Russell-Yasuda Kasai Model

Multi-stage

Asset / Liability Management

- Cariño, D. R., T. Kent, et al. (1994). "The Russel-Yasuda Kasai model: An asset-liability model for a Japanese insurance company using multistage stochastic programming." *Interfaces* **24**(1): 29-49.
- Cariño, D. R., D. H. Myers, et al. (1998). "Concepts, technical issues, and uses of the Russell-Yasuda Kasai financial planning model." *Operations Research* **46**(4): 450-462.
- Cariño, D. R. and W. T. Ziemba (1998). "Formulation of the Russell-Yasuda Kasai financial planning model." *Operations Research* **46**(4): 433-449.

- Developed by Frank Russell Company and The Yasuda Fire & Marine Insurance Company.
- Decisions are made on how best to invest in assets to meet a random liability stream over time, with random investment returns.
- Goal is to produce a high-income return to pay annual interest on savings-type insurance policies while maximizing the long-term wealth of the firm.
- Handles complex regulations imposed by Japanese insurance laws and practices.
- Model is multistage stochastic LP with recourse

Random Variables

rp_{jt} = price return of asset j in period t

ri_{jt} = income return of asset j in period t

F_t = deposit inflow in period t

P_t = principal payout in period t

I_t = income payout in period t

g_t = rate of interest paid on policies in period t

L_t = liability valuation at end of period t

Decision Variables

w_{jt} = market value held in asset j in period t

W_t = total fund market value in period t

u_t = income shortfall in period t

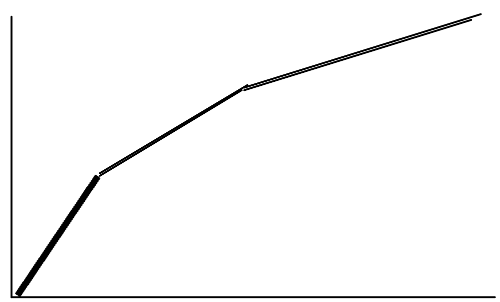
v_t = income surplus in period t

Objective:

$$\textit{Maximize} \quad E\left[W_H - \sum_{t=1}^{H} c_t\left(u_t\right)\right]$$

where $c_t\left(u_t\right)$ is a piecewise-linear concave function which specifies the penalties for income shortfalls.

(Converts to LP with introduction of additional variables.)



Constraints include:

$$\sum_{j=1}^{J} w_{jt} = W_t$$

$$W_{t+1} - \sum_{j=1}^{J} \left(1 + rp_{j,t+1} + ri_{j,t+1}\right) w_{jt} = F_{t+1} - P_{t+1} - I_{t+1}$$

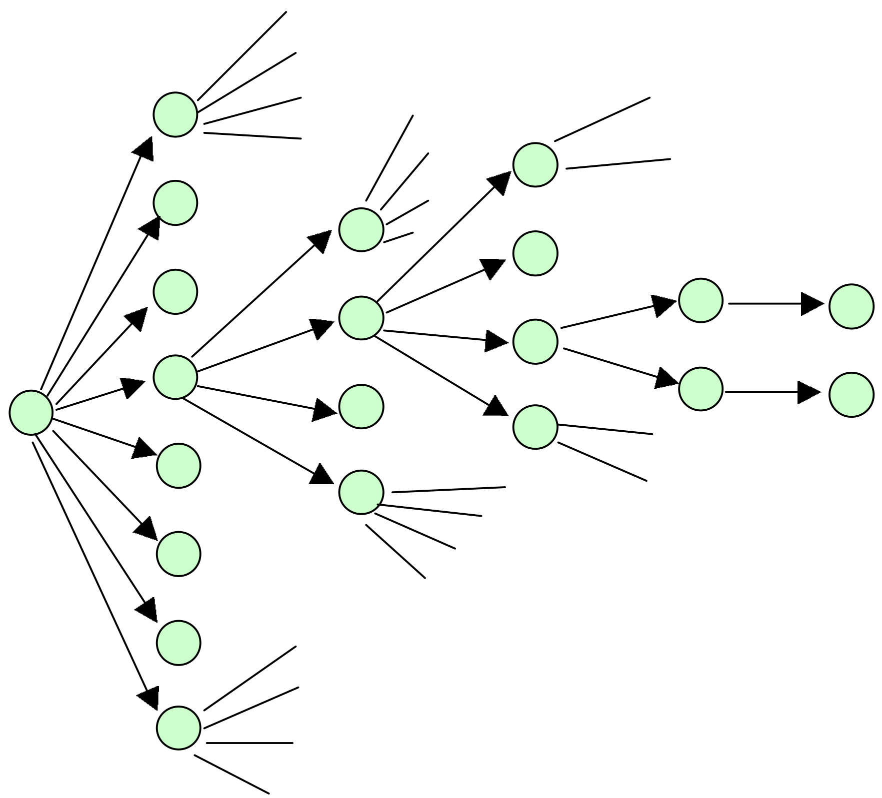
$$\sum_{j=1}^{J} ri_{j,t+1} w_{jt} + u_{t+1} - v_{t+1} = g_{t+1} L_t$$

$$w_{jt} \geq 0, \quad u_t \geq 0, \quad v_t \geq 0$$

Periods are of varying length:

- 8 branches in period 1 (first quarter)
- 4 branches in period 2 (remainder of first year)
- 4 branches in period 3 (year 2)
- 2 branches in period 4 (years 3-5)
- 1 branch in period 6 (terminal conditions)

Total number of scenarios: $8 \times 4 \times 4 \times 2 \times 1 = 256$



Size of Problem (# asset classes=7)

rows: 263

columns: 431

Size of Deterministic Equivalent Problem

rows ~ 31,000

columns ~ 44,000

Nested Benders' Decomposition was used.

Three hours of computation was required to solve full model.

Contributed 79 million US$ in first two years of use.