International Journal of Business and Management Invention (IJBMI)
ISSN (Online): 2319 – 8028, ISSN (Print): 2319 – 801X
www.ijbmi.org || Volume 13 Issue 2 || February 2024 || PP: 63-76

ANew Approach of Investment Project Appraisal under Risk and Uncertainty

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ABSTRACT:*The financial uncertainty in the results of the investment evaluation creates conditions of risk in the decision making of any strategy in the management of the industrial units. The recent crises (economic andpandemic) have only reinforced the need to explicitly introduce the factor of uncertainty in any new investment decision. The aim of the present paper is to develop a methodological approach contributing to the appraisal of an investment project under risk and uncertainty. Methods from statistical - econometrics, probabilistic analysis, numerical simulation methods and financial analysis are used and combined. The stochastic approach is used through the Monte Carlo simulation to appraisal the uncertainty. Finally, the implementation of probabilistic theory combined with the use of decision trees allows to estimate in a more relevant way the factor of uncertainty considering all perspectives.*

KEY WORDS*: investment, economic growth, risk, uncertainty, investment project appraisal, statistical methods, stochastic-probabilistic methods.*

Date of Submission: 26-01-2024 Date of acceptance: 08-02-2024

I. INTRODUCTION AND LITERATURE REVIEW

Economic volatility, because of the ten-year economic crisis in Greece, leads companies to financial uncertainty. Then the financial uncertainty in the results of the investment evaluation creates conditions of risk in the decision making of any strategy in the management of the industrial units. The recent crises (economic and pandemic) have only reinforced the need to explicitly introduce the factor of uncertainty in any new investment decision. If risk and investment are two inseparable concepts (Pezet, 2000) so are uncertainty and investment. In such a context, this paper proposes a methodological approach for the comprehensive appraisal of an investment project under risk and uncertainty. Methods from statistical - econometrics, probabilistic analysis, numerical simulation methods and financial analysis is used and combined. The stochastic approach is used through the Monte Carlo simulation to appraisal the uncertainty for all scenarios and perspectives. Finally, the implementation of probabilistic theory combined with the use of decision trees allows to estimate in a more relevant way the factor of uncertainty considering all perspectives.

II. LITERATURE REVIEW

The statistical and econometric models are used to forecast consumption. Some methods are more advanced than others and presuppose the existence of reliable statistical data. One form of the general equation is multiple linear regression which aims to study the relationship between the dependent variable and various independent variables (Polyzos, 2018). Another econometric model is the autoregressive integrated move average model. ARIMA models are stochastic mathematical models that describe the evolution of a physical quantity over time (Duquenne, 2017). To appraisal the investment, three scenarios can be developed and linked to estimates and corresponding probabilities. The favorable scenario which will correspond to optimistic estimates for the development of net cash flows and will be a result of good economic conditions. The possible scenario which will correspond to normal estimates for the evolution of net cash flows. Finally, the pessimistic scenario that will be the result of economic recession and will predict a bad development of net cash flow for the company (Polyzos,2018).

In cases where projects have a significant difference in project costs and different expected net cash flows, the standard deviation used in the previous case is not an indicative method for calculating risk. As the amount of investment differs significantly between the investment proposals, the importance of the standard deviation is altered. (Artikis, 2002). One method for limiting this alteration is to calculate the coefficient variation CV of each sentence. The coefficient of variation shows the amount of risk, as calculated from the standard deviation per unit of expected (NPV). The investment with the lowest rate of volatility has the lowest relative risk. Obviously, that investment proposal will be chosen from among a few mutually excluded investment proposals, which will have the highest expected average (NPV) and the lowest risk (Polyzos, 2018).

Another method in risk analysis is the decision tree. To solve a decision tree, it is usually divided into two parts: nodes of luck with all the resulting situations of nature and decision nodes with all their alternatives. The resolution process starts from the sections that end in the final returns, to the right of the tree, and continues to the left, section by section, in the opposite order to that of the tree design. At the node of luck can be noted the expected monetary value for all possible contingencies which will be equal to the product of the value of each contingent on the probability that this will occur. For every eventuality used the Net Present Value (NPV) thereof as well as the value or cost of all decisions (Polyzos, 2018).

The sensitivity analysis (Cacuci, 2003) is another method that concerns the study of the variable Y by ΔY, after changes by ΔX_m in the values X_m. In the appraisal of investments, the sensitivity analysis determines the "sensitivity" of the expected cash flows to changes in the parameters on which they depend. The degree of influence of the deviation of the value of a parameter from the initial estimate on the change of the financial decision determines how sensitive the financial decision is to the examined parameter (Polyzos, 2018).

In Monte Carlo simulation the empirical model that characterizes the investment proposal is determined (David Hertz, 1968). For each factor affecting $ENCFT_t$ a subjective probability distribution is defined for which the mean value and the standard deviation are calculated. Then a stochastic function is selected which describes the changes of the factors that affect the ENCFt of the investment proposal.

For investment proposals that last more than one period and their return varies from period to period, then both the number of expected net cash flows and the number of standard deviations will be the same as the years of application of the investment. The existence of the above precludes a general conclusion. To overcome the difficulty, Hillier proposes the calculation of the expected Net Present Value of the investment plans (ENPV) and then the standard deviation of the ENPV. This calculation is made from the expected net cash flows and standard deviations from the probability distributions of the net cash flows over the life of the investment. Bayes Theorem states that if an event F is known to have occurred and is also known to be associated with one of a set of mutually exclusive events: $E_1, E_2, \dots, E_n$, then for a particular event, E_j can calculated the values of $P(F/E_j)$ which called prior probabilities. The probability is $P(E_j/F)$, calculated after the outcome F is known, is called a posterior probability (Adams, 2015).

Other methods used in evaluating investments are ROA Analysis and CAPM. The term RO Analysis was first mentioned by Myers (1977), who studied the opportunities for making an investment in American rights and concluded that the possibility of postponing a decision allows for a more profitable investment. Models in which investments are valued by RO Analysis were developed by Pindyck, (1980), Brennan & Schwartz (1985), Mcdonald& Siegel (1986) and Majd (1987). Leahy (1993) further expanded RO Analysis. CAPM is a model that is used to calculate the return on an investment, so that it is decided to include it in the portfolio to be evaluated. It was based on the work of Markowitz and presented by Treynor (1961, 1962), Sharpe (1964), Lintner (1965), Mossin (1966). It formulates a theory of the relationship between investment risk i as measured by the bi (beta) coefficient and the return on investment required by investment i to cover that risk. The ROA and CAPM methods are characterized as unrealistic due to the assumptions of the perfect market (absence of taxes and transaction costs, provision of free perfect information, investors' indifference to risk).

