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The Importance of the Social License to Operate at the Investment and Operations Stage of Coal Mining Projects: Application using a Decision Support System

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ABSTRACT

The Social License to Operate (SLO) and the Value Chain business model are basic elements that need to be considered both at the planning and operation stages of mining operations and in particular in coal mining projects. If a coal mining enterprise loses its SLO, it may face risks in operations, which may lead to value chain risks. One of the causes of enterprise failure as related to coal mining operations is the inability to reliably assess/manage risk holistically and the inability to understand that lack of SLO is a critical risk. Although financial risks are typically assessed for mining projects, lack of SLO risk should also be taken into account starting as early as the bankable feasibility study.

Furthermore, as it is difficult to establish a proactive decision-making policy for SLO risk in coal mining operations, the Operational Risk Management (ORM) methodology is probably a good tool to apply towards that goal. For this reason, a Mining Operational Risk Management Model (MORMM) was developed to incorporate risk probabilities and risk severities evaluated by experts. The final risk assessment is coded using Risk Assessment Codes (RACs). A hypothetical scenario was developed utilizing the MORMM model in order to illustrate how risks can be managed during the SLO granting process. This scenario describes a hypothetical coal mining project evaluated by virtual risk evaluators under specific hazard categories. Risk evaluation involves the assessment of risk probability and risk severity. Through this scenario this paper presents ways: (i) to establish a baseline ORM process that will be applicable to any coal mining operation environment, and (ii) to provide a theoretical example to demonstrate how the method can be applied to coal mining operations. The resulting RACs can provide critical information to decision makers regarding the rejection, acceptance or re-engineering of the mining business plan.

1. Introduction

Four primary general types of business risk have been documented: strategic, market, credit and operational risks (Dorogovs, 2013). Risk is intrinsic in all human assignments, activities, tasks and businesses no matter how big or small they are, no matter what sector they belong to. Risk is involved in any individual activity no matter how repetitive. The most common cause of business enterprise failures is human error, explicitly, the incapacity to reliably manage corporate risk holistically.

Risk in mining business enterprises is rising (World Risk, 2019). Entrepreneurs are familiar with the term “Risk Management” (RM) mostly as a financial management tool which is usually associated with the monitoring of specific financial indicators or cash flows. Business executives are responsible for managing corporate risk in all tasks, while leaders at all levels are responsible for ensuring that proper procedures are in place and that appropriate resources are available for their employees to perform assigned business tasks. The importance of corporate operational risk attracted international attention 25 years ago. The management of operational risk has become a practical concern for many service and manufacturing firms (Lewis, 2003). Risks must be managed throughout the entire life cycle of a project/investment, starting with the planning phase, when risks must be identified and analyzed (Zwikael and Sadeh, 2007). Risk taking by banks has tremendous effects on economic welfare, as demonstrated by the recent
financial emergence of globalization reflected the inevitability for comprehensive financial sustainability; since then, financial stability is still considering a global public good (Moshirian, 2002). The banking crises, which have occurred both in transition economies and developing countries in the last 15 years, have strengthened conviction about the importance of a stable and well-regulated financial system. For that reason, increased attention has been given to ensuring financial system constancy and early warning systems have been proposed (Hamdaoui, 2016).

The Social License to Operate and the Value Chain business model are basic elements that need to be considered both at the planning and operation stages of mining operations and in particular in coal mining projects. The term Social License to Operate (SLO) was coined by a Canadian mining executive during the 1990’s (Prno, 2013) and since then it has become an important factor when assessing the sustainability of mining projects. Although SLO was initially applied to mining projects, currently SLO applies to the social acceptance of any project (e.g., pipeline installation, natural gas, etc.). In the context of this paper, SLO is used in reference to the social acceptance of coal mining projects. A project that moves forward without a SLO is currently considered very risky/uncertain. These risks may be associated with project delays and/or cancellations due to social turmoil, vandalisms, or increased operational costs, (Kamenopoulos and Tsoutsos, 2015).

A value chain is defined as a set of activities that a company performs in order to deliver a product or service to the market (Porter, 1985). According to the abovementioned definition of value chain, mining production is considered a primary activity of the value chain associated with a mining project (Fig. 1). As a result, value chains can act as decision support tools to enhance the competitiveness of a mining venture and, during downturns of the industry, to ensure its sustainability or even survival.

If a mining enterprise loses its SLO, it may face risks in operations, which may lead to value chain risks. Fig. 2 shows how granting a SLO plays an integral role in ensuring a low risk value chain.

