Fordypning i investering, finans og økonomistyring

Financial Engineering, specialization

Fagkoordinator høst 2023 - vår 2024: Professor Verena Hagspiel

Formål:
Emnet gir fordypning innenfor bedriftsøkonomi.
Faggruppen ønsker å gi dere en mulighet til å arbeide i en lengre periode med et problem som er mer komplisert og detaljert enn de problemer som normalt tas opp i forelesningene. Kompleksiteten i problemene er vanligvis av en slik art at dere trenger å bruke kunnskap fra flere fag dere har tatt eller tar parallelt, i tillegg til å lese seg til ny kunnskap. Faget er også et tilbud til dere om veiledning i relasjon til problemstillinger som dere reiser selv, til forskjell fra forelesninger hvor det er foreleseren som kommer med problemene. Det er altså mulig å foreslå oppgaver selv – kontakt en av veilederne om dette.

Forutsetning:
Presise krav til emnekombinasjoner som kvalifiserer til IFØ-fordypningen er beskrevet på Emner på Nett. Vi forventer minst kunnskaper tilsvarende TIØ4145 Finansstyring, og en av følgende: TIØ4317 Empirisk finans, TIØ4140 Prosjektfinans.

Dette er en større skriftlig oppgave.
Arbeidet med oppgaven vil ofte bestå av følgende:

- Lese ny "teori".
- Klargjøre/forstå det praktiske/teoretiske problemet.
- Framskaffelse av data.
- Lage økonomiske modeller.
- Implementere disse.
- Skrive rapport.

Besvarelsen redigeres mest mulig som en forskningsrapport med et abstract, konklusjon, litteraturliste, innholdsfortegnelse etc. Ved utarbeidelse av teksten skal kandidaten legge vekt på å gjøre teksten oversiktlig og velskrevet. Med henblikk på lesning av besvarelsen er det viktig at de nødvendige henvisninger for korresponderende steder i tekst, tabeller og figurer anføres på begge steder. Ved bedømmelsen legges det stor vekt på at resultatene er grundig bearbeidet, at de oppstilles tabellarisk og/eller grafisk på en oversiktlig måte og diskuteres utførlig. Det er meget viktig at alle benyttede kilder, også muntlige opplysninger, oppgis fullstendig. (For tidsskrifter oppgis tittel, årgang, sidetall og evt. figurnr. For bøker oppgis forfatter, tittel, årgang, opplag, sidetall og evt.

figurnr.).

Valg av oppgave

Beskrivelsene av problemene er ment som en hjelp for å velge oppgave. De er ikke ment som komplette oppgavetekster. Det vil heller ikke bli laget noen oppgavetekst. Oppgaven vil bli til underveis i diskusjon mellom studenter, veileder(e) og eventuell bedriftskontakt. Oppgaven som velges skal i utgangspunktet videreføres i masterprosjektet. Erfaring har vist at studenter som gjør prosjekt- og masteroppgave i tilknytning til samme problemstilling blir mest tilfreds. Derfor ønsker vi ikke å gi prosjektoppgaver som vi ikke tror at det finnes en masteroppgave-oppfølging til.

Hver oppgave er beskrevet med en kort tekst. Deretter følger informasjon om eventuell samarbeidspartner samt veileder. En person er listet som hovedveileder og det er denne som skal kontaktes om det er spørsmål knyttet til oppgaven. Videre er oppgaven merket med hvilken eller hvilke av IØTs strategiske forskningsinitiativ oppgaven er koplet mot. De strategiske forskningsinitiativene er; Technology-based organization design, Leading Transitions: Co-create a sustainable future, Green Value Creation – Circular Economy og Health and the Public Sector. Oppgaven er merket med «Sustainability» om bærekraft er et viktig tema i oppgaven.

Det vil bli arrangert workshops relatert til de strategiske forskningsinitiativene og bærekraft. Studenter som får tildelt oppgaver som er merket med forskningsinitiativ eller bærekraft vil bli invitert til disse workshopene. Det er frivillig å delta. Andre studenter vil også kunne delta med forbehold om plass og ressurser.

Valg av oppgave gjøres i et nettskjema. Nettskjemaet innebærer et valg av fem ulike oppgaver i prioritert rekkefølge. Studentene må velge oppgaver med minst tre ulike hovedveiledere. Studentene må forvente å få tildelt hvilket som helst av disse, inkludert 5. valget.

Studenter som vil skrive egendefinert oppgave må avklare oppgaven med veileder før de velger. Studenter med egendefinert oppgave velger IFØ1 som en av de fem valgte oppgavene. Se mer informasjon om egendefinert oppgave under IFØ1 senere i dokumentet. Det må i så fall også oppgis veiledere i nettskjemaet. Det er ikke sikkert at en student blir tildelt en egendefinert oppgave. Dette avhenger av den totale ressurssituasjonen blant veilederne.

Der det er oppgitt biveileder kan denne på grunn av ressursmessige årsaker bli hovedveileder for oppgaven. Det er ikke mulig å ønske seg eksplisitt en av veilederne blant de som er listet. Der det er angitt kontaktpersoner i samarbeidsinstitusjoner skal disse ikke kontaktes før det eventuelt er gitt klarsignal fra oppgitt hovedveileder (med mindre annet er angitt i oppgaveteksten).

I prosessen med tildeling av oppgaver vil det tas hensyn til fordelingen mellom de ulike veilederne og studentenes prioritering. Der en person står som hovedveileder på mange oppgaver, kan det tenkes at personen ikke vil ha kapasitet til å ha studenter på alle oppgavene. Dersom dette blir tilfelle kan en annen veileder bli tildelt av de som står listet i oppgaveteksten. Vi vil enda en gang understreke at dersom det er mange studenter som har valgt de samme oppgavene, må en være forberedt på at en får tildelt oppgave som står lenger ned på prioriteringslisten. En studentgruppe kan altså bli tildelt sitt femtevalg, til tross for at andrevalget ikke er tildelt en gruppe. En forklaring på dette kan være at veilederen på oppgaven ikke har kapasitet til å veilede flere oppgaver.

Det er sterkt anbefalt at studentene utfører arbeidet i grupper på to studenter, selv om det er mulig å være 1 eller 3 studenter i en gruppe. Vi anbefaler at dere selv finner en student å samarbeide med i prosjektet. Studenter som ønsker å skrive med noen, men som ikke har funnet noen å skrive med, kan oppgi dette i kommentarfeltet i nettskjemaet.

Det kan også være mulighet for å fortsette på doktorgradsstipend i etterkant av mastergraden. Dersom noen ønsker å forhøre seg om muligheten for dette, anbefaler vi at de tar kontakt med de aktuelle veiledere, helst så snart som mulig.

Mulige veiledere

Felipe van de Sande Araujo, tlf 48 65 59 90, felipe.van.de.s.araujo@ntnu.no

Felipe is a Ph.D. candidate at the Dept. of Industrial Economics and Technology Management. He conducts research in the field of electricity market design. He holds a MSc in Finance from PUC Rio, Brazil. His interests include game theory, blockchains and derivative pricing.

Førsteamanuensis II Einar Belsom, tlf 41 50 97 67, Einar.Belsom@oslomet.no

Hans hovedstilling er ved Oslomet. Hans doktorgrad innenfor industriell økonomi omhandler metoder for måling av produktivitet når det er behov for samtidig evaluering av flere faktorer. Hans faglige interesser ellers er rettet mot bedriftsøkonomiske temaer med vekt på styrings- og insentivsystemer, bedriftsfinans/fusjoner og oppkjøp, dvs i skjæringspunktet mellom finans og strategi. Flere ganger mottaker av IØTs pris for beste veileder. Bakgrunn fra bla McKinsey.

Professor Peter Berling, lars.p.berling@ntnu.no

I hold a Ph.D. in Production Management from Lund University. After my dissertation, I spent one year as a guest professor at MIT's logistics center in Zaragoza. After having spent some years as a faculty member at Linnaeus and Lund University I joined IØT at NTNU 2021. My primary fields of interest are operations research applied to production and inventory control problems. It includes work in the intersect of operations and finance, contract issues, sustainable inventory control and efficient heuristic for multi-echelon inventory control including Omni-channels.

Professor Stein-Erik Fleten, tlf. 46 69 47 93, Stein-Erik.Fleten@ntnu.no
Stein-Erik arbeider innen kvantitativ bedriftsøkonomi; beslutninger under usikkerhet og realopsjoner: teori, casestudier og empiriske analyser. Anvendelser er ofte innenfor kraftsektoren (investeringsanalyse, risikostyring, driftsplanlegging/ produksjonsoptimalisering, prisanalyse) og andre råvaremarkeder. Typiske oppgaver innebærer kombinasjon av mikroøkonomi/finans, optimering og ingeniørkunnskap, gjerne beregningsorientert.

Rodrigo Graça - rodrigo.graca@ntnu.no

Rodrigo is a Ph.D. candidate at the Dept. of Industrial Economics and Technology Management. He conducts his research in the field of Sustainable Finance. In particular, he is focused on providing data-driven insights on Positive Impact bonds, regarding their environmental and financial impacts.

Professor Verena Hagspiel, **verena.hagspiel@ntnu.no**

Verena holds a Ph.D. in Economics and a Dipl.-Ing. in Technical Mathematics as well as a M.Sc. in Quantitative Finance and Actuarial Sciences. After working as a postdoctoral researcher at the University of Lausanne and the Technical University of Lisbon, she joined the IØT department as an Associate Professor in 2013. Her primary fields of interest are microeconomics, industrial economics, energy economics and quantitative finance. She applies financial and operational methods for analyzing investment decisions under uncertainty. she is interested in how dynamics and uncertainty affect the firm's investment, operations and innovation. Her main field of research lies in the area of real options analysis. Here contributions range from the development of novel theoretical models to applications in industry. She has collaborated with several energy companies from the renewable as well as oil & gas sector but has also worked on applications related to the Norwegian aquaculture industry, deep sea mining or automotive industry.

Professor II Franziska Holz, **fholz@diw.de**

Franziska Holz is an International Adjunct Professor in the NTNU's Energy Transition Programme (NETI). Franziska studied economics at Paris 1 University Panthéon-Sorbonne (1998-2003) and obtained her PhD in energy economics in 2009 from TU Berlin. Franziska's main affiliation is with the German Institute for Economic Research (DIW Berlin) where she is Deputy Head of the Department of Energy, Transportation, and Environment and coordinates the research area resource and environmental markets in the department. Her research deals with international natural gas, coal, and oil markets. She focuses on the interaction of these markets with climate policies, mostly by using numerical equilibrium models (also see www.diw.de/cv/en/fholz).

Førsteamanuensis Maria Lavrutich, tlf 73 59 31 89, maria.lavrutich@ntnu.no

Maria holds a PhD from Tilburg University (2016). Fields of interest include mathematical finance, industrial organization and decision theory (with applications to real options) and sustainable finance. In her research she focuses on firms' investment and innovation strategies and has developed models of investment under uncertainty and risk management, as well as their applications in different industries, including aquaculture, electricity, oil and gas, pharmaceuticals.

Associate professor Malvina Marchese Malvina.Marchese@city.ac.uk

Malvina Marchese is a PhD and Associate Professor at Bayes Business School in London. Her field of specialization covers; Forecasting, with emphasis on commodity markets forecasting. Panel data Econometrics, with emphasis on quantile regressions for panel data models and applications to banking. Econometric Theory, with emphasis on asymptotic theory for fractionally integrated processes. Before entering academia, she has worked/work as a forecast consultant for Maersk Broker and head of risk management at Shell Oil.

Olga Noshchenko – tlf 92 97 41 65; olga.noshchenko@ntnu.no

Olga is a Ph.D. candidate at the Department of Industrial Economics and Technology Management. She conducts her research in the field of petroleum economics. In particular, she is focused on multi-objective optimisation and decision making under uncertainty. Her research is aimed to improve economic and environmental performance of offshore field projects.

