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Because the stakes are large when valuation model issues end up in court, valuation professionals should pay close attention to model risk.



MODEL

A close-up photograph of a hand holding a red apple. The hand is positioned on the left side of the frame, with fingers wrapped around the apple. The apple is bright red with some yellow highlights. A long, dark shadow of the hand and apple is cast across the light-colored, textured surface to the right. The overall lighting is soft, creating a dramatic effect with the shadow.

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RISK AND VALUATION



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odels are used in business all the time and for a variety of reasons. Without models, it would be hard to forecast earnings, simulate cash flows, measure risk, assess competitors, analyze economic conditions, evaluate management effectiveness, determine value of an ownership stake or an entire company, price an individual security, determine optimal capital structure, and so on. Models clearly play a big role in everyday commerce, but perhaps never more so than now. There are many reasons for this, not the least of which is a clamor for added financial transparency. People are tired of seeing the markets gyrate in

response to one headline after another about fraud, corporate excess, and hidden risks. Shareholders, lenders, regulators, and policy-makers want change now and are no longer willing to accept, without scrutiny, sweet-sounding reassurances from senior management.

As shown in Exhibit 1, the mandate for better numbers comes from several places. Major exchanges support improved corporate governance and they recently asked that listed companies get shareholder approval before management can implement or change stock option plans. Laudable and long overdue, this plan calls for informed shareholders, owners who understand

what an option represents, alternative valuation models, and the dynamic relationship between plan characteristics and the bottom line. The exchanges are not alone. Business valuers must similarly understand how an option plan affects a company's worth and be able to clearly and concisely explain this to interested parties. On a broader front, accountants are revisiting existing standards, many of which involve valuation models. Auditors and financial statement users alike must comprehend how model choice affects the quality of published information.

The Congressional response includes the Sarbanes-Oxley Act of 2002, ordering

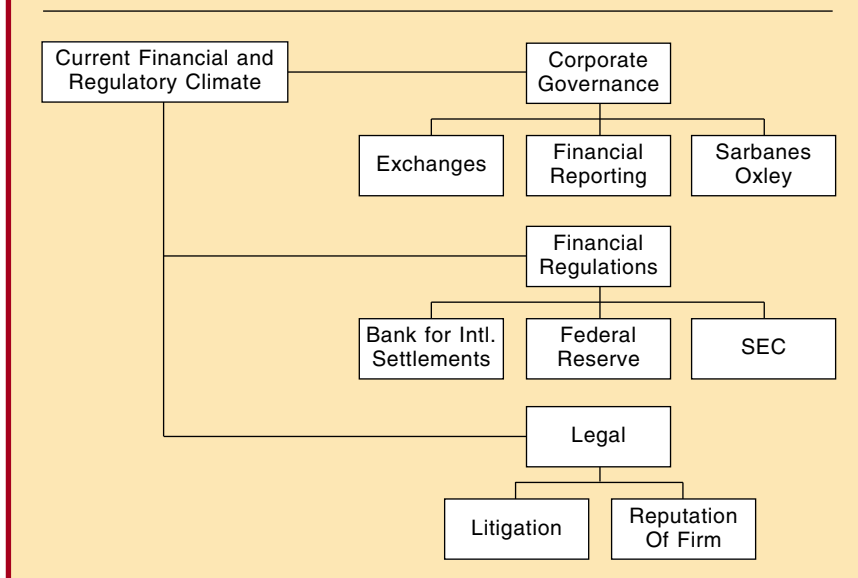
executives to certify that reported numbers “fairly present in all material respects the financial condition and results of operations of the issuer...”¹ The prospect of stiff penalties for falsification should encourage a greater focus on the models used to derive published financial data. Regulators like the SEC are also advocates of enhanced disclosure. Witness its recent proposal to have companies provide additional information about off-balance sheet items and various contingencies, including derivatives, “to the extent that the fair value thereof is not fully reflected as a liability or asset in the financial statements.”² Combined with FAS 133, Accounting for Derivative Instruments and Hedging Activities, modeling experts are in demand because valuation models are a critical part of determining what, how much, and when valuation changes hit earnings.

