

Solution to Assignment 4: Spreadsheet Simulation Using @Risk

There are three questions (15 total points) in this assignment. All relevant Excel files can be found on Sakai. Solve these questions in Excel and fill in the solution template provided below.

Question 1: Investing for retirement (Retirement.xlsx)

Consider a variation of the investing for retirement example we discussed in class and implement the following strategy:

- invest at mean 8%, standard deviation 25% if balance is < \$700,000;
- invest at mean 5%, standard deviation 15% if balance is \geq \$700,000 and < \$1,000,000;
- stop investing if balance is \geq \$1,000,000.

a. Specify the following @Risk Model in Excel:

	A	B	C	D	E
1	Personal Worth Analysis				
2					
3	Initial yearly investment	8000	Strategy: invest at mean 8%, standard deviation 25% if balance is < \$700,000; invest at mean 5%, standard deviation 15% if balance is \geq \$700,000 and < \$1,000,000; stop investing if balance is \geq \$1,000,000.		
4	Annual increase in investment	0.03			
5					
6	Annual return on investment (normal dist.)				
7	Mean	0.08		Mean	0.05
8	St. dev.	0.25		St. dev.	0.15
9					
10	Target	700000		Target	1000000
11					
12		Amount	Beginning		Ending
13	Year	invested	balance	Return	balance
14	1	=B3	=B14	=IF(C14<\$B\$10,RiskNormal(\$B\$7,\$B\$8),IF(C14<=\$E\$10,RiskNormal(\$E\$7,\$E\$8),0))	=C14*(1+D14)
15	2	=B14*(1+\$B\$4)	=E14+B15	=IF(C15<\$B\$10,RiskNormal(\$B\$7,\$B\$8),IF(C15<=\$E\$10,RiskNormal(\$E\$7,\$E\$8),0))	=C15*(1+D15)
16	3	=B15*(1+\$B\$4)	=E15+B16	=IF(C16<\$B\$10,RiskNormal(\$B\$7,\$B\$8),IF(C16<=\$E\$10,RiskNormal(\$E\$7,\$E\$8),0))	=C16*(1+D16)
17	4	=B16*(1+\$B\$4)	=E16+B17	=IF(C17<\$B\$10,RiskNormal(\$B\$7,\$B\$8),IF(C17<=\$E\$10,RiskNormal(\$E\$7,\$E\$8),0))	=C17*(1+D17)
18	5	=B17*(1+\$B\$4)	=E17+B18	=IF(C18<\$B\$10,RiskNormal(\$B\$7,\$B\$8),IF(C18<=\$E\$10,RiskNormal(\$E\$7,\$E\$8),0))	=C18*(1+D18)
19	6	=B18*(1+\$B\$4)	=E18+B19	=IF(C19<\$B\$10,RiskNormal(\$B\$7,\$B\$8),IF(C19<=\$E\$10,RiskNormal(\$E\$7,\$E\$8),0))	=C19*(1+D19)
20	7	=B19*(1+\$B\$4)	=E19+B20	=IF(C20<\$B\$10,RiskNormal(\$B\$7,\$B\$8),IF(C20<=\$E\$10,RiskNormal(\$E\$7,\$E\$8),0))	=C20*(1+D20)
21	8	=B20*(1+\$B\$4)	=E20+B21	=IF(C21<\$B\$10,RiskNormal(\$B\$7,\$B\$8),IF(C21<=\$E\$10,RiskNormal(\$E\$7,\$E\$8),0))	=C21*(1+D21)
22	9	=B21*(1+\$B\$4)	=E21+B22	=IF(C22<\$B\$10,RiskNormal(\$B\$7,\$B\$8),IF(C22<=\$E\$10,RiskNormal(\$E\$7,\$E\$8),0))	=C22*(1+D22)
23	10	=B22*(1+\$B\$4)	=E22+B23	=IF(C23<\$B\$10,RiskNormal(\$B\$7,\$B\$8),IF(C23<=\$E\$10,RiskNormal(\$E\$7,\$E\$8),0))	=C23*(1+D23)
