Simulating Financial Markets to Analyze Personal Retirement Plans

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Planning for Retirement

Pre-retirement:

- How much money do I need to retire?
- How long will it take to save that much?
- When should I retire?

Post-retirement:

- How much can I spend in retirement?
- How long will my money last?

Longevity Risk

- The probability of running out of assets in retirement

Financial Unknowns:

- Cost of Living (inflation)
- Equity Returns
- Medical Costs
- End of Life Costs

How is this risk treated?

Deterministic approach:

Inflation: 2%

Stock Returns: 5%, 8%

Short Term Interest Rate: 3%

Withdrawal Amount: $XXX.XX

How is this risk treated?

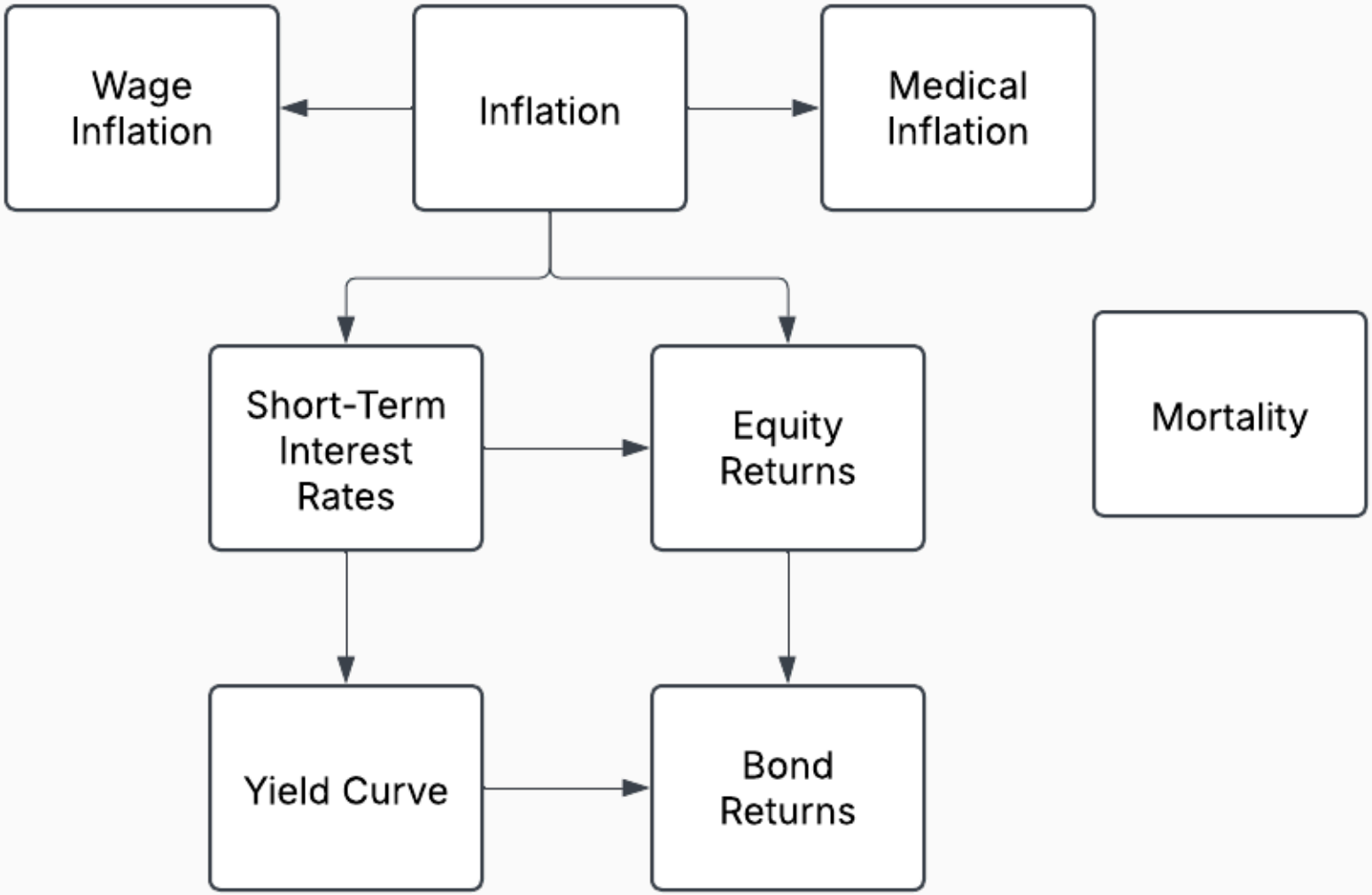
Simulation from the past:

- Apply a specific "retirement plan" to a year from the past
  1. Pick a "plan" (i.e. 4% Withdrawal Rate, 50% equity porfolio)
  2. Apply that plan to a year from the past
  3. Simulate cash-flows using past data
  4. Iterate over "all" years

Our Approach:

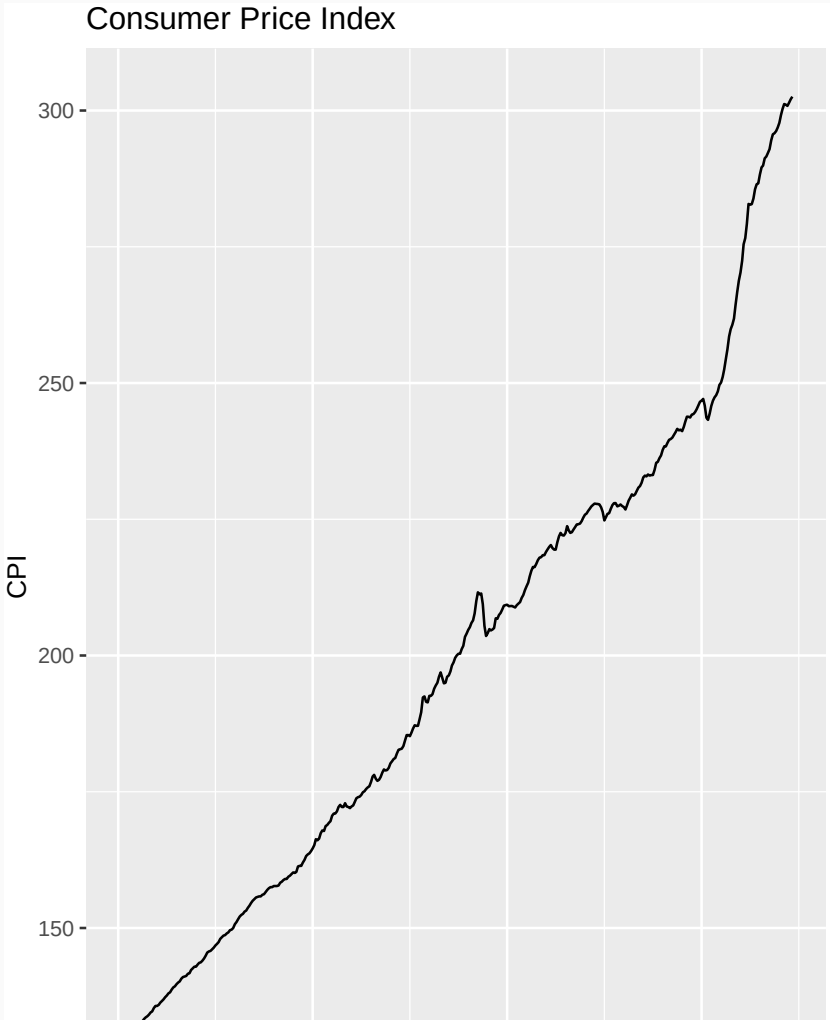
1. Build a model for each component of the economy that affects retirement plans
2. Combine individual models to represent “an economy” (Economic Scenario Generator)
3. Simulate economic scenarios
4. Apply retirement plans to these scenarios and analyze outcomes

