Geostrategic and Economic Risk Assessment
in the World Mining Investments

Key words: Mining investments, risk assessment, country rating, economic evaluation

Abstract
Mining project is a high risk venture and its level depends on the stage of advancement and its location (country, region). While evaluating the first stage of venture the special attention should be paid on political and economic environment of the country or region where the future project is located. World specialists agree that the project risk level is the highest during the first phase of implementation and reduces with its progress i.e. with acquisition of more data, the better prospection accuracy, enlarging the reserves, metals recovery or determining the necessary investment expenditures. The highest level of political risk will be in countries with unstable social, political and economic situation as well as in countries with high level of corruption. Many financial institutions and banks develop their own geopolitical risk analyses with regard of countries reach in natural resources. The most important elements which are evaluated include: foreign currency liquidity, transfer of financial means, safety of investment, export possibility of produced goods.

1. Introduction
It is clear that there is no objective basis for determining the best strategy by mining producers for the reserve replacement. Usually a potential reserve is bought or found. We have to know that the long and expensive development process is made up of many factors. Starting from the nature generosity, than the minds and tools of men, negotiate through the hurdles of intercompany or intracompany politics, deal with local and national government, landowners, banks, shareholders, metallurgists, engineers and management. Very often the calculate costs are based on the unknowns of future metals, energy, water and raw materials prices as well as fluctuating currencies.

The projects values at various stages of development is the question of the additional costs involved in moving deposits from the scoping stage to the mine construction. Producing mines already include the capital costs invested in mine construction, while earlier stage project do not.
The mining companies often have a portfolio exploration projects, which may not have reserves defined, but often have potential for future exploration successes, again making a clear evaluation difficult. This potential cannot be evaluated at the time of the acquisition, but when realized will reduce the acquisition cost per pound off copper over time [1,2,3].

The analysis show that most of the major copper producers undertake a combination of acquisition and exploration [4,6]. Some of companies upgrade resources to reserve finding deeper ore or satellite deposits to maintain production however other prefer to buy any projects located in different places. Using to the data from Metals Economics Group, the authors tried to characterize the investment opportunities and risk in world mining projects [10,11].

2. Country risk assessment

Country risk refers to the likelihood that changes in the business environment adversely affects operating profits or the value of assets in a specific country. For example, financial factors such as currency controls, devaluation or regulatory changes or stability factors such as mass riots, civil war and other potential events contributing to companies' operational risks. This term is also sometimes referred to as political risk, however country risk is a more narrow term, which generally only refers to risks affecting all companies operating within a particular country.

Political risk analysis providers and credit rating agencies use different methodologies to assess and rate countries' comparative risk exposure. Credit rating agencies tend to use quantitative econometric models and focus on financial analysis, whereas political risk providers tend to use qualitative methods, focusing on political analysis. However, there is no consensus on methodology in assessing credit and political risks.

Very good risk assessment is proposed by Coface [12]. The ratings for 154 countries are available and updated regularly via www.cofacerating.com under the country-rating heading. They can be accessed freely for consultation purposes. The Country rating assigned by Coface reflects the average level of short-term non-payment risk associated with companies in a particular country. It reflects the extent to which a country's economic, financial, and political outlook influences financial commitments of local companies. However, international trade actors know that sound companies can operate in risky countries and unsound companies in less-risky countries and that overall risk will depend not only on a company's qualities but also on those of the country in which it operates. In assessing overall risk associated with a particular operation, Country ratings are thus complementary to rating Credit Opinions on companies.
3. How ratings are assigned

Ratings are based on twofold expertise developed by Coface:
- macroeconomic expertise in assessing country risk based on a battery of macroeconomic financial and political indicators,
- microeconomic expertise that draws on Coface databases covering a lot of companies worldwide and 50 years experience with payment in trade flows it guarantees.

Seven families of risk are combined in order to determine an overall rating for each of the 154 countries monitored. Coface ranks country ratings on seven risk levels, A1, A2, A3, A4, B, C and D, in the order of increasing risk. The seven risk families are (table 1):
- growth vulnerability,
- foreign currency liquidity crisis,
- external over indebtedness,
- sovereign financial vulnerability,
- banking sector's fragilities,
- geopolitical and governance vulnerabilities,
- companies' payment behaviour.

Several selected countries and mining projects being within the KGHM CUPRUM interest, were characterized according to the proposed evaluation criteria.

