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ASSIGNMENT #3: MODEL SENSITIVITY ANALYSIS

BUSA2020, FUNDAMENTALS OF BUSINESS ANALYSIS

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Task 1: Exploring the age at which Alex's assets will be depleted

A spreadsheet model was employed to explore the sensitivity of the age at which Alex's assets will be depleted. The model was divided into two segments: **(a)** calculates the property market value at 2060, that is, when Alex sells the investment property and; **(b)** calculates the total savings accumulated in the bank at when Alex is 90 years old.

(a) Calculation of the property market value at 2060

The property market value was considered each year in a data table from *2020* (year *0*) to *2060* (year *40*). The market value at the start of year 0 was given as a parameter as *$718,685.00*. To simplify the model, the required parameters as given in figure 1.1 were calculated in their dollar value and categorised as either *cash inflows* or *cash outflows*, as illustrated in figure 1.2. *Cash inflows* include the reinvestment from the rental return as well as the property growth rate, as it was assumed these variables contribute to increasing the market value of the property. *Cash outflows* solely consist of inflation. Inflation was considered a cash outflow as it was assumed to be general inflation, increasing the value of costs associated with the property, and not housing inflation. For this reason, property prices were not adjusted for inflation. It was also assumed that the property growth rate accounts for housing inflation as it is determined by market forces, which includes inflation. Also note that family expenses from the rental return and GST were not considered in this model, as they were assumed to have no influence over the market value of the property. As inflation is the only cash outflow, *total cash outflow* equals the calculated inflation for the corresponding year. The *market value of the property at the end of the year* was calculated by taking the net of the total components, as shown in figure 1.3. Figure 1.1 shows that the output for model (a), the market value of the property at 2060, that is, the price at which Alex sells the property is $4,632,838.07. Figure 1.4 shows that the property market value grows by 616% by the time Alex turns 65; the figure also exhibits an exponential growth. This seems consistent with the model, as the reinvestment rate and property growth rate were assumed compounding factors.

(b) Calculation of the total savings accumulated in the bank when Alex is 90 years old

The accumulated savings in Alex's bank account was considered each year in a data table from *2060* (year *0*) to *2090* (year *39*), as the human life expectancy is 90 years. The *account balance at start of year for year 0* equals the *property market value at end of year* for *year 40*, calculated in model (a). Similarly, the required parameters were calculated in their dollar value and classified either as *cash inflows* or *cash outflows*, as illustrated in figure 1.5. *Cash inflows* solely consist of the compounding interest accumulated. *Total cash inflow* hence, equals the calculated interest for the corresponding year. *Cash outflows* consist of the total yearly expense calculated in figure 1.1, as well as the inflation. Inflation is a cash outflow as it is assumed an indirect cost, affecting the price of goods and services provided. *Total cash outflow* is the sum of these two variables. The *account balance at end of year* was calculated by taking the net of the total components as shown in figure 1.6. As exhibited in figure 1.2, model (b) shows that by the time Alex reaches 90 years of age, he has *$593,578.74* worth of savings in his bank account. Although the model shows that Alex in fact never runs out of saving before he dies, there is a clear decrease in his savings as illustrated in figure 1.7. However, Alex's savings appear to be linearly related to time, unlike model (a), possibly owing to the fixed yearly expense. Reasons as to why Alex's savings do not reach zero within the thirty-nine years could be that Drysdale may have a higher property market value and a higher property growth rate on average when compared to other suburbs; resulting in a much higher sale price than anticipated. Limitations in the calculation may also be a contributing factor such as excluding possible cash outflows in model (b) that may have occurred. However, figure 1.8 shows that if the model were to be extended i.e. assuming Alex lives past 90 years of age, the age Alex would be if his savings were to be depleted would be 97.

