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ECONOMIC EFFECTIVENESS OF INVESTMENT IN SECURITY

This article discusses the issue of security from the perspective of its economic effectiveness. Each investment increasing security can be analysed from the perspective of its economic effectiveness. The effectiveness is understood here as a ratio of outputs and inputs in the context of preservation and increasing security. The article describes the methods that can be applied to projects aimed at enhancing security.

Keywords: *security; economic effectiveness; investments.*
Peer-reviewed, approved and placed: *7.05.2016.*

Йозеф Ключка

ЕКОНОМІЧНА ЕФЕКТИВНІСТЬ ІНВЕСТУВАННЯ В БЕЗПЕКУ

У статті досліджено питання безпеки з точки зору її економічної ефективності, зокрема, описано інвестування в безпеку з огляду на економічну доцільність. Ефективність при цьому розуміється як співвідношення видатків та прибутків у контексті збереження та покращення безпеки. Проаналізовано методи, що можуть бути застосовані в проектах, які підвищують рівень безпеки на підприємствах.

Ключові слова: *безпека; економічна ефективність; інвестиції.*
Форм. 9. Рис. 4. Табл. 6. Літ. 13.

Йозеф Ключка

ЭКОНОМИЧЕСКАЯ ЭФФЕКТИВНОСТЬ ИНВЕСТИРОВАНИЯ В БЕЗОПАСНОСТЬ

В статье исследован вопрос безопасности с точки зрения её экономической эффективности, в частности, описано инвестирование в безопасность с позиции экономической целесообразности. Эффективность при этом понимается как соотношение расходов и прибыли в контексте сохранения и повышения безопасности. Проанализированы методы, которые могут быть применены в проектах, повышающих безопасность на предприятиях.

Ключевые слова: *безопасность; экономическая эффективность; инвестиции.*

Introduction. For many types of business activities the information system and its security are crucial, not only for long-term sustainability of the business entity and its core activities. Increasing security is usually associated with additional investments; therefore, it is a question of economic effectiveness of investments in security projects and the subject of growing interest in theoretical and practical fields.

Material and methods. In this paper further we present:

- quantification and application of different methods concerning investment effectiveness and investment decisions;
- specific methods relevant to security issues;
- results of the applied methods are discussed with the purpose to provide practical recommendations concerning investment decisions in the security framework.

The concept of economic effectiveness of investments is well known and widely discussed in publications. There are many scientific papers dealing with economic effectiveness of investments (Braley et al., 2014; McLaney, 1994). The term of economic effectiveness within these publications means the rationale for the eligibility of

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investment. They are all, however, committed to the fact that investment supports businesses process which outputs (reflected in the growth of cash) are easy to quantify. The calculation is based on net present value (NPV), internal rate of return (IRR) and return on investment (ROI).

Another fact is that in many sectors of the economy activities directly do not bring cash growth but benefits (benefit is a relevant gain of investment; benefits can be quantified directly or indirectly). Security-increasing investments (e.g., investing in back-up data centres) do not deliver extra cash flow in the short term but their aim is to enhance security and long-term sustainability of a business entity. New investments are thus a quantifiable input (negative cash flow), their implementation generates higher level of security.

F. De Rus (2010), R.J. Brent (2006), R.O. Zerbe (2006) and S. Farrow and R.O. Zerbe (2013) deal with the issue of costs and benefits analysis. Costs/losses and benefits have to be quantified here for the evaluation of economic effectiveness of security projects. On this basis, as well as on determining the discount rate and the life span of the project net present value of the analysed project is calculated. If cost items are clear in security projects (at least mostly), this does not refer to quantification of benefits and losses. Many of benefits and losses are indirect in nature, but affect long-term sustainability of business. For this reason, it is necessary to find the opportunities to deal with this issue.

