability required*;* I_0= investment estimated at time zero (total initial investments);I_t=investment estimated in each subsequent period. The *NPV* rule to decide on investment is: *NPV=0* - Indifferent *NPV>0* - Attractive (worth it) *NPV<0* - Unattractive (not worth it)
$IRR=I_0+\sum_{t=1}^{n} \frac{I_t}{(1+K)t} - I_0 + \sum_{t=1}^{n} \frac{CF_t}{(1+K)t}$	Where: I_0=total initial investments; I_t= investments estimated in each subsequent period*; K*=periodic annual rate of return (IRR)*; CF_t*= cash flow (benefit) during a single period *t.* The IRR rule to decide on investment is: *IRR = i* - Indifferent *IRR >i* - Attractive (worth it) *IRR <i* - Unattractive (not worth it)
$MIRR = \left[\frac{\sum_{j=0}^{n}(R-C)_{posit.}\,(1+i_c)^{n-1}}{\sum_{j=0}^{n}\frac{(R-C)_{neg}}{(1+i_d)^j}}\right]^{\frac{1}{n}} - 1$	Where: R= revenue; C= Costs; $(R - C)_{posit.}$ = Positive cash flow; I_d=Financing rate; $(R - C)_{negat.}$= Negative cash flow; Ic=Market interest rate. The decision rule for MIRR is very similar to IRR: an investment should be accepted if the MIRR is greater that the minimum rate of attractiveness (MRA). MIRR >MRA → investment project is economically viable; MIRR<MRA → investment project is economically unfeasible; and MIRR = MRA → indifferent
$PP = \sum_{t=0}^{n}(B-C)t = 0$	Where: B= benefits; C=the costs and investments generated by the project; t= time; and n= project life time.
$EUAW=\sum_{t-1}^{n}\frac{CF}{(1+i)^t} X \left[\frac{i\,x\,(1+i)^t}{(1+i)^t-1}\right]$	Where: CF=Cash Flow; i=Project Interest Rate; t= time; n= project life time.

Source: Prepared by the authors

Table 3. 12-year discounted cash flow of *Conillon*-type coffee – Pinheiros (Espírito Santo)[1]

	Year 1	Year 2	Year 3 to Year 12
GOR	0,00	11.800,00	23.600,00
(-) *TR*	0,00	271,40	542,80
NOR	0,00	11.528,60	23.057,20
(-) *PC*	9.999,92	11.931,52	18.366,34
GP	-9.999,92	-402,92	4.690,86
(-) *AC*	1.125,00	1.325,00	1.325,00
Gross Operating Profit	-11.124,92	-1.727,92	3.365,86
(-) Taxes on Revenue	0,00	0,00	0,00
Net Operating Profit	-11.124,92	-1.727,92	3.365,86
(+) Depreciation	1.604,85	1.604,85	1.604,85
(=) Operating cash flow	-9.520,07	-123,07	4.970,71
(-) Financial costs	924,99	1.103,67	1.698,89
(=) Farmer cash flow	-10.445,06	-1.103,67	3.271,82

Source: Prepared by the authors

βCGG is the average unlevered Beta of comparable companies quoting in the global market,obtained by the following equation: βA={βA/[1(1-t)(D/E]}. Where βA is the unlevered Beta; t is the income tax rate; D refers to the value of third-party capital or onerous liabilities; E represents equity. The unleveraged sectoral beta used in this study was calculated at 0.59 (DAMODARAN, 2002)3. The global market return (RMG)used MSCI ACWI4 asa proxy and the value found was 10.3180% p.a.R2 = 0,2747 is the coefficient of determination of the regression between the equity volatility of the domestic market (IBOVESPA index5) against the variation in country risk (EMBI + Brazil index).

The cost of equity *Ke* (minimum attractiveness rate -TMA) is then obtained from the *AH-CAPM* model:

$$Ke=2.88 + 2.58\% + 1.1172[0,59(10,3180\% - 2.88\%] (1-0.2747)$$
$$Ke=9.0160 \text{ p.a.}$$

NPV (the difference between the total revenues generated by an investment project and its total costs to the present value), IRR (internal discount rate generated by the project that makes NPV equal to zero), MIRR (modified internal rate of return) and EUAW (equivalent uniform annual worth) are described in Table 2.

