Mining project evaluation process for investment decisions: Modeling and assessment of project risk - part two

by H.M. Park and M.G. Nelson

Risk is a major factor in all mining activities, arising from many internal and external variables. The authors' research has resulted in a systematic method for the quantification of risk in mining projects (Park, 2012). This is the second part of a three-part series. The first part was published in the October 2013 issue of *Minining Engineering* magazine and can be found here at www.me.smenet.org.

This paper discusses methods of assessing the overall risk associated with those variables, and presents a statistical model based on a survey of 31 experts. The third paper, to be publised at www.me.smenet.org on Oct. 14, presents an evaluation of the statistical model, using data from previous mining investment decisions in which the authors have been involved.

Table 1

The initial risk assessment criteria.

Major categories	Minor categories
Partner risks	Domestic partners Foreign partners
Technical risks	Project stages Geological risks Operating risks Production scale Reliability of data
Marketability	Standard of products
Investment climate	Political risks Permitting Infrastructure
Economic values	Internal rate of return Net present value Payback period

Methods

A survey of 31 mining experts was taken to determine what current practice is being used when evaluating mineral investments. Specifically, this survey attempted to determine which risk factors are being employed and how they are weighted in the analysis of mining project risk. The survey also asked respondents to report the minimum rate of return used by their organizations in rating prospective investments.

The survey was performed by email and telephone. The respondents were current or retired employees of mining companies, mining consultants, commodity trading companies and end users of minerals that also participate in mining projects.

Individuals from the United States, the Republic of Korea, Canada, Australia, Japan, the Republic of South Africa, Chile and the United Kingdom responded to the survey. Eleven were from Asia, one from Europe, 11 from the United States, two from Africa and six from Oceania. The companies represented ranged in size from almost no annual revenue to $16 billion in annual sales as of 2010. The survey respondents represent a variety of companies related to the mining industry. Several major mining companies, senior mining companies, consulting firms, educational institutes and trading companies were surveyed. The titles of the respondents included vice president, former vice president, chief executive officer, chief operating officer, managing director, director, senior manager, manager, mine head, mine manager, former mine manger, former senior manager, professor and consultant.

In the survey, the experts were asked to consider the risk matrix described in Table 1 of the authors' previous paper (reproduced here), then to suggest the weighting factors for the major and minor risk factors, as percentages, based on respective their experience and opinions. The results for all risk categories are summarized in Table 7.

The following sections consider each major risk factor, showing how the experts rated the risks. For each major risk, the minimum, average

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Table 2

The partner risk matrix.

Major categories assessment	Investment assessment proportion	Minor categories	Weight	Grade and description	
Partner risks	8% Min. 5% Max 30 %	Domestic partners	34.5 Min 10 Max 60	A	Financially strong
				B	Financially weak
		Foreign partners	65.5 Min 40 Max 90	A	Listed company, senior company or with operating cash flow
				B	Private company, junior company or in poor finances
				C	No corporate entity

and maximum investment assessment proportions indicated by the experts are shown. This category represents the proportion of the overall project risk that will be attributed to a given risk factor. Similarly, the table for each risk factor shows the minimum, average and maximum weighting factors for the minor categories associated with each major risk factor, as indicated by the experts.

Results and discussion

Partner risk. Table 2 shows the average proportion for partner risks is 8 percent and the range of partner risk is from 5-30 percent. The weight assigned to domestic partner risk is 34.5, with a range of 10 to 60; for foreign partner risk it is 65.5, with a range of 40 to 90. For domestic partners, the major and perhaps the only criterion is the partner's financial condition. For foreign partners, financial condition should be considered in combination with the level of corporate and legal organization. In particular, the capabilities of the management team, the partner's financial condition, and its ability of secure funding for the project in question are essential considerations.

Table 3

The technical risk matrix.

