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Full Length Research Paper

Researching the dependence between dynamic indicators of investment profitability

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The paper presents the experimental research of mutual dependence between two methods of description of investment profitability: the investment's payback period and the internal rate of return based on the samples of investment programs realized in the economy of the Autonomous Province of Vojvodina, which represents economically the most developed area of Republic of Serbia, from 2003 to 2008. Working on investment project design in different industrial areas, the authors collected a sample of 23 projects, monitoring the mutual dependences between individual parameters, that is, methods of deciding the investments' profitability. The authors found explicit dependence which has been presented in this paper.

Key words: Investments, profitability, payback period, internal rate of return.

INTRODUCTION

Every single company is carrying out many investment projects during its life cycle. As Koop (2005) clearly underlines, a firm's decision to carry out a new investment will not immediately affect production. That process consists of many important phases, such as: planning, investment program documentation preparation, financing, etc. The investment program is an expert document and basis for investment decisions, which marks the closing stage of planning as part of the investment management process (Maric, 2008).

Project justification is recognized through the series of different indicators, and the indicators of the project's profitability have a decisive role. The profitability of an investment venture is shown through several dynamic methods and thus, the investment's payback period, the internal rate of return and the net present value are the most common (Heley and Jutkenhorst, 1989).

The aim of this paper is to examine the dependence between the dynamic indicators of investment profitability. By explaining the dynamic methods of a project's efficiency (profitability), we will test the dependence between major investment profitability indicators. Langdon (2002) considers investment's payback period and the internal rate of return as one of the most important dynamic indicators of investment profitability.

Theoretical background

Investment programs are designed on constant prices in order to avoid inflation account during the project's lifetime. The application of all dynamic methods of a project's efficiency (profitability) assessment is based on the economic course where the constant output and input prices are built-in during the project's entire lifetime, the category of NET INCOME (by their discounting) is used for drawing conclusions regarding the investment's profitability (Maginn et al., 2007).

Since all methods are based on data from the economic course and if the economic course is (hypothetically) "cleaned" of inflation in every year of the project's lifetime, it is obviously possible to establish a relationship between individual methods of project assessment.

The method of the investment's payback period

The method of the investment's payback period implies the establishment of the time necessary to return the

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JEL Classification: G11, G31.

Table 1. Payback periods and internal rates of return for the investment programs.

Investment program	Payback period (years)	Internal rate of return (%)
I	**II**	**III**
1.	3.0	63.72
2.	3.0	87.24
3.	2.0	49.47
4.	8.0	13.2
5.	6.5	15.0
6.	7.0	13.7
7.	6.0	20.38
8.	6.5	16.4
9.	3.5	32.16
10.	6.5	13.3
11.	3.0	44.4
12.	4.0	32.4
13.	8.0	21.27
14.	5.5	19.32
15.	4.0	43.6
16.	5.5	17.64
17.	5.5	20.48
18.	5.0	20.0
19.	2.0	57.0
20.	3.5	36.3
21.	4.0	26.58
22.	4.5	31.54
23.	3.5	20.67

investments. The mathematical expression of the method is as follows:

$$\sum_{n=0}^{t} TI_n^e = \sum_{n=0}^{t_p} NP_n^{ep} \quad (1)$$

where TI_n^e represents the total investment in the economic course, NP_n^{ep} is the net income in the economic course, t_p is the investment's payback period, and n represents the years in the project's lifetime.

In this method the measure of assessment is the longest acceptable period of payback, i.e. the investment's payback period must be shorter than the project's lifetime which is usually defined by the lifetime of equipment built into the project. In their study, Sengar and Kothari (2008) calculate both investment's payback period and internal rate of return for their economic evaluation and, therefore, explain the importance of these two dynamic indicators of investment profitability.

The method of internal rate of return

The project's internal rate of return is defined as the discount rate which settles the net present value to zero. It is determined by the following equation:

$$\sum_{n=0}^{t} \frac{NP_n^{ep}}{\left(1+\frac{ISR}{100}\right)^n} = 0 \quad (2)$$

where ISR is the internal rate of return. Kleczyk (2008) states that the level of the projects' internal rates of return for different strategies is one of the most important decision factors when deciding which new products to develop and which new investment program to conduct.

METHODOLOGY

During the research process, a sample has been collected consisting of 23 investment programs which were realized in the area of the Autonomous Province of Vojvodina over a period of five years. The sample consists of different randomly chosen investment programs from different industries. Parameters of the payback period and the internal rate of return are shown in Table 1.

Characteristics of statistical indicators for the sample of payback period

The main statistical characteristics of the sample are given in the

Table 2. Statistical characteristics.

