MFG 4.0

LUT University

Business Analytics @ LUT

Research group in business analytics and decision-making

- who we are & what we do

Mikael Collan, LUT-University, Finland

Who are we?

Mikael Collan

D.Sc. (Econ&BA), Professor, School of Business and Management, Lappeenranta University of Technology

Pasi Luukka

D.Sc. (Tech.), Professor, School of Business and Management, Lappeenranta University of Technology

Jan Stoklasa

D.Sc. (Tech.), Research fellow, Lappeenranta University of Technology

Assistant professor, Palacký University in Olomouc

Azzurra Morreale

D.Sc. (Econ&BA), Post-doctoral researcher, School of Business and Management, Lappeenranta University of Technology

Mariia Kozlova

D.Sc. (Econ&BA), Post-Doctoral researcher, School of Business and Management, Lappeenranta University of Technology

Jyrki Savolainen

D.Sc. (Econ&BA), Post-Doctoral researcher, School of Business and Management, Lappeenranta University of Technology

Christoph Lohrmann

Analyst, Osiris Asset Management AG

PhD student, Lappeenranta University of Technology

+ 7 Ph.D. Students working on analytics topics

Group based at LUT-School of Business and Management

We run two master´s programmes In Business Analytics:
One engineering programme and one business programme

http://www.softcomputing.fi

The group

Professors (2)
Collan & Luukka
Post-doc (4)
Stoklasa, Morreale, Kozlova, and Savolainen
Project MFG 4.0 (1)
Lohrmann
Doctoral students (8)
Talasek, Mailagaha, Vyunenko, Gadasina, Zaboev, Bogdanova, Urbani

Strong in house and international network!

- Strongest team in fuzzy logic in Finland
- Strongest practical real option analysis know-how in Finland
- Strong modeling and simulation know-how
- Strong AI and ML know-how, especially classifiers

Group experience

Strong scientific experience
- Corporate finance (valuation, analysis)
- Applied mathematics

} Together

Practical project and industry experience
- Experience from several industry funded R&D projects – typically the ”old” consortium driven projects connected to ”business decision-making” and to ”business development” – systems creation as a solution
- Investment management / Consulting work experience

Experience in BoD work / sparring executives
- BoD work in SME´s
- Efficiency / productivity / business management trainings

Analytics for business and industry

Creation and applications of new analysis methods
- Simulation-based methods / System dynamics
- Methods / systems that use fuzzy logic
- Advanced scorecards

Decision-making under uncertainty and imprecise information
- Project profitability analysis
- Real option analysis
- Valuation of assets (M&A, Start-Ups, Patents)

Portfolio choice of strategic investments
- Patent portfolios
- R&D investment portfolios
- Portfolios of industrial investments

} RANKING / OPTIMIZATION PROBLEMS IN PRACTICE

Data-based / data-guided business processes
- Predictive maintenance / maintenance scheduling
- Algorithms for ”tuning” systems based on performance

Application areas / fields of industry - examples

Mining industry
- Importance of building flexibilities to mining investments
- Valuing flexibilities (real options) in mining investments w. system dynamic modeling
- Profitability of mining asset portfolios
- Automation of ore sales systems

Energy industry
- Russian RE support mechanism (effect to productivity)
- Nordic electricity market derivatives (EPAD) and market efficiency

Modeling corporate acquisitions
- Pricing / Decision-support
- Acquisition strategy as a combination of real options

Construction industry connected analysis
- Area construction / construction industry related real options

R&D project and patent valuation and portfolio analysis

Large industrial investments
- Profitability / feasibility analysis
- Shutdown optimization / abandonment / re-investment
- Maintenance routines / scheduling (oil platforms)

Retail industry
- Customer segmentation / classification
- Data driven campaign planning

Application areas / fields of industry - examples – Paper Industry

Paper Industry
- Profitability analysis of new machine investments
- Shutdown timing analysis for an old paper machine
- R&D project portfolio management system construction
- Spin-off company evaluation & metrics

Healthcare & Healthcare analytics
- Predictive analytics system supporting triage for child patients
- Development of an analytics suite for healthcare analytics

IT industry
- Telemetric information based prediction of mobile device status

On the WWW


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SOFT COMPUTING
Researching Decision-Making under Uncertainty
We turn intuition into decision-support systems

