

ISEN 667 Project 1
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3 – 9 - 2017

Initial Estimate

In our initial approach we estimated that the project would cost \$500,000 and would take 1 year to complete. The project will result in an annual savings of \$125,000. 10 years after the project is started, it will be terminated with a salvage value of \$50,000. For the company the MARR is 10%.

In my analysis, I have structured it such that the costs of the project will occur at the beginning of a year, and the savings will be realized at the end of the year. In the figure below, the cost of the project is shown in red in year 0, and there is no cash flow occurring at the end of year 1. This is because the project would have taken the full first year to complete, and would result in savings at the end of the second year.

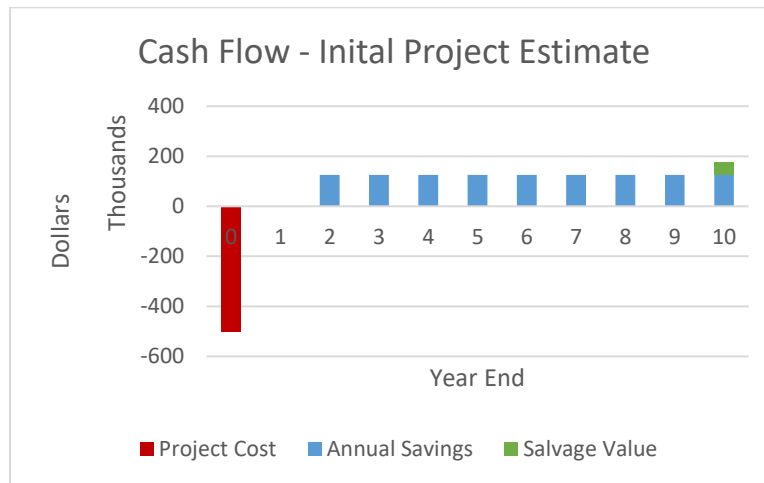


Figure 0.1.

The initial project cost is shown in red, occurring at year 0. The annual savings is shown in blue, and the salvage value at year 10 is shown in green.

Project Present Worth	\$173,711.68
Project Future Worth	\$450,563.36
Project Annual Worth	\$28,270.78

Table 0.1.

Cumulative worth of the initial project estimates.

Under these estimates, the project present worth (PPW) is \$173,711.68, shown in Table 0.1. Also, shown in Table 0.1, the project future worth would be \$450,563.36 and if the project was viewed as an annuity, the annual worth would be \$28,270.78. Since the focus is determining if the project will be profitable, I am primarily concerned with the values being greater than 0. Therefore, for the remainder of the analysis, I focus on PPW, since the present worth, future worth, and annual worth will always be all positive, or all negative.

Altered Estimations

Under further analysis, it has been determined that there is some uncertainty in the initial project estimates. There is uncertainty concerning the number of years required for project completion, the project cost, the annual savings, and salvage value at the end of the project. I have analyzed the impact of each of these parameters individually, and then combined them for a full project analysis.

1. Project Length

The first parameter to consider is the project length. There is a 60% chance that the project will finish within 1 year, 30% within 2 years, and 10% within 3 years. The project cost will be evenly spread out between the number of years till completion. With these estimates, the cash flows for a 2-year project would resemble the cash flows in Figure 1.1, and the cash flows for a 3-year project would resemble the cash flows in Figure 1.2.

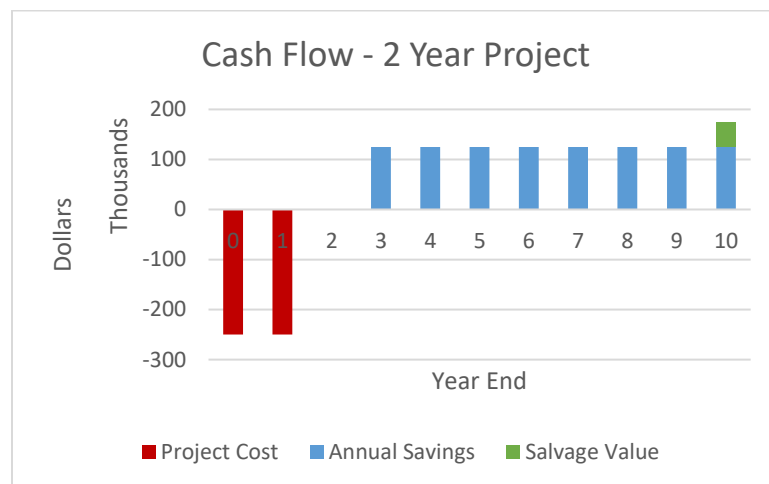


Figure 1.1
Cash flows for a project taking 2 years to finish.

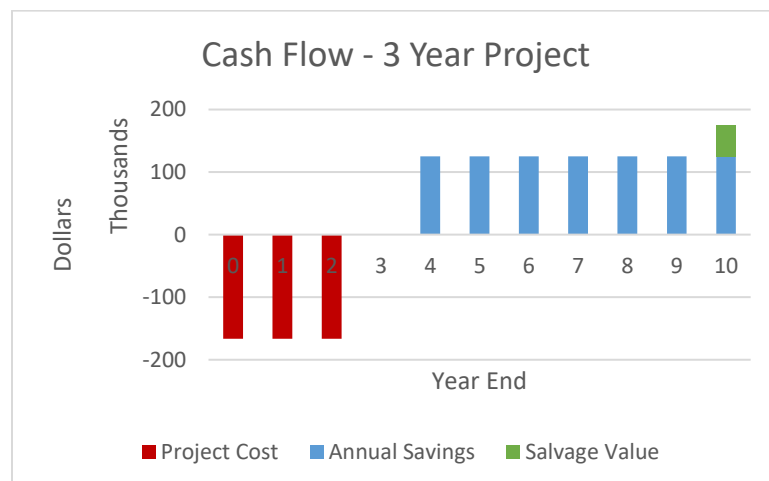


Figure 1.2
Cash flows for a project taking 3 years to finish.

