EVALUATION OF ENGINEERING SOLUTIONS IN WINE PRODUCTION

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Abstract: *Contemporary wine production, unlike traditional one, requires investments in certain technological equipment necessary for the production process itself. In order to assess the justification of the production improvement in this area, the application of the engineering economy methods is very suitable. Methods for evaluation of financial efficiency and improvement of alternatives have been used in this paper. Specific solutions and recommendations have been obtained.*

Keywords: TIME - MONEY, WINE PRODUCTION, ALTERNATIVES

1. Introduction

In the conditions of market economy, being competitive means to achieve an optimal relation between the price of a product and its quality. This, of course, applies to all branches of the economy, as well as to the wine production. To have a recognizable, quality wine with an enviable market share, inevitably implies constant improvement of the production technology, which must not be at the expense of the quality of future wine. In this paper, on the example of the winemaker which until now mainly relied on the traditional methods of wine production will be shown the justification of investment in the purchase of a discontinuous hydraulic press for pressing crushed grape (so called "kljuk"), in order for significantly higher quantity of quality wine to be obtained [1, 2].

2. Principles of Dependence Time – Money and Concept of Equivalence

Creating a larger or new value requires the engagement of capital in the form of money or assets. There is almost no engineering project that does not require capital investment in longer periods of time so that the time influence is an unavoidable factor that must be taken into account. Therefore, special attention should be given to the principles of time valuation of money that are essential for the evaluation of alternatives, while in this paper are used models given in Table 1.

Table 1: *Models used to determine the time value of money.*

Determination of F when P is known	$F = P\,(1+i)^N$	F = P(F/P, *i*%, N)
Determination of P when F is known	$P = F / (1+i)^N = F(1+i)^{-N}$	P = F(P/F, *i*%, N)
Determination of F when A is known	$F = A\left[\frac{(1+i)^N-1}{i}\right]$	F = A(F/A, *i*%, N)
Determination of P when A is known	$P = A\left[\frac{(1+i)^N-1}{i(1+i)^N}\right]$	P = A(P/A, *i*%, N)
Determination of A when F is known	$A = F\left[\frac{i}{(1+i)^N-1}\right]$	A = F(A/F, *i*%, N)
Determination of A when P is known	$A = P\left[\frac{i(1+i)^N}{(1+i)^N-1}\right]$	A = P(A/P, *i*%, N)

The basic elements of complex interest in tabulated models are:

- *i* – the effective interest rate, the amount which is paid per unit of money in units of time,
- N – number of interest periods, i.e. units of time during which interest is paid and which can be, day, week, month, 6 months or any agreed time interval,
- P – present value of money,
- F – future value of money,
- A – a complex amount, a sum of principal and interest that are paid in one uniform amount at the ends of the time (investment) periods.

Alternatives should be compared as much as possible when they give similar results, serve the same goal, or exercise the same function. It is only possible to do so by reducing them to an *equivalent basis* which depends on:

- interest rate,
- the amount of money involved,
- timing of cash income and / or expenses and
- the way in which the interest or profit for the capital invested is paid and the initial capital is returned.

3. Methods for the Evaluation of the Financial Efficiency of Investment Projects

One of the basic preconditions for applying the method for evaluating the financial efficiency of investment projects is to determine the Minimum Attractive Rate of Return (MARR) which is defined in the strategic goals of the management of the organization. In other words, this is the minimum acceptable rate of earnings under which a company or investor does not want to invest in a particular investment project, since it would be unprofitable. Therefore, the evaluation of the investment project is an analysis of the profitability, i.e. the applied inflow and outflow of cash, with a constant tendency to maximize the positive differences between the efficiency of the project and the investment.

There are a number of methods for evaluating investment projects, so it is difficult to single out one as the main one, since each one has its own advantages and disadvantages. However, depending on whether they take into account the time value of money, there can be distinguished:

- dynamic methods and
- static methods for evaluating the financial efficiency of investment projects.

Dynamic methods (take into account the time value of money) that are most frequently used in practice are:

The Present Worth Method (PW)

To find the PW as a function of *i*% (per interest period) of a series of cash inflows and outflows, it ic necessary to discount future amounts to the present by using the interest rate over the appropriate study period (years, for example) in the following manner [5]:

$$PW(i\%) = \sum_{k=0}^{N} F_k (1+i)^k \quad (1)$$

Where are:

i - effective interest rate, or MARR, per compounding period.

k - index for each compounding period ($0 \le k \le N$).

