GRA 65131 Financial Risk Management

Exam component weight: 20% of GRA 65131

Term: Spring 2025
To be answered: In groups
Answer paper size: 10 pages, excl. attachments and figures/tables.
Number and type of attachments allowed: 1 .zip file.

Formal requirements: *No additional requirements.*

Your team has been approached by the risk management division at a Dutch investment firm, who would like to consider financing some projects in the energy space. They would like you to help analyze their risk management practices and potential investments. They would like your team to help evaluate the risks of financing three different sources of electrical energy production within Europe.

They are currently considering providing debt financing of 200 million EUR via a zero-coupon bond with a face value of 352.468 million EUR (i.e., this is what the bond requires as principle at maturity) to a set of energy projects. This implies the firm expects to earn an annualized yield of 12%, assuming no default.

The 200 million EUR is to be invested into three potential projects with the following characteristics.

1. Investment into a Natural Gas plant:
    a. Each million invested yields a capacity of 95 MWh per day.
    b. The input is natural gas and you can assume the natural gas price is purchased at the TTF (Dutch) day ahead price. Note that natural gas is priced in EUR/MWh, so you can calculate the fuel cost directly.
    c. The per MWh cost of operation and maintenance amortized over the life of the plant is EUR 0.015.
    d. The carbon emissions that must be offset per MWh is 0.20 tons.
2. Investment into a Coal Plant:
    a. Each million invested yields a capacity of 100 MWh per day.
    b. The input is coal and you can assume the coal is purchased at the Rotterdam Month Ahead Coal futures price and that each metric ton yields 8 MWh of electricity.
    c. The per MWh cost of operation and maintenance amortized over the life of the plant is EUR 0.1.
    d. The carbon emissions that must be offset per MWh is 0.45 tons.

3. Investment into Wind Energy production:
    a. Each million invested yields a capacity of 50 MWh per day.
    b. The per MWh cost of operation and maintenance amortized over the life of the plant is EUR 0.2 (this is high because Wind turbines have shorter life-spans).
    c. The carbon emissions per MWh is 0.

You can assume all electricity is sold at the day ahead Dutch electricity price. Note that the actual generation per day will depend on the demands from the market. Therefore, even though the production capacity is described above, the utilization and actual production if often much less. You can assume that projects have equal rights to utilization, however the wind energy project is also limited by the weather. Therefore, you are given separate utilizations for the wind vs. fossil fuel plants.

The carbon offset price is based on the EUA Spot price per metric ton of carbon emissions.

For simplicity, you can assume that production starts as of February 2025 and will continue at the above rates for the next 5-years at which each of the proposed investments will end. You can assume 0 scrap value and 0 decommissioning costs.

The investment firm would like your team to evaluate their current risk management program and their investments. Specifically, they would like your team to evaluate the following scenarios:

1) Financing only one of the production technologies.
2) Financing each of the production technologies evenly.
3) Some optimal mix of the investments that your team determines. Note you cannot have negative investments.

For each they would want to know the expected cash flows from the projects, as well as the potential tail risks they face (e.g., a default on their loan). Given the limited time, they propose that you use the following simplifying assumptions:

Assumptions

1. **Focus only on these three investments, ignoring correlation with the rest of their asset portfolio.**
2. **For each investment, you can assume it is 100% debt financed.**
3. **You can assume a risk-free rate of 2% (annualized).**
4. **You can ignore taxes and treat operating cash flows as net cash flows.**
5. **Start all simulations as of February 1st 2025.**
6. **Assume there are 30-days per month (so 30/360 calendar).**
7. **You can aggregate prices, utilization, costs, and production to the monthly level.**

Support Materials:

Attached are:

- **Starting prices and utilizations rates as of January 31, 2025.**
- **Series of monthly log returns from 02.28.2011-01.31.2025 for Electricity Price (EUR/MWh), Wind Power utilization (as % of Production capacity), Fossil Fuel Power utilization (as % of Production Capacity), and prices for natural gas (EUR/MWh), Coal (EUR/ton), and the Carbon Offset (EUR/ton of CO2). All energy price data is from Bloomberg and utilization data is from ENTSOE as of February 2025. Note these returns have been pre-adjusted to deal with outliers and trends.**
- **A set of factor weights for 3 common latent factors. This analysis was done via a principal component analysis of the returns series for the items listed above. You can use these as given. The factor weights given to you in the data file are the latent factor weights from a Common Factor Analysis. This is similar to an APT type framework from your asset pricing courses. The given weights for each of the series is their weight on the first three common latent factors. This is just a statistical tool to analyze sources of common variation for a given series to reduce the dimensionality. You do NOT have to use this setup in your analyses, it is just given for those that want to.**

The report is due by 1700 CET on March 14th. Please submit a PDF of the report as well as a .zip attachment of any backup material on itsLearning. You do not need submit the complete set of any provided data or your simulations, snippets of the data and simulations are sufficient. You need to submit enough such that a person with reasonable experience and knowledge could replicate your analyses. If submitting code, please submit it in its original form and not as a separate pdf (e.g., do not submit a PDF of Python/R code, instead submit the Python/R code in its native format).