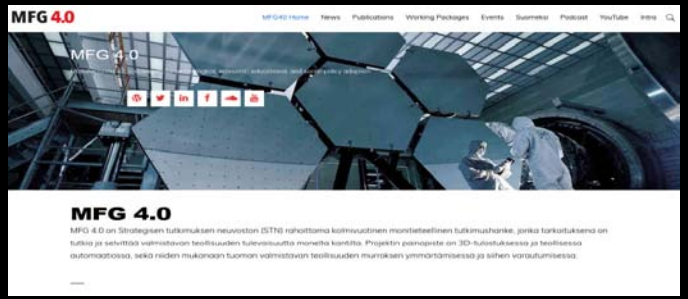
Specific Topics:

MFG 4.0 LUT University

MFG40 & Predictive maintenance
Classifiers & Feature selection
Renewable Energy Support Mechanisms
Mining Analytics

MFG40 – Manufacturing 4.0

MFG 4.0 is a Finnish Strategic Research Council @ Academy of Finland financed three-year research project that studies the future of the manufacturing industry from many points of view. The focus is on 3D-printing, industrial automation, materials, industry digitalization & business models, and on the societal and educational impacts of future manufacturing change.



Funding for the project (whole) 2018-2022 (6,4M€), www.mfg40.fi

Predictive Maintenance

We research *predictive maintenance policy modeling* and *future business models based on predictive maintenance*

- Prof. Collan, Dr. Savolainen & Dr. Luukka

Policy modeling is done in collaboration with:

- Dr. Matteo Brunelli & Michele Urbani (U. Trento, ITA)
- Prof. Antti Punkka, ACOR, Aalto
- Prof. Lawryshyn (U. Toronto, CAN)

Business models for predictive maintenance & MFG40 connected to additive manufacturing is done in connection with the MFG40 project

- Prof. Collan & Dr. Savolainen
- Prof. Karl-Erik Michelsen (LUT, Vuoden Professori 2018)
- Some Finnish industrial companies (anonymous)

15+ years experience on classifiers and predictive analytics ”algorithms” and information fusion necessary for the construction of good models

Predictive Maintenance

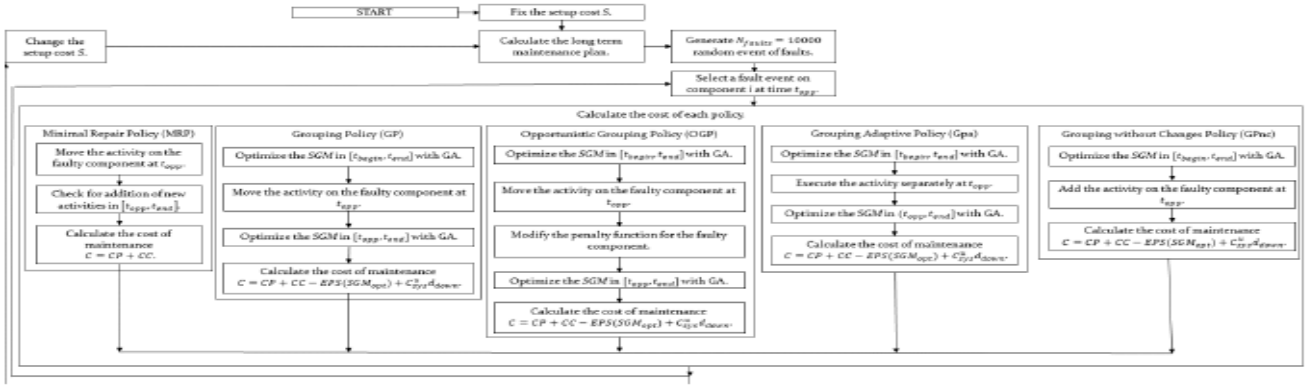


Figure 8: Flow chart of simulation with different policies.

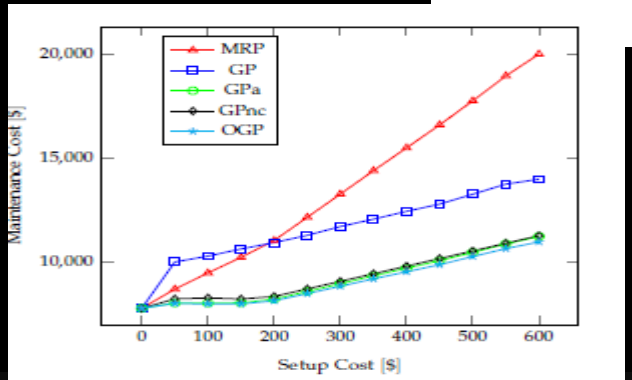


Figure 9: The average cost of maintenance with different policies with respect to different setup costs.

