ECONOMIC ASSESSMENT OF THE MODERNIZATION OF THE SHIPPING WAREHOUSE

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Abstract

The article presents a stochastic approach to the assessment of the economic efficiency of the modernization of the shipping warehouse. The assessment is based on simulations carried out through a software tool. The evaluation process is implemented in two steps. First, the economic efficiency of the modernization project is evaluated using financial dynamic criteria. Subsequently, the riskiness of the input variables for the chosen dynamic financial criterion is assessed using the Monte Carlo simulation method.

Keywords: Economic efficiency, Monte Carlo simulation, financial criterion, shipping warehouse

1. INTRODUCTION

The distribution of goods to end customers is constantly being improved, accelerated and automated. In this process, the handling of goods and their storage play a decisive role, affecting the quality, smoothness and efficiency of the entire process. The warehouse holds the accumulation and distribution function. High demands are placed mainly on capacity, safety and optimal use of space. Modern, efficiently working warehouse and logistics spaces cannot do without suitable automated systems. For this reason, it is important to invest in the technical equipment of warehouses.

Every investment decision will affect the economy of the company with its long-term effects. The profitability of investment projects is influenced by many factors. Therefore, the process of evaluating the effectiveness of the project should include all factors that can affect its value [1,2].

For this reason, investments must be carefully evaluated economically. This issue is dealt with by several authors who solve this problem in different ways. Commonly, authors assess economic efficiency only with a deterministic approach. Other authors use a stochastic approach using simulations, primarily the Monte Carlo method [3,4]. Another group of authors includes optimization as well as forecasting in the evaluation of the effectiveness of investment projects [5,6]. Others point to the advantages of multi-criteria evaluation of investment projects [7,8].

2. MATERIALS AND METHODS

2.1 Defining the problem

The contribution is aimed at assessing the economic efficiency of the modernization of the shipping warehouse. This is a renewal investment project, with the aim of ensuring the smoothness and efficiency of the process of dispatching a wide range of medicines and medical devices for pharmacies and hospitals in a specific region of Slovakia.

The reason for the modernization of the dispatching warehouse is the outdated technical equipment of the warehouse, an inefficient and unclear system for sorting crates with loaded goods for the customer. The activity in the dispatch warehouse is ensured by one worker.

In order to increase the smoothness and efficiency of the shipping process in the warehouse, it is necessary to make the handling of crates loaded with goods easier and more transparent. The activities in scope

- Manual shifting of crates with loaded goods onto the transport trolley, in the case when the shelf is far away and there are more crates.
- Manual sorting of crates and placing them on a shelf marked with the number of the district where the crates are to be shipped. At the same time, each crate is marked with a number that serves to identify the place of delivery (each district has its own number, which is stuck on the crate).

The current 3D layout of the main and dispatch warehouse is shown in **Figure 1**. As you can see, there is limited movement in the dispatch warehouse, as the room is crowded with shelves.

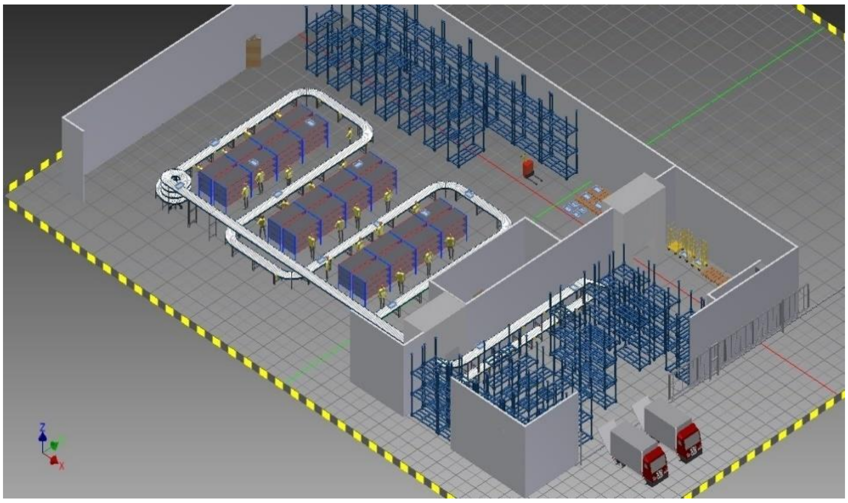

Figure 1 The current 3D layout of the main (left) and shipping warehouse (right)

The proposed modernization of the warehouse consists in the installation of a new automated multi-lane sorting line. This line (**Figure 2**) will make it possible to automatically sort crates by district. There is a wheeled container for crates at each sorting belt. The shippers push the filled containers to the vans, load the crates into the vans, which will distribute them to the destination.