Balliauw et al. (2019) propose Brownian motion to explain uncertainty in port competition analysis and Xiao et al. (2015) propose an integrated economic model to analyze disaster prevention investments in a port. Kumar et al., (2018) investigate the financial risk associated with highway infrastructure projects by identifying parameters such as traffic flow and project cost. Liu et al (2017) present an improved quantitative risk assessment model to help risk managers identify direct relationships between specific risk events and investor decision variables. Skourtos et al (2021), introduce a new approach for comparing alternative technological options for desalination plants under water cost uncertainty. Polyzos et al (2015) analyze the location decisions of agro-industrial investments in Greece.

Polyzos &Niavis (2013) present the efficiency assessment of ports in the Mediterranean. Polyzos &Minetos (2013) present a multinomial logistic regression analysis at regional level for informal housing in Greece. Polyzos &Minetos (2011) present an evaluation of tourism businesses using a regression model. Aquila et al. (2016) analyzed the effect of market incentives and environment on the risk of wind farm investments in Brazil. For this, a quantitative approach was used that allows an analysis of the investments by simulating the NPV values for different scenarios. The decision criterion used in this study (Aquila et al.,2016) to perform the investment analysis is NPV. In practice, the impact of uncertain parameters (such as cost, raw material price, selling price, manufacturing period and productivity) on decision variables is evaluated (Hacura et al., 2001; Ye and Tiong, 2000; Rezaie et al. al., 2007; Suslick et al., 2008). This usually involves calculating the variance of the net present value (NPV) and the internal rate of return (IRR) if the uncertain parameters vary within a certain range, and then obtaining the probability distributions of the NPV and IRR. Gómez-Fustera, &Jiménezb (2020), presented research whose main objective was to develop economic and financial risk analysis for infrastructure projects using Monte Carlo simulation and probability distributions.

Monte Carlo simulation has been widely used to assess a project's total cost and financial risk (Wylie et al., 2014). Today the Monte Carlo method is one of the useful tools in risk assessment and investment evaluation. It becomes necessary to study stochastic variables in the process of evaluating investment plans, pointing out that the determination of deterministic prices alone is not enough to make the right decision. According to Patris (2008), the Monte Carlo simulation method is appropriate in those cases where not enough historical data is available or unforeseen risks must be included in the assessment.

The most common indicators considered in a simulation are NPV and IRR. According to Hacura et al (2001), the NPV because of the simulation is the most reliable indicator in the evaluation of an investment, as all cash flows are considered for its determination. A group of researchers do not consider the use of IRR in the evaluation of investments to be credible. However, Brounen et al (2004) and Osborne (2010) use the IRR as much as the NPV in the investment appraisal process, due to the ease of comparison with the cost of capital. For this reason, the stochastic Monte Carlo simulation method will be used as a tool to appraisal the investment and its effectiveness will be examined to draw conclusions about its viability for the benefit of shareholders and investors.

III. RESEARCH METHODOLOGY

After above presentation of the methodologies based on quantitative analysis, the present section is devoted to the formulation of the proposed methodological framework of quantitative analysis. Our methodology refers to domestic industrial projects and the calculation of the parameters of the proposed models is based on data collected from the Hellenic Statistical Authority (ELSTAT).

The proposed methodological approach to the risk analysis and uncertainty of an industrial investment plan is based on a specific framework (Fig. 1), followed by a detailed description through a series of stages.

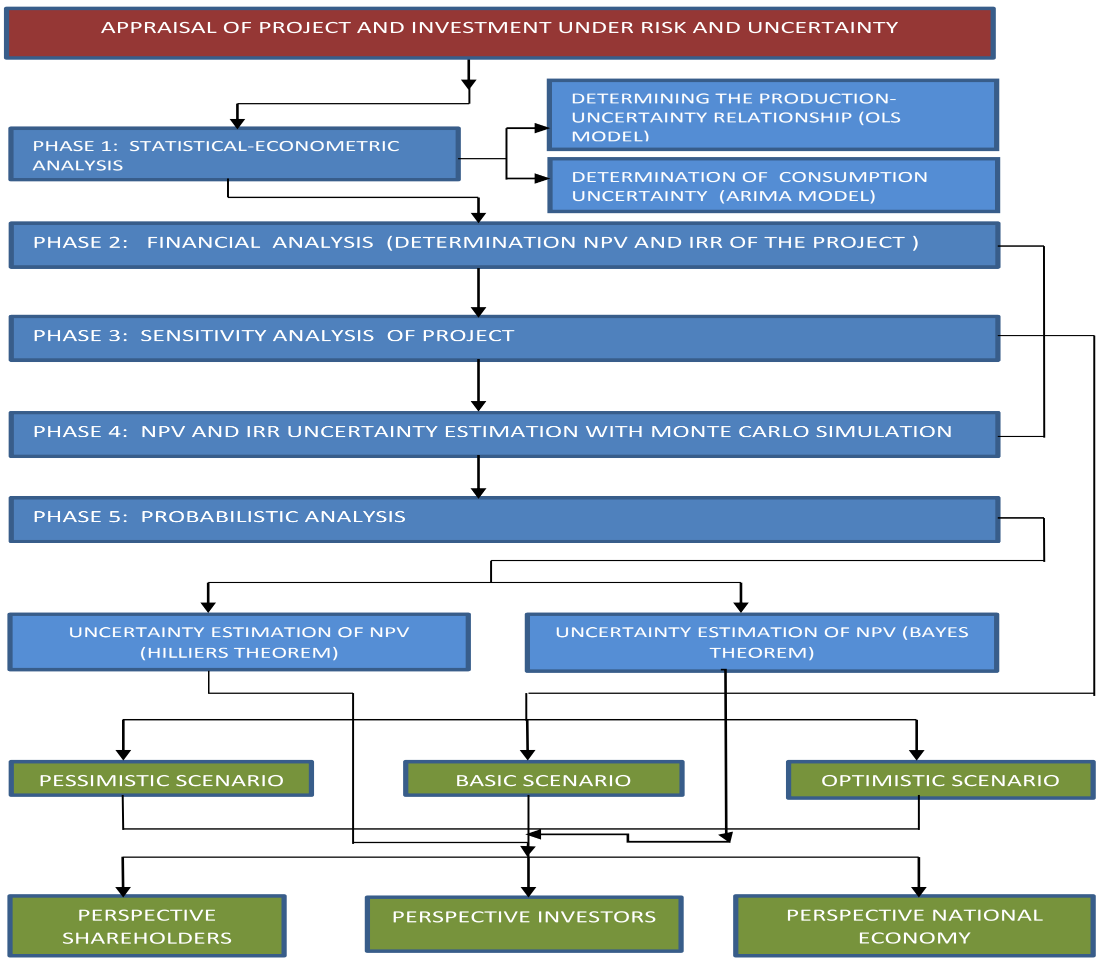


Figure 1: Methodological framework for risk and uncertainty approach

Phase 1 (A): Determining the production-uncertainty relationship (OLS)
The determination of the relation of production to the uncertainty is based on a multiple linear regression through OLS. The model is described the relation:

$$\mathrm{PRODUCT_i} = b_0 + b_1 * \mathrm{GDP_{i1}} + b_2 * \mathrm{TOUR_{i2}} + b_3 * \mathrm{TAX_{CONS\ i3}} + b_4 * \mathrm{PRICE_{i4}} + b_5 * \mathrm{CCI_{i5}} + \varepsilon_i \qquad i = 1,2,\ldots\ldots,20 \tag{1}$$

where:

PRODUCT:	the annual production quantity of the product
GDPper capita:	Great Domestic Product per capita
TOUR:	Tourism
TAXCONS	Taxes of consumption
PRICE:	price per unit of product
CCI:	Consumer Confidence Index
εi:	other factors

The Consumer Confidence Index is derived from gathering information on household spending and savings intentions and assessing their perception of the factors that influence their decisions. (The information refers to the assessment / forecast of the financial situation of the household, the economic situation of the country, the price level, the unemployment level, the purchase intention, and the intention to save them for the next 12 months). The CCI is weighted in the overall EU economic climate index with a weighting of 20% (industry: 40%, services: 30%, construction: 5%, retail: 5%). The above CCI index in the linear multiple regression model represents uncertainty. The investment in the sector is represented by the production variable PRODUCT. Therefore, the solution of the model indirectly describes the relation of the investment of the examined branch with the uncertainty.

Phase 1 (B): Determination of Consumption Uncertainty (ARIMA Model).
Consumption forecast for the next decade will be made with an ARIMA chronological model. The ARIMA model (p, d, q) is described by the relation:

$$Y_t = a_0 + a_1 y_{t-1} + \cdots + a_p y_{t-p} + b_1 \varepsilon_{t-1} + \cdots + b_q \varepsilon_{t-q} + \varepsilon_t \tag{2}$$

Phase 2: Determination NPV and IRR of the project
The indicators of Net Present Value (Fisher,1907) and Internal Rate of Return (IRR) are used for the financial appraisal of the project. The Net Present Value (NPV) of a project is its value reflected at the time of commencement of its commercial operation and is given by the equation:

$$\mathrm{NPV} = -C_0 + \sum_{t=1}^{N} \frac{\mathrm{NCF_t}}{(1+r)^t} + \frac{\mathrm{YA_N}}{(1+r)^N} \tag{3}$$

where:

C_0:	the cost of the investment project
NCFt:	the Net Cash Flow of year t
r:	the minimum required return on capital invested
N:	the duration of the investment in years
YAN:	the residual value of the investment project in the N year

Respectively, the IRR index is the value of the reference rate, for which during the economic evaluation, NPV = 0 applies. In particular, the IRR is the return on investment of the initial appraisal over its economic life cycle and is determined by the solution of the equation:

$$-C_0 + \sum_{t=1}^{N} \frac{\mathrm{NCF_t}}{(1+\mathrm{IRR})^t} = 0 \tag{4}$$

Depending on the resulting NPV and IRR price, the project plan is appraisal. If NPV > 0, the investment plan is selected, if NPV < 0, the investment plan is rejected, if NPV = 0 there is indifference of the investor regarding the acceptance or rejection of the investment plan. If IRR> r, there is a choice of investment plan, if IRR < r, the investment plan has been rejected, while if IRR = r there is indifference of the investor regarding the acceptance or rejection of the investment plan (Papathanassiou 2012; Polyzos 2018). The following applies to the financial appraisal of project plans:

$$\mathrm{NCF_t} = \mathrm{NET\_PROFIT_t} + \mathrm{DEPT_t} \quad \text{or}$$

$$\mathrm{NCF_t} = (\mathrm{REV_t} - \mathrm{COST_{tot}})(1 - \mathrm{ART_t}) + \mathrm{DEPT_t} * \mathrm{ART_t} \tag{5}$$

with: $\mathrm{COST_{tot}} = \mathrm{QTY_t} * \mathrm{COMP_t} + \mathrm{STAFF_t} + \mathrm{INTERATE_t} + \mathrm{INDUST_{COST\ t}}$
and

$$\mathrm{REV_t} = \mathrm{QTY_t} * \mathrm{PRICE_t}$$

where:

NET_PROFIT_t:	annual net profits
REV_t :	annual gross savings
$COST_{tot}$	annual total operating costs
$DEPT_t$:	annual depreciation costs
TAX_t :	annual taxes
ART_t :	tax rate
QTY_t :	annual number of sales, resulting from the consumption forecast with the ARIMA chronological model in the Phase 1(B)
$COMP_t$:	annual cost of A and B materials
$STAFF_t$:	annual staff costs
$INTERATE_t$:	annual interest rate
$INDUST_{COST\ t}$:	annual other industrial costs
$PRICE_t$:	annual selling price per unit of product

The appraisal of the project will be done from three perspectives: of the national economy, of the investors, of the shareholders. Finally, the Even Break Point of the investment plan for each scenario is calculated:

$$Q_t = \frac{FIX\_cost_t}{PRICE\_sale_t - PRICE_{cost\ t}} \quad (6)$$

where:

FIX_cost_t:	Fixed cost
$PRICE\_sale_t$:	Price of sales
$PRICE_{cost\ t}$:	Price of cost

A sensitivity analysis is also performed for the Even Break Point over a space of [-20%, 20%]. During the financial analysis of the investment, a series of tables are presented that help in the calculation of the NPV and the IRR.

Phase 3: Determination of NPV and IRR changes in investment plan (sensitivity analysis)

The change ΔNPV_t related to ΔNCF_t will be considered in relation to the changes $\Delta QTY_t, \Delta PRICE_t, \Delta COMP_t, \Delta ART_t, \Delta INTERATE_t$ in space (-20%, 20%) for each scenario and for each perspectives.

Phase 4: NPV and IRR uncertainty estimation with Monte Carlo simulation

In the Monte Carlo simulation, variables can get random values through probability distributions. This is achieved by sampling or generating values for the set of variables for each year of life, and then calculating the NPV for each of these sets. The model to be used is the Net Present Value (NPV) and Internal Investment Rate (IRR) indices. There will be three simulations, one for each scenario (basic, optimistic, pessimistic). In each scenario, conclusions will be drawn for the indicators and for the three perspectives, national economy (NPV1, IRR1), investors (NPV2, IRR2), shareholders (NPV3, IRR3).