The 1, 2, and 3 year projects will result in different PPWs. The PPWs for these are summarized in Table 1.1, and visualized in Figure 1.3. Additionally Figure 1.4 shows the number of iterations from a Monte Carlo simulation that resulted in 1, 2, and 3 year projects. As expected, approximately 60% of the iterations required a 1 year project, approximately 30% required a 2-year project, and approximately 10% required a 3-year project.

Project Length	PPW
1 Year	\$173,711.68
2 Years	\$93,133.17
3 Years	\$20,568.68

Table 1.1
PPW for projects requiring 1, 2, and 3 years.

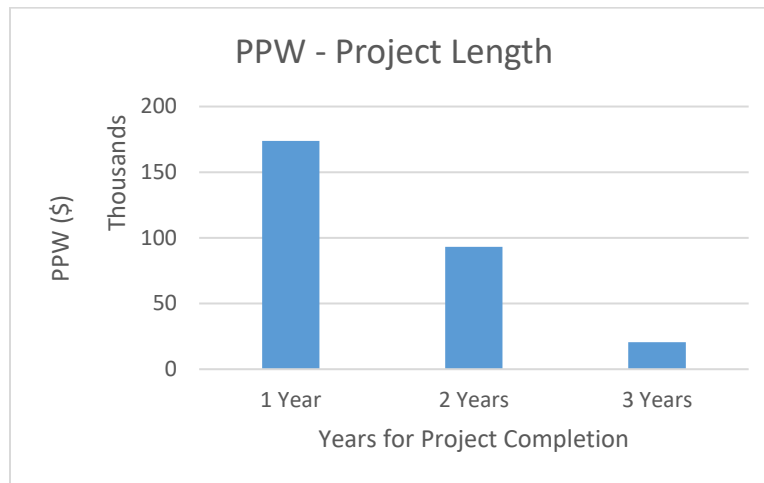


Figure 1.3
Visual representation of PPW for projects requiring 1, 2, and 3 years.

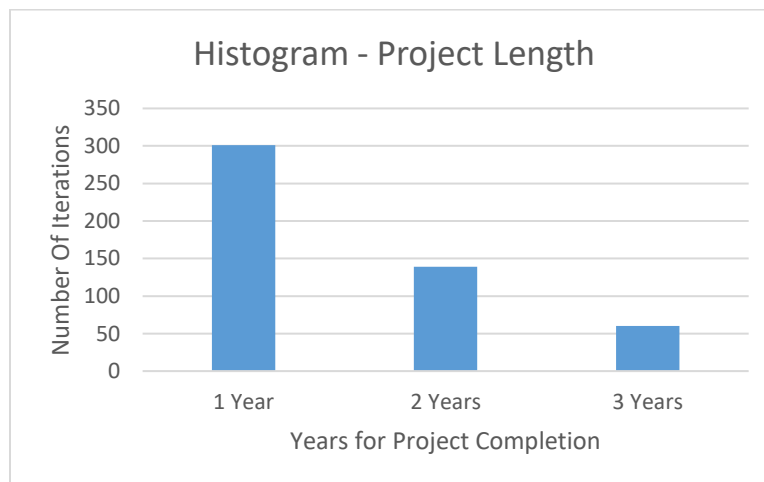


Figure 1.4
Monte Carlo simulation showing number of iterations resulting in 1, 2, and 3 years.

Each of the given scenarios still has a positive PPW. As seen in Figure 1.3, the PPW is noticeably sensitive to the number of years the project requires, although they all remain positive. Nevertheless, the project would still be recommended. The average PPW would be \$134,223.83.

Positive Iterations	100 %
Negative Iterations	0 %
Average PPW	\$134,223
Average Number of Years Required	1.5

Table 1.2
Summary of altering the years required for project completion.

2. Project Cost

The second parameter to consider is the project cost. The project cost is exponentially distributed with a mean of \$500,000. An example cash flow is shown in Figure 2.1. To test the sensitivity of this parameter, 500 Monte Carlo simulations were performed, and the project cost and resulting PPWs were recorded. Figure 2.2 shows a histogram of the generated project costs. The costs were left as negative values, so that as the cost becomes less negative, the PPW will increase. This is shown in Figure 2.3 where the resulting PPWs are graphed with their respective project costs.

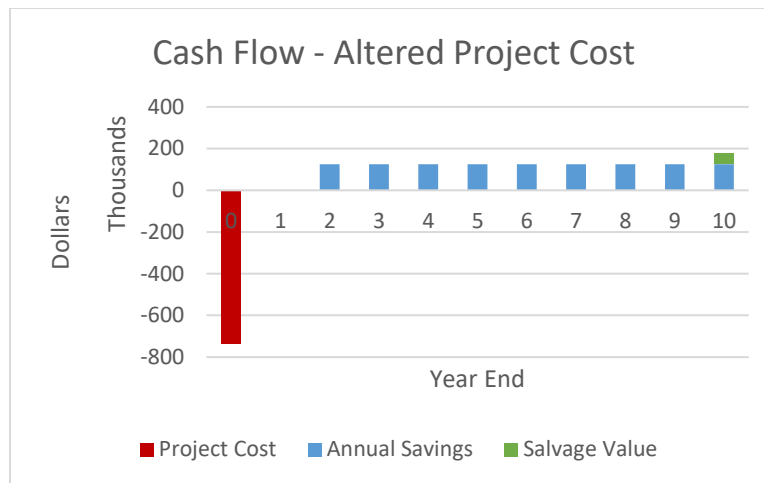


Figure 2.1
Example cash flow with the project cost being exponentially distributed.