Table 1

<table>
<thead>
<tr>
<th>Risk level</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>A1</td>
<td>The steady political and economic environment has positive effects on an already good payment record of companies. Very weak default probability.</td>
</tr>
<tr>
<td>A2</td>
<td>Default probability is still weak even in the case when one country's political and economic environment or the payment record of companies is not as good as in A1-rated countries.</td>
</tr>
<tr>
<td>A3</td>
<td>Adverse political or economic circumstances may lead to a worsening payment record that is already lower than the previous categories, although the probability of a payment default is still low.</td>
</tr>
<tr>
<td>A4</td>
<td>An already patchy payment record could be further worsened by a deteriorating political and economic environment. Nevertheless, the probability of a default is still acceptable.</td>
</tr>
<tr>
<td>B</td>
<td>An unsteady political and economic environment is likely to affect further an already poor payment record.</td>
</tr>
<tr>
<td>C</td>
<td>An very unsteady political and economic environment could deteriorate an already bad payment record.</td>
</tr>
<tr>
<td>D</td>
<td>The high risk profile of a country's economic and political environment will further worsen a generally very bad payment record</td>
</tr>
</tbody>
</table>

Source: Coface
Coface establishes also sector ratings on ten levels ranging from A+ for the lowest risks to D for the highest according to the following definitions (table 2):

<table>
<thead>
<tr>
<th>Activity sector rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>A+</td>
</tr>
<tr>
<td>A</td>
</tr>
<tr>
<td>A-</td>
</tr>
<tr>
<td>B+</td>
</tr>
<tr>
<td>B</td>
</tr>
<tr>
<td>B-</td>
</tr>
</tbody>
</table>

Table 2

3.1. Country rating – examples

**CHINA – rating A3.** Driven mainly by continued very dynamic investment and increasing exports, the economy has remained strong expanding 11.1 per cent in 2006 and 11.5 per cent in the 2007 first half with 11.2 per cent expected for the full current year. That evident economic strength has nonetheless obscured a few weaknesses. Industrial overcapacity in the automobile, steel, and construction sectors, for example, could squeeze margins and thus cause financial difficulties for companies. The lengthening payment times already noted by Coface reflect that risk. The transparency of companies has notably improved, however, with financial information often available. The new bankruptcy law going into effect this year will moreover constitute progress in protecting creditor rights. Disputes are nonetheless still commonplace reflecting the persistent shortcomings in corporate governance. As regards economic policy, Chinese officials have reaffirmed their concern over the risks associated with unbridled growth. Their priority has thus been to avoid a catastrophic hard-landing scenario. Toward that end, they have undertaken to raise interest rates and initiate an, albeit very moderate, Yuan appreciation. That moderate appreciation appears certain to continue or even accelerate slightly through this year and next. The government will moreover be likely to take other measures intended to cool off the economy like putting restrictions on industrial projects in overheated sectors and instituting quantitative credit controls. China’s financial situation has been healthy, meanwhile, with the country running current account
surpluses and boasting the world’s largest foreign currency reserves, covering over fourteen months of imports. The public sector balance improved in 2006 furthermore with tax revenues increasing and the budget deficit should thus remain near one per cent of GDP in 2007. The social impact of uncontrolled growth has nonetheless remained a source of concern for government officials amid growing inequality and an upsurge of protest. Risks of unrest have centred mainly on land ownership with property requisitioned for road, dam, and housing construction or for industrial area creation or enlargement triggering many conflicts.

PERU – rating B. Peru’s economic growth continues to be among Latin America’s highest and, buoyed by robust domestic and foreign demand, rests on solid foundations. A slight downturn should nonetheless develop in 2007 amid a less brisk export growth (particularly minerals) and restrictive monetary policy, intended to keep inflation at moderate levels. Centre-left President Alan Garcia, in office since July 2006, should pursue a prudent economic policy with IMF backing, expected to result in a limited fiscal deficit. Most public debt, however, remains denominated in foreign currency, which constitutes a source of vulnerability. The prospect of a free trade agreement with the United States coming into force in 2007 augurs increased exports and a continuing slight external account surplus, with foreign direct investment expected to cover all Peru’s modest financing needs. Foreign debt ratios have moreover continued to improve thanks to early repayment of Paris Club creditors in 2005 and the dynamism of raw material exports. The good level of foreign currency reserves has made it possible to substantially mitigate liquidity crisis risk. In this generally favourable context, payment experience, with companies has been relatively satisfactory, with the mining, civil engineering, and textile sectors the most dynamic. Peru is, however, still exposed to a sudden downturn of world prices for raw materials, and despite its consolidation, the banking system has remained weakened by the extent of dollar-denominated deposits and loans. Insufficient economic diversification and marked inequalities continue to constitute a risk for the nation’s cohesiveness, epitomized by the support for indigenes populism in Andean regions.

