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An Approach to Environmental Investment Decision-Making

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Abstract: Strategic decision-making processes utilized by company managers mainly involve decision-making with respect to a company's investment activities. In accordance with the principles of sustainable development, the environmental aspects of any planned investment should be incorporated in investment decision-making processes. Selection of the best investment strategy is based on multi-criterial decision-making which is in addition, variable over the long run. One of the many data mining modelling algorithms can be used to support the demanding process of selecting a suitable investment activity. Subject to certain prerequisites and limitations, the neural network model can be used for making investment decisions. The aim of this study is investigation of factors that can influence the selection of an environmental investment alternative using multi-criterial decision-making. Modern procedures and tools should be used to support these decision-making. Only relevantly collected, processed and analysed data can provide enterprise managers with a sufficient information platform when making qualified decisions.

Key words: Environmental investment, dynamic methods of investment evaluation, data mining algorithms, neural network, remediation project, enterprise managers

INTRODUCTION

Today's entrepreneurial environment places higher and higher demands on entrepreneurial entities. Under the pressure brought by both domestic and international competition, enterprises are forced to identify both external and internal factors that influence their economic situation and successful development. Decision-making processes employed by company managers have to be based on relevant data resulting from analyses of these factors. Important strategic decisions made by enterprise managers include selecting the optimum investment plan. Investment activities carried out by enterprises are always associated with capital expenditure which must be planned very carefully, since, it is an action of great import which significant affects a company's financial management.

One significant aspect of today's decision-making process when deciding whether or not a project is acceptable is its environmental impact. Projects aimed at environmental protection are often triggered by the necessity to comply with legislative requirements for protection of the environment. Enterprises may thus consider whether they should concentrate their investment activities on additional purifying technologies (end-of-pipe) or focus their investment policy on preventive corrective measures (integrated technologies). Enterprises should adopt a comprehensive approach when evaluating both possible alternatives and should explore the entire range of factors that can influence the selection of a particular investment alternative. This multi-criterial decision-making is very difficult for enterprise managers if they use common mathematical methods. A certain element of risk, uncertainty and variability of possible investment solutions within a certain time horizon should be integrated in the decision-making process. Algorithms generated in the data-mining environment may be a suitable modeling tool. Although, these tools have certain prerequisites and limitations, the potential of neural networks can be used when selecting an investment project.

MATERIALS AND METHODS

Problems, methodology and solutions: Selecting an enterprise investment strategy is one of the most important managerial decisions an organization faces. When deciding on the efficiency of specific alternative investment projects, enterprises usually employ the narrower concept of the enterprise strategy and project profitability is emphasized as one of the most important parameters in this decision-making process. Attention is also paid to possible risks and the time needed to generate future proceeds. Profitability, riskiness and the payback period are often the basic parameters used to evaluate individual investment plans and compare individual alternatives. For evaluating investment efficiency, it is necessary to specify capital expenditure on a particular investment project to estimate the future net monetary income and potential risks, define the cost of

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capital of the enterprise (or determine an adequate discount rate for income discounting) and calculate the net present value of the expected income. At the present time, enterprise investment strategies cannot be created without considering the relevant environmental issues. Therefore, environmental aspects are a fully-fledged criterion when selecting the optimum investment project. Enterprise managers have to perceive not only the economic but also the environmental context of each project that is being prepared when making strategic decisions including its long-term impacts.

The methodologies applied cover the synthesis method, causal method, system and ratio analyses, inductions, deductions and comparisons.

Environmental projects: It is always difficult to identify which project is primarily "environmental". Even other projects that do not have protection of the environment as their priority promote new technological processes, use new materials and modernize existing manufacturing equipment, thus helping to improve the environment. Therefore, project classification is not definitive, individual project types often overlap in their aims and potential benefits and it is impossible to clearly define what is and what is not an environmental project. Under a generally accepted/understood definition, environmental projects could be those projects that protect the environment, produce less pollution, use all resources in a more sustainable manner, allow for the recycling of larger quantities of waste and products and allow for the more reasonable disposal of remaining waste (Jasch, 2009).