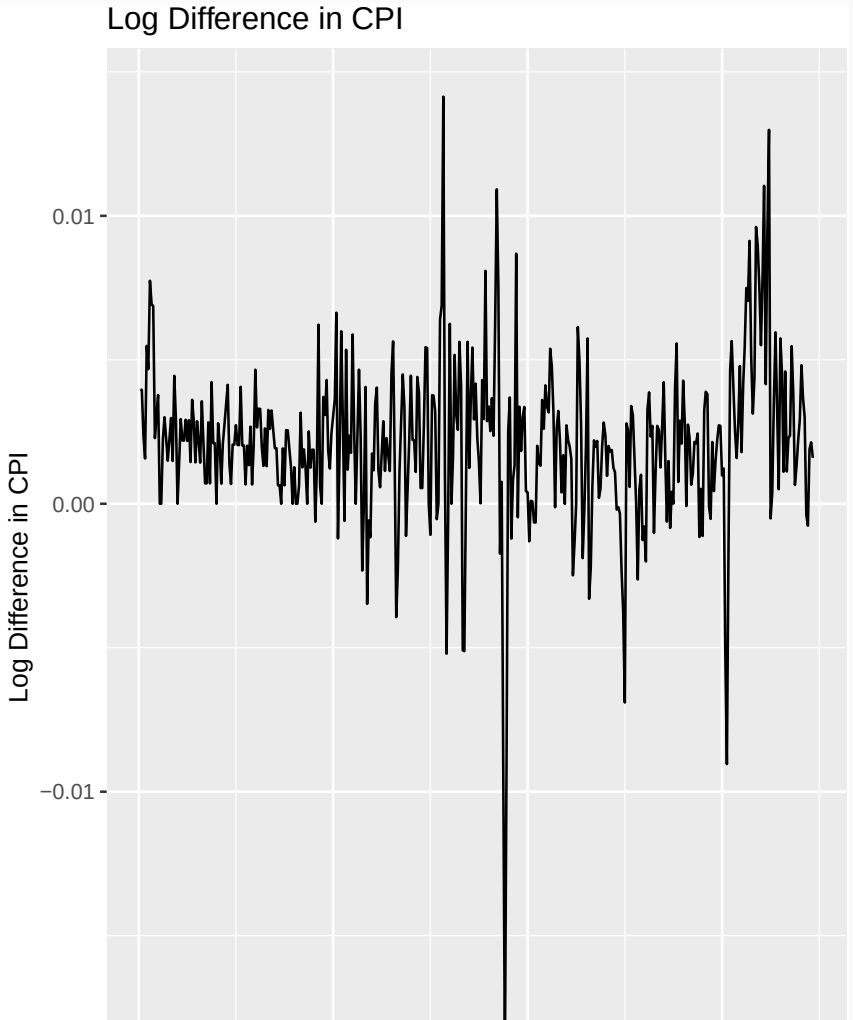
Economic Scenario Generator (ESG)



Step 1: Inflation

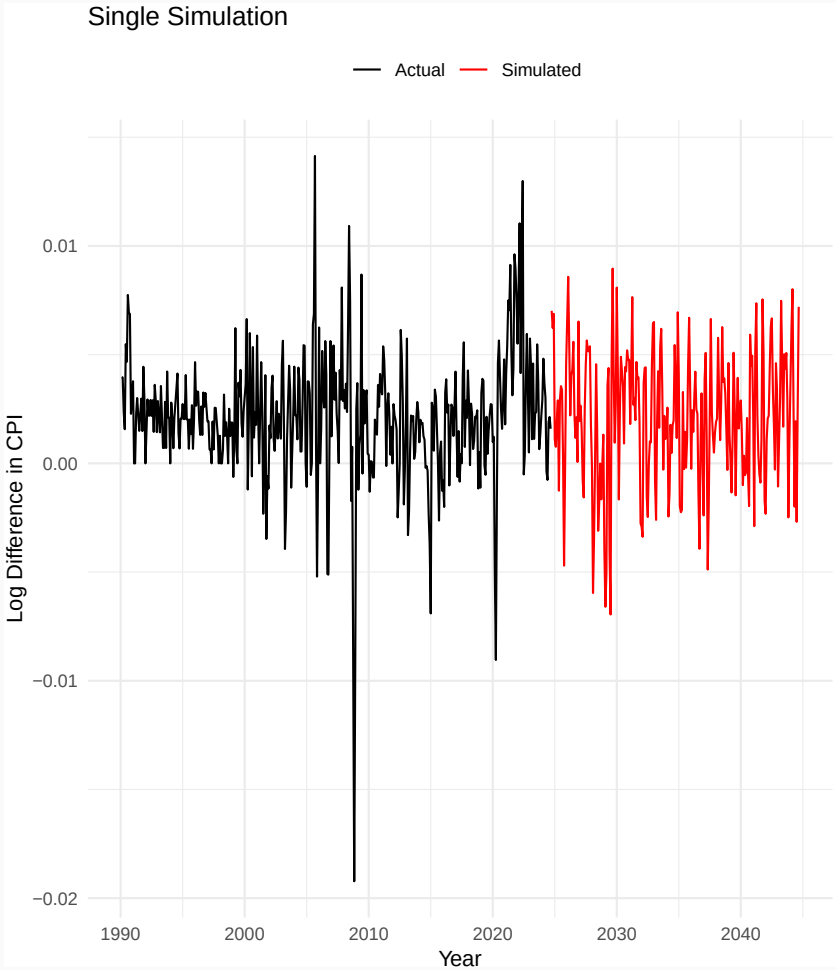
$$CPI \rightarrow \log(CPI_n) - \log(CPI_{n-1}) = \log(\frac{CPI_n}{CPI_{n-1}})$$