Sensitivity Analysis: The sensitivity analysis is based on probabilistic statistical methods that consider the effect of the risk in a project by estimating the probability of occurrence of each event, either individually or conjointly. This analysis allowed to recognize variables that most influence the economic-financial return through the observation of elasticities. The importance of sensitivity analysis lies in the recognition of the economic viability of a large investment project(POSSAMAI, 2017; BUARQUE, 1991). In the sensitivity analysis, the price elasticities (domestic and foreign markets) of the coffee bag, exchange rate and oil barrel were used to evaluate how the "shock effect" given in these variables changed the cash flow results synthesized in the economic and financial viability.A simplified version of Monte Carlo methods was used to find the price elasticities of the coffee produced in Espírito Santo. A cointegration model was applied to estimate the elasticities, which are precisely the coefficients within the cointegration vector.Before constructing the model, it was verified whether the series were (i) non-stationary, (ii) if there was cointegration between them and (iii) what was the best specification for estimating the cointegration model. The Augmented Dickey-Fuller test (ADF) was used to test if the series were non-stationary (DICKEY; FULLER, 1981; DICKEY; FULLER, 1979). Critical values tabulated for individual unit root tests were obtained in MACKINNON (1991), while values tabulated for joint tests were extracted from DICKEY and FULLER (1981). The unit root test permits to find long-term relationships between one or more variables through Johansen's cointegration test (JOHANSEN, JUSELIUS, 1990). This analysis also provides information on the specification of the cointegration model through the cointegration vectors, from which the elasticities were obtained.

The cointegration test presented fewer cointegration vectors than variables. For correction, there is a Vector Error Correction Model (VECM) that expresses the speed at which the behavior of the variables converges to a long-term equilibrium situation. VECM models also permit to examine the effects of individual variable shocks on system dynamics. The procedure used to diagonalize this matrix is the Cholesky decomposition, which allows verifying at each interval the effect of every single standard deviation shock in all variables. The impulse response function shows how a shock in each variable propagates to the other variables over time. Thus, it is possible to verify not only the magnitude of this impact on the other variables, but also its temporal horizon(MARGARIDO, 2004). Scenario simulations in the investment analysis are recommended when there is no certainty of future events, but the limits of variation of the variables under study (confidence intervals) are known. Thus, by knowing the minimum and maximum limits of variation of the variables, or their sensitivities, it is possible to simulate scenarios close to reality and to calculate the economic result of all possible combinations of variables.

RESULTS AND DISCUSSION

This study was based in the following assumptions: the economic-financial viability analysis was performed for a reference farm of 1 (one) hectare (ha); in the 1st year of the coffee cycle, only seedling planting and soil preparation were done in the area (no grain harvest); the harvest started from the 2nd year with an average of 40 bags / ha; between the 3rd and the 12th year cash flows were considered equal, with an averaged production of 80 bags / ha (8) and a 5-year averaged coffee price (R $ 295.00 / bag) projected; the *Conillon*-type coffee cycle ended in the 12th year of harvestwhen a (9) new planting began; the entrepreneur is the owner of the land with all the improvements, machinery, equipment and facilities necessary for growing coffee in the state of Espírito Santo. The cash flow of the *Conillon*-type coffee production starts with gross operating revenue (GOR). In the 1st year there wasn't revenue, but from the 2nd year revenue was R $ 11,800.00.Revenue between the 3rd and the 12th year remained constant at R $ 23,600.00.Taxes on Revenue (TR) are levied on GOR at a rate of 2.3% (value charged on the cost of producing Conillon-type coffee available in the *Agrianual Estatístico*).It was observed a deduction of R$ 271.40 in the beginning of the harvest (from the 2nd year). Between the 3rd and the 12th year deduction remained constant at R$ 542.80 due to increased revenues, as described in Table 3. Net operating revenue (NOR)was obtained by discountingTR from GOR. In the 2nd year, NOR was R $ 11,528.00; from the 3rdto the 12th year NOR remained constant at R $ 23,057.80.Production costs (PC) in the 1st year were R $ 9,999.92 and in the 2nd year were R $ 11,931.52. From the 3rd to the 12th year, PC remained at R $ 18,366.34. Then, PC was discounted from NOR to obtain the gross profit of the project (GP). In this cash flow, the 1st year (-R $ 9999.92) and the 2ndyear (-R $ 402.92) of the project did not present positive values due to the lack of revenues resulting from the low crop production. However, from the 3rd year until the end of the project, GP became positive (R $ 4,690.86).