An important environmental factor in investment decision-making processes is the legislative framework for protection of the environment which defines the quality of care for the individual domains of the environment, particularly in the form of normative and economic tools. Enterprises consider whether they should concentrate their investment activities on complying with legislative requirements and primarily on eliminating the consequences of damaging the environment (filters, separators) or focus their investment policy on preventive corrective measures (integrated technologies). Integrated technology projects are reflected in a number of economic processes in enterprises. When deciding on these projects, all potential impacts of the planned project have to be captured. Savings associated with eliminating or reducing non-product output (rejects, waste) and quantified savings in the legislative area (eliminating the payment of environmental fees, fines or penalties) (Albelda, 2011) can be significant. In addition, these investments can increase the enterprise's income in connection with the enterprise's or its product's achieving a better environmental image. Consideration of all these factors when selecting the optimum investment scenario can lead to selection of an apparently less advantageous alternative for preventing contamination which however will eventually bring not only a direct economic benefit but also a number of positive externalities.

Submitting particularities of environmental projects: The particularities of environmental projects, especially of projects focused on prevention are significantly reflected in the process of evaluating these projects. For environmental investments, it is necessary to create evaluation models with the potential to assess and evaluate the effects of these investments (including non-financial investments) and to also take the expected development of environmental regulations passed by state bodies into account. It is not always easy to specify in investment projects those expenses that are primarily related to an enterprise's environmental objectives. All potential benefits are determined with some uncertainty and carry a risk potential. Relevant decision-making can be based on conventional methods of evaluating investments, however, a number of other circumstances influencing the decision-making process has to be evaluated in a qualified manner. For a comprehensive evaluation of individual investment alternatives, even "soft" and less on-point data have to be taken into account as an essential piece of information for high-quality decision-making processes. In addition to standard calculations evaluating the efficiency of investment decision-making, the enterprise needs to consider factors such as the reputation of the enterprise, the observance of regulations and the motivation of its employees. It is problematic to express these factors financially because estimating them is inaccurate and determining the financial basis is difficult.

Methods of investment evaluation: Expert literature defines a number of statistical methods that can be used to decide on the acceptability of a given project (for example, average profitability of the planned investment, return on investment time period). With regard to the importance of the time factor, so-called dynamic methods which research with the time factor or to express it more clearly with the real value of money are particularly suitable for evaluation of the investment plan. The most familiar dynamical method for determining acceptability of the planned investment scenario is the net present value method.

To determine the net present value (and subsequently, the internal rate of return), it is necessary to define the evaluated project's cash flows over the course of its entire economic life. Estimated future cash flows are a key quantity when correctly evaluating planned alternatives, however such an estimate is quite complicated in practice (Ross *et al*.,

2015). In addition to the actual cash flow, it is also necessary to also consider opportunity costs and to clear the project from sunk costs (which occur without the relation to implementation of the project).

The enterprise is primarily interested only in those investment projects that will bring the required economic effect within a certain time horizon. However, environmental projects can be associated with benefits that manifest themselves over a longer time horizon and it is therefore appropriate to examine discounted cash flows over a longer period of time. In this connection, the issue of discounting future cash flows and the issue of which opportunity costs should be reflected in every project are discussed in expert literature. Discounting in the case of these projects is regarded as problematic, since, the environmental needs of future generations are usually assigned a lower value (due to conversion to the current value). In the case of environmental projects, opportunity costs are the non-economic aspects of the planned project that should be included in the decision-making process but it has to be considered to which extent they should be expressed financially. In an effort to financially express all effects, valid data can be distorted and subsequently, the whole investment project analysis can be rendered worthless (Kovalerchuk and Vityaev, 2000).

If we want a suitable supporting tool for creation of investment strategies, it is possible to use powerful analytic tools which not only enable processing of existing data but also serve to predict future developments. At the present time, one of these tools is the system of knowledge discovery in databases, defined as "non-trivial extraction of implicit, previously unknown and potentially useful information from data" (so-called data mining). This tool can enable enterprise managers to research with data from various points of view, thus, obtaining relevant information which can support planning and decision-making processes in the area of enterprise investment activities (Yin *et al*., 2011).

Variability of the environmental investment process and advanced methods for investment decision-making: Environmental investments are distinguished by the greater variability of their investment process. Managerial decision-making is not executed only with regard to the (non-) implementation of an investment project, it is also necessary to repeatedly evaluate the impacts and effects of implemented investments and to make decisions. Often, a decision has to be made on the suspension or postponement of an investment process, e.g. in the case of remedial processes where continuation in a current investment activity depends on the current level of contamination. When evaluating an investment, it is necessary to take into account the economic consequences of postponing or prematurely terminating the investment process (Witten *et al*., 2016). Such costs may include environmental taxes and penalty fees. Figure 1 shows the above-mentioned variability of the environmental investment process over the course of implementing an investment.

