# Coming up...

# Background

**Unclear** investment expectations.
**Ineffective, costly, inaccessible** portfolio management.
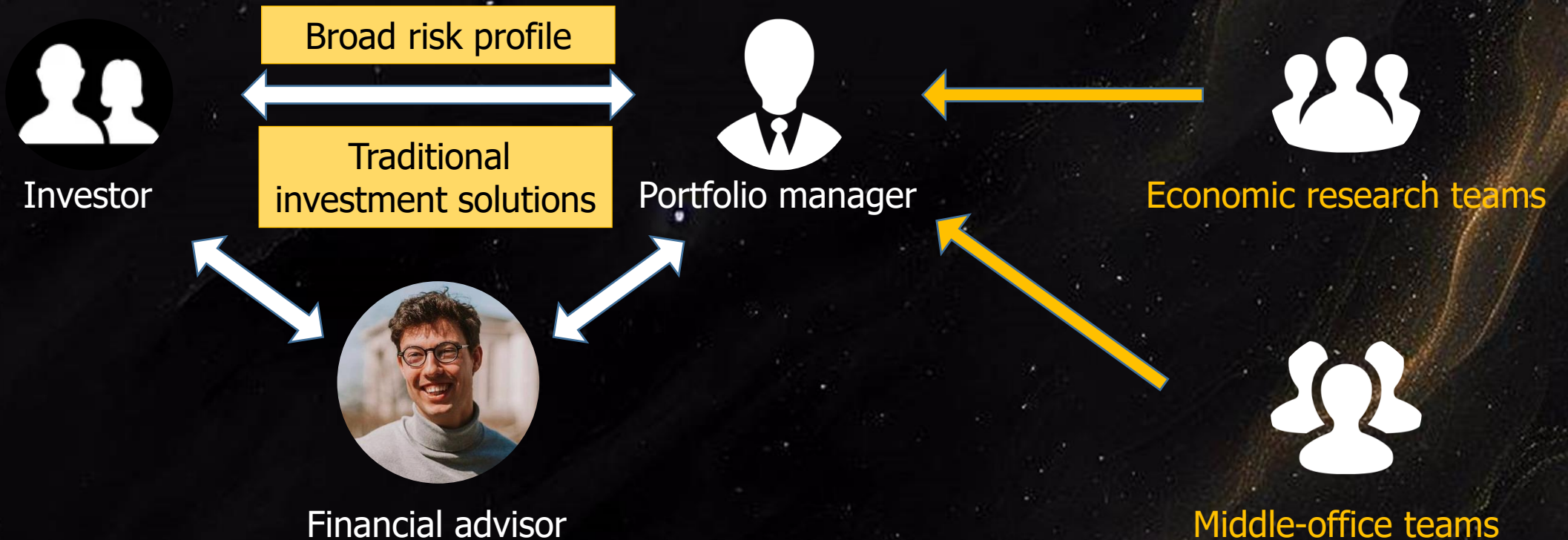
Investor

Broad risk profile

Traditional investment solutions

Portfolio manager

Financial advisor

Investment strategy teams

Economic research teams

Middle-office teams

# Coming up...

# Introduction (1/2)

| Objective | Determine the unique, optimal investment strategies for user-specified parameters. |
|---|---|
| In support | We consider a range of sub-questions. |

| Ideation | <ul><li>**Which financial instruments** would be most relevant?<ul><li>➤ Exclude individual assets, given survivorship bias and hindsight bias.</li><li>➤ Focus on complementary indices of equities, bonds and commodities.</li></ul></li><li>**Which indices** to include in our investment universe?<ul><li>➤ Brainstormed a longlist of 30+ indices.</li></ul></li></ul> |
|---|---|

| Data | <ul><li>**Price data of selected indices and currency pairs**:<ul><li>➤ ~~Refinitiv Eikon, Wharton (WRDS), Yahoo Finance,~~ Bloomberg Terminal.</li></ul></li><li>**Swiss inflation data**:<ul><li>➤ World Bank.</li></ul></li><li>**CHF money market rates**, and **spot interest rates on Swiss bonds**:<ul><li>➤ Swiss National Bank.</li></ul></li></ul> |
|---|---|