GERMANY – rating A1. An economic boom marked 2006. Exports continued to grow, spurred by improved economic conditions in Europe. With foreign orders straining production capacity, companies increased their equipment purchases. Meanwhile, public spending on transport and research infrastructure increased. Consumption recovered tentatively, buoyed by job growth. Some anticipatory buying linked to a VAT increase in 2007 had a favourable effect in the fourth quarter. The economy will be less dynamic in 2007. Exports, still the main growth driver, will grow at a slower pace due to the slowdown in both the United States economy and world investment. The three-point VAT increase on 1 January, coupled with the 0.4% increase in pension contributions, will squeeze household spending. But the impact should be limited and of short duration with jobs and wages continuing to grow. The surplus revenues generated by the growth and the
decline in the number of jobless receiving unemployment benefits will contribute to reducing public sector deficits. They will also make it possible to reduce unemployment and health insurance contributions and increase funds intended to finance charge-free health care for children and housing benefits for the unemployed. Companies may ultimately absorb part of the VAT increase considering both their good financial health and the competition between distribution channels. Although spending on housing will level off, corporate investment and the amounts devoted to infrastructure and research will continue to grow comfortably. Amid steady economic growth, company solvency has remained very satisfactory as evidenced by the good level of the Coface payment incident index and continued decline of bankruptcies. Margins have benefited from high competitiveness underpinned by productivity gains and continued rationalization of production tools. Easier conditions for obtaining bank credit have also had a favourable impact. Several sectors have, however, been experiencing difficulties including the manufacturing and distribution of computer and telecommunications-related products, wood processing, textiles, and car industry subcontracting.

MAURITANIA – rating C. Mauritania has been undergoing a twofold political and economic transition. The political transition initiated by the August 2005 coup is still underway. Besides implementation of many reforms intended to improve the management of public finances and ensure the transparency of oil revenues, the military authorities have abided by their commitment to hold a referendum in June on a constitution largely amended toward greater democracy, and then to hold free and transparent municipal and legislative elections in November 2006. In that context, the process that is supposed to culminate in March 2007 with the election of the Republic's president by popular vote seems to be on track. Concurrently, the start of oil extraction has spectacularly improved the country's economic prospects. The oil industry together with major investments made in the other mining sectors and transport infrastructure has been driving the economy. That dynamism has also benefited services. As a result, after the major imbalances suffered in recent years, public and external accounts will be in surplus in 2006 and 2007. Cancellation of a substantial portion of public foreign debt under the HIPC and MDRI programmes will moreover improve the country's solvency. Elements of weakness have nonetheless persisted, including high inflation and inadequate electric power generation capacity, which have hampered the manufacturing sector.

USA – rating A1. A marked slowdown will develop this year with the economy growing only 1.9 per cent, and it will continue in 2008, up 1.7%. The adjustment in the residential construction sector with growing stocks of available housing and declining prices will continue at least until the third quarter next year. Already deeply in debt, households will suffer from the reversal of the wealth effect that rising property values has produced and will be facing tougher conditions for refinancing mortgage loans. That will prompt them to significantly reduce their consumption (70% of GDP) and increase
savings. Several factors could compound that slowdown including a sluggish job market, slower wage growth, and a possible increase in petrol pump prices. The major car manufacturers, already particularly weakened by the competition with their Asian rivals, have begun to feel the effects of the crisis. The household consumption slowdown and more difficult access to financing will significantly affect corporate performance. Companies may cut back on production and slow the pace of their investments, which will ineluctably undermine their profitability and lead to higher unemployment. Exports will not suffer much from the world economic slowdown, continuing to benefit from the still robust demand from emerging countries and favourable exchange rates. Imports will stall under the effect of the household consumption slowdown thereby contributing to a slight reduction of the current account deficit. Military spending and smaller tax revenues should meanwhile affect the fiscal deficit. Corporate payment behaviour is still generally good at this juncture with profitability very satisfactory on average. Companies with the largest debt, notably as a result of debt leveraged operations, could nonetheless grow weaker in coming months especially with some sectors already contending with tense financial situations that a credit crunch would exacerbate. That would of course affect residential construction (housing promoters and builders, manufacturers and distributors of building materials, financial intermediaries and institutions, and so on), but also sectors focusing mainly on the domestic market like car manufacturing and housing-related distribution. Services to private individuals, leisure (restaurants, hotels, travel), textile-clothing sectors and others should also suffer from household budgetary adjustments.