Comparison of different maintenance policies

- 5 different policies modeled and 1000 test cases simulated for each one to see median costs

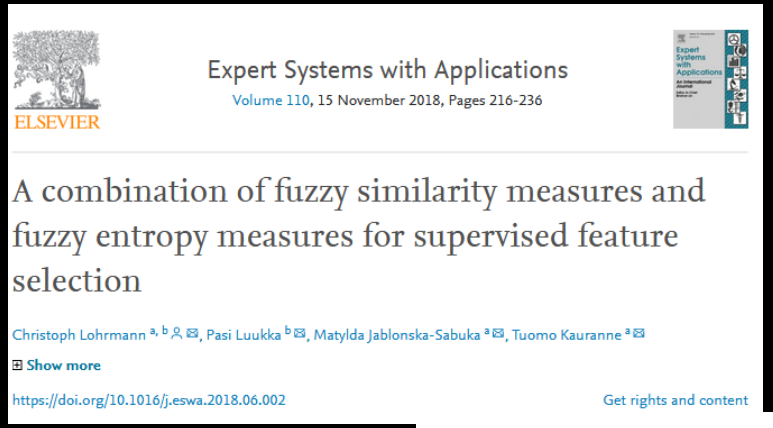
- Rather complex problems – long simulation Runtimes (up to 20 hours)

Classifiers and feature selection

One of our stronger research interests is connected to *classifiers*, especially using the concept of similarity and fuzzy logic in creating new classifiers. Also *feature selection methods* (selection of important variables from among many possible variables) is something we have been working on for years.

- Research is lead by Prof. Luukka and active are also Dr. Stoklasa, researchers Lohrmann, Talasek, and Mailagaha
- Prof. Luukka is the creator of the original ”similarity-based classifier” that has proven to give good results
  - there are already a set of variants of the similarity-based classifier
  - Research is also done on new variants of the K-nearest neighbor (KNN) and evolutionary classification altgorithms
- Applications have mostly been in the medical context, but we have also had collaboration with the telecommunications industry

Classifiers and feature selection



Expert Systems with Applications
Volume 110, 15 November 2018, Pages 216-236

A combination of fuzzy similarity measures and fuzzy entropy measures for supervised feature selection

Christoph Lohrmann [a, b], Pasi Luukka [b], Matylda Jablonska-Sabuka [a], Tuomo Kauranne [a]

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https://doi.org/10.1016/j.eswa.2018.06.002 Get rights and content

International Journal of Forecasting
Volume 35, Issue 1, January–March 2019, Pages 390-407

Classification of intraday S&P500 returns with a Random Forest

Christoph Lohrmann [a, b], Pasi Luukka [b]

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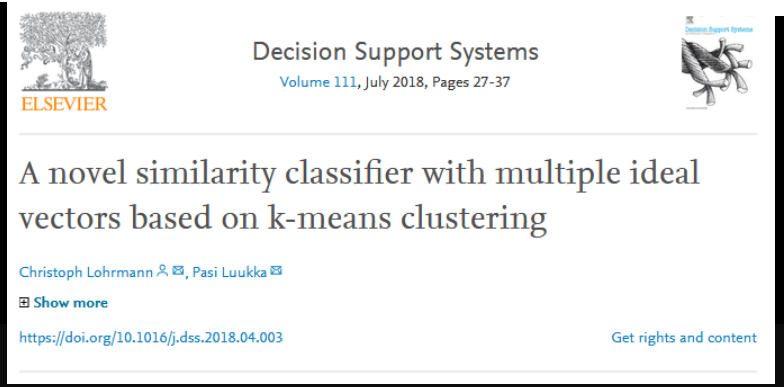
https://doi.org/10.1016/j.ijforecast.2018.08.004 Get rights and content



Decision Support Systems
Volume 111, July 2018, Pages 27-37

A novel similarity classifier with multiple ideal vectors based on k-means clustering

Christoph Lohrmann, Pasi Luukka

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https://doi.org/10.1016/j.dss.2018.04.003 Get rights and content

Renewable Energy Support Mechanisms

Ongoing research on the Russian renewable energy support mechanism for about five years

- ~10 arcticles, including the first published research article in English that in detail explains and analyzes the effect of the mechanism on investment profitability
  - Dr. Kozlova & Prof. Collan
- Also created new methods for the analysis of simulation results (a side product of the need to do better analysis)
  - Simulation decomposition
- Collaboration with:
  - Indra Overland, NUPI & Nord U. (NOR)
  - Fortum Foundation
  - Prof. Fleten, NTNU (NOR)
  - Prof. Yeomans, York. U (CAN)

Renewable Energy Support Mechanisms

Energy Policy 95 (2016) 350–360

Contents lists available at ScienceDirect

Energy Policy

journal homepage: www.elsevier.com/locate/enpol

Modeling the effects of the new Russian capacity mechanism on renewable energy investments

Mariia Kozlova *, Mikael Collan

School of Business and Management, Lappeenranta University of Technology, Skinnarilankatu 34, 53851 Lappeenranta, Finland

HIGHLIGHTS

- New Russian RE investment incentive mechanism is presented in detail.
- Effect of the mechanism on RE investment profitability is numerically illustrated.
- Sensitivity of project profitability to selected variables is studied.
- Sensitivity results are compared to results under a generic feed-in premium.
- The mechanism is shown to reduce market-related risks of RE investments.