It is difficult to establish a proactive decision making policy and a roadmap for corporate risk management in order to ratify SLO to mining operations.

There is no general agreement on the most suitable definition of risk for corporate enterprises (Dorogovs et al, 2013). For the purposes of this paper the following definitions are considered with regard to the mining sector and more specifically to the coal mining sector. The coal mining sector encompasses all coal mining operations, both open cut and underground which operate either as stand-alone extraction units or they are tied-in with specific thermal power plants or other coal consumers.

**Risk** is defined as the measure of the probability and severity of business adverse effects (Lowrance, 1976). **Hazard** is defined as any dangerous condition that can cause an interruption or interference with the expected orderly progress of a coal mining activity (DiBerardinis, 1999). Common business hazards, especially applicable to large scale (coal) mining projects include: natural hazards (earthquakes, floods, hurricanes, wild fires, etc.), financial hazards (leverage hazards, profitability hazards, liquidity hazards, credit hazards, etc.), societal hazards (demonstrations, riots, increased number of occupational mishaps, local-community’s dissatisfaction due to quality-of-life changes, etc.), technological and man-made hazards (misuse and or fraud, computer viruses, system failures, hacking, industrial espionage, spills of harmful waste or other materials, explosions, gas leaks, etc., extortion, strikes, kidnappings, vandalisms, violence among workers etc.), and (geo)political hazards (political instability, government change, corruption, violence, etc.) (Devlins, 2007). A hazard source is a location or condition that can give rise to a hazard (Queensland Government, 2020). Extending this definition to encompass all possible conditions, hazard sources can apply to all natural, financial, societal, technological / man-made or political modules that may cause damage to a mining enterprise.

**Mishap** refers to any unplanned event or series of events that result in death, injury, occupational illness, or damage to or loss of equipment or property, or damage to the environment (Ericson, 2005). This definition can be extended to include any natural, financial, societal, technological / man-made or political event that arises as a result of a hazard source. In a broader sense a mishap can interrupt or interfere with coal mining operations in a much broader sense. A good example is the Covid-19 pandemic, where coal mining operations may be directly affected by decreasing demand to disruptions in consumption (Mining, 2020). **Operational risk** is the risk arising from the operational activities when conducting mining coal (Mitra et al., 2015). Hahn and Kuhn (2012) defined operational risk as the result from the uncertainty of future events in the ordinary course of business. This definition includes legal risk, but excludes strategic and reputational risk. Hence, Operational Risk Management (ORM) is the process of dealing with risk associated with any mining operations, handled at the corporate level. This includes risk assessment, risk decision making, and implementation of effective risk controls (Kamenopoulos and Tsoutsos, 2015).

Often when a mining operation fails to gain an SLO it is because some stakeholders or communities of interest believe that the distribution of risks and benefits is unfair, i.e., they are being asked to accept risks to health, the environment or the economy without receiving commensurate benefits. Mining stakeholders fail to address both inbound risk (to the company) and outbound risk (to society and stakeholders). The world is under continuous change and compromising between different stakeholders is the norm. The outcome of this continuous negotiation between mining companies and local societies should ideally result in a “win-win” situation. The approach of this paper is to discuss gaining of SLO under the prism of risk assessment of both inbound and outbound risks.

The remainder of the paper is organized as follows: the research background is presented in Section 2; the methodology, societal and stakeholder hazards are presented in Section 3; the evaluated hypothetical scenario and discussion are presented in Section 4; the conclusions are presented in Section 5.

2. Research background

The research background on SLO and coal mining projects is very limited. Most of the international studies are focusing on the environmental or health impacts of coal mining in different regions (Hasanuzzaman et al., 2018; Dai et al., 2014; Adibee et al. 2013; Vizayakumar and Mohapatra, 1989; Weng et al., 2012; Alekseenko et al., 2018; Phillips, 2012; Espitia-Perez et al., 2016; Hota and Behera, 2015; Caballero-Gallardo and Olivero-Verbel, 2016; CDC, 2011).

Fig. 1. The interconnection between Social License to Operate and value chain in coal mining operations.
Kolovos (2013) examined the lignite deposits of the Florina area, Greece, and commented upon the consequences on mine production and social acceptance. Kolovos found that in areas where surface mining has been active for many years and the residents are quite familiar with common mining practices, a surface mining project can still not only be accepted, but welcomed by the local community. The mining project must be carefully planned and communicated to the local communities. A clear message should be transmitted, that the project acknowledges the problems of the society and addresses them.