Farida Mustafina – tlf 45398985; Farida.mustafina@ntnu.no

Farida is a Ph.D. candidate at the Depart. of Industrial Economics and Technology Management. She conducts her research in the field of economics of deep-sea mining activities. In particular, she is focused on investment decision making under uncertainty. Her previous research experience is related to deep-sea mining as well.

Førsteamanuensis Carlos Oliveira carlos.m.d.s.oliveira@ntnu.no

Carlos holds a Ph.D. in Mathematics, a M.Sc. in Mathematical Finance, and a bachelor's in Applied Mathematics to Economics and Management. Before he joined IØT, he was a postdoctoral researcher in the Group of Mathematical Physics in Lisbon, and an Assistant Professor at Lisbon School of Economics and Management, where he did research in Quantitative Finance and Actuarial Science. He is particularly interested in the field of real options, reinsurance, and sustainable finance. He has also collaborated as a researcher on projects in insurance and investment in alternative energy sources.

Førsteamanuensis Rita Pimentel, rita.pimentel@ntnu.no

https://www.ntnu.edu/employees/rita.pimentel

Rita holds a Ph.D. in Statistics and Stochastic Processes as well as an M.Sc. in Mathematical Finance. After working as a researcher at the Research Institutes of Sweden (RISE), she joined IØT as an Associate Professor in 2020. At RISE she applied different machine learning techniques to make predictions for companies in different sectors (such as ABB, Bombardier, Holmen, among others). Currently, she researches sustainable finance, applications of artificial intelligence (AI) in finance, Fintech, and decisions under uncertainty. She is also the project manager of COMPAMA, an interdisciplinary project funded by The Research Council of Norway, which the main purpose is to understand the economic impact of decisions, made by both machines and human agents. She has been collaborating in the COST (European Cooperation in Science & Technology) action called Fintech and Artificial Intelligence in Finance funded by the European Union.

Morten Risstad, tlf 97 16 62 63, morten.risstad@sb1markets.no

Morten Risstad is an industrial Ph.D-candidate at the Department of Industrial Economics and Technology Management (IØT) at the Norwegian University of Science and Technology (NTNU). His research interests lie in the fields of empirical finance, asset pricing and risk management. He holds a Master of Science in Business from NTNU/Nord University and is a Certified European Financial Analyst (CEFA) from NHH. Risstad is currently Head of FX and Rates at Sparebank1 Markets and has previously held various positions in the finance departments of Danske Bank, Norsk Hydro and Telenor.

Professor II Ståle Størdal, tlf 99 40 93 71, stale.stordal@ntnu.no

Ståle har hovedstilling på Høgskolen i Innlandet innenfor bedriftsøkonomi med hovedvekt på ressursbaserte næringer. Han har jobbet med studier av markeder for skogprodukter og energi, spesifikt med empiriske analyser av råvaremarkeder og finansielle beslutninger under usikkerhet, herunder investeringsanalyser. Han har tidligere jobbet 15 år innen energisektoren med kraftmarkedsanalyser, porteføljeforvaltning og hatt ansvar for finansiell handelsvirksomhet.

Professor Sjur Westgaard, tlf 73593511/ 91897096, sjur.westgaard@ntnu.no.

Sjur Westgaard forsker og underviser i ulike finansfag. Han er utdannet ved NHH og IØT-NTNU hvor han på også har sin PhD. Tidligere har han jobbet som kapitalforvalter, kredittanalytiker og prosjektleder ved ulike finans-/bankinstitusjoner. Hans forskningsinteresser omfatter risikomodellering og empirisk analyse av finans- og råvaremarkeder med for tiden spesiell fokus på energimarkedet.

Liste over prosjektoppgaver:

IFØ1. Egendefinert studentprosjekt

Studenter som vil skrive en egendefinert oppgave må avklare dette med en veileder på forhånd. For at dette skal fungere så bra og rettferdig som mulig gjelder følgende

Studenten må planlegge en egendefinert oppgave i god tid før valget skal tas 4. mai

Studenten må presentere en tydelig prosjektbeskrivelse til en potensiell veileder

Veilederen vurderer prosjektbeskrivelsen og om han/hun har kompetanse og mulighet for veiledning

Studenten bør ha fått godkjent fra veilederen før minglemøtet 26. april

Studenten kan etter godkjennelse fra veilederen velge IFØ1 som ett av sine fem valg. Navnet på veilederen må oppgis i kommentarfeltet i nettskjemaet

IFØ2. A risk aversion index for Norway

Identifying the dynamics of risk aversion (price of risk) and economic uncertainties (amount of risk) is crucial to understand their effects on both domestic and international asset prices.

Bekaert et. al (2021) separately identify time-varying uncertainty in U.S. fundamentals, using macro data, and time-varying aggregate risk aversion, using both macro data and financial asset prices, through the lens of a dynamic asset pricing model. In this project we will develop a similar risk aversion index for Norway.

Keywords

Risk aversion, utility, macroeconomic uncertainty

Main supervisor: Morten Risstad

Co-supervisor: Sjur Westgaard

Starting references

Bekaert, Geert, Eric C. Engstrom, and Nancy R. Xu. "The time variation in risk appetite and uncertainty." Management Science 68.6 (2022): 3975-4004.

Bowe et. al (2023). A high-frequency financial conditions index for Norway. Norges Bank Staff Memo 1/2023

For more information, please contact Morten Risstad, morten.risstad@sb1markets.no, to schedule a meeting.

IFØ3. Analysis of the short term markets for Norwegian crude oil

In this project we will analyse the short term markets for crude oil delivered from the Norwegian continental shelf. This includes the market for physical cargoes, as well as the short-term financial markets. The motivation is that this is these are the main markets that generate the Norwegian oil revenues.

We take the perspective of an oil field operator or an industrial buyer, and aim at supporting their pricing and valuation challenges. Prospective sellers include Equinor, Vår Energi, Okea, DNO, Aker BP, and prospective buyers include Exxonmobil, Preem, Shell, BP, Mongstad (Equinor). Also large distributors or consumers of oil products, and professional trading firms, are relevant contact companies.

Example background problems:

What is the value of converting the Mongstad refinery into a terminal?

How efficient are the short term markets for crude oil?

What are good strategies for pricing the differential value or cost associated with oil grades associated with different oil fields (relevant for field operators without a trading department, for example)?

An important aim for the project thesis is to get an overview of the spot market for crude oil, and its connection to short-term financial markets. Although this market is accessible only for large industrial players and constitute a small share of oil product turnover, it is crucial as an underlying reference for derivative transactions. Trade happens over the phone, text or online, and is standardized in terms of delivery location, whether freight is included or not, cargo size, and delivery timing. On the other hand, there are price differentials depending on the oil quality and location. The two major price assessment agencies are Platts and Argus. The main spot index is Platts Brent Dated, and the main financial contracts are traded on the ICE exchange. There are two intermediate markets in between; a “contracts for differences” financial market, and an “exchange of futures for physical” market operated by ICE. Some of the forward contracts can be physically settled, and we would like to learn if, and to what degree, this creates opportunities for trading gains. We also want to understand the tradeoffs involved in the exact timing of selling or buying crude oil. Finally, we want to understand the risks associated with using the various buying/selling channels, and how these risks can be managed.

A project thesis will naturally aim at addressing the questions just mentioned, while a master thesis would aim for one of the example background questions or a similar challenge.

Unfortunately, NTNU does not subscribe to (all) data series from Platts. Students need to get in touch with a company that has access, or rely on publicly available data and Eikon databases.

Main supervisor: Stein-Erik Fleten

For more information, please contact Stein-Erik Fleten, stein-erik.fleten@ntnu.no to schedule a meeting.

IFØ4. Approximating the exercise boundary for American options using machine learning

Monte-Carlo simulations are more suitable handling European option pricing problems if there are many stochastic variables. For American option pricing, as summarized in an overview by Kind (2005), a regression approach proposed by Longstraff and Schwarz (2001) and an exercise boundary parameterization approach proposed by Andersen (2000) are popular simulation methods.

In Andersen (2000), the early boundary is determined iteratively by starting at the maturity, with a known boundary of strike price, and going backward in time. More recent works using early exercising boundary approach can be found in, for example, Ibanez and Fernando (2004) and Ibáñez and Velasco (2018).

In this project, we investigate the exercise boundary approach for American option pricing using modern machine learning techniques. For example, a neutral network can be used to learn the hold and exercise regions, separated by the exercising boundary. Some pioneer work is done in Becker (2019).

Main supervisor: Rita Pimentel

Co-supervisor: Ying Ni (Mälardalens University, Sweden)

References:

Kind, A. (2005). Pricing American-style options by simulation. Financial markets and portfolio management, 19(1), 109-116.

Longstaff, F. A., and Schwartz, E. S. (2001). Valuing American options by simulation: a simple least-squares approach. The review of financial studies, 14 (1), 113-147.

Andersen, L. (2000). A Simple Approach to the Pricing of Bermudan Swaptions in the Multi-Factor Libor Market Model. Journal of Computational Finance, 3, 5–32.

Ibanez, A., & Zapatero, F. (2004). Monte Carlo valuation of American options through computation of the optimal exercise frontier. Journal of Financial and Quantitative Analysis, 39(2), 253-275.

Ibáñez, A., & Velasco, C. (2018). The optimal method for pricing Bermudan options by simulation. Mathematical Finance, 28(4), 1143-1180.

Becker, S., Cheridito, P., & Jentzen, A. (2019). Deep optimal stopping. Journal of Machine Learning Research, 20, 74.

For more information, please contact Rita Pimentel, rita.pimentel@ntnu.no, to schedule a meeting.

IFØ5. Assessment of electrification strategies under uncertainty

Climate change is a pressing global issue, and Norway has committed to cut carbon emissions by a minimum of 50% by 2030, relative to 1990 levels. Oil and gas production on the Norwegian continental shelf (NCS) contributes not only to the national budget and export revenues but also to a large share of GHG emissions in Norway. The use of on-site gas turbines to power energy-intensive operations on offshore platforms is the primary source of emissions.

Therefore, there is a growing interest in identifying effective strategies that promote the decarbonization of the operations on the NCS. For many years connection of platforms to the onshore grid has been the primary solution for mitigating emissions. However, this solution is not universally applicable due to the significant expenses associated with cable connection over large distances and political pushback. Offshore wind farms (OWFs) have emerged as a promising alternative for powering remote platforms. At the same time, the feasibility and profitability of such electrification projects are exposed to risks, due to significant uncertainties attached to the amount of capital expenditure required, geological and market factors, as well as commodity and CO2 price fluctuations.

In this project we will assess the economic feasibility of an electrification project when being confronted with uncertainty, gain insight into what drives the choice between different electrification alternatives and draw policy conclusions on the effect of different support mechanisms indented to incentivize investment in electrification to facilitate the decarbonization of offshore operations.

We will apply the methodology to a real-life case of an offshore installation on the NCS. To correctly make decisions under uncertainty we will apply two different real options approaches.

Formulate the decision problem as an optimal stopping problem (Dixit and Pindyck, 1994) and applying the simulation based least-square Monte Carlos approach as in e.g., Fedorov et al. (2021).

Formulate the decision problem as a multistage stochastic integer programming model that will be solved using a Stochastic Dual Dynamic Integer Programming algorithm as in e.g., Bakker et al. (2021).

The students could, for example, focus on one method during Fall and on the second method during Spring. Comparing the two methods against each other will give us important insight on their strengths and weaknesses in terms of solving real-life cases.

It will be beneficial for students to have a background in computer science.

This project is linked to the BRU21–NTNU Research and Innovation Program on Digital and Automation Solutions for the Oil and Gas Industry (www.ntnu.edu/bru21) and supported by OKEA ASA. This will give students access to the multidisciplinary network of the program.

References:

[1] Semyon Fedorov, Verena Hagspiel, Thomas Lerdahl, Real options approach for a staged field development with optional wells, Journal of Petroleum Science and Engineering, Volume 205, 2021.

