The Decision Tree in the Valuation of Mining Investments

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Abstract

The present paper is dedicated to the valuation of mining investments by means of the decision tree method. The paper consists of four parts. The introduction presents the purpose of work. The second section describes the decision tree method. The next part of the paper focuses on a short sample calculation of an investment valuation by means of the discussed method, meant for a mining company which intends to undertake an investment involving the extraction of a new mineral deposit. The paper ends with a summary and a list of literature used in its development.

Keywords: expected value of NPV, valuation of mining investments, decision trees, decision problems

Introduction

The valuation of mining investment projects is a difficult task. This results primarily from the fact that mining investments are characterised by high investment expenses and a long payback period. The first positive financial incomes in these kinds of investments take place after several up to about a dozen years. Due to these conditions, a decision to implement an investment may cause a lot of problems. In order to enable limitation of the risk associated with making the given decisions before its initiation, it is suggested that a valuation should be conducted for an investment whose purpose is an initial estimation of its value. There are many different methods allowing this kind of estimation. One of them is the decision tree method. In contrast to the standard investment valuation method, involving the discount of future cash flows, known as the NPV method, the decision tree method enables estimation of the expected value (ENPV), which takes into account the probabilities of events in the individual phases of the investment. The purpose of this paper is to present the decision tree method and to conduct a sample calculation using this method.

The decision tree

Decision trees are one form of assessment of the financial effectiveness of investments, including those related to mining. Unlike the traditional method (NPV), this method takes into account the probabilities of the occurrence of events unfavourable for the company. Chief financial officers often use decision trees to analyse undertakings in which they deal with the consequences of decisions (Brealey R. A., Myers S. C. 1999). Decision making in individual investment phases is also a characteristic feature of mining investment projects. The people in charge of a mining company must make a decision whether a given investment should be commenced or not. In some cases, difficult decisions must be also made, e.g. involving refraining from or suspension of certain investment decisions.

The decision tree method is based on discounted cash flows which are generated in the individual nodes. Several to even about a dozen such values can be created depending on the complexity of the investigated investment project. Various variants of NPV are generated in this manner, based on which the expected value of NPV is calculated (ENPV), where the weights are the probabilities acquired for each NPV by multiplying the elementary probabilities of each node (branch) (Rogowski W. 2008). The obtained values undergo interpretation which does not deviate from what is known from the NPV method, meaning: if the ENPV is above zero, then it has to be assumed that the investment should be implemented; in the case when the ENPV equals zero, the investment is uncertain but its implementation might be attempted (high investment risk); when the ENPV is below zero then such an investment should be abandoned. A general chart presenting the methodology of calculating the ENPV is shown in figure 1.

The value referred to in figure 1 as "X" presents the amount of investment expenses. "PW" marks the probability of accomplishment (e.g. when the price of a raw material increases); "PS" marks the probability of non-occurrence (e.g. when the prices of raw materials drop). If one assumes that a company must make a decision within the next two years which determine the future of an investment, then two phases will have to be considered

by the people in charge. Different values of NPV were obtained in periods "1" and "2". The calculation of the expected value of NPV takes place according to formula (1).

$$ENPV = \left(\frac{NPV3}{(1+r)^2} + \frac{NPV1}{(1+r)^1}\right) * PW^2 + \left(\frac{NPV4}{(1+r)^2} + \frac{NPV1}{(1+r)^1}\right) * PW * PS + \left(\frac{NPV2}{(1+r)^1} - x\right) * PS \quad (1)$$

where:
ENPV – the expected value of NPV
r – the risk-free rate
x – the amount of investment expenses
NPV 1 to 4 – the value of discounted cash flows in the individual nodes
PW – the probability of an increase
PS – the probability of a decrease

The use of the decision tree in the valuation of a mining investment

In this part of the paper a sample hypothetical calculation will be conducted for an investor who considers investing in a new mineral deposit. The example assumes that a company is considering three decision steps (points) in predefined time intervals. In the first place, the potential benefits resulting from the planned investment are taken under consideration. The second stage involves making a decision about the location and technology of shaft sinking (the sample calculation assumes that the time necessary to sink a shaft will amount to 5 years). In the third step it will be taken under consideration whether to make a mineral deposit accessible or refrain from further investment (assuming it will take 3 years to make a deposit accessible). The sample calculation also assumes that the current and prognostic price of a raw material is a factor determining further investment. It has been assumed that the price in the individual stages of decision making may increase, decrease or remain steady. A graphic image of the decision tree for the present example is shown in figure 2.