24	11	=B23*(1+\$B\$4)	=E23+B24	=IF(C24<\$B\$10,RiskNormal(\$B\$7,\$B\$8),IF(C24<=\$E\$10,RiskNormal(\$E\$7,\$E\$8),0))	=C24*(1+D24)
25	12	=B24*(1+\$B\$4)	=E24+B25	=IF(C25<\$B\$10,RiskNormal(\$B\$7,\$B\$8),IF(C25<=\$E\$10,RiskNormal(\$E\$7,\$E\$8),0))	=C25*(1+D25)
26	13	=B25*(1+\$B\$4)	=E25+B26	=IF(C26<\$B\$10,RiskNormal(\$B\$7,\$B\$8),IF(C26<=\$E\$10,RiskNormal(\$E\$7,\$E\$8),0))	=C26*(1+D26)
27	14	=B26*(1+\$B\$4)	=E26+B27	=IF(C27<\$B\$10,RiskNormal(\$B\$7,\$B\$8),IF(C27<=\$E\$10,RiskNormal(\$E\$7,\$E\$8),0))	=C27*(1+D27)
28	15	=B27*(1+\$B\$4)	=E27+B28	=IF(C28<\$B\$10,RiskNormal(\$B\$7,\$B\$8),IF(C28<=\$E\$10,RiskNormal(\$E\$7,\$E\$8),0))	=C28*(1+D28)
29	16	=B28*(1+\$B\$4)	=E28+B29	=IF(C29<\$B\$10,RiskNormal(\$B\$7,\$B\$8),IF(C29<=\$E\$10,RiskNormal(\$E\$7,\$E\$8),0))	=C29*(1+D29)
30	17	=B29*(1+\$B\$4)	=E29+B30	=IF(C30<\$B\$10,RiskNormal(\$B\$7,\$B\$8),IF(C30<=\$E\$10,RiskNormal(\$E\$7,\$E\$8),0))	=C30*(1+D30)
31	18	=B30*(1+\$B\$4)	=E30+B31	=IF(C31<\$B\$10,RiskNormal(\$B\$7,\$B\$8),IF(C31<=\$E\$10,RiskNormal(\$E\$7,\$E\$8),0))	=C31*(1+D31)
32	19	=B31*(1+\$B\$4)	=E31+B32	=IF(C32<\$B\$10,RiskNormal(\$B\$7,\$B\$8),IF(C32<=\$E\$10,RiskNormal(\$E\$7,\$E\$8),0))	=C32*(1+D32)
33	20	=B32*(1+\$B\$4)	=E32+B33	=IF(C33<\$B\$10,RiskNormal(\$B\$7,\$B\$8),IF(C33<=\$E\$10,RiskNormal(\$E\$7,\$E\$8),0))	=C33*(1+D33)
34	21	=B33*(1+\$B\$4)	=E33+B34	=IF(C34<\$B\$10,RiskNormal(\$B\$7,\$B\$8),IF(C34<=\$E\$10,RiskNormal(\$E\$7,\$E\$8),0))	=C34*(1+D34)
35	22	=B34*(1+\$B\$4)	=E34+B35	=IF(C35<\$B\$10,RiskNormal(\$B\$7,\$B\$8),IF(C35<=\$E\$10,RiskNormal(\$E\$7,\$E\$8),0))	=C35*(1+D35)
36	23	=B35*(1+\$B\$4)	=E35+B36	=IF(C36<\$B\$10,RiskNormal(\$B\$7,\$B\$8),IF(C36<=\$E\$10,RiskNormal(\$E\$7,\$E\$8),0))	=C36*(1+D36)
37	24	=B36*(1+\$B\$4)	=E36+B37	=IF(C37<\$B\$10,RiskNormal(\$B\$7,\$B\$8),IF(C37<=\$E\$10,RiskNormal(\$E\$7,\$E\$8),0))	=C37*(1+D37)
38	25	=B37*(1+\$B\$4)	=E37+B38	=IF(C38<\$B\$10,RiskNormal(\$B\$7,\$B\$8),IF(C38<=\$E\$10,RiskNormal(\$E\$7,\$E\$8),0))	=C38*(1+D38)
39	26	=B38*(1+\$B\$4)	=E38+B39	=IF(C39<\$B\$10,RiskNormal(\$B\$7,\$B\$8),IF(C39<=\$E\$10,RiskNormal(\$E\$7,\$E\$8),0))	=C39*(1+D39)
40	27	=B39*(1+\$B\$4)	=E39+B40	=IF(C40<\$B\$10,RiskNormal(\$B\$7,\$B\$8),IF(C40<=\$E\$10,RiskNormal(\$E\$7,\$E\$8),0))	=C40*(1+D40)
41	28	=B40*(1+\$B\$4)	=E40+B41	=IF(C41<\$B\$10,RiskNormal(\$B\$7,\$B\$8),IF(C41<=\$E\$10,RiskNormal(\$E\$7,\$E\$8),0))	=C41*(1+D41)
42	29	=B41*(1+\$B\$4)	=E41+B42	=IF(C42<\$B\$10,RiskNormal(\$B\$7,\$B\$8),IF(C42<=\$E\$10,RiskNormal(\$E\$7,\$E\$8),0))	=C42*(1+D42)
43	30	=B42*(1+\$B\$4)	=E42+B43	=IF(C43<\$B\$10,RiskNormal(\$B\$7,\$B\$8),IF(C43<=\$E\$10,RiskNormal(\$E\$7,\$E\$8),0))	=RiskOutput("Final Balance")+C43*(1+D43)