[2] Steffen J. Bakker, Andreas Kleiven, Stein-Erik Fleten, Asgeir Tomasgard, Mature offshore oil field development: Solving a real options problem using stochastic dual dynamic integer programming, Computers & Operations Research, Volume 136, 2021.

Main supervisor: Verena Hagspiel

Co-supervisor: Steffen Bakker, Olga Noshchenko (PhD candidate of NTNU's BRU21 program),

Strategic research initiative: Leading transitions: Co-create a sustainable future

Sustainability

For more information, please contact Verena Hagspiel, verena.hagspiel@ntnu.no, email, to schedule a meeting.

IFØ6. Bruk av batterier for å utnytte kapasitet i strømnettet

Som en del av det grønne skiftet står Norge overfor en stor økning i forbruk av fornybar elektrisitet og dermed også behov for ny produksjon. Mye av denne er uregulert for eksempel i form av vindkraft. Produksjon oppstår derfor ikke nødvendigvis når det er behov for det og heller ikke nødvendigvis i nærheten av forbruket. Dette krever et robust strømnett. I og med at strømnettet må dimensjoneres etter høyeste last vil forbruks- og produksjonsutviklingen kunne medføre behov for store nettinvesteringer.

Bruk av batterier er blitt framsatt som en mulighet for å unngå eller utsette nettinvesteringer. Batterier vil dermed kunne nyttes til å jevne ut lasten i strømnettet og dermed utnytte kapasiteten bedre. Dette vil ha store positive samfunnsøkonomiske konsekvenser, og gi mulighet for bedriftsøkonomisk lønnsomhet, som igjen vil medføre lavere nettleie for forbrukerne. Samtidig kan batterier kunne brukes til å levere systemtjenester (balansere ut forbruk og produksjon, spenningsregulering mv.) og gi mulighet for prisarbitrasje ved å utnytte prisvariasjoner. Denne oppgaven skal se på økonomiske effekter av bruk av batterier i strømnettet i samarbeid med energiselskapet Eidsiva Energi AS, som blant annet eier Elvia AS, Norges største nettselskap (sett bort fra Statnett).

Innledningsvis vil man i samarbeid med Eidsiva velge en egnet case for å se på bruken av batterier i Norden. Deretter må det velges en hensiktsmessig metode. Her vil det være naturlig å se på ulike former for investeringsanalyser både nåverdianalyser og bruk realopsjoner. Analysene kan utføres enten fra batterieiers ståsted, fra nettselskapets ståsted, eller fra begge parters ståsted.

En mulig oppdeling i prosjektoppgave og master er å gjennomføre en litteraturstudie som kartlegger mulige problemstillinger og metoder, og i masteroppgaven å velge en spesifikk problemstilling og metode og utvikle dette for Eidsiva.

Industry partner: Eidsiva Energi AS

Main supervisor: Ståle Størdal

Industry Co-supervisor: Jørn Gunnar Kleven (jorngunnar.kleven@eidsiva.no)

Strategic research initiative: Green Value Creation - Circular Economy

For more information, please contact Ståle Størdal, stale.stordal@ntnu.no, to schedule a meeting

IFØ7. Convergence of regional natural gas prices in the global market?

Recently, much public attention has been paid to natural gas markets. However, many features of the global natural gas markets are still not well understood. One reason is that natural gas markets have substantially evolved in the last two decades: more and more countries have started to use and import natural gas, shale gas has turned the U.S. into a net exporter that provides flexible LNG deliveries to the global market, oil price indexation in the contracts has increasingly been abandoned, etc. During the energy crisis in Europe in 2022, extremely high prices in the European lead marketplace, TTF, ensured a constant high inflow of LNG. At the same time, prices in Asia and the U.S. were only a fraction of European prices.

There have been recurrent investigations whether LNG has contributed to linking regional (pipeline-based) natural gas markets (e.g., Siliverstovs et al. 2005, Neumann 2009, Maxwell and Zhu 2011, Li et al. 2014, Barnes and Bosworth 2015). Back then natural gas prices around the world were still very much linked to oil prices and decoupling had only started (Brown and Yucel 2009, Asche et al. 2013). Another major regional energy crisis, the Fukushima accident in Japan, led to similar regional gas price spikes (Stern 2014). Geng et al. (2016) find no evidence that the shale gas revolution impacted gas prices in other world regions such as Europe, but their data only cover a time period without U.S. LNG exports. Surprisingly, there has not been much literature since the U.S. started LNG exports in 2016 even though this was a paradigm shift.

The aim of the project is for students to estimate the existence of (long-term) convergence of regional prices in the global natural gas market.

Activities include:

Familiarization with the topic, relevant literature and relevant methods;

Collecting relevant gas price data from several world regions;

Use of time series or panel analysis using STATA, R or Eviews;

Analysis and discussion of results.

There will be an opportunity to spend time in Berlin and work as guest researcher at the German Institute for Economic Research (DIW Berlin) in downtown Berlin within walking distance to Brandenburg Gate, Gendarmenmarkt, HU Berlin, Checkpoint Charlie, Potsdamer Platz….

Main supervisor: Franziska Holz | Secondary supervisor: Anne Neumann

Strategic research initiative: [Leading transitions: Co-create a sustainable future]

External partner: DIW Berlin (German Institute for Economic Research)

References:

F. Asche, B. Misund, M. Sikveland (2013): The relationship between spot and contract gas prices in Europe. Energy Economics 38: 212-217.

R. Barnes, R. Bosworth (2015): LNG is linking regional natural gas markets: Evidence from the gravity model. Energy Economics 47: 11-17.

S. P. A. Brown, M. K. Yucel (2009): Market arbitrage: European and North American natural gas prices. The Energy Journal 30 (Special Issue): 167-186.
J.-B. Geng, Q. Ji, Y. Fa (2016): The impact of the North American shale gas revolution on regional natural gas markets: Evidence from the regime-switching model. Energy Policy 96: 167-178.
R. Li, R. Joyeux, R. D. Ripple (2014): International natural gas market integration. The Energy Journal 35 (4): 159-180.
D. Maxwell, Z. Zhu (2011): Natural gas prices, LNG transport costs, and the dynamics of LNG imports. Energy Economics 33: 217-226.
A. Neumann (2009): Linking natural gas markets - Is LNG doing its job? The Energy Journal 30 (Special Issue): 187-200.
B. Siliverstovs, G. L'Hégaret, A. Neumann, C. v. Hirschhausen (2005): International market integration for natural gas? A cointegration analysis of prices in Europe, North America and Japan. Energy Economics 27 (4): 603-615.
J. Stern (2014): International gas pricing in Europe and Asia: A crisis of fundamentals. Energy Policy 64: 43-48.

For more information, please contact Franziska Holz, fholz@diw.de, to schedule a meeting

IFØ8. Corporate Risk Management for Power Producers

This project addresses risk management tools for energy companies. The liberalization and integration of energy markets (oil, gas, coal, el, carbon) has fundamentally changed the way power companies do business over the last two decades. Competition has created both strong incentives for improving operational efficiency as well as the need for effective financial risk management. Several factors have increased the total risk exposure for power companies: More renewables in the input mix have changed the dynamics of European electricity markets; Political risk (e.g. Ukrainian war) has created huge supply risk on the supply side of energy commodities (particularly natural gas); Monetary policy (tapering of quantitative easing and higher interest rates) and possible stagflation will also affect the demand side of energy commodities in the near future. European market integration creates the need to investigate the dynamics of several energy markets jointly as companies have exposure to many markets. In addition to these factors, policy and new regulations also introduce additional risk for power companies.

The objective of enterprise risk management (ERM) is to model and forecast all possible risk factors and investigate how they affect future cash flows and key ratios (e.g. return on equity, debt ratio, credit rating) under different scenarios and policy actions (e.g. investment policy and hedging policy). The steps in ERM are to (1) Identify all market risk variables and other risk factors that affects the company, (2) Link these risk variables into the accounting statements of the firm, (3) Establish consistent simulation models for all risk variables, (4) Analyze possible scenarios' status quo and changes under various policy actions (e.g. invest or not to invest in certain renewable projects, hedge or not to hedge certain exposures).

Despite the plethora of material written on the subject, many organizations struggle with numerous aspects of the practical implementation (e.g., Anton and Nucu, 2020; Leech, 2018; McShane, 2018; Aabo et al., 2005). One of the key references here a Canadian utility company (Hydro One) that has been very successful in the implementation and success of ERM over a 23-year period. This work has been documented in several papers (Aabo et al. (2005), Fraser et al. (2014), and Fraser et al. (2021a, b)). Hydro One was approached by over 90 organizations between 2004 and 2015 seeking practical advice as to how best to implement all or specialized aspects of ERM (see Frazer et al., 2021a, 2021b). There are very few documented cases like this in Norway according to our knowledge, and this project has the ambition to be the first to implement and document an ERM solution for a Norwegian power company. In our study, we will in particular address how all uncertain factors (both market risk factors and new policy risk factors) can be modelled and simulated going forward. These factors will be linked to the key future performance indicators of the firm and analyzed under various market scenarios as well as under various investment and hedging decisions performed by the firm.

Starting references:

Aabo, T., Fraser, J.R. and Simkins, B.J., 2005. The rise and evolution of the chief risk officer: Enterprise risk management at Hydro One. Journal of Applied Corporate Finance, 17: 62-75

Anton, S.G. and Nucu, A.E.A., 2020. Enterprise risk management: A literature review and agenda for future research. Journal of Risk and Financial Management, 13: 281.

Fraser, J.R., Quail, R. and Simkins, B. eds., 2021b. Enterprise risk management: Today's leading research and best practices for tomorrow's executives. Wiley.

Fraser, J.R., Simkins, B. and Narvaez, K., 2014. Implementing enterprise risk management: Case studies and best practices. Wiley.

Data from Montel

Industry partner: SimulationFinance AS

Main supervisor: Sjur Wesgaard

Industry Co-supervisor: Frank Isaksen, frank.isaksen@simulationfinance.no

For more information, please contact Sjur Westgaard, sjur.westgaard@ntnu.no, to schedule a meeting

IFØ9. Economic and environmental impacts of a pesticide ban in Europe

The use of pesticides has become a contentious issue in modern agriculture due to the negative impacts they can have on both the environment and human health. Pesticides are chemicals used to control pests and diseases in crops, but their widespread use has led to a range of negative consequences. One of the main environmental concerns associated with pesticide use is their potential to harm non-target species such as beneficial insects, birds, and wildlife. Pesticides can also contaminate waterways and soil, causing long-term damage to ecosystems and threatening biodiversity. In addition to environmental impacts, the use of pesticides can also have serious health consequences. Exposure to pesticides has been linked to a range of health problems.

On the other hand, a ban on the use of pesticides could have significant economic impacts, both in the short-term and long-term. In the short-term, farmers may face decreased yields and increased production costs due to the loss of a key tool for pest control. Without pesticides, farmers may need to rely on alternative methods for controlling pests, which can be more labor-intensive and costly. This can lead to decreased profits and potentially higher food prices for consumers.

This study will use a macroeconomic equilibrium model to analyse the effectiveness of a tax on the usage of pesticides or of a total ban towards the adoption of alternative techniques such as integrated pest management (IPM) and organic farming as well as on their impact on the profitability of the agricultural sector and the price of agricultural products

The project is suited to students interested in preservation of biodiversity and sustainability topics as well as to ethical aspects of food production.

Main supervisor: Paolo Pisciella

Co-Supervisor: Rita Vasconcellos D'Oliveira Bouman

External Partner: The Flemish Land Agency (VLM), Department of Economy, Science

Innovation (EWI), andPublic Waste Agency of Flanders (OVAM).

Strategic research initiative: [Health, Sustainability]

For more information, please contact Paolo Pisciella, paolo.pisciella@ntnu.no, to schedule a meeting.