# Introduction (2/2)

| | |
|---|---|
| **Methodology** | • **Data preprocessing**: <br> ➢ Data cleaning, integration and transformation. <br> ➢ Data preparation (feature engineering). <br> • **Derive unique optimal investment strategies** for user-specified parameters: <br> ➢ Apply (machine learning) algorithms to the relevant dataset. <br> ➢ Balance model performance and computational efficiency. |
| **Final result** | A reliable tool for decision-making in investment management. |

# Coming up...

# Research question

**What is the unique optimal investment strategy that corresponds exactly to a given user-specified set of investment parameters?**

**Sub-questions:**

1. Identifying the most relevant investment parameters.

2. Choosing the appropriate securities to be considered.

3. Defining and balancing criteria for model accuracy and computational efficiency.

4. Determining restrictions to possible combinations of securities.

5. Developing a method to determine an optimal investment strategy.

6. Identifying the optimal estimation method and corresponding specification

7. Validating the robustness of the optimal investment strategy.

8. Considering the impact of inflation and foreign exchange movements.

9. Evaluating the theoretical underpinnings and assumptions of the optimization model.

# Coming up...

# Data
## Data sources and data collection

**Leveraging data from multiple sources:**
sources that are reliable and comprehensive, thus well-suited for our research objectives.

| File name (raw data) | Data source | Description | Date range (frequency) | File size |
|---|---|---|---|---|
| Bloomberg_Terminal-spreadsheet_builder.xlsx | Bloomberg Terminal | price data of selected indices and currency pairs | 1 Jan 1973 – 16 May 2023 (daily) | 4.363 KB |
| API_FP.CPI.TOTL.ZG_DS2_en_excel_v2_5454868.xls | World Bank Open Data | Swiss inflation data (CPI in %), | 1960 – 2022 (annual) | 315 KB |
| snb-chart-data-rendeidglfzch-en-all-20230502_1430.xlsx | Swiss National Bank data portal | CHF money market rates | 4 Jan 1988 – 28 Apr 2023 (daily) | 359 KB |
| snb-chart-data-zimomach-en-all-20230502_1430.xlsx | Swiss National Bank data portal | CHF spot interest rates on Swiss Confederation bond issues | 3 Jan 2000 – 28 Apr 2023 (daily) | 177 KB |

**Collecting and integrating the data correctly is a significant task:**
loading the raw data into R from different sources, each with different data formats.

# Data
## Data cleaning and data preparation (1/2)

| R data frames with raw data, collected from multiple sources | | | |
|---|---|---|---|
| **index_prices_local_currency** | **CHF_FX** | **swiss_inflation** | **CHF_rf_rates** |
| *daily price data of selected indices, denoted in their local currency* | *daily price data of selected currency pairs* | *annual Swiss inflation data (CPI, %)* | *daily CHF money market rates and spot interest rates on Swiss confederation bond issues* |