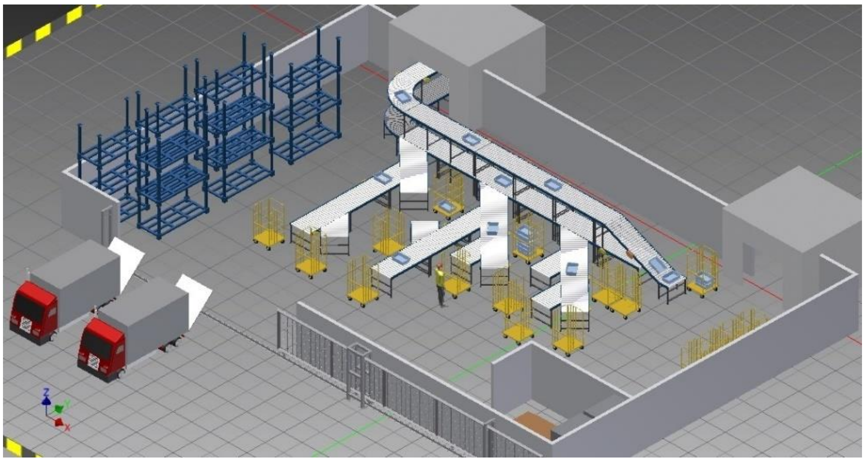

Figure 2 Proposal for the modernization of the shipping warehouse

2.2 Methodology for assessing the economic efficiency of the investment

The methodology provides guidance for assessing the economic efficiency of a renovation investment in two steps. In the first step, the economic efficiency of the modernization project is evaluated using dynamic financial criteria, which are calculated on the basis of data obtained from a deterministic financial model. In the second step, the riskiness of the input variables for the chosen dynamic financial criterion is assessed using the Monte Carlo simulation method. In this case, the data is drawn from a stochastic financial model. The second step of the investment assessment is presented in **Figure 3**.