The complexity and high level of randomness of environmental investment processes requires the use of advanced methods when making an evaluation. Applying advanced methods for investment decision-making is

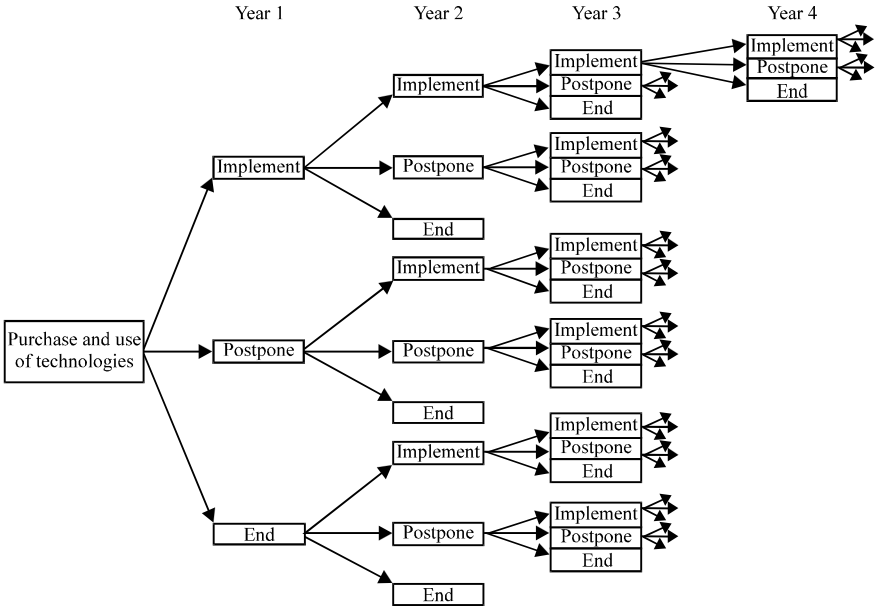

Fig. 1: Decision-making tree for the environmental investment process

based on the assumption of finding the optimal function that maximizes the investment project's cash flow subject to pre-determined constraints. Data mining computational models offer a number of approaches to solve certain problems. In particular, the neural networks model may be useful when deciding on a suitable investment strategy.

Thanks to the neural network characteristics, a neural network appears to be a suitable tool for supporting investment decision-making in the entrepreneurial sphere (Testa *et al*., 2015; Wei and Qi., 2011; Wei *et al*., 2014). The input data for the neural network has to be prepared as a matrix where the individual investment alternatives can be found on the vertical axis while the individual characteristics of investment can be found on the horizontal axis (Chattamvelli, 2011; Shaikh and Chhajed, 2012).

Successful utilization of the neural network is conditioned by a careful and fitting definition of the partial characteristics of the analysed project. With common investment projects, characteristic can be represented by the following variables:

- Planned income from implementation of the investment
- Income from the sale of replaced property
- Depreciation increment due to implementation of the investment
- Planned income from sale of the investment after the end of its useful life
- Tax effects (related to sale of the investment)
- Changes in the net working capital of the enterprise
- Value of the Weighted Average Cost of Capital (WACC) of the given enterprise
- Other variables such as type of company, location of the implemented investment and other data from

The company's financial statements if relevant for the given investment project. However, in case of an environmental investment project, other specific criteria have to be taken into account in addition to the above-mentioned common criteria such as: environmental taxes paid due to the non-implementation or suspension of the project, environmental fees or one-time penalties paid due to the non-implementation or suspension of the project, added environmental value obtained as a result of implementation of the investment project. This concerns improving the environmental image of the enterprise or its product which can manifest itself in an increase of revenues and the associated economic impacts, value of positive externalities produced by implementing the investment project.