Banks have known for some time that modeling is a big deal, as they gear up for changes in capital adequacy standards that are directly tied to valuation. Model choice, good or bad, will determine the size of pledged reserves for loans and traded assets. Corporations and individuals who borrow from banks could feel the pinch in the form of higher fees if banks get it wrong.³ Expert witnesses encounter model risk in the courtroom as unhappy shareholders and lenders, beset with losses, cry foul, alleging improper valuation in the form of inflated purchase prices. For securities that seldom trade or are part of an investment pool about which is little known, calculation methodology takes on an altogether different meaning with respect to assessment of damages.⁴ Bad or inappropriately used models affect legal outcomes in yet another way if they fail to meet the standards set out in *Daubert v. Merrell Dow Pharmaceuticals, Inc.*⁵ and testimony is excluded.⁶

Without a doubt, model-related issues are relevant as never before. Anyone using a financial model must be prepared to defend it, warts and all. No one can afford to look at output alone. Valuation professionals will be under even more pressure to explain

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EXHIBIT 1
Current Operating Environment and Models



what goes into the black box, how it gets assembled, and whether the output makes sense.

Anatomy of a Financial Model

As shown in Exhibit 2, all good models share certain characteristics, starting with a set of generalized assumptions that reflect economic reality most of the time. Moreover, a model must be able to be tested to discern whether the output makes sense, falling within the range of expected values. A stock valuation model that spits out negative prices makes no sense. A model that generates a company value that falls significantly below the sum of prices for fungible assets merits inspection.

Assuming tests on the model reflect accuracy, repeated runs with different sets of data should generate consistent results. Extreme data points should not lead to wildly different numbers. Generally speaking, the model should be relatively insensitive to the variation of inputs. Otherwise, data quality dominates the integrity of the model selection process. Business valuers when choosing from a variety of vendors will want to know something about each provider’s data-generation methodology. Ignorance is not bliss. Inappropriately used data or use of inappropriate data costs time, money, and reputations later on. The model must be cost-effec-

EXHIBIT 2
Characteristics of a Good Model

1. Based on generalized assumptions.
2. Validation results comport with expected outcomes.
3. Generates consistent results.
4. Logical.
5. Cost-effective to implement.
6. Robust to outliers.
7. Can be easily explained to others.

tive to use or it will remain on the shelf, collecting dust. Finally, the model must be easy enough to explain to others. Brilliant models that cost a fortune in processing time or cannot be explained to a client, judge, regulator, or programmer are bad news.

Model Risk

There is no perfect model; all have problems, some worse than others. Stated another way, model risk is a fact of life. Though experts disagree on a precise formal definition, model risk occurs in situations such as:

- Inappropriate use of an otherwise valid model.
- Bad data.
- Hard-to-obtain data.
- Incorrect form of data.

EXHIBIT 3
Model Risk Categories

| | Problem | Example |
|---------------------|--|---|
| Completeness | (1) Missing variable and related mis-specification | (1) Model for income considers education and ignores experience |
| | (2) Redundancy and related multi-collinearity | (2) Age and years of experience are both included |
| Consistency | Meaningless results or dramatically different results due to data form | Using prices instead of returns |
| Data Quality | (1) Hard to get data (2) Data that changes in unpredictable fashion | (1) Emerging market prices (2) Historical ratios used for Chapter 11 firms |
| Mathematical Issues | Outputs are unreliable | Simulations that require large amounts of processing time |
| Use | Inappropriate some or all of the time | Linear regression used for non-linear relationship |

EXHIBIT 4
Volatility Scenarios*

| Volatility Assessment | Volatility Range | Volatility Midpoint | Option Value |
|------------------------------|-------------------------|----------------------------|---------------------|
| Low | 0% to 30% | 15% | \$ 2.49 |
| Medium | 30% to 70% | 50% | \$ 7.34 |
| High | > 70% | 85% | \$12.10 |

Assumptions:

1. \$50 stock price.
2. \$50 strike price.
3. Six month time to expiry.
4. No dividends.
5. 3% risk-free rate.