DEMOCRATIC REPUBLIC OF CONGO – rating C. The legislative and presidential elections won by incumbent President Joseph Kabila in 2006 marked the end of the institutional transition period that began in 2003 after five years of civil war. Consolidation of the institutions is nonetheless uncertain. It will depend on the role the president is prepared to grant the opposition, and thus to the Parliament. The security challenges have moreover not lost their importance with the instability fomented by various militias persisting in many eastern and southern regions despite the efforts of UN forces.

Both multilateral and bilateral financial backers have, however, been investing massively in the country's reconstruction and spurring strong growth as a result. Private investors have been focusing particularly on the Katanga region, the Congo's mining province that has become the second destination, behind the Angolan coastal region, for foreign direct investment in Africa. Cobalt and copper exploitation have thus been benefiting from robust demand from India and China with Katanga alone generating 70 per cent of the Congolese government's revenues. A sustainable upturn will necessitate, however, resumption of vigorous structural reform policy and improvement of the business environment with those two objectives coming up against major entrenched interests. In that regard, renewal of relations with the IMF, after the FRPC programme's suspension in March 2006 due to
slippage in public sector finances, will be of first importance. It will be a prerequisite for foreign debt cancellation under the HIPC and MDRI programmes and more generally for support from financial backers over the long haul.

This practical guide has nothing to do with the country rating established by the big rating agencies which are dedicated to institutional investors such as bank making loans in foreign countries (Coface). A good rating indicates that regarding some big pictures, the country will be able to pay back its loans. Although such a global rating could be useful, it does not fit to a small investor who needs more sensitive or qualitative information's such as the behaviour of opinion toward small business or the quality of human relations between boss and employees.

Consequently, the rating takes mainly in account:

− security of goods and persons, countries suffering from civil or foreign wars are systematically rated with red stars,
− legal protection of properties and ability to repatriate money,
− infrastructures such as power energy, telecom's, roads, airports and so on,
− ratio cost quality of the labour force,
− governance behaviour toward business, We cannot recommend a country where State regulations and heavy tax pressure prevent any biz to expect a reasonable profit,
− economic prospects such as the size of internal market and /or the openness to foreign trade.

It's difficult to weight each condition. It means that the rating reflects a global corporate can invest in a dog state because it has some means of pressure on the local appreciation rather than a mathematical notation.

We underline the fact that this rating only applies to small business. A transnational authorities: For example, oil and gold mining corporations are currently investing in countries which are rated with three or four red stars by us!

With this reservation, the guide applies both to the citizens who want to invest in their own country and to the foreigners who aim to implement their new biz in a foreign country. Considering globalization the appreciation tends to be the same: Nevertheless, in our short comments, we take notice of the difference (notably in case of necessary or compulsory joint ventures).

Each country is rated with stars:

− five blue stars: ***** mean the best possible conditions to start a new biz,
− four blue stars: **** mean very good conditions,
− three blue stars: *** mean good conditions,
− two blue stars: ** mean acceptable conditions,
− one blue star: * mean that it is worth to invest but you can meet some hurdles,
one to five red stars: * mean inversely that we do not recommend to invest in this country.

USA: *****+ (blue): The imperial kingdom of free enterprise. The big States such as California or Texas should be privileged. If you need a cool environment, move to the rocky mountains States such as Colorado, Montana or Arizona.

Canada, Australia ****+ (blue): Canada is close to the States. Australia offers the best living conditions in the world (Sydney and Perth notably).

China ***+ (blue): A lot of uncertainties and risks but it's worth to assume because of the market size. A joint venture with Chinese partners is quite necessary.

Germany *** (blue): Global standards are decreasing. Obviously, Germany suffers from its eastern former communist part: People were more trained to denounce than to work hard! What is more, German labour costs are the higher in Europe. The socialists and the so called Green party (it means in fact, hard leftists and former communists) have kept the political power and, in our opinion, the economic and social prospects are not good. However, remind that Germany represents the biggest market in Europe.

Peru * (blue): Limited prospects in Andin countries.

Israel * (red): A very friendly country, with high tech opportunities. Unfortunately no investment prospects during war time.

Ghana, Mali, Senegal, Ethiopia, Kenya ** (red): These countries have gotten a democratic governance. Unfortunately, infrastructures are very bad (Power, Telecom, Roads, and so on). Labor is cheap but you have interest to include a vocational training module in any investment. However, workers have a good spirit and you can get a very motivated staff.

Nepal, Tibet, Burma, Cambodia, Togo, Mauritania, Ivory Coast, Chad: ***(red): Special situations and remnant civil wars. Ivory coast which represents 40% of the West African GDP is entering in an obscure ethnic war.

Colombia, Iraq, Algeria, Yemen **** (red): Fierce civil wars. Countries very dangerous for westerners.