Administrative costs (AC) during the *Conillon*-type coffee cycle were R $ 1,125.00 in the 1st year and R $ 1,325.00 from the 2nd year to the end of the cycle. The gross operating profit (GOP) of R $ 3,365.86 between the 3rd and 12th year of the project was then obtained by discounting AC from GP. Individual Income Taxes (IIT) was considered in the cash flowaccording to the current rates for the year 2017. However, this study opted for not taxing the gross revenue, since the cash flow was calculated in a base year. For individual income taxation, it isconsidered the annual progressive table for the year 2017, calendar year 2016. However, in none of the years the revenue reached the minimum ceiling of R $ 22,847.76; therefore, the farmer was exempt from paying these taxes. Net profit is obtained after the calculation of gross operating profit and tax on revenue, by deducting taxes due from gross profit. In this project, the revenue was less than R $ 22,847.76, so there were no tax rate and any portion to be deducted from the IIT. Therefore, the gross profit is equal to the net operating profit - generated by the operation of the business, discounting the administrative and operational costs, without financial movement. To complete the cash flow, it is necessary to calculate the project depreciation. Depreciation is the systematic allocation of the value of an asset's wear over its useful life. It is the record of the reduction of the value of goods by wear or loss of functionality by use, action of nature or obsolescence. Project depreciation was then obtained by the sum of the depreciations of the machinery, facilities and *Central Pivot*. Operating Cash Flow (OCF) was obtained by adding NOP to depreciation, which presented a deficit of -R $ 9,520.07 in the 1sr year of the project, a deficit of -R $ 123.07 in the 2nd year, and surplus of R $ 4,970.71 from the 3rd year to the end of the project (Table 1). Finally, the financial expenses were deducted to obtain the farmer cash flow (FCF). The financial expenses represent

[3]http://pages.stern.nyu.edu
[4]http://msci.com
[5]http://br.investing.com

the interest that should be paid to the creditors of loans contracted (banks).In this study, the current financing rate of Banco do Brazil's FUNCAFÉ of 9.25% p.a. was used. From the FCF it was possible to calculate NPV, IRR, MIRR, PP and EUAW. The project showed a deficit in cash flow in the first two years, R $ 10,445.06 and R $ 1,103.67, respectively. From year 3, an annual surplus of R $ 3,271.82 was observed until the end of the project.Arêdes et al. (2007), Amaral (2011) e Prazeres (2016) observed similar values in their respective studies, which presented negative values in the first two years followed by positive values from the 3rd year up to the end (projects of 12 and 15 years). From a complete cash flow, it is possible to calculate NPV. Table 4 shows a positive NPV (R$7,789.8) for a baseline scenario. It can be concluded that the project is economically viable within all assumptions considered in this study.

Table 4. Techniques of economic feasibility investment for growing 1 ha of Conillon-type coffee in Pinheiros (ES)

Variables	Values
IRR	20.14% p.a.
Cost of Equity (Farmer)	9.0160% p.a.
PV of Farmer Cash Flow	R$18,234.92
NPL of Farmer Cash Flow	R$ 7,789.86
Cash Generation Index	1.75
PP	6.87 years
EUAW	R$ 1,088.74
MIRR	14.28%

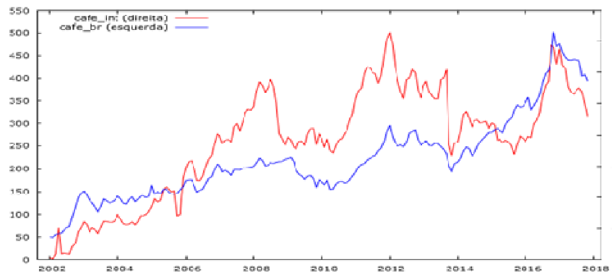
Source: Research data

From the NPV value it was possible to obtain a IRR (20.14% p.a.) considering a discount rate based on the cost of equity (9.016% p.a.).The results show that the IRR (20.14%) was superior to minimum rate of attractiveness (9.016%), which justifies and corroborates the value found for NPV. Therefore, based on assumptions and hypotheses adopted, the Conillon-type coffee cultivated in Pinheiros (ES) presents economic viability (Table 3). It is possible to give greater robustness to these results using a sensitivity analysis. In addition, the minimum attractive rate of return (MARR) is obtained from the *AH-CAPM* model, usually chosen for emerging markets such as Brazil. The *AH-CAPM* model is an adaptation of a normal CAPM model; it estimates the Cost of Equity and minimizes the volatility effects of emerging countries that interfere with the measurement of *betas* and market premiums that make up the CAPM model in its original version. With a discount rate of 9% p.a.Arêdes *et al.*, (2007)obtained NPV = R$ 823.72, IRR = 10,04% p.a., MIRR = 9,47% p.a. and PP = 8,39 years; therefore the project was considered economically viable according to all investment techniques. Noticeable is the PP indicator of this paper (6.87 years) that indicates a faster return on investment.

With a discount rate of 12% p.a, Amaral (2011) found PP = 3.09 years, NPV = R$ 45,190.68 and MIRR = 41,42%, which is a very high value for an economic evaluation. The results of Amaral (2011) contrast the results of this paper since the farmer's return is shorter and financially higher. However, the author does not consider the same economic risks as this study. In this study, the impact of seasonality or deflation on the coffee price in the 5-year period was eliminated using regression to the average price of the Conillon-type coffee. It is worth mentioning that, unlike this study, most studies discuss Arabic-type coffee. Within the baseline scenario and market conditions presented in this study, coffee production in the city of Pinheiros (ES)can be considered economically viable.The reliability of this result is tested by assessing the variables elasticities and then using sensitivity analysis and scenarios.