Characteristic	Value
Sample size	23
Mean value	4.78
Median	4.5
Mode	4
Geometrical mean	4.45
Variance	3.15
Standard deviation	1.77
Standard error	0.37
Minimum	2
Maximum	8
Interval	6
Lower quartile	3.5
Upper quartile	6.5
Interquartile interval	3
Curvature	0.24
Standard curvature	0.48
Flatness	0.89
Standard flatness	0.87

Table 3. Statistical distribution types.

Distribution type	
1. Bernoulli's	10. Exponential
2. Binomial	11. F – division
3. Discrete uniform	12. Gamma
4. Geometrical	13. Log-normal
5. Negative binomial	14. Normal
6. Poisson's	15. Student's
7. Beta	16. Triangular
8. Hi-quadrate	17. Uniform
9. Erlang's	18. Weibull's

Table 2. Data calculated in Table 2 were tested with regard to adaptability by means of the following distribution types, presented in Table 3. It is concluded that the best method to represent the law of distribution of investment payback period is that of Weibull's distribution (Figure 1).

Characteristics of the statistical indicator for the sample of internal rate of return

The main statistical characteristics of the sample are given in the Table 4. Data from Table 3 are treated the same way as data from Table 2 regarding 18 different types of distribution, thereby obtaining the log-normal distribution (Figure 2).

RESULTS AND DISCUSSION

By marking the payback period of an investment as a randomly variable dimension (X), and the internal rate of return as another one (Y), the question is: what is the relation between them if there is any? (ODA, 1988)

By expressing the dependence $Y = f(X)$, i.e. placing the payback period and the internal rate of return in mutual dependence, the polygon of frequencies has been obtained (Figure 3). Through the points of mutual relationship, it is possible to draw several different curves, describing this dependence more or less well. In the following, three models of dependence of the payback period on internal rate of return have been shown, presented in the following subsections.

Model of the shape's linear dependence

$Y = a + bX$

where, the following coefficients have been calculated

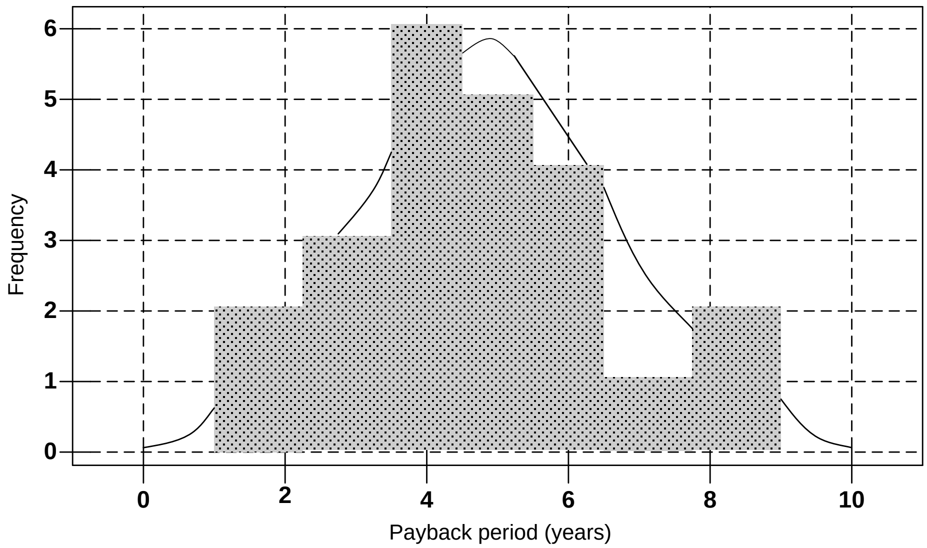

Figure 1. Weibull's distribution of investment payback period.

Table 4. Statistical characteristics.

Characteristic	Value
Sample size	23
Mean value	29.72
Median	22.76
Mode	20.48
Geometrical mean	25.44
Variance	335.95
Standard deviation	18.33
Standard error	4.09
Minimum	13.20
Maximum	87.24
Interval	74.04
Lower quartile	18.48
Upper quartile	36.11
Interquartile interval	17.63
Curvature	1.72
Standard curvature	3.15
Flatness	4.03
Standard flatness	3.68

based on regression analysis:

a = 68.8 and b = -7.96

Hence the linear dependence is Y = 68.8 – 7.96X and the curve (straight line) of dependence of the linear shape is shown in Figure 4.

Model of the shape's exponential dependence

$Y = a^* X^b$

where the values of parameters a and b are as follows:

a = $e^{5.00192}$ and b = -1.15406

Hence the dependence of the curved shape is: Y = $e^{5.00192} * X^{-1.15406} = 148.7 * X^{-1.15}$ which is shown in Figure 5.