IFØ10. Economic and environmental impacts of a transition towards clean public transport in Europe

Public transport vehicles that use old combustion technologies are a significant source of pollution, contributing to poor air quality and a range of health problems. Older vehicles often emit high levels of pollutants such as nitrogen oxides (NOx), particulate matter (PM), and carbon monoxide (CO), which can have harmful effects on both human health and the environment. In this respect, the substitution of public transport fleets towards low emissions is crucial in addressing the negative impacts of transportation on the environment and public health. The transition to low-emission public transport fleets will not only have environmental benefits but also economic consequences. One of the primary economic impacts will be the shift from purchasing fossil fuels to purchasing electricity or hydrogen to power vehicles. Another economic impact of transitioning to low-emission public transport fleets is the potential for increased public demand for sustainable and environmentally-friendly transport options. By offering cleaner and more sustainable public transport services, agencies may be able to attract more passengers and generate increased revenue. On the other hand, transitioning to low-emission public transport fleets may also present challenges for transit agencies, particularly those with limited financial resources. The cost of purchasing new vehicles and developing the necessary infrastructure to support low-emission transport systems can be substantial, and may require significant investment and planning.

In this project the students will use an economic equilibrium model for Europe to assess the impact of a transition of public transport towards a low-carbon structure. The analysed impacts will involve the value of the transport sectors and related sectors, the impact on the employment level and on the price and demand of energy commodities.

Main supervisor: Paolo Pisciella

Co-Supervisor: Asgeir Tomasgard, Steffen Bakker

External Partner: TØI, IRES Piemonte

Strategic research initiative: [Energy, Sustainability]

For more information, please contact Paolo Pisciella, paolo.pisciella@ntnu.no, to schedule a meeting.

IFØ11. Environmental social and governance (ESG) investing

The unforeseen global pandemic of Covid-19 triggered substantial social and economic repercussions worldwide. Amidst this period of high uncertainty and volatility in the markets, the firms with more solid environmental policies rewarded the investors with higher returns than their peers [1]. This study exemplifies the paradigm shift that seems to be happening regarding the importance of environmental, social, and governance (ESG) aspects in the financial world. More studies and reports are being published highlighting the severity and inevitable consequences of the current environmental problems [2, 3].

Financial markets have developed approaches to accompany this reconfiguration, integrating ESG data in a financial analysis of the increasingly popular ESG investment strategies. Including these non-financial factors in financial decision-making intends to enhance conventional financial analysis, as it allows for the identification of additional risks and opportunities. Thus, it is intended to achieve high financial returns while promoting firms that have a positive role in other societal dimensions.

Some of the topics that can be explored in this project include:

In recent periods of high uncertainty and volatility in the financial markets, e.g. Brexit, Covid pandemic, and Russia-Ukraine war, have the ESG funds exhibited higher returns and/or lower volatility when compared to the traditional funds?

What are the ESG factors that have higher materiality in the differences between the ESG and conventional portfolios?

What are the ESG strategies that are associated with higher financial performance? What is the relation between financial performance and environmental and social performance?

References

[1] Alexandre Garel and Arthur Petit-Romec. Investor rewards to environmental responsibility: Evidence from the covid-19 crisis. Journal of Corporate Finance, 68:101948, 2021.

[2] IPPC. Ar6 climate change 2021: The physical science basis. https://www.ipcc.ch/report/ar6/wg1/ , 2021.

[3] WEF. The global risks report 2023. https://www.weforum.org/reports/global-risks-report-2023 , 2023.

Main supervisor: Rita Pimentel

Co-supervisor: Rodrigo Graça, Maria Lavrutich,

Strategic research initiative: [Sustainability]

For more information, please contact Rita Pimentel, rita.pimentel@ntnu.no, to schedule a meeting.

IFØ12. Forecasting Realized Volatility from the Implied Volatility Term Structure

Implied volatility is known to be helpful for forecasting realized volatility of foreign exchange rates. The volatility surface in the interdealer foreign exchange rate options market is particularly well suited for extracting predictive information, as dealers quote implied volatilities of options with standardized maturities and moneyness every day. This constitutes a high-quality time series especially useful for empirical analysis. In this project, we will use optimization techniques to find optimal combinations of implied volatilities to forecast realized volatility, exploiting the full EUR/USD implied volatility term structure.

Data

In our empirical investigation, the target variable is the realized volatility and predictors are the implied volatilities. Sparebank 1 Markets will supply the data.

Main supervisor: Morten Risstad

Co-Supervisor: Stein-Erik Fleten

Starting reference

Plihal, T., and Lycosa, S.: Modeling realized volatility of the EUR/USD exchange rate: Does implied volatility really matter? International Review of Economics and Finance 71, 811–829 (2021)

For more information, please contact Morten Risstad, morten.risstad@sb1markets.no to schedule a meeting.

IFØ13. Green Bonds and Transition

Climate change is one of the greatest challenges of our contemporary society. The Intergovernmental Panel on Climate Change (IPCC) of the United Nations, in their most recent report, alerts and urges, once again, to the critical situation that the world is facing and the actions required. A shift of the actual economic paradigm to a greener and lower carbon one is critical [1]. To limit and minimise the consequences of already undergoing climate changes, the transition must be significant and occur in a short timeframe. This is only feasible with the active involvement of both public and private organisations [2].

Green bonds are fixed-income securities that mobilise their funds into projects that actively contribute to the better environmental performance of the issuer. Thus, these instruments can portray a key role in the transition process. Evidence points to the improvement of the ESG scoring and carbon intensity of the firms within a couple of years that follow the issuance [3]. However, the role of green bonds in a more medium- and long-term impact is still marginally represented in the current literature.

Some questions that can be explored in this project:

Are the green bonds accelerating the transitions of the business issuers when compared to their competitors? Are these firms investing in more efficient technology in their lines of business?

What are the sectors where the issuance of green bonds is associated with the most significant change? Are there sectors where this impact is not seen?

Is it possible to develop a model that predicts the evolution of the carbon intensity of the firms upon the issuance of a green bonds?

Main supervisor: Rita Pimentel

Co-supervisor: Rodrigo Graça, Maria Lavrutich

Strategic research initiative: [Sustainability]

References

[1] Pörtner, H. O., Roberts, D. C., Adams, H., Adler, C., Aldunce, P., Ali, E., Ara Begum, R., Betts, R., Bezner Kerr, R., Biesbroek, R., Birkmann, J., Bowen, K., Castellanos, E., Cissé, G., Constable, A., Cramer, W., Dodman, D., Eriksen, S. H., Fischlin, A., ... Zaiton Ibrahim, Z. (2022). Climate change 2022: impacts, adaptation and vulnerability. IPCC. https://www.ipcc.ch/report/ar6/wg2/ .

[2] Voica, M. C., Panait, M., & Radulescu, I. (2015). Green investments–between necessity, fiscal constraints and profit. *Procedia Economics and Finance*, 22, 72-79.

[3] Flammer, C. (2021). Corporate green bonds. *Journal of Financial Economics*, 142(2), 499-516.

For more information, please contact Rita Pimentel, rita.pimentel@ntnu.no, to schedule a meeting.

IFØ14. Halo effects of green bonds

Climate change represents one of the greatest challenges facing humanity today. To combat this, green bonds were invented as a tool to attract capital towards green investments. A green bond is a fixed-income instrument designed specifically to support specific climate-related or environmental projects. Since they were introduced by the European Investment Bank as "climate awareness bonds" in 2007, they have received widespread attention as novel financial instruments with the specific goals of improving environmental impacts and social welfare. The issuance of green bonds and other likely-minded products has grown drastically during the last decade. As the market has gained traction, academic attention towards the subject has increased. One of common research questions here is whether there exist any financial advantages to issue green bonds. Recently, some studies showed that apart from the direct effects (such as lower yields for green bonds in comparison to an otherwise equivalent vanilla bond), there exist also indirect effects of green bond issuance, the so-called halo effects. For example, several studies document a significantly positive equity market reaction following the announcement of green bonds as well as market-wide effects for bond portfolio of the green bond issuers. These effects arise because green bonds serve as signaling tools of climate commitment in addition to their purpose as financial instruments.

In this project, we will further investigate the existence of the green halo effect on debt, expanding the discussion of financial incentives to issue green bonds. Our starting point will be to discover if the green halo debt effect of green bonds and/or other sustainability linked products in secondary markets still exists in the most recent dataset. Another interesting question is whether secondary market effects carry over to the primary market, as then it would provide bond pricing advantages to the issuer. Lastly, as the green bond market matures and green bonds' market share increases, the green halo effects may disappear as the climate commitment signal could become less salient. This could lead to vanilla bonds being perceived as brown bonds calling for a study on potential negative brown externalities of vanilla bond issuances.

Potential research questions. Is the green halo debt effect in the secondary markets present in the most recent data? Can the green halo effect be observed in the primary markets for bonds? Are there any other halo effects that companies experience at the moment when they announce green bond issuance? Do other types of sustainability linked products experience halo effects?

Methods. Methods used will be from finance and econometrics/data analysis.

Main supervisor: Maria Lavrutich

Co-supervisor: Rita Pimentel

Strategic research initiative: Green Value Creation - Circular Economy

For more information, please contact Maria Lavrutich, maria.lavrutich@ntnu.no to schedule a meeting

IFØ15. Implications of policy uncertainty on green investments

The increasing awareness of the potential consequences of climate change has led to international commitments to reducing greenhouse gas emissions. In the European Union, specific targets under the EU2030 climate and energy framework are being pursued to cut emissions 'substantially' by 2050 (European Commission, 2012). Increasing the share of renewable energy production in the overall energy mix is recognized as a critical step in reaching these goals. However, following the deregulation of the European electricity market, investments in renewable energy (RE) production have largely been made by private companies, meaning that investment decisions are constrained by profitability concerns (Abadie and Chamorro, 2014).

Policy uncertainty and investor risks (e.g., introduction, revision, and removal of taxes or subsidies) alters the criteria for decision making and impacts the intensity of investments and where investments are directed. The general perception is that policy risk reduces the willingness to invest.

The governmental expert committee for climate-friendly investments has stated as both a goal and a recommendation the need of increasing the credibility and predictability of policy means (Ekspertutvalget for klimavennlige investeringer, 2022).

In this work we want to assess how crucial the credibility and predictability of policy means are for the investor environment in green projects.

We will empirically estimate the effect of policy uncertainty in the form of potential introduction, revision, and removal of taxes or subsidies on investment behavior in terms of intensity of investments and where investments are directed.

Starting references:

[1] European Commission Energy Roadmap 2050. 2 February, 2012

[2] L.M. Abadie, J.M. Chamorro. Valuation of wind energy projects: a real options approach, Energies, 7 (5) (2014), pp. 3218-3255.

Industry partner: Hafslund Eco

Main supervisor: Sjur Westgaard

Co-supervisors: Verena Hagspiel NTNU, Maria Lavrutich NTNU, Ståle Slørdal HINN, NTNU and Hafslund Eco

Strategic research initiative: Leading transitions: Co-create a sustainable future sustainability

For more information, please contact Sjur Westgaard, sjur.westgaard@ntnu.no to schedule a meeting.

IFØ16. Investment Decisions in Renewable Energy Projects under Policy Uncertainty

Power companies face high uncertainty about potential renewable energy support schemes since they do not know if any new support schemes will be provided and how such new policies would look. Currently, there is a discussion in Norway about possible support schemes for offshore wind power since the government targeted to open up new areas for offshore wind power production to generate 30000 MW by 2040. Additionally, there has been a global shift towards Contracts for Difference (CfD) auctions to support emerging technologies like offshore wind energy or low-carbon hydrogen production. However, a few real options papers have examined these auctions and found that they incentivize speculative bidding and too little investment. This creates additional uncertainty (policy uncertainty) for power companies that intend to invest in this market. The traditional approaches to capital budgeting do a poor job of analyzing such situations but are nevertheless still used by many practitioners. Real Options analysis takes methods developed to value financial derivatives and uses them to analyze real-world business decisions. As opposed to traditional discounted cash flow valuation, real options analysis accounts for the fact that decision-makers use all available information when making decisions in the future. This provides better advice than using only traditional techniques for which models are based on assumptions neglecting this managerial flexibility. In this project, students will examine problems related to investment decisions in renewables under policy uncertainty by applying a real options approach. We are particularly interested in including possible continuous revisions of support schemes since it has already happened in the past. Examples of papers that deal with policy uncertainty using a real options approach are provided below.