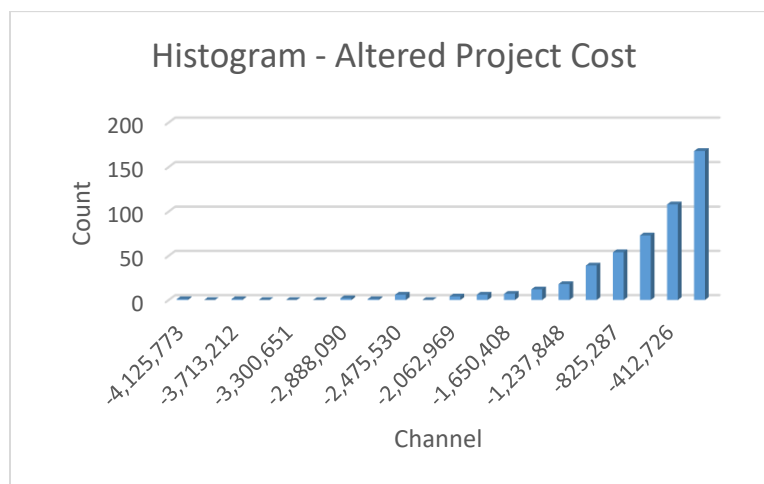


Figure 2.2
Histogram of project costs using an exponential distribution. The costs are displayed using negative values.

It is apparent from Figure 2.3 that the PPW is very sensitive to the project cost. The PPW was positive 73.2% of the time, and negative 26.8% of the time. The average PPW was \$160,806.8, and the average project cost was -\$512,905. When only changing the project cost, the PPW is monotonically increasing with the project cost. Therefore, all projects casts that were less negative than -\$673,454.15 had positive PPW.

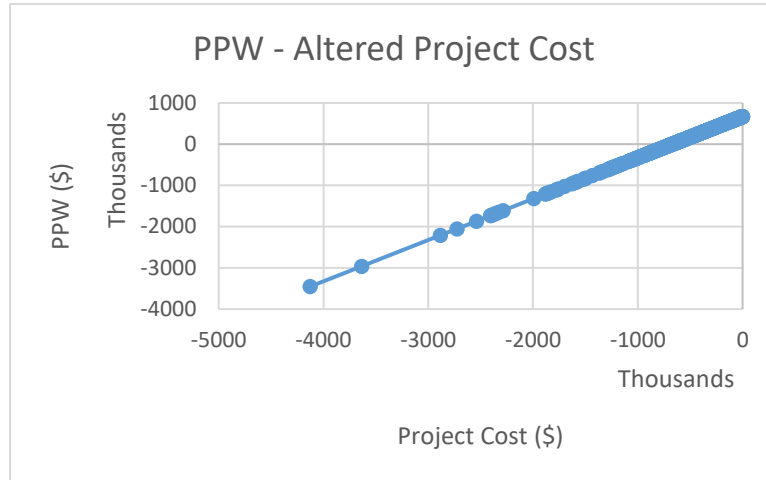


Figure 2.3

PPWs graphed as the dependent variable, with the project cost acting as the independent variables.

Positive Iterations	73.2 %
Negative Iterations	26.8 %
Average PPW	\$160,806.8
Average Project Cost	-\$512,905

Table 2.1

Summary of altering the project cost.

3. Annual Savings

The next parameter to consider is the annual savings. The annual savings were varied using a uniform distribution between \$50,000 and \$200,000. An example cash flow is shown in Figure 3.1, where the annual savings in years 2 through 10 are each generated from a uniform distribution.

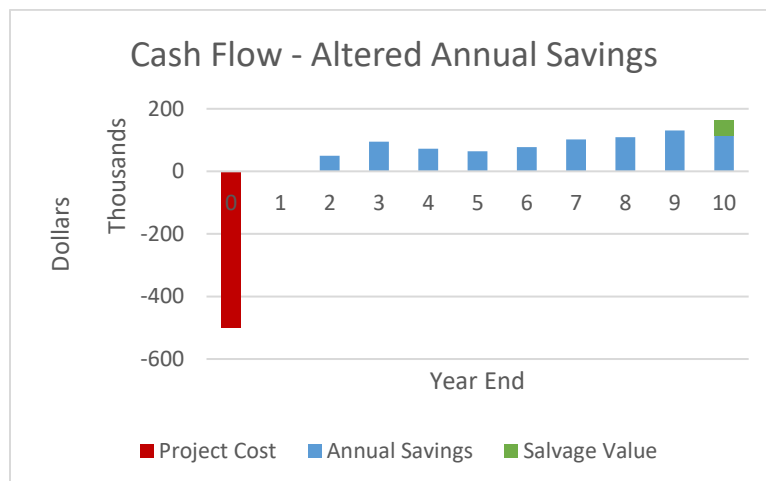


Figure 3.1

Example cash flow with the annual savings generated from a uniform distribution.

Figure 3.2 contains a histogram of the generated annual savings values. Each channel has roughly the same number of counts as expected from a uniform distribution. The average annual savings generated was \$124,690.

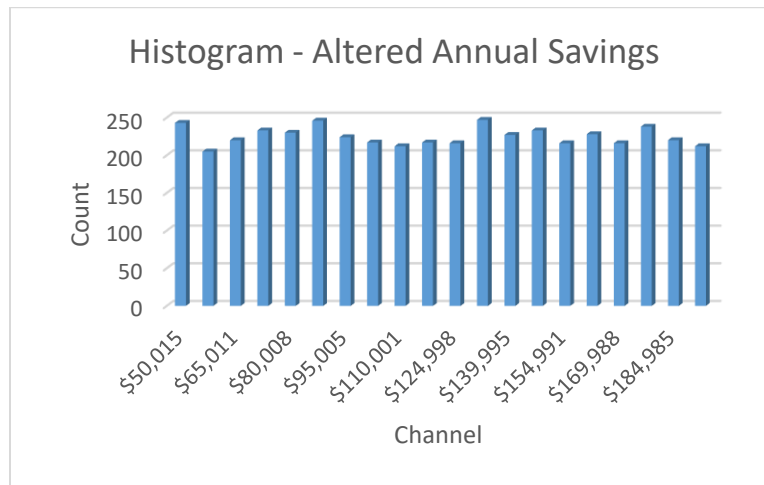


Figure 3.2
Histogram of the annual savings being generated from a uniform distribution.