Major categories assessment	Investment assessment proportion	Minor categories	Weight	Grade and description	
Technical risks	43.2% Min. 25% Max 50 %	Project execution risk	17.3 Min 5 Max 20	A	Developing or operating
				B	Engineering study (Scoping Study, Pre F/S, F/S)
				C	Exploration
		Geological risk	38.6 Min 20 Max 50	A	Measured and indicated resources, or proven and probable reserves
				B	Inferred resources
				C	No source statement
		Operating risk	20.7 Min 10 Max 40	A	Standard extraction
				C	New technology proposed
		Production scale risk	13 Min 5 Max 30	A	Coal - 2Mt/a; copper - 100 kt/a
				B	Coal - 1-2 Mt/a; copper - 50-100 kt/a
				C	Coal - less than 1 Mt/a; copper less than 50 kt/a
		Data reliability	10.5 Min 0 Max 20	A	International standard applied (JORC, NI 43-101
				B	Domestic standard
				C	No standard

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Table 4

The partner risk matrix.

Major categories assessment	Investment assessment proportion	Minor categories	Weight	Grade and description	
Marketability	8.6% Min. 5% Max 25 %	Product standard	100	A	Sutiable for investors market
				B	Suitable for foreign market
				C	Market uncertainty

These considerations are often made difficult by the fact that the bigger companies want to operate projects by themselves, while the smaller (and often less qualified) companies are interested in working with a partner, to decrease mining risks.

Technical risks. Technical risks are the most critical factor in new investors' investment analysis. Table 3 shows that the average assessment proportion assigned by the experts to technical risks is 43.2 percent. Most experts considered technical risks as the most important of the major risks.

The weighted average of project execution risk is 17.3 with a range of 5 to 20. In project execution, the initial stage is always more risky but it also carries a lower cost. Thus there is a range of competing factors such as cost, approval risk, construction risk and geological uncertainty. In the case of geological risk, the weighted average is 38.6, varying from 20 to 60. The experts considered geological risk the most important factor among the technical risks. Many of the experts mentioned the importance of using definitions of resources and reserves from international standards such as those previously cited.

Experts from some medium- and small-sized mining companies indicated that their companies require a minimum grade when they determine to invest or develop copper projects. For example, in sulfide deposits, copper grade should be greater than 0.5 percent for opencut mining and greater than 1 percent for underground mining. In oxide deposits, copper grade should be greater than 0.3 percent for opencut mining. The average minimum size for a copper reserve to justify investment is 9.1 Mt (10 million st) of contained copper. In contrast, the bigger companies are willing to invest in prospects with lower grades, because they can finance bigger operations and achieve economies of scale that result in lower unit costs. Thus, these companies can show more resources and reserves, even though many of their projects have lower grades.

For operating risk, the weighted average for investment assessment is 20.7, varying from 10 to 40. Operating risk is the second most important among the technical risks. The quality of the feasibility study and the execution planning for a project have a big impact on the ultimate success of an operation. These require a good understanding of geology, ore quality and product

Table 5

The investment climate matrix.

Major categories assessment	Investment assessment proportion	Minor categories	Weight	Grade and description	
Investment climate	18.2% Min. 10% Max 30 %	County risks	35.2 Min 10 Max 50	A	Standard and Poor's A, Fitch A, Fraser top 15
				B	Standard and Poor's B, Fitch B, Fraser top 30
				C	Less than above
		Permitting	31.1 Min 20 Max 50	A	EIS and mining permit approved, cleared land status
				B	EIS approved in process
				C	None
		Infrastructure	33.6 Min 20 Max 60	A	Secured transportation, power, water labor
				B	Available transportation, power, water, labor
				C	Two elements available

Table 6

The investment climate matrix.