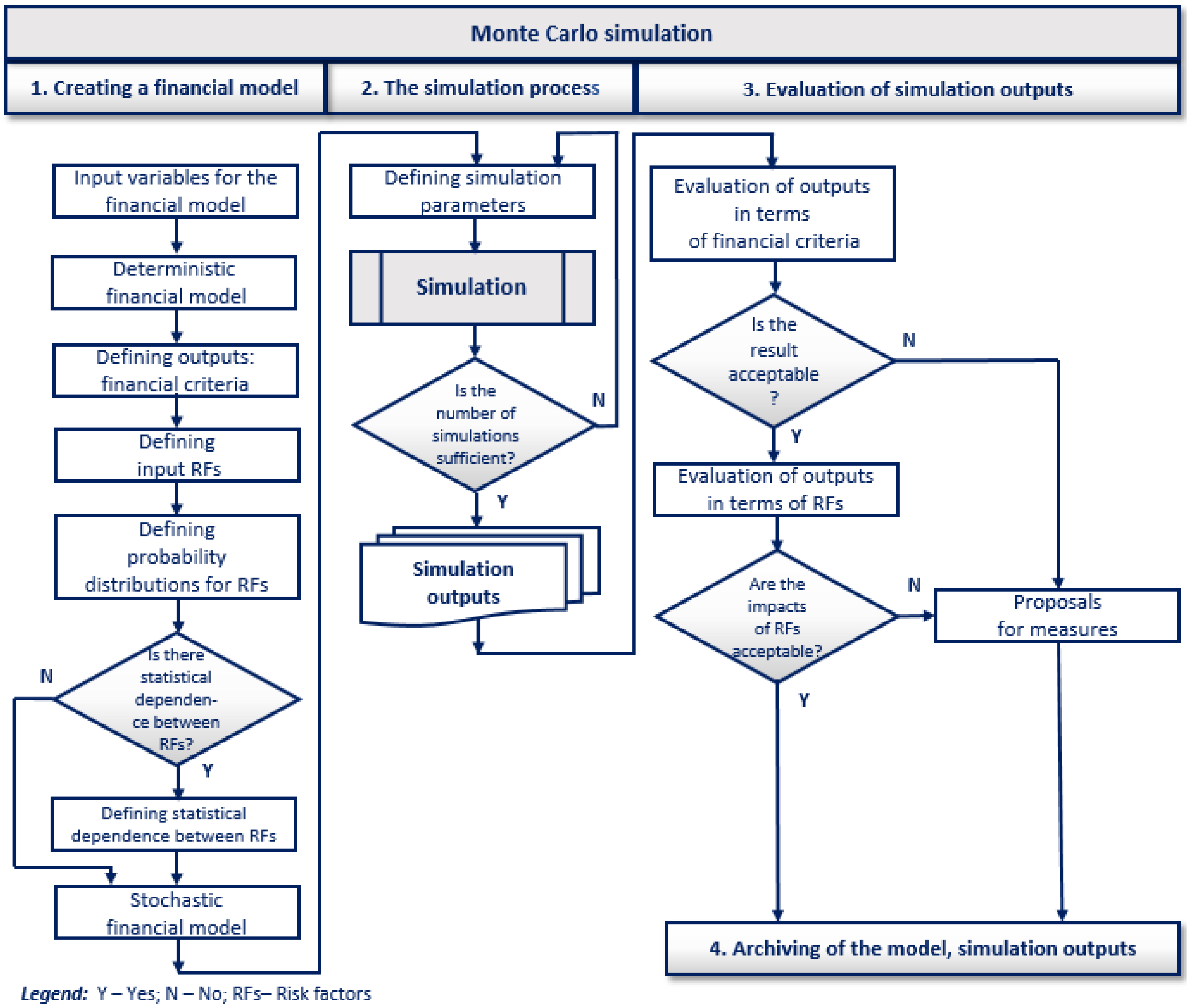

Figure 3 Monte Carlo simulation

Creating a financial model. Based on the input variables of a deterministic nature, a deterministic financial model is defined, with the help of which the values of the output variables are calculated with certainty. If at least one of the input variables is stochastic, the output value can only be determined with a certain probability. Simulations are possible only in the case of such variables. For this reason, it is necessary to identify significant risk factors. It is necessary to define probability distributions for them. The reliability of the simulation result directly depends on the type and accuracy of the probability distribution estimate. If the values of some risk factors depend on other risk factors, then there is a statistical dependence between them. Statistical dependence is expressed by a correlation coefficient whose values range from "-1" to "1". The authors Korecký and Trkovský [9] recommend using only extreme values of the correlation coefficient "0", "1", or "-1" because the strength of the bond usually does not significantly affect the results achieved.

Finally, it is necessary to define the output value using upper and lower limits, or its target value. The financial model should be elaborated in such detail as to include all input variables that have been identified as significant risk factors.

The simulation process. Before starting the simulation itself, it is necessary to define the conditions under which the calculations of the output value will be realized; select and define other desired outputs from the simulation.

The simulation process itself consists of a set number of simulation steps that are repeated until the end of the simulation, determined by the number of repetitions or the specified accuracy of the results is achieved. Each simulation step generates random values of risk factors, and the value of the output variable - the financial criterion - is subsequently calculated from their probability distribution. After the end of the simulation, the results of the simulation are usually generated in graphic form (for example: forecast chart, trend charts, sensitivity charts, overlay charts) and numerical form (statistics) to the extent and form in which the conditions for starting the simulation were defined.

Evaluation of simulation outputs. The simulation outputs, the average value of the simulated output variable, including its probability profile and the impact of risk factors, are assessed against the established goals and risk criteria.

From the output of the simulation, it is possible to determine the severity of individual risk factors in terms of their impact on the output, how they affect the value of the output (or the probability of achieving the goal), how they affect the risk of the output (usually represented by the standard deviation).