b. Report the mean and standard deviation of the ending balance after 30 years.

Mean = \$877,373

Standard deviation = \$360,291

c. What is the probability that the ending balance is $\geq \$1,000,000$? (You get the probability by looking at the detailed statistics output and typing in 1,000,000 into a “target value” cell in the column corresponding to the ending balance. See page 593-594 of the text.)

Prob (the ending balance $\geq \$1,000,000$) = 51.5%

d. Compare the strategy you analyzed in this problem to the strategy we discussed in class (Model 3: invest at 8% if balance is $< \$1,000,000$ and stop investing if balance is $\geq \$1,000,000$). Suppose Amanda’s investment target is to achieve an ending balance of \$1,000,000. Which strategy would you recommend? Why?

The strategy (Model 3) we discussed in class should be recommended because it gives Amanda a higher chance to achieve an ending balance of \$1,000,000 than the strategy analyzed in this problem.

Question 2: Doubling strategy in Roulette (Roulette.xlsx)

Suppose you have \$100 at the beginning and you decide to bet on Red in Roulette.

Simulate the following *doubling* strategy. You begin by betting \$1. Each subsequent bet is decided as follows: If you won the last bet, you again bet \$1. If you lost the last bet, you bet twice the previous bet, if you have enough money. Otherwise, you return to betting \$1 unless you've run out.

a. Specify the following @Risk Model in Excel:

	A	B	C	D	E	F	G	H	I	J
1	Simulating Roulette Strategies									
2										
3										
4	Outcome		Prob.	Total bank			Bet #	Bet size	Spin result	Winings
5	1	(your chosen color)	=18/38	100			0			=E5
6	2		=1-C5				1	1	=RiskDiscrete(A\$5:A\$6,C\$5:C\$6)	=IF(I6=1,J5+H6,J5-H6)
7							2	=IF(I6=1,MIN(1,J6),IF(J6>=2*H6,2*H6,MIN(1,J6)))	=RiskDiscrete(A\$5:A\$6,C\$5:C\$6)	=IF(I7=1,J6+H7,J6-H7)
8							3	=IF(I7=1,MIN(1,J7),IF(J7>=2*H7,2*H7,MIN(1,J7)))	=RiskDiscrete(A\$5:A\$6,C\$5:C\$6)	=IF(I8=1,J7+H8,J7-H8)
9							4	=IF(I8=1,MIN(1,J8),IF(J8>=2*H8,2*H8,MIN(1,J8)))	=RiskDiscrete(A\$5:A\$6,C\$5:C\$6)	=IF(I9=1,J8+H9,J8-H9)
10							5	=IF(I9=1,MIN(1,J9),IF(J9>=2*H9,2*H9,MIN(1,J9)))	=RiskDiscrete(A\$5:A\$6,C\$5:C\$6)	=IF(I10=1,J9+H10,J9-H10)

...

b. Define *Final Winning* as the winning after 100 rounds of betting. If your money runs out before 100 rounds, then the winnings remain zero.

