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Monte Carlo Simulation and Risk Assessment in Capital Budgeting

By Caitlin Gallagher

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Advisor Approval_____ Dated_____.

To fulfill the requirement for the Honors Program at the University of Connecticut

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BACKGROUND

A 56 year old food conglomerate, Heavenly Foods Corporation currently holds a strong financial position in the marketplace with its major product lines in cereals, frozen dinners, canned sodas and fruit juices. Eighteen months ago the athletic drink High Energy was introduced. A milkshake type drink, it replaces electrolytes without a bad aftertaste and comes in vanilla, chocolate and strawberry. However, new management is now concerned that the firm could lose its market share if it does not begin fulfilling consumer's desire for replenishing athletic drinks with a low sodium and low fat content.

With the success of High Energy, Heavenly Foods Corporation wants to introduce a new athletic drink line for the nutrient conscious consumer by adding a lite option with half the calories and less fat. Marketing research shows that offering the lite option would increase the market share, despite cutting into the sales of High Energy. If the lite option is successful, the firm could carry it over into the frozen dinner line by developing lite frozen pizzas.

Launching this new product line will take initial investment of capital increasing the company's debt ratio and cannibalize an already strong product. However new leadership in the company strongly believes in the necessity of introducing this product to maintain position in the healthy foods market and most especially in athletic drinks. After gathering as accurate cash flow estimates as possible, the project needs to be analyzed for potential profitability over the next four years initially using the traditional analyses, sensitivity and scenario, then comparing those results to those produced with Monte Carlo simulation using @risk software.

ANALYSIS

Cash Flows

Year 0

Although not a direct factor in the calculation, the sunk cost on consumer research predicted 'enthusiastic acceptance' of a new lite product despite the higher cost. Market share would greatly increase beyond the group steadily purchasing the High Energy according to market surveys and lure new consumers to the company. Research shows the market favorable to a product like this; however Heavenly Foods wants to be financially successful in breaking into the potential market.

Currently, Heavenly Food's plant has an available section that will be free of any opportunity cost for the next 2-3 years until the expected increased growth in the company's other projects will need the space. Used machinery would be given a MACRS three year class life, salvage value of $87,500 and shipping and instillation cost will be required, $35,000 and $70,000 respectively.

Depreciation Schedule

Year	1	2	3	4
MACRS	0.33	0.45	0.15	0.07
Depreciation	$265,650	$362,250	$120,750	$56,350
Book Value	$539,350	$177,100	$56,350	$0

Investment Outlays

Machinery	$(700,000.00)
Shipping	$ (35,000.00)
Instillation	$ (70,000.00)
Basis for Depreciation	$(805,000.00)

While this option is used in the analysis, Heavenly Foods has other alternatives if the project is decided to be a long term success. At the very least, the analysis will need to incorporate an opportunity cost for the space once the company's growth would require its use. For a more long term solution, Heavenly Foods could rent a space from Coca-Cola which would require no initial lump sum, instead making monthly rental payments and would allow Heavenly Food to rent out its own space. Because there has already been interest in renting that available space, Heavenly Foods should seriously consider eventually moving in favor of a 20 year steady monthly income from the interested renter, All Natural Foods. It is incredibly important for the company to lock in favorable long term cost contracts to reduce risk if at all possible.

Additionally inventories would increase net operating working capital by $30,000. Added to the total change in net working capital, Heavenly Foods is looking at a Year 0 net investment of $835,000.

With a 40% combined state and federal tax and a target structure of 40% debt and 60% equity, Heavenly Foods is currently operating with a 12% cost of capital. In this company the cost of equity or issuing new stock is 14.8% while the cost of long term debt is 14%. However a new project would more than likely change the ratio and therefore the WACC, for better or for worse.

$$.4\ (.13)\ (.6) + .4\ (.148) = .12$$

Years 1-3

Management has predicted sales of 700,000 in the next four years. Because the cash flows will be discounted at the WACC (a nominal rate), the sales price is adjusted from the current dollar terms using neutral inflation rate of four percent. While this makes the analysis simpler, a neutral inflation rate is often an inaccurate assumption because inflation does not affect revenues and costs exactly the same. Often future costs can be locked in through futures contracts with suppliers or employees, like monthly rental payments, making these costs less affected by inflation variation. However, the potential of these constant futures costs would have to be further explored to be included in the analysis.

The marketing departments' research of the future variable operating costs came to the conclusion that the variable operating costs should be adjusted at two percent per year. They are currently estimated at $1.25 per unit.

Since the new lite product would appeal to a similar customer base there is an expected amount of erosion of the profits of High Energy Original, down 30% to $80,000 a year. However this would also result in lower production costs, saving an estimated $35,000 per year. However, if management believes a competing firm will take the opportunity to produce a similar product, then the cannibalization effects should be included in the analysis of the company's financial position regardless of the ultimate decision.