A scenario manager was used to explore three different scenarios. *Scenario 1* explores the sensitivity of the age at which Alex's savings are depleted when common cash outflow variables, that is, the average yearly expense, GST and inflation are doubled. Figure 1.9 exhibits a much slower market value growth and a 50% lower market value at year 40 compared to figure 1.4; this is consistent with greater expenses. Alex's savings deplete at a faster rate as he reaches the age of 70, this decline appears to be slightly exponential, possibly due to the higher (compounding inflation). *Scenario 2* utilises the model when common cash inflow variables, that is, the rental return, the property growth rate and the cash saving rate are doubled. Figure 1.11 illustrates a much faster growth rate and a much higher market value of $57,921,569.09, likely due to the higher rental return and growth rate, which are both compounding. Figure 1.12 shows a notable increase in Alex's savings, which never deplete, also due to the compounding interest which surpasses the fixed cash outflows. *Scenario 3* explores the model when common cash inflow variables, that is, the rental return, the property growth rate and the cash saving rate are halved. The property market value increases but at a much slower rate to $1,232,876.83 in figure 1.13, as the effect of compounding is much lower. Alex's savings deplete when he is 72 in figure 1.14, the same rate as Scenario 1.

Parameters	
Initial market value at 2020	$ 718,685.00
Rental return	5.0%
Reinvestment from rental return	5.0%
Family expenses from rental return	95.0%
Property growth rate	6.4%
Cash saving rate	1.5%
Inflation	2.0%
Life expectancy	90
Average yearly expense	$ 80,000.00
GST	10%
Total yearly expense	$ 88,000.00
Market value at 2060 i.e. sale price	$4,632,838.07

Figure 3.1 The parameters required for the spreadsheet model, total yearly expenses is a calculated value and the

(a) Calculation of Property Market Value at 2060:

				Cash Inflows			Cash Outflows		
n	Year	Alex's Age	Market value at start of year	Reinvestment from rental return	Property growth rate	Total cash inflow	Inflation	Total cash outflow	Market value at end of year
0	2020	25	$718,685.00	$1,796.71	$45,995.84	$47,792.55	$14,373.70	$14,373.70	$752,103.85
1	2021	26	$752,103.85	$1,880.26	$48,134.65	$50,014.91	$15,042.08	$15,042.08	$787,076.68
2	2022	27	$787,076.68	$1,967.69	$50,372.91	$52,340.60	$15,741.53	$15,741.53	$823,675.75
3	2023	28	$823,675.75	$2,059.19	$52,715.25	$54,774.44	$16,473.51	$16,473.51	$861,976.67
4	2024	29	$861,976.67	$2,154.94	$55,166.51	$57,321.45	$17,239.53	$17,239.53	$902,058.58
5	2025	30	$902,058.58	$2,255.15	$57,731.75	$59,986.90	$18,041.17	$18,041.17	$944,004.31
6	2026	31	$944,004.31	$2,360.01	$60,416.28	$62,776.29	$18,880.09	$18,880.09	$987,900.51
7	2027	32	$987,900.51	$2,469.75	$63,225.63	$65,695.38	$19,758.01	$19,758.01	$1,033,837.88
8	2028	33	$1,033,837.88	$2,584.59	$66,165.62	$68,750.22	$20,676.76	$20,676.76	$1,081,911.34
9	2029	34	$1,081,911.34	$2,704.78	$69,242.33	$71,947.10	$21,638.23	$21,638.23	$1,132,220.22
40	2060	65	$4,426,983.34	$11,067.46	$283,326.93	$294,394.39	$88,539.67	$88,539.67	$4,632,838.07

Figure 2.2 (a) Data table showing the calculation of the property market value from 2020 to 2060; rows from n=10 to n=29 have been hidden

Figure 1.4 Column graph depicts the property market value increasing with Alex's age

F	G	H	I	J	K	L	M	N	O
(a) Calculation of Property Market Value at 2060:									
				Cash Inflows			Cash Outflows		
n	Year	Alex's Age	Market value at start of year	Reinvestment from rental return	Property growth rate	Total cash inflow	Inflation	Total cash outflow	Market value at end of year
0	2020	25	=$C$9	=($C$10*I9)*$C$11	=$C$13*I9	=J9+K9	=$C$15*I9	=M9	=I9+L9-M9
=F9+1	=G9+1	=H9+1	=O9	=($C$10*I10)*$C$11	=$C$13*I10	=J10+K10	=$C$15*I10	=M10	=I10+L10-M10