4. Economic risk of project implementation

The economic risk is when there is a uncertainty about the conditions of project implementation in future. In geological-mining project it is caused by different factors such as deposit exploration level, costs of mine and concentrator construction, changes in mineral price, taxes as well as uncertainty concerning the demand and supply. Acquiring necessary information as well as the high quality and the current possible data is essential for risk minimizing and while making a decision. Taking into consideration that it bears a big costs, the data should be gathered until the cost of acquisition is equal with the benefit they offer. Elaboration of appropriate scenarios for the project development will enable to avoid
unnecessary expenditures and will be helpful while making decisions at every stage of the project. Risk factors have different weights in evaluation of total risk of planned investment project [9].

Characteristic of risk factors in geological-mining projects is presented in Table 3, below.

<table>
<thead>
<tr>
<th>Risk factor</th>
<th>Risk factor characteristic</th>
</tr>
</thead>
</table>
| **Geologic/Geographic** | - reserves quantity,  
|  - prospection stage | - reserves quality (useful elements, qualitative parameters),  
|  - exploration stage | - resources identified,  
|  - extraction stage | - deposit structure (mineral composition, rocks),  
|  | - deposit environment,  
|  | - geometry of strata,  
|  | - deposit depth,  
|  | - deposit model,  
|  | - reserves accessibility,  
|  | - displacements of strata,  
|  | - natural hazards,  
|  | - geographic attitude, above sea level location.  
| **Technical/Technological** | - physical and mechanical properties of rock mass,  
|  - surface mining | - opening out procedure,  
|  - underground mining | - deposit dissection system,  
|  - offshore mining | - technology and mining system,  
|  - oil mining | - water and gaseous hazards,  
|  | - machinery and equipment availability/operational reliability,  
|  | - rate and fluidity of extraction,  
|  | - extraction and processing (depletion and output).  
| **Environmental** | - topographic profile,  
|  - water | - water table,  
|  - atmospheric | - emissions,  
|  | - brine and acid drainage discharge,  
|  | - heavy metals content in soil and water,  
|  | - out-of-control waste storage,  
|  | - environmental regulations,  
|  | - hazard for unique species of biota.  

One of the methods of risk bonus evaluation is a scenario analysis. Scenarios are the projection of NPV describing variables. Usually they are analysed in three options: basic, optimistic, and pessimistic. To each scenario, the predicted probability is assigned. This is the basis for NPV calculation. Criterion of economic evaluation and the project risk as well is expected value of net present cash flow described by the formula:

$$E(\text{NPV}) = P_{\text{opt}} \cdot \text{NPV}_{\text{opt}} + P_{\text{baz}} \cdot \text{NPV}_{\text{baz}} + P_{\text{pes}} \cdot \text{NPV}_{\text{pes}}$$

where:

- $E(\text{NPV})$ - expected value of discounted cash balance from the period of project operation, PLN
- $\text{NPV}_{\text{opt}}$ - net present value at optimistic scenario of events, PLN
- $\text{NPV}_{\text{pes}}$ - net present value at pessimistic scenario of events, PLN
- $\text{NPV}_{\text{baz}}$ - net present value at basic scenario of events, PLN
- $P_{\text{opt}}$ - probability of optimistic scenario of variables,
- $P_{\text{pes}}$ - probability of pessimistic scenario of variables,
- $P_{\text{baz}}$ - probability of Basic scenario of variables.

Different methods are used to evaluate the risk and some of them are presented below.
4.1. Discount rate considering the risk bonus

Discount rate considering the risk bonus is the simplest method of risk assessment.

\[ \text{RADR} = \text{WACC} + \text{PR} \]  

(2)

where:

- \( \text{RADR} \) - discount rate with risk bonus
- \( \text{PR} \) - risk bonus
- \( \text{WACC} \) - average weighted capital cost

Risk bonus may be assumed arbitrary according to the table 4 [7]:

<table>
<thead>
<tr>
<th>Risk category</th>
<th>Investment type</th>
<th>Risk bonus %</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>reconstructed</td>
<td>0</td>
</tr>
<tr>
<td>II</td>
<td>modernized</td>
<td>1÷3</td>
</tr>
<tr>
<td>III</td>
<td>developmental:</td>
<td></td>
</tr>
<tr>
<td>III a</td>
<td>in present trade</td>
<td>3.2÷5</td>
</tr>
<tr>
<td>III b</td>
<td>in related trade</td>
<td>5.1÷8</td>
</tr>
<tr>
<td>III c</td>
<td>in other trade</td>
<td>over 8</td>
</tr>
</tbody>
</table>

