Quantifying Water related Financial Risk for the Mining Industry

Operator/Investor
- CAPEX, OPEX, Production Losses, Profit Margins
- Asset Stranding, Operating License, Reputation, Regulatory Pressure

Society
- Environmental Degradation, Loss of Access to Water, Poverty Trap, Property and Life Casualty Losses

Minera Escondida Copper, Chile
- Water Scarcity - Desalination

Tuslequah Chief Copper-Lead Mine, BC
- Cumulative Effects - Acid Mine Drainage

Kennecott Copper, Utah
- Groundwater contamination

Upmanu Lall, Yash Amonkar, Jose Blanchet, Luc Bonnafous, Lauren Butler, Paulina Concha, Madison Condon, Chris Dolan, Juan Guiterrez, Garud Iyengar, Nicolas Maennling, Karthyek Murthy, Jason Siegel, Jorge Suito & Sophie Thomashausen

Columbia University with support from NBIM with contributions from Gavin Mudd, Stephen Northey, & Tim Werner
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Research Objective

How to quantify financial risks from environmental factors for long term investors?

Specific Case: Copper/Gold Mining & Water Risks

Water Management Risks in Mining:
• Scarcity - Aridity, Drought
• Water Quality/Pollution, Waste Spills
• Increasing Water Sourcing & Treatment Costs
• Flooding
• Social Conflict & Asset Stranding
• Regulations & their Effectiveness
• Failure of Risk Mitigation Actions
Research Questions

1. How do increasing water management costs for mining impact project risk and long run industry cost curve?
2. What are the financial risk exposure pathways for mining related to water & climate? How can data and estimates on these be developed?
3. What are the mine's risk mitigation strategies, their costs and residual risks?
4. Given limited data, high uncertainty, and the potential for catastrophic events, how best can financial risk at the asset and portfolio level be assessed?
5. How well do regulatory and financial disclosure processes address these risks?
Problem framing

- Mines are heavily engineered and regulated with life > 10 years
- Environmental/water factors have led to significant social conflict, non-performing assets and production cost risks
- Mining companies disclose their efforts to address these challenges and provide environmental and financial reports
- Analysts and regulators use these reports to assess performance and value the mines
- Is there data to assess whether the risks are properly assessed and disclosed?
- How does one assess the **residual financial risk (beyond the market valuation)** recognizing the complexity in the physical, social/legal, environmental inter-dependence over the long life of a mine? Or for a portfolio of mines?

What are the material financial risks related to water, how do they emerge, and how can one value them? Are they priced right?
Short vs Long Term Investor Perspectives

**Short Term Investors:**
- Will the company (and its assets) beat market expectations when it announces its results?
  - Is the spot commodity price going up (or down) this quarter?
  - Will the company have positive exploration results in the near-term?
  - Will the company produce more (less) payable metal than the market expects?
  - Are costs going to be lower (or higher) than anticipated?
  - Will the company’s assets get permitted in the near-term?

**Long Term Investors:**
- Are the company’s assets fundamentally more/less valuable than market perception?
  - What should the fundamental commodity price be (supply and demand)?
  - Is it likely that company’s assets will have reserves higher than estimated?
  - Will the company be able to economically extract all of its defined resources?
  - What level of costs are sustainable in the long-run?
  - Will the company’s assets get permitted?
  - Are there potential increases in costs due to unforeseen factors that could lead to a stranded or non-productive asset?
Long Term Investment & Sustainability Goals

What kind of risks are captured by Market Research & Valuation?

- **Typically Discounted Cash Flow is Used**
  - Emphasizes Short or Near term Cash Flows
  - Valuations are updated as companies disclose costs, yields and reserves, and analysts update metal prices
  - Production Costs change relatively slowly
    - Water Management cost changes are included
  - Risk discounts are applied to address uncertainties
    - Cost and production uncertainties are high in early stages of mine development
    - Remediation costs occur late in mine development and are highly discounted in Present Value, but = liabilities.
  - Not clear how “shocks” are priced accounting for potential mitigation efforts by the company?
  - Correlated risks across mines limited to metal prices

Residual Financial Risk
due to systematic bias in estimation and disclosure of either the value at risk or the uncertainty associated with the risk
Financial Implications of Environmental Factors

**VALUE**

**REVENUE**
- Examples: Production stoppage, permanent mine closure, modified expansion plans

**COSTS**
- Examples: Legal costs, monitoring, community relations, ongoing remediation, permitting

**CAPEX**
- Examples: Clean-up costs, settlements, reconstruction

**UNCERTAINTY**

**PROBABILITY OF FOREGONE REVENUE**

**PROBABILITY OF INCREASED COSTS**

**PROBABILITY OF INCREASED CAPEX**

Decisions are made in response to “risk events” → may change assumed mine trajectory.
Value Creation / De-risking Over Time

- Mine Plans include environmental impact assessments and mitigation over decades. They are updated over time.
- **Value is created as the mine is “de-risked”** as analyses and data improve (therefore theoretically more accurate)
- Mines become less risky as future outcomes are better understood
- Biggest water risks → non-performing or stranded assets
  - Loss of license to operate
  - Social conflict
  - Irreversible Pollution
  - Catastrophic Infrastructure failure
  - Competition over water

Are there critical triggers and exposure pathways for water risks?
Understanding Profitability Impact of Environmental Factors

