Example: Investing for retirement

Amanda has 30 years to save for her retirement. Initially, she invests $8,000 in her retirement account. Each subsequent year she invests 3% more. Estimate the balance of Amanda's retirement account at the end of 30 years.

Model 1: Suppose the *mean* annual return on stocks is 8% (a representative return for her investment style).

	A	B	C	D	E
1	Investing for retirement				
2					
3	Initial yearly investment	$8,000			
4	Annual increase in investmen	3.00%			
5					
6	Annual return on investment	8.00%			
7					
8		Amount	Beginning		Ending
9	Year	invested	balance	Return	balance
10	1	=B3	=B10	=B$6	=C10*(1+D10)
11	2	=B10*(1+B$4)	=E10+B11	↓	↓
12	3	↓	↓		
13	4				
14	5				
15	6				
16	7				
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35	26				
36	27				
37	28				
38	29				
39	30				

Model 1 Results:

	A	B	C	D	E
1	**Investing for retirement**				
2					
3	Initial yearly investment	$8,000			
4	Annual increase in investment	3.00%			
5					
6	Annual return on investment	8.00%			
7					
8			Amount	Beginning		Ending
9		Year	invested	balance	Return	balance
10		1	$8,000.00	$8,000	8.00%	$8,640
11		2	$8,240.00	$16,880	8.00%	$18,230
12		3	$8,487.20	$26,718	8.00%	$28,855
13		4	$8,741.82	$37,597	8.00%	$40,605
14		5	$9,004.07	$49,609	8.00%	$53,577
15		6	$9,274.19	$62,852	8.00%	$67,880
16		7	$9,552.42	$77,432	8.00%	$83,627
17		8	$9,838.99	$93,466	8.00%	$100,943
18		9	$10,134.16	$111,077	8.00%	$119,963
19		10	$10,438.19	$130,401	8.00%	$140,833
20		11	$10,751.33	$151,585	8.00%	$163,712
21		12	$11,073.87	$174,785	8.00%	$188,768
22		13	$11,406.09	$200,174	8.00%	$216,188
23		14	$11,748.27	$227,937	8.00%	$246,172
24		15	$12,100.72	$258,272	8.00%	$278,934
25		16	$12,463.74	$291,398	8.00%	$314,710
26		17	$12,837.65	$327,547	8.00%	$353,751
27		18	$13,222.78	$366,974	8.00%	$396,332
28		19	$13,619.46	$409,951	8.00%	$442,747
29		20	$14,028.05	$456,775	8.00%	$493,317
30		21	$14,448.89	$507,766	8.00%	$548,388
31		22	$14,882.36	$563,270	8.00%	$608,332
32		23	$15,328.83	$623,660	8.00%	$673,553
33		24	$15,788.69	$689,342	8.00%	$744,489
34		25	$16,262.35	$760,752	8.00%	$821,612
35		26	$16,750.22	$838,362	8.00%	$905,431
36		27	$17,252.73	$922,684	8.00%	$996,498
37		28	$17,770.31	$1,014,269	8.00%	$1,095,410
38		29	$18,303.42	$1,113,714	8.00%	$1,202,811
39		30	$18,852.52	$1,221,663	8.00%	$1,319,396

Problem?

The flaw of averages

Model 2: Suppose the annual return on stocks follows a *normal distribution* with a mean of 8% and a standard deviation of 25%.

	A	B	C	D	E
1	Investing for retirement				
2					
3	Initial yearly investment	$8,000			
4	Annual increase in investme	3.00%			
5					
6	Annual return on investment (normal dist.)				
7	Mean	8.00%			
8	St. dev.	25.00%			
9					
10		Amount	Beginning		Ending
11	Year	invested	balance	Return	balance
12	1	=B3	=B12	=RiskNormal(B$7,B$8)	=C12*(1+D12)
13	2	=B12*(1+B$4)	=E12+B13		
14	3				
15	4				
16	5				
17	6				
18	7				
19	8				
...					
39	28				
40	29				
41	30				output cell

Step 1: Loading @Risk.

       Start → All Programs → Palisade Decision Tolls → @Risk

Step 2: Revise Excel worksheet.

       RiskNormal

Step 3: Specify *output cells*.

       Add output

Step 4: Choose simulation settings.

       Iterations = 10,000
       Simulations = 1

Step 5: Run simulation.

       Start simulation

Step 6: Examine the results.

