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, σ_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 $\sigma_s = \sqrt{252} * 0.973\% = 14.87\%$.

Computing σ_{n} , Probability of Default

1 year

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

Time (Yrs)	Dividend
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-	
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-	
Imply Vo	latility
O Put	
-	
Call	
	Imply Vo

Thus, by using the result that the call option price=7.671B, we can calculate the asset volatility $\sigma_v = \sigma_s S \partial V / V \partial S = 0.1487*7.671*1/13.57=8.41\%$.

By merton model S=VN(d_1)-K e^{-rt} N(d_2), d_1 =-ln(K e^{-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 $5.9B*e^{r_2*2}=6.19$, then we get

Underlying Type:	Time (Yrs)	Dividend
Equity		
Stock Price: 13.57 Volatility (% per year): 14.87% Risk-Free Rate (% per year): 2.39%		
Option Type:		
Black-Scholes - Europeaı▼	Imply Vo	latility
Life (Years): 2.0000	O Put	
Strike Price: 6.19	Call	
C <u>a</u> lculate		
Results:		
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 $\sigma_v = \sigma_s S \partial V / V \partial S = 0.1487*7.6729*1/13.57=8.41\%$.

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 $5.9B*e^{r_3^{*3}}=6.35$, then we get

Underlying Type: Equity ▼	Time (Yrs) Dividend
Stock Price: 13.57 Volatility (% per year): 14.87% Risk-Free Rate (% per year): 2.47%	
Option Type:	
Black-Scholes - Europear▼	Imply Volatility
Life (Years): 3.0000 Strike Price: 6.35	Put Call
C <u>a</u> lculate	
Results: Price: 7.67789311 Delta (per \$): 0.99961886 Gamma (per \$ per \$): 0.00039524 Vega (per %): 0.00032487 Theta (per day): Rho (per %): 0.176728	

Thus, by using the result that the call option price=7.6779B, we can calculate the asset volatility $\sigma_v = \sigma_s S \partial V / V \partial S = 0.1487*7.6779*1/13.57=8.41\%$.

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 $5.9B*e^{r_4^{*4}} = 6.54$, then we get

Underlying Type: Equity Stock Price: 13.57 Volatility (% per year): 14.87% Risk-Free Rate (% per year): 2.58%	Time (Yrs)	Dividend
Option Type: Black-Scholes - Europeal Life (Years): 4.0000 Strike Price: 6.54 Calculate	Imply Vo	alatility
Price: 7.67726005 Delta (per \$): 0.99841652 Gamma (per \$ per \$): 0.00126996 Vega (per %): 0.0013918 Theta (per day): -0.0042238 Rho (per %): 0.23500983		

Thus, by using the result that the call option price=7.6773B, we can calculate the asset volatility $\sigma_v = \sigma_s S \partial V / V \partial S = 0.1487*7.6773*0.998/13.57=8.396\%$.

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 $5.9B*e^{r_5^{*5}} = 6.71$, then we get

Underlying Type: Equity ▼	Time (Yrs) Dividend
Stock Price: 13.57 Volatility (% per year): 14.87% Risk-Free Rate (% per year): 2.57%	
Option Type: Black-Scholes - Europea₁▼ Life (Years): 5.0000 Strike Price: 6.71	Imply Volatility Put Call
C <u>a</u> lculate	
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	

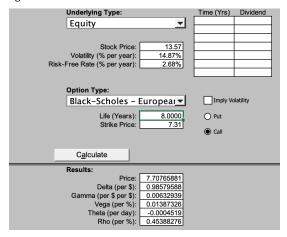
Thus, by using the result that the call option price=7.6789B, we can calculate the asset volatility $\sigma_v = \sigma_s S \partial V / V \partial S = 0.1487*7.6789*0.996/13.57=8.38\%$.

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



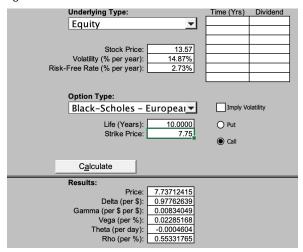
Thus, by using the result that the call option price=7.7077B, we can calculate the asset volatility $\sigma_v = \sigma_s S \partial V / V \partial S = 0.1487*7.7077*0.986/13.57=8.33\%$.

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

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

10 Year

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



Thus, by using the result that the call option price=7.7371B, we can calculate the asset volatility $\sigma_v = \sigma_s S \partial V / V \partial S = 0.1487*7.7371*0.9776/13.57=8.29\%$.

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_trustcd-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

1 year 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