Risk aversion and optimal rotation: a stochastic efficiency approach

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Background

• Risk aversion affects forest investments and management

\[ \tilde{p}f(T^0) = iE[\text{NPV}(T^0)] + \text{interest on the value of forest land} \]
\[ \times \text{interest on the value of the stand} \times \text{effect of introducing risk aversion} \]

• The effect of risk aversion on rotation length is ambiguous

• Objective: Analyze optimal rotation under risk aversion within a stochastic dominance framework
Framework

• Utility function and degree of risk aversion are not known – use efficiency criteria that allow ranking of risky alternatives
• Second-order stochastic dominance (Caulfield 1988, Gong 1998): \( 0 \leq r_a(w) < +\infty \)
• Stochastic dominance with respect to a function (Meyer 1977): \( r_L(w) \leq r_a(w) \leq r_U(w) \)
• Stochastic efficiency with respect to a function (Hardaker et al. 2004)

Stochastic efficiency with respect to a function (SERF)

• Equivalent annuity is the maximand – the forest owners’ permanent income
• Expected NPV: \( E[NPV] = \frac{\bar{p}(T) \cdot \bar{f}(T) \cdot e^{-iT} - I_0}{1 - e^{-iT}} \)
• Distribution of the NPV from one stand: \( E[U(NPV, r)] = U(NPV, r) = \int U(NPV, r)f(NPV)dNPV \)
• Certainty equivalent (CE) for for values of U in selected values of r: \( CE(NPV, r) = U^{-1}(NPV, r) \)
Monte Carlo simulation

1. Select a rotation length
2. Run one iteration and record cash flows
3. Select a coefficient of $r_a$ in the range $[r_1, r_2]$
4. Use a negative exponential utility function and convert cash flows to utility, $U(\text{NPV})$
5. Loop back to 3
6. Loop back to 2
7. After enough iterations, compute $E[U(\text{NPV})]$ for each $r$ and use $U^{-1}(\text{NPV})$ to get CEs for each $r$
8. Loop back to 1 and do all over for different rotation lengths
9. For each value of $r_a$, select rotation length with highest CE

Application

• A hypothetical forest property in Norway where forest is the sole source of wealth
• 3000 hectares, Norway spruce, even site quality ($H_{40} = G14$)
• Need a (stochastic) volume function (cubic function with multiplicative heteroskedasticity)
• Need a (stochastic) price function
• Investment costs: NOK 7000 ha$^{-1}$
• Real interest rate: 2% p.a.
• Simulation sample size=5000, rotation lengths from 60 – 110 years, five different degrees of risk aversion
Results

Sensitivity analysis
Conclusions

• The forest owners degree of risk aversion influence the optimal rotation strategy, i.e. risk aversion increase rotation length
• The degree of risk aversion becomes less important with a higher interest rate
• The size of investment costs affects only the level of CE, and only slightly the rotation length