Volatility and Cost Estimating

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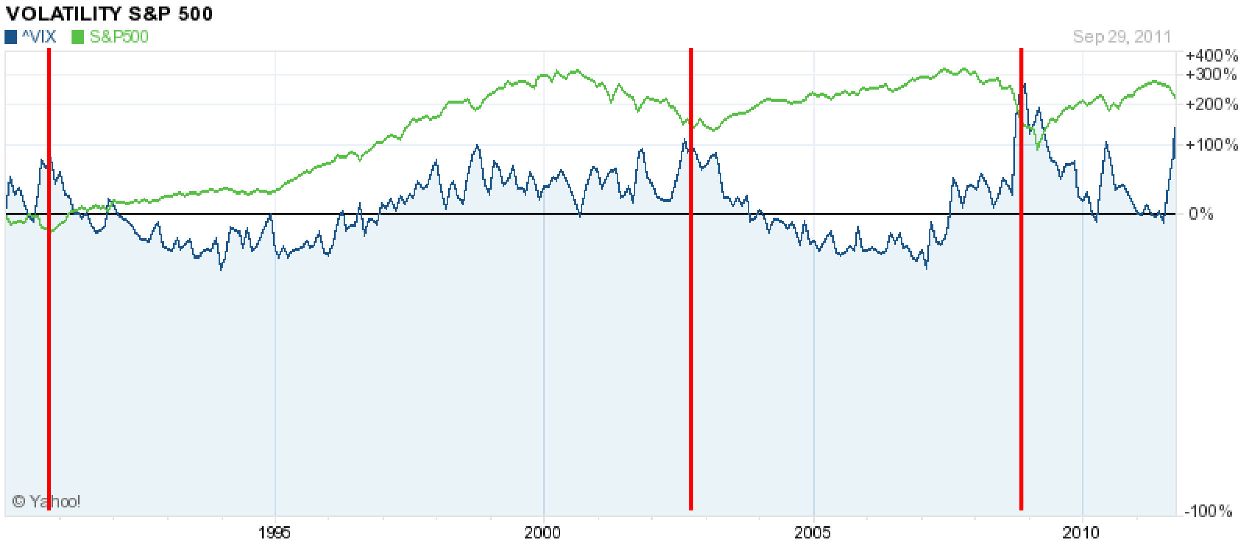
Outline

- Introduction
- Implied and Stochastic Volatility
- Historic Realized Volatility
- Applications to Cost Estimating
- Conclusion

INTRODUCTION

- Volatility can impact the final price of a program
  - Programs are very reliant on commodities
    - During times of economic uncertainty, more volatility can be observed in the market, as shown on the graph below



- Reliance on commodity prices places a higher level of ambiguity on a program's final price
  - This presentation will focus on fluctuation in commodity prices and their impact on program costs

Implied and Stochastic Volatility

- Definitions
  - Volatility: statistical measure of dispersion of returns for a given security or market index
  - Implied Volatility: Used as part of option pricing theory this is a forward-looking estimate based on market consensus at a single point in time
  - Stochastic Volatility: A forward-looking estimate primarily identified by two key principles:
    - Second source of risk affecting the level of instantaneous volatility
    - Application of continuous time

Implied and Stochastic Volatility

- Implied Volatility Equation:

$$dS_t = \mu S_t dt + \sigma S_t dW_t$$

  - Where:
    - S_t is the Security Price at time t
    - μ is the constant drift (expected return) of S_t
    - σ is the constant volatility
    - dW_t is the standard Wiener process with zero mean and a unit rate of variance

- Stochastic Volatility Equation (Heston Model):

$$dv_t = \theta(\omega - v_t)dt + \varepsilon\sqrt{v_t}dB_t$$

  - Where:
    - v_t is a function of volatility at time t
    - ω is mean long term volatility
    - Θ is the rate at which volatility reverts to its long term mean
    - ε is the randomness associated with the underlying asset
    - dB_t and dW_t are Gaussian equations with zero mean and unit standard deviation (correlated to each other with correlation ρ)

Implied and Stochastic Volatility

- Problems
  - Implied volatility:
    - Captures only a single moment in time and does not account for exogenous market shocks
  - Stochastic Volatility:
    - Many stochastic volatility models to choose from- which one is the right one for your estimate?