Figure 2 shows a typical decision-making situation working with multiple criteria using the neural

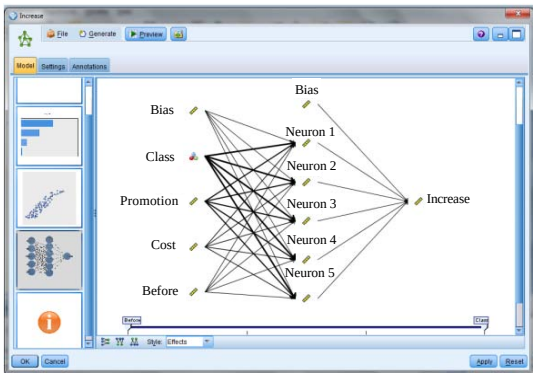

Fig. 2: Example of neural network model

network model. This neural network shows a multi-criterial model task created using PASW Modeller Software.

An example of using neural networks for evaluation of the environmental project: From the end of the 1980's the Czech Republic faced many challenges and not only those in the area of improvement of the living environment. The former socialist regime generated some of the worst environmental conditions in Europe. Now a days, the state of the Czech environment is much better; it is however, still necessary to ensure good quality in some particular areas.

Our example presents investment decision making process of the use of clean-up technologies in locations contaminated after the Soviet military occupation of Czech territory (prior to 1989).

A particular case of a remedial process can be seen in a contaminated area where military activity polluted the sources of groundwater. Specifically, this area had been used for the cleaning of machine parts and equipment. The clean-up process is still ongoing. High concentrations of chlorinated hydrocarbons, tetrachloroethylene, trichloroethylene, dichloroethylene and vinyl chloride prevailed at that time.

It is possible to define the target parameters of the remediation process using various methods. We divided the most relevant types of financial expenditures related to variable clean-up methods into three groups:

- Exploration and preparation research, project research
- Clean-up process
- Concluding activities

The assessment of the economic effectiveness of remedial processes is a very difficult discipline. The decision-making process within the management of remediation is followed by a certain level of risks and

Table 1: Example of an input data matrix for neural network for evaluation of remediation project

	Costs							Other parameters				
	Exploration, preparation and project working			Realization of remediation								
Investment strategy of remediation	Praparation of the wells	Pilot tests	Technology installation	Main decontaminating substances	Water consumption	Technology operation	Conducting activities	Depth contamination	Depth of contamination	Type of contaminant	Expected target parameters (pollution level)	Degree of feasibility
IS_1	$IS_{1,1}$	$iS_{1,2}$	$iS_{1,3}$	$IS_{1,4}$	$iS_{1,5}$	$iS_{1,6}$	$iS_{1,7}$	$iS_{1,8}$	$iS_{1,9}$	$iS_{41,10}$	$iS_{41,11}$	$A_{1,DF}$
IS_2	$IS_{2,1}$	$iS_{2,2}$	$iS_{2,3}$	$IS_{2,4}$	$iS_{2,5}$	$iS_{1,6}$	$iS_{1,7}$	$iS_{1,8}$	$iS_{1,9}$	$iS_{41,10}$	$iS_{41,11}$	$A_{2,DF}$
IS_3	$IS_{3,1}$	$iS_{3,2}$	$iS_{3,3}$	$IS_{3,4}$	$iS_{3,5}$	$iS_{1,6}$	$iS_{1,7}$	$iS_{1,8}$	$iS_{1,9}$	$iS_{41,10}$	$iS_{41,11}$	$A_{3,DF}$
IS_4	$IS_{4,1}$	$iS_{4,2}$	$iS_{4,3}$	$IS_{4,4}$	$iS_{4,5}$	$iS_{1,6}$	$iS_{1,7}$	$iS_{1,8}$	$iS_{1,9}$	$iS_{41,10}$	$iS_{41,11}$	$A_{4,DF}$
IS_5	$IS_{5,1}$	$iS_{5,2}$	$iS_{5,3}$	$IS_{5,4}$	$iS_{5,5}$	$iS_{1,6}$	$iS_{1,7}$	$iS_{1,8}$	$iS_{1,9}$	$iS_{41,10}$	$iS_{41,11}$	$A_{5,DF}$
Is_6	$IS_{6,1}$	$iS_{6,2}$	$iS_{6,3}$	$IS_{6,4}$	$iS_{6,5}$	$iS_{1,6}$	$iS_{1,7}$	$iS_{1,8}$	$iS_{1,9}$	$iS_{41,10}$	$iS_{41,11}$	$A_{6,DF}$
Is_n	$IS_{7,1}$	$iS_{7,2}$	$iS_{7,3}$	$IS_{7,4}$	$iS_{7,5}$	$iS_{1,6}$	$iS_{1,7}$	$iS_{1,8}$	$iS_{41,9}$	$iS_{41,10}$	$iS_{41,11}$	$A_{n,DF}$
IS_{n+1}	$Is_{n+1,1}$	$iS_{n+1,2}$	$iS_{41,3}$	$Is_{n+1,4}$	$iS_{n+1,5}$	$iS_{n+1,6}$	$iS_{n+1,7}$	$iS_{n+1,8}$	$iS_{n+1,9}$	$iS_{n+1,10}$	$iS_{n+1,11}$	?