Kopacz et al. (2017) developed an integrated model and assessed the level of sustainable development of hard coal mining industry in Poland. The analyses were performed using multi-criteria decision-making method (AHP), Monte Carlo simulation, bootstrap technique, empirical copula, and frequency distributions. In total, 24 criteria were included: economic, environmental, and social aspects of the problem were analyzed. The obtained results have shown limited improvement of sustainable development of hard coal mining industry in Poland in the analyzed period (an upward trend in the period 2007-2013 and a decline in following years). The highest increase of the indicator in the 2007-2016 period was recorded for the economic dimension (10.4%), which is mainly a consequence of increasing production of coking coal and revenues. At the same time, total bituminous coal production in Poland was reduced by 19.5%. In the environmental and social dimensions, the indicators show a downward trend (falling by a total of 4.0% and 5.5% by 2016).

Luke (2017) examined the social resistance to coal seam gas project in the Northern Rivers region of Eastern Australia and proposed a new model of SLO. Luke utilized reported empirical data obtained from an election survey and a previous comparative social case study for the specific geographical area. In accordance to Luke’s findings, a social license does not hinge on a decision made by an expert or even the leader of a stakeholder organization; it is a community process of social positioning carried out by (and between) each citizen, based on complex factors relating to values, knowledge, risk perception and social connectivity.

Wozniak and Jurczyk (2020) presented an analysis of the issue of corporate social responsibility (CSR) in the context of the planned launching of the Polish open pit lignite mine in the area of Zloczew municipality on the basis of the research method of surveying, implemented among the residents of this territory. The analysis had the form of an anonymous survey and was carried out in September of 2018 in the area of the town Zloczew. The survey respondents comprised of town inhabitants who wished to participate in the research. The survey questionnaire consisted of 5 questions. The group of survey participants comprised 65 persons; however, due to incorrect filling out of part of the questionnaires (non-filling out of open-ended questions or marking a larger than required number of answers) the final analysis was performed on 40 questionnaires. The data obtained from the analysis of sheets served as the basis for drawing conclusions regarding the assumed topic. The majority of the respondents (57%) were aware of the possible benefits for the municipality which were related to the planned launching of an open pit mine. The idea of compensating for the use of areas belonging to the municipality, used for economic activity, was considered by the majority of the respondents as a useful one (75%).

SLO practices requires all stakeholders to assess their own potential contributions towards a broadly acceptable and mutually beneficial solution. This principle was applied in Appalachian coal mining operations (Cook et al., 2015). More specifically, the underlying factors of inadequately treated wastewater discharges which not only represent a potential human health hazard, but also contribute to the relatively high incidence of bacterial impairments in surface waters, were surveyed in the Appalachian region. The central Appalachian region accounts for the majority of the fossil energy production in greater Appalachia; for that reason, the central Appalachian region was for many years at the center of several debates on related issues of environmental and social justice. A later study in the same coal rich area revealed potential health issues related to dust inhalation by the coal miners (Reynolds et al., 2018). However, in many cases of the latest study, miners refused to be screened for different health conditions. Recent literature does not explain why miners refused to be screened; yet, it was well known since at least 1973 that many afflicted employees were afraid to tell their employers they had health problems (i.e., arthritis) for fear of losing their jobs (Stevens, 1973). As a result, the employers were facing the question of how to achieve the best working situation for an arthritic employee and at the same time protect their companies from huge costs in sickness and disability benefits. In addition, employee’s fears of medical screening may be related to employers’ economic pressures; one of the roles served by medical screening is keeping costly, high-risk workers out of the work force; medical screening could also be related to workplace social pressure and a socially-driven response (Rothstein,

Fig. 2. Integration of SLO into coal mining Value Chain through Operational Risk Management.
In a similar manner, it could be postulated that coal miners are afraid that they will have to quit their jobs if health issues are discovered during medical screening. This could definitely be an indirect endorsement of coal mining operations in certain regions.

On 8 February 2019, the Land and Environment Court of New South Wales (Australia) refused the application for the Rocky Hill Coal Project. In accordance with the judge’s decision the mine would have significant adverse impacts on the visual amenity and rural and scenic character of the valley, significant adverse social impacts on the community and particular demographic groups in the area, and significant impacts on the existing, approved and likely preferred uses of land in the vicinity of the mine. In addition, the construction and operation of the mine, and the transportation and combustion of the coal from the mine, would result in the emission of greenhouse gases, which would contribute to climate change. In accordance to the court’s decision, these are direct and indirect impacts of the mine. The costs of this open cut coal mine, exploiting the coal resource at this location in a scenic valley close to town, exceed the benefits of the mine, which are primarily economic and social (New South Wales Government, 2019).

