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AUDITING THE VALUATION OF DERIVATIVE CONTRACTS: RECOGNITION, EVIDENCE, AND CONTROL ISSUES

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IMPLICATIONS COMPTABLES DES PRODUITS DÉRIVÉS
ACCOUNTING FOR DERIVATIVES

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See table of contents

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Article abstract

This paper considers three issues that confront the auditor of derivatives. These issues are: 1. Recognition, meaning the identification of the circumstances in which derivatives occur, and must therefore be valued; 2. Appropriate audit evidence, meaning the determination of appropriate evidence when estimates of values must be audited; and 3. Procedures for gathering that evidence in a systematic fashion, given that auditors try to avoid replication-intensive activity.

This paper will not consider the strategic uses or abuses of derivatives, or the evaluation of complex strategies, or performance measures. Nor will it deal with the accounting issues that surround derivatives, such as the categorization of certain contingent claims as being "remote" or "trivial", or the determination of an option as being "reasonably assured" or even "virtually assured" of being exercised. These are purely accounting policy matters, not related to valuation.

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ABSTRACT

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Keywords: Auditing, Derivative contracts, Recognition, Control issues.

RÉSUMÉ

Cet article examine les trois enjeux suivants auxquels est confronté le vérificateur des produits dérivés :
1. *La reconnaissance, c'est-à-dire l'identification des circonstances qui donnent naissance aux instruments financiers dérivés et qui déterminent son évaluation;*
2. *La justification de la vérification, c'est-à-dire la détermination de la force probante montrant quand l'estimation des valeurs doit être vérifiée;*
3. *Finalement, les procédures permettant de recueillir ces justifications d'une façon systématique, expliquant ce que les auditeurs éprouvent en vue d'éviter une activité fortement répétitive.*

Toutefois, cette analyse n'examine pas les utilisations stratégiques d'instruments financiers dérivés ou leurs abus, ni l'évaluation de stratégies complexes, ni encore les mesures de performance. Ce papier ne porte pas non plus sur les enjeux comptables qui entourent les produits dérivés, tel que la classification de certains droits contingents comme étant «peu probables» ou «négligeables», ou la détermination d'une option, comme étant «raisonnablement assurée» ou «quasi assurée», d'être exercée. Ces questions sont de nature purement comptable et sans conséquence sur l'évaluation.

Mots clés : Vérification, instruments financiers dérivés, reconnaissance, contrôle.

The author:

Peter D. Chant is partner at Deloitte & Touche LLP. He would like to thank referees for their comments on this paper.

Derivative contracts are fundamental to much of modern corporate finance. They are ubiquitous, and appear in many disguises. They are often invisible, in a monetary sense, requiring no cash consideration to be exchanged until they expire. They are often valued in a complex fashion, in many cases by reference to unobservable variables, such as the volatility of a price series. Many derivatives are not traded, requiring the outright estimation of their value prior to exercise. The values that do arise are often very volatile, given the leveraged bet implicit in many of the contractual forms of derivatives that involve the exchange of one notional value for another. In this context, it is easy to see that while derivatives may be the fundamental building blocks of the financial engineer, they are often stumbling blocks for the financial auditor.

This paper considers three issues that confront the auditor of derivatives. These issues are:

1. Recognition, meaning the identification of the circumstances in which derivatives occur, and must therefore be valued;
2. Appropriate audit evidence, meaning the determination of appropriate evidence when estimates of values must be audited; and
3. Procedures for gathering that evidence in a systematic fashion, given that auditors try to avoid replication-intensive activity.

This paper will not consider the strategic uses or abuses of derivatives, or the evaluation of complex strategies, or performance measures. Nor will it deal with the accounting issues that surround derivatives, such as the categorization of certain contingent claims as being "remote" or "trivial", or the determination of an option as being "reasonably assured" or even "virtually assured" of being exercised. These are purely accounting policy matters, not related to valuation. Furthermore, it will not discuss such matters as assessing the controls over derivative use, and the appropriate levels of authorization and trading limits that one would use to govern the usage of derivatives. It will consider, simply, the recognition, measurement, evidential, and disclosure issues that arise from pricing or valuation of derivatives.

■ RECOGNITION

There are innumerable cases in which derivatives appear in financial statement contexts requiring a valuation and, hence, an audit. These include, among other things:

- stock options used for other than executive compensation,
- the options embedded in convertible securities recognized separately under Canadian GAAP,
- foreign currency derivatives used for hedging or for speculation, and
- early termination options embedded in such commonplace transactions as residential mortgages or pools of residential mortgages found in Mortgage-Backed-Securities ("MBS").