Model 2 Results:

One particular simulation result for Model 2:

	A	B	C	D	E
1	**Investing for retirement**				
2					
3	Initial yearly investment	$8,000			
4	Annual increase in investment	3.00%			
5					
6	Annual return on investment (normal dist.)				
7	Mean	8.00%			
8	St. dev.	25.00%			
9					
10			Amount	Beginning		Ending
11		Year	invested	balance	Return	balance
12		1	$8,000.00	$8,000	16.93%	$9,354
13		2	$8,240.00	$17,594	45.27%	$25,558
14		3	$8,487.20	$34,045	17.07%	$39,856
15		4	$8,741.82	$48,597	16.28%	$56,508
16		5	$9,004.07	$65,512	9.55%	$71,766
17		6	$9,274.19	$81,041	-46.97%	$42,979
18		7	$9,552.42	$52,531	1.02%	$53,066
19		8	$9,838.99	$62,905	-12.15%	$55,265
20		9	$10,134.16	$65,399	43.95%	$94,145
21		10	$10,438.19	$104,583	-10.11%	$94,005
22		11	$10,751.33	$104,757	7.12%	$112,217
23		12	$11,073.87	$123,291	25.08%	$154,212
24		13	$11,406.09	$165,619	-7.83%	$152,650
25		14	$11,748.27	$164,398	15.43%	$189,758
26		15	$12,100.72	$201,859	14.61%	$231,356
27		16	$12,463.74	$243,820	-29.55%	$171,766
28		17	$12,837.65	$184,603	-29.66%	$129,842
29		18	$13,222.78	$143,065	48.88%	$213,002
30		19	$13,619.46	$226,621	11.11%	$251,806
31		20	$14,028.05	$265,834	-8.06%	$244,409
32		21	$14,448.89	$258,858	23.71%	$320,221
33		22	$14,882.36	$335,103	49.16%	$499,854
34		23	$15,328.83	$515,183	44.20%	$742,884
35		24	$15,788.69	$758,673	29.47%	$982,240
36		25	$16,262.35	$998,503	26.65%	$1,264,613
37		26	$16,750.22	$1,281,364	11.56%	$1,429,518
38		27	$17,252.73	$1,446,771	42.92%	$2,067,653
39		28	$17,770.31	$2,085,423	-13.63%	$1,801,123
40		29	$18,303.42	$1,819,426	41.19%	$2,568,768
41		30	$18,852.52	$2,587,621	42.40%	$3,684,843

@Risk output for Model 2:

Browse results:
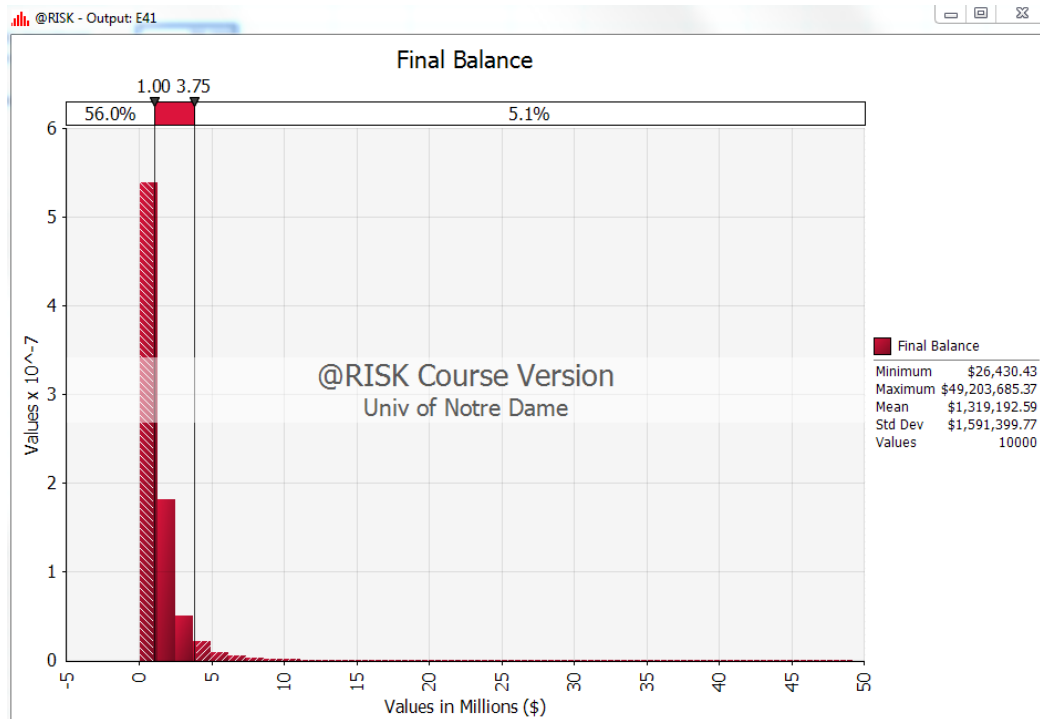
Simulation Detailed Statistics:

Name	Final Balance
Description	Output
Cell	Model 2 Results!E..
Minimum	26430.43
Maximum	4.920368E+07
Mean	1319193
Std Deviation	1591400
Variance	2.532553E+12
Skewness	8.066064
Kurtosis	159.3809
Errors	0
Mode	473230.4
5% Perc	240736.9
10% Perc	313589.4
15% Perc	377160.6

...