The PPW was very insensitive to the change in the annual savings. Figure 3.3 graphs the PPW as the independent variable, and the annual savings as the dependent variable. As the PPW increases, the annual savings increases as well, but it is very subtly, and there is only a small difference between the left and right endpoints. Additionally, only 1.2 % of the iterations resulted in a negative PPW, with 98.8 % of the iterations resulting in a positive PPW.

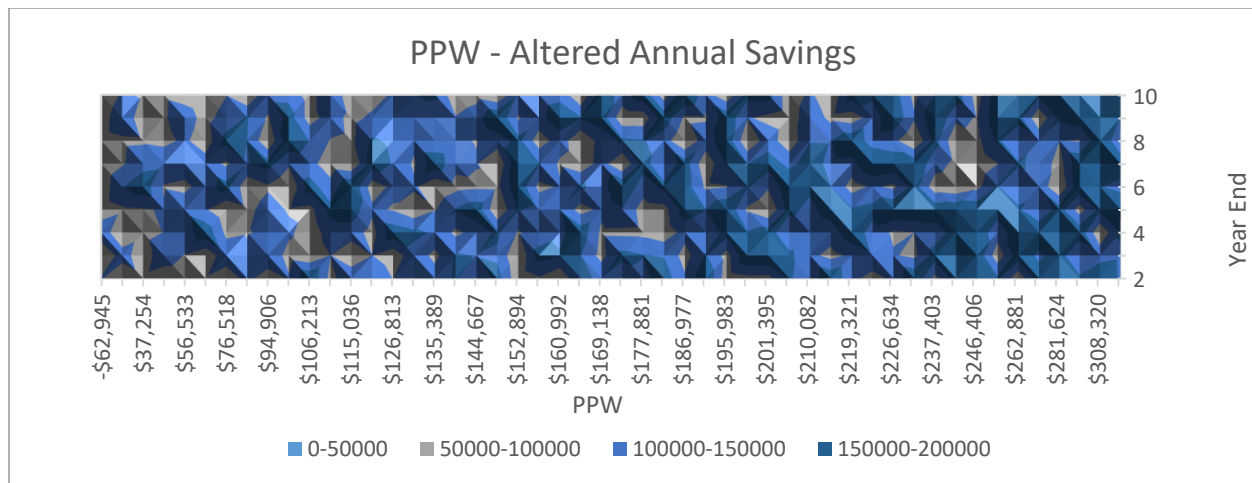


Figure 3.3
Annual savings graphed against the PPW. As the PPW increases the annual savings increases, but only by a small amount.

Positive Iterations	98.8 %
Negative Iterations	1.2 %
Average PPW	\$171,819
Average Annual Savings	\$124,690

Table 3.1
Summary of altering the annual savings.

4. Salvage Value

The last parameter to consider is the salvage value. The salvage value varied using a Gaussian distribution with a mean of \$50,000, and variance of \$20,000. An example cash flow is shown in Figure 4.1. Although it may be challenging to see, the salvage value at the end is slightly more than it had been previously. It is easy to infer from the cash flow that a change to the salvage value will have little impact on the PPW.

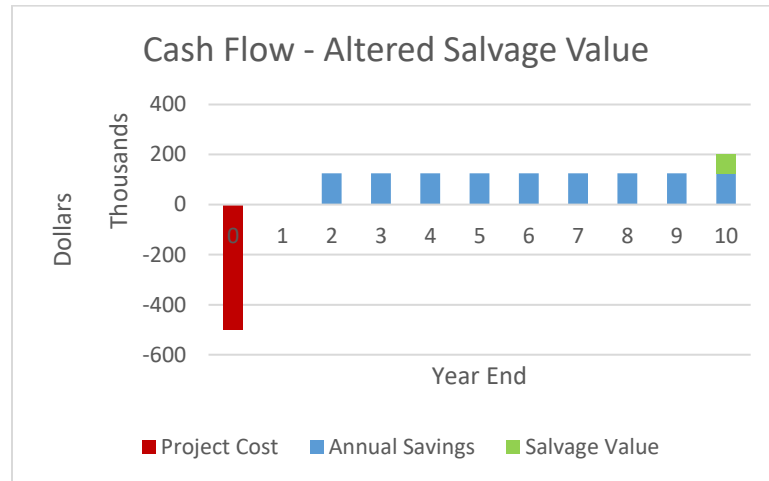


Figure 4.1
Cash flow resulting from altering the salvage value.

Figure 4.2 shows the a histogram of the resulting distribution for the salvage values. It should be noted that a salvage value should not be less than 0 as there would just be nothing to salvage. Instead, any negative values were truncated to 0. As expected, the histogram shows a normal distribution. The average salvage value was \$50,469.

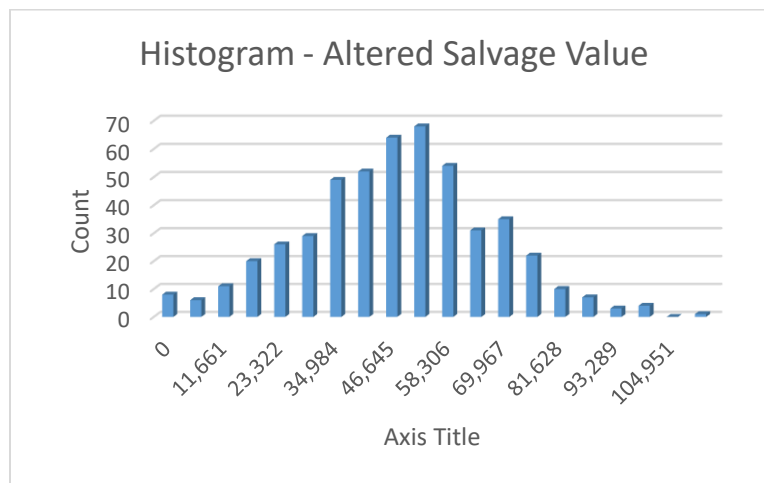


Figure 4.2
Histogram of salvage values generated from a Gaussian distribution.