It is interesting to note, that due to a combination of factors and strong economic drivers, coal mining projects in many parts of the world had always enjoyed a SLO without many issues. Therefore, social acceptance was not considered a risk at the feasibility stage. Bankable feasibility studies looked only at the technical aspects of coal mining operations, including but not limited to the mining method, haulage considerations, potential markets, etc. Given the recent decision of the Land and Environment Court of New South Wales it is important to address social acceptance even at the initial stages and before a lot of time and effort is spent on developing the technical aspects of a potential coal mining operation.

3. Methodology

3.1. Risk assessment

The lack of a SLO can be an inherent risk to coal mining operations (the process was presented in Fig. 2). Thus, it is imperative to apply a risk management method to assess and eliminate or mitigate these risks, such as the Operational Risk Management methodology. In order to illustrate how coal mining operational risks can be assessed using an ORM system a hypothetical scenario was constructed.

This scenario describes a conceptual coal mining project evaluated by the same imaginary corporate risk evaluators/experts under specific illustrative conditions. Risk evaluation involves the assessment of corporate risk probability and risk severity utilizing the ORM method. The scope of this paper is: (i) to establish a baseline holistic ORM process that will be applicable (as a risk management technique) in any coal mining enterprise environment, and (ii) to provide a hypothetical paradigm as the demonstration of how the ORM method may be applicable into the risk management of coal mining enterprises.

The four principles of the ORM method are (Kamenopoulos and Tsoutsos, 2015):

(a) Accept risk when benefits outweigh the cost;
(b) Accept no unnecessary risk;
(c) Anticipate and manage risk by planning;
(d) Make risk decisions at the right level.

The advantages of the ORM when compared to Risk Management are the following:

(a) The ORM as a tool addresses the risk holistically and not unilaterally.
(b) The ORM projects the big picture: it refers holistically to the broader concept of business risks.
(c) The ORM addresses the two dimensions of risk: probability and severity.
(d) The ORM method may reduce or counterbalance business risks by systematically identifying business hazards and assessing and controlling the associated risks allowing decisions to be made that weigh risks against profits.

Indicative examples of risks that may or may not be acceptable by a local community are the following:

- a local community may not accept the risk of environmental deterioration;
- a local community may not accept the risk of social degradation and/or safety deficiencies due to mining policies;
- a local community may not accept the risk of ore economic exploitation without financial benefits to society;
- a local community may accept some of the above risks under tradeoff discussions.

Indicative examples of risks that may or may not be acceptable by a mining company are the following:

- a mining company may not accept the risk of project delays due to social turmoil, vandalism, etc.
- a mining company may not accept the risk of project delays due to political or legal procedures and/or objections etc.
- a mining company may not accept the risk of project delays due to union strikes;
- a mining company may accept the risk of supporting local communities with financial tools under tradeoff discussions.

An ORM assessment model called Mining Operational Risk Management Model (MORMM) was constructed in a Microsoft Excel environment and its core is based on probability and severity evaluation by risk evaluators. MORMM may assist decision makers/risk evaluators to holistically assess the global enterprise risk. The proposed MORMM may be integrated into the organizational framework of any coal mining company.

This state-of-the-art of the presented model is governed by the following:

(a) It may be utilized by both expert professionals and those professionals with less experience at any organizational business level.
(b) It addresses the risk holistically and not in a fragmented way.
(c) It may support the whole lifecycle of a global business/investment plan.
(d) It may incorporate qualitative and quantitative hazards (including financial ratios etc.).
(e) It may be very useful in situations of Time Critical Risk Decisions.
(f) If incorporated into a cell phone application, it may be utilized by mine personnel when they operate in remote distances.

The result of applying the ORM methodology may accomplish one or more of the following:

(a) Improve coal mining business accomplishments by increasing the probability of profits by reducing/minimizing risks to acceptable levels;
(b) Improve decision-making skills based on a systematic, reasoned and repeatable process;
(c) Provide a systematic structure to perform holistic coal mining risk assessments;
(d) Provide improved confidence for coal mining executives to make informed risk decisions.
(e) Preserve business resources by avoiding unnecessary risk, thus reducing business “mishaps” and the associated costs;
(f) Provide a procedure for constant feedback through the planning, preparation, and execution phases of any coal mining business plan;
(g) Identify feasible and effective risk control measures, particularly where specific business standards do not exist;

The ORM method involves five steps.