Sensitivity analysis: From a positive result of the economic viability of coffee production in Pinheiros (ES), a sensitivity analysis was considered for the variables of this study.It was estimated the elasticities between the prices of coffee in the Brazilian market and (i) the price of coffee in the foreign market, (ii) the exchange rate and (iii) the price of oil in the foreign market. Prior to obtain the elasticities, unit root tests were performed to evaluate if the series were non-stationary, and other tests were performed to evaluate if the series were cointegrated. Then, with the estimated cointegration model, impulse response functions were estimated to evaluate how the price of domestic coffee reacts to a shock in the other variables. Finally, once the estimated elasticities were obtained, the behavior of economic viability indicators was evaluated based on changes in the price of coffee in the foreign market and in the values of the exchange rate.For each of these variables, through a normal distribution, 100 different values were generated which, in turn, fed the cash flow presented in the previous section.With this, it becomes possible to understand the conditions under which coffee production remains economically viable or not.

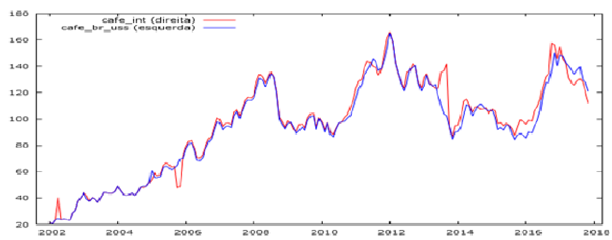
Relationship between the domestic price and the international price of coffee, exchange rate and oil price: This section examines if the price of coffee in Brazil can be affected by variables such as the price of coffee in the foreign market, as well as by the exchange rate and the price of oil. Figure 2 analyzes the evolution of domestic and international prices of coffee, so the behavior of domestic prices can be verified against the evolution of international prices.



Source: prepared by the author based on data from CEPEA / ESALQ

Figure 2. Relationship between domestic price and international coffee price

According to Figure 3, the relationship between the price of coffee in Brazil and international prices is not clear. Peaks and oscillations appear in different periods and are clear in the years 2008, 2012 and 2017. In those years the sack of coffee was highly valued, however, a downward trend is observed in 2018. The price of coffee in the domestic market was converted to dollars using the exchange rate, as shown in Figure 3. Thus, it was possible to observe a similar behavior between the price of coffee in Brazil and the price of coffee in the foreign market.



Source: prepared by the author based on CEPEA / ESALQ and World Bank data

Figure 3. Exchange rate /price of coffee in the domestic market converted to dollar

In Figure 4 the relationship between domestic and international prices seems to be more intense and long term. That is, the peaks occur almost simultaneously and the three variables - domestic price, exchange rate and international price interact with each other. The international price of oil also follows the same trend of the price of coffee in the long term, both in the domestic and in the foreign markets (Figure 4). Although the four variables - price of coffee in Brazil and in the foreign market, exchange rate and oil price in the foreign market appear to be correlated in previous analyzes, correlation and correlation intensity need to be tested and evaluated empirically.Then, Augmented Dick-Fuller (ADF) test was used to evaluate if the series were non-stationary. The test results are presented in Table 5.

Source: prepared by the author based on CEPEA / ESALQ and World Bank data

Figure 4. Domestic price behavior (in dollars) in relation to international coffee price and oil price

In general, it is not possible to reject the null hypothesis that the series are non-stationary. The result is confirmed by repeating the ADF test with the series in the first difference. After identifying non-stationary series in level, the Johansen cointegration test is used to check if there is still some linear combination that can make the relationship among the four variables stationary.In principle, the vector cointegration specification is unknown, then we used the three most common ways to test: with a constant term, with a constant and a trend term, or neither in the model. According to Table 6, the cointegration tests confirmed a long run relation among variables independently of specification (constant term, constant + trend term, neither). The estimates of the three specifications for the cointegration model are presented below:

The coefficients of the cointegration vectors indicate that there is price transmission between the variables (elasticities), except oil. The result of oil price is contrary to the ICO conclusions (2015) but corroborates with the results of Du, Yu and Hayes (2011), indicating that oil price does not affect significantly the elasticities. The cointegration vector of model 1 (without constant) with the estimated values for the elasticities is presented in the equation below. In this case, the coefficient associated with the price of oil in the foreign market is statistically zero.

*Coffee_br = 1.008*Coffee_int + 0.985*exchange - 0.010*oil*

Where:
Coffee_br = coffee price in Espirito Santo (domestic Market)
Coffee_int = coffee price in the foreign market
Exchange = exchange rate
Oil = oil price

Autocorrelation problems of the residuals from the third lag on occurred in both models - without constant and with unrestricted constant (Table 7). Thus, a high number of short-term lags and outliers could occur; therefore, the normality hypothesis of the residuals was rejected. Despite these problems, since the estimates remained unbiased, the elasticities obtained were used in the simulation of the scenarios. Before presenting the simulation of the scenarios, the model without a constant was used to estimate the impulse response functions involving the four variables.