Source: Rogowski W. 2004: Efficiency calculus of investing companies. Wydawnictwo Oficyna Ekonomiczna, Kraków

However, the standard is the following procedure:

1. Calculation of variation of net present value:

\[
\sigma_{NPV}^2 = \left[ \text{NPV}_{\text{opt}} - E(\text{NPV}) \right]^2 \cdot P_{\text{opt}} + \left[ \text{NPV}_{\text{pes}} - E(\text{NPV}) \right]^2 \cdot P_{\text{pes}} + \left[ \text{NPV}_{\text{baz}} - E(\text{NPV}) \right]^2 \cdot P_{\text{baz}}
\]

(3)

2. Calculation of standard deviation (absolute risk):

\[
\sigma_{NPV} = \sqrt{\sigma_{NPV}^2}
\]

(4)

3. Calculation of variation coefficient (unit risk):

\[
CV_{NPV} = \frac{\sigma_{NPV}}{E(\text{NPV})}
\]

(5)
In all normal distributions the density function is symmetric vs. average value of distribution. Expected value and standard deviation may by interpreter after the rule of 3σ, i.e.:

- there is 68.3% of chances that obtained values of criteria will be within the range: \( E(NPV) + \sigma(NPV) \); \( E(NPV) - \sigma(NPV) \),
- there is 95.5% of chances that obtained values of criteria will be within the range: \( E(NPV) + 2\sigma(NPV) \); \( E(NPV) - 2\sigma(NPV) \),
- there is 99.7% of chances that obtained values of criteria will be within the range: \( [E(NPV) + 3\sigma(NPV); E(NPV) - 3\sigma(NPV)] \).

Variation coefficient may be also used to evaluate the risk bonus. The highest coefficient the highest risk of certain investment project implementation. Basing on the practice, the value of risk bonus, depending on the level of variation coefficient at established interest rate, was proposed (table 5) [8].

<table>
<thead>
<tr>
<th>Variation coefficient from</th>
<th>Variation coefficient to</th>
<th>Risk bonus [%]</th>
<th>Rate of interest [%]</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.0</td>
<td>0.1</td>
<td>0</td>
<td>( r )</td>
</tr>
<tr>
<td>0.1</td>
<td>0.3</td>
<td>1</td>
<td>( r + 1 )</td>
</tr>
<tr>
<td>0.3</td>
<td>0.5</td>
<td>3</td>
<td>( r + 3 )</td>
</tr>
<tr>
<td>0.5</td>
<td>0.7</td>
<td>6</td>
<td>( r + 6 )</td>
</tr>
<tr>
<td>0.7</td>
<td>0.9</td>
<td>10</td>
<td>( r + 10 )</td>
</tr>
<tr>
<td>0.9</td>
<td>1.1</td>
<td>15</td>
<td>( r + 15 )</td>
</tr>
<tr>
<td>1.1</td>
<td>1.4</td>
<td>22</td>
<td>( r + 22 )</td>
</tr>
</tbody>
</table>


Then the variation coefficient for the investing company is high, it is reasonable to calculate \( E(NPV) \) once more taking into consideration the interest rate gross of risk bonus. If \( E(NPV) \geq 0 \), then the project is accepted for implementation. About the risk scale of the project attests the level of standard deviation \( 6_{\text{NPV}} \) and variation coefficient \( cv_{\text{NPV}} \).

### 4.2. Coefficient of certainty equivalent

Method of certainty equivalent (coefficient) is an alternative to the discount rate method. The difference is that in certainty coefficient method the cash flow (numerator) is corrected, while in the discount rate with risk method, the discount rate (denominator) is corrected.

Coefficient of certainty equivalent is defined as balance of cash flows certainly received \( (NCF_{\text{IRF}}) \), which has the same value (utility) for the decision-maker, than the expected value of uncertain balance of cash flows \( (NCF_{\text{IR}}) \).
This relationship may be expressed by the formula:

\[ NCF_{IRF} = CE_t \cdot NCF_{IR} \]  

(6)

where:

- \( NCF_{IRF} \) - balance of net cash flow free of risk, PLN/year
- \( NCF_{IR} \) - balance of cash flow burden with risk, PLN/year
- \( CE_t \) - coefficient of certainty equivalent

The certainty coefficient takes the value within the range from 0 to 1, while evaluating it using subjective, objective or based on discount rate with risk method.

In subjective method, the certainty coefficient is evaluated using expert mode what is presented in table 6 [7].