(a) Identify hazards/hazard sources
(b) Assess the hazards and the associated risk
(c) Make risk decisions
(d) Implement controls
(e) Supervise and watch for change

The identification of hazards is carried out by reporting the conditions that may result in a potential business mishap. A review of business statistics to identify hazards that resulted in business mishap is strongly recommended. The hazard assessment step refers to the process, which describes the possibility that something could go wrong businesswise and the worst thing that could happen in terms of probability and severity. The decision-making step is targeting the manageable business risk: in this step, the level of risk is determined as acceptable or unacceptable. The decision maker performs an evaluation of the risk and he/she has the opportunity to decide what business tasks may be decreasing the level of business risk. To better identify hazards, someone should ask questions as follows: “how could my business/investment plan get hurt?” and/or “are there any potential natural hazards?” and/or “are there any potential political hazards?” etc. For example, with regard to the political hazards, Kyaw et al. (2011) have determined that transparency and political risk have a negative effect on the performance of enterprises. It is very important to remember that not all business risks are manageable, and sometimes the best decision is not to go ahead with a particular business venture. Both corporate social responsibility and SLO depend on business transparency. This implies that companies have a disincentive to be transparent. The public is sensitized to environmental protection and has lost confidence in mining companies due to a number of policies that led to environmental disasters. When the public is not satisfied with the policies of elected administrations they have the right to vote against the local or national governments and push against mining projects. This may become a political risk for a mining company that may result in project cancellations and delays (Kamenopoulos, 2018). The fourth step of the ORM incorporates the implementation of control measures, i.e. decrease the business risk or eliminate it by applying relevant controls. The final step of ORM involves the supervision process, which ensures that the assessment was accurate and checks if the business controls are effective. Due to the absence of a real case situation for the purposes of this paper only two first steps of the ORM (hazards identification and hazards assessment) were engaged. The Risk Assessment Codes (RACs) can assist in the ranking of the control priorities putting values in the level of risk as follows (Kamenopoulos and Tsoutsos, 2015):

| Severity   | Probability |
|------------|-------------|
| (1) Critical | A: 1, B: 1, C: 2, D: 3 |
| (2) Serious  | A: 1, B: 2, C: 3, D: 4 |
| (3) Moderate | A: 2, B: 3, C: 4, D: 5 |
| (4) Minor    | A: 3, B: 4, C: 5, D: 5 |

Four levels are used to assess Hazard Severity:

(I) Catastrophic: May cause irreversible catastrophic damage to coal mining operations
(II) Critical: May cause severe damage to coal mining operations
(III) Marginal: May cause minor damage to coal mining operations
(IV) Negligible: Probably would not affect coal mining operations

Four levels are used to assess Mishap Probability:

(A) Likely to occur immediately or within a short period;
(B) Probably will occur in time;
(C) May occur in time;
(D) Unlikely to occur.

The resulting RACs are shown in Table 1. Risks with a RAC code 1 or 2 are unacceptable. In this case any type of operation/investment plan shall be terminated due to an imminent danger situation. Risks with a RAC code 3 need to be re-engineered. Risks with a RAC code 4 or 5 are accepted.

The risk assessment process of the proposed modified MORM model is presented in Fig. 3.

3.2. Identification of hazards

People have different values across different socioeconomic groups, cultures, and religions (Kamenopoulos et al., 2015). Consequently, there are various perceptions about risk and hazards and sustainable development. What a mining company may consider a “risk” may be different from what society consider a “risk”. Mining companies are driven by financial gains and, therefore, their point of view is economically determined. Thus, most of their metrics and indicators are also economically determined. They use financial ratios that are relevant to corporate financing. On the other hand, local societies have a different views regarding risk which may involve safety risks, environmental risks, social risks and economic risks. As a result, these different perceptions of risk between stakeholders may lead to the inclusion of additional indicators and metrics.

Fig. 2 presented how the lack of SLO may lead to a high-risk investment environment, increased operation costs and project delays or cancellation. Such risks are directly related hazards inherent to coal mining projects. For the purposes of this paper, seven hazard categories and fourteen hazards were taken into consideration (Table 2). It is obvious that many other hazards exist. It is important to note that hazards are discussed not only from the point of view of the coal mining company, but also from the point of view of the society and the probable negative impacts to it, as the society grants the Social License to Operate to any mining company. For instance, the accidental release of chemicals to the ground could not only become a risk for the environment and...
have a negative impact to the local society, but also it could be transformed into financial risk for a coal mining company due to legal fines/penalties.