For the appraisal of the investment, the normal and the triangular distribution are chosen for the representation of the variables of the specific model, giving a good approximation of the cash flows of the investment. Random numbers, the range of which is between 0 and 1, are generated by random number generators and the normal and triangular distributions are applied to these numbers to generate the random observation for the variables. The variables used in the simulation are the most sensitive, i.e., the most uncertain, which are crucial for the return on investment. These are: the cost of raw materials, the quantity of production, the selling price, the excise tax. The results of the indicators resulting from the simulation are:

$$(NPV_{kin})_{MC} = -C_i + \sum_{t=1}^{N} \frac{(NCF_{kin})_t}{(1 + r_{ki})^t}$$

$$-C_i + \sum_{t=1}^{N} \frac{(NCF_{kin})_t}{(1 + (IRR_{kin})_{MC})^t} = 0$$

where:

$k = 1$	perspective of national economy
$k = 2$	perspective of investors
$k = 3$	perspective of shareholders
$i = 1$	basic scenario
$i = 2$	optimistic scenario
$i = 3$	pessimistic scenario
$n = 1,2,3, \dots 1000$	Number of repetitions

The arithmetic means $(ENPV_{ki})_{MC}$, the standard deviation $(\sigma_{NPV\ ki})_{MC}$ and the coefficient of variation $(CV_{ki})_{MC}$ are given by the equations:

$$(ENPV_{ki})_{MC} = \frac{\sum_{n=1}^{1000}(NPV_{kin})_{MC}}{n} \quad (7)$$

$$(\sigma^2_{NPV\ ki})_{MC} = \frac{\sum_{n=1}^{1000}[(ENPV_{ki})_{MC} - (NPV_{kin})_{MC}]^2}{n} \quad (8)$$

$$(CV_{ki})_{MC} = \frac{(\sigma_{NPV\ ki})_{MC}}{(ENPV_{ki})_{MC}} \quad (9)$$

After the Net Cash Flow $(ENPV_{ki})_{MC}$ for each scenario i and each perspective kare calculated:

$$(ENPV_{ki})_{MC} = -C_i + \sum_{t=1}^{N}\frac{(NCF_{ki})_t}{(1 + r_{ki})^t} \Rightarrow$$

$$\sum_{t=1}^{N}\frac{(NCF_{ki})_t}{(1 + r_{ki})^t} = (ENPV_{ki})_{MC} + C_i \Rightarrow$$

$$ENCF_{ki}[(1 + r_{ki})^{-1} + (1 + r_{ki})^{-2} + \cdots + (1 + r_{ki})^{-10}] = (ENPV_{ki})_{MC} + C_i \Rightarrow$$

$$ENCF_{ki} = {(ENPV_{ki})_{MC} + C_i} \Big/ {[(1 + r_{ki})^{-1} + (1 + r_{ki})^{-2} + \dots + (1 + r_{ki})^{-10}]} \quad (10)$$

Phase 5 (A): Estimation uncertainty of NPV using probabilities.

The variance of NPV is given by the equation:

$$(\sigma^2_{NPV\ k}) = \sum_{i=1}^{3}\sum_{j=1}^{4}[P(A_i) \cap P(B_j)]\left[\overline{NPV}_k - NPV_{kij}\right]^2 \quad (11)$$

where:

$$\overline{NPV}_k = \sum_{i=1}^{3}\sum_{j=1}^{4}[P(A_i) \cap P(B_j)]NPV_{kij} \quad (12)$$

and

$$NPV_{kij} = -C_{ik} + (DCF_{kj})_{MC} \qquad i = 1,2,3 \quad j = 1,2,3,4 \quad (13)$$

with:

$k = 1$	perspective of national economy
$k = 2$	perspective of investors
$k = 3$	perspective of shareholders
$i = 1$	basic scenario of construction period
$i = 2$	optimistic scenario of construction period
$i = 3$	pessimistic scenario of construction period
$j = 1$	basic scenario of operation period
$j = 2$	optimistic scenario of operation period
$j = 3$	pessimistic scenario of operation period
$j = 4$	super-pessimistic scenario of operation period
C_{ik}:	cost of project for each scenario i and perspective k
$(DCF_{kj})_{MC}$:	Discount Cash Flow which calculated by MC simulation for each scenario j and perspective k

The standard deviation $\sigma_{NPV\ k}$ is:

$$\sigma_{NPV\ k} = \sqrt{\sigma^2_{NPV\ k}} \quad (14)$$

and the coefficient of variation which shows the risk of project is:

$$CV_k = \frac{\sigma_{NPV\ k}}{\overline{NPV}_k} \quad (15)$$

After the Expected Net Present Value for each perspective k is calculated:

$$E(NPV)_k = -E(C_{ki}) + E(DCF)_{kj}$$

$$E(NPV)_k = -\sum_{i=1}^{3} P(A_i)C_{ki} + \sum_{j=1}^{4} P(B_j)(DCF_{kj})_{MC} \quad (16)$$

where:

$P(A_i)$: Probabilities of financial conditions in construction period
$P(B_j)$: Probabilities of financial conditions in operation period
$(DCF_{kj})_{MC}$: Discount Cash Flow which calculated by MC simulation for each scenario j and perspective k

$$(DCF_{kj})_{MC} = \sum_{n=1}^{10} \frac{ENCF_{kj}}{(1 + r_{kj})^n}, \qquad j = 1,.,,4 \qquad n = 1,.,10 \qquad r = \text{discount rate}$$

with:
$ENCF_{kj}$: Expected Net Cash Flow which calculated by MC simulation for each scenario j and perspective k.

Finally, the table with the probabilities of the financial conditions of the construction and operating period is given (Table 3.1). A sensitivity analysis is performed on the changes of the probability percentages of the realization of the financial conditions. The cases are described:
1. Increase the probability percentage of stagnation conditions by 0.05 and 0.10 points and at the same time decrease (equal cumulatively) the probability percentage of growth and recession conditions, respectively.
2. Reduction of the probability percentage of stagnation conditions by 0.05 and 0.10 points and simultaneous increase (equal cumulatively) of the probability percentage of growth and recession conditions, respectively.

Table 1: Possibilities of financial conditions of construction and operating period of investment plan

POSSIBILITIES OF FINANCIAL CONDITIONS OF CONSTRUCTION PERIOD		POSSIBILITIES OF FINANCIAL CONDITIONS OF OPERATING PERIOD	
FINANCIAL CONDITIONS (A_i)	PROBABILITIES $P(A_i)$	FINANCIAL CONDITIONS (B_j)	PROBABILITIES $P(B_j)$
A1. STAGNATION (BASIC SCENARIO)	$P(A_1)$	B1. STAGNATION (BASIC SCENARIO)	$P(B_1)$
A2. GROWTH (OPTIMISTIC SCENARIO)	$P(A_2)$	B2. GROWTH (OPTIMISTIC SCENARIO)	$P(B_2)$
A3 RECESSION (PESSIMISTIC SCENARIO)	$P(A_3)$	B3 RECESSION (PESSIMISTIC SCENARIO)	$P(B_3)$
		B4HIGH RECESSION (VERY-PESSIMISTIC SCENARIO)	$P(B_4)$

Phase 5 (B): Estimation uncertainty of NPV using Bayes probabilities.