These are obvious examples of derivatives that need to be valued.

More subtle, and often more difficult to evaluate, are the options that are embedded in other forms of contracts. For example, Black and Scholes in their seminal paper note that under certain conditions[1]:

> ...stockholders have the equivalent of an option on their company's assets. In effect, the bond holders own the company's assets, but they have given options to the stockholders to buy the assets back."

That is, an equity security can be viewed as a pure option, and a debt security as a combination of the ownership of real assets and a written call (owned by the equity holders). This view of debt and equity securities provides a useful model for evaluating equity and debt securities both in cases of financial difficulty and in start-up situations. In these circumstances the "option" value attached to the equity security may be, and in fact in most instances will be in excess of the value attributed to the underlying assets less the debt. This is because the creditors bear some of the risk of loss, hence providing the option-like payoff and valuation to the equity.

Likewise, this model provides a basis for valuing debt as an option-type contract. That is, the value of the default risk of debt is the pure time value of the assets less the value of the option written to the shareholders. The option is to redeem the debt for its face value (or less) with the proceeds of the assets. It is sometimes potentially more tractable to value the assets, the plain vanilla debt, and the option embedded in the debt, than to directly measure the value of the debt as risky debt. This is particularly true when the equity holders are playing strategic games about servicing the debt, such as in the case of many receiverships.

Embedded derivatives are also found in pure asset plays. "Strategic" or "real" options are embedded in such assets as natural resource deposits, or in undeveloped land. The options embedded in assets such as natural resource pools are the options to forgo production of a resource this period and produce it the next. Essentially, the periodic payoff from a mine that can be shut down when unprofitable is the maximum of zero and the net cash flow from operations. Knowing the price behaviour of the stream of output i.e. the price of the commodity, and unit production costs, provides a measure of future cash flows. From such cash flows one can derive the volatility of the future revenue stream. Together with the risk-free interest rate, one can (in theory) model a tracking portfolio that imitates the value of a mine that can be shut down.

The technique can be enriched to deal with stand-by costs, and similar real-world complications. Such streams of uncertain cash flows can be valued by modeling the payoff streams as an option.[2]

This technique can be applied to such diverse assets as vacant land (the option is to build it out or hold it vacant for another period), technological improvement in an existing plant (the option is to improve or hold the existing level of productivity), and even research and development projects.[3] In the latter case, the option is essentially to continue to fund the R&D project each period, or to cease funding it. It is assumed that ceasing to fund a research and development project is to abandon it. The payoff profile is the maximum of zero and the expected value of research; the exercise price is the periodic cost of the next round of research; volatility can be derived from the future revenue stream associated with the output of the project. Given the future price of the output and a measure of volatility, an R&D project can be valued as an option.

Recognition that such mundane types of assets have attributes that are essentially options provides some insights into the occasionally counterintuitive actions observed in business. Goodwill in a business combination, for example, is often unexplainable when looking at the basic asset and liability position acquired. However, buying a business may, in certain circumstances, be conceived as buying the strategic option embedded in the business. For example, buying a business with non-recourse debt limits the buyer's exposure to loss to an amount equal to the purchase price. The option-theoretic value of the business depends in part on the volatility of the underlying cash flow stream, which may not be reflected in the individual assets.

In the extreme, the payroll benefits received by employees have option-like attributes. The employee may receive the maximum of the contracted wage or zero, the latter payout if the entity goes bankrupt. Thus a wage contract becomes a series of contingent payments resembling options. Such options may in fact increase in value to the holder with increases in volatility if the future level cash flows are otherwise diminishing. Thus employees in declining situations often take seemingly irrational gambles of taking less cash and options in the business instead of a higher salary. This behaviour can be shown to be value-maximizing – but also volatility-motivating behaviour.

The extent to which derivative valuation and pricing issues pervade common business situations is thus far greater than those situations involving explicit derivative contracts. What implications does this have for auditors? The first implication is that valuation techniques must be enhanced to recognize the manifestations of the optional elements of asset prices, even if such assets aren't explicitly recognized as options. This topic is considered next in the discussion of appropriate audit evidence.

The second implication is that otherwise reasonable valuations may have deficiencies because of the optional implications. Classical valuation methods that do not incorporate attributes such as volatility may omit significant positive and negative attributes of asset prices. These are of particular concern in the valuation of natural resources, where there are complicated interperiod option attributes that tend to add to the value otherwise estimated for a resource pool.

