Tracking error and portfolio construction

Portfolio optimization with Mosek

BANKINVEST

NORDIC SWAN ECOLABEL
Investment fund
3101 0034

Curriculum Vitae

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Portfolio Manager in Global Equities
BankInvest

Mads Stenbo Nielsen joined BankInvest in 2019 as Portfolio Manager. Mads holds a position as Associate Professor of Finance at Copenhagen Business School (CBS). He has published in several international, peer-reviewed journals including Journal of Corporate Finance, Journal of Financial Intermediation, and Journal of Financial Econometrics. Mads also serves as external examiner at M.Sc.- and Ph.D.-level exams at several Danish universities. Mads holds a M.Sc. in Statistics from University of Copenhagen and a Ph.D. in Finance from Copenhagen Business School.

Curriculum Vitae

2019- Portfolio Manager BankInvest
Quantitative Strategies, Factor Investing, Portfolio Construction, Risk Modelling
2012- Associate Professor, Department of Finance, CBS
Research in Equity and Fixed Income, Teaching and Supervision in Statistics and Finance
2009-2012 Assistant Professor, Department of Finance, CBS

Research in Equity and Fixed Income, Teaching and Supervision in Statistics and Finance

Education / distinctions

M.Sc. in Statistics (2005), University of Copenhagen

Ph.D. in Finance (2011), Copenhagen Business School

CBS Education Prize 2011 (teaching award)

Best Paper Award 2012, Swiss Society for Financial Market Research (for the paper *Credit Spreads Across the Business Cycle*)

About BankInvest

BankInvest was founded in 1969 and is a leading asset manager and provider of UCITS funds and alternative investment funds (AIFM).

- BankInvest is a Danish investment association and asset manager. BankInvest provides mutual funds, investment and capital associations with a total assets under management and administration of **DKK 139 billion kroner**.
- BankInvest was established in 1969 as one of the first investment associations in Denmark.
- The ownership of the parent company BI Holding A / S consists of 38 regional and nation-wide banks
- The majority of the funds managed by BankInvest comes from approx. 210,000 investors who are customers of the roughly 50 Danish and foreign banks as distributors and advisors on BankInvest's investment products
- 44% of the assets under management are invested in bonds, **41% in equities** and the remaining assets are invested in alternatives and mandates with active allocation between shares and mandatory
- Approx. **62% of the assets are actively managed** for retail and institutional clients. BankInvest collaborates with local specialists in global submarkets. The remaining part is the administration of UCITS and AIFMs, which are not branded under the name BankInvest
- The BankInvest Group, which includes a number of financial companies, employs a total of more than 100 people.