As seen from the example cash flow in Figure 4.1, the PPW will be very insensitive to changes in the salvage value. This is confirmed by Figure 4.3, which graphs the salvage value as the independent variable, and the PPW as the dependent variable. As the salvage value increases, so does the PPW, but not by much. Additionally, the PPW is never negative, and even without a salvage value the project would still be recommended.

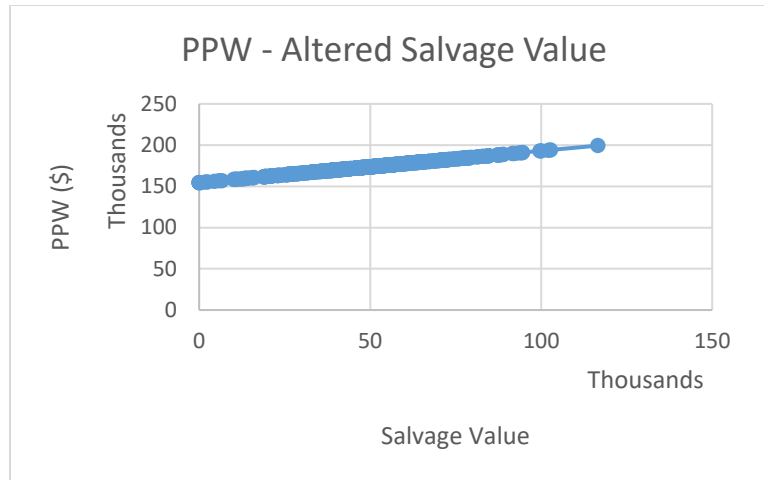


Figure 4.3

Graph depicted the PPW against the salvage value generated from a Gaussian distribution.

Positive Iterations	100 %
Negative Iterations	0 %
Average PPW	\$173,892
Average Salvage Value	\$50,469

Table 4.1

Summary of altering the annual savings.

5. Individual Summary

Of each of the studied factors, the PPW is most sensitive to the changes in the project cost. This will be seen further when combining all variables. Table 5.1 shows a summary of altering each of the individual variables.

	Years Required	Project Cost	Annual Savings	Salvage Value
Positive Iterations	100 %	73.2 %	98.8 %	100 %
Negative Iterations	0 %	26.8 %	1.2 %	0 %
Average PPW	\$134,223	\$160,806.8	\$171,819	\$173,892
Respective Average	1.5	-\$512,905	\$124,690	\$50,469

Table 5.1

Summary of changes to each individual variable.

Combining Variables

Simulating each variable individually is informative, however it is most important to study the effects of a Monte Carlo simulation when all variables are varied together. The following simulations describe the scenario where the number of years to complete the project varies between 1 to 3 years, the project cost is exponentially distributed, the annual savings is uniformly distributed, and the salvage value has a Gaussian distribution. In total, 72.4 % of the iterations had a positive PPW, with the remaining 27.6 % of simulations having a negative present value. Additionally, the average PPW was \$144,266.2.

6. Combined – Project Length

Originally when altering the project length, all iterations with the same length, 1, 2, or 3, years, had the same PPW. Now, this is no longer the case. Instead, there will be variations of the PPW within each project year length. Figure 6.1 shows the histogram for each of the respective project year lengths. As expected, 1 year was approximately 60 %, 2 years was approximately 30 %, and 3 years was approximately 10 %. The number of iterations for each can be seen in Table 6.1.

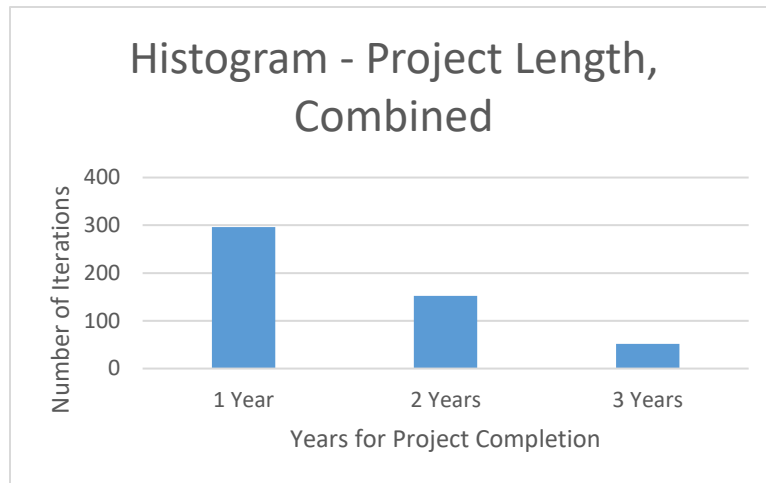


Figure 6.1

Histogram showing the number of iterations selected for each project year length.

Figures 6.2, 6.3, and 6.4 show the PPW for each iteration that fell in its given project length. As it can be seen, each curve looks very similar. Additionally, Table 6.1 confirms that changes to the project length, 1, 2, or 3 years, has very little impact on whether the project is economically a wise choice. Although the 1 year project has a higher average PPW, the percent of positive and negative iterations, which ultimately decides if a project is feasible, between each project length is almost identical.

	1 Year Project Length	2 Years Project Length	3 Years Project Length
Positive Iterations	72.6 %	71.1 %	75 %
Negative Iterations	27.4 %	28.9 %	25 %
Number of Iterations	296	152	52
Average PPW	\$165,568	\$116,148	\$105,198

Table 6.1

Summary of the effects of changing the project length on the total project.

