PINCOCK Perspectives

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The Future Ain't What It Used To Be
Treatment of Uncertainty in Economic Analysis

Section 1: Variability in Economic Parameters

"The future ain't what it used to be." This quote, attributed to the noted mineral economist Yogi Berra, certainly describes the markets for natural resources over the last few years: Gold at $725 per ounce;[1] copper at $3.70 per pound;[2] oil at over $72.00 per barrel;[3] Powder River Basin coal at $22.00 per ton. These are but examples of the dramatic increases in the prices of a wide range of commodities. To further complicate matters, not only have prices risen dramatically, but price volatility has increased as well. Figure 1 (page 3) shows the price of 8800 BTU/lb. Powder River Basin (PRB) coal since the beginning of 2004. Pincock Allen & Holt (PAH) estimates that the historical price volatility over this period has been approximately 35%, a roughly 700% increase over the volatility that these prices showed during the 1990s. The prices of other commodities have shown similar patterns.

Prices are not the only economic variables that have shown such uncertainty. Figure 2 (page 3) shows indicative operating costs at a PRB surface mine.[4] As can be seen, operating costs are also variable and have increased approximately 50% from the first quarter of 2004 to the first quarter of 2006, driven in large part by increases in fuel, explosive, and labor costs. PAH believes that most mining operations, whether in coal or other minerals, have experienced similar operating cost increases.

Lastly, prices and operating costs are not the only parameters that show uncertainty. Capital costs and production volume are also quite variable, particularly over the long time horizons associated with many natural resource and energy investments.

Section 2: Treatment of Economic Parameters in Traditional Discounted Cash Flow Analysis

As opposed to the uncertainty in economic parameters discussed above, traditional discounted cash flow (DCF) economic analyses generally treat such parameters as "deterministic," i.e., the DCF analysis assumes that these variables have fixed values that are realized in all instances. The simple example shown in Table 1 (page 2), based loosely on the coal prices and costs discussed above, emphasizes this important issue.

This simple example analyzes a capital project that requires an initial investment of $250 MM (Row 18) and sustaining capital totaling $120 MM (Row 19). These investments are depreciated over the remaining project life, assumed initially to be five years. (Depreciation amounts are shown in Row 12). As a result of these investments, production increases are shown in Row 5. Based on the prices shown in Row 6, revenue increases are calculated in Row 7. This price, $13.50 per ton, represents the latest price presented in Figure 1. Cash operating costs associated with the incremental production are given in Row 9 (on a

[1] Source: http://www.onlygold.com/TutorialPages/SearchPricesFS.asp
[2] Source: New York Mercantile Exchange http://www.nymex.com/cop_fut_cso.aspx
[3] Source: New York Mercantile exchange. http://www.nymex.com/lsco_fut_condet.aspx
[4] These costs are PAH estimates based on review of actual production costs for a number of PRB operations.

CALENDAR

- **National Coal Show 2006**
  June 13–15, 2006
  David L. Lawrence Convention Center
  Pittsburg, Pennsylvania
  e-mail: share@mining-media.com

- **Diggers & Dealers Mining Forum 2006**
  August 7–9, 2006
  Goldfields Arts Centre
  Kalgoorlie, Australia
  e-mail: admin@diggersndealers.com.au

- **Argentina Mining 2006**
  August 29–31, 2006
  Emilio Civit Convention Center
  Mendoza, Argentina
  e-mail: info@argentinamining.com

- **Oil Sands Trade Show & Conference 2006**
  September 12 –13, 2006
  C.A. Centre
  Fort McMurry, Alberta, Canada
  e-mail: stevehenrich@ca.dmgworldmedia.com

- **29th Platts Coal Marketing Days**
  September 14–15, 2006
  Marriott City Center
  Pittsburg, Pennsylvania
  e-mail: james_gillies@platts.com

- **Runge North American Professional Development Courses**

  Dragline Mining Systems
  Denver: Sept. 27–28
  Mining Economics
  Denver: Sept. 21–22 Calgary: Sept. 25–26
  Mining for Non Miners
  Calgary: Sept. 15 Denver: Sept 29
  Truck & Loader
  Calgary: Sept. 18–20 Denver: Oct. 2–4

