„Methodology for assessing the attractiveness of a deposit and quantifying of risk in the exploitation process”

Mining, due to natural hazards, is one of the economy sectors with a high level of risk. Conditions for coal mining in Poland are also deteriorating: the more easily accessible reserves in active mines are being depleted, the depth of exploitation is increasing, which translates into higher temperature values in pits, the transport routes for crews and materials are getting longer, the effective working time is shortening, and the scale of natural hazards and the content of waste rock in deeper lying coal seams is increasing.

The progressive digitalisation of economic life (the so-called fourth industrial revolution) is creating new opportunities for the use of large data sets collected at various stages of deposit exploration and development. These data, aggregated in a digital model of the deposit, can be used to assess the deposit's attractiveness. The attractiveness of a coal deposit is understood as a parameter, based on geological, economic and technical (mining) factors, which influences the profitability and feasibility of coal extraction and allows the comparison of individual zones and deposits.

A problem defined in this way prompts the development of a methodology for assessing attractiveness that can be applied at any stage of an investment project. Data from a three-dimensional digital model of the deposit constitute a kind of reservoir of information, which can be updated on an ongoing basis along with the progress of exploration and mining works (e.g. new information on the structure and quality of the deposit). The development of a methodology for assessing the impact of natural and technical risk factors can be universal in nature and lead to the creation of practical solutions, e.g. as a prompt for adjusting the discount rate of an investment project. The proposed methodology is applicable to deposits where the risk is assessable, i.e. deposits that have already been developed, with a known pattern of major faults and identified and quantified geology and mining conditions (such as degrees and categories of natural hazards).

The thesis sets out the following research thesis:

"It is possible to use information on the variability of geological and mining conditions contained in a digital model of the deposit to assess its attractiveness and estimate risks in the mining process".

The methodology developed in the dissertation for assessing the attractiveness of a deposit and the level of risk of underground coal mining takes into account the influence of the most relevant risk factors resulting from geological and mining conditions. In the research process, one of the MCDA (Multiple Criteria Decision Analysis) techniques was applied, which uses FAHP (Fuzzy Analytic Hierarchy Process). It was hypothesised that the variability of specific geological and mining factors affecting the mining process, safety, and efficiency, can be presented as a risk indicator in the assessment of attractiveness and the estimation of the risk included in the discount rate.

Quantifying this impact can provide an argument for adjusting the overall project risk. To this end, the following outline of the research process has been developed:

1. development of a digital geological model of the deposit (and mining schedule), extended with selected risk factors linked to geological and mining conditions;
2. identification and selection of factors deemed relevant for quantifying the deposit attractiveness and risk index (as its inverse) by means of statistical analysis using segmented regression;
3. development of the RF mining risk factor using the fuzzy analytical hierarchical process FAHP;
4. determination of RF values for individual zones in the test coal deposit and independently for selected coal deposits;
5. implementation of the RF value for the purpose of adjusting the discount rate, which can be used to value a specific mining zone (parcel) or the entire deposit.

The verification of the proposed methodology included an assessment of economic efficiency using the NPV method of the selected two hard coal deposits, and economic models were developed based on the calculation of free cash flow to equity owners and creditors (FCFF, Free Cash Flow to Firm). The saleable coal production schedule (based on data from a digital model of the deposit), sales revenue (based on a reference coal price and time-varying ore quality parameters), capital expenditure volumes, operating costs and other technical and financial aspects were estimated. An assessment of economic efficiency was then carried out using the discounted cash flow method (in two variants: with (i) a fixed and (ii) a time-varying discount rate) for two mines, proposed according to the size of the RF index.