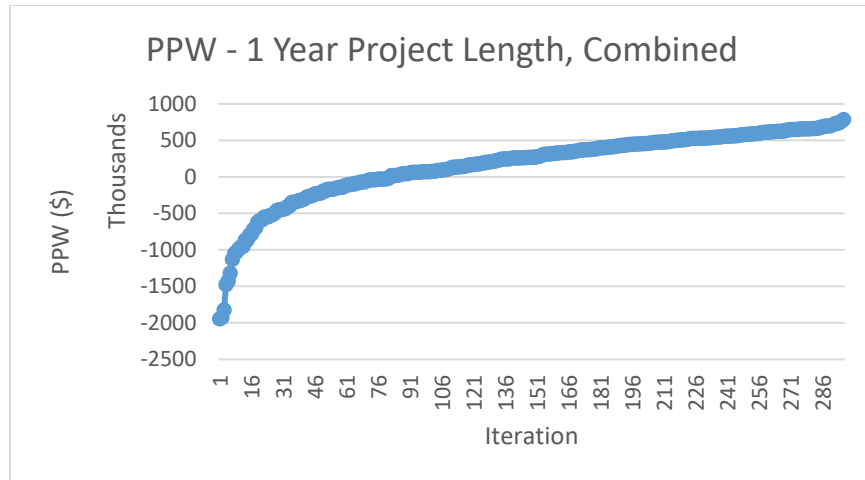


Figure 6.2

Shows the PPW for each iteration where the project length was 1 year.

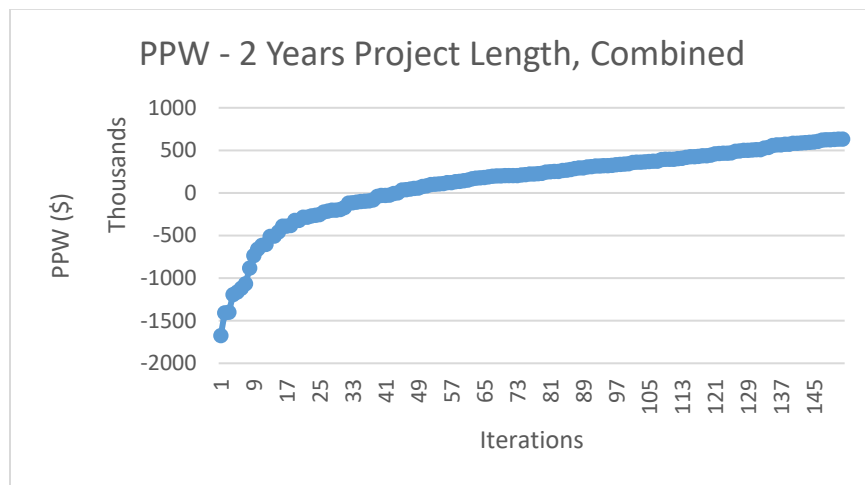


Figure 6.3

Shows the PPW for each iteration where the project length was 2 years.

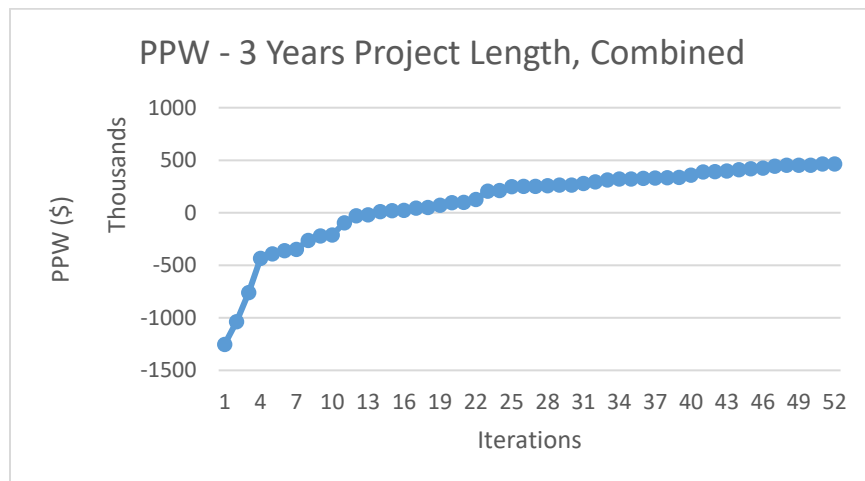


Figure 6.4

Shows the PPW for each iteration where the project length was 3 years.

7. Combined – Project Cost

Under the individual analysis, the PPW was most sensitive to the project cost. Similarly, that will be the case with all the variables combined. Figure 7.1 shows a histogram of the generated project costs. Again, the cost has been left negative and looks exponential. Because the cost is shown as negative, the exponential appears to be increasing, instead of the standard decreasing exponential distribution. Since the project cost is independent of the other variables, it is not surprising that its histogram looks similar to the independent case.

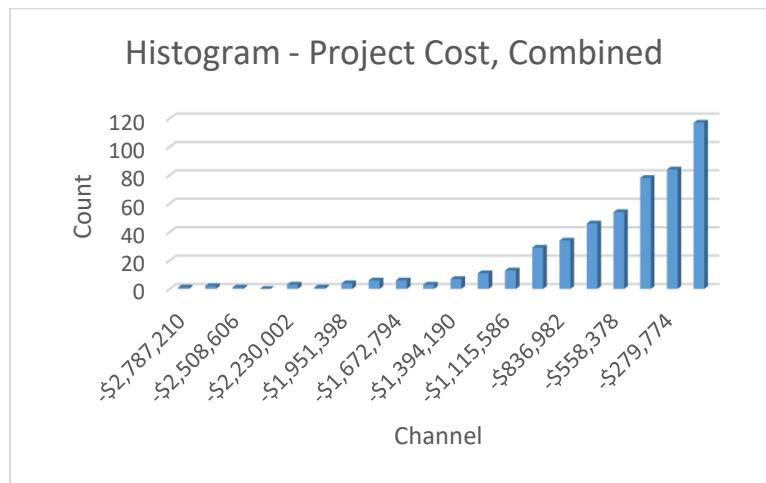


Figure 7.1

A histogram of the generated project cost from an exponential distribution.