Net Cannibalization Effect = -80,000 + 35,000 = -45,000

Year 4

Assuming that the project will be terminated after four years, the cash flow in the final year will include the salvage value and the recovery of the initial net working capital investment. The salvage value was estimated to be $87,500 taxed at the 40% rate.

Termination Cash Flow = 87,500 – 35,000 + 30,000 = 82,500

Projected Cash Flow: Years 0-4

	Year 0	Year 1	Year 2	Year 3	Year 4
Change in NWC	$(805,000.00)				
Incr. in NOWC	$ (30,000.00)				
Unit Price	$ 2.00	$ 2.08	$ 2.16	$ 2.25	$ 2.34
Unit Sales		700000	700000	700000	700000
Revenues		$ 1,456,000	$ 1,514,240	$ 1,574,810	$ 1,637,802
Fixed Operating Cost		$ (190,000)	$ (190,000)	$ (190,000)	$ (190,000)
Variable Operating Cost		$ (892,500)	$ (910,350)	$ (928,557)	$ (947,128)
Total Operating Cost		$ (1,082,500)	$ (1,100,350)	$ (1,118,557)	$ (1,137,128)
Depreciation		$ (265,650)	$ (362,250)	$ (120,750)	$ (56,350)
Cannibalization Effects		$ (45,000.00)	$ (45,000.00)	$ (45,000.00)	$ (45,000.00)
Before Tax Income		$ 62,850	$ 6,640	$ 290,503	$ 399,324
Taxes		$ (25,140)	$ (2,656)	$ (116,201)	$ (159,730)
Net Income		$ 37,710	$ 3,984	$ 174,302	$ 239,594
Depreciation		$ 265,650	$ 362,250	$ 120,750	$ 56,350
Net Operating CF		$ 303,360	$ 366,234	$ 295,052	$ 295,944
Salvage Value					$ 87,500.00
SV tax					$ (35,000.00)
Recovery of NWC					$ 30,000.00
Termination CF					$ 82,500.00
Project CF	$ (835,000)	$ 303,360	$ 366,234	$ 295,052	$ 378,444

Risk Measurements

NPV

Using the five cash flows above and discounting at the current WACC gives the project a net present value of $178,336.83. Based on this calculation the project should be accepted since the NPV>0.

IRR

The rate that would set the NPV=0 based on the projected cash flows is 21.56%, a yield much higher than the 12% cost of capital and therefore by this calculation as well the project should be accepted.

MIRR

The IRR has the very optimistic assumption that the cash flows earned by the project can be invested at the higher rate of this project every year. For a company like this, that does not often invest in high yield projects, it is a much safer and realistic assumption for the cash flows to be reinvested at the cost of capital each year, the WACC. This assumption yields an MIRR 17.55% for the project. Again this estimates a higher rate of return then the cost of capital but a much closer one. The project should still be accepted.

Any risk with a new project also affects the company as a whole. The outcome will also impact the reputation and financial structure of the company by increasing debt and depleting available cash. This particular project could potentially be the starting point for other lite products or it could simply split the customers it already has if the cannibalization is more than projected and the new unit sales are lower than estimated. There are two traditional ways to evaluate the riskiness of the project: sensitivity analysis and scenario analysis.

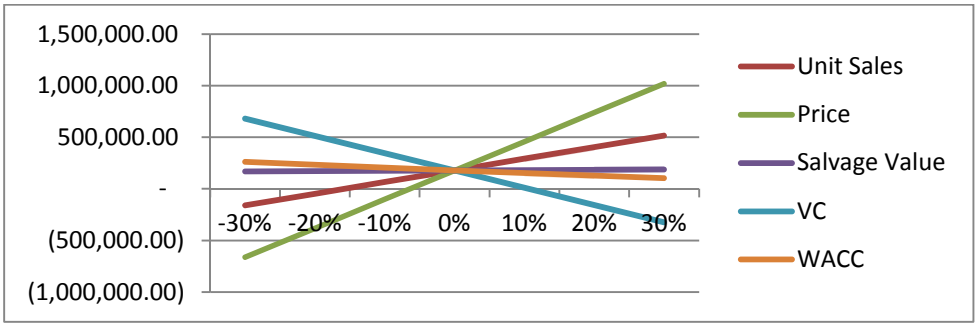
Sensitivity Analysis

By changing a single variable, sensitivity analysis shows the magnitude of the impact on the decision variable, in this case NPV. This method highlights the most volatile variables, gives break even information and indicates some idea of standalone risk. What it misses however is the relationship among the variables and the impact diversification has on it. Additionally there is nothing showing the likelihood of the change in a particular variable occurring. This is where the real weakness of the sensitivity analysis lies.

