

## Canadian Company: RioCan Real Estate Investment Trust

### Computing Risk Free Rate (government yield curve)

Similar to A1, collecting 10 Canada government bonds to compute risk free rate. I select bonds “CAN 0.25 Aug 1 (2022)”, “CAN 1.75 Mar 1 (2023)”, “CAN 0.25 Aug 1 (2023)”, “CAN 2.25 Mar 1 (2024)”, “CAN 1.5 Sep 1 (2024)”, “CAN 2.25 Jun 1 (2025)”, “CAN 0.5 Sep 1 (2025)”, “CAN 0.25 Mar 1 (2026)”, “CAN 1.00 Sep 1 (2026)”, “CAN 1.5 Mar 1 (2027)”. By

bootstrapping,  $P = \sum_i p_i e^{-r(t_i)t_i}$ , using the same code as A1 we can get risk free rate from year 1

to 5,  $r_1=2.13\%$ ,  $r_2=2.39\%$ ,  $r_3=2.47\%$ ,  $r_4=2.58\%$ ,  $r_5=2.57\%$ .

### Merton Model

#### Collecting data (S, K, V, $\sigma_s$ )

<https://ca.finance.yahoo.com/quote/REI-UN.TO/key-statistics?p=REI-UN.TO>

From yahoo finance, we can find out

Market Capitalization (S) = 7.674B

Total Liabilities (K) = 5.9B

Firm's Value (V) = 13.574B

Base on previous 1 year stock price (2021-04-16 to 2022-04-16), we get the stock daily volatility 0.937%, and we can get the stock annual volatility  $\sigma_s = \sqrt{252} * 0.937\% = 14.87\%$ .

#### Computing $\sigma_v$ , Probability of Default

##### 1 year

The strike price is  $5.9B * e^{r_1} = 6.03$ , then we get

Underlying Type:		Time (Yrs)	Dividend
Equity			
Stock Price:	13.57		
Volatility (% per year):	14.87%		
Risk-Free Rate (% per year):	2.13%		

  

Option Type:		<input type="checkbox"/> Implied Volatility
Black-Scholes - European		
Life (Years):	1.0000	<input type="radio"/> Put
Strike Price:	6.03	<input checked="" type="radio"/> Call

Calculate

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Results:	
Price:	7.67108079
Delta (per \$):	0.99999999
Gamma (per \$ per \$):	2.0152E-08
Vega (per %):	5.5212E-09
Theta (per day):	-0.00034447
Rho (per %):	0.05902919

Thus, by using the result that the call option price=7.671B, we can calculate the asset volatility

$\sigma_v = \sigma_s \frac{\partial V}{V \partial S} = 0.1487 * 7.671 * 1 / 13.57 = 8.41\%$ .

By merton model  $S = VN(d_1) - Ke^{-rt}N(d_2)$ ,  $d_1 = -\ln(Ke^{-rt}/V)/\sigma\sqrt{T} + \sigma\sqrt{T}/2$ ,  $d_2 = d_1 - \sigma\sqrt{T}$

Then apply all the value, we get  $d_1 = -\ln(6.03e^{-0.0213}/13.57)/0.0841\sqrt{1} + 0.0841\sqrt{1}/2 = 9.93996$ ,  
 $d_2 = 9.93996 - 0.0841\sqrt{1} = 9.8559$ .

Then we get the 1 year probability of default is  $1 - N(d_2) = 0$

**2 year**

The strike price is  $5.9B * e^{r \cdot 2} = 6.19$ , then we get

<b>Underlying Type:</b>		Time (Yrs)	Dividend
Equity			
Stock Price:	13.57		
Volatility (% per year):	14.87%		
Risk-Free Rate (% per year):	2.39%		
<b>Option Type:</b>			
Black-Scholes - European		<input type="checkbox"/> Implied Volatility	
Life (Years):	2.0000	<input type="radio"/> Put	
Strike Price:	6.19	<input checked="" type="radio"/> Call	
<b>Calculate</b>			
<b>Results:</b>			
Price:	7.67293764		
Delta (per \$):	0.99997613		
Gamma (per \$ per \$):	3.5872E-05		
Vega (per %):	1.9657E-05		
Theta (per day):	-0.00038658		
Rho (per %):	0.11801477		

Thus, by using the result that the call option price = 7.6729B, we can calculate the asset volatility  
 $\sigma_v = \sigma_s \frac{\partial V}{V \partial S} = 0.1487 * 7.6729 * 1/13.57 = 8.41\%$ .