Figure 5.3 The calculation of components in (a)

Q	R	S	T	U	V	W	X	Y	Z
(b) Calculation of Accumulated Savings at 2090:									
				Cash Inflows		Cash Outflows			
n	Year	Alex's Age	Account balance at start of year	Interest	Total cash inflow	Yearly expense	Inflation	Total cash outflow	Account balance at end of year
0	2060	65	=O49	=$C$14*T9	=U9	=$C$19	=$C$15*T9	=W9+X9	=T9+V9-Y9
=Q9+1	=R9+1	=S9+1	=Z9	=$C$14*T10	=U10	=$C$19	=$C$15*T10	=W10+X10	=T10+V10-Y10

Figure 6.6 The calculation of components in (b)

(b) Calculation of Accumulated Savings at 2090:

				Cash Inflows		Cash Outflows			
n	Year	Alex's Age	Account balance at start of year	Interest	Total cash inflow	Yearly expense	Inflation	Total cash outflow	Account balance at end of year
0	2060	65	$4,632,838.07	$69,492.57	$69,492.57	$88,000.00	$92,656.76	$180,656.76	$4,521,673.87
1	2061	66	$4,521,673.87	$67,825.11	$67,825.11	$88,000.00	$90,433.48	$178,433.48	$4,411,065.51
2	2061	66	$4,411,065.51	$66,165.98	$66,165.98	$88,000.00	$88,221.31	$176,221.31	$4,301,010.18
3	2062	67	$4,301,010.18	$64,515.15	$64,515.15	$88,000.00	$86,020.20	$174,020.20	$4,191,505.13
4	2062	67	$4,191,505.13	$62,872.58	$62,872.58	$88,000.00	$83,830.10	$171,830.10	$4,082,547.60
5	2063	68	$4,082,547.60	$61,238.21	$61,238.21	$88,000.00	$81,650.95	$169,650.95	$3,974,134.86
6	2063	68	$3,974,134.86	$59,612.02	$59,612.02	$88,000.00	$79,482.70	$167,482.70	$3,866,264.19
7	2064	69	$3,866,264.19	$57,993.96	$57,993.96	$88,000.00	$77,325.28	$165,325.28	$3,758,932.87
8	2064	69	$3,758,932.87	$56,383.99	$56,383.99	$88,000.00	$75,178.66	$163,178.66	$3,652,138.20
9	2065	70	$3,652,138.20	$54,782.07	$54,782.07	$88,000.00	$73,042.76	$161,042.76	$3,545,877.51
40	2081	91	$593,578.74	$8,903.68	$8,903.68	$88,000.00	$11,871.57	$ 99,871.57	$502,610.84

Figure 4.5 (b) Data table showing the calculation of the accumulated savings in Alex's bank account from 2020 to 2060; rows from n=10 to n=29 have been hidden.

(b) Calculation of Accumulated Savings at 2090:

				Cash Inflows		Cash Outflows			
n	Year	Alex's Age	Account balance at start of year	Interest	Total cash inflow	Yearly expense	Inflation	Total cash outflow	Account balance at end of year
0	2060	65	$4,632,838.07	$69,492.57	$69,492.57	$88,000.00	$92,656.76	$ 180,656.76	$4,521,673.87
40	2081	91	$593,578.74	$8,903.68	$8,903.68	$88,000.00	$11,871.57	$ 99,871.57	$502,610.84
41	2082	92	$502,610.84	$7,539.16	$7,539.16	$88,000.00	$10,052.22	$ 98,052.22	$412,097.79
42	2083	93	$412,097.79	$6,181.47	$6,181.47	$88,000.00	$8,241.96	$ 96,241.96	$322,037.30
43	2084	94	$322,037.30	$4,830.56	$4,830.56	$88,000.00	$6,440.75	$ 94,440.75	$232,427.11
44	2085	95	$232,427.11	$3,486.41	$3,486.41	$88,000.00	$4,648.54	$ 92,648.54	$143,264.98
45	2086	96	$143,264.98	$2,148.97	$2,148.97	$88,000.00	$2,865.30	$ 90,865.30	$54,548.65
46	2087	97	$54,548.65	$818.23	$818.23	$88,000.00	$1,090.97	$ 89,090.97	-$33,724.09
47	2088	98	-$33,724.09	-$505.86	-$505.86	$88,000.00	-$674.48	$ 87,325.52	-$121,555.47
48	2089	99	-$121,555.47	-$1,823.33	-$1,823.33	$88,000.00	-$2,431.11	$ 85,568.89	-$208,947.69
49	2090	100	-$208,947.69	-$3,134.22	-$3,134.22	$88,000.00	-$4,178.95	$ 83,821.05	-$295,902.95
50	2091	101	-$295,902.95	-$4,438.54	-$4,438.54	$88,000.00	-$5,918.06	$ 82,081.94	-$382,423.44