3. RESULTS

3.1 Economic efficiency of investment – deterministic approach

The economic efficiency of the modernization of the shipping warehouse is assessed comprehensively, i.e. in terms of its profitability, liquidity and risk. From the point of view of profitability, the investment is assessed using the financial criteria of Net Present Value (NPV) and Profitability Index (PI), and from the point of view of liquidity, using Discounted Payback Period (DPP). The stated financial criteria are calculated according to relations (1) – (3). The prediction of annual cash flow (CF) from operational activity is determined according to relation (4). When calculating annual sales and costs, the incremental method is applied.

$$NPV = \sum_{n=1}^{N} CF_n \cdot \frac{1}{(1+d_r)^n} - IC \tag{1}$$

$$PI = \frac{\sum_{n=1}^{N} CF_n \cdot \frac{1}{(1+d_r)^n}}{IC} \tag{2}$$

$$\sum_{n=1}^{DPP} CF_n \cdot \frac{1}{(1+d_r)^n} = IC \tag{3}$$

$$CF_n = \left(\sum_{j=1}^{3} S_{jn} - \sum_{j=1}^{3} C_{jn} \right) \cdot (1 - T_n) + (D_n \cdot T_n) - \Delta NCWC_n \tag{4}$$

Where CF_n is cash flow in year n, *n* number of years of life of the investment, *N* life of the investment, d_r discount rate, *IC* investment costs, *S sales, C costs, j crates* (A, B, C), *D* depreciation, *T* income tax rate and *NCWC* non-cash working capital.

The input variables needed to calculate the financial criteria are recorded in **Table 1**. Their resulting values are shown in **Table 2** and confirm the acceptability of the investment. Realization of the investment will result in profitability for a period of four years in the amount of EUR 836,490, profitability per one euro of invested investment costs in the amount of EUR 5.80, and the return on the investment will be in 1.01 years.

Table 1 Input variables – deterministic approach

Input variables	Unit	Value		
		A	B	C
Average value of a crate	EUR/pc	100	400	900
Percentage of crates	%	35	50	15
Total number of crates	pcs/day	220		
Nominal time fund	day/year	247		
Loss times (repairs, …) from nominal time fund	%	5		
Number of shifts	day	1		
The length of a shift	h/shift	7.5		
Labor costs	EUR/h	8.00		
Price of diesel	EUR/l	1.87		
Repair and maintenance costs in years 2. – 4. (in % of investment costs)	%	2.00		
Income tax	%	21		
Discount rate	%	8		
Investment costs	EUR	180,000		

Table 2 Financial criteria of economic efficiency – deterministic approach

Financial criterion	Unit	Acceptable value	Expected value
Net Present Value	EUR	NPV > 0	863,490
Profitability Index	coeff.	PI > 1	5.80
Discounted Payback Period	years	DPP < 6	1.01

3.2 Monte Carlo simulation – stochastic approach

Taking risk into account when evaluating the economic efficiency of the investment is implemented using the Monte Carlo simulation method. Individual input risk factors defined using statistical characteristics and probability distributions are listed in **Table 3**.

By running the simulation, 10,000 NPV calculation trials were performed. The output is a forecast of the NPV financial criterion, including a statistical profile. The simulation outputs are presented in the form of a histogram (**Figure 4**) and statistical characteristics of the simulated value. The simulation found that the mean NPV is EUR 856,894 and the standard deviation (Ϭ) is EUR 78,010. One indicator of the level of risk is precisely the standard deviation, which points to the reliability of the forecast. Practically, this means that the NPV forecast is with a reliability of 68 % in the mean NPV ± Ϭ interval.

Table 3 Probability distributions and statistical characteristics of risk factors

Risk factor	Unit	Statistical charactistics	Distribution function
Percentage of crates A	%	Mean 35; Std. Dev. 3.50	Normal
Percentage of crates B	%	Mean 50; Std. Dev. 5.00	Normal
Percentage of crates C	%	Mean 15; Std. Dev. 1.50	Normal
Nominal time fund	day/year	Min. 240; Likeliest 247; Max. 250	Triangular
Investment costs (IC)	EUR	Min. 162,000; Likeliest 180,000; Max. 198,000	Triangular
Labor costs	EUR/h	Min. 7.20; Likeliest 8.00; Max. 8.80	BetaPERT
Price of diesel	EUR/l	Min. 1.68; Likeliest 1.87; Max. 2.06	Triangular
Repair and maintenance costs in years 2 - 6	% of IC	Mean 2.00; Std. Dev. 0.20	Normal

