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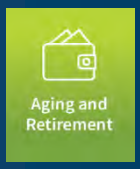
Deep Learning for Liability-Driven Investment



SUMMARY

Liability-driven investment (LDI) is a key investment approach adopted by insurance companies and defined benefit (DB) pension funds. However, the sophisticated liability portfolio and volatile asset market make strategic asset allocation very challenging. The optimization of a dynamic asset allocation strategy is difficult to achieve without simplified assumptions.

This report uses deep learning models and reinforcement learning (RL) to construct a framework for learning the optimal dynamic strategic asset allocation plan for LDI. It designs a stochastic experimental framework of the economic system in which the program finds the optimal strategy by trying different and nonconstant asset allocation plans from time to time.

It provides a workable example to demonstrate the application of RL to LDI and assess its effectiveness. Without simplifying any aspect of liability and asset modeling, it shows the potential of RL to solve complex actuarial problems.

HIGHLIGHTS

- The report introduces RL and deep learning to actuaries.
- Using a dynamic LDI example based on a DB plan, the research shows that RL can incorporate liability complexity, which is challenging for dynamic programming. RL can also handle multiple asset classes with reduced training time, which is challenging for a full-blown asset allocation grid search approach.
- The drivers of the dynamic strategies by RL are liability development and funding status. With the experimental environment set up, RL models can be trained to find appropriate but not necessarily optimal dynamic investment strategies. An RL-based investment strategy may achieve a better risk return tradeoff in some cases.
- RL can reflect risk appetite by adjusting the reward function. By increasing the weight on negative reward (penalty) in the total reward calculation, RL moves from aggressive to conservative strategies.
- With quarterly scenarios and rebalance, investment strategies suggested by RL are driven by average returns rather than periodic fluctuations.
- Sample implementation codes are made public for educational purposes and hosted at GitHub - Society-of-actuaries-researchinstitute/FP198-Deep-Learning-for-Liability-Driven-Investment.

GET THE FULL REPORT

Deep Learning for Liability-Driven Investment
https://www.soa.org/resources/research-reports/2021/liability-driven-investment/

METHODOLOGY

- The report starts with discussing the LDI problem faced by traditional methods, followed by introducing the RL framework that has the potential to solve the problem, and uses a complicated case study to evaluate the suggested solution.
- The case study based on a DB pension plan includes the entire process.
  - An LDI benchmark model that contains economic scenario generation, asset and liability projection, and evaluation of LDI strategies.
  - RL and deep learning model training and validation
  - Analysis of LDI strategies suggested by RL with comparison against static optimal strategies.
    - Two asset classes with/without rebalance constraint
    - Four asset classes without rebalance constraint.

REPORT SPECS

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- Research sponsor: Committee on Finance Research of the Society of Actuaries
- Author: Kailan Shang, FSA, CFA, PRM, SCJP
- Contents: Introduction and executive summary, LDI problem, reinforcement learning model, dynamic LDI example, further developments, conclusion, acknowledgements, appendices, 30 figures, and 19 tables.
- Data source: Bureau of Economic Analysis, U.S. Department of the Treasury, Federal Reserve Economic Data, Yahoo Finance, etc.

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