Table 5. Unit root test by Augmented Dick-Fuller (ADF)

Variable (in ln)	Deterministic term (s)	Estimated value	Test Stats	*P-value*	Variable (in ln and 1st difference)	Deterministic term (s)	Estimated value	Test Stats	*P-value*
Domestic coffee	Constant and trend	-0,0941	-4,6052	0,0010	Domestic coffee	Constant and trend	-0,7325	-10,3805	0,0000
	Constant	-0,0290	-3,1762	0,0214		Constant	-0,7220	-10,2731	0,0000
	None	0,0013	1,7082	0,9793		None	-0,6954	-10,0065	0,0000
International coffee	Constant and trend	-0,0492	-2,6399	0,2624	International coffee	Constant and trend	-1,1685	-8,9082	0,0000
	Constant	-0,0403	-3,5125	0,0077		Constant	-1,1078	-8,5091	0,0000
	None	0,0018	1,4762	0,9659		None	-1,0588	-8,2561	0,0000
Exchange rate	Constant and trend	-0,0146	-1,3700	0,8697	Exchange rate	Constant and trend	-0,6242	-7,6747	0,0000
	Constant	-0,0152	-1,4092	0,5795		Constant	-0,6078	-9,0327	0,0000
	None	0,0001	0,0221	0,6899		None	-0,6069	-9,0461	0,0000
International oil	Constant and trend	-0,0332	-2,3393	0,4119	International oil	Constant and trend	-0,8734	-6,3663	0,0000
	Constant	-0,0330	-2,6125	0,0904		Constant	-0,8283	-6,2321	0,0000
	None	0,0006	0,4226	0,8047		None	-0,6684	-9,6912	0,0000

Source: Prepared by the authors; Note: Critical Values Used by Davidson & Mackinnon (1993)

Table 6. Cointegration test (Johansen)

Variables (in ln)	Deterministic terms	Nº lags (level)	H_0: $r = r_0$	Test Stats	*P-value*
Domestic coffee, international coffee, Exchange rate, oil	Without const.	1	$r_0 = 0$	91,265	0,000
			$r_0 = 1$	24,629	0,046
			$r_0 = 2$	4,120	0,697
			$r_0 = 3$	0,874	0,402
	Restricted const.	1	$r_0 = 0$	110,570	0,000
			$r_0 = 1$	42,804	0,006
			$r_0 = 2$	18,384	0,091
			$r_0 = 3$	1,139	0,917
	Const.	1	$r_0 = 0$	102,300	0,000
			$r_0 = 1$	34,537	0,013
			$r_0 = 2$	15,786	0,045
			$r_0 = 3$	1,012	0,318
	Without const.	2	$r_0 = 0$	73,819	0,000
			$r_0 = 1$	21,280	0,119
			$r_0 = 2$	5,585	0,498
			$r_0 = 3$	1,233	0,310
	Restricted const.	2	$r_0 = 0$	89,401	0,000
			$r_0 = 1$	36,859	0,033
			$r_0 = 2$	17,164	0,131
			$r_0 = 3$	2,214	0,733
	Const.	2	$r_0 = 0$	84,372	0,000
			$r_0 = 1$	31,843	0,029
			$r_0 = 2$	14,975	0,060
			$r_0 = 3$	2,051	0,155

Source: Prepared by the author; Critical values of Johansen (1995)

Table 7. Autocorrelation tests up to the 12th lag

Model without constant			
Lags	Rao F	Approximate Distance	P-value
lag 1	1,110	F(16, 541)	0,3422
lag 2	1,424	F(32, 639)	0,0630
lag 3	2,230	F(48, 653)	0,0000
lag 4	2,201	F(64, 648)	0,0000
lag 5	1,971	F(80, 637)	0,0000
lag 6	2,058	F(96, 624)	0,0000
lag 7	2,052	F(112, 610)	0,0000
lag 8	2,172	F(128, 595)	0,0000
lag 9	2,243	F(144, 580)	0,0000
lag 10	2,285	F(160, 564)	0,0000
lag 11	2,153	F(176, 549)	0,0000
lag 12	1,985	F(192, 533)	0,0000

