

# DIGITAL TWIN MODEL FOR METAL MINING INVESTMENTS

## Managing Complexity with Simulation

### RESEARCH GROUP

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### Introduction

Mining investments are long term industrial investments with large initial capital lay-outs that operate in an uncertain environment. The long economic life and the dependence on market prices of metals underline the importance of good profitability management and analysis of mining investments as drivers in guaranteeing economic viability and the sustainability of these investments.

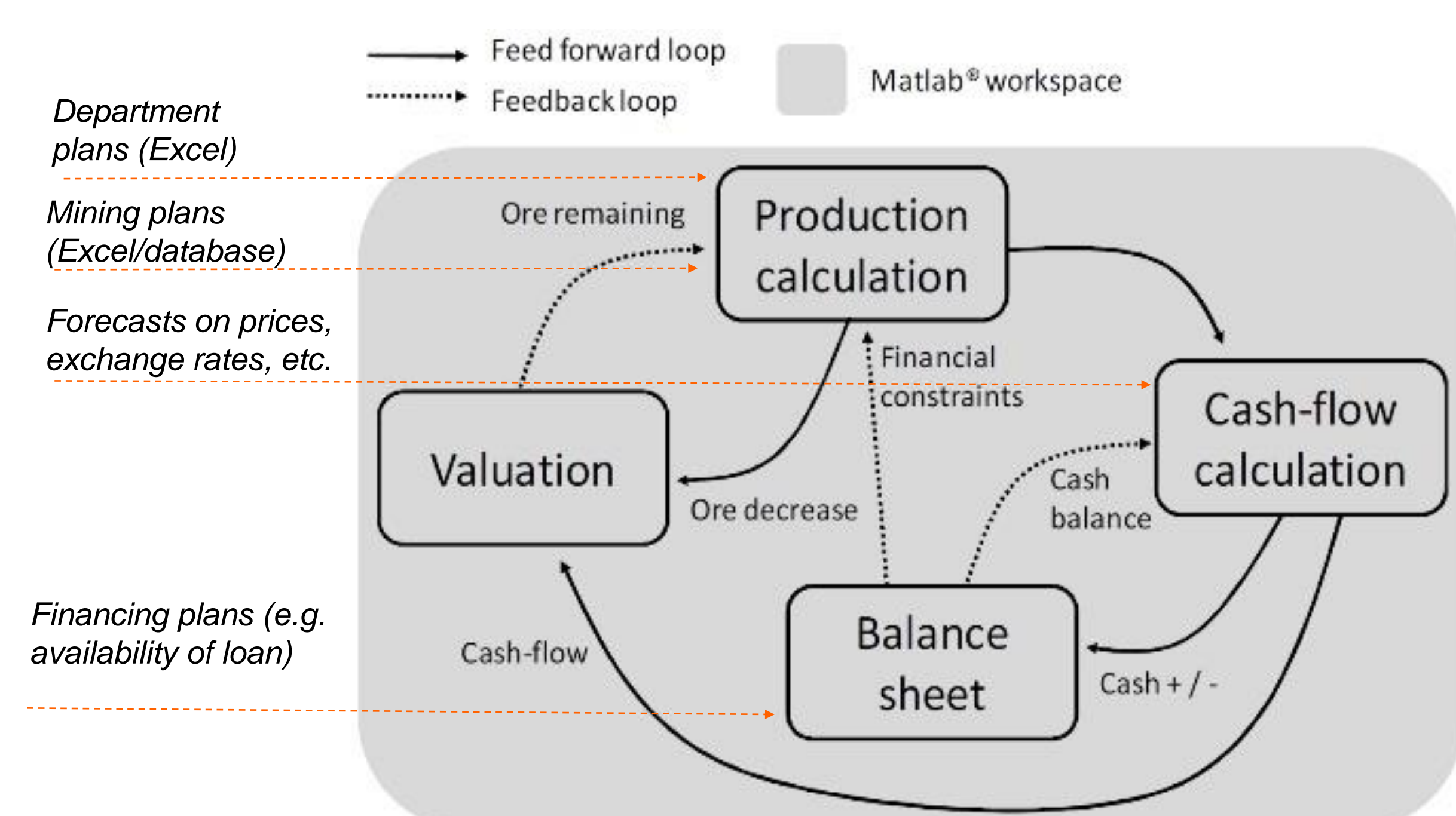


Figure 1. High-level illustration of the Digital Twin model.

### Methodology

The Digital Twin model built mimics the characteristics of real-world mining investments, where different aspects—most importantly production rates, cash flow, and the balance sheet—simultaneously affect the overall economic profitability of the mining investments studied. The SD model accounts not only for the variability in key parameters, but more importantly models the reactions to changes by altering the outcomes when the changes occur.