**(1)** aligning dates across different data frames

**(2)** sorting and filtering data

**(3)** revising column names

**(4)** recalculating inflation values into percentages

**(5)** removing indices that did not contain sufficiently long dated price data and were not essential

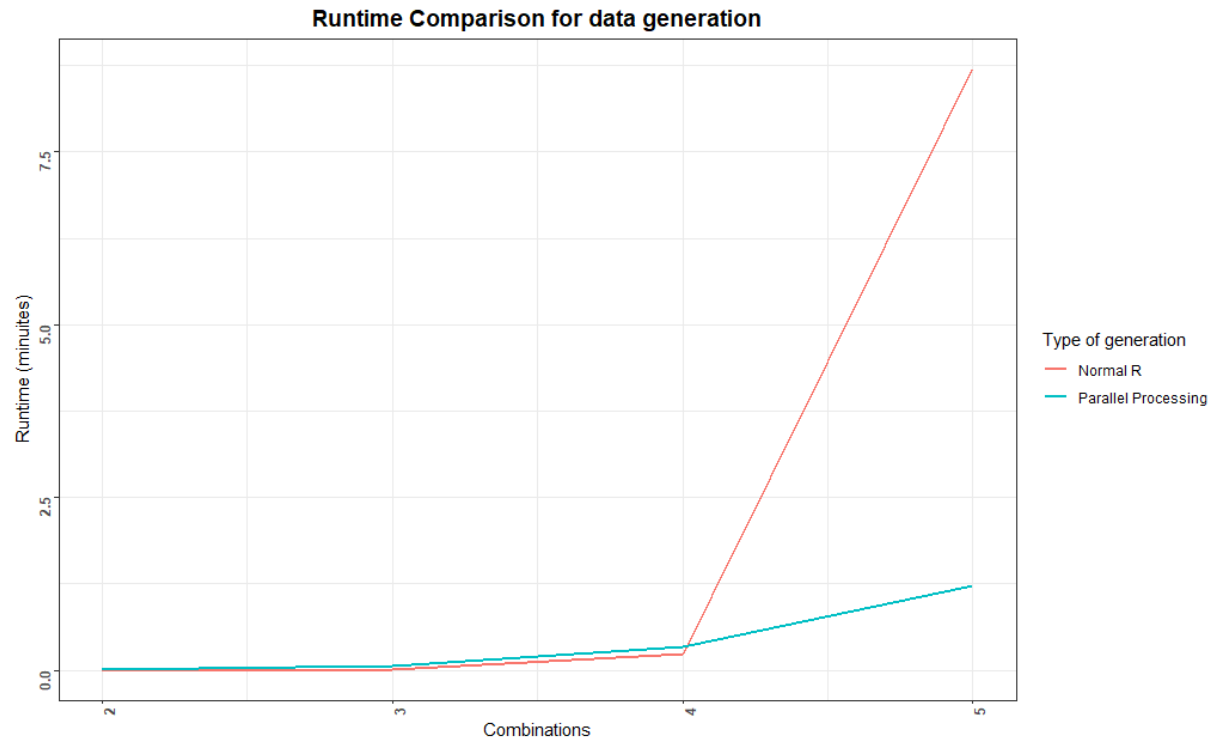**(6)** removing dates that still contained N/A values

**Data that is clean, consistent and prepared for further analysis or transformations:**
➤ number of columns (indices) reduced from 49 to 26;
➤ rows (dates) include only observations for which all remaining indices display values.

# Data
## Data cleaning and data preparation (2/2)



**Runtime Comparison for data generation**

Type of generation
— Normal R
— Parallel Processing

| Combinations | Columns | File_Size_MB |
|---|---|---|
| 2 | 351 | 14 |
| 3 | 2951 | 115 |
| 4 | 17901 | 694 |
| 5 | 83681 | 3245 |
| 6 | 313911 | 12171 |
| 7 | 971711 | 37675 |
| 8 | 2533986 | 98248 |
| 9 | 5658536 | 219394 |
| 10 | 10970271 | 425342 |