Source: Prepared by the author

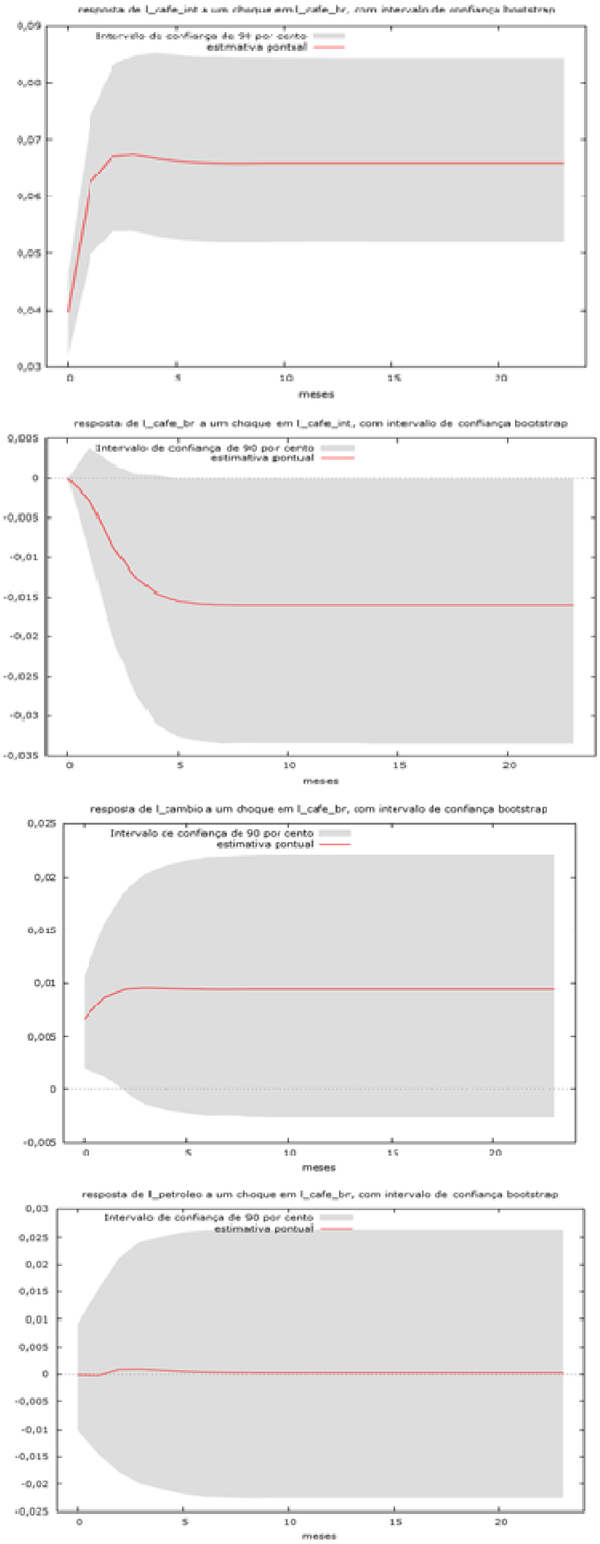
The estimated impulse response functions suggest that:

- The price of coffee in the foreign market responds to shocks in the price of Brazilian coffee;
- The price of Brazilian coffee does not respond to changes in the price of coffee in the foreign market;
- The price of coffee in the Brazilian market does not respond to changes in the price of oil in the foreign market;
- The price of coffee in the Brazilian market responds quickly to changes in the exchange rate and this shock dissipates after 2 months.

The cointegration models previously estimated had already indicated this result. However, the non-response of the price of domestic coffee to changes in the price of international coffee is a remarkable result. Probably the influence of the price of domestic coffee on international prices has already been controlled by the impulse-response function estimate. If the influence of domestic coffee on international coffee prices is more intense than in the opposite direction, the cointegration model may have lost the ability to capture the influence of the price of international coffee on the price of domestic coffee.

Simulations of Scenarios: Under some conditions considered in this study, coffee production in Pinheiros (ES) was considered economically viable (NPV positive). Sensitivity analysis was performed based on the critical variables of the model, that is, those that when altered may have a greater effect on NPV or IRR.For the sensitivity analysis, we found the elasticities of the variables: exchange rate, price of oil barrel and price of coffee in the foreign market. Scenario simulations were made based on these elasticities to know in which scenarios coffee production in Espírito Santo was economically feasible. A baseline scenario (cash flow) was designed to identify the elasticities that establish a relationship between coffee prices in Espírito Santo, coffee prices in the foreign market and exchange rates. A cointegration model that considers coefficients within the vector was used to estimate the elasticities. Thus, it was possible to verify that the price of oil did not influence the price of coffee in Espírito Santo. However, it was identified two sensitive variables and thus shocks in the price of international coffee and in the exchange rate were simulated, characterizing the sensitivity analysis used in this study (shocks on the baseline scenario). Scenarios were designed for 100 random numbers, following a normal distribution for the international coffee price and exchange rate. For each variable a standard deviation change was considered, and this deviation was calculated through the historical series of each variant.