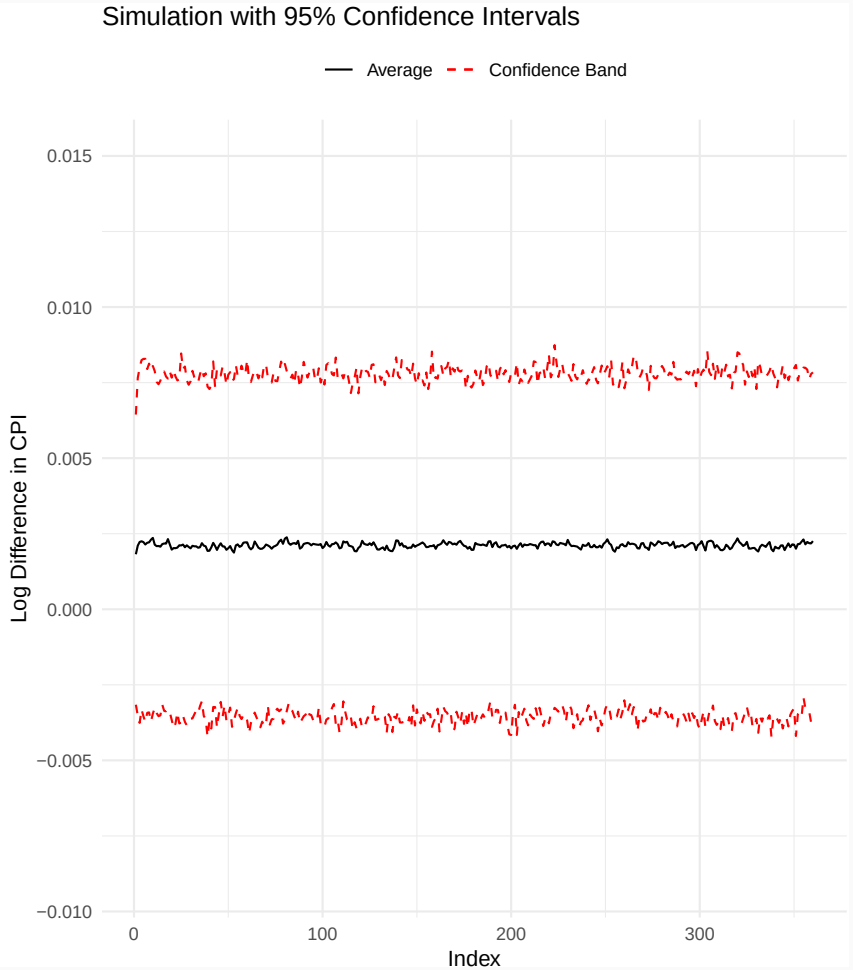




Step 1: Inflation

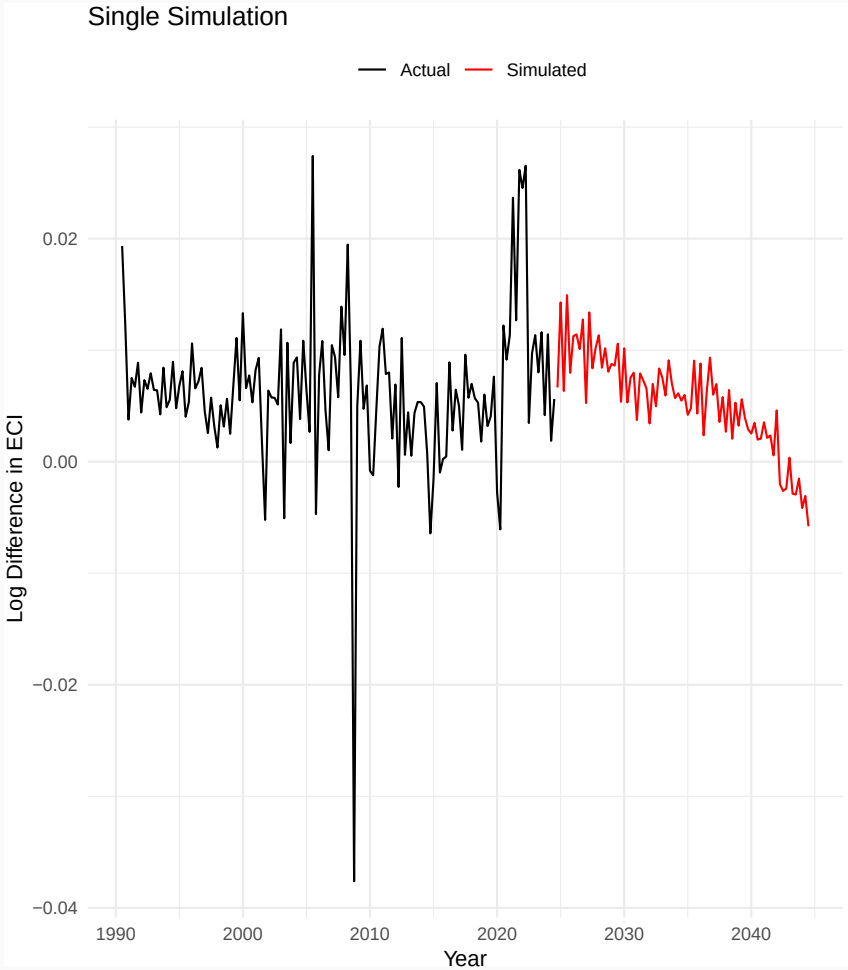
$$\log(\frac{CPI_n}{CPI_{n-1}}) \sim ARIMA(1,0,1)$$