- Limitations
  - Already highly complex models in use for cost estimates
    - Implied and Stochastic volatility could be too cumbersome to apply to already complex cost models/estimates

Historic Realized Volatility

- Alternative to implied and stochastic volatility is historic realized volatility
  - Definition: volatility that has been manifested in the past for an asset or market index

- The following equations are used to calculate historic realized volatility:

$$v_t = 100 * \sqrt{\frac{252}{n} \sum_{t=1}^{n} R_t^2}$$

$$R_t = LN \frac{P_t}{P_{t-1}}$$

  - Where:
    - v_t is the historic realized volatility
    - n is the total number of trading days in the interval
    - 252 represents the total number of trading days in a year
    - R_t is the continuously compounded daily return
    - P_t is the underlying asset's price at time t
    - P_{t-1} is the underlying asset's price for the interval immediately preceding time t

Historic Realized Volatility (Cont)

- Benefits
  - Easy to calculate
  - Plethora of data readily available for a wide range of commodities
  - Intraday trading data allows results to come closer to capturing continuous time
  - Traceable and verifiable method

- Problems
  - Backward looking rather than forward looking.
    - Since volatility follows a random walk, is this really the best way to insert volatility into the estimate?

Historic Realized Volatility Example

- The following table shows the values for historic volatility for the ten year period of 1994-2004 for both the S&500 and NASDAQ Indexes:

Interval	S&P 500	NASDAQ
Daily	1.1%	1.8%
Weekly	2.4%	3.8%
Monthly	4.5%	8.3%

- From the table it can observed that:
  - The larger the interval, the more volatility is present
    - However, the increase in volatility is not proportional to the increase in the interval
  - More volatility for an "unbalanced portfolio"

Applications to Cost Estimating

- Steps to Apply Historic Realized Volatility into a cost estimate:
  - **Step 1:** Identify appropriate commodity for that estimate
  - **Step 2:** Break out program/estimate's life cycle into varying periods
  - **Step 3:** Collect daily data for the commodity and calculate historic volatility for all intervals/periods
  - **Step 4:** Build uncertainty ranges around point estimate inputs
  - **Step 5:** Run distributions to get a confidence level for each period identified

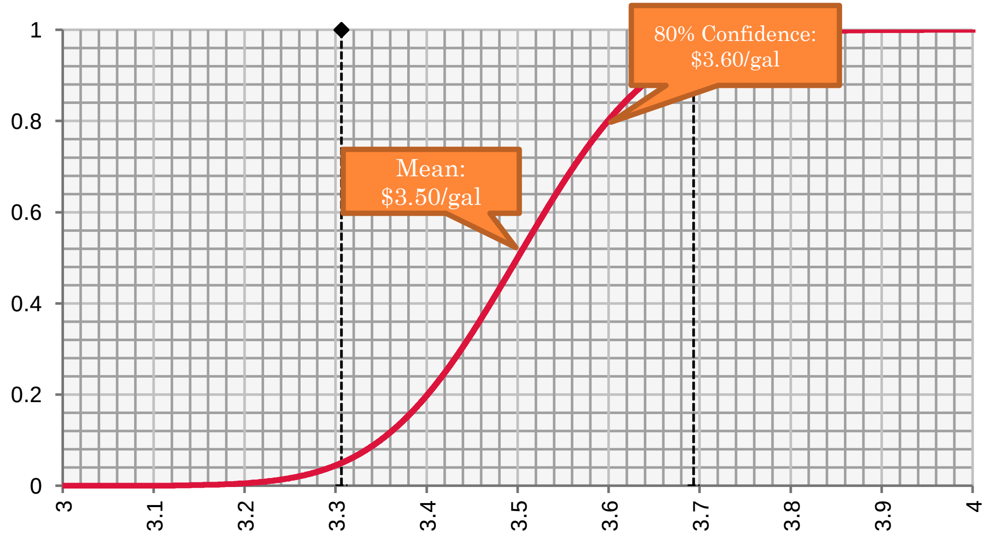
- Example: Ground Vehicle O&M Estimate
  - **Step 1**: Identify Commodity
    - Fuel; example uses the SPDR Energy Fund (XLE)
  - Assume that the vehicle has a 15 year operating life