References:

Sendstad, L. H., Hagspiel, V., Mikkelsen, W. J., Ravndal, R., & Tveitstøl, M. (2022). The impact of subsidy retraction on European renewable energy investments. Energy Policy, 160, 112675.

Nagy, R. L., Hagspiel, V., & Kort, P. M. (2021). Green capacity investment under subsidy withdrawal risk. Energy Economics, 98, 105259.

Dalby, P. A., Gillerhaugen, G. R., Hagspiel, V., Leth-Olsen, T., & Thijssen, J. J. (2018). Green investment under policy uncertainty and Bayesian learning. Energy, 161, 1262-1281.

Hagspiel, V., Nunes, C., Oliveira, C., & Portela, M. (2021). Green investment under time-dependent subsidy retraction risk. Journal of Economic Dynamics and Control, 126, 103936.

Oliveira, C., & Perkowski, N. (2020). Optimal investment decision under switching regimes of subsidy support. European Journal of Operational Research, 285(1), 120-132.

Main supervisor: Carlos Oliveira

Co-supervisor: Verena Hagspiel, NTNU

Strategic research initiative: [Sustainability]

For more information, please contact Carlos Oliveira, carlos.m.d.s.oliveira@ntnu.no, to schedule a meeting.

IFØ17. Investment under uncertainty in deep sea mining from a company perspective

The global energy transition is fueling the growth of new value chains like batteries, renewable and electric infrastructure. The rapid growth of these industries will require a significantly higher supply of minerals in the coming decades. The demand for metals will increase in correlation to society's combat for climate change. Onshore mines are challenged by controversial working conditions and put severe stress on resources and the environment. A low carbon future requires additional metals supply, which could be provided by marine minerals.

On 1st July 2019 the Norwegian Seabed Minerals Act entered into force. This Act is intended by the Norwegian authorities to "facilitate exploration for and extraction of mineral deposits on the Norwegian Continental Shelf (NCS) in accordance with societal objectives" (NPD 2021a). Exploration of minerals on the NCS has so far been exclusively performed by governmental actors. However, the Ministry of Petroleum and Energy aims to present a white paper (Stortingsmelding) on the opening of the NCS for mineral activity by private companies in the spring of 2023. This comes after an impact assessment performed by the Norwegian Petroleum directorate that concludes that the impact from mineral activity on the NCS is manageable (MPE 2022). Given that the NCS opens up for mineral activity, private companies will initially be given the opportunity to apply for exploration licenses for given areas.

From the corporate perspective, deep-sea mining represents a potential business venture with both a high potential up- as well as downside. A key takeaway from a recent report by Rystad (*Marine Minerals - Norwegian Value Creation Potential*, 2020) evaluating the potential of deep-sea mining on the NCS is that marine minerals are "in the money", with a projected income significantly higher than the estimated cost of extraction. However, committing resources to deep-sea mining at this stage entails a great deal of risks. When assessing investment opportunities and developing entry strategies, companies are confronted with various sources of uncertainty and risk factors as many of the determining modifying factors as well as future regulation are highly uncertain at this point. Uncertainties are spanning from regulatory to market, environmental impact, and resource uncertainties.

In cooperation with Green Minerals, a pioneering company in offshore mining, the students will study how a firm should respond to uncertainty about resources in place, future regulation and commodity prices when evaluating an exploration licence on the Norwegian continental shelf. In the analysis we will take the perspective of a corporate decision maker seeking to commercially mine the deep sea. The students will apply methods like real options valuation, value of information, commodity price forecasting and dynamic optimization to develop a methodology that allows to quantify the value of an exploration license and assess the optimal decision policy with respect to subsequent decision gates in the exploration and exploitation phase. The aim is to develop a decision tool that can be tested for realistic problem cases.

This thesis project is directly related to the project The Deep Dilemmas: Deep-sea Mining for the new Deep Transition (TripleDeep) which is part of the Interdisciplinary Sustainable Initiatives at NTNU (see https://www.ntnu.no/sustainability/calls/deep-sea-mining-dilemmas-by-tripledeep for more information). More specifically, this project is related to the WP on The Economics of Deep-sea Mining.

This project will build upon the results in earlier related projects. The students working on this project should have a background in computer science.

Industry partner: Green Minerals

Main supervisor: Verena Hagspiel

Co-supervisor: Farida Mustafina (PhD candidate of TripleDeep project)

Industry Co-supervisor: Maxime Lesage (Chief Engineer at Green Minerals)

Strategic research initiative: Leading transitions: Co-create a sustainable future

Sustainability

For more information, please contact Verena Hagspiel, verena.hagspiel@ntnu.no, email, to schedule a meeting.

IFØ18. Machine learning for ESG

The fight against global warming is probably one of the biggest challenges of our time. This implied the development of Environmental, Social and Governance (ESG) policies, which made companies to act in a way to improve their ESG score. However, there are still several questions to understand the firm's motivation and financial incentives behind these investments. Indeed, ESG preference shocks represent a novel risk source.

In this project, we will explore this topic, building on previous Avramov works listed below. For example, in Avramov (August 5, 2022), it is shown that the presence of ESG preferences may lead to utility loses, illustrating the economic significance of nonpecuniary motives. Further, Avramov (2022) analyzes the asset pricing and portfolio implications of an important barrier to sustainable investing, the corporate ESG profile. On the other hand, Avramov (2022) shows that investments based on deep learning signals extract profitability from difficult-to-arbitrage stocks and during high limits-to-arbitrage market states. We aim on combining advanced methods of machine learning to better understand the financial incentives behind ESG investments.

This project is related with the two following research initiatives: Leading transitions: Co-create a sustainable future and Green Value Creation | Circular Economy.

Main supervisor: Rita Pimentel

Co-supervisor: Doron Avramov, Interdisciplinary Center (IDC) Herzliyah (https://faculty.runi.ac.il/davramov/)

References:

Avramov, Doron and Cheng, Si and Tarelli, Andrea, Active Fund Management when ESG Matters: An Equilibrium Perspective (August 5, 2022).

Avramov, Doron and Lioui, Abraham and Liu, Yang and Tarelli, Andrea, Dynamic ESG Equilibrium (October 3, 2021).

Doron Avramov, Si Cheng, Lior Metzker (2022) Machine Learning vs. Economic Restrictions: Evidence from Stock Return Predictability. Management Science.

Doron Avramov, Si Cheng, Abraham Lioui, Andrea Tarelli (2022), Sustainable investing with ESG rating uncertainty, Journal of Financial Economics, Volume 145, Issue 2, Part B, 642-664.

For more information, please contact Rita Pimentel, rita.pimentel@ntnu.no to schedule a meeting.

IFØ19. Modeling cryptocurrency prices

This project aims to investigate which type of stochastic processes should be considered to model cryptocurrency prices.

Whenever we want to use a model to price a derivative based on an asset, we need to consider a stochastic process to model the price of the underlying asset. The geometric Brownian motion (GBM) is the most common choice to model the stock prices. For instance, the well-known Black-Scholes model, which is used to price European vanilla financial options, is based on the GBM. Also, for more complex options (exotic, time dependent, American), the Monte Carlo simulation is often used, in most of the cases assuming again that the stock price follows a GBM.

The use of GBM is convenient because of its positiveness, normality, independence between the returns and mathematical tractability. Nevertheless, in the past few years many researchers and practitioners have been refuting some of its basic assumptions. Two of the main criticisms are: the paths are continuous, and the volatility is constant. The former comes from the fact that the GBM is a diffusion. But in fact, stock prices often show jumps caused by unpredictable events or news. There is the recent downside impact of the coronavirus in the beginning of March 2020 in most of the stock markets in Europe and USA, with some indexes having the biggest fall on their history, and others showing falls as big as the ones during the 2007-2009 financial crisis. Regarding the volatility, the GBM assumes that it is constant. However, the stock prices often show volatility changing over time. Particularly, the cryptocurrencies are known for being extremely volatile. A discussion about the assumptions of the model can be found, for instance in Eraker (2004), McKenzie et al. (2007), Teneng (2011) and Yalincak (2012).

Lately, cryptocurrencies are in the spotlight, where Bitcoin is the most well-known. It remains to be defined if cryptocurrencies should be classified as an asset, a currency, or a commodity (see, for instance, Glaser, 2014 and Baur et al., 2018). Therefore, investigating the process that better fits its price contributes to this discussion.

In this project different classes of continuous and discontinuous stochastic processes will be considered to assess which fits better cryptocurrency prices. As a starting point, to overcome the continuity of the GBM, for instance jump diffusions may be explored, while to enable different volatilities, switching diffusions (diffusion with coefficients varying over time) could be inspected. Another possible extension of the work is to explore the market efficiency assumption on cryptocurrencies market.

Main supervisor: Rita Pimentel

Co-supervisor: Carlos Oliveira

References:

Baur, D. G., Hong, K., Lee, A. D. (2018). Bitcoin: Medium of exchange or speculative assets?, Journal of International Financial Markets, Institutions and Money, 54, 177-189.

Eraker, B. (2004). Do Stock Prices and Volatility Jump? Reconciling Evidence from Spot and Option Prices, The Journal of Finance, 59 (3), 1367-1403.

Glaser, F., Zimmermann, K., Haferkorn, M., Weber, M. C. and Siering, M. (2014). Bitcoin - Asset or Currency? Revealing Users' Hidden Intentions, ECIS 2014 (Tel Aviv).

McKenzie, S., Gerace, D., and Subedar, Z. (2007). An empirical investigation of the Black-Scholes model: evidence from the Australian Stock Exchange, Australasian Accounting, Business and Finance Journal, 1(4), 5.

Teneng, D. (2011). Limitations of the Black-Scholes model, Collection of Papers 1: 143.

Yalincak, O. H. (2012). Criticism of the Black-Scholes Model: But Why is It Still Used?: (The Answer is Simpler than the Formula).

For more information, please contact Rita Pimentel, rita.pimentel@ntnu.no to schedule a meeting.

IFØ20. Modeling multivariate risk using copulas in energy markets

Energy markets play a fundamental role in our economy, and they have been passing for several changes, some of them linked to the need to reduce greenhouse gas emissions. Moreover, these markets are usually subject to governmental policies since they have an enormous impact on the price of other commodities and consumer and producer prices in general. In the last years, the pandemic, Ukrainian war, and supply issues has increased the volatility and hence risk in energy markets dramatically. Therefore, managing the risk of portfolios composed of energy commodities such as electricity, oil, natural gas, and coal is vital for energy companies. Often risk measures applied to the returns of these portfolios are estimated based on the assumption of normality and linear dependencies, which is not empirically verified often.

In this project, we intend to model the joint distribution of the returns using different types of copulas. The use of copulas is natural when we intend to describe the non-linear dependency of different variables. The use of copulas can be compared to the use of predetermined parametric distributions, where we only need to estimate the right using a suitable estimation method.

Having a distribution for the portfolio's return, we will estimate and forecast various risk measures to assess the portfolio's risk.

References:

Hult, H., Lindskog, F., Hammarlid, O., & Rehn, C. J. (2012). Risk and portfolio analysis: Principles and methods. Springer Science & Business Media.

Masala, G. (2021). Backtesting energy portfolio with copula dependence structure. Energy Systems, 12(2), 393-410.

Ghorbel, A., & Trabelsi, A. (2014). Energy portfolio risk management using time-varying extreme value copula methods. Economic Modelling, 38, 470-485.

Jäschke, S. (2014). Estimation of risk measures in energy portfolios using modern copula techniques. Computational Statistics & Data Analysis, 76, 359-376.