Figure 7.8 (b) Data table showing the depletion of Alex's savings if the life expectancy were to be extended, rows from n=1 to n=39 have been hidden

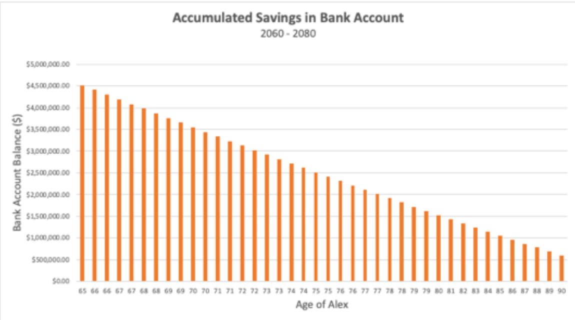


Figure 8.7 Column graph depicts the bank account balance (accumulated savings) decreasing with Alex's age

Figure 9.9 Column graph depicts the property market value increasing with Alex's age under Scenario 1

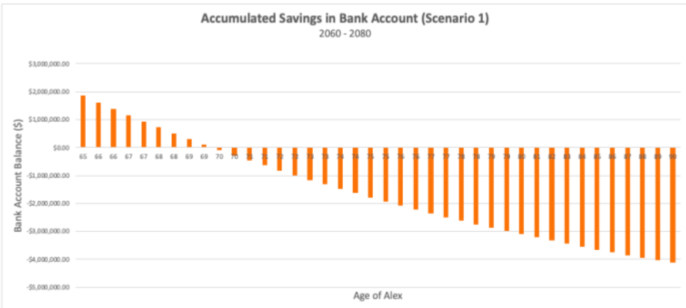


Figure 10.10 Column graph depicts the bank account balance (accumulated savings) decreasing with Alex's age under Scenario 1

Figure 12.11 Column graph depicts the property market value increasing with Alex's age under Scenario 2

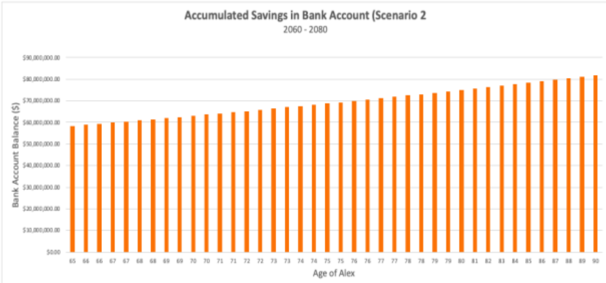


Figure 11.12 Column graph depicts the bank account balance (accumulated savings) increasing with Alex's age under Scenario 2

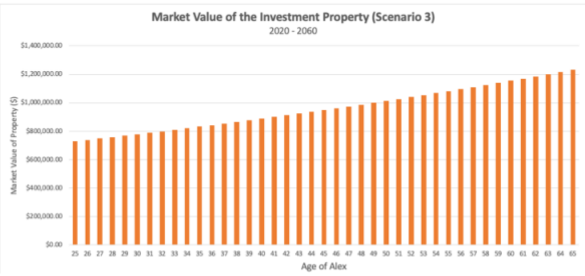


Figure 14.13 Column graph depicts the property market value increasing with Alex's age under Scenario 3

