# Contents



# Impacts: Reiterating Research Objective

Identify risks that manifest themselves over the **long term** for mining companies that companies and investors may not effectively consider

- Identify key risk exposure pathways and mitigation strategies
- Develop probabilistic measures of risk factors & their valuation where possible from available data
- Assess potential mispricing or under/over statement of the risks
- Translate risks to financial risk measures (VAR, CVAR) where possible
- Integrate risks, mitigation strategies into a robust real options modeling framework for risk based valuation (with bounds)
- Assess & compare risk adjusted portfolios

# Recommendations: What does this mean for Companies & Investors?

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| **BIAS IN REPORTING / MISALIGNMENT OF INCENTIVES** | **Company-formulated estimates of reclamation costs are biased and tended to increase nearer to the end of the mine life** | **Consider potential bias in investment and decision processes** |
| **LOW PROBABILITY / HIGH IMPACT EVENTS** | **The risks associated with tailings dam failures can be to identify companies / assets most at risk.** | **Consider potential asset and portfolio level risk and uncertainty** |
| **LONG DURATION TEMPORAL TRENDS & CUMULATIVE IMPACTS** | **Certain companies are more exposed to climate extremes than others, based on the locations of their assets.** | |
| | **Even when a mine conforms to environmental regulations, significant contamination of water (even far away from site) can occur over time.** | **Consider long-term implications on license to operate and clean-up costs** |
| | **Quality and availability of water impacts social conflict. Parameters were identified that can help predict the likelihood of future conflicts.** | **Consider potential impact on asset level production, capex, costs and timelines** |

# Recommendations: What does this mean for Companies & Investors?

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| **DATA / DISCLOSURE** (COMPANY ACCOUNTABILITY) | • Long-term stakeholders need to be aware of risks that can slowly manifest themselves over time, such as cumulative pollution effects. Through **better disclosure**, investors will be able to identify and encourage companies to mitigate these risks before the problem escalates to a level that is unsolvable.<br>• **Working with mining companies can help identify available data** to help inform better analyses. |
| **METHODOLOGY** (INVESTOR / STAKEHOLDER ANALYSIS) | • Discounted cash flows should not be the only methodology relied upon for decision making. Our robust **real options approach is superior for risk based valuation with limited data**.<br>• Stakeholders can **use a data driven approach to identify the likelihood of social conflict**. The key parameters inducing conflict can be identified, which can help shape decision processes by investors, regulators and company management. |
| **KEY CONCLUSIONS** | • Investors, local communities, employees and regulators need to be cognizant that **mine study work is prone to bias** – different stakeholders need to find ways to hold mine management accountable for providing biased and consistently inaccurate information.<br>• **Low-probability high-impact events can have a catastrophic impact on local communities and on company and portfolio valuations / returns**. Long term stakeholders need to be cognizant of these risks in their decision processes and encourage better alignment between themselves and management.<br>• **Certain companies are more exposed to climate extremes and social conflict than others,** based on the locations of their assets among other factors. |

# Research Extensions: What other relevant projects are we working on at Columbia?

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| How prevalent is bias in other areas of mining company study work? | Focus on timelines, production, capex, opex and producing a method to standardize mining project “discounts to NAV” |
| How can we apply our findings from this analysis on mining to other industries? | Applying our conclusions / methodologies regarding real options & climate extremes to other industries |
| Can we identify “red flags” that cause problems for stakeholders early on before they materialize? | Using Bayes and other statistical methods to expand upon conclusions from the work with NBIM |
| Can we create a generalized model for water valuation to integrate into ordinary company decision making processes? | Working with Major Mining Company to develop a risk-based water valuation for mining, taking into consideration environmental and social aspects |
| How can we validate / increase accountability of mining company management for their disclosure / estimates? | Attempting to put forth metrics to objectively measure performance both over time and retrospectively, and identify additional data that can be disclosed by mining companies to help inform further analyses |
| How can we improve regulatory models to reduce cumulative effects and reduce social risk? | Developing Pilot Process for integrated monitoring, attribution and statistical control for Peru |