Simulation and Forecasting

MGMT 675: AI-Assisted Financial Analysis

Outline

- Setting up a simulation in Julius/python
- Random walks
- Mean reversion
- Estimating parameters from historical data
- Forecasting the crude oil price
- Julius workflow

Simulating in Julius

Setting up a simulation in Julius/python

- Model calculates outputs given inputs
- Ask Julius to create a function that calculates outputs given inputs
- Ask Julius to run a given number of simulations drawing inputs from given distributions
- Ask Julius to describe the distributions of the outputs: histogram, mean, median, standard deviation, 90% confidence interval, etc.

Retirement planning

- Inputs:

Retirement planning

- Inputs:
- Treat array of investment returns as an input

Retirement planning

- Inputs:
- Treat array of investment returns as an input
- To simulate, ask Julius to create the array in each simulation as an array of independent random variables drawn from some distribution.

Random Walks and Mean Reversion

Random walks

- A random walk is a variable for which the changes or percent changes are independent random variables.
- Example
  - Model stock returns as independent random variables
  - Implies stock price is a random walk
- Interest rates are very close to random walks.

Mean reversion

- A variable is mean reverting if changes are usually partially reversed by subsequent changes.
- "What goes up must come down"
- Interest rates don't get infinitely large. Positive changes tend to be somewhat reversed by subsequent negative changes.
- Commodity prices (crude oil, etc.) tend to be mean reverting.

A simple mean-reverting variable

- Simple example of mean reverting variable is

$$x_{t+1} = a + bx_t + \epsilon_{t+1}$$

  where ϵ's are iid with mean 0.
- $E[x_{t+1} \mid x_t] = a + bx_t$.
- $E[\Delta x_{t+1} \mid x_t] = a + (b-1)x_t$.
- Assume $b < 1$. Then,
  - $E[\Delta x_{t+1} \mid x_t] > 0 \Leftrightarrow x_t < a/(1-b)$.
  - $E[\Delta x_{t+1} \mid x_t] < 0 \Leftrightarrow x_t > a/(1-b)$.
  - $a/(1-b)$ is the long-run mean of x.

Example

Simulating the Price of Crude Oil

- Ask Julius to get monthly crude oil prices from FRED for the longest possible history using pandas data reader.
- Ask Julius to regress the crude oil price on the lagged price.
- Ask Julius to compute intercept / (1 - slope coefficient).
- Ask Julius to plot the crude oil prices and include a horizontal line at intercept / (1 - slope coefficient).
- Ask Julius to simulate from the model assuming normally distributed residuals and plot the distribution of the crude oil price 24 months from today.
- Warning: Julius may talk about AR(1) models and change the notation.

Julius Workflow

Retirement planning workflow: User prompt

Specify in real terms (today's dollars)

- current investment account balance,
- number of years before retirement
- planned annual savings amounts before retirement,
- expected annual investment return and standard deviation
- number of years of withdrawals after retirement
- planned annual withdrawals after retirement
- borrowing rate if balance goes negative

Retirement planning workflow: Julius prompt

- Simulate returns by year
- Update the investment account balance each year based on the planned deposit or withdrawal and the simulated return (using the borrowing rate instead if the balance is negative)
- Repeat 1,000 times
- Report the probability that the plan is successful (ending account balance is not negative).
- Compute the median (across simulations) account balance each year and plot by year.
- Produce a histogram of the ending account balance across simulations