Applications to Cost Estimating (Cont)

- The following table shows the results for Steps 2-4 of the process:

	Year 1	Year 2	Years 3-5	Years 5-10	Years 10-15
Point Estimate Fuel Cost ($/gal)	$3.50	$3.50	$3.50	$3.50	$3.50
Historic Volatility (%)	2.38%	3.25%	7.34%	8.78%	9.56%
High Value ($/gal)	$3.58	$3.61	$3.76	$3.81	$3.83
Low Value ($/gal)	$3.42	$3.39	$3.24	$3.19	$3.17

- **Step 5:** Run distributions to get a confidence level for each period identified
  - The following is an example of an S-Curve run for the Year 1 input (using a normal distribution)



Conclusion

- Not accounting for market volatility in estimates where commodities are heavily used can lead to cost overruns
- May not be practical to implement implied or stochastic volatility into estimates
- Proposed method of implementing volatility into estimates:
  - Use commodity indexes and historic volatility to create uncertainty ranges around estimate's inputs

Back-Up

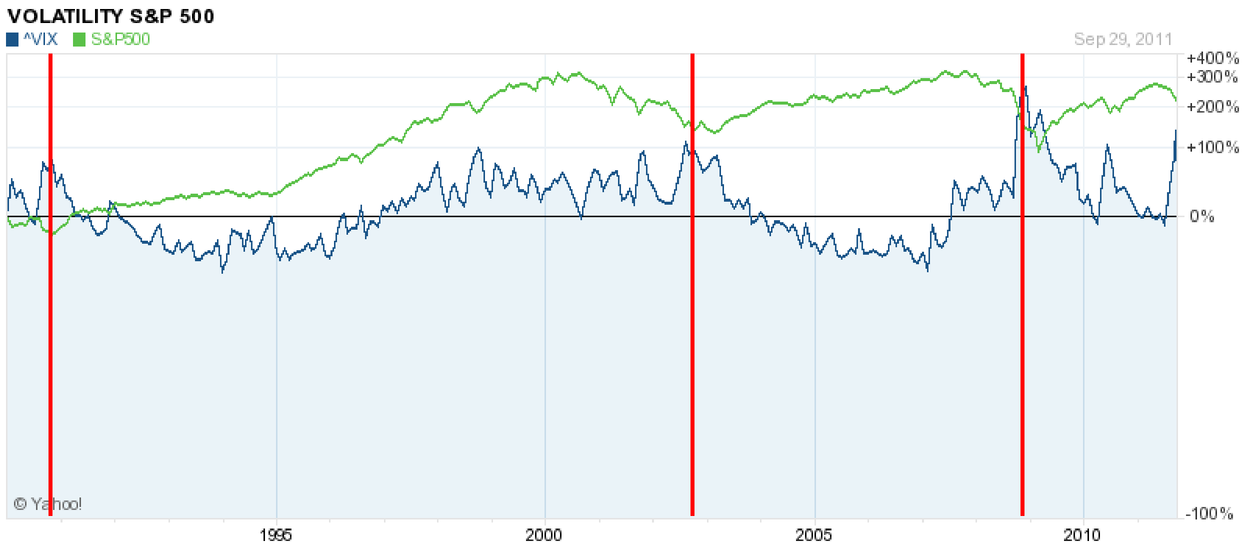
Intro: Volatility during Economic Uncertainty

Unbalanced Portfolio Volatility

S-Curve Years 10-15

Bibliography

Volatility During Periods of Economic Uncertainty



- Graph represents the S&P500 (green) and VIX (blue)
  - S&P500 is an index that is used to gauge the health of the overall economy
  - VIX is a measure of volatility of the S&P500
- Red Lines represent periods of economic uncertainty/decline:
  - Far Left: Recession that began in the early 1990s
  - Middle: Technology bubble that burst in ~2001
  - Far Right: Recession beginning in 2007/2008