For additional information or to register, please contact Marcie Schmidt at 403-217-4981 or mschmidt@runge.com.au per ton basis) and Row 10 (on a total dollar basis). These costs are deducted from revenue, as are taxes at an assumed tax rate of 40%, to arrive at after tax income (Row 16). Capital requirements are subtracted from after tax income and non-cash expenses are added back to arrive at annual net cash flow (Row 22). These amounts are then discounted (in this example at 10%) and summed to arrive at a project NPV of $122.4 MM. Project IRR is 32%.

This familiar DCF methodology contains numerous deterministic assumptions, including those related to production volume, price, cash costs, and capital costs. Regardless of the care with which these variables were specified, everyone involved in the analysis and subsequent decision making knows that the specific values the analysis incorporates will not, in fact, be realized. More colloquially, this emperor has no clothes! We know the assumed values will not be realized, but we simply ignore this inconvenient fact. And yet, the project is extremely sensitive to these assumptions. As shown in Figure 3 (page 4), the project NPV can range from a negative $330 MM to a positive $500 MM depending on the price assumption. The lower of these values was calculated using the minimum price during the period covered in Figure 1, while the latter value was calculated using the maximum price during the same period. Using the average price over the period, $8.51 per ton, rather than the latest price during the period of $13.50 per ton, results in an NPV of negative $187 MM rather than the positive NPV of $122 MM as determined in Table 1. Which price to use? A reasonable argument can be made for the most recent price, the minimum price, or the average price, while a less convincing case, but one that frequently used in actual practice, can be made for the maximum. The same dilemma applies to all the deterministic variables incorporated into the traditional DCF analysis.

Section 3 – Quantifying Uncertainty

As noted above, all managers and analysts recognize that considerable uncertainty is associated with the variables used in economic analysis. This recognition results, in large part, from their observations of the varying values of these variables over time, as illustrated in Figure 1 and Figure 2. This Section 3 describes how various statistical measures can be used to quantify this uncertainty. Uncertain variables, i.e., those that can assume a range of values, are known as "stochastic" variables.

The data shown in Figure 1 and Figure 2 can be represented in an alternative fashion that provides additional insight into their behavior. Figure 4 (page 4) presents the distribution of prices that were shown in a time series in Figure 1. As can be seen, the mean, or average price, is $8.51 per ton, but most price points lie to the left of the mean. The mean value is increased by a small number of higher price points on the long right hand tail of the distribution. By definition, there is a fifty percent chance that the price will be less than the mean and a similar 50% chance that it will be greater. Also shown in Figure 4 are the 10% and 90% confidence intervals. For the period analyzed, there was only a 10% chance that the price will be less than $5.90 per ton or greater than $15.47 per ton. Finally, Figure 4 shows that there is only a 17% probability that the price will be $13.50 per ton or greater based on historical patterns. As noted above, this was the most recent price and the price used in the Table 1 DCF analysis.

Similar observations can be made regarding production, operating costs, and capital costs. Figure 5 (page 4) is a distribution of production volume, in this case for Year 2 of the example. Based on its internal research, as well as the operating experience of many in the mining and energy industries, PAH believes that the production values assumed in traditional DCF analysis are most often the "mode" values, that is the most likely single value, rather than the mean, or average, value. Because mining projects often have a larger chance of falling well short of projected production than exceeding projections by a similar amount, the mode is generally higher than the mean. The so-called "triangular" distribution shown in Figure 5 is one way of representing this common experience.

Figure 6 and Figure 7 (page 4) show distributions for capital and operating costs, respectively. Figure 6 is a sharp triangular distribution, recognizing the common experience that capital costs are rarely, if ever, less than anticipated. This general statement is true not only for initial capital costs as shown in Figure 6, but also for sustaining capital costs.