Model of the shape's exponential dependence

$Y = e^{(a+bX)}$

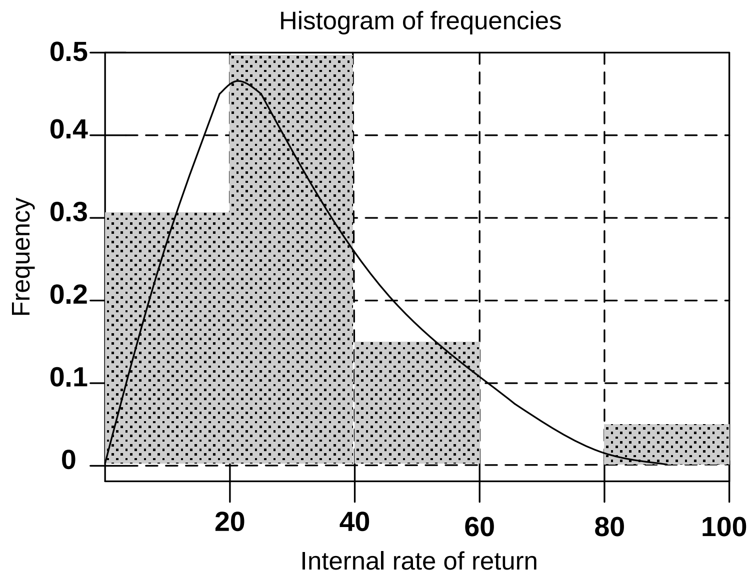

Figure 2. Log-normal distribution of investment internal rate of return.

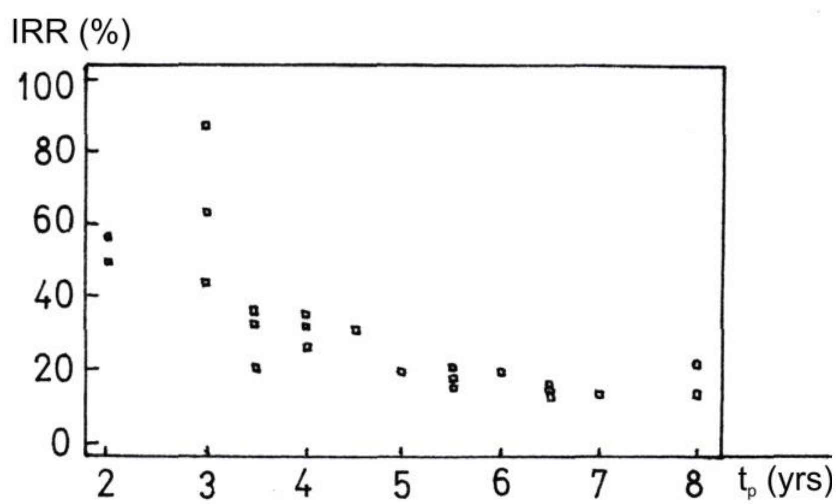

Figure 3. The polygon of frequencies of mutual dependence.

where the values of parameters *a* and *b* is as follows: *a* = 4.49905 and *b* = -0.255122

By replacing of parameter values into the initial form the following dependence is obtained:

$$Y = e^{a} * e^{bX} = e^{4.499} * e^{-0.255X} = 89.927 * 1.29^{X}$$

The curve is shown in Figure 6.

By contrasting the correlation coefficients and the standard error of the regression for all three dependences (Table 5), a conclusion may be drawn that the mutual relationship between the investment's payback period and the internal rate of return for the 23 investment programs which have been presented is best described by the curved exponential dependence of the following form:

$$Y = a * X^{b} = \frac{148.7}{X^{1.15}} = 148.7 * X^{-1.15}$$

Conclusions

This paper presents a research which is conducted in the domain of mutual relationship between the elements

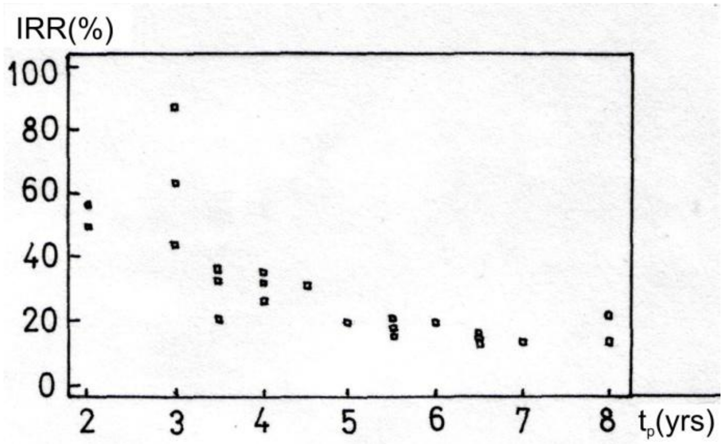

Figure 4. The curve of dependence of the linear shape.