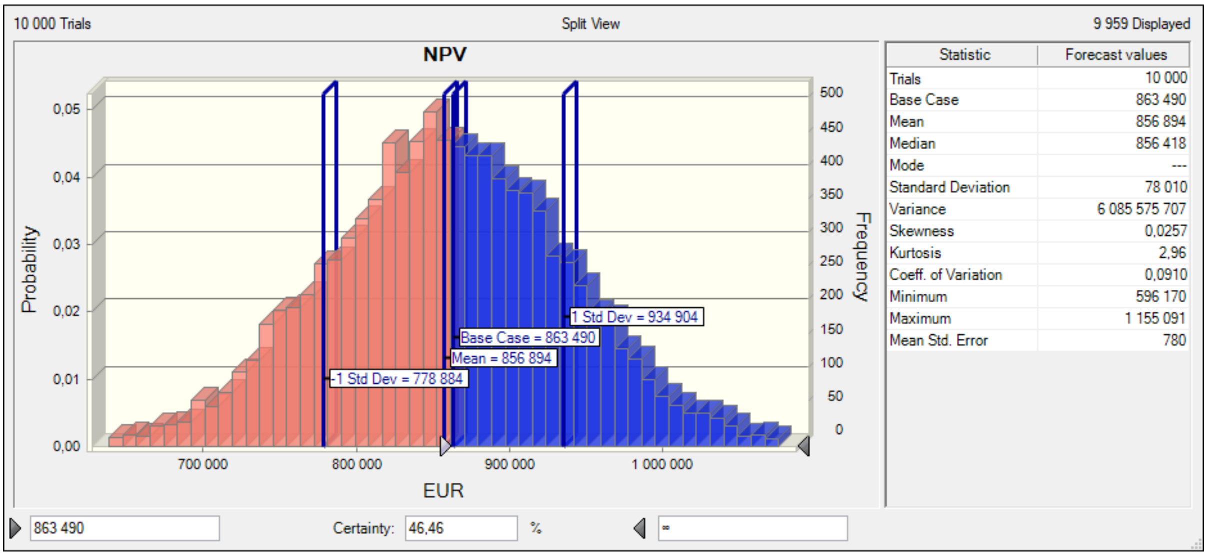

Figure 4 Histogram and statistical characteristics of NPV

Another important output of the simulation is the NPV sensitivity graph. It provides information on the contributions of risk factors to the overall investment risk in relation to NPV. Among the most significant risk factors are the percentage of crates B, which contributes 64.6 % to the project risk, and the percentage of crates C, whose contribution to the total risk is 30.0 %. The contribution of other risk factors (nominal time fund, percentage of crates A, etc.) to the risk of renewal investment is 2.3 % or less. When trying to reduce the risk of this investment, it is advisable to focus attention on the first two most significant risk factors.

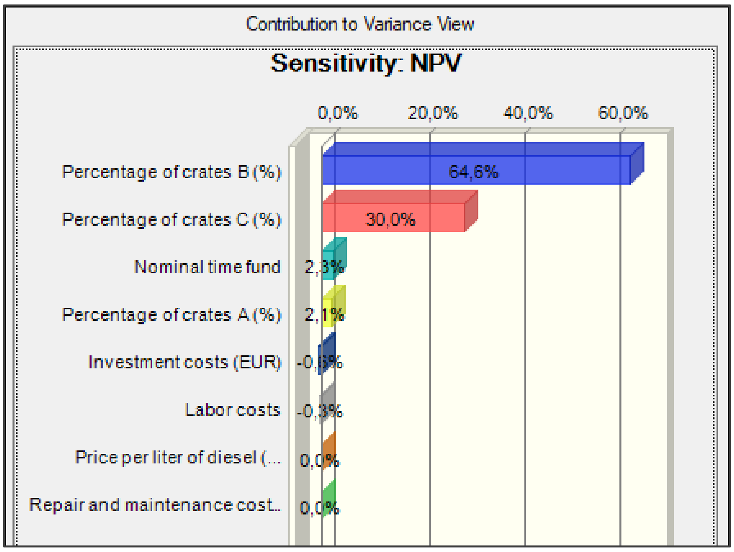

Figure 5 Sensitivity chart of NPV

Table 4 Comparison of NPV and mean NPV values

Financial criterion	Value (EUR)	Deviation from NPV	
		(EUR)	(%)
NPV	863,490	N/A	N/A
mean NPV	856,894	6,596	-0.77

4. CONCLUSION

In conclusion, it should be emphasized that the renovation investment project is acceptable from an economic point of view as well as from a risk point of view. The simulation using the Monte Carlo method must be repeated in case of detected changes in the development of the analyzed risk factors of the project, or when new risk factors are discovered. Successful implementation of this probabilistic tool into business practice requires top management support, change in mind set, change in traditional work style, education and training in the field, and appropriate software support.

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