The case of the sample survey Δ is introduced, according to which in a total of n companies in the sector, x has a market share of p_1 which is desirable for the investment to be examined. In case of optimistic economic conditions, the share amounts to p_2, in pessimistic conditions to p_3, while in very pessimistic conditions it reaches p_4. The priori probabilities Bayes $P(\Delta/B_i)$, i.e., the result for Δ to occur since the economic conditions are B_i , $i = 1,2,3,4$ is made using the binomial distribution,

$$P(X = x) = \frac{n!}{x!\,(n - x)!} p^x (1 - p)^{n-x} \quad (17)$$

p: market share in the respective economic conditions

The posterior probabilities $P({}^{B_i}/_{\Delta})$ from Bayes' theorem are then calculated:

$$P\left({}^{B_j}/_{\Delta}\right) = \frac{P\left({}^{\Delta}/_{B_j}\right)P(B_j)}{\sum_{i=1}^{4} P\left({}^{\Delta}/_{j}\right)P(B_j)} = \frac{P(\Delta \cap B_j)}{P(\Delta)} \quad (18)$$

Similarly for the construction period the priori $P({}^{\Delta}/_{A_i})$ and then the posterior probabilities Bayes $P({}^{\Delta}/_{A_i})$are calculated.

$$P\left({}^{A_i}/_{\Delta}\right) = \frac{P\left({}^{\Delta}/_{A_i}\right)P(A_i)}{\sum_{i=1}^{3} P\left({}^{\Delta}/_{A_i}\right)P(A_i)} = \frac{P(\Delta \cap A_i)}{P(\Delta)} \quad (19)$$

The variance of NPV is given by the equation:

$$\sigma^2_{NPV\ BAYES\ k} = \sum_{i=1}^{3}\sum_{j=1}^{4}[P({}^{A_i}/_{\Delta}) \cap P({}^{B_j}/_{\Delta})]\left[\overline{NPV}_{BAYES\ k} - NPV_{kij}\right]^2 \quad (20)$$

where:

$$\overline{NPV}_{BAYES\ k} = \sum_{i=1}^{3}\sum_{j=1}^{4}[P({}^{A_i}/_{\Delta}) \cap P({}^{B_j}/_{\Delta})]\ NPV_{kij} \quad (21)$$

And

$$NPV_{kij} = -C_{ki} + (DCF_{kj})_{MC} \qquad k = 1,2,3 \quad i = 1,2,3 \quad j = 1,2,3,4$$

where:

C_{ki} : cost of project for each scenario i and perspective k

$(DCF_{kj})_{MC}$ Discount Cash Flow which calculated by MC simulation for each scenario j and perspective k

The standard deviation $\sigma_{NPV\ BAYES\ k}$ is:

$$\sigma_{NPV\ BAYES\ k} = \sqrt{\sigma^2_{NPV\ BAYES\ k}} \quad (22)$$

And the Coefficient of Variation (Bayes) which shows the risk of project is:

$$CV_{BAYES\ k} = \frac{\sigma_{NPV\ BAYES\ k}}{\overline{NPV}_{BAYES\ k}} \quad (23)$$

After the Expected Net Present Value (Bayes) for each perspective k is calculated:

$$E(NPV)_{BAYES\ k} = -E(C_i)_{BAYES} + E(DCF)_{BAYES\ kj}$$

$$E(NPV)_{BAYES\ k} = -\sum_{i=1}^{3} P\left({}^{A_i}/_{\Delta}\right)C_{ki} + \sum_{j=1}^{4} P\left({}^{B_j}/_{\Delta}\right)(DCF_{kj})_{MC} \quad (24)$$

where:

$P\left({}^{A_i}/_{\Delta}\right)$: Posteriori probabilities Bayes of financial conditions in construction period

$P\left({}^{B_j}/_{\Delta}\right)$: Posteriori probabilities Bayes of financial conditions in operation period

$(DCF_{kj})_{MC}$: Discount Cash Flow which calculated by MC simulation

$$(DCF_{kj})_{MC} = \sum_{n=1}^{10} \frac{ENCF_{kj}}{(1 + r_{kj})^n}, \qquad j = 1,2,3,4 \quad n = 1,2,\ldots,10 \quad r = \text{discount rate}$$

with:

$ENCF_{kj}$: Expected Net Cash Flow which calculated by MC simulation for each scenario j and perspective k

Then a sensitivity analysis will be performed on the changes in the priori probabilities of the economic conditions of stagnation, growth, and recession. Finally, the uncertainty (probability) and the Bayesian probability of E(NPV)will be estimated to be between different values for all optical k (national economy, investors, shareholders) using the formula:

$$P(a \leq NPV_k \leq b) = P\left(\frac{a - E(NPV)_k}{\sigma_{NPV\,k}} \leq \frac{NPV_k - E(NPV)_k}{\sigma_{NPV\,k}} \leq \frac{b - E(NPV)_k}{\sigma_{NPV\,k}}\right)$$
$$= \Phi\left(\frac{b - E(NPV)_k}{\sigma_{NPV\,k}}\right) - \Phi\left(\frac{\alpha - E(NPV)_k}{\sigma_{NPV\,k}}\right) \quad (25)$$

Then the application of the methodology to the construction of an industrial brewery unit will be presented.

IV. RESULTS

Table 2: Linear multiple regression data (GDP, TOURISM, PRODUCT, TAX_CONS, CCI, PRICE, SALES) period 2000-2019

YEAR	GDP (€)	TOURISM	PRODUCT (HL)	TAX_CONS (€/HL) cl	CCI	SALES (€)	PRICE (€/HL)
2000	13071	13567453	4437669	283	-15,25	402934994	90,79879
2001	14011	14678688	4129200	283	-26,83	423081743	102,4609
2002	14994	14918177	3980133	283	-27,33	443124128	111,334
2003	16371	14784560	4049502	283	-39	434754037	107,3599
2004	17683	14267420	4055000	283	-26	439851211	108,4713
2005	18134	14276465	4053600	283	-34	444215300	109,5854
2006	19769	15226241	4016429	283	-33	464230572	115,5829
2007	21061	16165283	4300000	283	-28,5	530388034	123,3461
2008	21845	15938806	4398319	283	-46	567804936	129,0959
2009	21386	14914534	4164075	340	-45,7	544610396	130,7878
2010	20324	15007490	4042500	650	-63,4	560288462	138,5995
2011	18643	16427247	3628000	650	-74,1	552489045	152,2847
2012	17311	15517621	3620285	650	-74,8	522920409	144,4418
2013	16475	17919580	3763080	650	-69,4	511902756	136,0329
2014	16402	22033463	3619233	650	-54	518638539	143,3007
2015	16381	23599455	3806985	650	-50,7	435129932	114,2978
2016	16378	24799300	3946274	1250	-68	454543025	115,1828
2017	16736	27194200	3554227	1250	-63	444525632	125,0696
2018	17220	30123000	3933000	1250	-46,7	547430000	139,1889
2019*	18005	31227000	3772000	1250	-21,1	550000000	145,8112