BACK

Unbalanced Portfolio Volatility

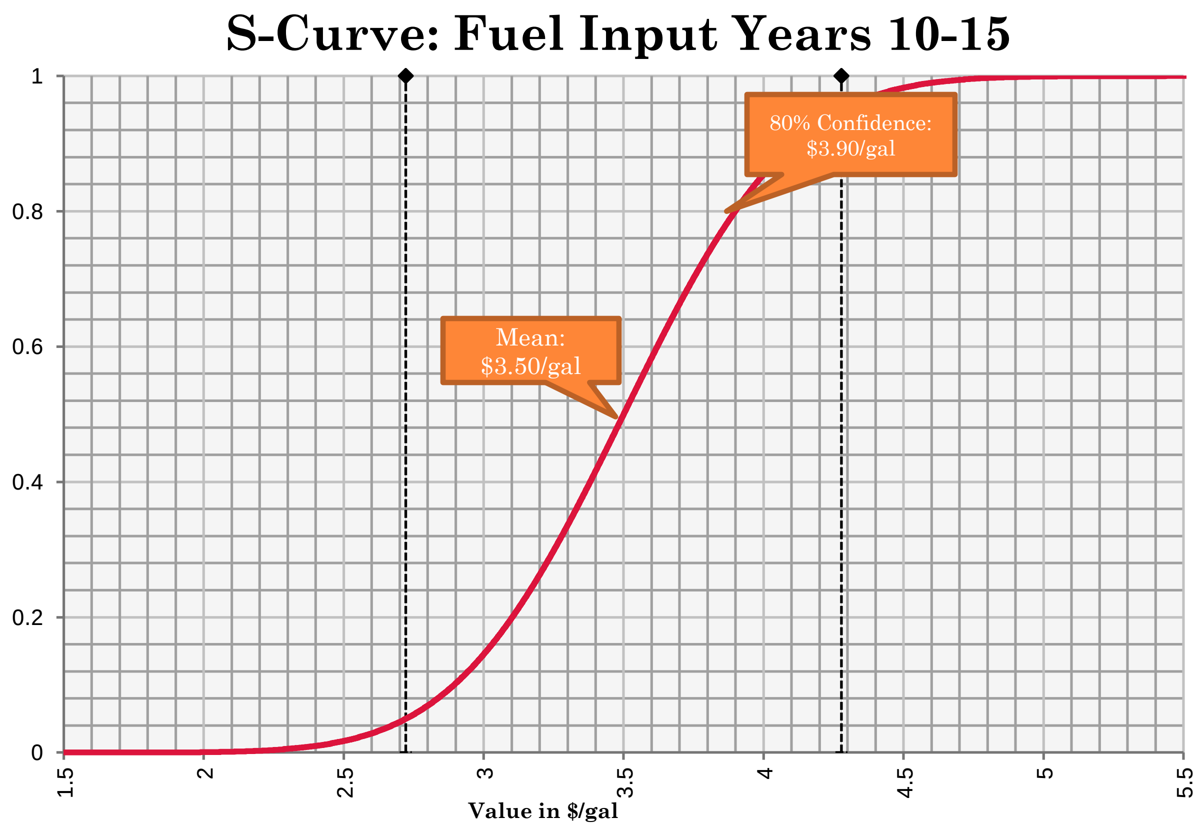
- The following table shows the results of calculating the historic realized volatility for three SPDR accounts with varying intervals:

Interval	Energy SPDR	Materials SPDR	Technology SPDR
Daily	9.6%	8.7%	9.5%
Weekly	51.2%	46.5%	51.3%
Monthly	218.0%	204.6%	225.4%

- The amount of volatility is relatively consistent across each sector (for each interval examined).
  - However, volatility is significantly higher for each industry sector than for the market's measure of volatility (the S&P500 Index; VIX)

BACK

S-CURVE: YEARS 10-15



- Comparing this S-Curve to the S-curve for Year 1, it is apparent that using this method applies more risk to the out years of the estimate

BACK

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