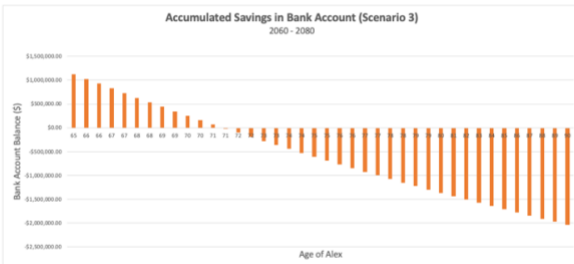


Figure 13.14 Column graph depicts the bank account balance (accumulated savings) decreasing with Alex's age under Scenario 3

Task 2: Exploring the balance of the mutual fund when Alex's parents die

A spreadsheet model was employed to explore the balance of the mutual fund when Alex's parents die under three different scenarios: *Scenario 1*, where the human life expectancy was assumed to be 85 years; *Scenario 2*, the human life expectancy was 90 years and; *Scenario 3*, the human life expectancy being 95 years.

The required parameters as given in figure 2.1 were used in the spreadsheet model with the *dividend distribution per annum*, *d* and the *mutual fund growth rate*, *r* being variant values. As it was given that the dividend distribution follows a uniform distribution with a lower bound of 0% and an upper bound of 10%, *d* was calculated by selecting a random number within that range. Once *d* was calculated, the reinvestment rate from the dividend was calculated to correspond with the random changes in the dividend distribution. The mutual fund growth rate was known to follow a normal distribution with a mean of 8% and a standard deviation of 6%. Hence, the NORM.INV function was used to calculate *r*, returning the inverse of the normal distribution given a random probability of that event occurring. Once all parameters were known, the balance of the mutual fund at maturity, that is, when Alex's parents die, was calculated as shown in figure 1.1. The reinvestment from distribution rate was treated as a compounding factor, as dividends are typically compounded when calculation future annuities. The growth rate of the mutual fund was assumed to be a non-compounding factor to obtain realistic balances, thus why it is multiplied by the time to maturity. This method was employed for all three scenarios with the only difference being the *life expectancy* parameter set equal to 85, 90 and 95 in *Scenario 1*, *Scenario 2*, and *Scenario 3* respectively. A thousand simulations were then produced for each of the three scenarios by using a data table and inputting a random value for the column field to calculate the mutual fund balance for each simulation when Alex's parents die, as illustrated in figure 2.2. For each scenario a summary statistics for the mutual fund balance was produced to show the mean, standard deviation, the minimum balance, the maximum balance, the count (of simulations), the probability that the balance falls under $0 and the probability that the balance is above $0 (see figure 2.3).

Scenario 1: results

When considering the results of the simulated mutual fund balances at the time of maturity, figure 2.6 shows that the mutual fund balance yielded a mean of $3,358,395.07 and a standard deviation of $1,869,412.09. The statistics summary also shows a minimum balance of roughly -$1.8 million, that is, a loss of $1.8 million, likely from a negative growth rate in that corresponding year. Despite this, the probability of the balance being negative in the 1000 various simulations was considerably low, at only 4%. Although the maximum balance is stated as roughly $9.3 million, the relatively low mean and standard deviation indicate that the mutual fund balance is likely to be around the early few millions. This notion is supported by figure 2.3 as the top three bins in the histogram with the highest frequency are four million, three million and five million respectively. When deciding whether Alex should invest in the fund, the investment property yielded a higher return ($6,302,249.02) in the same time frame; as such, it is not advised that he invest in the mutual fund.

Scenario 2: results

With the life expectancy being increased by five years, this change is reflected in Scenario 2's results. Figure 2.7 shows a slightly higher mean of $3,837,016.00, suggesting that the longer the mutual fund is held, the greater the balance at maturity. What is also interesting to note is that the standard deviation is higher at $2,132,208.88; this is also reflected in the wider range of values from the minimum balance (-$3.3 million) and the maximum balance ($13.4 million), suggesting that the longer the maturity, the higher the likelihood of making a greater gain and also, a greater loss. Despite this, the histogram in figure 2.4 does not show a significant change with the top three bins of the highest frequency remaining as four million, three million and five million respectively, this could be owing to the notion that the model is based on random variables. The probability of the balance being negative in those 1000 simulations remains as 4% but is ever so slightly lower when compared to Scenario 1. Following a calculation performed on the investment property under the same circumstances, the property resulted in a higher value of $8,594,165.23 which being far higher than the mean suggests Alex should not invest in the mutual fund