In the first step, referred to in figure 2 as "1", a mining company appraises the profitability of an investment; the estimated cost of this operation amounts to 500 000 zlotys. If a decision is made to initiate the investment (with an estimated probability of 80%), the company will enter stage "2"; if there is no decision about the investment then the flows in the "N1" period will be negative and will equal the cost of the appraisal study. In the first year the company enters stage "2", in which it decides to sink the shafts. The estimated cost of this part of the investment amounts to 700 mln zlotys. If the price remains steady or increases, the company will decide to make the deposit accessible for extraction. After five years since making the decision about sinking the shafts the company decides to make the deposit accessible (the predicted time necessary for this is 3 years); the estimated cost of making it accessible amounts to 300 mln zlotys. The last decision to be made involves whether the extraction is to be initiated or not. In this case, it is planned to make the decision refraining from extraction only if between stages "2" and "3" the prices remain steady, and after stage "3" the prices drop (the estimated probability of such an event

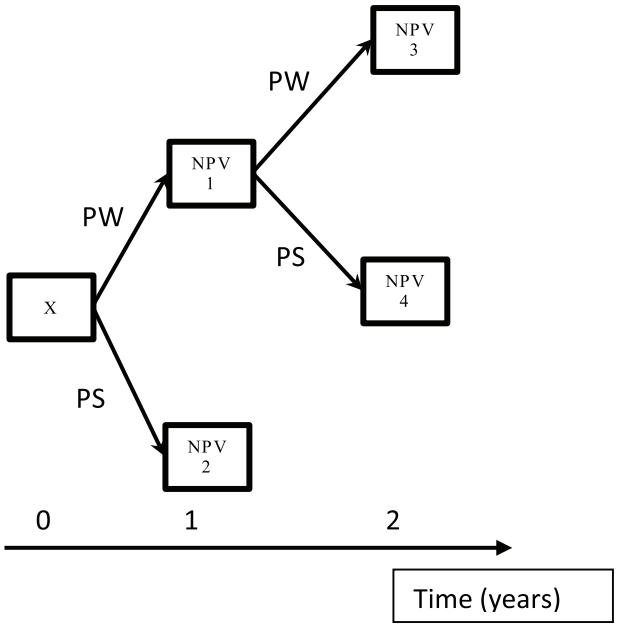

Fig. 1. ENPV value calculation chart (source: own research)
Rys. 1. Schemat obliczenia wartości ENPV (źródło: badania własne)

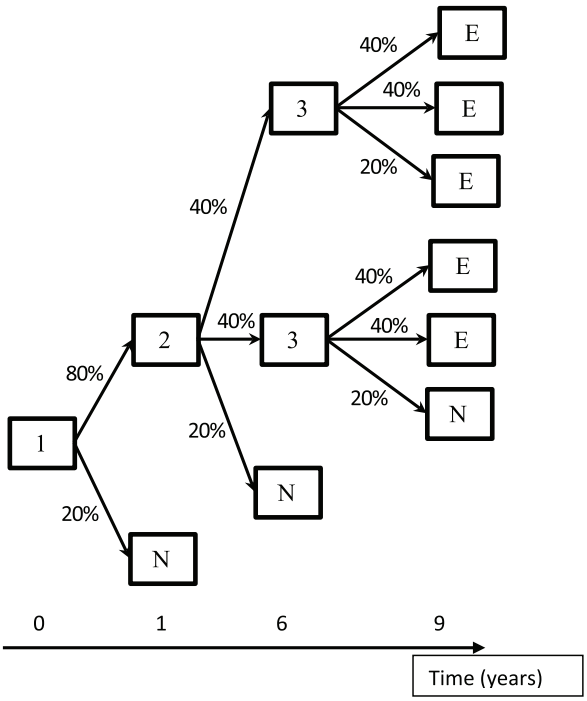

Fig. 2. A decision tree for investing in a new deposit with three decision points (source: own research)
Rys. 2. Drzewo decyzyjne dla inwestycji w nowe złoże z trzema punktami decyzyjnymi (źródło: badania własne)