The sensitivity of the PPW to the project cost can best be seen in Figure 7.2. In this figure the project cost is graphed as the independent variable, with the PPW being the dependent variable. As the project cost becomes less negative, the PPW increases. While the PPW does not monotonically increase, there is a very strong relationship. Most importantly to note, when the project cost was between -\$569,218 and 0, the PPW was always positive. The project cost was less negative than -\$569,218 66.8 % of the time. These results are also reflected in Table 7.1.

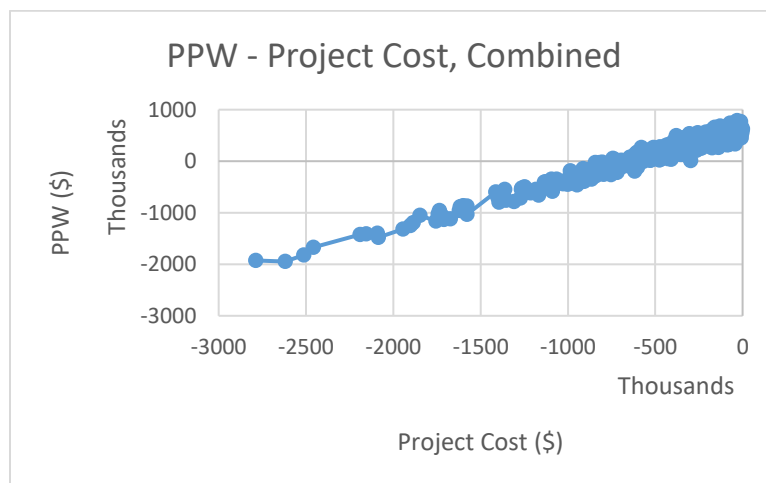


Figure 7.2

Graphing the PPW versus the project cost. There continues to be a strong relationship, indicating that the PPW is sensitive to the project cost.

Because the project cost is exponentially distributed, it is possible for the upper and lower bounds to be more extreme. The worst case was a project cost of -\$2,787,210, and a PPW of -\$1,929,337. The best case was a project cost of -\$1,169 leading to a PPW of \$623,983, which is 359% of the initial estimate. These large extremes create some concern when determining whether to execute the project, however with 66.8 % of the iterations in the guaranteed positive PPW range, and 72.4 % of iterations resulting in a positive PPW, the project has a high potential.

Average Project Cost	-\$489,488
All Positive After	-\$569,218
All Positive After Percentage	66.8 %
Minimum Project Cost (Most Negative)	-\$2,787,210
Maximum Project Cost (Least Negative)	-\$1,169

Table 7.1

Summary of the effects of an exponentially distributed project cost.

8. Combined – Annual Savings

The annual savings were generated from a uniform variable between \$50,000 and \$200,000. The PPW was affected by the annual savings, but there was not a strong sensitivity. Figure 8.1 shows a histogram of the generated annual savings values, and as expected, they appear as a uniform distribution.

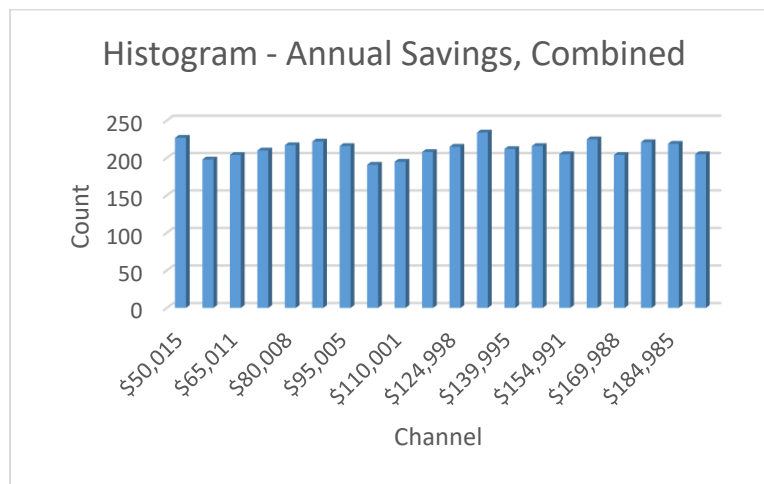


Figure 8.1

Histogram showing the uniform distribution of the annual savings values.

Figure 8.2 shows the annual savings values from the lowest PPW to the highest PPW. On the right end, where PPW is the highest, the annual savings does appear to be a little darker, however not by much. From this it can be determined that the PPW is not sensitive to the annual savings given our estimate using a uniform distribution.