Scenario 3: results

The results shown in figure 2.8 for Scenario 3 appear to be consistent with the increased life expectancy to 95 years of age, as both the mean and standard deviation correspondingly increased to $4,127,405.35 and $2,501,583.53 respectively. Similar to Scenario 2, the maximum balance increased to $13.8 million, however, the minimum balance dropped slightly to -$2.9 million. Equally surprising, the probability of the balance being negative in those remained at 4%. Whether a relationship exists between time to maturity and the range in the mutual fund balance, a greater number of scenarios are needed to explore this notion. The histogram exhibited in figure 2.5 conveyed that the majority of the balance values were slightly higher than those seen in Scenario 1 and Scenario 2 with the highest three bins having frequencies of five million, six million and four million respectively. With the investment property yielding a far higher return of $11,719,574.35, it is recommended that Alex should not invest in the mutual fund.

Although the simulations are based on random variables with the dividend distribution per annum and mutual fund growth rate being variant, there is a clear relationship between the life expectancy, that is, how long the funds are kept in the mutual fund, and the mutual fund balance at the time of maturity.

Parameters	
Market value of property at 2020 ($)	$718,685.00
Reinvestment from distribution	10%
Family expenses from distribution	90%
Life expectancy	95
Alex's parent's age	50
Dividend distribution p.a., *d*	5.3%	F20+(F21-F20)*RAND()
Reinvestment from distribution	0.5%	C8*C12
Mutual fund growth rate, *r*	0.0%	NORM.INV(RAND(),F24,F25)

Model		
Balance of mutual fund	$921,400.67	(C7*(1+C13)^(C10-C11))*((1+C14*(C10-C11)))

Dividend distribution p.a., *d* (%) [uniform distribution]	
Lower bound	0%
Upper bound	10%

Mutual fund growth rate, *r* (%) [normal distribution]	
Mean	8%
Standard deviation	6%

Figure 2.1 (left) The parameters required for the spreadsheet model, dividend distribution, d and mutual fund growth rate, r are variant values; along with reinvestment from distribution are all calculated using the formulas in column D. The balance of mutual fund is calculated as the output (shown in cell D19).

Simulations

Simulation Trial	Dividend distribution (%)	Mutual fund growth rate (%)	Mutual fund balance ($)
1	1.6%	5.9%	$2,343,914.84
2	6.9%	7.4%	$3,273,873.83
3	9.9%	21.3%	$8,583,053.79
4	8.9%	16.2%	$6,534,496.49
5	5.3%	22.6%	$7,710,399.92
6	7.6%	15.3%	$5,940,360.93
7	5.6%	16.8%	$6,006,891.29
8	5.3%	6.3%	$2,782,977.60
9	7.8%	3.8%	$2,213,239.92
10	8.4%	6.5%	$3,149,547.46
11	2.2%	7.2%	$2,740,665.47
12	6.7%	5.9%	$2,767,837.92
13	5.5%	7.1%	$3,015,802.83
14	3.1%	11.0%	$3,877,791.84
15	2.0%	6.2%	$2,447,987.37
16	1.3%	3.3%	$1,625,387.05
17	1.4%	8.9%	$3,092,564.00
18	6.7%	8.4%	$3,580,199.99
19	4.0%	12.5%	$4,432,749.32
20	5.2%	10.8%	$4,114,421.36
1000	9.9%	2.4%	$1,855,989.69

Mutual fund balance summary statistics		
Mean	$3,238,493.48	AVERAGE(E33:E1032)
Standard Deviation	$1,887,481.54	STDEV.S(E33:E1032)
Minimum Balance	-$2,876,228.05	MIN(E33:E1032)
Maximum Balance	$11,114,134.10	MAX(E33:E1032)
Count	1000.00	COUNT(E33:E1032)
Prob(Balance < $0)	0.05	COUNTIF(E33:E1032,"< 0")/COUNT(E33:E1032)
Prob(Balance > $0)	0.954	COUNTIF(E33:E1032,"> 0")/COUNT(E33:E1032)

Figure 2.2 (below) 1000 simulations were produced, calculating the mutual fund balance for a given dividend distribution rate and mutual fund growth rate; from which summary statistics was performed with a corresponding formula for each statistic shown in column I.