What's the probability of losing all your initial \$100?

$$\text{Prob}(\text{Final Winning} = 0) = \text{Prob}(\text{Final Winning} \leq 0) = 18.54\%$$

What's the probability of getting a final winning of \$150 or more?

$$\text{Prob}(\text{Final Winning} \geq 150) = 1 - \text{Prob}(\text{Final Winning} \leq 149) = 1 - 82.05\% = 17.95\%$$

Question 3: When to pull the goalie in hockey (Hockey.xlsx)

Consider a variation of the hockey example we discussed in class and implement the following strategy: Pull your goalie if you are behind at any point in the last *three minutes* of the game; put him back in if you tie the score.

a. Specify the following @Risk Model in Excel:

	A	B	C	D	E	F
1	When to pull the goalie in hockey					
2				Possible strategies (seconds left when goalie is pulled)		
3	Seconds left when goalie is pulled	=RiskSimtable(D3:F3)		60	120	180
4						
5	Inputs					
6	Prob of goal full-strength	=0.05/6				
7	Prob of our goal (our goalie pulled)	=0.08/6				
8	Prob of their goal (our goalie pulled)	=0.12/6				
9						
10	Current score (ours minus theirs)	-1				
11						
12	Simulation					
13	Time left (seconds)	Our score minus theirs	Are we behind?	Goalie Pulled?	We score?	They score?
14	180	=B10	=IF(B14<0,1,0)	=IF(AND(C14=1,A14<=\$B\$3),1,0)	=IF(D14=1,RiskBinomial(1,\$B\$7),RiskBinomial(1,\$B\$6))	=IF(D14=1,RiskBinomial(1,\$B\$8),RiskBinomial(1,\$B\$6))
15	170	=B14+E14-F14	=IF(B15<0,1,0)	=IF(AND(C15=1,A15<=\$B\$3),1,0)	=IF(D15=1,RiskBinomial(1,\$B\$7),RiskBinomial(1,\$B\$6))	=IF(D15=1,RiskBinomial(1,\$B\$8),RiskBinomial(1,\$B\$6))
16	160	=B15+E15-F15	=IF(B16<0,1,0)	=IF(AND(C16=1,A16<=\$B\$3),1,0)	=IF(D16=1,RiskBinomial(1,\$B\$7),RiskBinomial(1,\$B\$6))	=IF(D16=1,RiskBinomial(1,\$B\$8),RiskBinomial(1,\$B\$6))
17	150	=B16+E16-F16	=IF(B17<0,1,0)	=IF(AND(C17=1,A17<=\$B\$3),1,0)	=IF(D17=1,RiskBinomial(1,\$B\$7),RiskBinomial(1,\$B\$6))	=IF(D17=1,RiskBinomial(1,\$B\$8),RiskBinomial(1,\$B\$6))
18	140	=B17+E17-F17	=IF(B18<0,1,0)	=IF(AND(C18=1,A18<=\$B\$3),1,0)	=IF(D18=1,RiskBinomial(1,\$B\$7),RiskBinomial(1,\$B\$6))	=IF(D18=1,RiskBinomial(1,\$B\$8),RiskBinomial(1,\$B\$6))
19	130	=B18+E18-F18	=IF(B19<0,1,0)	=IF(AND(C19=1,A19<=\$B\$3),1,0)	=IF(D19=1,RiskBinomial(1,\$B\$7),RiskBinomial(1,\$B\$6))	=IF(D19=1,RiskBinomial(1,\$B\$8),RiskBinomial(1,\$B\$6))
20	120	=B19+E19-F19	=IF(B20<0,1,0)	=IF(AND(C20=1,A20<=\$B\$3),1,0)	=IF(D20=1,RiskBinomial(1,\$B\$7),RiskBinomial(1,\$B\$6))	=IF(D20=1,RiskBinomial(1,\$B\$8),RiskBinomial(1,\$B\$6))