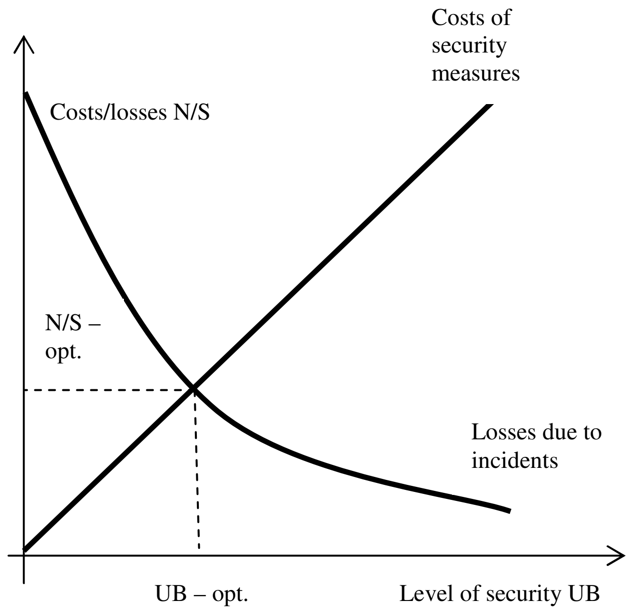
An incident is an event that can cause serious consequences in the functioning of any system – enterprise as a whole or a certain operation at a plant. The result of an incident is damage to a machine or functionless operation. Duration of the effects from an the incident corresponds to the amount of losses.

Costs that emerge from the incident (i.e. fire) with its consequences (losses) on IT and the referring subsystems (e.g., marketing, payrolls, production etc.) can be defined as direct and indirect ones. Direct are linked to fire destroying a building and IT directly. Indirect costs lie in possible losses of revenues, loss of customers, markets etc. In connection with fire, there can also be the loss of human lives and some injuries. So the cost of damages resulting from a damage to a building and IT (hardware + software) can be relatively easy to quantify. The loss of human lives, injuries can be classified as damage, however, determination of exact amount is ambiguous (similarly, with indirect damages from functionless IT).

B. Mertz et al. (2010), J. Klucka and V. Mozer (2014) presented mixed qualitative and quantitative approaches to evaluation of security investment in IT. Losses can be classified into direct and indirect and then into tangible and intangible.

S. Bistarelli et al. (2006) also presented mixed qualitative and quantitative approach to evaluation of security investment in IT. R. Bojanc and B. Jerman-Blazic (2008) defined the approaches to quantitative risk assessment, together with some examples. They use new as well as known approaches to evaluation of the effectiveness of investments in the IT sector.

Figure 1 demonstrates the relationship between losses as a result of the incident and costs of measures increasing security. Figure 1 shows that for a given course of costs and losses, a point (UB – opt., C/D – opt.) represents an optimum level, i.e., the coordinates of this point of equilibrium optimizers represent the cost of security measures and losses as a result of an incident.



Fugure 1. **The expression of optimizing conflict – damages as a result of the incident and level of security,** *author's*

The paper will proceed further as follows:

- methods quantifying investment effectiveness;
- application of these methods on an example documenting a security concept;
- an investment decision based on the results from the explained methods.

Calculation and results. The scope of economic impact of the incident is determined by the following factors:

- economic impacts can be direct and indirect;
- loss of human lives and injuries represent a specific loss, which can be (even if controversially) quantified;
- economic impacts of an incident are determined by the level of system resilience.

Methods that are most commonly applied to investment decisions are the methods of net present value, the internal income per cent and return on investment.

For calculation of the net present value (*NPV* in EUR) we apply the equation:

$$NPV = \sum_{n=0}^{t} \frac{CF_n}{(1+i)^n}, \quad (1)$$

where t – the life span of the investment project; CF_n – represents the cash flow – the difference in income and expenses of the investment planned in each year of the life span n, EUR; i – the interest rate required by the assessor/owner emerging from an investment, %.

Example: Let the investment of 50,000 EUR generate cash flow in each year (1–5) (Table 1). The challenge is to determine NPV for the assignment and to decide on the implementation or non-implementation.

Table 1. **Investment cash flow for the calculation of NPV,** *author's*

Time period	Cash Flow*
0	-50,000
1	-33,000
2	-33,000
3	-33,000
4	-33,000
5	-33,000

* cash flow is given by the amount of losses in respect of fire/year + investment in fire prevention measures + insurance reduction + other benefits.

Table 2 shows the result.

Table 2. **The result of the solution for specified capital value,** *author's*

Capital Value	NPV
5%	-183,688.31 EUR

A negative NPV value for a specified investment flow (presumed) leads to the decision on non-implementation of this investment. In spite of the investment, costs (cash out) excess the revenue (cash in).