Similar to year 1, we get  $d_1 = 7.06266$ ,  $d_2 = 6.9437$ ,

Then we get the 2 year probability of default is  $1 - N(d_2) = 0$

**3 year**

The strike price is  $5.9B * e^{r \cdot 3} = 6.35$ , then we get

<b>Underlying Type:</b>		Time (Yrs)	Dividend
Equity			
Stock Price:	13.57		
Volatility (% per year):	14.87%		
Risk-Free Rate (% per year):	2.47%		
<b>Option Type:</b>			
Black-Scholes - European		<input type="checkbox"/> Implied Volatility	
Life (Years):	3.0000	<input type="radio"/> Put	
Strike Price:	6.35	<input checked="" type="radio"/> Call	
<b>Calculate</b>			
<b>Results:</b>			
Price:	7.67789311		
Delta (per \$):	0.99961886		
Gamma (per \$ per \$):	0.00039524		
Vega (per %):	0.00032487		
Theta (per day):	-0.00040085		
Rho (per %):	0.176728		

Thus, by using the result that the call option price=7.6779B, we can calculate the asset volatility

$$\sigma_v = \sigma_s \frac{S \partial V / V \partial S}{V \partial S} = 0.1487 * 7.6779 * 1 / 13.57 = 8.41\%.$$

Similar to year 1, we get  $d_1 = 5.8808$ ,  $d_2 = 5.7351$ ,

Then we get the 3 year probability of default is  $1 - N(d_2) = 0$

**4 year**

The strike price is  $5.9B * e^{r * 4} = 6.54$ , then we get

Underlying Type:		Time (Yrs)	Dividend
Equity			
Stock Price: 13.57			
Volatility (% per year): 14.87%			
Risk-Free Rate (% per year): 2.58%			

  

Option Type:		<input type="checkbox"/> Implied Volatility <input type="radio"/> Put <input checked="" type="radio"/> Call	
Black-Scholes - European			
Life (Years):	4.0000		
Strike Price:	6.54		

Calculate

  

Results:	
Price:	7.67726005
Delta (per \$):	0.99841652
Gamma (per \$ per \$):	0.00126996
Vega (per %):	0.0013918
Theta (per day):	-0.00042238
Rho (per %):	0.23500983

Thus, by using the result that the call option price=7.6773B, we can calculate the asset volatility

$$\sigma_v = \sigma_s \frac{S \partial V / V \partial S}{V \partial S} = 0.1487 * 7.6773 * 0.998 / 13.57 = 8.396\%.$$

Similar to year 1, we get  $d_1 = 5.0441$ ,  $d_2 = 4.8762$ ,

Then we get the 4 year probability of default is  $1 - N(d_2) = 0$

**5 year**

The strike price is  $5.9B * e^{r * 5} = 6.71$ , then we get

Underlying Type:		Time (Yrs)	Dividend
Equity			
Stock Price: 13.57			
Volatility (% per year): 14.87%			
Risk-Free Rate (% per year): 2.57%			

  

Option Type:		<input type="checkbox"/> Implied Volatility <input type="radio"/> Put <input checked="" type="radio"/> Call	
Black-Scholes - European			
Life (Years):	5.0000		
Strike Price:	6.71		

Calculate

  

Results:	
Price:	7.67893267
Delta (per \$):	0.99622617
Gamma (per \$ per \$):	0.00249148
Vega (per %):	0.00341314
Theta (per day):	-0.00042538
Rho (per %):	0.29219207

Thus, by using the result that the call option price=7.6789B, we can calculate the asset volatility

$$\sigma_v = \sigma_s \frac{S \partial V / V \partial S}{V \partial S} = 0.1487 * 7.6789 * 0.996 / 13.57 = 8.38\%.$$