* Volatility inputs are in standard deviation form.

- Computational trouble.
- Incomplete or over-specified model.

It is necessary to recognize model risk before there can be any chance of improvement. Some common examples are shown in Exhibit 3.

Importantly, model risk may exist when applied in one way but not another.⁷ For instance, a single-variable regression is seldom the best way to quantify an individual's lifetime expected earnings stream for product liability cases. On the other hand, a single-variable regression may be appropriate in a lost profits case that estimates equity costs as a function of a single factor, returns on a market basket of investments. A single-variable regression used to compute a hedge ratio that determines how much of a derivative instrument to buy or sell is just as logical.

Although never easy, a business valuator must be able to discern:

- What risks are likely to plague a particular model.
- The cost of these risks.
- Whether adjustments can easily and logically be made.
- When the model should be jettisoned in favor of something else.

A failure to do so can be disastrous and costly in more ways than one.

Model Risk Example

One could write a book about model risk and still have plenty to say.⁸ The case of employee stock options is apropos, given the current debate about whether and how to expense them. A popular valuation approach is the famil-

1 "Sarbanes-Oxley Act of 2002, Section 302, Corporate Responsibility for Financial Reports," Public Law No: 107-204, 7/30/02.

2 "Proposed Rules: Disclosure In Management's Discussion and Analysis About Off-Balance Sheet Arrangements, Contractual Obligations and Contingent Liabilities and Commitments," SEC, 67 Fed. Reg. 68054 (2002).

3 "Consultative Document: The New Basel Capital Accord, Issued for Comment by 31 May 2001," Basel Committee on Banking Supervision, Bank for International Settlements, January 2001.

4 "Up Front: Lipper II: Judgment Day," edited by Sheridan Prasso, cites debate over valuation methodology to determine investor restitution. See BusinessWeek, 1/20/03, page 10.

5 509 U.S. 579 (1993). See also Kumho Tire Co. v. Carmichael, 526 U.S. 137 (1999), which extends Daubert to persons other than scientists.

6 Mangiero, "Financial Model Risk Looms Large," 9 Investment Lawyer 1 (November 2002).

7 Emanuel Derman cites inapplicability as a primary type of model risk. See "Model Risk," Goldman Sachs Quantitative Strategies Research Notes (April 1996).

8 The author is currently working on a book about financial model risk that looks at commonly used models, including derivative instrument models.

9 The third key person, Fischer Black, died in 1995, making him ineligible for this honor since the award is not given posthumously. See <http://www.ams.org/new-in-math/nobel1997/econ.html>.

10 See <http://www.riskglossary.com> for one of many introductory expositions about the Black-Scholes option pricing model.

11 The International Employee Stock Options Coalition recently praised the FASB for request-

ing that information about stock options be provided to the public on a quarterly basis. At the same time, it cited problems with the B-S model, applied to employee stock options. See "Statement by International Employee Stock Options Coalition," Business Wire, 10/7/02.

12 2002-8 IRB 549.

13 The logarithmic form of returns is often used. See <http://www.investorwords.com> for one of many definitions of volatility. Historical volatility is mainly used as the output. However, a market option price can be used to estimate what is known as "implied" volatility.