Tab. 1. The values of discounted cash flows (NPV) in individual nodes (source: own research)
Tab. 1. Wartości zdyskontowanych przepływów pieniężnych (NPV) w poszczególnych węzłach (źródło: badania własne)

	NPV (mln zł)
E1	980
E2	700
E3	560
E4	700
E5	500

Fig. 2. A decision tree for investing in a new deposit with three decision points (source: own research)
Rys. 2. Drzewo decyzyjne dla inwestycji w nowe złoże z trzema punktami decyzyjnymi (źródło: badania własne)

Etap	Wycena	Głębienie szybu	Udostępnianie	Eksploatacja	Suma	Prawdopodobieństwo	ENPV
E1	-0.5	-636.4	-169.3	2493.7	1687.5	13%	216.0
E2	-0.5	-636.4	-169.3	1781.2	975.0	13%	124.8
E3	-0.5	-636.4	-169.3	1425.0	618.8	6%	39.6
E4	-0.5	-636.4	-169.3	1781.2	975.0	13%	124.8
E5	-0.5	-636.4	-169.3	1272.3	466.1	13%	59.7
N3	-0.5	-636.4	-169.3		-806.2	6%	-51.6
N2	-0.5	-636.4			-636.9	16%	-101.9
N1	-0.5				-0.5	20%	-0.1
Suma						**100%**	**411.3**

after phase "3" equals 20%). Decisions involving initiation of the extraction are referred to as "E". The values of discounted cash flows in the individual nodes are presented in table 1.

Based on the presented assumptions: the costs in the individual phases, the probabilities of the individual events and the results of the NPV values listed in table 1, one can estimate the expected value of NPV (ENPV). The calculations assume that the discount rate amounts to 10%. The results of the analysis are presented in table 2.

As indicated by the conducted analysis, the expected value of NPV amounts to 411.3 mln zlotys. If the company assumed an optimistic scenario, then the value of investing in a new deposit would amount to 1687.5 mln zlotys. Taking into account the subjectively estimated risk of the decreasing or increasing prices of the raw material in the individual time periods, it should be therefore concluded that the investment is profitable.

Summary

As mentioned in the introduction to the present paper, the making of investment decisions is an extraordinarily difficult task. In these kinds of situations it is helpful to use one of the investment valuation methods. The presented article suggests the decision tree method which allows obtaining the estimated value of NPV. The suggested investment valuation method has its drawbacks, however unlike the traditional NPV method it is extended by the possibility to attribute (subjective) weights of the occurrence or non-occurrence of a specified event in the future. It also enables restricting too optimistic an approach towards the given investment.

Literatura – References

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Drzewo decyzyjne w wycenie wartości inwestycji górniczych

Niniejszy artykuł został poświęcony wycenie inwestycji górniczych przy użyciu the metody drzewa decyzyjnego. Artykuł składa się z czterech części. We wstępie do opracowania przedstawiono cel artykułu. W drugiej części przedstawiono metodę drzewa decyzyjnego. Kolejna część artykułu została poświęcona na przeprowadzenie krótkiego przykładu obliczeniowego wyceny inwestycji z zastosowaniem omawianej metody dla przedsiębiorstwa górniczego, które zamierza podjąć inwestycję w eksploatację nowego złoża. Artykuł został zakończony podsumowaniem oraz spisem literatury użytej do opracowania artykułu.

Słowa kluczowe: wartość oczekiwana NPV, wycena inwestycji górniczych, drzewa decyzyjne, problemy decyzyjne