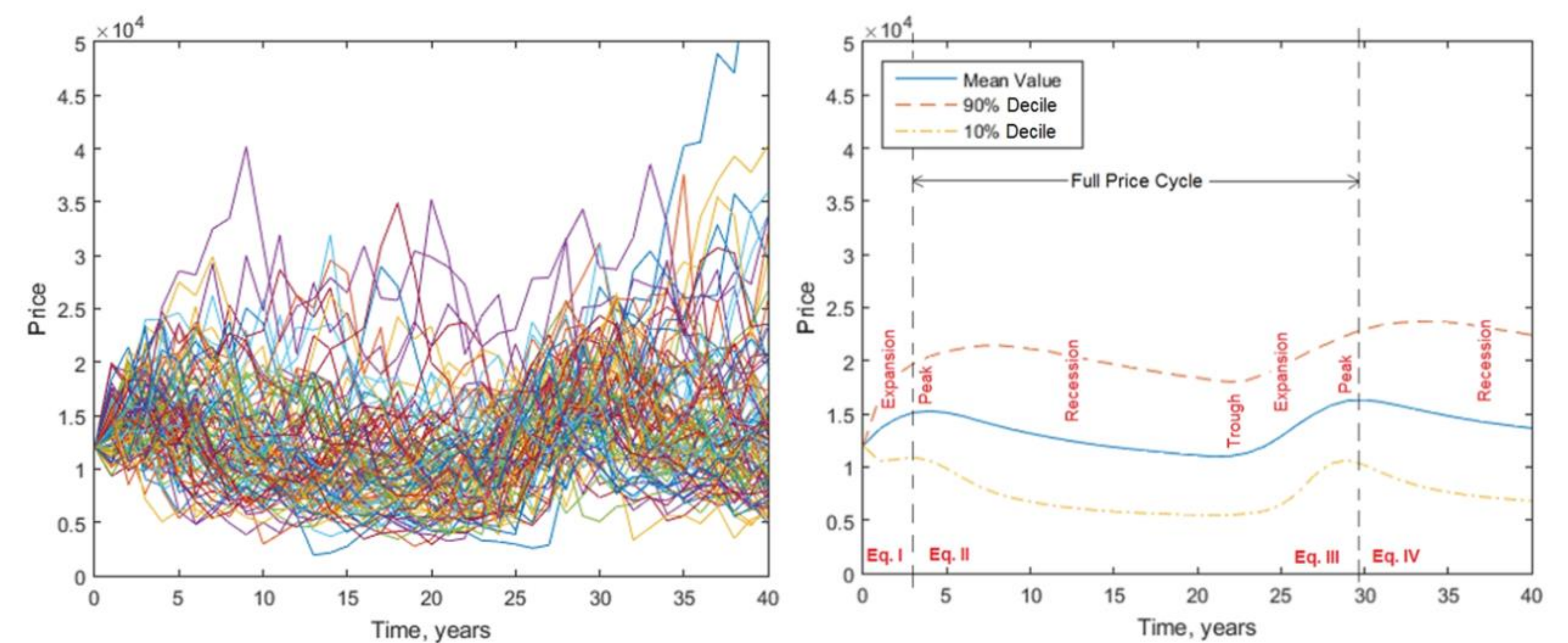


Figure 2 and 3. *LEFT*: Simulation of 1000 random price paths; *RIGHT*: Statistical values of the simulated 1000 price paths.

### Results and Conclusions

- Dynamic and probabilistic simulation of metal mining operations can be used to enhance both their profitability (Savolainen, Collan & Luukka, 2017) and environmental sustainability (Savolainen, Pedretti & Collan, 2019)
- Machine Learning (ML) –based methods should be taken advantage of when analyzing the results of complex, dynamic simulations (Savolainen & Collan, 2019)

### References

- Savolainen, J., & Collan, M. (2019). Using meta-models in simulation-based investment analysis – studying the financing mix of metal mining investments. In XX SIGEF Congress - Harnessing Complexity through Fuzzy Logic. Naples, Italy.
- Savolainen, J., Collan, M., & Luukka, P. (2017). Analyzing operational real options in metal mining investments with a system dynamic model. *The Engineering Economist*, 62(1), 54–72.
- Savolainen, J., Pedretti, D., & Collan, M. (2019). Incorporating Hydrologic Uncertainty in Industrial Economic Models: Implications of Extreme Rainfall Variability on Metal Mining Investments. *Mine Water and the Environment*, 38(2), 447–462.

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