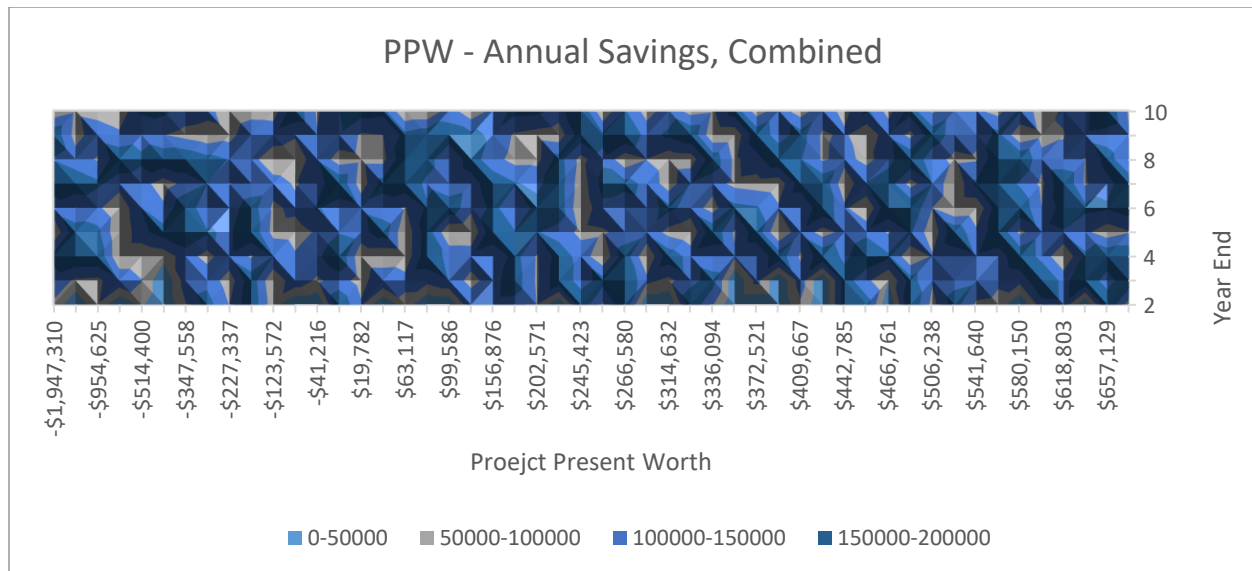


Figure 8.2
Contour graph showing the change in annual savings as PPW increases.

9. Combined – Salvage Value

In the individual analysis, the salvage value had very little effect on the PPW. This will be true in the combined case as well. Figure 9.1 shows the histogram for the salvage values generated using a Gaussian distribution. Again, note that there is no merit to a negative salvage value, so the salvage values have been truncated at 0. The average salvage value was \$49,971.

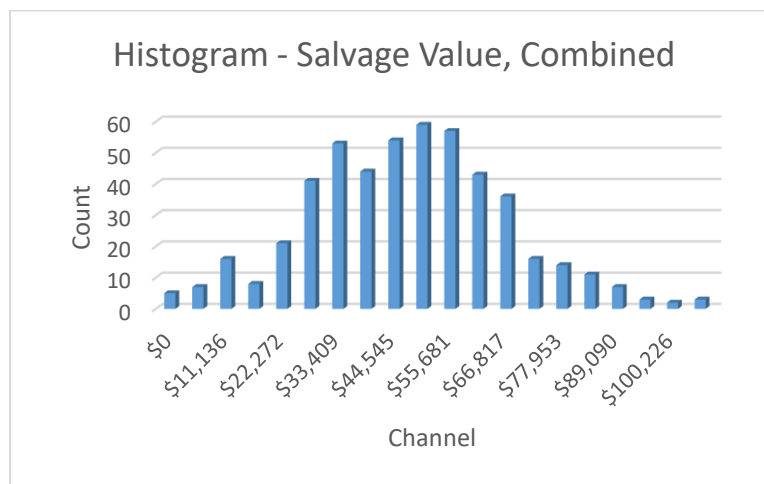


Figure 9.1
Histogram of the salvage values generated from a Gaussian distribution.

Figure 9.2 shows the PPW graphed as the dependent variable, with the salvage value being used as the independent variable. As it is seen in the figure, there is no strong correlation between the salvage value increasing, and the PPW. It can be concluded that the PPW is not sensitive to the salvage value. Intuitively, this makes sense because our estimate for the salvage value is a moderately small cash flow that occurs at the end of the last year.

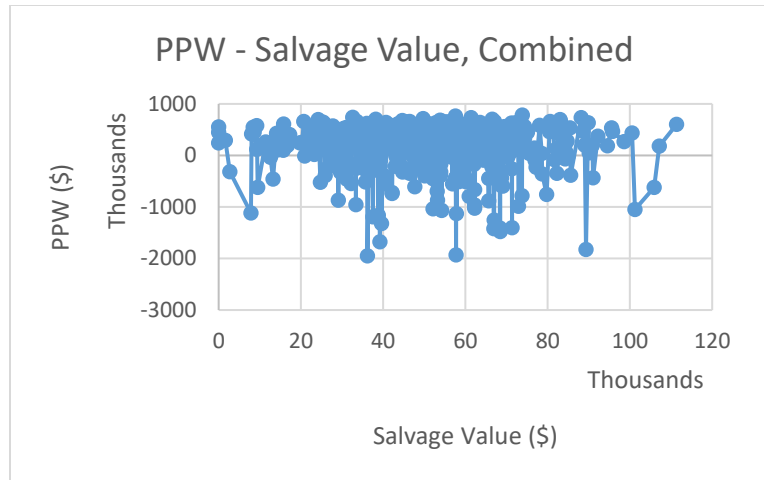


Figure 9.2

Graphing the PPW against the respective salvage value. There is clearly no relation.

10. Combined – Expected Value

To better determine the accuracy of our estimation, it would be worthwhile to calculate the expected value. The expected value for the project cost is -\$500,000, the expected value for the annual savings is \$125,000, and the expected value for the salvage value is \$50,000. We must take into consideration the variation in project years, and use that to calculate our expected value. The expected value from this project is \$134,223.83. This is shown in Table 10.1.

Years for Project Completion	Expected Present Worth	Probability	Weighted Average	Expected Present Worth Total
1 Year	\$173,711.68	60 %	\$102,227.00	\$134,223.83
2 Years	\$93,133.17	30 %	\$27,939.95	
3 Years	\$20,568.68	10 %	\$2,056.87	

Table 10.1

Calculating the expected PPW.

The average value from the Monte Carlo simulation was \$144,266.20. To test the model, I performed simulations on the order of 10,000 iterations, and the average value approached much closer to the expected value.

Conclusion

After simulating the new estimates both individually, and combined, it is clear that the most sensitive variable is the project cost. The PPW was sensitive to the required years till completion in the stand alone simulation, but was not sensitive to this factor in the combined simulation. Also, the PPW was not sensitive to the annual savings or salvage value. Ultimately, the project had a positive PPW 72.4 % of the time, a negative PPW 27.6 % of the time, and an average PPW of \$144,266.20. While this is clearly not a no risk situation, there is over a 70% chance that the project will be profitable. Additionally, there is some potential for the project to be much more profitable than expected. I encourage the company to pursue the project, and be most mindful of the expense of the project. While it will not be guaranteed to lose money if the project costs is more negative than -\$569,218, but it will be very concerning if the project can make money.