TABLE 1
Discounted Cash Flow Analysis, Deterministic Inputs

	A	B	C	D	E	F	G
1			Year 1	Year 2	Year 3	Year 4	Year 5
2	Discount Rate	10%					
3	Discount Factor (Mid Year)		0.9512	0.8607	0.7788	0.7047	0.6376
4							
5	Production Volume (MM Tons)		10	20	30	40	40
6	Price ($/ton)		$13.50	$13.50	$13.50	$13.50	$13.50
7	Revenue ($MM)		$135	$270	$405	$540	$540
8							
9	Cash Operating Costs ($/ton)		$8.00	$8.00	$8.00	$8.00	$8.00
10	Cash Operating Costs ($MM)		$80.0	$160.0	$240.0	$320.0	$320.0
11							
12	Depreciation and other non-cash costs ($MM)		$50.0	$60.0	$80.0	$90.0	$90.0
13							
14	Pre-tax Operating Margin ($MM)		$5.0	$50.0	$85.0	$130.0	$130.0
15	Tax Rate	40%					
16	After Tax Income		$3.0	$30.0	$51.0	$78.0	$78.0
17							
18	Initial Capital ($MM)		$250				
19	Sustaining Capital ($MM)			$40	$60	$20	$0
20							
21	Add Back Depreciation		$50.0	$60.0	$80.0	$90.0	$90.0
22							
23	Net Cash Flow		-$197.0	$50.0	$71.0	$148.0	$168.0
24	Discounted Cash flow		-$187.4	$43.0	$55.3	$104.3	$107.1
25	Project Net Discounted Cash Flow		$122.4				
26	Project IRR		32%				

Figure 7 is also triangular, but less sharp, recognizing that operating costs more often fall below the mode value due to improvements in productivity or other factors.

An important characteristic of the triangular distributions shown in Figures 5 through 7 is that the mode value, which as discussed above is often the value incorporated into traditional DCF analysis, is often more optimistic that the mean values derived from more rigorous statistical analysis. Mean production tends to be lower than mode production, while mean capital and operating costs tend to higher than the modes of those distributions. The impact of these deviations is negative. Actual project NPV tends to be lower as a result.

The astute reader will also note that these variables are not unrelated. For example, operating costs are much more likely to be higher if production volume is lower. To a lesser extent, prices may be higher if costs are higher. These relationships, known as correlations, are also ignored in traditional DCF analysis.

Section 4 – Incorporating Uncertainty in Economic Analysis through Simulation Analysis

Uncertain economic parameters like those discussed in Section 3 can be incorporated into economic analysis through the use of so-called "simulation analysis." Using specialized software,[5] the statistical description of each stochastic variable and the correlations[6] between them can be input into the DCF model.

The model is then run numerous times. In each run, it selects a value for each stochastic variable based on the appropriate distribution and correlations. It then calculates the value of the ultimate dependent variable, which in our example is the Project NPV. Crystal Ball then "remembers" this result and re-runs the model. This process is repeated hundreds or thousands of times. The end result is a distribution of the dependent variable(s). Figure 8 (page 4) shows the result for this example project using the distributions described above for price, operating costs, initial capital costs, and production volume. In addition, sustaining capital costs were assumed to be stochastic with distributions similar to initial capital costs. A high degree of correlation between costs and production volume and a lesser degree of correlation between costs and price were also incorporated.

As can be seen in Figure 8, the results of the economic analysis using simulation analysis are dramatically different than the results of the traditional DCF model. Compared to a Project NPV of plus $122 MM obtained with the traditional methodology, the simulation analysis shows mean Project NPV of negative $259 MM.

Section 5 – Conclusions

Prices, costs, production volumes, and other important inputs into economic analyses are highly variable. Rather than assuming single, fixed values for these inputs, simulation analysis permits managers and analysts to incorporate quantitative descriptions of uncertainty. The results of simulation analysis allow greater insight into the impact uncertainties play in project returns. Stated somewhat differently, simulation analysis provides a much better picture of project risk than traditional DCF analysis.