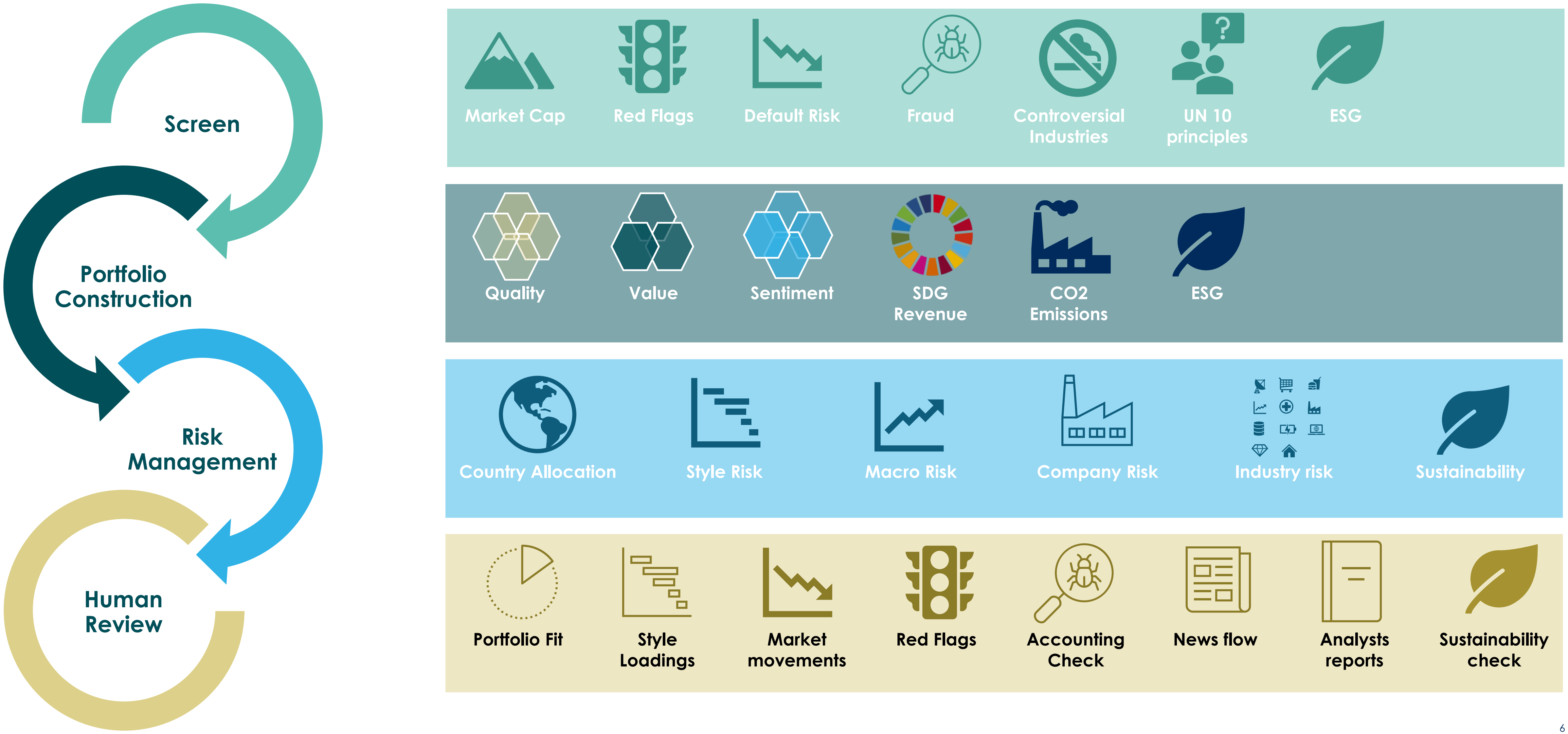
On the road to Mosek I…

- BankInvest's equity funds have traditionally applied a bottom-up, stock picking approach
- In 2019, BankInvest started an equity quant team (currently accounts for approx. AUM 27 billion kroner)
- Main IT infra structure building blocks:
    - SQL databases
    - R
    - Python
- Main data sources:
    - Market data (price, volume, turnover etc)
    - Company fundamentals (income statement, balance sheet, analysts' assessment)
    - Sustainability screens
    - Proprietary factor scores
- Portfolio optimization is applied to...
    - Factor investment objectives
    - Index tracking objectives

On the road to Mosek II…

- Portfolio optimization – 1st try:
    - Use simple, standard optimization packages in R/Python
    - Infeasible because of dimensionality, computational time, problem complexity (constraints, risk etc)
- Portfolio optimization – 2nd try:
    - Use 3rd party provider tools (Bloomberg, BlackRock Aladdin etc)
    - Cumbersome to implement with our existing code (requires external data upload, problems pre-specified)
    - Infeasible for back testing and risk analysis
- Portfolio optimization – 3rd try:
    - Mosek
    - Smooth implementation with existing code
    - Bespoke problem specification

