Motivation

Robo-advisors have emerged prominently as an alternative to traditional human advisors. Using built-in algorithmic procedures, robo-advisors monitor and re-balance investors’ portfolios in a low cost and efficient manner. The performance of the robo-advisor strongly depends on its ability to accurately assess the investor’s risk tolerance. We develop a framework in which the robo-advisor learns the investor’s risk preference from investors’ trading actions.

Model

- $T$ period investment framework
- Robo-advisor makes a decision $\sigma_t^a = \{\text{ask}\} \cup \{p^{(1)}, \ldots, p^{(m)}\}$ at each time $t$
- $S = \{s^{(1)}, \ldots, s^{(n)}\}$ is the set of economic scenarios
- Portfolio $p^{(i)}$ in state $s \in S$ has random return $X_{s^{(i)}}$
- Probability of a transition from state $s \in S$ to $s' \in S$ is known
- Investor’s risk aversion parameter $\theta_s$ depend on state $s \in S$
- Investor makes mistakes
- Trading imposes a cost $\kappa$ on the investor
- Investor utility in each period is $u(\theta_s, s_t, \sigma_t)$

Robo-advisor goal: maximize $E(\sum_t u(\theta_{s_t}, s_t, \sigma_t^a))$

Methodology and Results

We propose an algorithm, and show that it converges to the (intractable) optimal policy in a number of steps that is polynomial in the quantities describing the system. Convergence rate depends on the consistency of the investor’s portfolio choices.

Calibration

We calibrate our model to business cycle data from the National Bureau of Economic Research (NBER) and Vanguard’s economic and market outlook reports.

Benchmarks:
- Human-Only System – Investor makes all portfolio decisions and incurs the cost $\kappa$ every period
- Omniscient Robo-advisor – robo-advisor that knows the true human preference $\theta_s$ for all states $s \in S$

Conclusion

We provide a framework that allows the investor making portfolio choices, and propose an algorithm through which a robo-advisor can quantify and assess the investor’s subjective risk tolerance from his portfolio choices. The algorithm allows the robo-advisor to be $\epsilon$-close to the (intractable) optimal policy with high probability after a polynomial number of steps.