The input values used in the example above, while based on not unrealistic assumptions, were skewed in order to illustrate the dramatic effects of variances. The example was also deliberately simplified for brevity. More realistic simulation models incorporate a large variety of variables and thorough analysis of their distributions. In addition to economic analysis, simulation models are often used to analyze inventory and scheduling problems. PAH routinely develops such models. Please contact Casey Kaptur with comments, questions, or to discuss whether simulation analysis can help with your business problems.

This month's article was provided by Casey J. Kaptur, Senior Analyst - Coal and Energy casey.kaptur@pincock.com.

[5] PAH uses a software package known as "Crystal Ball"® manufactured by Decisioneering, Inc. to perform simulations.
[6] Crystal Ball permits the use of actual historical data to describe distributions. In the absence of historical data, a number of typical distributions can be used. Statistical tests to determine whether correlations are statistically significant are also available.

FIGURE 1
8800 BTU/lb. Powder River Basin Coal Prices
January 2004 – Present

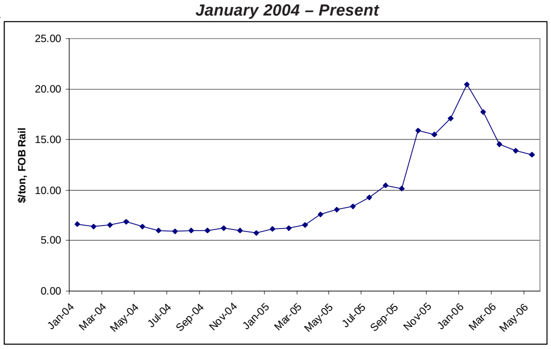


FIGURE 2
Indicative Operating Costs for Large PRB Surface Mine

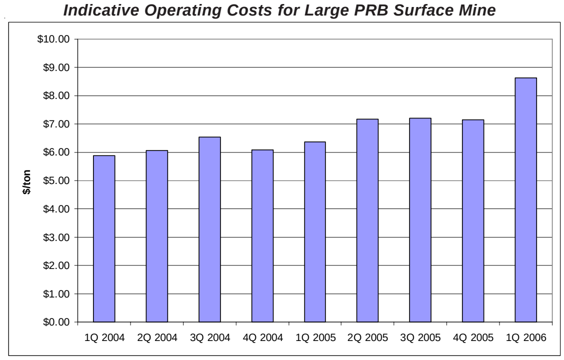


FIGURE 3
Project NPV versus Price

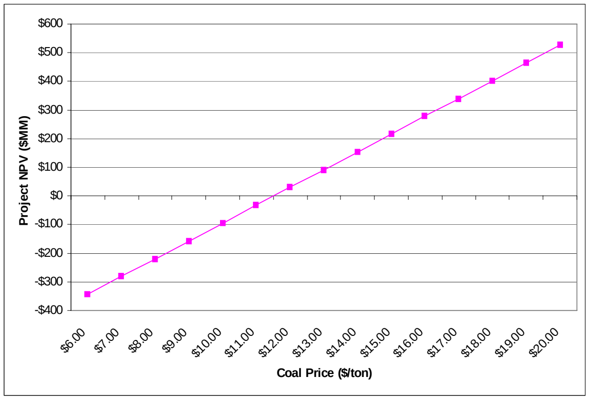


FIGURE 4
8800 BTU/lb. Powder River Basin Coal Prices
January 2004 – Present

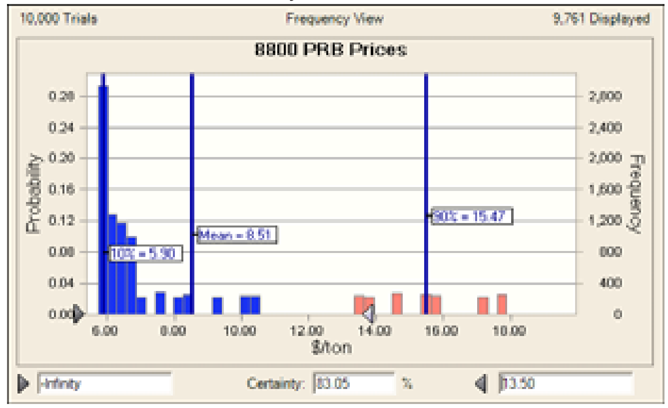


FIGURE 5
Distribution of Year 2 Production

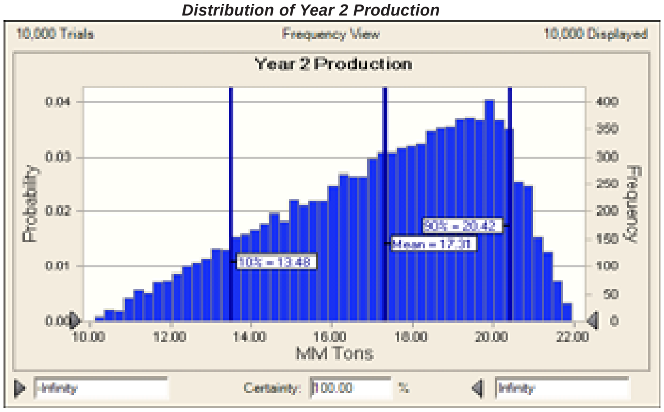


FIGURE 6
Distribution of Initial Capital Costs

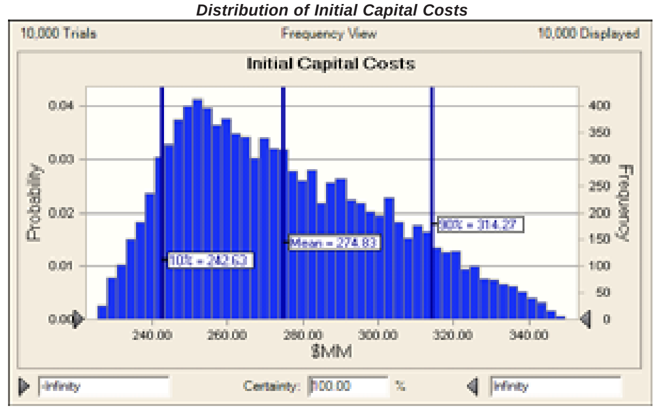


FIGURE 7
Distribution of Operating Costs

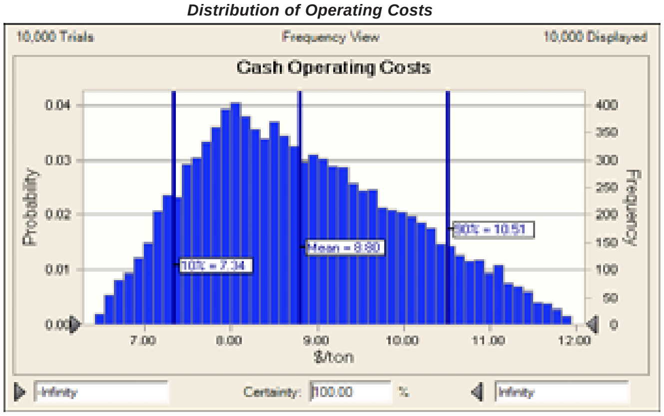
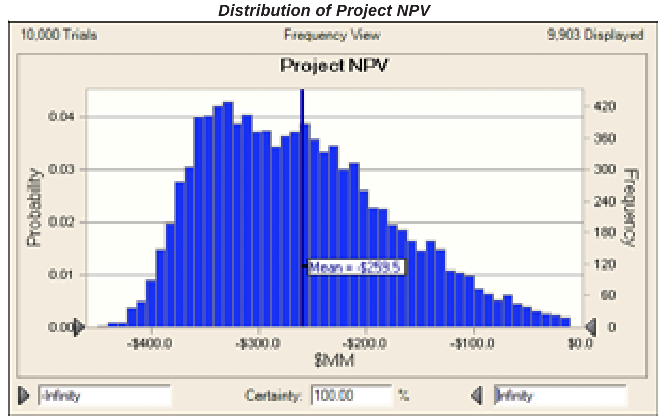


FIGURE 8
Distribution of Project NPV



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