F_k - future cash flow at the end of period k.

N - number of compounding periods in the planning horizon (i.e., study period).

The relationship given in Equation (1) is based on the assumption of a constant interest rate throughout the life of a particular project. If the interest rate is assumed to change, the PW must be computed in two or more steps [5, 6].

The Future Worth Method (FW)

The future worth metod is based on the equivalent worth of all cash inflows and outflows at the end of the planning horizon (study period) at an interest rate that is generally the MARR. Also, the FW of a project is equivalent to its PW; that is, FW = PW(F/P, i%, N). If FW ≥ 0 for project, it would be economically justified. Equation (2) summarizes the general calculations necessary to determine a project's future worth [5, 6]:

$$\mathrm{FW}(i\%) = \sum_{k=0}^{N} \mathrm{F}_k (1+i)^{N-k} \qquad (2)$$

The Annual Worth Method (AW)

The Annual Worth (AW) of a project is an equal annual series of money amounts, for a stated study period, that is equivalent to the cash inflows and outflows at an interest rate that is generaly the MARR. Hence, the AW of a project is annual eqivalent revenues or savings (R) minus annual equivalent expenses (E), less its annual equivalent Capital Recovery (CR) amount. An annual equivalent value of R, E, and CR is computed for the study period, N, which is usually in years. In equation form the AW, which is a function of i%, is [5, 6]:

$$\mathrm{AW}(i\%)=\mathrm{R}-\mathrm{E}-\mathrm{CR}(i\%) \qquad (3)$$

Also, we need to notice that the AW of a project is equivalent to its PW and FW. That is: AW = PW(A/P, i%, N), and AW = FW(A/F, i%, N). Hence, it can be easily computed for a project from these equivalent values.

As long as the AW is greater than or equal to zero, the project is economically attractive. An AW of zero means that an annual return exactly equal to the MARR.

The Internal Rate of Return Method (IRR)

IRR method is the most widely used rate of return method for performing engineering analyses. It sometimes calls by several other names, such as investor's method. Discounted cash flow method, and profitability index.

By using a PW formulation, the IRR is the i'% at which:

$$\sum_{k=0}^{N} \mathrm{R}_k (\mathrm{P/F},\, i'\%, k) = \sum_{k=0}^{N} \mathrm{E}_k (\mathrm{P/F},\, i'\%,\, k) \qquad (4)$$

Where are:

R_k - net revenues or savings for the kth year.

E_k - net expenditures including any investment costs for the kth year.

N - project life (or study period).

Once i' has been calculated, it is compared with the MARR to assess whether the alternative in question is acceptable. If i' ≥ MARR, the alternative is acceptable; otherwise, it is not.

The External Rate of Return Method (ERR)

This method directly takes into account the interest rate (ε) external to a project at which net cash flows generated (or required) by the project over its life can be reinvested (or borrowed). If this external reinvestment rate, which is usually the firm's MARR, happens to equal the project's IRR, than the ERR method produces results identical to those of the IRR method.

In general, three steps are used in the calculating procedure. First, all net cash outflows are discounted to time 0 (the present) at ε% per compounding period. Second, all net cash inflows are compounded to period N at ε%. Third, the external rate of return, which is the interest rate that establishes equivalence between the two quantities, is determined. The absolute value of the present equivalent worth of the net cash outflows at ε% (first step) is used in this last step. In equation form, the ERR is the i'% at which

$$\sum_{k=0}^{N} \mathrm{E}_k (\mathrm{P/F},\, \varepsilon\%, k)(\mathrm{F/P},\, i\%,\, \mathrm{N}) = \sum_{k=0}^{N} \mathrm{R}_k (\mathrm{F/P}, \varepsilon\%,\, \mathrm{N-k}) \quad (5)$$

Where are:

R_k - excess of receipts over expenses in period k

E_k - excess of expenditures over receipts in period k

N - project life or number of periods for the study

ε - external reinvestment rate per period

Static methods (do not take into account the time value of money) are:

- method of the period of investment return,
- investment balance diagram.

4. Comparison Between Proposed Alternatives

Most of engineering problems usually have a limited number of possible solutions. Certainly, any of the proposed alternatives, as an input, implies different amounts of money for their realization, which results in different annual revenues and expenditures.

The inevitability of the existence of different factors, which are specific to each alternative, requires defining of a basis for comparison based on which their economic and financial evaluation will be done in the same time period.