Another example may involve using the land for agricultural production. If the local economy is highly dependent on such production, then, the presence of a surface coal mining site near the area may decrease local gross agricultural domestic product, due to the decrease of agricultural acres. This may result in possible societal turmoil before and/or during the coal mining operations. Furthermore, a coal mining project may create other economic costs to residents if the area is considered highly touristic; in that case fewer tourists may visit the area due to coal mining operations and this may result in financial losses for the local society (Kamenopoulos et al., 2015). Again, this may result in a potential economic risk for the coal mining company due to societal turmoil before and/or during the coal mining operations. Another economic hazard for local societies would be related to the loss of income due to decrease of land value as the presence of a coal mining project may decrease the value of the land. Again, as a consequence, this may turn into a potential economic risk for the coal mining company due to societal turmoil before and/or during the coal mining operations. In general, the use of land in the case of coal mining projects may become the stake for competition and create potential turmoil among stakeholders.

On the other hand, it should be noted that in certain U.S coal-dependent communities this may not be considered as a risk but on the contrary, it may be considered as a finance tool for further economic development. Currently, 26 U.S counties are classified as “coal-mining dependent” meaning the coal industry is a major employer of approximately 53,000 employees (Morris et al., 2019). The downsizing of the coal-mining industry in these coal-dependent areas may present a higher economic risk to these employees.

The first hazard category is “natural hazards”: earthquakes and
The impact of natural hazards can be negative for both the society and a coal mining company. The second hazard category is related to “corporate financial hazards”: leverage, profitability and liquidity. The impact of corporate financial hazards can be negative for a coal mining company. Another hazard category is related to dust and other health and safety hazards. The rest of the hazard categories are described in Table 2.

### 3.3. Hazard assessment

For the purposes of this paper the number of risk evaluators/experts that will perform the risk identification and risk assessment will be five (arbitrary). The scale and actual probability and severity values were selected arbitrarily for the purposes of the present paper. Since there are no actual data available in order to test the proposed MORMM model, a number of arbitrary assumptions were made (Table 3).

As it is shown in Table 3 the weight of each hazard category and each hazard is equal to one (1). The model may be modified into a Multi-criteria Decision-Making problem if the weights are different than one (1). For the purposes of this paper fourteen hazard indicators were selected to describe the seven hazard categories (Table 4).

For the quantification of risk severities, the following process was adopted:

- **Stage #1:** Each evaluator ranks the hazards in terms of their risk severity from 1 to 4 by assigning 'I' to the hazard that is most severe (catastrophic), and 'IV' to the least severe (negligible).
- **Stage #2:** A fixed number of 100-points are automatically assigned to the most severe hazard (hazard ranked as 'I'). Then 75 points are assigned to the second least severe (hazard ranked as 'II') and so on.
- **Stage #3:** The average risk severities are calculated for all hazards.
  - If the average severity is between 76 - 100 then the hazard rank is I = Catastrophic
  - If the average severity is between 51- 75 then the hazard rank is II = Critical
  - If the average severity is between 26 - 50 then the hazard rank is III = Marginal
  - If the average severity is between 0 - 25 then the hazard rank is IV = Negligible

For the quantification of risk probabilities, the following process was adopted:

- **Stage #1:** Each evaluator ranks the hazard in terms of their risk probability from “A” to “D” by ranking with ‘A’ the hazard that is most probable to occur, and with ‘D’ the least probable.
- **Stage #2:** A fixed number of 10-points is automatically assigned to the least probable hazard (hazard ranked as "D"). Then 2 × 10 points are assigned to the second least probable (hazard ranked as "C") and so on.
- **Stage #3:** The average risk probabilities are calculated for all hazards.
  - If the average probability is between 76 - 100 then the hazard rank is A = Likely to occur immediately or within a short period;
  - If the average probability is between 51- 75 then the hazard rank is B = Probably will occur in time;
  - If the average probability is between 26 - 50 then the hazard rank is C = May occur in time;
  - If the average probability is between 1- 25 then the hazard rank is D = Highly improbable

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#### Table 3

| Assumption | Explanation |
|------------|-------------|
| Number of risk evaluators/experts | Five |
| Selection of indicators | Through bibliographic research |
| Hazard categories | Seven: Natural, Corporate financial, Economic, Environmental, Economic, Societal, (Geo)political |
| Hazard Assessment (risk & severity assessment) | Performed by the authors |
| All hazard categories and hazards have equal weight | The weight of each hazard category and each hazard is equal to one (1) |
| Probabilities scales (using 4-Likert scale) under ORM modeling | (Kamenopoulos and Tsoutsos, 2015) |
| Severities scales (using 4-Likert scale) under ORM modeling | (Kamenopoulos and Tsoutsos, 2015) |