Major categories assessment	Investment assessment proportion	Minor categories	Weight	Grade and description	
Economic values	22% Min. 10% Max 40 %	IRR	23 Min 15 Max 40	A	Greater than 19%
				B	Greater than 15%
				C	Less than 10%
		NPV	57.7 Min 40 Max 70	A	Positive NPR
				C	Negative NPR
		PBP	19.3 Min 10 Max 20	A	Less than 6 years
				B	Less than 12 years
				C	Greater than 12 years

markets, as well as proper equipment selection, good mine planning and production management and adequate process testing leading to design of an appropriate processing facility. The weighted average of the production scale risk is 13, with a range of 5 to 30. The production size required for investment depends on company size and project specifics, and the opinions of the respondents varied considerably. Experts from some coal mining companies indicated that a good project should be 4.5 Mt/a (5 million stpy) to more than 45 Mt/a (50 million stpy) of coal. On the other hand, representatives copper companies expected annual production from 91 kt (100,000 st) to 1.6 Mt (1.8 million st) of copper. The production scales shown are relatively small. The determination of appropriate production size must be supported by robust financial analysis, thorough tradeoff studies, and excellent engineering and technical assessments.

In fact, all risk factors in the technical risks category depend on the reliability of data.

The accuracy of data affects all the other factors in this category. The weighted average assigned by the experts to data reliability is 10.5, with a range of 0 to 20. Major mining companies may be less concerned about data reliability because they often have their own properties that are ready to develop with expert, in-house geologists and engineers.

Marketability. Table 4 shows the experts' weighting of marketability risk. The weighted average investment proportion is 8.6 percent, with a range of 5-25 percent. Most trading companies put great value on marketability, because the profit earned in trading is their main source of revenue. Markets for new or dormant mining projects are usually more difficult to develop than operating projects. Marketability may also be affected by the location of project, or if the product is of low quality, compared to competitors.

Investment climate. Table 5 shows that investment assessment proportion for investment climate risk was ranked by the experts at 18.2 percent, over a range of 10-30 percent. This ranking made investment risk is the third most important factor in assessing investment risk. For the political risks associated with investment climate, the weighted average is 35.2, and varied from 10 to 50.

The matrix sent to experts for evaluation included some suggested guidelines for rating political risk, based on rating provided by financial services companies such as the Fraser Institute, Standard & Poor's and Fitch Ratings. Some companies are hesitant to invest in countries that are considered extremely risky, such as some African countries. Recent investments by some of the major mining companies suggest that they are, at least in some instances, willing to bear this risk.

The experts were asked to consider permitting status on the basis of the degree of completion of applicable environmental impact statements. While standards certainly vary among countries, this is considered a reasonable guideline. In case of permitting, the weighted average is 31.1, varying over a range of 20 to 50.

Finally, those surveyed were asked to consider specific and important elements of the required infrastructure. The weighted average is 33.6 with a range from 20 to 60.

Economic values. Detailed financial analysis must be supported by a range of sophisticated financial risk tools. Table 6 shows the experts' weightings of factors in the economic values matrix. The weighted average of economic values is 22 percent, the second highest factor among the

Table 7

Comparison of construction and pumping equipment costs, for high-efficiency ESPs versus conventional ESPs.

Major	Proportion	Minor	Weight	Grade and description		Applied %
Partner risks	8%	Domestic partners	34.5	A	Financially strong	100 %
				B	Financially weak	50 %
		Foreign partners	65.5	A	Listed company	100 %
				B	Private company	50%
				C	No corporate entity	0 %
Technical risks	43.2%	Project execution	17.3	A	Developing or operating	100%
				B	Engineering study	50%
				C	Exploration	25%
		Geological risks	38.6	A	Measured & indicated resources or reserves	100%
				B	Inferred resources	50%
				C	No source statement	0%
		Operating risk	20.7	A	Standard extraction	100 %
				C	New technology proposed	25%
		Production scale risk		A	Coal 2 Mt/a, Copper 100 kt/a	100 %
				B	Median production	50%
				C	Coal - less than 1 Mt/a, copper less than 50 kt/a	0%
		Data reliability	10.5	A	International standard applied	100%
				B	Domestic standard	40%
				C	No standard	0%
Marketability	8.6%	Product standard	100	A	Suitable for investors' market	100%
				B	Suitable for foreign market	50%
				C	Market uncertainty	0%
Investment climate risks	18.2%	Country risks	35.2	A	S and P, Fitch A, Fraser 15	100%
				B	S and P, Fitch A, Fraser 30	50%
				C	Less than above	0%
		Permitting	31.1	A	EIS and mining permit	100%
				B	EIS approval in process	50%
				C	None	0%
		Infrastructure	33.6	A	Secured infrastructure	100%
				B	Available infrastructure	50%
				C	Limited infrastructure	20%
Economic values	22%	IRR	23.0	A	Greater than 19%	100%
				B	Greater than 15%	75%
				C	Less than 10%	25%
		NPV	57.7	A	Positive NPV	100%
				C	Negative NPV	0%
		PBP	19.3	A	Less than 6 years	100%
				B	Less than 12 years	50%
				C	Greater than 12 years	0%