When determining the observation period for the offered alternatives in relation to their total lifetime, two cases are possible:

1. Case: The lifetime is the same for all alternatives and equal to the observation period (Methods of equivalent value, Return Rate Methods).
2. Case: The lifetime is different for all alternatives and there are one or more alternatives whose lifetime is not equal to the observation period.

For the considered research, the 1st case is of interest where the justification of the investment will be tested on a concrete example of a winery, by using the method of equivalent value.

5. Application of A Method for the Evaluation of Alternatives in Wine Production

The analyzed winery has based its long-term business on the traditional way of grape processing, so that at present, it produces 20 000 liters of wine annually. The backbone of the production consists of "Žilavka" (white wine), "Vranac" (red wine) and Chardonnay wines, as well as several other types of grapevine varieties of the same name, such as Merlot, Cabernet Sauvignon, Procurator and various blends of these wines. Constantly taking into account the quality of the produced wine and in order to meet the needs of permanent but also new customers with sufficient quantities of wine, a need for production expansion occurred [3, 4, 7].

This, for sure, requires certain investments in terms of increasing the capacity and improving the technological process itself with the emphasis on keeping and possible increase of the achieved level of wine quality. The set goals are expected to be achieved by purchasing a discontinuous hydraulic press for pressing crushed grape (so called "kljuk"). This is a very important stage in the modern processing of red and especially white grapes. This, unlike the current gravity method of wicking out of wine, is expected to obtain a greater quantity of wine in a percentage of 10% compared to the same amount of processed grapes. The justification of this investment will be examined, firstly, through Research 1.

Research 1

The winery expects qualitative and quantitative business improvement through the purchase of a discontinuous hydraulic press which costs € 8000. Based on the experience gained in this field, they calculated that their annual income, by gaining larger amount of quality wines (2000 l), will be increased by 5000 €. Costs that are included in annual expenditures are:

- amortization according to Uniform (Straight – Line: SL) method 1000 €,
- costs of exploitation and labor force 200 €,
- loss of approximately 240 l of "komovica" schnapps 1200 €.

Data:

- investment (cost) 8000 €,
- lifetime 7 years,
- market value at the end of the lifetime 1000 €,
- annual income 5000 €,
- annual expenditure 2400 €.

It is necessary to determine the following:

a) current, future and annual value when MARR = 12% for the year,
b) internal rate of the project, whether it is acceptable?
c) external rate of the project if we assume that ε = 12% for the year,
d) simple and discounted return period.

Solution:

a) PW = - 8000 € + 2600 € (P/A, 12%, N) + + 1000 € (P/F, 12%, N) = 4317, 48 €

FW = - 8000 € (F/P, 12%, 7) + 2600 € (F/A, 12%, 7) + + 1000 € = 8545, 97 €

AW = - 8000 € (A/P, 12%, 7) + 2600 € + + 1000 € (A/F, 12%, 7) = 946, 17 €

Since the values obtained for PW, FW and AW are greater than zero, the investment is justified.

b) to determine the internal rate of return (IRR) of the project, it is necessary to equalize the present value of the cash flow with zero:

PW = 0 = 8000 € + 2600 € (P/A, *i*'%, 7) + 1000 € (P/F, *i*'%, 7);

Linear interpolation results in *i*% (IRR) = 27.18%.

As shown internal rate of return (IRR) is 27,18% and it is more than twice higher than minimum acceptable rate of return (MARR = 12%), so this project is quite safe from the perspective of risk.

c) FW = - 8000 € (F/P, i'%, N) = 2600 € (F/A, 12%, 7) + 1000 €

i'% = 19,12%

Calculation by this method shows that the external rate of return is 19,12%, and since it is larger than the MARR of winery, the project is acceptable

d)

Table 2: *Calculation for simple and discounted return period, MARR = 12% based on Research 1.*

End of year (k)	Net cash flow	Accumulative PW under rate *i*= 0%/year over k years	PW of cash flow by the rate = 12%/year	Accumulative PW under rate *i* = 12%/year over k years
0	- 8000	- 8000	- 8000	- 8000
1	2600	-5400	2321	-5679
2	2600	-2800	2073	-3606
3	2600	- 200	1851	-1755
4	2600	2400	1652	- 103
5	2600	5000	1475	1372
6	2600	7600	1317	2689
7	3600	11200	1628	4317

So, the economic justification for the purchase of a discontinuous hydraulic press is, from the standpoint of obtaining a higher quantity of quality wine, undoubtedly correct. However, the final decision on this investment should be made after analyzing all the accompanying factors. Namely, by obtaining a higher quantity of wine by pressing, a certain amount of "komovica" schnapps, which significantly contributes to the successful business of the winery, will be lost. Therefore, it is necessary from this aspect to compare these two alternatives through Research 2.