#### Table 4

| Hazard Category | Indicators | Metric (Indicative) |
|-----------------|------------|---------------------|
| 1. Natural hazards | Number of earthquakes with magnitude above 5 in the Richter scale Depth of inundation | |
| 2. Corporate financial hazards | Number. It shall be above 1.5. Number. The higher the better Number. A ratio between 1.2 and 2.0 is sufficient |
| 3. Economic hazards | (%) Proportion of local GDP based on agriculture (ratio) Number of local residents divided to number of tourists visiting the area per year |
| 4. Environmental/health hazards | Number (ranking) |
| 5. Societal hazards | Number (ranking) Number (ranking) |
| 6. Technological hazards | Number of structural/technical deficiencies of the coal mining company. |
| 7. (Geo)political hazards | Present of Corruption |
Table 5
Evaluations of probabilities and severities for the specific scenario.

| Hazard                                | Evaluator 1 Probability | Evaluator 1 Severity | Evaluator 2 Probability | Evaluator 2 Severity | Evaluator 3 Probability | Evaluator 3 Severity | Evaluator 4 Probability | Evaluator 4 Severity | Evaluator 5 Probability | Evaluator 5 Severity |
|---------------------------------------|-------------------------|----------------------|-------------------------|----------------------|-------------------------|----------------------|-------------------------|----------------------|-------------------------|----------------------|
| Earthquakes                          | D                       | IV                   | D                       | IV                   | C                       | D                    | III                     | III                  | D                       | IV                   |
| Floods                                | D                       | D                    | D                       | IV                   | C                       | C                    | C                      | C                   | C                       | C                   |
| Leverage                              | D                       | IV                   | IV                      | IV                   | C                       | C                    | C                      | C                   | C                       | C                   |
| Liquidity                             | D                       | IV                   | IV                      | IV                   | C                       | C                    | C                      | C                   | C                       | C                   |
| Decrease in agricultural activities   | D                       | IV                   | D                       | IV                   | C                       | C                    | III                    | III                  | D                       | IV                   |
| Toxic waste/greenhouse gases          | D                       | IV                   | D                       | IV                   | D                       | IV                   | III                    | III                  | C                       | III                 |
| Rioting, boycotts, demonstrations     | D                       | IV                   | C                       | III                  | C                       | C                    | III                    | III                  | C                       | III                 |
| Technical failures                    | D                       | IV                   | D                       | III                  | D                       | IV                   | III                    | III                  | C                       | III                 |
| Political stability                   | D                       | IV                   | C                       | III                  | C                       | C                    | III                    | III                  | C                       | III                 |
| Corruption                            | D                       | IV                   | C                       | III                  | C                       | C                    | III                    | III                  | C                       | III                 |

- If the average probability is between 0 - 25 then the hazard rank is D = Unlikely to occur.

4. Analysis of a hypothetical scenario and discussion

Fig. 2 described how various coal mining operational risks can affect the granting of SLO. The presence of any of the abovementioned 14 hazards (Table 4) may become a halting factor to the SLO granting procedure. Not all decision makers have the same perception of risk. For that reason, a hypothetical scenario was built under which five imaginary risk evaluators are used to evaluate each of the 14 hazards in Table 4. Table 5 represents the resulting hypothetical scenario, which was built for the purposes of this paper. In accordance to this scenario, Evaluator #1 seems to be a risk taker. He/she evaluates all hazard probabilities as “Unlikely to occur” and all hazard severities as “Negligible”. Evaluator #2 believes that corporate financial, societal and (geo)political hazards may occur in time, but natural, economic and technological hazards are “Unlikely to occur”; regarding hazard severities. Evaluator #2 evaluates that corporate financial, (geo)political, societal and technical hazards are marginal. Evaluators #3, #4 and #5 agree on the corporate financial probabilities and severities under the specific hypothetical scenario. The resulting RACs for all hazards are shown in Table 6. According to the results presented in Table 5 the decision makers may accept the risks regarding natural, economic, and technological hazards. The resulting RACs related to these risks were 4 or 5. Yet, the low quality of life (societal hazard) seems to trouble the evaluators; for that reason evaluators have accepted this hazard with a RAC 3. In that case the decision makers need to implement controls in the specific field. Furthermore, the evaluators are nervous over the corporate financial risks; for that reason, they have also allowed financial risks with a RAC 3; in that case the implementation of financial controls is also essential in order to make the business plan safer. Table 7 describes the arguments for and against the implementation of the proposed MORMM model.