The task is to determine the amount of interest rate *i* by the internal income percentage solution in the equation:

$$NPV = 0. \tag{2}$$

Example: For assignment from Table 1, let us calculate IRR. The solution for the specified value is not defined.

The return on investment ROI (%) is another frequent indicator for investment effectiveness evaluation. It can be calculated as follows:

$$ROI = \frac{\dfrac{\sum cash\ flow}{project\ lifespan}}{project\ investment}. \tag{3}$$

The investor can compare the achieved amount of the proposed investment with the internally fixed amount, which has a link to the overall performance of an enterprise.

Example: For the assignment (Table 1) let us define the indicator of the return on investment. The result is ROI = -377% (negative ratio suggests the economic ineffectiveness of such an investment).

Calculation of NPV, IRR was done by the use of "EXCEL".

Another approach (Table 3) is based on defining marginal benefits and costs of defining an optimal security strategy.

The practical application issue lies in quantification of losses as a result of a fire. It is up to the solver, whether and how to incorporate in the calculation the estimated amount of indirect as well as immaterial losses due to fire. The issue of benefits' quantification is reduced here to access that benefit constitutes losses saving in a fire due to taken fire-fighting measures.

Example: Let the costs of fire-fighting measures be 0 EUR/year (period 0) and losses due to fire be 65,000 EUR/year. Let the costs of fire-fighting measures (period 1) be 50,000 EUR/year and losses due to fire are 45,000 EUR/year. Benefits/costs ratio is then equal to 0.4. As the requirement is that benefits should be prevailing (higher than) costs, the required value should be greater than 1.

Table 3. **Cost/benefit ratio definition,** *author's*

Items	Period	
	0	**1**
Fire elimination costs	0	50,000
Losses due to fire	65,000	45,000
Amount of losses and costs	65,000	95,000
Marginal costs	0	50,000
Marginal benefits	0	20,000
Ratio benefits/costs	-	0.4

The above approach (modified) is applied by V. Mozer (2015) in calculations of economic effectiveness of fire-fighting measures in buildings. It is based on the assumption that for the increase of fire security of buildings, an electric fire alarm, fire extinguishers, automatic sprinklers and fire separating construction can be installed. Their installation/non-installation creates 15 possible classes of fire security levels. Economic effectiveness is expressed by comparing the current state and proposal of fire-fighting measures installation (after transformation of these items into the corresponding financial statements). The acceptability of the new solution is that its economic effectiveness coefficient is positive. The subject of comparison is the status quo and the status after the adoption of the selected fire-fighting measures.

This approach reflects the following:

- investment preference, which exhibits the highest level of economic effectiveness coefficient;
- damages/losses level of the given construction as the sum of direct and indirect costs (also tangible and intangible);
- this economic effectiveness coefficient does not compare benefits and costs but actually costs/losses in the period 1 and 2, i.e., before the introduction of fire-fighting measures, and after their introduction (cost comparisons); in these expressions, absent are the quantified benefits that can be derived from the elimination of losses as a result of fire-fighting measures implementation.

Each security level is characterized by a certain combination of security features, which reduce the risk of an incident. It is possible to express the amount of investment in EUR.

Benefits resulting from investment can be expressed in terms of security growth as a result of the implemented measures.

Evaluation criterion is expressed in terms of economic effectivness coefficient:

$$c_e = \frac{(S_{d,y1} \times V_d + L_{i1}) - (S_{d,y2} \times V_d + L_{i2})}{(C_{p2} - C_{p1})}, \quad (4)$$

where C_e – economic effectiveness coefficient; $S_{d,y}$ – the estimated annual fire losses range for a certain level of fire security, m^2/year; V_d – the average concentration values for the type of building or space under consideration, EUR/m^2; L_i – indirect losses from a certain level of fire security, EUR/year; C_p – annual costs of installation and operation of fire-fighting measures, EUR/year.

Next, let it be valid that:

$$A1 = (S_{d,y1} \times V_d + L_{i1}); \qquad (5)$$

$$A2 = (S_{d,y2} \times V_d + L_{i2}). \qquad (6)$$

For economic assessment of the fire-fighting measures effectiveness (equation 4) the following situations are possible (Table 4).