# Coming up...

# Analysis



**Correlation matrix of the initial dataset**
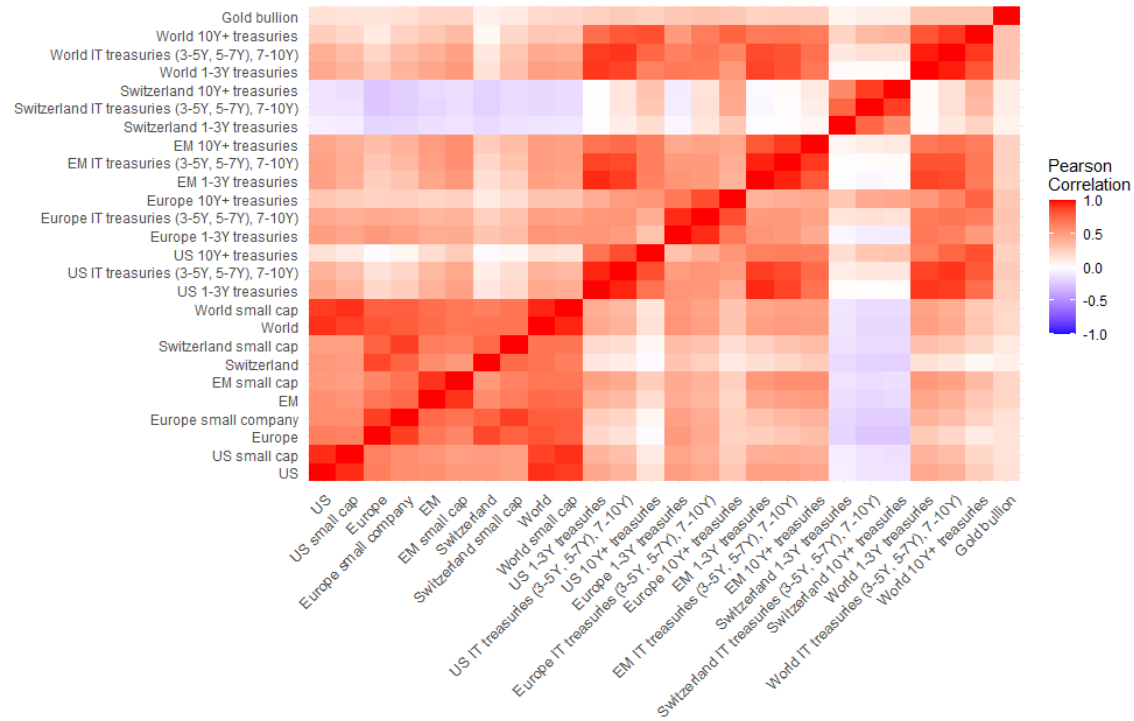
**Annualised mean and standard deviation of all the investment strategies**
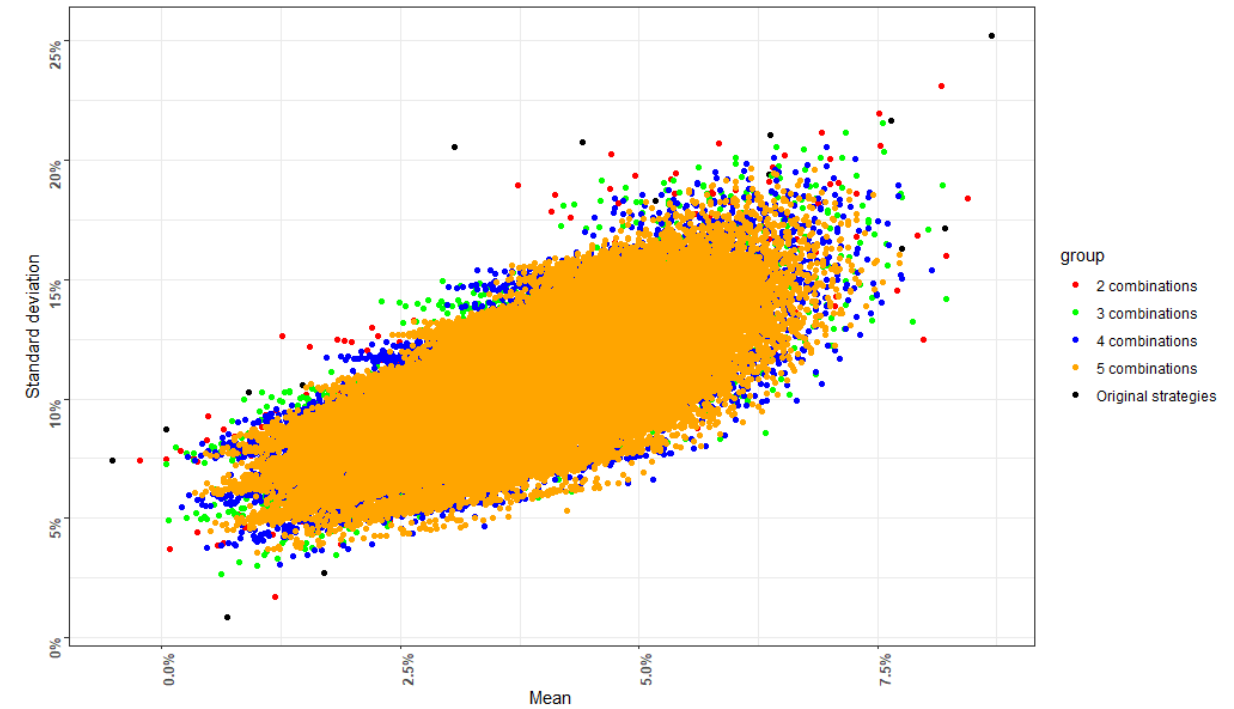
# Coming up...