Table 3: ARIMA time series data (CONSUM) period 1990-2019

YEAR	C0NSUM (HL)	YEAR	CONSUM (HL)
1990	4443571	2005	4312613
1991	3907481	2006	4245019
1992	4131256	2007	4487828
1993	4020381	2008	4643889

1994	4093604	2009	4371289
1995	4024305	2010	4318545
1996	3793250	2011	3950951
1997	4053536	2012	3868730
1998	4421650	2013	3975457
1999	4575651	2014	3830733
2000	4555233	2015	3831371
2001	4208147	2016	4114923
2002	4159916	2017	3499279
2003	4185848	2018	3849000
2004	4302567	2019	3900000

Phase 1 (A): Determining the production-uncertainty relationship (OLS)
The mathematical model that describes PRODUCT is given by the relation:
PRODUCT = 4421248,667 + 50,116 * GDP – 0,08 * TOURISM + 4841,140 * CCI - 7764,539 * PRICE

Phase 1 (B): Determination of Consumption Uncertainty (ARIMA Model).
The model that best describes the data is the ARIMA(1,1,1)

$$w_t = -12049{,}950 + 0{,}588 w_{t-1} + 0{,}997 \varepsilon_{t-1} + \varepsilon_t$$
$$\hat{Y}_t = Y_{t-1} + (-12049{,}950) + 0{,}588 * (Y_{t-1} - Y_{t-2})$$

Table 4: Uncertainty Product Demand Forecast Table 2020-29

YEAR	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029
CONSUM	3917939	3916437	3903504	3883851	3860245	3834315	3807019	3778919	3750347	3721497

Phase 2: Determination NPV and IRR of the project
Table 5: NPV, IRR (National Economy, Investors, Shareholders) for the Baseline Scenario

	NATIONAL ECONOMY	INVESTORS	SHAREHOLDERS
NPV	12.255.385	3.635.859	5.057.967
IRR	19,9%	9,8%	33,6%

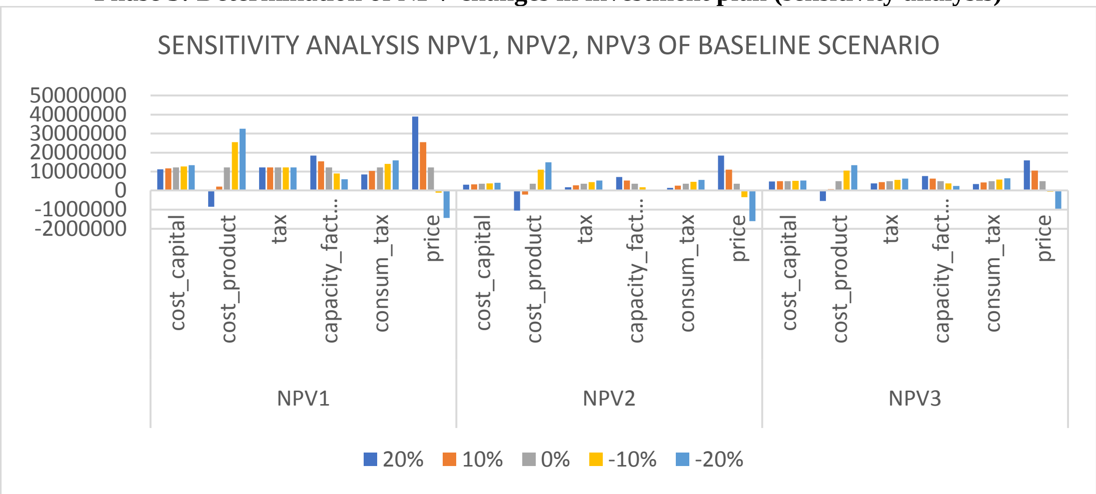
Table 6: NPV, IRR (National Economy, Investors, Shareholders) for the Optimistic Scenario

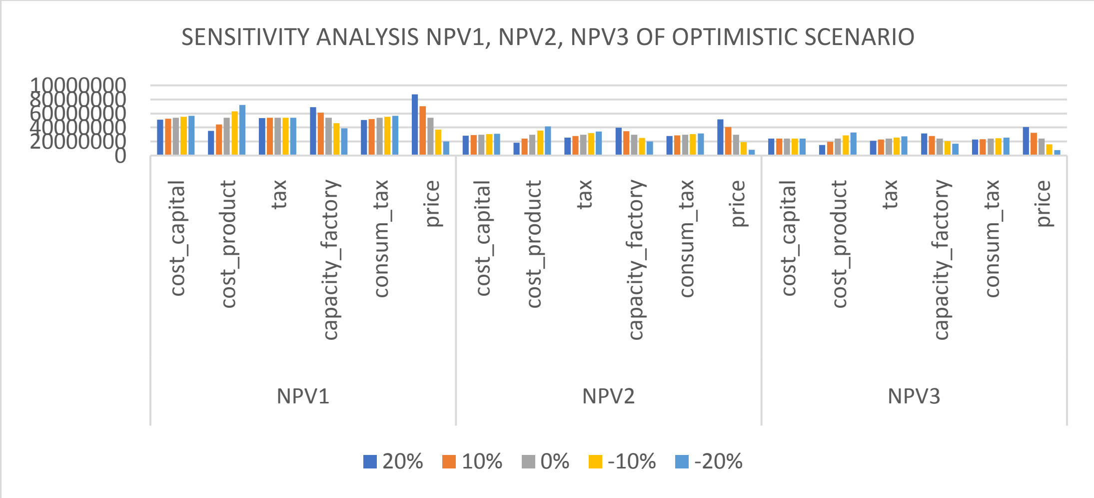
	NATIONAL ECONOMY	INVESTORS	SHAREHOLDERS
NPV	53.756.898	29.888.939	24.157.215
IRR	77,2%	48,6%	140,0%

Table 7: NPV, IRR (National Economy, Investors, Shareholders) for the Pessimistic Scenario

	NATIONAL ECONOMY	INVESTORS	SHAREHOLDERS
NPV	-9.249.109	- 11.052.910	- 5.740.950
IRR	-7,2%	-12,5%	-13,9%

Phase 3: Determination of NPV changes in investment plan (sensitivity analysis)