Table 4. **Possible situations of economic effectiveness coefficient calculation,** *author's*

	A1, A2	
1	A1 > A2	Measures are taken to reduce fire losses
2	A1 < A2	Measures taken will not reduce fire losses; fire losses are higher than the situation after the measures taken.
3	A1 = A2	Measures taken to retain the amount of losses after fires are at the same level as the original condition
	Cp1, Cp2	
A	Cp2 > Cp1	Costs of fire-fighting measures taken are higher than the costs of the initial situation
B	Cp2 < Cp1	Costs of fire-fighting measures taken are lower than the costs of the initial situation
C	Cp2 = Cp1	Costs of fire-fighting measures taken are the same as the costs of the initial situation

The proposed procedure for the quantification of economic effectiveness for security solutions is relevant/valid for variants (2,A) and (3,B). Other combinations represent inefficient, unsustainable solutions. Combinations (1,C), (2,C) and (3,C) show unacceptable solutions (from a formal point of view, it is not a permissible value of the denominator to be equal to zero).

The result of the installation (capital and operating costs) corresponds to some level of security. However, if costs do not match the amount of expected losses/damages elimination (it is higher), then such investment is not effective; it is expected that investment in security will reduce the effects/losses of an incident; its height is limited to a maximum of the amount of the expected losses (in theory); in practice, we always expect to see differences in the proportion – the investment: the effects/losses.

Example: Let the losses before the investment be 65,000 EUR/year, concentration of values is 100 EUR/m^2, and indirect losses of the building are 45,000 EUR/year. Due to implemented fire-fighting measures the losses estimates are set at 45,000 EUR, concentration of values is unchanged, and indirect losses for the investment are unchanged. The annual costs for installation (initially zero), due to the realisation of the investment, have changed to the value of 50,000 EUR. Then it is valid that economic effectiveness coefficient is 40. Economic merits of the investment carried out points to the solution increasing fire security.

The practical application issue lies in the quantification of losses as a result of the fire. It is up to a solver, whether and how to incorporate in the calculation the estimated amount of indirect losses as well as immaterial losses from a fire. The issue of benefits' quantification is reduced here so that benefits constitute losses saving in a fire due to taken fire-fighting measures.

Another approach comes from (Bistarelli et al., 2006) and it is applied to calculation of the effectiveness of a secured information system. The calculation procedure is shown in Figure 2.

1. Set the security level
2. Calculation of SLE, ALE
3. Calculation of CBA
4. Selection of the minimal CBA for a given security level

Figure 2. **Calculation method**

For each level of security (which corresponds to the combination of fire-fighting equipment) shall be calculated *SLE* and *ALE*. Applying costs and benefits analysis we obtain a solution that maximizes *CBA*.

$$SLE = AV \times EF, \tag{7}$$

where *SLE* – single loss expectancy; expresses financial loss due to incident occurrence, EUR; *AV* – asset value, EUR; *EF* – exposure factor; expresses the expected extent (%) asset loss.

$$ALE = SLE \times ARO, \tag{8}$$

where *ALE* – annualized loss expectancy; expressed as financial loss which can be expected, EUR; *ARO* – annualized rate of occurrence in a given year.

$$CBA = ALE(prior) - ALE(post) - ACS, \tag{9}$$

where *CBA* – cost benefit analysis, EUR; *ALE(prior), ALE(post)* – expected annual loss before and after application of fire-fighting measures, EUR; *ACS* – total costs of implemented security measures, EUR.

Example: assignment with a solution is given in Table 5.

The resulting negative value implies the ineffectiveness of the investment. The expected annual savings on losses as a result of investment does not compensate its volume.

A different approach to economic effectiveness of fire-fighting measures may be expressed as follows (Figure 3).

The approach is based on identifying costs and benefits emerging from investment. Capital expenditures are calculated for a year. Preference is given to the projects which benefits are higher than the costs.

Example: To calculate the economic effectiveness of the project focused on the realization of fire-fighting measures for the back-up data centre. Investment is 50,000 EUR, life span is 5 years. The expected benefits of the project are: reduction in the annual amount of insurance by 2,000 EUR/year and reduction in damages/losses due to fire occurrence (calculated for a year) 8,000 EUR (Table 6).