The 5-year averaged price of domestic coffee, was calculated(R $ 325.04) from data available at Agrolink; value not far from the price worked on the cash flow (R $ 295.00). It is worth remembering that in the years 2016 and 2017, peaks in the Arabica and Conillon coffee bag prices were observed in comparison with previous years (2014 and 2015), that is, oscillations occurred in a short period of time (less than 5 years).



Source: Prepared by the author

Figure 5. Impulse - Response Functions Model

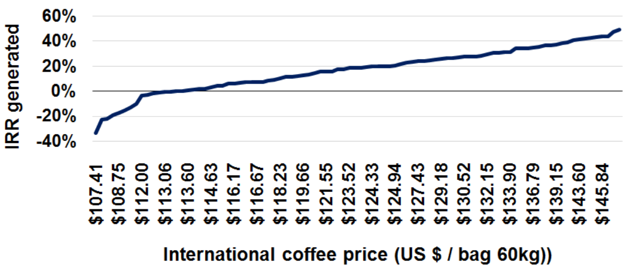
The oscillations may be related to variations in coffee production due to pests, climate change, light and temperature for flowering and grain yield. The international coffee price presented elasticity of 1.0084, with an average of $ 124.70 / bag and standard deviation of 12.37. The simple average and the standard deviation were taken from international coffee prices, obtained from a 5-year historical series in the World Bank database. The NPV in the baseline scenario was positive (R $ 7,789.86), enabling the evaluation of optimal and pessimistic scenarios for a total of 100 random numbers of normal distribution. In the first variant, international coffee prices, NPV was positive in 60% of the scenarios, from the price of $ 118.23 / coffee bag, equivalent to R $ 279.56 / coffee bag in the domestic market

(Espírito Santo). Corroborating an 80% confidence interval, the scenarios generated a NPV between R$ 10,368.79 and R$ 23,643.76, as shown in Figure 6.

Source: Prepared by the author

Figure 6. NPV (R$) varying the international coffee

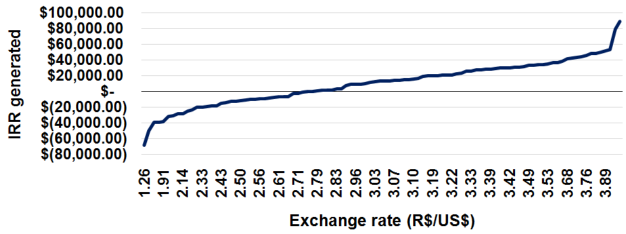
In this simulation, the curve extremity (pessimist scenario) reached U$$ 94,26 with a -24,41% variation on the international price not distant from domestic price (-24,62%); therefore, domestic price would be approximately R$222,38, generating a negative NPV of -R$ 25.601,33. An extremely positive scenario is illustrated by a traded international price of US$151,93, with a 21,84% variation in the foreign market and a 22,02% variation in the domestic market and with the coffee bag price reaching R$359,96 and generating a NPV of R$37.658,40. Prices like those were already traded in market places of Conillon-type coffee during years 2016 and 2017 and at values higher than those of the simulation. However, there is a downward trend in the price of the coffee bag at the beginning of 2018, as verified in Agrolink (2018). To give robustness and support to the scenarios and to compare the profitability of the alternatives presented in the project, shocks in the IRR were applied with the price of international coffee, as shown in Figure 7.



Source: Prepared by the author

Figure 7. IRR (%) varying the international coffee

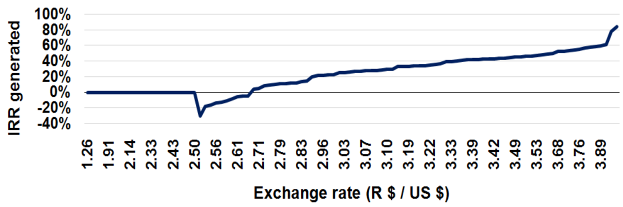
Figure 8 shows positive IRR in 76% of the simulated scenarios, with US $ 113.46 /coffee bag on the foreign market and R $ 268.19 /coffee bag on the domestic market.If 80% of scenarios are likely to happen, the extremities of the IRR are between -22.0% (price in the foreign market) and 37% (domestic market). It was not possible to obtain a viable IRR in some simulated scenarios where the coffee bag price in the foreign market was between US $ 94.26 and US $ 104.00. The IRR of the hypothetical scenarios also depends on the rate adopted in the baseline scenario, which in this work was 9.25% pa (available at FUNCAFÉ / Banco do Brasil-SELIC). However, since there is no guarantee that these values are real, it cannot be assumed that the function is polynomial. Perhaps a modified internal rate of return could be obtained in this case by MIRR calculation. The second step is to analyze the NPV and the IRR to simulate scenarios with the exchange rate. At first, we can notice a similarity with the first scenario (foreign price), where great extremities occur. In the simulations (Figure 8), some values follow the baseline scenario: 5-year averaged exchange rate (R $ 2.92), standard deviation (0.59), elasticity (0.985) and national price (R $ 295, 00), all obtained from a historical series available at the Central Bank. The positive NPV in 65% of the simulations occurs from an exchange rate above R $ 2.76 and a domestic minimum price of R $ 278.68. Considering a confidence interval of 80%, the range is -R $ 23,130.68 to R $ 42,134.89. Based on the analysis, a pessimistic scenario would have an exchange rate of R $ 1.26, with changes of -57.01% in the exchange rate and -56.16% in the price of the coffee bag, thus reaching R $ 129.00 / coffee bag and a negative NPV of - R $ 68,381.71. However, the value of the coffee bag in the last 10 years has not reached that price. In the most perfect scenario, the exchange rate would be 4.72, changing the exchange rate by 61.32% and 60.40% in the national price, capturing a price of R $ 473.19 / coffee bag and a positive NPV of R $ 89,722.06.