Main supervisor: Carlos Oliveira

Co-supervisor: Sjur Westgaard, NTNU

For more information, please contact Carlos Oliveira, carlos.m.d.s.oliveira@ntnu.no, to schedule a meeting.

IFØ21. Multivariate GARCH yield curve models

Principal Component Analysis (PCA) is well established as a powerful statistical technique in the realm of yield curve modeling. PCA based term structure models typically provide accurate fit to observed yields and explain most of the cross-sectional variation of yields. Although principal components are building blocks of modern term structure models, the approach has been less explored for the purpose of risk modelling - such as Value-at-Risk and Expected Shortfall. Interest rate risk models are generally challenging to specify and estimate, due to the regime switching behavior of yields and yield volatilities. Pimentel et al. (2022) combine estimates of conditional principal component volatilities in a quantile regression (QREG) framework to infer distributional yield estimates. Their proposed PCA-QREG model offers predictions that are of high accuracy for most maturities while retaining simplicity in application and interpretability.

The PCA-QREG model of Pimentel et al. (2022) utilizes a multivariate exponentially weighted moving average (EWMA) specification. Bauwens et. al (2006) outlines alternative conditional volatility specifications:

1. Direct generalizations of the univariate GARCH models (VEC, BEKK, factor models)

2. Linear combinations of univariate GARCH models (Generalized orthogonal models, latent factor models)

3. Non-linear combinations of univariate GARCH models (constant and dynamic correlation/covariance models, Copula GARCH)

This project will explore whether other more advanced multivariate volatility models are more appropriate than EWMA.

Keywords

Yield curve modelling, multivariate GARCH, PCA

Main supervisor: Morten Risstad

Co-supervisor: Rita Pimentel, Malvina Marchese

Starting references

Pimentel, Rita, Morten Risstad, and Sjur Westgaard. "Predicting interest rate distributions using PCA & quantile regression." Digital Finance 4.4 (2022): 291-311.

Bauwens, Luc, Sébastien Laurent, and Jeroen VK Rombouts. "Multivariate GARCH models: a survey." Journal of applied econometrics 21.1 (2006): 79-109.

Hagenbjörk, Johan, and Jörgen Blomvall. "Simulation and evaluation of the distribution of interest rate risk." Computational Management Science 16.1 (2019): 297-327.

For more information, please contact Morten Risstad, morten.risstad@sb1markets.no to schedule a meeting.

IFØ22. Myopic Improvement of Current Operational Policies for Dual Sourcing

It is well known that demand uncertainty sparks the need for safety stock and that the longer the lead-time is the more safety stock is needed. Dual sourcing is a commonly used method to reduce the need for safety stock by using an alternative supplier with a shorter lead-time and a higher cost unit cost as an "emergency" source when the stock is running low.

Determining when and how much to order from the "normal" and "emergency" source is a complicated problem as the optimal decision depends on the exact location of all the units currently in the pipeline. For example, it makes less sense to order from the "emergency" source if there is some units order from the "normal" source that will be available just a short time after any unit ordered from the "emergency" source. The most used policies, e.g., the dual-index policy and standing order policy, are easy and intuitive to implement but make little or no use of the exact information about the current pipe-line inventory.

Simple methods to myopically improve on these policies thus have a great potential of reducing the total cost. Moreover, they serve as a good benchmark and starting point for more advanced methods for optimizing the system such as for example machine-learning approaches.

Tasks within the project can include:

Study of existing models and solution methods for dual sourcing.

Developing a method for myopic improvement of some selected policies.

Evaluation of a heuristic based on this myopic improvement.

Main supervisor: Peter Berling

Strategic research initiative: Leading transitions: Co-create a sustainable future / Sustainability.

For more information, please contact Peter Berling, lars.p.berling@ntnu.no, to schedule a meeting.

IFØ23. Optimal project portfolio selection under uncertainty using real options valuation

Many firms in the energy sector are faced with the choice between a set of alternative investment opportunities given a constraint set of resources. This choice is to be done under several uncertain factors: future prices, demand, new technologies, regulations, etc.

In this project we aim to determine an optimal project selection and implementation strategy by allocating resources in an optimal way given existing uncertainties. The problem of project portfolio selection is a typical combinational optimization problem. The concept of portfolios originates from the study of investment combination in the field of finance. Many portfolio selection applications are based upon Markowitz's (1952) efficient-portfolio theory. In the standard implementation of this framework, an efficient portfolio is defined as one that yields the highest value given a specific degree of risk.

A corporate decision maker will aim, however, to select a portfolio that meets several often-competing objectives (i.e., maximize portfolio value while minimizing capital expenditure). The optimal portfolio choice given one constraint is typically not optimal given one of the competing constraints. This requires the portfolio manager to identify and select those portfolios that best meet all corporate constraints. Deciding which portfolio to develop is often compounded by the presence of several portfolios having similar economic characteristics. However, these portfolios can generally be differentiated by strategy, which may depend on nonfinancial attributes such as the geographic location of the assets or on settings that might require different engineering expertise, or environmental considerations.

The most widely applied methods of project selection are based on net present value (NPV). However, in project valuation, NPV contains two assumptions that project decision cannot afford delay and project will not be adjusted in the future, which often entail project undervaluation or even wrong decision. The consequence is that the NPV approach is often ineffective under uncertain environments. In this project we will aim to extend current approaches to account correctly for uncertainty about the future profitability of projects.

In this project the students will apply methods such as real options valuation using simulation-based approaches, commodity price forecasting and portfolio optimization. The main goal is to present a transparent and practical multicriteria portfolio-optimization method. We will focus on developing a methodology that is application oriented and designed for decision support in practice. We will consider the problem from the perspective of both a regulator and on company level. While we will apply this problem to cases related to the oil and gas sector this problem is relevant for a wide range of (energy) companies.

This thesis will be directly related to the innovation project ProDecs initiated by the two supervisors of the thesis project and part of NTNUs Technology transfer office project catalogue. In ProDecs we develop a software tool to support better investment decisions in industry. The students will get the opportunity to work in collaboration with our partners at the Norwegian Petroleum directorate (NPD) and OKEA ASA.

This project will build upon the results in earlier related projects. A background in computer science will be beneficial.

References:

[1] H. Markowitz, “Portfolio Selection,” The Journal of Finance, vol. 7,no. 1, pp. 77–91, 1952.

Collaborator: Norwegian Petroleum Directorate

Main supervisor: Verena Hagspiel

Co-supervisor: Semyon Fedorov (Post-doc of NTNU’s BRU21 program and inventor of ProDecs)

Industry Co-supervisor: Sophie Haseldonckx (Senior Reservoir Engineer at NPD)

For more information, please contact Verena Hagspiel, verena.hagspiel@ntnu.no, to schedule a meeting.

IFØ24. Optimal Transfer Pricing with Autonomous Investment Centers

The combination of decentralization and needs for transfers of products and services between responsibility centers, give rise to transfer pricing systems and the difficult problem of finding optimal transfer prices in real-life settings where decision making units are to be stimulated both to be efficient in the short-term perspective and to invest based on longer-term profitability effects in the value-chain. The aim of this project it to analyze the transfer pricing problem in settings where decentralization implies that the organization consists of relatively autonomous responsibility centers that have investment authority. One example may be highly successful electronic-gadget firm Haier that has been described as "Ecosystems of Micro Communities – EMCs" where transfers are governed by a contacting framework: "EMC Contract reflects another important feature of blockchain – decentralized automated value transmission. In an EMC contract, all values and all nodes are interconnected." Another example is the Norwegian grocery chain COOP. Many COOPs across the country collectively own COOP Norge SA which is responsible for sourcing, distribution and marketing functions that are fundamental for the profitability of the individual COOPs. The markup on transfers of products to the COOPs creates a difference between local and value-chain profitability effects of day-to-day decisions as well as investments decisions. This is a special case of the well-known variable-versus-fixed-costs dilemma of transfer pricing. The aim of the project is to create new insights into the question of optimal transfer prices in organizations where transfer prices will affect investment behavior. Students will have substantial freedom in deciding on actual approach to analyze the issues. It is natural to consider both theoretical analysis and simulation models as tools.

Main supervisor: Einar Belsom

For more information, please contact Einar.Belsom@ntnu.no, to schedule a meeting.

IFØ25. Power Grid Investment Decisions

Distribution grids are experiencing a transformation driven by decarbonization, decentralized generation, digitalization, and the emergence of flexibility markets. In particular, this transition brings new opportunities for utilization distributed energy resources (DERs) e.g. photovoltaics, wind etc., and for the emergence of the role of end-users as flexibility providers. In this transition, achieving a flexible, robust, and cost-efficient electricity distribution system requires complex interactions of a variety of actors and technologies. As more DERs start to emerge, physical constraints in the distribution power network become more and more relevant for the operation of the power market. In countries where transmission system operators and distributed system operators are not the same entity, the need to coordinate between the two emerges.

In this project, we would like to investigate how different level of flexibility investments and active participation of end-users can affect the investment and operation strategies of the distribution system operators (DSOs), transmission system operators (TSOs). Within this general topic there are many specific questions and tradeoffs that can be investigated within the scope of the thesis. On the one hand, in today's deregulated electricity markets, power companies that will optimally decide on DER investment given their objective to maximize profit. The distribution level investment planning, however, is currently at the discretion of DSO that cannot provide crucial network data to private companies, which can lead to sub-optimal decisions for the latter. On the other hand, in the absence of TSO-DSO coordination framework, TSO are not able to exploit the flexibility available at the distribution level, especially when it comes to end-user flexibility. In this project, we will cover come of the aspects of the complex investment decisions of these actors.

Potential research questions. What are optimal transmission level investment strategies in the presence of private power companies? How different TSO-DSO coordination schemes and end-user flexibility affect investment decisions on different levels? What is the optimal way to exploit distributed flexibility provided by private power companies and end-users by the DSO?

This project will be in collaboration with the Centre for Intelligent Electricity Distribution (CINELDI). CINELDI is a multidisciplinary research Centre for Environment-friendly Energy Research (FME). CINELDI seeks to develop expertise and promote innovation through focus on long-term research, development and education related to flexible and intelligent energy systems (smart grids). More information can be found here https://www.sintef.no/cineldi.

Methods. Potential methods are from finance (investment valuation and/or real options) and optimization.

Industry partner: possibility to collaborate with CINELDI user partners, including Statnett and Tensio.

Main supervisor: Maria Lavrutich

Strategic research initiative: Green Value Creation - Circular Economy

For more information, please contact Maria Lavrutich, maria.lavrutich@ntnu.no to schedule a meeting

IFØ26. Prediction of commodity prices using machine learning and big macro/financial data

Predicting commodity prices (e.g. fuel, electricity, aluminum, pulp & paper, soybeans, fish) are crucial for producers and consumers, as well as for public authorities such as the central bank. Commodity prices drives income and costs and determine indirectly both producer prices and consumer prices in the macroeconomy.

Commodities are highly sensitive to economic cycles. Based on this insight, a growing literature has analyzed the predictability of commodity spot returns suggesting various financial and economic variables covering data from economic output and income, labor markets, consumption and orders, inventories, monetary policy and credit markets, interest and exchange rates, housing markets, consumer and producer prices, and stock market data.

With the growth in big data and machine learning methods (e.g. elastic net, pca, Bayesian VAR methods, AI and XAI methods etc.), one are now able to build potentially better forecasting models than in the previous literature using less data and simpler methods. These methods can potentially take into account complex non-linear relationship between many variables as well as time varying sensitivities to economic condition. Whether state of the art methods do forecast better commodity prices will be explored in this project.