Similar to year 1, we get  $d_1 = 4.5387$ ,  $d_2 = 4.3513$ ,

Then we get the 5 year probability of default is  $1 - N(d_2) = 0$

**8 year**

$r_8 = 2.68\%$ , The strike price is  $5.9B * e^{r_8 * 8} = 7.31B$ , then we get

<b>Underlying Type:</b>		Time (Yrs)	Dividend
Equity			
Stock Price:	13.57		
Volatility (% per year):	14.87%		
Risk-Free Rate (% per year):	2.68%		
<b>Option Type:</b>			
Black-Scholes - European		<input type="checkbox"/> Implied Volatility	
Life (Years):	8.0000	<input type="radio"/> Put	
Strike Price:	7.31	<input checked="" type="radio"/> Call	
<b>Calculate</b>			
<b>Results:</b>			
Price:	7.70765881		
Delta (per \$):	0.98579588		
Gamma (per \$ per \$):	0.00632939		
Vega (per %):	0.01387326		
Theta (per day):	-0.0004519		
Rho (per %):	0.45388276		

Thus, by using the result that the call option price = 7.7077B, we can calculate the asset volatility

$$\sigma_v = \sigma_s \frac{\partial V}{V \partial S} = 0.1487 * 7.7077 * 0.986 / 13.57 = 8.33\%$$

Similar to year 1, we get  $d_1 = 3.6530$ ,  $d_2 = 3.4173$ ,

Then we get the 5 year probability of default is  $1 - N(d_2) = 0.00032$

**10 Year**

$r_8 = 2.73\%$ , The strike price is  $5.9B * e^{r_{10} * 10} = 7.752B$ , then we get

<b>Underlying Type:</b>		Time (Yrs)	Dividend
Equity			
Stock Price:	13.57		
Volatility (% per year):	14.87%		
Risk-Free Rate (% per year):	2.73%		
<b>Option Type:</b>			
Black-Scholes - European		<input type="checkbox"/> Implied Volatility	
Life (Years):	10.0000	<input type="radio"/> Put	
Strike Price:	7.75	<input checked="" type="radio"/> Call	
<b>Calculate</b>			
<b>Results:</b>			
Price:	7.73712415		
Delta (per \$):	0.97762639		
Gamma (per \$ per \$):	0.00834049		
Vega (per %):	0.02285168		
Theta (per day):	-0.0004604		
Rho (per %):	0.55331765		

Thus, by using the result that the call option price = 7.7371B, we can calculate the asset volatility

$$\sigma_v = \sigma_s \frac{\partial V}{V \partial S} = 0.1487 * 7.7371 * 0.9776 / 13.57 = 8.29\%$$

Similar to year 1, we get  $d_1 = 3.3083$ ,  $d_2 = 3.0461$ ,

Then we get the 5 year probability of default is  $1 - N(d_2) = 0.00116$

### CreditMetric-type Model

**Assumption:** Assuming only 2 possible credit states: solvency and default, and the company's recovery rate  $R=50\%$ .

#### Computing Company's Credit Spread

Given company's bond, which matures at 2023 April 18 with 3.725% coupon paying semi annually. The closing price at 2022/4/14 is 100.52.

[https://markets.businessinsider.com/bonds/riocan\\_real\\_estate\\_inv\\_trusted-debts\\_201313-23-bond-2023-ca766910aw33](https://markets.businessinsider.com/bonds/riocan_real_estate_inv_trusted-debts_201313-23-bond-2023-ca766910aw33)

Since  $P = \sum_i p_i e^{-r(t_i)t_i}$ , then  $100.52 = 1.8625e^{-r*0.5} + 101.8625e^{-r}$ , we get the company's

1year yield rate  $r=3.16\%$ . Hence the credit spread is  $h_i=r - r_1=3.16\%-2.13\%=1.03\%$

#### Computing Probability of Default

Since  $V = Ne^{-r}q + R * Ne^{-r}(1 - q)$ , then

$$100.52 = (1.8625e^{-0.0213/2} + 101.8625e^{-0.0213})q + 0.5(1.8625e^{-0.0213/2} + 101.8625e^{-0.0213})(1-q)$$

Solving it and we get  $q=0.9795$ .

Hence the probability of default is  $1-q=0.0205$ .

### Results

year	1	2	3	4	5	8	10
Merton	0	0	0	0	0	0.00032	0.00116
CreditMetric	0.0205	0.0406	0.0602	0.0795	0.0984	0.1527	0.1871