Source: Prepared by the author

Figure 8. NPV (R $) varying the exchange rate

Unlike the pessimistic scenario, this price has already been worked in the national trade, reaching up to R $ 510,17 / coffee bag. With the support of the simulated data, if IRR is applied in this variable, it will be possible to compare its elasticity and profitability to the project scenarios, as shown in Figure 09.



Source: Prepared by the author

Figure 9. NPV (%) varying the exchange rate

To obtain a positive IRR in 89% of the simulated scenarios, the exchange rate should be above R $ 2.69, that is, the coffee bag should be priced above R $ 272.17. Assuming a confidence interval of 80% for the graphically displayed extremities, the TIR rate ranges from -4.4% to 53.9%. In the 100 random scenarios of normal distribution, the positive NPV varied the exchange rate to R $ 2.76 to obtain R $ 278.68 / coffee bag in the domesticmarket. In this variant, 65% of the scenarios generated positive NPV. For the IRR, 89% of the scenarios were considered economically viable with a minimum exchange rate of R $ 2.69. For future research, we suggest a deepening in the probability calculations of the simulated scenarios to check which specific points make coffee production economically viable. In addition, actions of specialized companies and research projects in partnership with companies should be also considered. Breeding studies to improve grain quality are desirable since specialized agencies have already detected poor quality in the nationally produced coffee grain.

Final Considerations

Given the importance of coffee commodity for Brazilian agriculture, it is fundamental for the farmer to produce coffee in a financially profitable way. Therefore, this study aimed at assessing the economic viability of Brazilian coffee production in different market conditions. This article proposes to demonstrate the elasticities of variables that the literature considered to be influential in the formation of the domestic price of coffee: quotation of the coffee price in the international market, oil price and exchange rate. Conventional indicators of economic viability such as Internal Rate of Return (IRR) and Net Present Value (NPV) were used to evaluate the profitability of coffee production through sensitivity analysis of variables considered important by literature to formulate the price of the coffee bag. The elasticities of the variables show that the price of coffee in the foreign market does not affect the price of coffee in the domestic market. In fact, the movement is contrary, the price of coffee in the national market is what influences the formation of the price of coffee in the foreign market. Oil price, as presented in the literature, is not directly related to the price formation of coffee in the domestic market. Probably the market competitiveness causes the producer to retain possible variations in coffee price. Thus, among the analyzed variables, only exchange rate exerts influence on the price of the Conillon-type coffee in the national market. The Brazilian crops have a great capacity to interfere with the prices of coffee in the foreign market. Unlike OIC (2015), this work demonstrates that there is no positive correlation between the price of coffee and the prices of petroleum products, so the price of oil does not influence the formation of coffee prices. Therefore, the critical variables in this project were the price of coffee in the foreign market and the exchange rate. Moreover, in analyzing the impulse-response effects, Brazil is the price-maker of Conillon-type coffee. Sensitivity analysis showed that domestic coffee production becomes feasible for the foreign market in 60% of the simulated scenarioswith a NPV of US $ 118.23. IRR was positive in 76% of the simulated scenarios, with US $ 113.46 /coffee bag on the foreign market. Within the 100 random scenarios of normal distribution, NPV becomes positive at an exchange rate of R $ 2.76, that is, with R $ 278.68 / coffee bag in the domestic market. In this variant, 65% of the scenarios generated positive NPV. Analyzing the IRR, 89% of the scenarios were considered viable, with a minimum exchange rate of R $ 2.69. For future research, we suggest a deepening in the probability calculations of the simulated scenarios to check which specific points make coffee production economically viable. In addition, actions of specialized companies and research projects in partnership with companies should be also considered. Breeding studies to improve grain quality are desirable since specialized agencies have already detected poor quality in the nationally produced coffee grain.

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