Table 5. **Solution of fire-fighting measures B/C formulation,** *author's*

	Active	
	Before investment	**After investment**
	Back-up data centre	**Back-up data centre**
Value	450,000	500,000
Threat	fire	fire
EF	10%	1%
SLE	1%	5,000
ARO	0,65	0,04
ALE	29,250	200
Costs of fire-fighting measures	0	45,000

CBA	**-15,950 EUR**

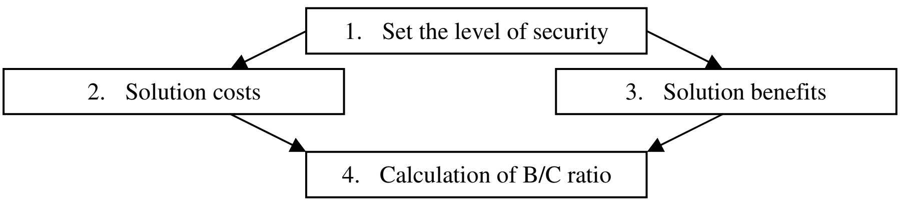


Figure 3. **Calculation method,** *author's*

Table 6. **Calculation of B/C ratio,** *author's*

Life span	Annual value	B/C
5	11,548.74 EUR	0.87

The result shows that the amount of the total costs related to 1 year is 11,548.74 EUR (the PMT function in "EXCEL") and B/C ratio is 0.87. It follows that benefits are lower than costs and, therefore, the effectiveness of the investment is again negative.

Discussion. It is clear that the methods to quantify the effectiveness of an investment strongly depend on the context of investment (business, non-business). This dictates also possible methods and their application in the projects focused on increasing security. Based on the presented results we can summarize that there are methods the application of which in security projects is preferable.

There are two approaches to quantify economic efficiency (Figure 4):

- based on quantification of costs and benefits;
- based on quantification of different levels of security that correspond to different investments and expected losses.

The net present value method can be characterized as:

- has a direct link to maximize the assets of the enterprise owners;
- based on the acceptance of changes in the value of money at the time;
- is easy when choosing option (maximizing the positive value from more than one variant).

The advantage of IRR application lies in the indicator transparency and the possibility to compare the outcome with the required valuation of capital expressed as %.

Benefits/costs ratio refers to the category that shows the highest ratio of benefits to costs as the optimal variant. This approach is based on the fact that benefits are identified as losses savings from the occurrence of fires. Savings are due to the reduction of consequences from fires due to application of fire-fighting measures. Marginal benefit reflects the difference in the increase of security level by one level corresponding to the increase of costs on the reduction of the effects of fire. Marginal costs reflect the (expected) fall of losses as a result of an increase in the level of security by one level.

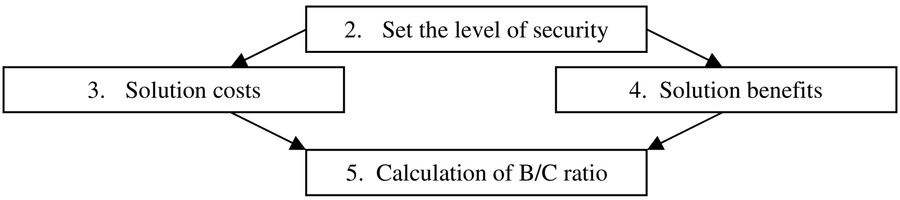


Figure 4. **Two approaches to quantify economic efficiency,** *author's*

Conclusion. Calculation of economic effectiveness for the investments aimed at increasing security is not simple due to the fact that the amount of benefits and losses is difficult to quantify. However, it is desirable to deal with the economic effectiveness as a part of the decision-making process in the implementation of the investment.

Evaluation of the investment effectiveness in the projects relating to production and sale of material and nonmaterial products is known and applied in practise by means of NPV, IRR and ROI and other methods (cost benefit analysis, B/C ratio). The subject of this article was to describe also other methods that can be applied to projects aimed at enhancing security.

Acknowledgment. *This work was supported by the Slovak Research and Development Agency under the contract No. APVV-0727-12.*

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