Starting reference:

World Bank, Commodity Market Outlook
https://openknowledge.worldbank.org/bitstream/handle/10986/38160/CMO-October-2022.pdf

Hollstein et al. (2021): "Predictability in commodity markets: Evidence from more than a century." Journal of Commodity Markets, Volume 24, December 2021

Gargano and Timmermann, Forecasting commodity price indexes using macroeconomic and financial predictors, International Journal of Forecasting, Volume 30, Issue 3, July–September 2014, Pages 825-843

Data from FRED-MD (FED USA database) and World Bank, Google Trends

Industry partner:	Sparebank 1 Markets
Main supervisor:	Sjur Westgaard, NTNU
Co-supervisors:	Morten Risstad, Rita Pimentel

For more information, please contact Sjur Westgaard, sjur.westgaard@ntnu.no, to schedule a meeting

IFØ27. Regime Shifts in Stock-Bond Correlation

Low or even slightly negative expected correlation between stocks and bonds justify combining both asset classes in investment portfolios. The well-known 60/40 portfolio, consisting of 60% equity and 40% bonds, or the rule specifying 60-80% stocks and 20-40% bonds in the Norwegian "oil fund", i.e., Government Pension Fund Global, reflect an expectation of maximizing the Sharpe ratio by combining these asset classes in portfolios. However, correlations between asset classes must be expected to change over time as financial markets develop, raising questions regarding the wisdom of specific, long-term allocation rules. The aim in this project is to analyze the stock-bond relationship historically, identifying potential correlation-regime shifts, and assessing the predictability of stock-bond correlations. Machine-learning approaches may well be used, but students may also rely on more traditional econometric methodology.

Main supervisor: Einar Belsom

For more information, please contact Einar.Belsom@ntnu.no, to schedule a meeting.

IFØ28. Regulatory capital for credit risk in bond portfolios

Financial institutions (banks, life insurance companies and pension funds) are subject to regulatory capital requirements. When investing in fixed income securities, for instance in bonds issued by sovereigns or corporates, the financial institution will have to set aside capital to cover the potential loss if the obligor defaults. This capital requirement is referred to as “spread-risk”. The capital requirement is computed as a function of potential increases in the credit spread of the issuer, expressed in basispoints (0.01% = 1 basispoint).

Financial institutions in Norway are currently subject to the EU-area capital requirements (Solvency II). The “spread-risk” under Solvency II is based on historical data from European bond markets, more specifically a 1 year/99,5 % confidence level Value-at-Risk model. In this project we will investigate whether this requlatory risk model is appropriate for the Norwegian bond market.

The first stage of the project will comprise of defining an appropriate Value-at-Risk model for a portfolio of bonds issued by Norwegian banks. Finding suitable volatility models for credit spreads will be crucial for this purpose. The empirical analysis will be based on market data supplied by Sparebank 1 Markets.

Keywords

Fixed income securities, regulatory capital, Value-at-Risk

Main supervisor: Morten Risstad (Sparebank1Markets / NTNU)

Co-supervisor: Erik Skjetne (Trondheim Kommunale Pensjonskasse)

Starting references

Kollar, B. "Credit Value at Risk and options of its Measurement." 2nd international conference on economics and social science (ICESS 2014), Information Engineering Research Institute, Advances in Education Research. Vol. 61. 2014.

Bernard, Carole, et al. "How robust is the value-at-risk of credit risk portfolios?." The European Journal of Finance 23.6 (2017): 507-534.

IFØ29. Reinforcement learning for portfolio optimization

The modern theory of portfolio optimization was initiated by Markowitz when he wrote his Ph.D. thesis on Portfolio Selection in the early 1950s. Since then, portfolio optimization has been considered one of the most challenging problems in finance. It consists of a sequence of decisions of allocating/reallocating funds in different financial products with different objectives: optimizing the return of the portfolio, managing the risk of a fund, etc.

Researchers and practitioners have been trying to use different methods to improve the performance of portfolios, which can be measured with different risk measures according to the goal of the portfolio manager. Recently, more advanced methods, such as reinforcement learning, have been explored to solve this complex optimization problem. In this project, we will address this topic by considering different risk measures, for example, Value-at-Risk, Expected Shortfall, Sharp ration. The empirical analysis will be developed using data from Eikon Datastream.

References:

Almahdi, Saud, and Steve Y. Yang. "An adaptive portfolio trading system: A risk-return portfolio optimization using recurrent reinforcement learning with expected maximum drawdown." Expert Systems with Applications 87 (2017): 267-279.

García-Galicia, Mauricio, Alin A. Carsteanu, and Julio B. Clempner. "Continuous-time reinforcement learning approach for portfolio management with time penalization." Expert Systems with Applications 129 (2019): 27-36.

Chaouki, Ayman, et al. "Deep deterministic portfolio optimization." The Journal of Finance and Data Science 6 (2020): 16-30.

Main supervisor: Carlos Oliveira

Co-supervisor: Rita Pimentel, NTNU

For more information, please contact Carlos Oliveira, carlos.m.d.s.oliveira@ntnu.no, to schedule a meeting.

IFØ30. Reinsurance: an optimal strategy to protect against risk

Insurance companies are essential players in the financial sector. Their business relies on retaining the risk of policyholders upon paying a premium. In normal conditions, the premium received is sufficient to cover the losses the insurance company may have. However, losses can be significant, and the insurance company can become insolvent. To protect from large losses, insurers commonly transfer part of the risk of their portfolios to other insurance companies through the payment of a premium. These companies are called reinsurers.

There are different ways to transfer the risk between policyholders, insurance companies, and reinsurers. Whenever an insurer buys a reinsurance policy, it has to decide how much of its risk will transfer to the reinsurer. There are many factors that can interfere with this decision, such as

the amount of the premium charged by the reinsurer;

the criteria used by the insurance company to optimize its profit versus its risk (minimizing the ruin probability, maximizing the utility of the wealth process, among others).

In this project, we intend to analyze the problem of how much reinsurance should a given insurance company buy. There are mainly two types of reinsurance, proportional and non-proportional reinsurance. We propose to consider a particular type of proportional reinsurance, the surplus treaty. This treaty has remained unexplored, although some insurance companies use it. Combinations between proportional contracts and stop-loss treaties, which are non-proportional, are also used by companies and may also be studied. Additionally, we would like to explore how dependencies can affect the optimal reinsurance policy. Catastrophic events are examples of events that can impact more than one business line, and consequently, risks are correlated.

References:

Lampaert, Ilse, and Jean-Francois Walhin. "On the optimality of proportional reinsurance." Scandinavian Actuarial Journal 2005.3 (2005): 225-239.

Román, Sebastián, Andrés M. Villegas, and Juan G. Villegas. "An evolutionary strategy for multiobjective reinsurance optimization." Journal of the Operational Research Society 69.10 (2018): 1661-1677.

Browne, S. (1995). Optimal investment policies for a firm with a random risk process: exponential utility and minimizing the probability of ruin. Mathematics of operations research, 20(4), 937-958.

Schmidli, H. (2001). Optimal proportional reinsurance policies in a dynamic setting. Scandinavian Actuarial Journal, 2001(1), 55-68.

Luo, S., Taksar, M., & Tsoi, A. (2008). On reinsurance and investment for large insurance portfolios. Insurance: Mathematics and Economics, 42(1), 434-444.

Hansjörg Albrecher, Jan Beirlant, Jozef L. Teugels. “Reinsurance: Actuarial and Statistical Aspects, John Wiley & Sons, Nov 6, 2017

Main supervisor: Carlos Oliveira

Co-supervisor: Alexandra Moura, ISEG – Lisbon School of Mathematics and Management

For more information, please contact Carlos Oliveira, carlos.m.d.s.oliveira@ntnu.no, to schedule a meeting.

IFØ31. Risk management in the aquaculture industry

Problem description. An increase in global population has created a growing demand for high-quality marine proteins. Fisheries are reaching their limits in providing a foundation for further production growth due to global wild fish stocks being fully or overexploited. This creates a great potential for the aquaculture industry to satisfy the need for expansion in seafood production. The opportunities for expansion are, however, limited due to environmental challenges that the industry is facing today. These include negative impacts on the wild salmon population through disease outbreaks and escapes, inefficient waste management, as well as scarcity of farm sites. Due to these challenges, Norwegian authorities impose stringent regulations on salmon farmers in order to limit the industry's growth. For example, the production is currently restricted by the Maximum Allowed Biomass limit. In addition, in 2017, the government approved a new measure allowing growth only in specific regions based on the "traffic light" system. Under these circumstances, the key to achieving sustainable growth is to ensure the profitability of the industry by tackling existing inefficiencies.

This project aims to improve the decision-making expertise among the Norwegian salmon producers to best mitigate financial and environmental risks caused through market, operational and biological uncertainties. The challenge here is that realistic modelling in the aquaculture context often requires a higher number of variables, which includes stochastic prices, biomass, feed costs, mortality, as well as new variables that reflect sustainability-related risks. In addition, there exists a substantial time lag between making an investment decision, e.g. to build a new facility, and receiving profit form it due to the length of the production cycle. This makes it harder to incorporate potential risks in the decision-making process. In this project, we will analyze the risks inherent in the aquaculture industry and look at the potential ways of risk reduction that are available to aquaculture producers.

Potential research questions. How to correctly measure and quantify multiple risks the aquaculture companies are exposed to? How should aquaculture companies optimally deal with these risks in new investments? How to correctly quantify the value of these investments in the presence of multiple risk sources? Can market-based instruments such as futures on price, biomass and ESG indicators be used as hedge for revenue in the aquaculture sector?

Methods. Potential methods are from risk management, valuation and/or real options

Industry partner:	SalMar
Main supervisor:	Maria Lavrutich
Industry Co-supervisor:	Tord Olsen, Prosjektmedarbeider Forretningsstøtte
Strategic research initiative:	Green Value Creation - Circular Economy

For more information, please contact Maria Lavrutich, maria.lavrutich@ntnu.no to schedule a meeting

IFØ32. Skewness in energy returns: estimation, testing and implications for tail risk

In this project we intend to estimate the skewness of the unconditional distribution of energy returns and test its statistical signifcance. We will compare the performance of traditional and robust tests for symmetry with those based on the implied unconditional skewness in a TGARCH model with Gram-Charlier (TGARCH-GC) innovations. We also analyze the implications of TGARCH-GC skewness for tail risk through evaluation of Value-at-Risk (VaR) and expected shortfall (ES) accuracy. We analyze Nordic and German power contracts, Crude Oil contracts, Natural Gas contracts, Coal contracts, and CO2 contracts.

Starting reference:

Fernandez-Perez, A., Frijns, B., Fuertes, A.M., & Miffre, J. (2018) The skewness of

commodity futures returns. Journal of Banking and Finance 86, 143-158.

Aloui, C., & Mabrouk, S. (2010) Value-at-risk estimations of energy commodities via

long-memory, asymmetry and fat-tailed GARCH models. Energy Policy 38, 2326-2339.

Baur, D.G., & Dimp, T. (2018) The asymmetric return-volatility relationship of commodity prices. Energy Economics 76, 378-387.

Data from Montel

Main supervisor: Sjur Westgaard

Co-supervisors: Stein-Erik Fleten, Angeles Carnero Fernández University of Alicante

For more information, please contact Sjur Westgaard, sjur.westgaard@ntnu.no, to schedule a meeting

IFØ33. Sustainability impacts of the aquaculture industry

With the establishment of the United Nations (UN) Sustainable Development Goals (SDGs) in 2015, the role of sustainability aspects in financial markets has increased substantially. The ability to divert funds to sustainable projects and companies through investment decisions makes the financial sector a key player in achieving SDGs. With sustainability becoming an important consideration in financial decision making, a key question for capital providers is how to integrate them into portfolio management and investment strategies. Nevertheless, financial institutions that are looking to invest in the aquaculture companies currently lack suitable tools and methodologies to properly quantify portfolio impacts. While data on company level Environmental, Social and Governance (ESG) factors is readily available, it lacks nuance related to specifics of the aquaculture industry. At the same time, there is still lack of studies that attempt to measure and identify company level sustainability impacts and performance. In particular, among the major environmental challenges that the aquaculture industry is facing are negative impacts on the wild salmon population through disease outbreaks and escapes, as well as and inefficient waste and emissions management. All of these create a negative pressure on marine biodiversity.