The opposite holds for estimates of research projects. In a research project, hitting a periodic barrier of no periodic funding is terminal. That is, the project is over. Thus research projects tend to have value attributes that are similar to knock-out options and other path-dependent contracts. These generally have lower values than plain vanilla options, i.e. they cost less, which explains the use of knock-out options by corporate treasurers. The same value consequences applied to research projects should have the same implications for the review of their carrying values for financial statement purposes and other purposes.

The recognition by auditors of the option attributes of many assets would probably yield the highest benefit of any of the matters discussed in this paper. Recognition is obviously a pre-requisite to measurement. But the audit implications of measurement issues are not trivial either; these are considered next.

■ APPROPRIATE AUDIT EVIDENCE

The measurement of the value of a derivative contract, whether embedded or otherwise, may not be difficult. It may be established from a market quote in a thick and active market. Even some embedded derivatives that are not separately traded have a well-known price. For example the price of a mortgage pre-payment option is discernable from the difference between the price of an open and a closed mortgage. However, many derivatives, specifically those embedded in other contracts or in real assets, are not explicitly traded or priced. Valuation of these derivatives is not easy. The auditor's task is one level beyond that. It is to assemble the *evidence* that supports the valuation in a meaningful way.

The forms of audit evidence that one can use to support the value of a derivative contract depend critically on the manner in which a derivative contract has been recognized. The recognition of a derivative may be done in general in one of three ways:

1. If the liability or asset is held at cost or amortized cost, then the derivative may be measured as part of the original cost of the debt contract, or, if it is an asset, its original cost less amounts amortized less, all subject to impairment tests where appropriate;
2. If the asset or liability is held at market, by recognition of its market value, if it is traded in an active market; or
3. If the asset or liability is held at estimated market value, by recognition of its estimated market value.

The nature of the evidence that is required depends on the type of recognition given to the contract, as well as the type of contract, i.e. exchanged traded, negotiated in a private market, etc.

□ Historical cost

If a derivative contract is carried at cost (which is frequently nil, when the value of the derivative is not explicitly or separately recognized) the evidence requirements might seem to be reasonably straightforward. One looks to the transaction amount that included the acquisition or sale of the option and the documentary evidence supporting the allocation of that contract's cost. Acquiring an option to acquire land, for example, is a simple asset acquisition transaction. The cost of the option is established as its purchase price.

In certain cases, however, such as in the recognition of the equity component of convertible debt securities, the "cost" of the derivative is not easy to determine directly, and must be estimated. Unfortunately, this usually means carving up a "simple" convertible security into two components:

1. An option to convert the security at some future time into equity, at some future time, and
2. An "option" to hold the debt security to maturity.

One of the problems with valuing the first option is that the exercise price at the future exercise date is not known at date of issuance. It is the market value of the future security at the conversion or exercise date. It may be greater or less than the value of the security at issuance. In short, both the option and the debt security that is its exercise price is a very complicated security to model.

Most accountants, in my experience, simply estimate the value of the underlying cash debt payments assuming the payments will run to maturity. That is, they do not consider the fact that the conversion option often limits the expected lifetime of the cash flows, as those flows terminate on exercise of the embedded option. In short, even though accountants recognize the optional components of securities and try to determine the value of the optional amount, it is usually a very difficult exercise, and not done that carefully.

In some cases the amount of an option based upon an historical cost will be amortized as a charge or credit to income over time. For example, the periodic cost of an insurance policy, which is simply a "put option" exercisable under limited circumstances, is determined by amortizing the original cost over the period over which the coverage is paid for. There are few audit issues here; in fact the audit of prepaid insurance (that is, of coverage acquired) is often considered the least risky of all elements of an audit. The evaluation of the accounting for the option writer in the prepaid insurance case, however, is an entirely different matter. It is usually done by estimate, of which more is said below.

More problematic is the determination of whether or not an asset carried at cost is impaired, i.e. the entity will not be able to recover the cost of the asset throughout its operations (this is a highly personal definition of impairment) . Frequently option-type arguments are raised in support of asset values in these circumstances. These include values of assets as established by optional alternative uses, or option-theoretic arguments related to time.

The most common "alternative use" argument is that an asset currently being employed in a loss-engendering use can be sold for a profit or put to more profitable alternative uses. The argument that an asset can be sold for more than its carrying value, even though it is currently running losses, must be based on the idea that someone else would either simply pay more for the asset than the unamortized cost to the current owner. This may involve the prospective buyer paying for some positive "option" value inherent in the asset. Usually this brings the argument around to a discussion of the many reasons such option values exist, even though buyers willing to pay cash for them are not in sight.