multi-criterial decision making with different costs and environmental utilities. The neural network model may be particularly useful when deciding on a suitable investment strategy of remediation. The input data for the neural network has to be prepared as shown in the following matrix (Table 1).

The neural network evaluates the degree of feasibility of a particular remediation strategy based on the knowledge obtained during the learning stage. On the basis of this tool, project managers are able to choose the optimum solution.

RESULTS AND DISCUSSION

Selecting the right investment alternative depends on a number of aspects that have to be taken into account when selecting the optimum investment alternative. If environmental aspects of the planned investment are also monitored, the number of analysed criteria increases. To support the decision-making process, a multi-criterial matrix has to be created that not only includes all variables but also assumes a change of sub-alternatives within a certain time horizon. Data mining modelling tools can be used to solve this matrix. The neural networks algorithm can be seen to be most suitable tool for these purposes. The basic problem associated with using this tool is the quantity and quality of input data. To apply neural networks within the framework of investment decision-making, the quantity of data available is critical. Since the neural network first requires the stage of learning with the use of testing data, these data have to be obtained which can be sometimes difficult in the case of particular environmental projects. It is advantageous if the project has been executed repeatedly or by a larger number of investors. In such cases, the use of neural networks for evaluating environmental investment projects is less problematic. Another limitation is to a certain degree, the availability of monetarily or at least numerical data. Environmental projects often research with non-monetarily expressed effects or benefits. To make a relevant decision, it is necessary to convert this information into numerical form as much as possible. Last but not least, it is necessary to emphasize that evaluating investment projects using data mining algorithms requires a certain interdisciplinary approach. Although, most available data mining SW tools (such as PASW modeller) present themselves as intuitive and "user friendly", processing each task requires a certain knowledge platform and good experience with this environment. Cooperation between economic experts and IT support staff is therefore, always beneficial when optimizing decision-making processes.

CONCLUSION

Selecting an optimal enterprise investment strategy is a complicated process. A wrongly selected investment strategy can have a fatal impact on an enterprise's financial management. A number of criteria must be taken into account when selecting the optimal investment alternative and these criteria may significantly evolve and change within the monitored time horizon. Managers should consider more than just the economic benefits of a p lanned investment in the form of positive cash flow. In compliance with the concept of sustainable development, enterprises should monitor not only satisfactory economic results but also the impact of their activities on the environment. It is necessary not only to consider improving the enterprise's attitude towards the environment but also to quantify a decrease in the enterprise's environmental expenditure and last but not least to identify positive externalities brought about by a particular investment project. These environmental aspects should become a natural element when making decisions about the acceptance of every investment plan. If the enterprise respects environmental aspects in its investment decision-making processes, the matrix of variables is significantly extended. The task of multi-criterial decision-making in environmental investments can be processed in the data mining support environment. This platform offers a number of algorithms. Decision-making in the investment scenario can be

fittingly supported by neural network modeling. Neural networks have the ability to research with multiple criteria and to offer variable solutions over the course of a certain time horizon. However, one has to research with certain limitations when using these models. The necessary volume of data that are required the neural network to learn can pose a problem. Also, numerically quantifying of all impacts of a planned investment can be difficult, particularly in connection with the environmental aspects of such investments.

In today's economic practice, enterprises should not only fulfill the basic idea of maximizing profit, they should perform their activities with full responsibility towards all segments of the environment. Modern procedures and tools should be used to support the decision-making processes within the framework of entrepreneurial activities. Only relevantly collected, processed and analysed data can provide enterprise managers with a sufficient information platform when making qualified decisions.

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