Additionally numbers generated can be used to evaluate a project given the current climate. If prices have been changing dramatically or the economy is volatile the company may want to invest in something that is less subject to a dramatic downturn of these factors and potentially cancel new projects altogether. However it swings both ways. If management believes the economic climate is improving the correlation between cost inflation and price inflation may make this an even more cost-effective project.

	NPV after Indicated Change				
Change	**Unit Sales**	**Price**	**Salvage Value**	**VC**	**WACC**
-30%	(160,687.52)	(662,067.80)	168,327.31	679,717.00	262,248.92
-20%	(47,679.44)	(381,932.96)	171,663.78	512,590.24	233,063.68
-10%	65,328.64	(101,798.12)	175,000.25	345,463.48	205,115.74
0%	178,336.72	178,336.72	178,336.72	178,336.72	178,336.71
10%	291,344.79	458,471.56	181,673.19	11,209.95	152,662.81
20%	404,352.87	738,606.40	185,009.66	(155,916.81)	128,034.43
30%	517,360.95	1,018,741.24	188,346.13	(323,043.57)	104,395.89

Heavenly Foods should further research the most reactive data to find the most accurate estimates possible because of the large impact a small change can have on the profitability of the project, in this case the unit sales, price and variable cost. If the unit sales or price are projected to be too high, the NPV will be inflated because of the positive correlation. On the other side too large variable cost may cause the project to be rejected when it is profitable. Because these three inputs have the most impact on the NPV they should and will be the focus of further analysis.



There is a possibility the company can use contracts with suppliers to stabilize variable costs so the likelihood of variable costs changing is low, making the high correlation less relevant. If these costs are expected to change, creating consistency should be looked into because of the relatively large effect that is does have on NPV.

Scenario Analysis

Focusing on standalone risk, scenario analysis uses several possible situations and models a range of possible outcomes. The likeliness of the situations is weighted in this analysis. However there is the assumption that inputs are perfectly correlated in the selective situations explored, which is likely a rash assumption. It is highly unlikely that the acceptance level will affect every part of the NPV inputs in the same way. But as in any analysis the accuracy of the result heavily depends on the accuracy of the inputs.

Heavenly Foods has identified three possible consumer acceptance levels for the new product: poor, average and excellent with a probability of 25%, 50% and 25% respectively. These three scenarios only change the amount of units sold each year to 450,000, 700,000 and 950,000 units respectively.

Scenario	**Prob.**	**NPV**	
Poor	0.25	(258628)	(64657)
Normal	0.5	178336.8	89168
Strong	0.25	596236	149059
		E(NPV)	173570.415
		E(Stdev)^2	91371776024
		E(Stdev)	302277.6472
		CV	***1.741527479***

This new project will likely change the company's debt structure. Based on the capital budgeting department, the company's projects usually have a coefficient of variation between 0.5 and 1. To adjust for abnormal riskiness 3 percentage points are added or subtracted from the cost of capital to projects who's CV is outside this range, making the new cost of capital 15%. The cash flows must be discounted at this higher cost of capital.

Higher Risk Adjusted NPV	$	116,094.77

Because scenario analysis incorporates risk, the NPV is much lower than the initial riskless assessment; however the NPV is still a very positive number and therefore introducing the lite alternative should be considered a profitable investment.

Like with sensitivity analysis, there are weaknesses to this analysis. It is risky for a company to base all their decisions on a couple of scenarios without incorporating a range of possibilities. It is not very accurate to assume that the projects acceptance level will result in one specific NPV. Additionally these scenarios only change the units sold. Any other potential reasons for lower revenues are ignored as are any effects a change in units sold has on other factors.

While these two more traditional analyses can be combined to make a more informed decision, there are still shortcomings that state-of-the-art simulation analysis can effectively overcome.

MONTE CARLO SIMULATION

Simulation analysis models risky input variables by specifying them with statistical probability distributions. Once accomplished, a large number of scenarios can be performed whose output is a distribution of the decision variable that affords not only a point estimate but probabilities of failure or success.

In this case Monte Carlo simulation provides a more complex relationship among the different factors that affect NPV by using 10,000 random draws chosen from selected statistical

distributions. This allows for risk to be incorporated in the estimated cash flows from a project by skewing distributions for a variety of unknown factors in an NPV analysis.

While it is a much more complete picture of a projects potential than the traditional sensitivity or scenario analysis, it is only as effective as the estimates of numbers and distributions and the awareness of the weaknesses. Assumptions must come from executives who have been in the company for a long time, know the industry and can make knowledgeable predictions based on their experience. Additionally, Monte Carlo simulation will not give an explicit accept/reject decision criterion, it simply produces probabilities based on the inputted distributions; there is always going to be unaccounted for and unforeseeable risk.