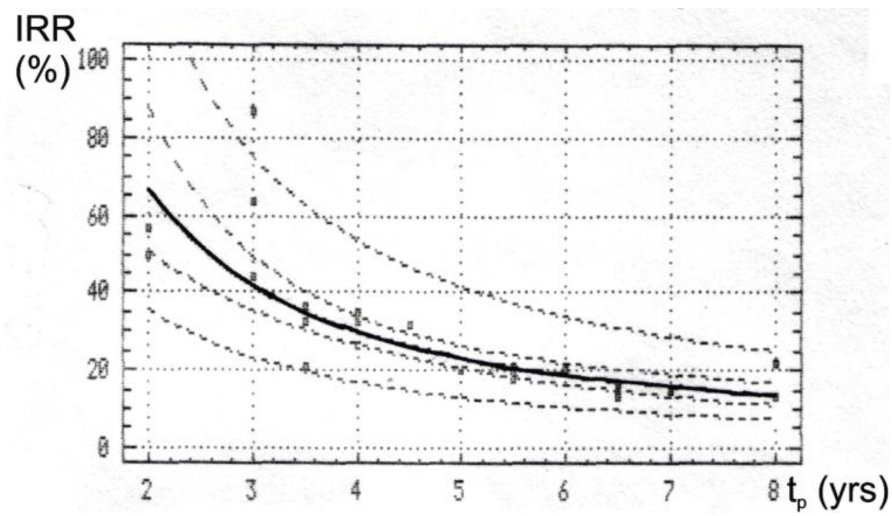

Figure 5. The curve of dependence of the exponential shape.

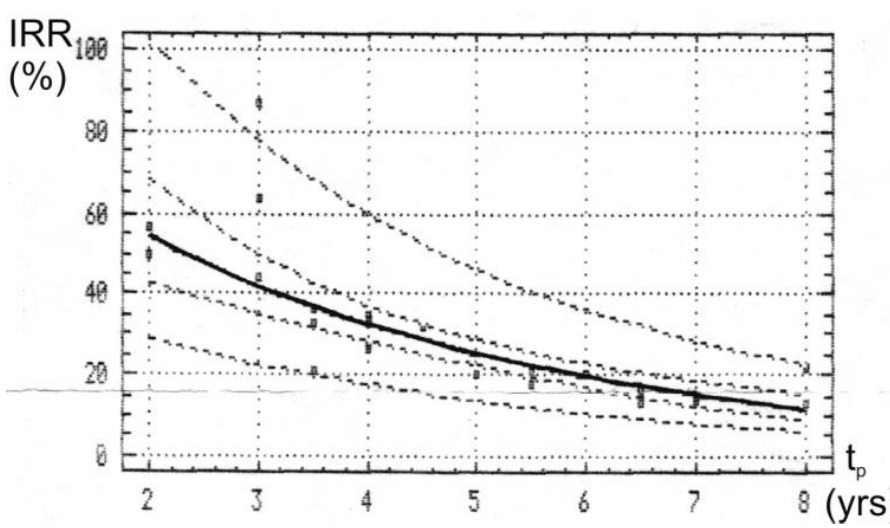

Figure 6. The curve of dependence of the exponential shape.

Table 5. The correlation coefficients and the standard error of the regression.

Dependence of shape	Correlation	Standard error of the regression
$Y = a + bX = 68.8 - 7.96X$	0.753	0.126
$Y = a \times X^{b} = 148.7 \times X^{-1.15}$	0.865	0.273
$Y = e^{(a + bX)} = 89.93 \times 1.29^{-X}$	0.850	0.287

describing the efficiency of investments (Maric, 2000).

The dependence of frequency distribution which was obtained and mathematically verified describes the relationship between the basic dynamic methods of assessment of investment projects with sufficient accuracy. It is among the first steps in the area of theoretical researches of this kind in the Republic of Serbia. The equations and graphical dependences which have been obtained between individual variables may facilitate the procedure of quick computation and shifting from one parameter to another. Likewise it points the right direction for further researches of this type.

The initial hypothesis that "there is a reasonable relationship between individual parameters of efficiency based on the project's economic course" is verified by the results which have been obtained (coefficients of correlation). In our further research, we would like to further investigate mutual relation of different dynamic indicators of investment profitability, based on various data samples and statistical analyses. We are eager to research how the expansion of the sample and classification of the companies in economic branches will influence the results and to distinguish those branches where investment's payback period and internal rate of return are the most connected.

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