This project will assess and quantify biodiversity impact performance on a company level within the aquaculture industry. The starting point for that will be the datasets from the Directorate of Fisheries, Aquaculture Registry and Barentswatch that contain the information on the biophysical factors, production losses and escapes, ownership, as well as more disaggregated information on specific production issues at each plant, and links between plants such as distance, as well as ownership and which licenses are operated at which locations. This allows a deeper analysis of variation in regional risk, company risk as well as the impact of potentially harmful events such as escapes, pancreatic disease, infectious salmon anemia, and other diseases and lice levels. This also allows us to study the link of sustainability related variables with financial risks of listed aquaculture companies in order to assess the value of these investments from the perspective of debt and equity portfolios of capital providers.

Potential research questions. How to assess biodiversity impact performance of individual companies in a transparent and standardized way? How to integrate these insights into portfolio management decisions? How to correctly evaluate and hedge against risks related to sustainability performance?

Methods. Potential methods are from data analysis, econometrics and/or portfolio management and risk management

Industry partner: DnB Asset Management

Main supervisor: Maria Lavrutich

Industry Co-supervisor: Audun Wickstrand Iversen, Porteføljeforvalter

Strategic research initiative: Green Value Creation - Circular Economy

For more information, please contact Maria Lavrutich, maria.lavrutich@ntnu.no, to schedule a meeting

IFØ34. Tactical Supplier Selection Under Exchange Rate Uncertainty

A common problem in tactical supplier selection is the trade of between more distant supplier offering a low price and local suppliers that provides a shorter lead-time. The shorter lead-times have a cost benefit as it reduces the lead-time demand uncertainty and thus the shortages and or need for safety stock. It is fairly straight forward to determine which supplier is optimal, i.e., minimizes the total cost, if demand is the only source of uncertainty.

However, many of the suppliers, particularly the ones providing a lower cost per, operates abroad and thus there also exists a price uncertainty due to fluctuating exchange rates. To complicate the problem further there is a correlation between the exchange rate and the demand that must be accounted for when optimizing the decision of from where to source. We can currently see anecdotal evidence of this as smaller currencies as NOK have lost value against the US$ and € as we have entered an economic down-turn linked to the Russian invasion of Ukraine.

This project aims to develop optimization models for determining the optimal supplier (i.e., the supplier that minimizes the total cost alt. maximizes the total profit) taking the demand and price uncertainty as well as the correlation between these into consideration. The work can also be extended to include other sustainability aspects.

Tasks within the project can include:

Study of existing models and solution methods under price and demand uncertainty.

Formulation and implementation of a stochastic optimization model.

Empirical study of the correlation between exchange-rate fluctuations and demand.

Collaborator: IESE-Business School – Barcelona, Spain

Main supervisor: Peter Berling

Co-supervisor:

Industry Co-supervisor: Prof. Alejandro Serrano

Strategic research initiative: Leading transitions: Co-create a sustainable future / Sustainability.

For more information, please contact Peter Berling, lars.p.berling@ntnu.no, to schedule a meeting.

IFØ35. The dependency structure of interbank swap rates and credit spreads

For fixed-income investors the codependency between interbank swap rates and credit spreads is important for portfolio allocation and risk management. At the same time, this relationship has complex, time-varying non-linear dynamics and represent a risk modelling challenge.

This paper will analyze the dependency structure of interest rate swaps and credit spreads in the Norwegian bank bonds market.

The potential contribution from the paper is twofold. First, this particular market and related data has, to the best of our knowledge, not previously been researched. Second, our methodological approach will be novel, and potentially applicable to other markets.

Data and methodology:

Sparebank 1 Markets will supply the data. We will use time series data retrieved from Bloomberg and Nordic Bond Pricing (NBP). NBP provides credit index data for six different rating classes from 2014 until today. This data includes different classes of debt instruments; including covered, senior, senior-unsecured and non-preferred bonds. This enables us to analyze different sections of the bank capital structure.

We will consider models capable of capturing time-varying paramaters. This includes state-space models (SSM), Bayesian vectorautoregressions (BVAR)and possibly Long-Short Term Memory neural networks (LSTM) in combination with Explainable Artifical Intelligence (Shapley-values).

Main supervisor: Morten Risstad

Co-supervisor: Sjur Westgaard

Starting references:

Asia Aman (2019). 'Are CDS spreads sensitive to the term structure of the yield curve? A sector-wise analysis under various market conditions'. In: Journal of Risk and Financial Management 12.4, p. 158

For more information, please contact Morten Risstad, morten.risstad@sb1markets.no to schedule a meeting.

IFØ36. Unveiling the risk structure of yield farming in DeFi – decentralised finance.

Decentralised finance (DeFi) is a term that encompasses a growing ecosystem of financial services and asset trading based on blockchain networks. This definition is neither legal nor technical [1], yet it is an umbrella term for a market sized at approximately USD 12 billion in 2021-2022 [2,3].

One relevant strategy within this segment is yield farming, which consists mainly of the passive allocation of funds in assets that provides rent, with rates usually above those available for fixed-income investment vehicles in the more traditional financial markets.

This project aims to understand the risks associated with passive yield farming strategies and if those can be quantified and explained using conventional financial analysis.

Main supervisor: Stein-Erik Fleten

Co-supervisor: Felipe Van de Sande Araujo

References:

1. Zetzsche, D. A., Arner, D. W., & Buckley, R. P. (2020). Decentralised finance. *Journal of Financial Regulation*, *6*(2), 172-203.

2. https://www.grandviewresearch.com/industry-analysis/decentralized-finance-market-report

3. https://www.zionmarketresearch.com/report/decentralized-finance-market

For more information, please contact Stein-Erik Fleten, stein-erik.fleten@ntnu.no, to schedule a meeting.

IFØ37. Using Sales Data to Improve the Accuracy of Inventory Records

Inventory inaccuracies is a large problem in practice and empirical studies have shown instances where as many as 65% of the inventory records were incorrect. Securing a perfect (or near perfect) accuracy typically requires costly auditing processes where one manually count the amount of goods in stock for each product. Some methods have been developed where one use the observed sales data to improve the accuracy of the inventory record based on Baysian updating.

There are some inherent problems with the original methods developed which includes:

The updating is done product by product and thus ignores correlation and substitution effects.

For products with a high service level, which one can argue are the majority of products, the value of the Baysian updating is limited.

There have been some later work that remedy some of the drawbacks linked to the first point above but there is still room for additional improvement.

To remedy the problem linked to the second point one need to develop a policy which in an efficient manner ensures that target service level is achieved in the long run while still having periods with high likelihood of shortages to ensure that Baysian updating provides a substantial reduction of the inventory inaccuracy.

Tasks within the project can include:

Identifying current best practice when it comes to inventory accuracy using sales observation.

Developing method that balance the cost of physical audits, the cost of safety stock under planned shortages.

Main Supervisor: Peter Berling

Strategic research initiative: Leading transitions: Co-create a sustainable future / Sustainability.

Sustainability

For more information, please contact Peter Berling, lars.p.berling@ntnu.no, to schedule a meeting.

IFØ38. Solving the Feeder Network Design with inventory as a buffer mechanism.

Liner shipping is the world's most important mode of freight transport, accounting for about 60% of the total volume of international trade. Typically, large container vessels sail regular routes to connect major hub ports on different continents. Containers are then transported from a hub port to regional (feeder) ports using medium and small vessels. The process of establishing liner routes from/to feeder ports and assigning vessels (in terms of number and size) to deploy these routes on a regular basis is called *Feeder Network Design*. This process is at a tactical level and the routes are planned to be used over several months.

The Feeder Network Design has been solved using optimization methods, considering various problem characteristics, from integrating homogeneous fleet of vessels to adopting a more complex routing structure. Although more realistic characteristics are considered when solving the problem, the demand for containers between the hub and feeder ports is considered to be known and weekly fixed for the whole planning period. However, in practice, the demand is usually uncertain, making the problem even more complex. In fact, if weekly demand is lower than expected, vessels operate at a lower capacity. Conversely, higher demand leads to a need to chartering excess capacity, delayed deliveries or lost sales. In all cases, additional (unplanned) costs are incurred by the logistics company. To cope with the demand uncertainty, safety measures must be determined, e.g., safety-stock or excess transport capacity.

This project aims to study the Feeder Network Design with demand control. Two aspects of the problem can be considered:

Optimal/efficient inventory policy given limitations of transport capacity.

Creating feeder routes that are more robust to the demand variations.

The case studies will be based on realistic data for a feeder network between the port of Rotterdam and Norwegian ports.

The following main tasks are expected to be part of the project work:

Understand the problem.

Write a literature review of related works.

Formulate the problem mathematically and possibly propose a specialized solution method.

Conduct a computational study.

Discuss and analyze the results.

Main supervisor: Peter Berling (NTNU)

Co-supervisor: Kais Msakni (NTNU) and Kjetil Fagerholt (NTNU)

Strategic research initiative: Leading transitions: Co-create a sustainable future, Sustainability.

For more information, please contact Peter Berling, lars.p.berling@ntnu.no, to schedule a meeting.

IFØ39. Value-optimized scheduling in commodity operations

For commodities where there is a forward market, it is possible to estimate future cash flows from operations quite accurately, by using the fact that forward prices reveal the current market value of future delivery of the commodity. This can be contrasted with traditional approaches to operational scheduling, where planners rely on spot price forecasts and weighted average cost of capital when estimating the value of future cash flows. Both forecasts and capital costs are hard to estimate with high accuracy, while risk free interest rates and forward prices are readily observable by searching the web. This project will quantify the potential difference in present value of operational schedules when employing traditional planning policies vs a value-optimized policy that is consistent with information available by inspecting prices in the forward markets.

A natural case to consider is hydropower reservoir management, where schedulers need to time-plan releases of water from mountain reservoirs under uncertainty of electricity spot prices as well as weather-driven inflow uncertainty. This planning problem has the same horizon as traded forward contracts in the Nordic financial electricity market, up to 2-3 years.

We have data in the form of historical spot price forecasts and historical forward curves for the Nordic electricity market. Time series of inflows to reservoirs can be downloaded from www.nve.no. We will select a case study/power plant that is not too complicated in terms of number of reservoirs and power stations.

This project is suitable for IFØ students who has some interest in optimization, or for a group across IFØ and AØO. The optimization aspects include setting up an optimization model for the reservoir release scheduling problem. This problem is usually set up as an approximate dynamic programming problem and solved via nested Benders decomposition, and there exists publicly available software libraries that can be employed. The financial aspects involve analysis and modelling of electricity prices, forward curves, and forecasting inflow. A technical background from EMIL is not strictly necessary. At least one of the students should have an AI specialization.

A natural division from the project thesis to the master thesis, is that the project thesis will review the relevant literature, design the experimental study, learn the relevant methods and problem area, and collect and describe the data. In the master thesis, one can do more realistic modelling of the production scheduling problem, as well as more realistic modelling of prices and inflow, before finally performing the quantification/studies and dive into what drives the results.

Main supervisor: Stein-Erik Fleten

Co-supervisor: Felipe van de Sande Araujo

For more information, please contact Stein-Erik Fleten, stein-erik.fleten@ntnu to schedule a meeting.

IFØ40. Volatility Prediction using Artificial Intelligence

The efficient-market hypothesis (EMH) points toward limited potential for artificial intelligence providing valuable forecasts of stock price developments over time since predictive power used in trading will tend to eliminate the same predictive power. Predictability of volatility may, however, persist even given widespread knowledge of forecasting methods. The aim of this project is to evaluate the performance of novel machine learning methods in forecasting stock-market volatility based on price data and possibly other features that improve predictive power. Econometric volatility forecasting models are potential benchmarks, and in the project phase, students may choose to have a main focus on assessing their performance laying a good foundation for analysis of machine learning models in the master thesis phase. A more direct approach toward machine learning models is clearly also a viable option.

Main supervisor: Einar Belsom

For more information, please contact Einar.Belsom@ntnu.no, to schedule a meeting.