BankInvest Quant Engine I



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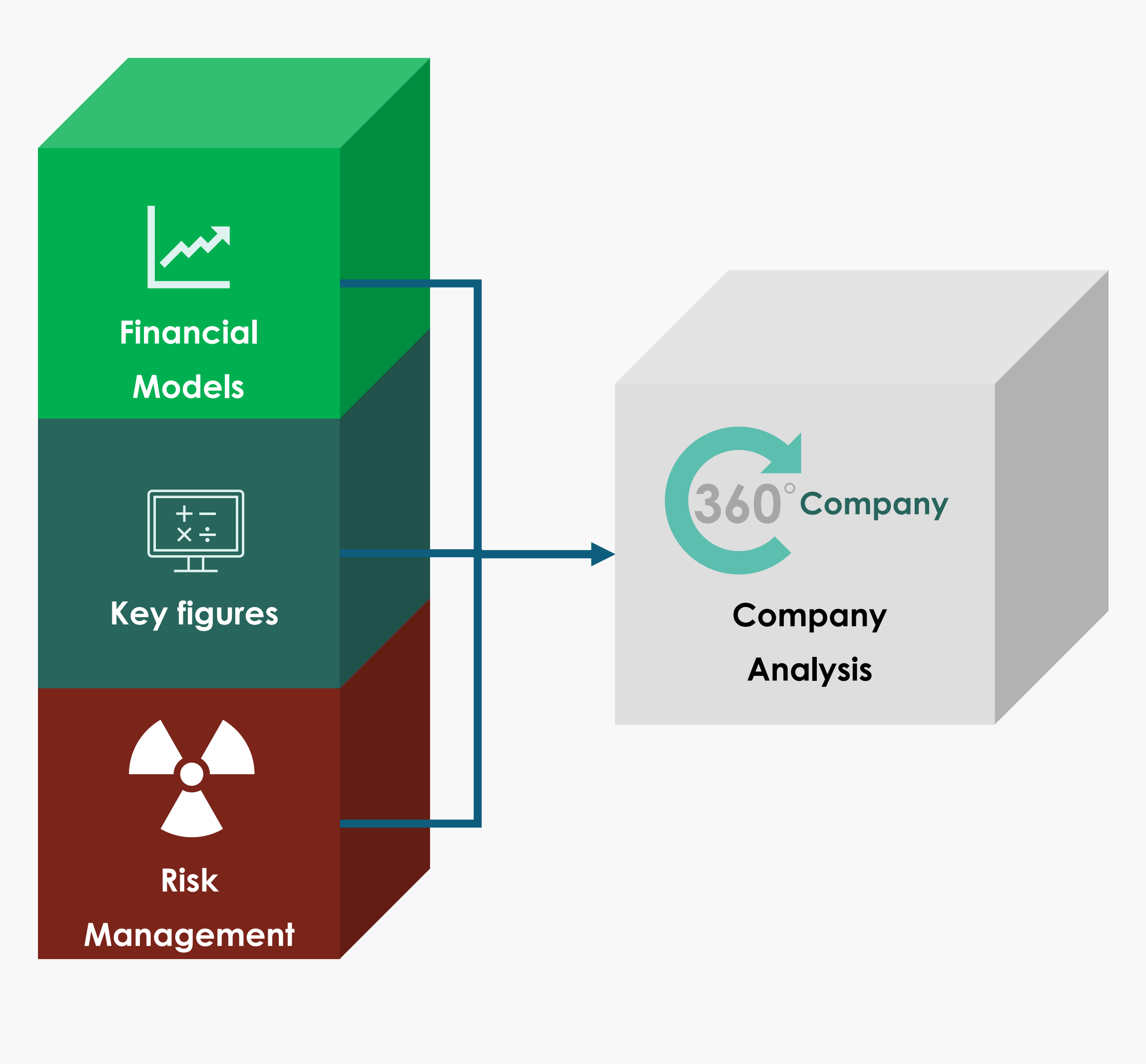
BankInvest Quant Engine II



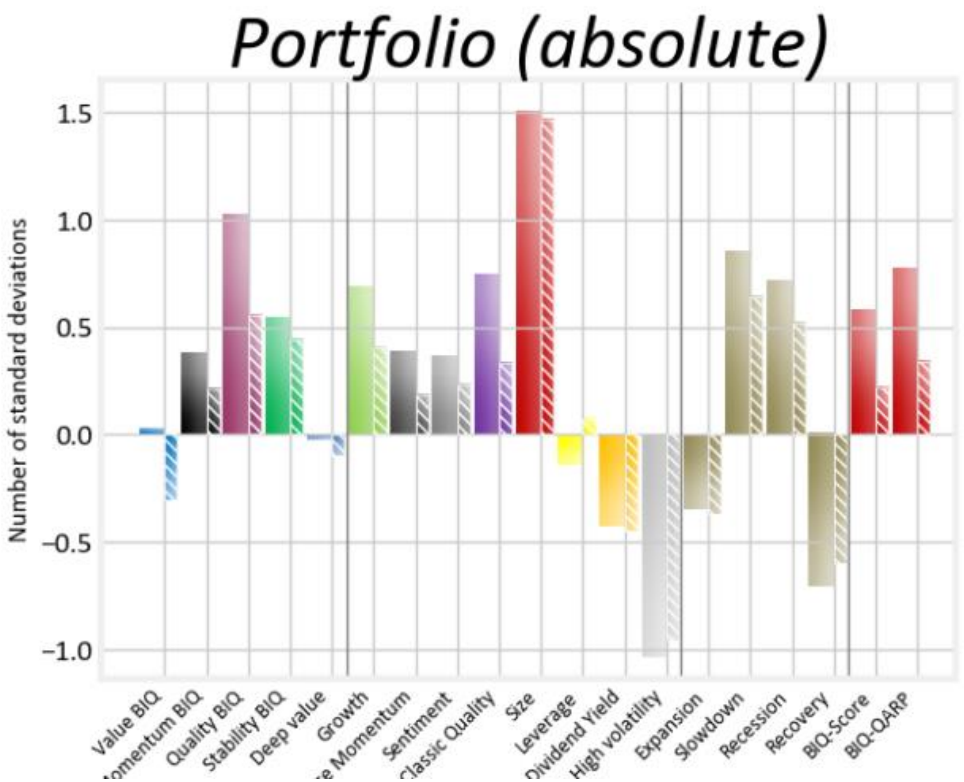
Our powerful combined Quant engine is built around the individual company. Everyday we calculate a full 360-degree company analysis of all companies in our universe.