# Results

| Column | Worst_Period_End_Value |
|---|---|
| US | 106.95353 |
| US small cap | 118.89280 |
| Switzerland | 85.80458 |
| Switzerland small cap | 111.33754 |
| World | 86.70190 |
| World small cap | 102.65978 |
| US 1-3Y treasuries | 90.38016 |
| US IT treasuries (3-5Y, 5-7Y), 7-10Y) | 107.61577 |
| US 10Y+ treasuries | 111.47750 |
| Europe 10Y+ treasuries | 85.21149 |
| EM 1-3Y treasuries | 108.08380 |
| EM IT treasuries (3-5Y, 5-7Y), 7-10Y) | 116.25697 |
| EM 10Y+ treasuries | 115.20969 |
| Switzerland 1-3Y treasuries | 95.40698 |
| Switzerland IT treasuries (3-5Y, 5-7Y), 7-10Y) | 97.21826 |
| Switzerland 10Y+ treasuries | 96.01914 |
| World 1-3Y treasuries | 85.48971 |
| World IT treasuries (3-5Y, 5-7Y), 7-10Y) | 97.02807 |
| World 10Y+ treasuries | 95.42560 |
| Gold bullion | 100.54892 |

Input parameters: 10 year time period, 85% threshold

Best of the worst: US small cap

# Coming up...

# Scaling and Cloud Deployment
# (Work in progress)

**Leveraging the power of cloud platforms and data processing technologies:**

1. Employ better (machine learning) algorithms for our investment optimization model.

2. Evaluate and improve the out-of-sample performance of our model.

3. Improve computational performance.

4. Store increasingly large data sets more efficiently.

| Functionality | Amazon AWS | Google Cloud Platform | Microsoft Azure | Open-Source Software |
|---|---|---|---|---|
| Object Storage | Amazon S3 | Google Cloud Storage | Azure Blob Storage | Hadoop Distributed File System (HDFS) |
| Data Warehousing / Analysis | Amazon Redshift | BigQuery | Azure Databricks | Apache Hadoop (MapReduce), Apache Spark (Spark SQL) |
| Compute Instances | AWS EC2 | Google Compute Engine | Azure Virtual Machines | - |
| Machine Learning Platform | AWS SageMaker | Google Colab, Google Cloud AI | Azure Machine Learning | Apache Spark (Spark MLlib), H2O.ai, TensorFlow, PyTorch |
| Database Management System | Amazon RDS | Google Cloud SQL | Azure SQL Database | SQLite |
| Data Orchestration | AWS Step Functions | Google Cloud Composer | Azure Logic Apps | Apache Airflow |

Thank you!

Questions?