14 According to Rev. Proc. 2002-13, "If the stock is not publicly traded on an established securities market or otherwise, but the stock is required to be registered under the Securities Exchange Act of 1934, the volatility for such stock is assumed to be the same as the volatility for a comparable corporation that is publicly traded" and is similar with respect to "indus-

iar Black-Scholes (“B-S”) option pricing model, for which the Nobel Prize in Economics was awarded to Robert C. Merton and Myron S. Scholes in 1997.⁹ This model is based on a set of assumptions including, but not limited to: (1) zero transaction costs, (2) no dividends paid during the life of the option, (3) no short-selling of the underlying security, (4) a constant risk-free rate of interest, and (5) unchanging volatility of the underlying security.¹⁰

As stated before, evaluating a model to determine its appropriateness for the task at hand is an important first step. Applied to employee stock options, critics cite several factors that make the B-S model less than ideal, including the long-term nature of stock options, the fact that few stock options trade in an open market, if at all, their exercise is restricted, and issuance by closely held companies complicates stock price determination.¹¹ Nevertheless, the B-S model shows up in many places, including tax rules. According to Rev. Proc. 2002-13,¹² a “taxpayer may value a compensatory stock option using any valuation method that is consistent with generally accepted accounting principles (such as FAS 123),” adjusted for factors cited in other sections of the Code. Rev. Proc. 2002-13 goes on to say in section 4 that “the safe harbor valuation method provided by this revenue procedure is based on the Black-Scholes model...”

Input selection is a critical second step and often overlooked in terms of its impact on final numbers. The B-S option pricing model takes five inputs: (1) price of the underlying stock, (2)



option strike price, (3) risk-free interest rate, (4) time to expiration, and (5) volatility. A discussion of volatility is beyond the scope of this article but is typically defined as the annualized standard deviation of the stock’s daily return.¹³ While it is possible to examine the impact of any of the five variables on option price, Exhibit 4 considers the three volatility categories described in Rev. Proc. 2002-13, i.e., “low, medium or high.” Although not reflected here, the filer is further advised to consider whether a company is privately held or publicly traded as part of settling on a volatility number.¹⁴

Even when the B-S model is established as a suitable model, model risk *still* arises due to volatility choice, as seen in big value differences across categories.¹⁵ Notice that the relationship between volatility and option value is neither proportional, nor constant across the range of all possible volatilities.¹⁶ A jump to \$12.10 from \$7.34 is not exactly the same percentage change as the move from 50% to 85% volatility.¹⁷

Why does any of this matter? A mistake in volatility choice has a cost. Suppose that a low estimate is used when a medium category volatility number should have been used instead. For the taxpayer, this would ultimately result in additional taxes and penalties on dis-

covery of the error. For an employee seeking damages as part of a termination lawsuit, insufficiently low volatility would result in underestimating sought-after damages. For a company that issues options, use of low volatility would lead to insufficient expense recognition, which in turn would cause inflated earnings.

Volatility is singled out for illustrative purposes in this example. Other examples can and should be created to demonstrate each type of model risk. Running sensitivity tests is a good way to evaluate pitfalls. Unfortunately, model risk is sometimes left undetected until too late. Being proactive goes a long way towards keeping things on track.

Tip of the Iceberg

Model risk is a reality that is here to stay. Ignoring it or paying scant attention is a luxury few can afford. Generating good numbers is codified in regulations, “best practices” management, and public expectations. By the time valuation model issues end up in court, the stakes are large. Business valuation associations can help by offering educational programs about model risk, making the topic accessible to those who do not ordinarily look behind the curtains with the requisite critical eye. ■

try, corporate size, earnings, market capitalization, and debt-equity structure.”

¹⁵ Employee stock options are call options that entitle the employee to buy the stock at a stated price. A European call is exercised at expiration. An American call can be exercised at or prior to expiration.

¹⁶ Vega measures the volatility-option value relationship and is actively used for risk management purposes.

¹⁷ Moving from 50% to 85% volatility does not result in a price that is 1.7 times greater. In other words, 85% is 1.7 times a 50% value, but the resulting price of \$12.10 is 1.65 times greater than \$7.34, the price associated with the 50% value. Moreover, 50% is 3.3 times the 15% volatility level but generates an option price of \$7.34 that is 2.95 times as big as the \$2.49 price associated with the 15% volatility input.