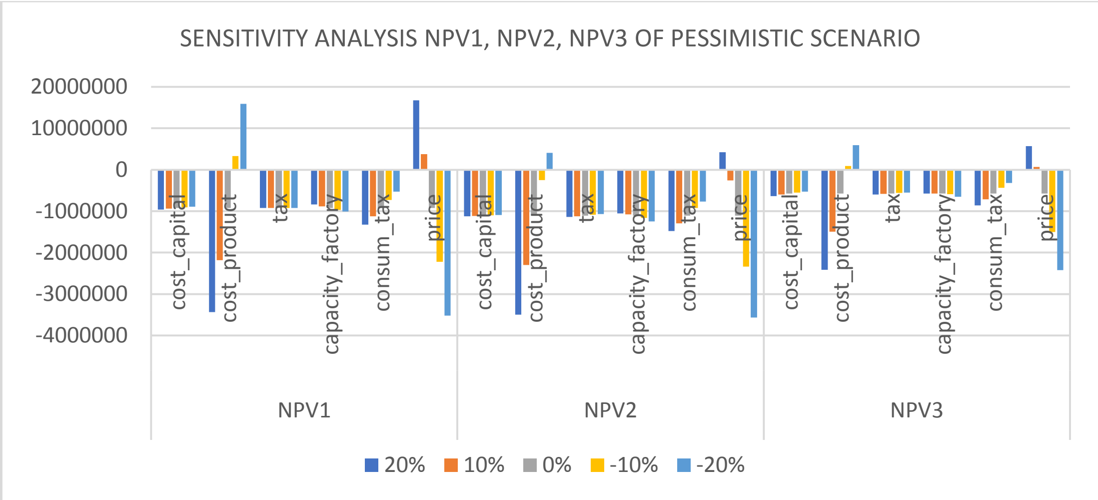


Figure 2: Sensitivity analysis

Phase 4: NPV and IRR uncertainty estimation with Monte Carlo simulation

Table 8: MC Simulation and Investment Expenditure for the Baseline Scenario

NPV SimulationMonte Carlo	Investment Expenditure	Capital Cost
$\overline{\mathbf{NPV_1}} = \mathbf{12.178.723}$	10.000.000	4,4%
$\overline{\mathbf{NPV_2}} = \mathbf{3.592.555}$	10.000.000	4,4%
$\overline{\mathbf{NPV_3}} = \mathbf{5.010.899}$	3.210.000	10%

Table 9: MC Simulation and Investment Expenditure for the Optimistic Scenario

NPV Simulation Monte Carlo	Investment Expenditure	Capital Cost
$\overline{\mathbf{NPV_1}} = \mathbf{60.243.567}$	8.000.000	4,2%
$\overline{\mathbf{NPV_2}} = \mathbf{33.722.881}$	8.000.000	4,2%
$\overline{\mathbf{NPV_3}} = \mathbf{26.912.257}$	2.610.000	10%

Table 10: MC Simulation and Investment Expenditure for the Pessimistic Scenario

NPV Simulation Monte Carlo	Investment Expenditure	Capital Cost
$\overline{\mathbf{NPV_1}} = -\mathbf{10.594.194}$	12.000.000	4,6%
$\overline{\mathbf{NPV_2}} = -\mathbf{12.336.003}$	12.000.000	4,6%
$\overline{\mathbf{NPV_3}} = -\mathbf{6.677.310}$	3.810.000	10%

Table 11: Net Cash Flows (NCF), Investment Costs (C) and Cost of Capital (CostCap) for the three scenarios under consideration

BASELINE SCENARIO	OPTIMISTIC SCENARIO	PESSIMISTIC SCENARIO
$\mathbf{NCF_1 \cong 2.735.000}$ € $\mathbf{C_1 = 10.000.000}$ € $\mathbf{cost_{cap} = 4,4\%}$	$NCF_1 \cong 8.415.000$ € $C_1 = 8.000.000$€ $cost_{cap} = 4,2\%$	$NCF_1 \cong 182.000$ € $C_1 = 12.000.000$€ $cost_{cap} = 4,6\%$

$\mathbf{NCF_2 \cong 1.676.000}$ € $\mathbf{C_2 = 10.000.000}$€ $\mathbf{cost_{cap} = 4,4}$%	$NCF_2 \cong 5.145.000$ € $C_2 = 8.000.000$€ $cost_{cap} = 4,2$%	$NCF_2 \cong -43.500$ € $C_2 = 12.000.000$€ $cost_{cap} = 4,6$%
$\mathbf{NCF_3 \cong 1.967.000}$ € $\mathbf{C_3 = 3.210.000}$ $\mathbf{cost_{cap} = 10}$%	$NCF_3 \cong 7.063.000$ € $C_3 = 2.610.000$ $cost_{cap} = 10$%	$NCF_3 \cong -686.000$ € $C_3 = 3.810.000$ $cost_{cap} = 10$%

Phase 5 (A): Estimation uncertainty of NPV using probabilities.

Table 12: Possibilities of financial conditions of construction and operating period of investment plan

POSSIBILITIES OF FINANCIAL CONDITIONS OF CONSTRUCTION PERIOD		POSSIBILITIES OF FINANCIAL CONDITIONS OF OPERATING PERIOD	
FINANCIAL CONDITIONS (A_i)	PROBABILITIES $P(A_i)$	FINANCIAL CONDITIONS (B_j)	PROBABILITIES $P(B_j)$
A1. STAGNATION (BASIC SCENARIO)	$P(A_1) = 0,5$	B1. STAGNATION (BASIC SCENARIO)	$P(B_1) = 0,40$
A2. GROWTH (OPTIMISTIC SCENARIO)	$P(A_2) = 0,25$	B2. GROWTH (OPTIMISTIC SCENARIO)	$P(B_2) = 0,30$
A3RECESSION (PESSIMISTIC SCENARIO)	$P(A_3) = 0,25$	B3 RECESSION (PESSIMISTIC SCENARIO)	$P(B_3) = 0,20$
		B4HIGH RECESSION (VERY-PESSIMISTIC SCENARIO)	$P(B_4) = 0,10$

Table 13: Valuation of risk (CV) and average expected net present value (NPV) of investment project E(NPV) under conditions of uncertainty for the national economy, investors, and shareholders

NATIONAL ECONOMY	INVESTORS	SHAREHOLDERS
$\mathbf{S_{NPV1} = 26.704.320}$ $\mathbf{CV_{NPV1} = 1,354}$ $\mathbf{E(NPV_1) = 19.722.339}$	$S_{NPV\,2} = 16.865.262$ $CV_{NPV\,2} = 2,184$ $E(NPV_2) = 7.721.972$	$S_{NPV\,3} = 13.493.475$ $CV_{NPV\,3} = 1,793$ $E(NPV_3) = 7.526.330$

Phase 5 (B): Estimation uncertainty of NPV using Bayes probabilities.