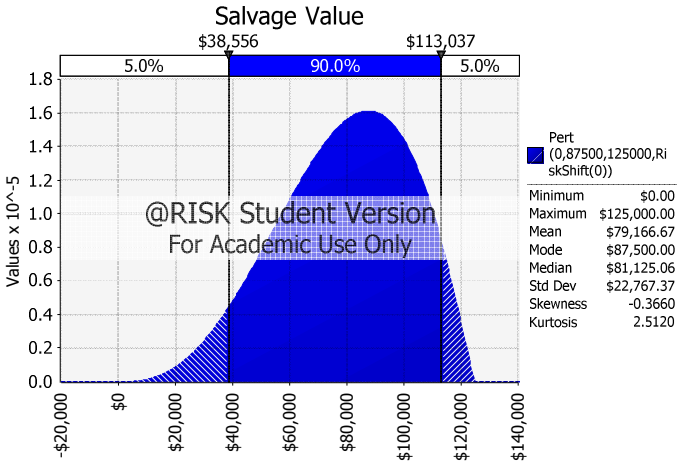
In this case, the driving factor in the success of the product is how well the product is accepted as measured through unit sales. The distributions for other variable inputs: salvage value, price inflation, cost inflation and the WACC, will be kept fixed while the median and the skewness for the unit sales changes according to the assumed acceptance. Additionally the correlations among the price inflation, cost inflation and unit sale will be fixed throughout. The three simulations will be centered on an average acceptance, a poor acceptance and an excellent acceptance level of unit sales while the four risky input distributions are kept fixed.

Fixed Input Distributions

In order to make the most accurate estimations for the factors that would be distributed consistently throughout the various acceptance levels, the least predictable and most influential variables were first simulated using normal, pessimistic and optimistic assumptions about the reception of the product. Using the outcomes, the final distributions selected to model the four inputs besides unit sales are a mixture of the average acceptance level and the poor acceptance level at a confidence interval of 90%.

Salvage Value

The salvage vale of the equipment needed for the lite product is one of the least predictable cash flow estimates. However the sensitivity analysis showed minimal impact that it has on the NPV; Monte Carlo simulation reinforced that assessment. Keeping all other factors constant, the salvage value only affects the NPV to the range of $144,974 and $ 192,635. These are estimates well above the project acceptance level. However the uncertainty of salvage value means much more when compiled with the other inputs.

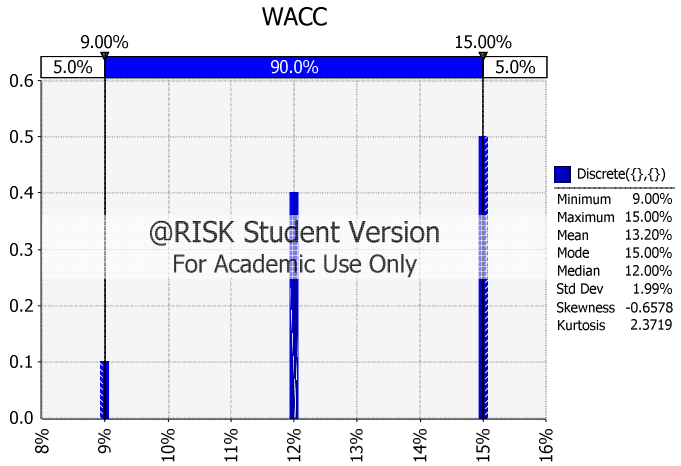


To best model these characteristics, salvage value was distributed with a negative skew using a special kind of beta distribution that fits to a defined minimum, maximum and maximum likelihood estimate or mode as "best guess": $0, $125,000 and $87,500 respectively. These estimates were specifically outlined by the company's management.

WACC

Historically, most of Heavenly Foods project have had a lower coefficients of variation then the scenario analysis predicted according to the director of capital budgeting. Projects that are estimated to lie outside this risk level are then associated with a different cost of capital than the current 12%. The WACC then either increases or decreases by 3% depending on which side of the coefficient of variation ranges the project is estimated.

Discounting the expected cash flows of a project at a higher cost of capital is one of the easiest ways to incorporate added risk although it eliminates the possibility that the project will not increase the WACC. A simulation analysis that discretely distributes the WACC at all three of these points allows for other probabilities than 100% at the highest WACC, 15%.