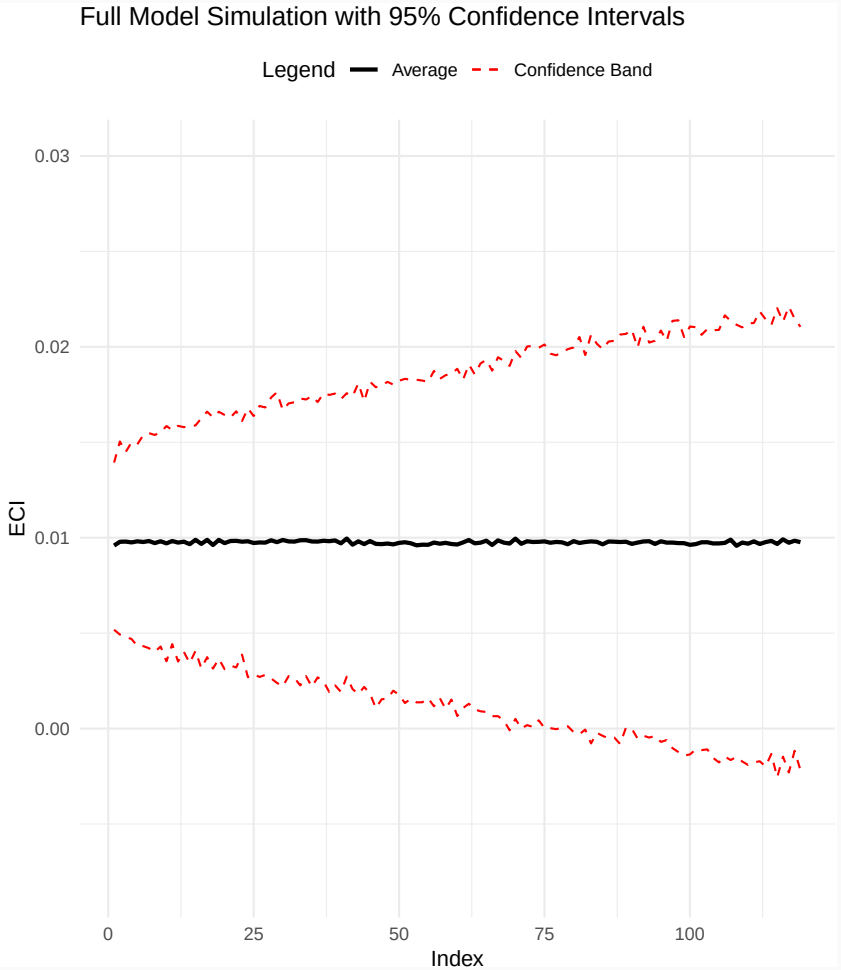




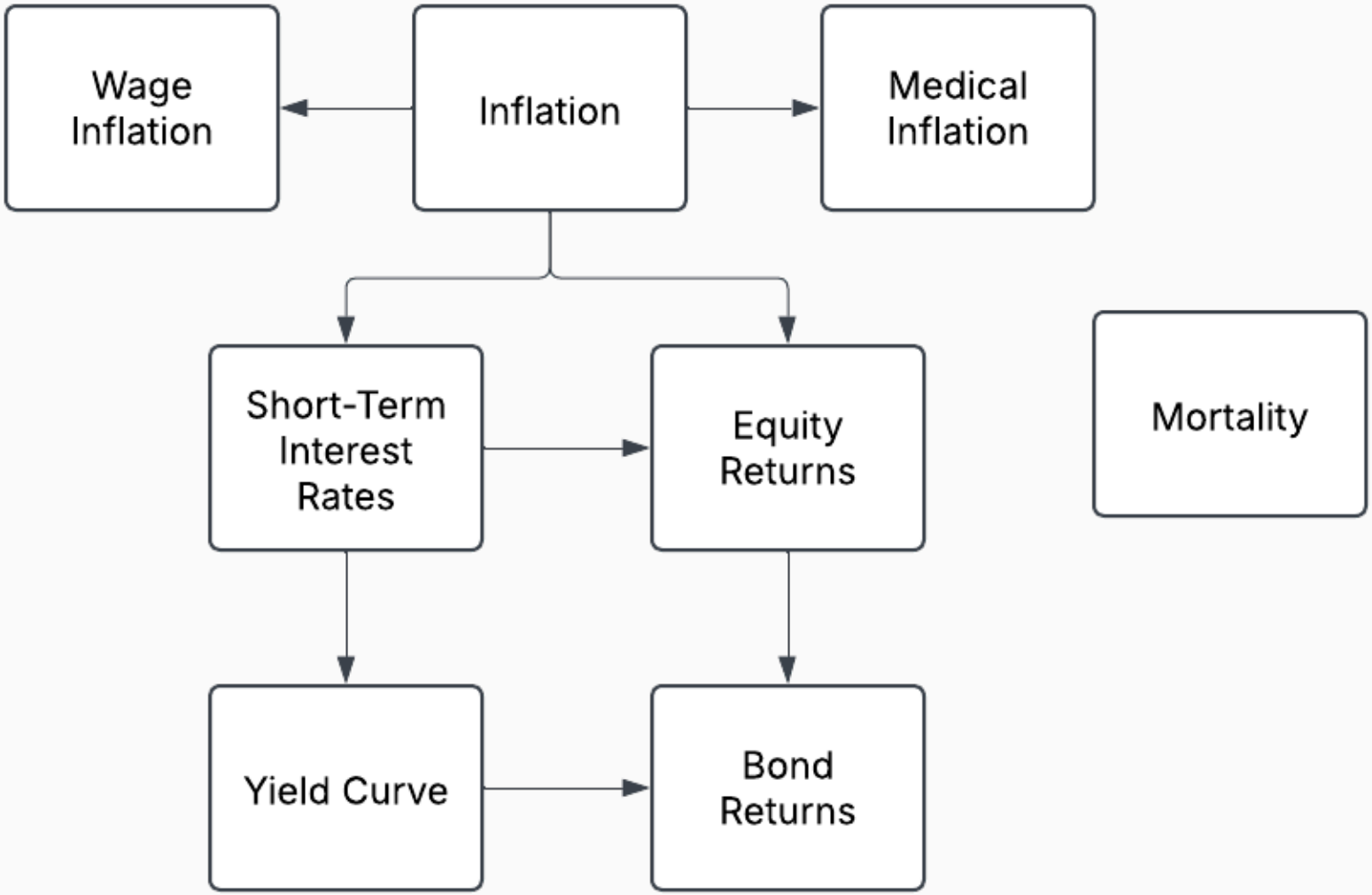
Step 2: Wage Inflation (ECI)

$$\log\left(\frac{ECI_n}{ECI_{n-1}}\right) \sim ARIMA(1,1,1) + \log\left(\frac{CPI_{n-1}}{CPI_{n-2}}\right)$$





Looking Ahead



Looking Ahead

- Continue building the ESG
- Address questions:
  - How much should someone withdraw each year into retirement (safe-withdrawal rate)?
  - How much should someone annuitize?
  - How risky would “x” spending plan be?
- Shiny App