Research 2

Out of two offered options, one of which is innovation of the technological process of production (A), and the other for the traditional wine-producing method (B), it is necessary to choose a more acceptable solution. Between the offered solutions there is a difference between the capital invested and the income. The observation period is equal to the lifetime of the discontinuous hydraulic press and it is 7 years for both alternatives. The minimum acceptable wage rate is MARR = 12%.

Data:

Table 3: *Comparations of Alternatives.*

	Alternatives	
	A	B
Investment	8000 €	24000 €
Cost saving/year	2600 €	6000 €

Investment and cost savings are being approximated for Alternative B by which a larger quantity of wine in a percentage of 10% for settling newly emerging market needs wants to be received. Namely, by traditional production with the gravitational method of wicking out the wine (without pressing "kljuk"), it is possible to achieve, after the first streaming, wine yield up to 40%. This means that for the production of 2000 liters of wine, annually, quantity of 5000 kg of grapes is required. Taking into account the observed lifetime of the investment, the total required amount of grape is 35000 kg, which at current market prices is 22436 €. Proportional to the growth of the quantity of grapes for processing, needs for expansion of processing capacities grow, for which purpose, with the engagement of the labor force, it is necessary to invest 1564 €.

Cost savings of alternative B versus alternative A is higher on a basis of:

- absence of amortization costs in the amount of 1000 €,
- there are no costs of exploitation (electricity, maintenance ...) in the amount of 200 €,
- larger amount of "komovica" schnapps (450 l) in the amount of 2200 €.

Out of 100 kg of not pressed grape pomace about 15 l of “komovica” schnapps is obtained.

Solution:

Method of present value

$PW\ (12\%)_A$ = - 8000 € + 2600 € (P/A, 12%, 7) = 3865, 13 €

$PW\ (12\%)_B$ = - 24000 € + 6000 € (P/A, 12%, 7) = 3381 €

Method of annual value

$AW\ (12\%)_A$ = - 8000 € (A/P, 12%, 7) + 2600 € = 847, 20 €

$AW\ (12\%)_B$ = - 24000 € (A/P, 12%, 7) + 6000 € = 741, 60 €

Method of future value

$FW\ (12\%)_A$ = - 8000 € (F/P, 12%, 7) + 2600 € (F/A, 12%, 7) = = 8545, 80 €

$FW\ (12\%)_B$ = - 24000 € (F/P, 12%, 7) + 6000 € (F/A, 12%, 7) = = 7477, 20 €

Based on the results obtained from the calculation by all three methods, investment priority is on the side of the alternative A. In addition, the estimated market value of the discontinuous hydraulic press is 1000 € at the end of the lifetime, which, also supports the fact that innovation in the technological process is justified.

6. Conclusion

Parameters obtained by evaluating the offered alternatives in the case of the analyzed winery undoubtedly favor the alternative that includes innovation of the technological process. In Table 5. 1 it is noticeable that on the basis of a simple return period, investment costs are covered by revenues in the third year, and according to the discounted return period in the fourth year. The discounted return period shows a certain risk of investment, as the tendency is that in developed economic activities the return period should be no longer than 3 years. However, taking into account the seven-year lifetime of the investment and the fact that internal rate of return (IRR = 27, 18%) and the external rate of return (ε = 19, 12%) are significantly higher than the minimum acceptable rate of return of winery (MARR = 12%), with positive values of the method of equivalent value, the innovation of the technological process has no alternative.

Applying new or innovating existing technical and technological processes is an imperative relevant for all industries. However, improving productivity of production can be successful only in the case of quantity being followed by quality. In the conditions of market competition, only a quality product can provide a stable market position. To survive in this position is harder than to gain it, as it is often proved in practice. That's why the analyzed winery searches for a way to make its wine a combination of traditional and contemporary. The first step towards this is the introduction of a discontinuous hydraulic press into the technological process, by which can be determined the extent to which the grape pomace needs to be pressed, without adversely affecting the quality of the future wine. These presses, unlike the continuous ones, do not damage the hard parts of the grapes, which is also one of the prerequisites for quality wine. This will improve their business without the risk of endangering their participation in the sophisticated wine market.

7. Literature

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