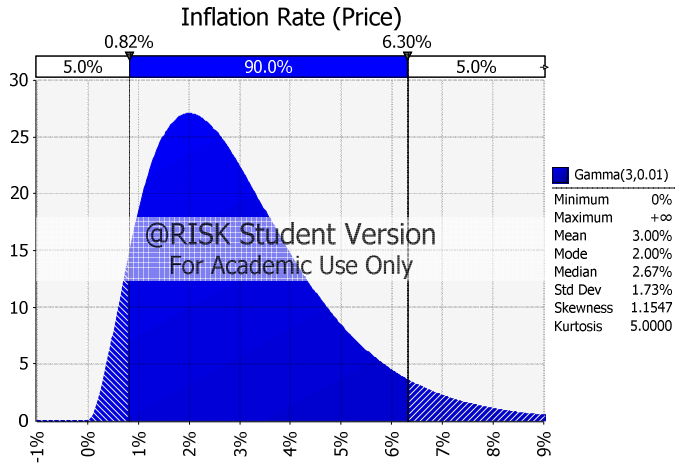


The distribution is heavily weighted to the right because of the scenario analysis' results and a conservative outlook on the prospects of a new project. This definitely biases the results towards rejection of the project. From the lowest to the highest WACC the probabilities are estimated at 10%, 40% and 50% respectively. Most of the randomly drawn numbers will be from the larger two WACC estimates which allows for a more realistic incorporation of the risk of this project. This distribution actually makes the project slightly less risky than a traditional scenario analysis because of the allocation of probability across all three possibilities, although there still is not much of a chance for a 9% WACC. However, the median of 12% as the robust point estimate of the WACC means that there is an implicit assumption that the project is high risk. This along with modeling of the input risky cash flows as a form of "certainty equivalency risk adjustment incorporates risk in two ways.

Price Inflation

Estimating price inflation as accurately as possible is important because of the effects it has not only on the input itself but on the cost inflation and ultimately on unit sales as well. Price inflation is substantially correlated with both these factors.

The United States Department of Agriculture (USDA) currently estimates the CPI for all beverages to increase only 2.5 to 3.5% in the next year, much less than the estimated 4% by the company. Additionally the nonalcoholic estimates are even lower and the average increase over the past 20 years has been less than 3%. Overestimating the neutral price inflation can drastically change the expected cost inflation as well as the unit sales in this analysis. It is important for the company's financial analysts to trust the estimates of the managers that know the industry and their own product best; however price inflation may be better estimated by a source with more statistics to incorporate, like the USDA.



To model the less optimistic government estimates along combined with a cautious outlook, the price inflation was distributed using a very positively skewed gamma distribution with the mode and median well below the mean. Although the static value was still set at 4%, the distribution

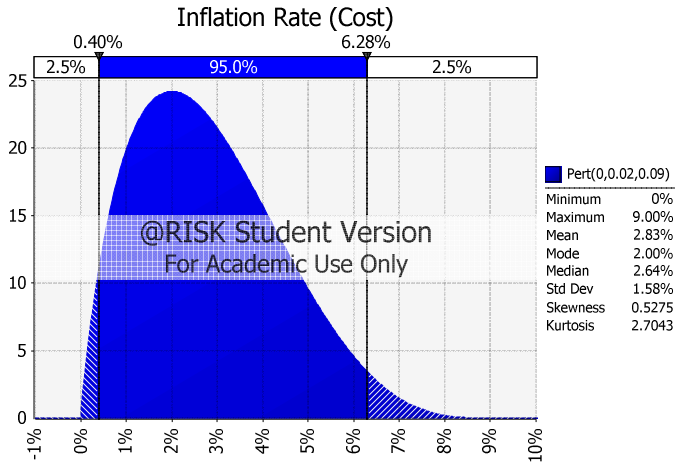
centered around the 2.67% median, an inflation rate closer to the industry wide inflation rate across the country, although still optimistic for nonalcoholic beverages.

Cost Inflation

Because Heavenly Foods does not have all of their costs tied up in long term contracts, there is some natural cost inflation to go along with the price inflation. Although at best the price inflation will serve as a buffer to the increased expenses of cost inflation that would take away from the benefits of higher prices in a way. This relationship has a significant impact on the success of the project, most directly by making changes of these two inputs modeled in the sensitivity analysis less severe.

Currently energy prices are increasing at a much faster rate than most commodity prices. Depending on the production systems used throughout Heavenly Foods, the 2% cost inflation estimated rate may not fully include the energy price spike not just in the analysis of this project but in the company as a whole.

This is probably the input that can be most controlled by the company based on futures and long term contract decision making. With more knowledge of the company's financial planning the distribution choice could be much more accurate. If the company currently has or is actively investing in long term and futures contracts from their suppliers, cost inflation could be modeled using a distribution with a much smaller standard deviation centered on a more accurate, though at a possibly higher rate.



Given what is currently known about the company, cost inflation was modeled using the same special beta distribution as the salvage value using 0% as the minimum, 2% as the most likely and 9% as the maximum. Although the distribution has a positive skew, because about 65% of the mass of the distribution above the most likely value it is still a pessimistic view of cost inflation. Using the assumption of some long term contracts standard deviation for the cost inflation is modeled as slightly less than that of price inflation but only by about .2%.