360-degree Company analysis:

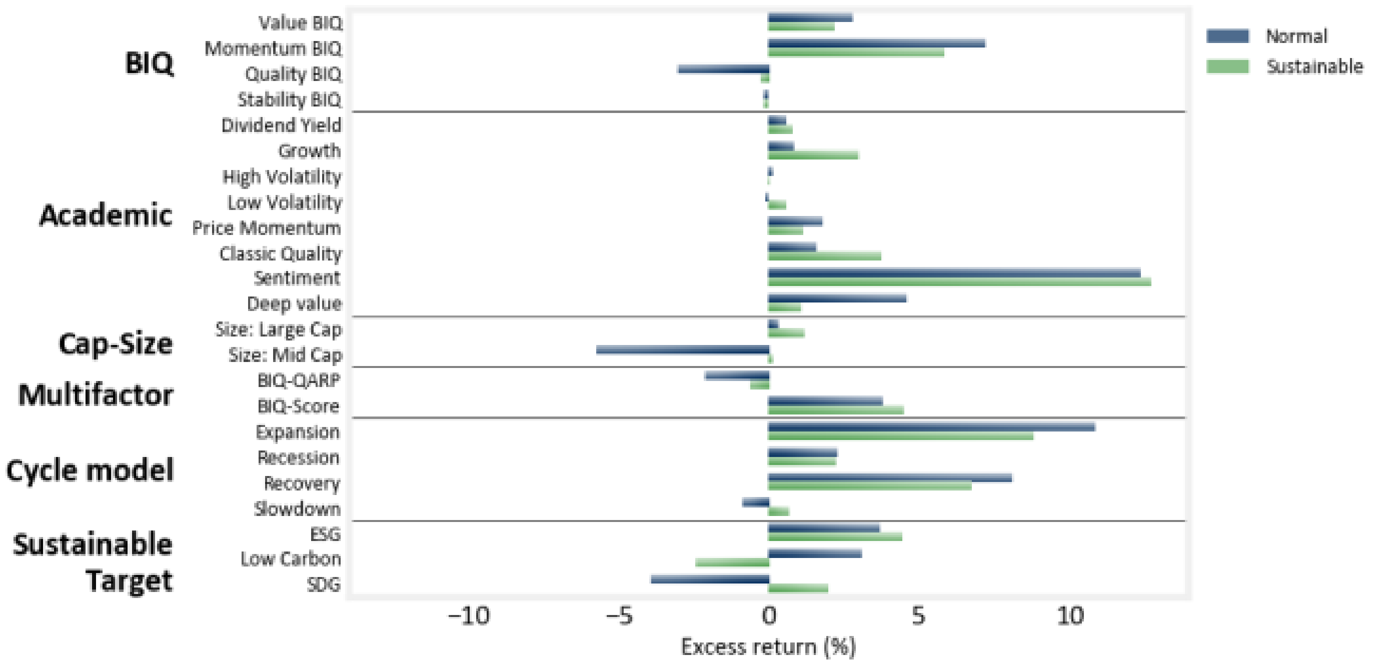
- **A full sustainability review**
- **A full risk overview**
- **A full balance sheet update**
- **All key figures**
- **A complete factor loading**

BankInvest Quant Engine III

Style map



Year-to-date



Case: Index tracking objective I

- Minimize tracking error subject to constraints
- Quadratic minimization
- Linear and binary constraints
- Control:
    - Number of stocks
    - Single-stock over-/underweights
    - Regional and section over-/underweights
    - Factor exposures (sector & regional)
    - Single-stock restrictions
    - Sustainability restrictions (ESG, SDG, CO_2 etc)
    - Turnover
    - Nuts and bolts
- Mixed-Integer is the only option
- Covariance matrix is – by definition – NOT sparse
- Dimensionality is an issue

Case: Index tracking objective II

- Challenges:
  - Specification of covariance matrix (rich but robust)
  - Fast optimization to accommodate multiple constraint specifications
  - Fast optimization to implement in daily task scheduling
  - Stable optimization ("prefer" local to global stability)
  - Is more constraints a blessing or a curse?

Disclaimer

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www.bankinvest.dk