A member of the investment firm's team has agreed to provide a set of information sessions for your team to ask questions. These will be arranged separately. Note the % given at the start of each question are the % that the question represents in determining the overall grade in the assignment component of the course (i.e., the percentages for this assignment add up to 50%).

Questions

You should examine the following items (not necessarily in this order) and report your findings to the investment firm's risk management team. These questions are meant as a guide in writing your report, the final product should not be written in a question/response format. They would like to examine your work so please include any backup material and calculations. Your write-up should be no more than 10 pages not including any tables, figures, or backup.

1. Estimate a model for future monthly movements in the energy prices and carbon prices, as well as the Wind and Fossil Fuel power utilization. Note that there is not a single correct model or tool to simulate prices, but you need to justify your choices in your answers. (10%)
    a. What are the main inputs that go into your model?

    b. Simulate the monthly return and movement series. Explain why you chose your method and discuss the advantages of the model you chose over other potential models. Can include discussion of parametric assumptions, how much historical data was used to form inputs, and the specifics of the model including things such as copula types, return assumptions, volatility estimation (historical, ARMA, GARCH, etc.).

    c. Discuss the potential sensitivity of your model to your modeling assumptions and technique. Do your estimates seem reasonable given historical data?

2. Using your price and utilization estimates from above in each of the 5 investment scenarios discussed (the three scenarios with 100% weight in each project, one scenario with equal weights among projects, and one scenario where your team choses the weights), estimate the underlying firm's monthly cash flows over the next 5-years. Use this to estimate the underlying firm's expected monthly cash flows for each month and the minimum and maximum monthly cash flows with 95% certainty for each month over the next 5-years and report your results. Note in your analysis that there might be potential outliers of prices, you can choose to deal with these as you see fit. (7.5 %)

3. Estimate whether the underlying project would potentially default for the given simulations. For each simulation, you can assume the project retains its monthly cash flows and they earn the risk-free rate. The project will default if the total retained cash flows are less than the face value of the bond at maturity. Using these estimates, calculate the overall frequency that the underlying firm defaults on the final principal payment (i.e., does not have enough retained cash to cover the face value of the bond). (5 %).

4. Given your estimates from above, you will now determine whether the firm needs to update its pricing of the bond. (10%)
    a. Which of the scenarios appears to have the lowest default frequency for the given face value? Which appears to have the highest default frequency?

    b. What are the max losses you would expect on the bond for each project with 95% confidence (losses are the face value of the bond less the retained cash flows if the bond defaults and 0 if not)? Why might this be more useful than default frequency as a measure of risk?

    c. If the given project produces defaults, calculate the correct face value of the bond for the given project such that investment firm would get their expected rate of return (i.e., 12% annualized) on the bond. Hint: To do this you need to calculate a face value of the bond such that in non-default states they receive the face value and in default states they receive the accumulated cash flows, and that on average they earn 12% annualized (i.e., their expected payment is 352.468 million EUR). You will likely need to use a minimization routine (i.e. solver in Excel, scipy.optmize.minimize in Python, or the optimize function in R).

5. Assume the investment firm uses the updated face value. Further, assume, if cash flows are negative in a given month the project faces distress costs of an additional 10% (e.g., if the calculated monthly cash flow from above was -2 million, then the project would have an actual cash flows of -2.2 million). (10%)
    a. Why might the investment firm want the underlying firm they are financing to hedge their cash flows?

    b. Suppose an investment bank offers to sell the underlying firm a derivative that guarantees that the project never has negative monthly cash flows, i.e., the derivative pays –min{cash flow, 0}. Note the derivative does not cover distress costs, just the implied cash flows of the project. Given your simulations, estimate the value of this derivative for each project and discuss how this derivative might be constructed in practice.

    c. How would the firm determine if it is worth buying this derivative on the underlying company? You do not have to calculate, just explain.

6. What general recommendations do you have for the firm's risk management team concerning this investment? This can include discussions of: (7.5%)
    a. What other forms of risk might exist and how these risks might affect your estimates (i.e., other product prices, regulatory risk, etc.)?

    b. What types of things should they consider when implementing and deciding on a risk management strategy if they wanted to hedge some of their market risk with derivatives?

    c. Your overall recommendation for the firm's investment strategy and why?