Table 14: Bayesian probability matrix of economic conditions for annual net operating flows

$(\boldsymbol{B_i})$	$\boldsymbol{P(B_i)}$	$\boldsymbol{P(\Delta / B_i)}$	$\boldsymbol{P(\Delta \cap B_i) = P(\Delta / B_1) P(B_1)}$	$\boldsymbol{P(B_i / \Delta)}$
0,035	0,30	0,2713833618	0,0814150085	0,3654788005
0,025	0,40	0,2271107333	0,0908442933	0,4078076507
0,020	0,20	0,1858008572	0,0371601714	0,1668151256
0,015	0,10	0,1334312857	0,0133431286	0,0598984232
SUM	1		0,2227626018	1

Table 15: Valuation of risk (CV) and average expected net present value (NPV) of investment project E(NPV) under conditions of uncertainty for the national economy, investors, and shareholders (Bayes)

NATIONAL ECONOMY	INVESTORS	SHAREHOLDERS
$\mathbf{S_{NPV1BAYES} = 25.805.662}$ $\mathbf{CV_{NPV1\,BAYES} = 1,173}$ $\mathbf{E(NPV_1) = 22.002.477}$	$S_{NPV\,2BAYES} = 16.968.362$ $CV_{NPV\,2\,BAYES} = 1,567$ $E(NPV_2) = 10.824.816$	$S_{NPV\,3\,BAYES} = 13.363.096$ $CV_{NPV\,3\,BAYES} = 1,335$ $E(NPV_3) = 10.010.425$

Table 16: Uncertainty estimates of 〖NPV〗_1 〖NPV〗_2, 〖NPV〗_3 for various intervals.

$P(NPV_1 > 0)$	76,73%
$P(15.000.000 < NPV_1 < 25.000.000)$ $P(0 < NPV_1 < 15.000.000)$	15.07% 19,35%
$P(NPV_1 > 15.000.000)$	57,4%
$P(NPV_1 > 25.000.000)$	42,07%
$P(NPV_2 > 0)$ $P(0 < NPV_2 < 5.000.000)$	67,72% 11,36%
$P(5.000.000 < NPV_2 < 15.000.000)$	23%
$P(NPV_2 > 5.000.000)$	56,36%
$P(NPV_2 > 15.000.000)$	33,36%
$P(NPV_3 > 0)$ $P(0 < NPV_3 < 5.000.000)$	71,23% 13,70%
$P(5.000.000 < NPV_3 < 15.000.000)$	28,41%
$P(NPV_3 > 5.000.000)$	57,53%
$P(NPV_3 > 15.000.000)$	29,12%

Table 17: Uncertainty estimates (Bayes) of 〖NPV〗_1〖NPV〗_2, 〖NPV〗_3 for various intervals

$P(NPV_{1\ BAYES} > 0)$ $P(0 < NPV_{1\ BAYE\Sigma} < 15.000.000)$	80,23% 19,59%
$P(15.000.000 < NPV_{1\ BAYE\Sigma} < 25.000.000)$	15%
$P(NPV_{1\ BAYE\Sigma} > 15.000.000)$	60,64%
$P(NPV_{1\ BAYE\Sigma} > 25.000.000)$	45,62%
$P(NPV_{2\ BAYES} > 0)$ $P(0 < NPV_{2\ BAYE\Sigma} < 5.000.000)$	73,57% 10,26%
$P(5.000.000 < NPV_{2\ BAYES} < 15.000.000)$	23,18%
$P(NPV_{2\ BAYES} > 5.000.000)$	63,31%
$P(NPV_{2\ BAYES} > 15.000.000)$	40,13%
$P(NPV_{3\ BAYES} > 0)$ $P(0 < NPV_{3\ BAYE\Sigma} < 5.000.000)$	77,34% 12,91%
$P(5.000.000 < NPV_{3\ BAYES} < 15.000.000)$	28,86%
$P(NPV_{3\ BAYES} > 5.000.000)$	64,43%
$P(NPV_{3\ BAYES} > 15.000.000)$	35,57%

V. CONCLUSIONS

The thematic sections of the paper and the corresponding contribution to science are summarized as follows:
A. Development of methodology for the determination of production-uncertainty relationship and the assessment of demand, the evaluation of an industrial investment plan in conditions of risk and uncertainty aiming at making optimal business decisions.
B. Ability to evaluate alternative scenarios of an investment plan in conditions of uncertainty.
C. Through the application of the proposed methodology, the work highlights in a case study of investment in an industrial unit in conditions of risk and uncertainty:
a. the number of financial data necessary for the investor and the shareholder
b. the possibility of quantifying and calculating the sensitivity of the economic impact (NPV, IRR) on changes in the cost of materials, energy, finance, inflation, taxation, bank interest rates, etc. for all scenarios and visuals.
c. the formulation of a long-term planning of the investment to be evaluated.
The added value of the work lies in:
1. to facilitate the evaluation of investments in conditions of risk and uncertainty, and the planning of industrial investment projects in general
2. pursuing a more effective administrative policy in setting up new industrial units; and
3. better planning of the contribution of specific industrial investments to economic development.
A disadvantage of the above approach is the subjective choice of the probabilities of the statements of the Economy, as well as the given situation of a minimum quantity of product produced by the industrial unit. In terms of demand forecasting methods, the use of quantitative methods is preferred, especially the use of statistical and econometric models, as they are considered the most advanced of the rest. Decision trees are one of the simplest and most widely used techniques in decision making and investment appraisal problems. They are applied in strategy development problems under uncertainty about the appraisal of various events and multiple options that can be selected along the way. An alternative technique that is widely used in practice in uncertainty problems is the simulation one. In this case, it is considered that the system is in an initial state and that the rules by which the parameters that characterize it change values are known. Therefore, the knowledge of the changes that the system will go through, makes it possible to assess the final situation (Prastakos, 2005).

Another category of uncertainty estimation is probabilistic models. The Hillier method uses subjective probability distributions to model the uncertainty about the estimated frequency values, while Bayes' theory calculates the earlier and later probabilities. Based on the above, the new methodology will be approached with an econometric model for estimating consumption and using simulation and probabilistic methods (Hillier and Bayes) to estimate the economic performance (uncertainty) of the three scenarios (basic, optimistic, pessimistic), after their financial analysis. In our proposed methodology above analysed, the results of the simulations of the three scenarios (average net cash flows for each scenario and each perspective) were incorporated into the method of using the probabilities - with the help of decision trees - to estimate the uncertainty for each perspective. (National Economy, Investors, Shareholders). In addition, with the help of Bayes' theorem, the value of information was incorporated into the uncertainty estimation process using ex ante and ex post probabilities.

The methodology developed in this paper is an approach, which helps to formulate a framework for evaluating future industrial investments in conditions of uncertainty. It is therefore a useful guide in decision-making at the level of strategic planning of industrial investments and projects of local or national scope. It is nevertheless necessary to underline that investment planning should include a quantification of the interaction between production and the uncertainty of economic conditions. Therefore, those responsible for the selection and planning of investments must consider the parameter of uncertainty in their evaluation. The exploitation of the positive results brought by the development of investment plans, after their evaluation - contributing to economic growth - requires the strengthening of the efficiency of the economy, giving incentives that improve productivity and competitiveness.

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