EXAMPLE: TAILINGS SPILL

**REVENUE**

**WILL THE ASSET EVER MAKE MONEY AGAIN?**

**COST**

**WHAT ARE THE CARE & MAINTENANCE AND ONGOING MONITORING COSTS?**

**CAPEX**

**WHAT WILL BE THE RESULTING CLEAN-UP COSTS / LIABILITY / LITIGATION?**

**FULL WRITE-OFF**: Asset does not have sufficient economic reserves to justify restart → ASSET HAS RESIDUAL VALUE OF ZERO

**PARTIAL WRITE-OFF**: Asset has sufficient reserves to justify restart → ASSET HAS RESIDUAL VALUE GREATER THAN ZERO

**IF FULL WRITE-OFF → ZERO**

**IF PARTIAL WRITE-OFF → EQUAL TO FIXED COSTS OF MINE DURING PERIOD OF RESTART + INCREASED MONITORING COSTS AS A RESULT OF THE INCIDENT**

**FUNDAMENTAL ESTIMATE BASED ON:**

- Proximity to major population centers / water resources
- Capacity and quantity of tailings
- Impurities / toxicity
- Mine / Company insurance protection
• Investors rely heavily on mining company analyses as a basis for their investment decisions
• Regulators have tried to standardize these analyses under JORC and 43-101 to protect investors and preserve the credibility of these studies/public data and their respective classifications
• Research has shown that analyses are historically inaccurate. However, in the absence of other publicly available information investors have no alternative as a basis for their analyses
• Thus, investors have to come up with subjective determinations of risk associated with company estimates (discounts to NAV)

Issues with Reliance on Company Provided Information

M&A Discounts to NAV by Project

Changing environment/climate and socio-economic conditions may invalidate mine company assumptions and disclosure
There are empirical examples of bonds being inadequate to cover reclamation costs. Examples include:

- Summitville Mine in Colorado, cyanide spill required $192 million Superfund cleanup while financial assurances posted by operating company were $4.5 million.

Later in this presentation, we discuss in detail how bias is prevalent in reclamation cost estimates which can have a profound impact on stakeholders (including local communities, regulators and investors).
Key Issues Focused on

**FINANCIAL RISK MODELING**
- Model long term risk evolution and mitigation, over quantifiable risk exposure pathways ← information biases & uncertainties
- Robust real options model theory and application

**CLIMATE EXTREMES**
- As a trigger for water scarcity & flooding → infrastructure impacts and social conflict
- Mispricing of at site risk Correlated Portfolio risk

**LOW PROBABILITY / HIGH IMPACT EVENTS**
- Infrastructure Failure with water system impacts
- Tailings Dam State Identification & Failure Impact Analysis

**CUMULATIVE WATER POLLUTION EFFECTS**
- Regulatory effectiveness and outcomes
- Reputational Risk, Watershed Impacts

**WATER USE & COSTS**
- Bounds on potential water use and wastewater treatment costs
- Long run cost risk for at site water use

**SOCIAL CONFLICT**
- Covariates of water related social conflict
- Asset Stranding potential

**BIAS IN REPORTING**
- Mispricing of Risk due to systematic errors in company reports
- Reclamations Cost Disclosure Analysis

**REGULATIONS**
- Comparative Analysis Across Countries
- Potential Effectiveness, Delays
1. Financial exposure pathways for a mine ← water related risks?

- Severe Sustained Drought
- Replacement water
- Wastewater Treatment Requirements
- Social conflict
- Stranded asset
- Climate
- Short term Profit
- Revenue
- INVESTMENT LOSS
2. Financial exposure pathways for a mine ↔ water related risks?

- Climate
- Extreme Rain & Flood
- Tailings Dam Failure
- Toxic Discharge
- Social conflict
- INVESTMENT LOSS
- Short term Profit
- Revenue
- Stranded asset
3. Financial exposure pathways for a mine ↔ water related risks?

- Toxic Discharge
- Cumulative effects
- Degraded Water Bodies
- Social conflict
- Stranded asset
- Revised Regulations
- Regulatory Compliance
- Costs
- Liabilities
- Investment Loss
Consider climate extremes, Tailings failures, Social conflict emergence as stochastic shocks whose probability of occurrence changes over time based on covariates \(\rightarrow\) risks that change over time.

Mining companies design/insure some of the risks.

**Outcomes** = function of planning + event effects.

*Discounted present value reflects the risk?*

Simulate all possible occurrences, and best decision forward at each time.
Real Options Model:
Simulation-Optimization Modeling framework for risk and asset/portfolio valuation

**Simulation** = performance/outcomes in the face of stochastic shocks over time that lead to
decisions on changes in system design or operation and hence costs and revenues

**Optimization** = at any given time where such a decision is needed, assuming the company is a
rational economic actor, identify the economically optimal decision to the end of the
operating horizon

Thus, the nonlinear dependence between shocks, decisions and outcomes is explicit

**Robust:**
Recognizes that data on shocks and the outcomes of the shocks may be quite limited and or
biased.

How does one derive appropriate bounds for the probabilities of shock events in this setting?
How does one simulate shocks using these robust probability bounds?

Theory Developed. Database and App Developed and available.

Applied to Assess whether a Mine/Company is over/under Valued considering risks