<table>
<thead>
<tr>
<th>If presence of NCF of given value is:</th>
<th>Than the value of coefficient of certainty equivalent is:</th>
</tr>
</thead>
<tbody>
<tr>
<td>absolutely impossible</td>
<td>0</td>
</tr>
<tr>
<td>extremely improbable</td>
<td>0.01÷0.1</td>
</tr>
<tr>
<td>very improbable</td>
<td>0.05÷0.2</td>
</tr>
<tr>
<td>almost improbable</td>
<td>0.1÷0.3</td>
</tr>
<tr>
<td>improbable</td>
<td>0.2÷0.4</td>
</tr>
<tr>
<td>possible after all</td>
<td>0.3÷0.5</td>
</tr>
<tr>
<td>quite possible</td>
<td>0.4÷0.6</td>
</tr>
<tr>
<td>very possible</td>
<td>0.5÷0.7</td>
</tr>
<tr>
<td>probable</td>
<td>0.6÷0.8</td>
</tr>
<tr>
<td>almost probable</td>
<td>0.7÷0.9</td>
</tr>
<tr>
<td>very probable</td>
<td>0.8÷0.95</td>
</tr>
<tr>
<td>extremely probable</td>
<td>0.9÷0.99</td>
</tr>
<tr>
<td>absolutely certain</td>
<td>1</td>
</tr>
</tbody>
</table>

Source: Rogowski W. 2004: Efficiency calculus of investing companies, Wydawnictwo Oficyna Ekonomiczna, Kraków

In the objective (statistic) method value of coefficient is determined basing on probability distribution of cash flows balance formulated using for instance the scenarios method. If the investor assumes the probability of Cash flow balance on the level of:

\[ 99.7\%, \text{ than } CE \text{ value is: } CE = \frac{E(NCF_{IR}) - 3\sigma_{NCF_{IR}}}{NCF_{IR}} \]
99.5%, than CE value is: \[ CE = \frac{E(NCF_R) - 2\sigma_{NCF_R}}{NCF_R} \]

68.3%, than CE value is: \[ CE = \frac{E(NCF_R) - \sigma_{NCF_R}}{NCF_R} \]

If in economic evaluation the NPV criterion is used, the NPV including coefficient of certainty is calculated from the formula:

\[ \text{NPV}_{CE} = \sum_{t=0}^{T} \frac{NCF_R \cdot CE}{(1 + WACC)^t} \] (7)

While calculating the coefficient of certainty equivalent using discount rate with risk two equations are proposed:

\[ PV_{NCF_R} = \frac{NCF_R}{(1 + RADR)} \] (8)

\[ PV_{NCF_{RF}} = \frac{CE \cdot NCF_R}{(1 + WACC)} \] (9)

Since:

\[ PV_{NCF_R} = PV_{NCF_{RF}} \] (10)

then:

\[ \frac{NCF_R}{(1 + RADR)} = \frac{CE \cdot NCF_R}{(1 + WACC)} \] (11)

from where:

\[ (1 + WACC) = CE(1 + RADR) \] (12)

from where:

\[ CE = \frac{1 + WACC}{1 + RADR} \] (13)
4.3. Boundary period of investment costs return

The essence of this method is that NPV is calculated at arbitrary assumed boundary period of return. When assuming such period the decision-maker may take into consideration:

− historical aspect, i.e. experience from previous projects,
− contracts with buyers,
− technological progress in the branch where project is implemented,
− market studies.

Condition of project approval is meeting the following inequality:

\[ \sum_{t=0}^{t_{gr}} \frac{NCF_t}{(1 + WACC)^t} - IC_{akt} \geq 0 \]  \hspace{1cm} (14)

where:

\( NPV_{gr} \) - present value of net cash flows from the boundary period, PLN
\( t_{gr} \) - boundary return period, years
\( NCF_t \) - balance of net cash flows, PLN/year

If then it is assumed the investment cost are distributed equally – in-kind expenses in \( T_b \) period and a pre-investment expenses in \( T_p \) period – then their future (updated for zero year) value is calculated from the formula:

\[ IC_{akt} = IC \frac{(1 + WACC)^{T_b} - 1}{WACC} + IP \frac{(1 + WACC)^{T_p}}{WACC} (1 + WACC)^{T_b} \]  \hspace{1cm} (15)

where:

\( T_p \) - period of pre-investment expenses , years
\( T_b \) - period of project construction , years
\( IC \) - investment costs, PLN
\( IC_{akt} \) - investment cost updated for zero moment

In practice the formula (15) is not very useful with regard of mine construction projects because:

− investment costs are distributed on several years (construction cycle of mine),
− mine reaches its full production capacity progressively,
− assumption, that after boundary period of return, the positive balance of cash flow is reached, may be incorrect.
5. Market project value at various stages of development

Comparing acquisitions reserves at various stages of development, the additional costs involved in upgrading deposits from the scoping stage to the mine production. The producing mines already include the capital costs invested in the mine construction while earlier stage projects do not. The copper in reserves acquired reflects the development stage of the project and the geographical location [9]. The value of copper in reserves for different projects transactions shows table 7.