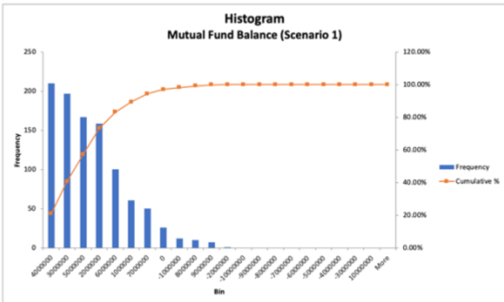
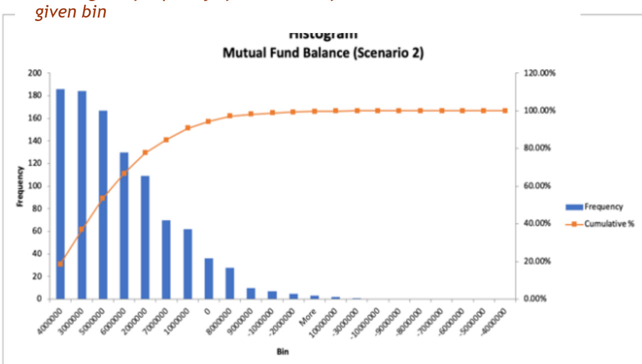


Figure 2.3 (left) A histogram was produced for Scenario 1, showing the frequency of the mutual fund balance values in a given bin

Figure 2.4 (below) A histogram was produced for Scenario 2, showing the frequency of the mutual fund balance values in a given bin



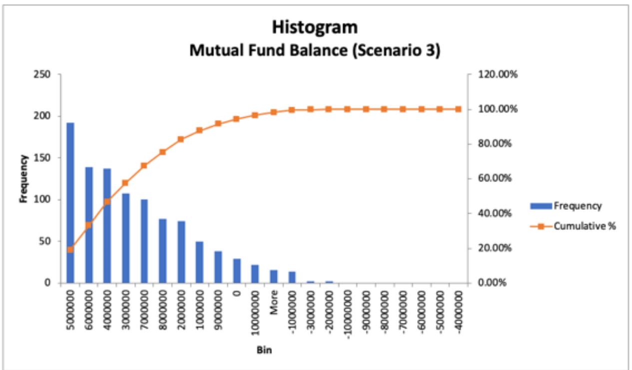


Figure 2.5 (left) A histogram was produced for Scenario 3, showing the frequency of the mutual fund balance values in a given bin

Scenario 1

Mutual fund balance summary statistics	
Mean	$3,358,395.07
Standard Deviation	$1,869,412.09
Minimum Balance	-$1,832,900.38
Maximum Balance	$9,300,270.80
Count	1000.00
Prob(Balance < $0)	0.04
Prob(Balance > $0)	0.963

Figure 2.6 Summary statistics for the mutual fund balance in Scenario 1

Scenario 2

Mutual fund balance summary statistics	
Mean	$3,837,016.00
Standard Deviation	$2,132,208.88
Minimum Balance	-$3,305,713.54
Maximum Balance	$13,393,901.01
Count	1000.00
Prob(Balance < $0)	0.04
Prob(Balance < $0)	0.965

Figure 2.7 Summary statistics for the mutual fund balance in Scenario 2

Scenario 3

Mutual fund balance summary statistics	
Mean	$4,127,405.35
Standard Deviation	$2,501,583.53
Minimum Balance	-$2,919,677.76
Maximum Balance	$13,756,365.82
Count	1000.00
Prob(Balance < $0)	0.04
Prob(Balance < $0)	0.957

Figure 2.8 Summary statistics for the mutual fund balance in Scenario 3