

## Risky Bond Pricer 평가로직 설명서

### 1. Notation

Survive Probability:  $\Pr[\tau > T] = e^{-\int_0^T \lambda_t dt}$

Marginal Hazard Rate:  $\Pr[t < \tau < t + dt] = \lambda_t e^{-\int_0^t \lambda_s ds} dt$

Default Probability:  $\Pr[\tau \leq T] = \int_0^T \lambda_t e^{-\int_0^t \lambda_s ds} dt$

### 2. 리커버리가 없는 Risky Zero Coupon Bond

$$\begin{aligned}\hat{B}(0, T) &= E \left[ e^{-\int_0^T r_t dt} \cdot 1_{\tau > T} \right] = E \left[ E \left[ e^{-\int_0^T r_t dt} \cdot 1_{\tau > T} \mid \{r_t, \lambda_t\}_{t \in [0, T]} \right] \right] \\ &= E \left[ e^{-\int_0^T r_t dt} E[1_{\tau > T} \mid \{r_t, \lambda_t\}_{t \in [0, T]}] \right] \\ &= E \left[ e^{-\int_0^T (r_s + \lambda_s) ds} \right] \approx Z(0, T)Q(0, T)\end{aligned}$$

### 3. 파산시 1을 주는 증권의 가치

$$\begin{aligned}\hat{D}(0, T) &= E \left[ e^{-\int_0^T r_t dt} \cdot 1_{\tau < T} \right] = E \left[ E \left[ e^{-\int_0^T r_t dt} \cdot 1_{\tau < T} \mid \{r_t, \lambda_t\}_{t \in [0, T]} \right] \right] = E \left[ \int_0^T \lambda_t e^{-\int_0^t (r_s + \lambda_s) ds} dt \right] \\ &= \int_0^T Z(0, t) E \left[ \lambda_t e^{-\int_0^t \lambda_s ds} \right] dt = \int_0^T Z(0, t) d(-Q(0, t))\end{aligned}$$

### 4. 리커버리가 존재하는 제로쿠폰채의 가치

$$B(0, T) = Z(0, T)Q(0, T) + RR \cdot \int_0^T Z(0, t) d(-Q(0, t))$$

### 5. CDS 평가모듈 내 부도확률 추정 Calibration 로직

$$B(0, T) = e^{-\text{RiskyZeroRate} \cdot T} = Z(0, T)Q(0, T) + RR \cdot \int_0^T Z(0, t) d(-Q(0, t))$$

위 식을 통해  $\lambda$ 를 역산

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