Table 6
Resulted Risk Assessment Codes under the specific hypothetical scenario.

| Hazard                              | RAC   | Comments                        |
|-------------------------------------|-------|---------------------------------|
| Earthquakes                        | 4     | Risk accepted                   |
| Floods                             | 5     | Risk accepted                   |
| Leverage                           | 3     | Plan needs to be re-engineered  |
| Profitability                       | 3     | Plan needs to be re-engineered  |
| Liquidity                          | 3     | Plan needs to be re-engineered  |
| Decrease in agricultural activities | 4     | Risk accepted                   |
| Toxic waste/greenhouse gases        | 4     | Risk accepted                   |
| Dust                               | 4     | Risk accepted                   |
| Rioting, boycotts, demonstrations   | 4     | Risk accepted                   |
| Low quality of life                | 3     | Plan needs to be re-engineered  |
| Technical failures                 | 4     | Risk accepted                   |
| Political stability                 | 4     | Risk accepted                   |
| Corruption                         | 4     | Risk accepted                   |

Table 7
Arguments for and against the implementation of the proposed MORMM model.

| Arguments                              | For       | Against                        |
|----------------------------------------|-----------|--------------------------------|
| It provides the decision makers and/or evaluators with the opportunity for transparent decision making and/or evaluation. | Sufficient data are not yet available for testing. |
| It addresses the risk holistically and not in a fragmented way. | Sufficient data are not yet available for testing. |
| It is a “value” oriented tool: evaluators are encouraged to incorporate and directly or indirectly attribute a “value” on the stake of the business plan. | Sufficient data are not yet available for testing. |
| It may be utilized by both expert and less experienced professionals at any business level. | Sufficient data are not yet available for testing. |
| It is designed to support the whole lifecycle of a coal mining business plan. | The demo included five hazard categories. Modifications may be needed when at the prototype stage. |
| If modified it may include any number of hazard categories. | The demo included 14 hazards. Modifications may be needed when at the prototype stage. |
| If modified it may include unlimited number of evaluators/experts. | Sufficient data are not yet available for testing. |
| If modified it may include unlimited number of hazards. | Sufficient data are not yet available for testing. |
| It may incorporate qualitative and quantitative hazards (including financial ratios etc.). | Sufficient data are not yet available for testing. |
| If modified it may include different weights for each hazard category and/or hazards. In that case the sum of all weights shall be one. | Sufficient data are not yet available for testing. |
| It may be very useful in situations of Time Critical Risk Decisions. | Sufficient data are not yet available for testing. |
| If incorporated into a cell phone application, it may be utilized by mine personnel when they operate in remote distances. | Sufficient data are not yet available for testing. |
5. Conclusions

The aim of this paper was to present a Decision Support System with which decision makers may eliminate potential risks that can halt SLO granting during the investment and operations stage of coal mining operations. For that reason, a state-of-the-art Operational Risk Management model was created for the evaluation of risk management of coal mining operations. The model, called Mining Operational Risk Management Model (MORMM), incorporates hazard probabilities and hazard severities evaluated by experts. The final risk assessment is coded using Risk Assessment Codes (RACs). In order to demonstrate the use of the model, a hypothetical coal mining operations scenario was created. The scenario included fourteen hazards divided into seven categories; hazards were evaluated by five imaginary evaluators/experts. The resulting RACs provided critical information to decision makers regarding the rejection, acceptance or re-engineering of the coal mining business plan. Gaining the SLO is invariably the desideratum for most mining companies. The method presented above aims to support mining companies to gain the SLO. The application of the proposed assessment methodology may contribute to a better risk communication through different business levels of decision making and to address risk in a holistic manner.

Further development work needs to focus on improving model implementation and on testing model performance and robustness. Future research should focus on collecting data from actual case studies with respect to the following fields (including but not limited to): transparency of decision making, training of inexperienced decision makers, implementation on the entire lifecycle of a coal mining business plan, inclusion of additional number of hazards and hazard categories, inclusion of additional evaluators and/or experts, use of more quantitative and qualitative hazards, and use of different hazard weights. Additionally, the presented model may be very useful in situations of Time Critical Risk Decisions. If incorporated into a cell phone application, it may be utilized by mine personnel when they operate at remote locations. The theoretical model presented is just a demo, but may set the stage for what needs to be considered when global investment plans stall due to a number of unpredicted risks. It is clear that further research is necessary towards the goal of a uniformly accepted holistic coal mining operational risk assessment tool.

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