Correlations

Much like this project operates within a company as a whole, none of these inputs operates in a vacuum alone. Changes within the company or in the economy will impact all three variables, for better or for worse. This can be modeled through adding correlations in the simulation. Incorporating these relationships is an important factor in what makes simulation analysis so much more complete than traditional analysis, especially when compared to sensitivity analysis. Correlation among the inputs both increases and decreases the magnitude of a change of the project's ultimate NPV.

As mentioned before price and cost inflation are positively correlated since a change in price inflation for a producer will likely result in the same change in cost inflation for a supplier. This correlation coefficient is estimated to be .4 because a high correlation strips away much of the risk since the relationship serves as a buffer. If the cost correlation increases increasing expenditures in a company, the accompanying price increase in its products will then offset some of those extra costs. Without this correlation the impact of either one of these variables on NPV would be overestimated.

The laws of supply and demand require a negative correlation between price and sales, if the price increases the unit sales are going to decrease. This correlation reduces the risk if the price decreases however it also decreases the advantages to a price increase because the unit sales are not held constant like in the sensitivity analysis. The correlation is estimated to be the same extent as the previous one, only negative, a -.4. It is again kept low because simply the relationship itself eliminates risk and the analysis wants to maintain conservative assumptions about the success of the new lite beverage.

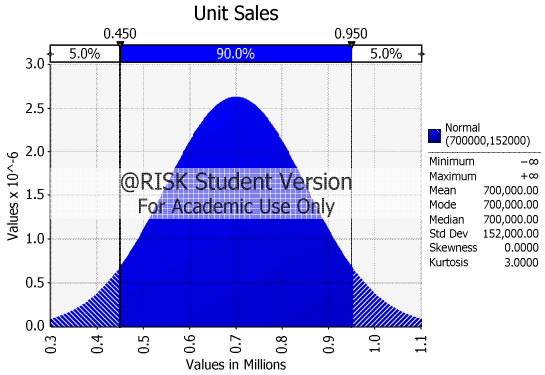
The first two correlations are simple to see, however the relationship between unit sales and cost is much more complicated because the driving factor is the macro economy, wholly outside the company. In a bad economy unit sales are likely to drop, leading to a decrease in cost inflation. If this is happening to Heavenly Foods it is very likely happening to their suppliers as a direct result of companies like this needing to produce less of their product. This results in a decrease in the cost inflation and a positive correlation. In this simulation the correlation is estimated to be only .3 because it is a product of factors well outside the company and therefore may have less of a direct impact on the prospects of this particular project.

@RISK Correlations	**Price Inflation Rate**	**Cost Inflation Rate**	**Unit Sales**
Price Inflation Rate	1		
Cost Inflation Rate	0.4	1	
Unit Sales	-0.4	0.3	1

Expected Acceptance

Unit Sales Distribution

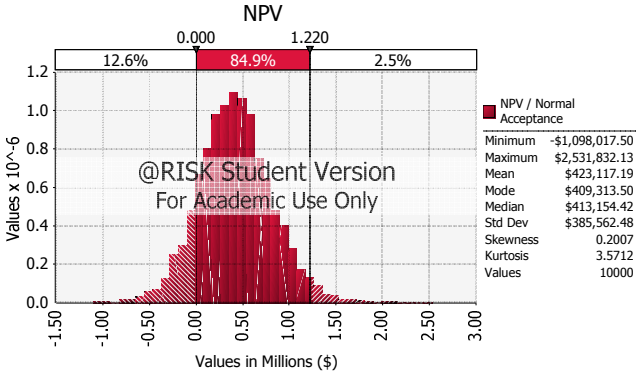
For a normal acceptance level the unit sales were modeled using a normal distribution that selected between the lowest level of acceptance, 450,000 units, and the greatest level of acceptance, 950,000 units, with a 90% confidence interval. This represented a situation where there was just as much of a chance that the unit sales would be to the left as to the right of the mean, median and mode amount, 700,000 units. There is equal risk in both directions but almost no possibility that the marketing department under or over estimated.



NPV

The results from the baseline unit sales assumptions show only a 12% chance of a negative NPV. While management will have to decide the amount of risk they are willing to take with this project, almost 85% of the probability mass is between 0 and $1,220,000 even after modeling the other four conditions in less than favorable circumstances.

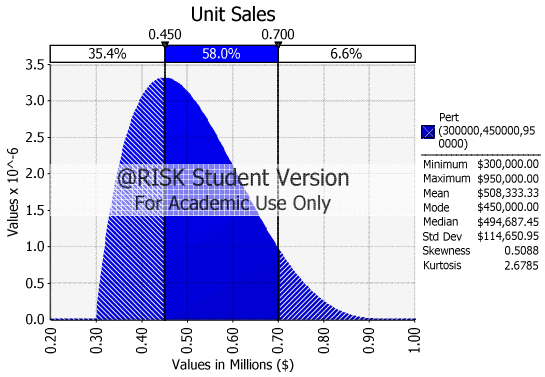
Although the unit sales parameter in this case is normally distributed for success and failure, the other risky parameters are skewed toward failure. The baseline case produced some very positive results especially when compounded with the other potential assets that are not numerically included like the potential for other lite products and first mover benefits.