<table>
<thead>
<tr>
<th>Development stage</th>
<th>Value of copper (US$/lb)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prospection</td>
<td>0.002 – 0.008</td>
</tr>
<tr>
<td>Reserves development</td>
<td>0.008 – 0.050</td>
</tr>
<tr>
<td>Feasibility</td>
<td>0.050 – 0.130</td>
</tr>
<tr>
<td>Preproduction</td>
<td>0.130 – 0.350</td>
</tr>
<tr>
<td>Production</td>
<td>0.350 – 0.750</td>
</tr>
</tbody>
</table>

Source: Formulated basing on MEG

Knowing the amount of reserves, i.e. basic and accompanying metals content, we can calculate the approximate value of the project at the current state of development. Unit value of metal in the deposit ($/lb) we may set up basing on already closed buy/sell transactions for similar projects. In the case of one metal it is enough to multiply two values, for the accompanying metals, however, it is necessary to use special calculating formula.

6. Summary

Each kind of large scale business, needs the strategic decisions, which bear a certain level of risk. It concerns especially the mining companies which activity requires complementing or enlarging the reserves on the level securing the production needs. The simplest method of increasing the reserves is acquisition of existing mine or the deposit with already proven reserves. This procedure, however less risky, requires great financial means, already at the initial stage, what may be a serious problem for the company. More risky but timely, with regard of costs, distributed solution is exploration of already known deposit area or new perspective area, located in the vicinity of prospected deposits, within the metal bearing formation or within new zone with interesting mineralization potential (metalogenic province). Exploration works are carried out in stages. Initial stage includes detailed studies of available documents or information. If the result confirm the possibilities of interesting mineralization ore deposit occurrence, the program, time schedule and budget of further activities should be made. The task of initial stage is specification of possible, exact prospecting activities. Defined targets help to intensify efforts in selected, the most interesting
areas. Discovery of deposit changes totally the nature of Works from prospecting to exploration, which is more detailed. At this stage the geologic information changes from qualitative to quantitative one, and at the same time the technical and economical studies start. Then the feasibility study is made which is the summary of deposit prospecting and detailed review, verification and confirmation of information obtained. The task of this study is to confirm the technical and economic possibilities, including geological, environmental, metallurgical, social and market aspects, necessary for making a decision with regard of the project completion.

Mining project is a high risk venture and its level depends on the stage of advancement and its location (country, region). Country risk refers to the possibility that changes in the business environment adversely affects operating profits or the value of assets in a specific country. The country rating is based on seven risk levels, from A1 to D, in the order of increasing risk.

References


Geopolityczna i ekonomiczna ocena ryzyka w światowych projektach górniczych

Słowa kluczowe: inwestycje górnicze, oszacowanie ryzyka, ranking krajów, ocena ekonomiczna

Studium techniczno-ekonomiczne projektów górniczych charakteryzuje się na ogół wysokim ryzykiem, które zależy od etapu zawansowania projektu jak i miejsca jego lokalizacji. W ocenach początkowej fazy realizacji pracy szczególną uwagę należy zwracać na otoczenie polityczne i ekonomiczne kraju bądź regionu w którym zlokalizowany będzie przyszły projekt. Światowi analitycy są zgodni, że stopień ryzyka projektu jest największy w pierwszym etapie jego realizacji i maleje wraz z zaawansowaniem, czyli pozyskiwaniem większej ilości danych, zwiększeniem dokładności rozpoznania, powiększeniem bazy zasobowej, uzyskaniu metali oraz określeniem niezbędnych nakładów inwestycyjnych. Największy stopień ryzyka geopolitycznego występuje w krajach o niestabilnej sytuacji społeczno-politycznej i ekonomicznej, a także tam gdzie spodziewać się można wysokiego stopnia korupcji. Liczne instytucje finansowe oraz banki opracowują własne analizy ryzyka geopolitycznego dla wszystkich ważniejszych krajów zasobnych w surowce. Najważniejszymi elementami podlegającymi ocenie są transfer środków finansowych, bezpieczeństwo inwestycji, możliwość wywozu pozyskanych dóbr i eksport z danego kraju. Stopień ryzyka określany jest od najniższego (A1) do najwyższego (D).