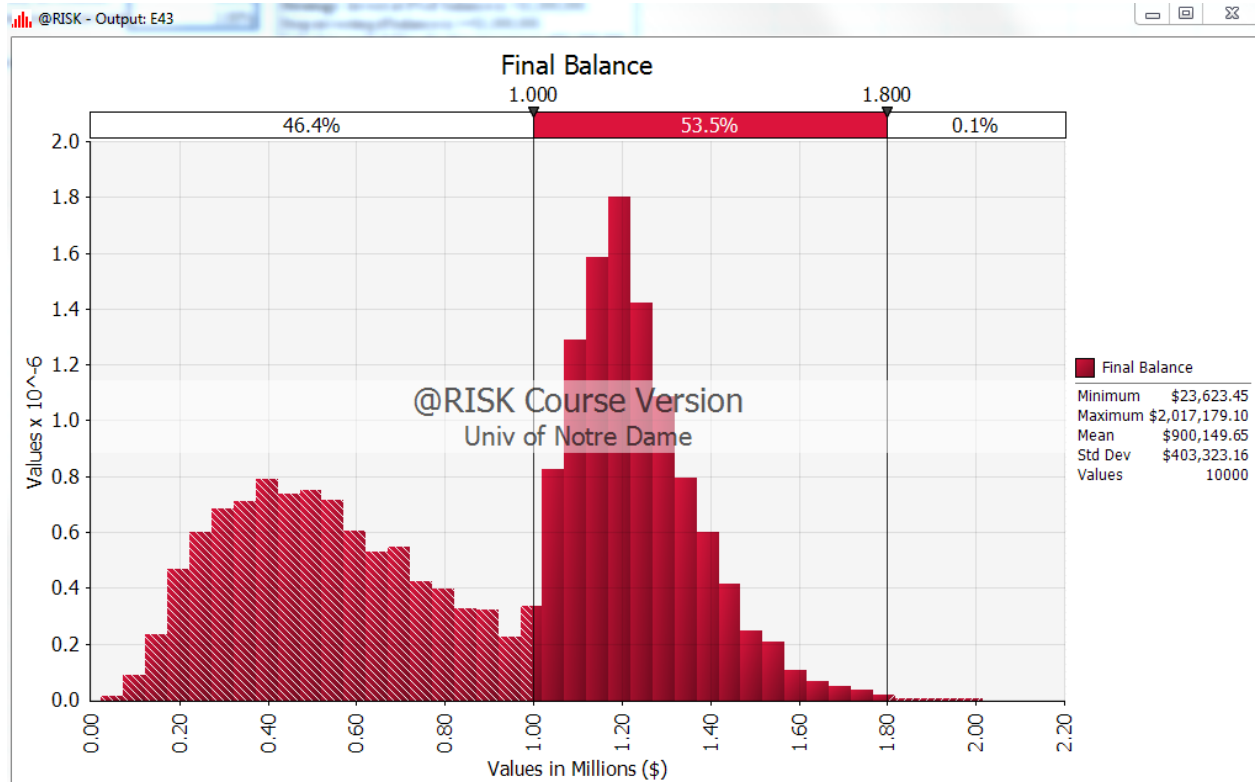| Target #1 (Value)	1000000
Target #1 (Perc%)	56%

Question: What's the probability of getting a final balance of more than $1,000,000?

Prob(Final Balance $>=$ 1,000,000) $= 1 - 56\% = 44\%$

Model 3: Examine a strategy to invest at 8% if balance is <$1,000,000. Stop investing if balance is >=$1,000,000. Calculate the probability of achieving target of $1,000,000.

	A	B	C	D	E
1	Investing for retirement				
2					
3	Initial yearly investment	$8,000			
4	Annual increase in invest	3.00%			
5					
6	Annual return on investment (normal dist.)				
7	Mean	8.00%			
8	St. dev.	25.00%			
9					
10	Target	$1,000,000			
11					
12		Amount	Beginning		Ending
13	Year	invested	balance	Return	balance
14	1	=B3	=B14	=If(C14>=1,000,000,0,	=C14*(1+D14)
15	2	=B14*(1+B$4)	=E14+B15	RiskNormal(B$7,B$8))	
16	3				
17	4				
18	5				
19	6				
20	7				
21	8				
22	9				
23	10				
24	11				
25	12				
26	13				
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36	23				
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38	25				
39	26				
40	27				
41	28				
42	29				
43	30				

Strategy: Invest at 8% if balance is <$1,000,000.
Stop investing if balance is >=$1,000,000.
Calculate probability of achieving target of $1,000,000.

@Risk output for Model 3:

Question: What is the probability of achieving target of $1,000,000?

Prob(Final Balance >= 1,000,000) = 53.5% + 0.1% = 53.6%
or = 1 − 46.4% = 53.6%