Poor Acceptance

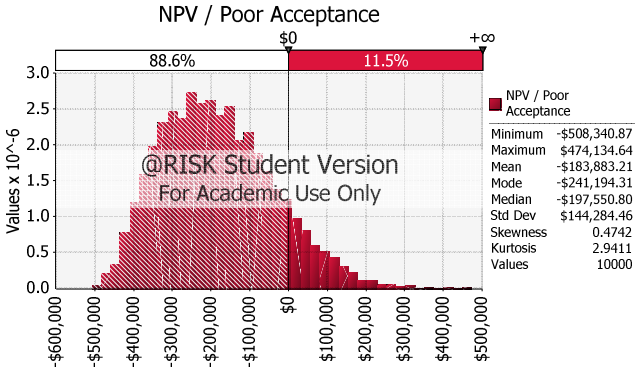
Unit Sales Distribution

The assumptions made about unit sales in the event of poor acceptance were extreme. In this situation a Pert distribution was used, with the most likely event being the lowest estimate of 450,000 units. However, while marketing used this amount as a floor in this case it was the mode with 35.4% of the mass of the distribution lying below this amount. In fact there was only a 6.6% chance that the unit sales could be above the normal acceptance amount, 700,000 units. A distribution this negative combined with already unfavorable circumstances lead to a dismal NPV.



NPV

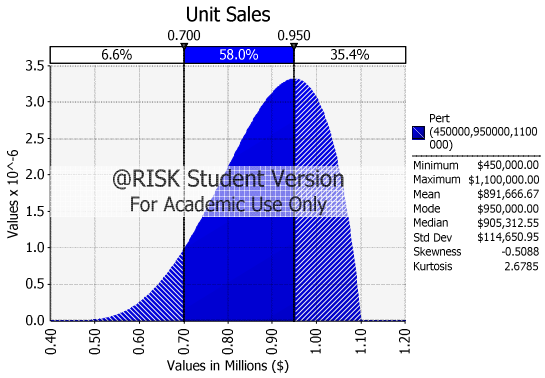
The NPV in the case of poor acceptance is abysmal. With only an 11.5% chance that it should be accepted at all this represents the worst case scenario in every aspect. In addition to the heavily skewed unit sales distribution, all four of the other inputs are modeled toward an unfavorable situation. While this situation would have to be a perfect storm of unfortunate situations, it is useful to look into because there is so much of the mass below the acceptance limit. The median is almost $200,000 below zero. While a situation this catastrophic is highly unlikely it's a useful tool when stress testing the project to see how it will hold up, especially when comparing it to almost as extreme favorable circumstances.



Excellent Acceptance

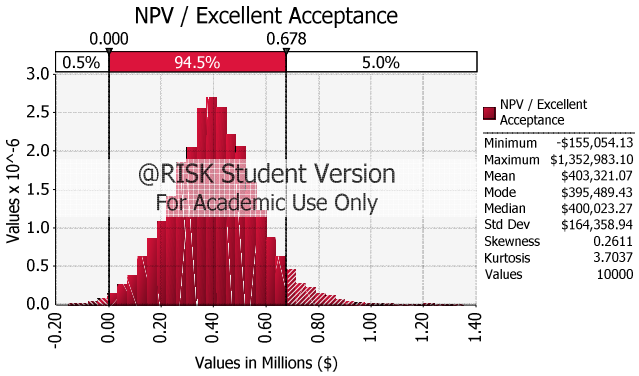
Unit Sales Distribution

Almost the exact mirror image of the poor acceptance distribution of unit sales, the excellent acceptance was modeled using the same Pert distribution and has about 35% of the probability mass to the right of the maximum outlined by the marketing department of 950,000 units, the most likely value.