Mining Analytics

World´s first holistic techno-economic analysis model for metals mining

- System dynamic model that encompasses both the technical side of a metal mining operation and the economics (cash-flows, balance sheet, profitability) of a metal mine
  - 10+ articles published on the topical area
  - Dr. Savolainen, prof. Collan, and prof. Luukka
- Extended model that exists analysis for the water balance of a metal mine has been constructed
  - Collaboration with the Finnish Geological Survey (GTK)
  - 2 articles (1 + 1 pending publication)
- Present and previous collaboration with:
  - Outotec, Terrafame, BHP Billiton (AUS)
  - University of Western Australia
  - University of Milano
  - Prof. Tuomas Koiranen (LUT) & Prof. Heikki Haario (LUT)
- We are on a second round with our EIT application about ”Intensive course on system dynamic simulation and real options for mining professionals”
- Collaboration around critical materials with Prof. Kraslawski (LUT)

Appendix 1: Simulation model

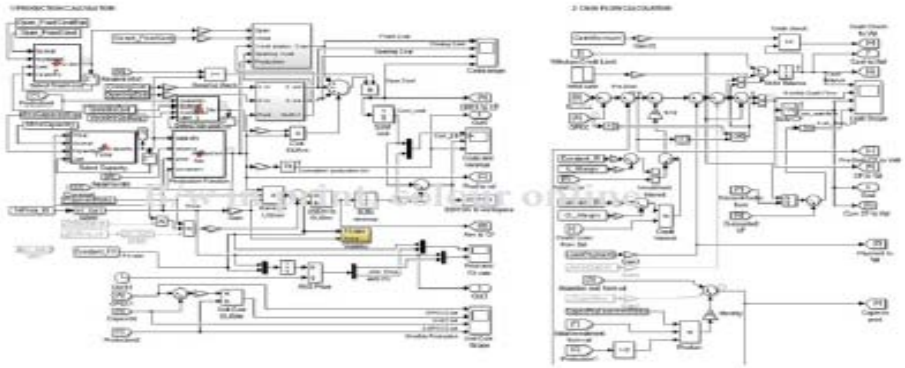


Figure A1. Function block diagrams of production and cash flow calculations from MATLAB Simulink.

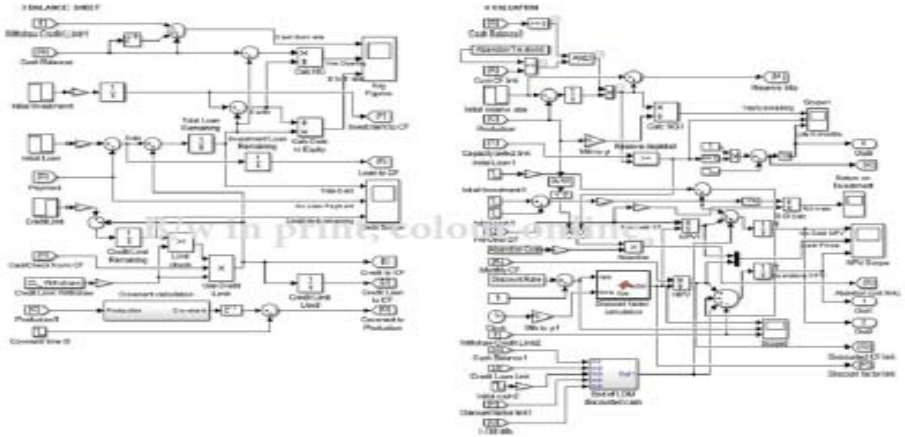
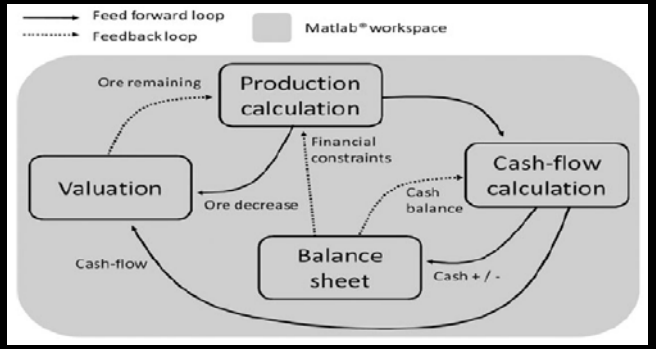


Figure A2. Function block diagrams of balance sheet and valuation calculations from MATLAB Simulink.