21	110	=B20+E20-F20	=IF(B21<0,1,0)	=IF(AND(C21=1,A21<=\$B\$3),1,0)	=IF(D21=1,RiskBinomial(1,\$B\$7),RiskBinomial(1,\$B\$6))	=IF(D21=1,RiskBinomial(1,\$B\$8),RiskBinomial(1,\$B\$6))
22	100	=B21+E21-F21	=IF(B22<0,1,0)	=IF(AND(C22=1,A22<=\$B\$3),1,0)	=IF(D22=1,RiskBinomial(1,\$B\$7),RiskBinomial(1,\$B\$6))	=IF(D22=1,RiskBinomial(1,\$B\$8),RiskBinomial(1,\$B\$6))
23	90	=B22+E22-F22	=IF(B23<0,1,0)	=IF(AND(C23=1,A23<=\$B\$3),1,0)	=IF(D23=1,RiskBinomial(1,\$B\$7),RiskBinomial(1,\$B\$6))	=IF(D23=1,RiskBinomial(1,\$B\$8),RiskBinomial(1,\$B\$6))
24	80	=B23+E23-F23	=IF(B24<0,1,0)	=IF(AND(C24=1,A24<=\$B\$3),1,0)	=IF(D24=1,RiskBinomial(1,\$B\$7),RiskBinomial(1,\$B\$6))	=IF(D24=1,RiskBinomial(1,\$B\$8),RiskBinomial(1,\$B\$6))
25	70	=B24+E24-F24	=IF(B25<0,1,0)	=IF(AND(C25=1,A25<=\$B\$3),1,0)	=IF(D25=1,RiskBinomial(1,\$B\$7),RiskBinomial(1,\$B\$6))	=IF(D25=1,RiskBinomial(1,\$B\$8),RiskBinomial(1,\$B\$6))
26	60	=B25+E25-F25	=IF(B26<0,1,0)	=IF(AND(C26=1,A26<=\$B\$3),1,0)	=IF(D26=1,RiskBinomial(1,\$B\$7),RiskBinomial(1,\$B\$6))	=IF(D26=1,RiskBinomial(1,\$B\$8),RiskBinomial(1,\$B\$6))
27	50	=B26+E26-F26	=IF(B27<0,1,0)	=IF(AND(C27=1,A27<=\$B\$3),1,0)	=IF(D27=1,RiskBinomial(1,\$B\$7),RiskBinomial(1,\$B\$6))	=IF(D27=1,RiskBinomial(1,\$B\$8),RiskBinomial(1,\$B\$6))
28	40	=B27+E27-F27	=IF(B28<0,1,0)	=IF(AND(C28=1,A28<=\$B\$3),1,0)	=IF(D28=1,RiskBinomial(1,\$B\$7),RiskBinomial(1,\$B\$6))	=IF(D28=1,RiskBinomial(1,\$B\$8),RiskBinomial(1,\$B\$6))
29	30	=B28+E28-F28	=IF(B29<0,1,0)	=IF(AND(C29=1,A29<=\$B\$3),1,0)	=IF(D29=1,RiskBinomial(1,\$B\$7),RiskBinomial(1,\$B\$6))	=IF(D29=1,RiskBinomial(1,\$B\$8),RiskBinomial(1,\$B\$6))
30	20	=B29+E29-F29	=IF(B30<0,1,0)	=IF(AND(C30=1,A30<=\$B\$3),1,0)	=IF(D30=1,RiskBinomial(1,\$B\$7),RiskBinomial(1,\$B\$6))	=IF(D30=1,RiskBinomial(1,\$B\$8),RiskBinomial(1,\$B\$6))
31	10	=B30+E30-F30	=IF(B31<0,1,0)	=IF(AND(C31=1,A31<=\$B\$3),1,0)	=IF(D31=1,RiskBinomial(1,\$B\$7),RiskBinomial(1,\$B\$6))	=IF(D31=1,RiskBinomial(1,\$B\$8),RiskBinomial(1,\$B\$6))
32	0	=B31+E31-F31	=IF(B32<0,1,0)	=IF(AND(C32=1,A32<=\$B\$3),1,0)	=IF(D32=1,RiskBinomial(1,\$B\$7),RiskBinomial(1,\$B\$6))	=IF(D32=1,RiskBinomial(1,\$B\$8),RiskBinomial(1,\$B\$6))
33						
34	We win or tie?	=IF(B32>=0,1,0)				
35						
36	Selected summary measures from @RISK					
37			Prob(we win or tie)			
38	Strategy	1 minute	2 minutes	3 minutes		
39	Mean	=RiskMean(B34,1)	=RiskMean(B34,2)	=RiskMean(B34,3)		

b. What's the probability that we win or tie?

Selected summary measures from @RISK			
	Prob(we win or tie)		
Strategy	1 minute	2 minutes	3 minutes
Mean	0.1428	0.1589	0.172