major risks. The range for economic values is from 10-40 percent. All companies surveyed indicated that they have their own required internal rate of return (IRR). The average weight for IRR is 23, and values range from 15 to 40. The respondents indicated that, in most cases, their companies preferred projects where the IRR is 10-20 percent, depending on project status and location.

In case of net present value (NPV), the weighted average is 57.7, with a range of 40 to 70, the highest ranked factor among the economic factors. According to the survey results, NPV generally plays a major role in decision making by larger firms. The responses in the survey regarding the payback period varied considerably. The weighted average is 19.3, varying from 10 to 20. The survey indicates that the payback period is relatively less important than other factors but all companies, especially the smaller ones, prefer the payback period to be short. Most companies hope to see less than 6 to 12 years in the payback period.

Summary and discussion

The improved risk assessment criteria, based on the opinions of the 31 experts surveyed, are shown in Table 7. The weight for each minor factor is determined from the grade assigned to that factor. The applied percentages for each grade were based on the authors' experience, with some slight modifications as suggested experts' experience.

Of course, the risk assessment criteria should be applied differently for each company, depending on the size of the organization, the magnitude of the mining projects where the company is involved, and the company's internal investment philosophy. Smaller companies may take on more risk because there may be fewer projects available to them, compared to international mining majors. Also major firms may have greater resources, and may be more willing than other companies to take risks. They may be marginally less risk averse than their smaller competitors, depending on their assessment of the host country and other factors.

In considering overall project risk for an investor, it is important to recognize the objective of the investor in making the investment. In some cases this might be to generate a clear financial return. In other cases it might be to secure access to the resource for long-term resource security. There may be several other reasons for investment. Risk must be considered against the investment objectives. Thus we need to recognize that if a major mineral deposit exists, even in a high-risk country, investment may be made.

Conclusions

Based on a survey of 31 experts, the criteria were revised and improved. It was concluded that the logic and weightings of the matrix model are robust and accurately reflect the realities of the various elements that come into play in an investment analysis. The analysis showed that the most important areas relating to investment risk are, in order of decreasing importance:

1. The nature of the resources – resource, grade, access, and development potential
2. Economic values – positive NPV
3. Marketability – suitable for newcomer
4. Operating risk
5. Country risk and environmental constraints related permitting

The authors suggest that, although a new investor may be late coming into the market for mining properties, that investor will be able to assess its risks and narrow the gap with larger mining companies using the results model presented here. By using this model, an investor will be able to complete those reviews more quickly and more effectively, making it possible to review more projects, or to review the same number of projects in great detail. This should lead a mining newcomer to better investment decisions.

It is suggested that the use of this method will facilitate more rational and consistent investment decisions, which will allow potential investors to develop more precise business plans for developing overseas mineral resources. The proposed model and the associated risk assessment criteria will lead to reduction of the risks associated with mineral investments by facilitating systematic research and analysis of the technical and economic feasibility of mining projects. ■

Read part three of this series on Oct. 14 exclusively at www.me.smenet.org