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The Engineering Economist
Mineral Economics
Kybernetes
Int. J. of Production Economics

THE ENGINEERING ECONOMIST
2016, VOL. 0, NO. 0, 1–19
http://dx.doi.org/10.1080/0013791X.2016.1167988

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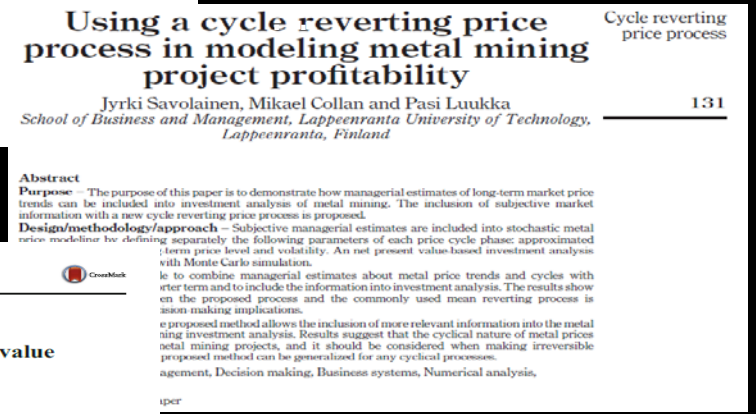
Analyzing operational real options in metal mining investments with a system dynamic model

Jyrki Savolainen, Mikael Collan, and Pasi Luukka

School of Business and Management, Lappeenranta University of Technology, Lappeenranta, Finland

ABSTRACT

This article presents a detailed system dynamic (SD) model of a metal mining investment that is usable in ex-ante profitability and operations management analysis. We show how the SD model can be used to analyze the profitability effect of three operational real options: the option to temporarily close production, the option to abandon production, and the option to increase production through cutoff grade change. The SD model allows for intuitive modeling of the multiple interactive real



Using a cycle reverting price process in modeling metal mining project profitability

Cycle reverting price process

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Jyrki Savolainen, Mikael Collan and Pasi Luukka

School of Business and Management, Lappeenranta University of Technology, Lappeenranta, Finland

Abstract

Purpose – The purpose of this paper is to demonstrate how managerial estimates of long-term market price trends can be included into investment analysis of metal mining. The inclusion of subjective market information with a new cycle reverting price process is proposed.

Design/methodology/approach – Subjective managerial estimates are included into stochastic metal price modeling by defining separately the following parameters of each price cycle phase: approximated [illegible]term price level and volatility. An net present value-based investment analysis [illegible]with Monte Carlo simulation.

[illegible]le to combine managerial estimates about metal price trends and cycles with [illegible]rter term and to include the information into investment analysis. The results show [illegible]en the proposed process and the commonly used mean reverting process is [illegible]ason making implications.

[illegible]e proposed method allows the inclusion of more relevant information into the metal [illegible]ning investment analysis. Results suggest that the cyclical nature of metal prices [illegible]netal mining projects, and it should be considered when making irreversible [illegible]proposed method can be generalized for any cyclical processes.

[illegible]agement, Decision making, Business systems, Numerical analysis,

[illegible]per

Miner Econ
DOI 10.1007/s13563-017-0102-2

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ORIGINAL PAPER

Investigating the effect of price process selection on the value of a metal mining asset portfolio

Mikael Collan[1] · Jyrki Savolainen[1] · Pasi Luukka[1]

Received: 20 June 2016 / Accepted: 20 January 2017

Abstract This paper studies how the selection of the metal price process used and the choice of selected other modeling assumptions affect the value of a metal mining company's mining asset portfolio. We compare results from when metal prices are assumed to be independent of each other, correlated with each other, and correlated with an external factor. These studies are carried out by using the geometric Brownian motion-based and mean-reverting metal price processes. What is also studied is the effect caused by replacing one of

Introduction

Profitability analysis of large industrial investment with long economic lives is difficult, and there are many issues that affect the accuracy and the credibility of these analyses. In this paper, the goal is to highlight the importance of the choice of stochastic processes, such as the price processes used in modeling the profitability of large industrial investments. Here, the focus is on the effect the choice of processes used

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