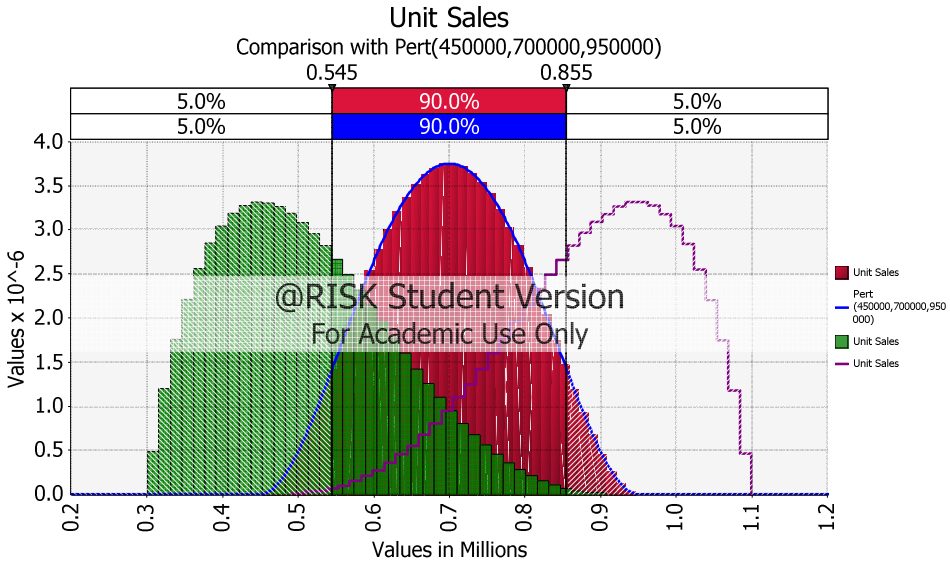
NPV

Even with the extremely favorable unit sales, the NPV had a very similar mean, median and mode to the normal assumptions. Because the other four distributions were are so unfavorable there seemed to be a limit on exactly how profitable this project could be regardless of the amount of units sold. However what the excellent NPV did have going for the project was the slim .5% chance that this project would be unacceptable. Additionally the standard deviation was about one third of the baseline or expected scenario. Higher unit sales seemed to center the probability mass on about $400,000, the same estimation as the normal acceptance. In the case of excellent acceptance the project is going to make money, however there seems to be a boundary of the profitability of the project.



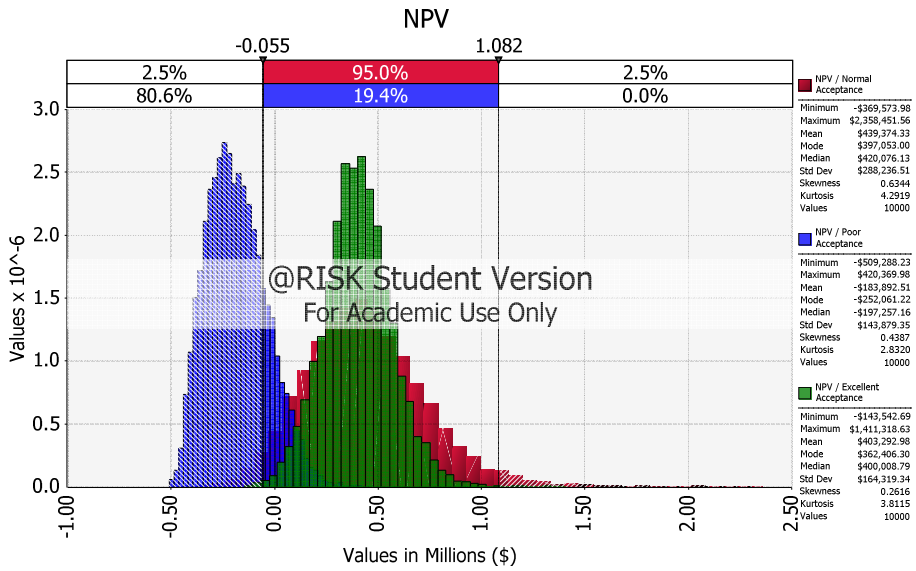
Summary

Because unit sales are the indicator of expected, poor or excellent acceptance, it was the distribution that varied across the three models. Each simulation used the marketing team's limits as a median creating a range of possibilities. The acceptance levels were distributed using mirror images of each other for the poor and excellent unit sales flipped on the expected acceptance level with each having about a 30% probability that the sales will exceed that of the highest or lowest estimations.



It is important to recognize the likelihood of each of these distributions. According to the research there is only a 25% chance that the sales will be 450,000 or 950,000 units and the distributions have these as the median will a good chance it will be above or below those limits. This represents the possibility that the unit sales are not accurately estimated. However, trusting the estimations would seriously decrease the relevancy of the extremely low and high unit sales.

The other 50% is represented by the expected acceptance which when combined with the other factors is not even the average that expected acceptance would be as shown in the distributed NPV outputs.



While the NPV graphs model these three scenarios the possibility of each makes this project likely to succeed. Straight forward there is a 75% chance that the project will result in an NPV of expected or excellent acceptance. The 80.6% probability that if the acceptance is poor the NPV will be negative is unnerving; this is represented by every bad thing happening all at once. All the input variables are skewed to pulling the ultimate NPV distribution down. The chance that this will fail has been inflated by pessimistic assumptions across the board.

With this in mind it is a project that while not as obviously and exceptionally profitable as in the traditional analysis, should still be accepted.

References

"Heavenly Foods - Case 60." *Capital Budgeting Methods, Cash Flow Estimation and Risk Analysis* (1997). *Cengage Learning*. South-Western.