For example, management of an enterprise might argue that a parcel of land in a temporarily depressed area may simply be held until inevitably the value of the land exceeds its carrying value. Thus the land shouldn't be written down. Expressed in option-theoretic terms, this is an argument that the volatility of land prices is sufficiently high that the option value of holding the land for sale exceeds the periodic cost of that option, being the periodic carrying cost of the land.

Unfortunately the argument often fails (or at least partly so) because the enterprise cannot afford to pay the option price, i.e. it runs out of cash. An option only has value if one can afford to buy it. Thus option-theoretic arguments for not recognizing impairment in assets, while intuitively appealing, must be analyzed to ensure that all embedded assumptions are valid.

Similar arguments occur in the natural resource sector. It is often argued that mines that produce resources that are currently fetching low prices have a long-run value based on cash flows determined when prices recover. Thus the mines needn't be written down to reflect current commodity prices. The concept is that the volatility in the commodity price makes the option of holding the mine worth more than the periodic stream of option premiums , being quarterly interest payments or similar measures of the periodic cost of capital , needed to keep the option alive. These arguments are option-based arguments and are enhanced by significant volatility in prices.

An issue which complicates the use of such option theoretic approaches to the valuation of real assets is the effects of the assumed price process of the underlying commodity on which the option is inherently based. For example, a general model of stock prices underlying the Black-Scholes model assumes it is generated by a price process with a drift, or trend, and with a constant

diffusion parameter. The latter assumption implies no mean-reverting behaviour in the price series.

It can be shown that if expected returns are time-varying, so that returns are predictable to some degree, the assumption of a constant diffusion parameter is invalid. In fact, if there is mean-reversion in the price formation process, the sample variance of continuously compounded returns is not an appropriate estimator of the volatility of the price process. In specified circumstances, as returns become more highly (negatively) correlated, options become more valuable, ceteris paribus. In general, the effects of asset return predictability on the price of derivatives depends intimately on the precise nature of the predictability.

These arguments support the use of option-theoretic arguments involving mean-reverting tendencies in the determination of carrying value. When these attributes are used to justify a carrying value, the audit evidence must consider not only the fact that such options often have periodic costs, which must be paid, but also the assertion that projections of prices are based on a specific price formulation process.

☐ Market value

If a contract is carried at market value, and there is a ready market for the contract, the audit issues are generally quite straightforward. The required procedure is to obtain a quote from the market and apply it to the contract held or sold. If all the conditions are met, the auditing task is not very challenging.

Nonetheless challenges are occasionally presented in marking to market various traded contracts. It has been observed that irregular events occur in markets that are not predicted or explained by any generalized model. For example, presidential elections in the US have been known to drive fixed income portfolio managers to cover their interest rate bets and bid up the price of options spanning the day of the election. Certain provincial elections in Canada probably drive all traders for similar cover, as will the consequences of Y2K problems as the millenium approaches). Because such events are fixed calendar dates, and apply across all securities traded over that date, the pricing anomaly will not appear uniformly in any time series of prices of any security, but will appear in all securities spanning the election date. Thus volatility estimates based on historical data may not identify the fixed calendar date effect. True mark to market accounting does not rely on a model,

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but takes the market price as the right answer and requires the market trader to recalibrate his or her model.

☐ Estimated market value

Difficult auditing issues arise for those derivative contracts that are held at estimated market value, or estimated fair value. Two specific circumstances that are fraught with difficulties are when the specific contract is not traded, such as in certain over-the counter ("OTC") derivatives, and when a derivative value has to be estimated in the course of fair valuing a real asset.

The most important realization is that any valuation model involves not only a formula but also some underlying assumptions about the operation of price formation in the market. As noted above, the Black-Scholes option pricing model assumes a specific diffusion processes for prices.[6] There are also assumptions about the lack of market imperfections, transaction costs, short sales, and unlimited borrowing and lending at the risk-free rate. All these permit the development of arbitrage portfolios that can be used to replicate the payoff from options contracts.

The most important of these is the pricing model. As Campbell, Lo and MacKinlay state[7]:

> ...the most important aspect of a successful empirical implementation of any option-pricing model is correctly identifying the dynamics of the [underlying] stock price....

In the case of the Black Scholes model, a specific price diffusion process is assumed that does not involve mean reversion. In other circumstances, such as with interest rate or exchange rate products, mean reversion may be a reasonable assumption, simply to reflect the political oversight of exchange rate and interest rate levels. For such mean-reverting processes, option prices may be an increasing function of the absolute value of the first order autocorrelation coefficient.

Further difficulties may exist if the option is written in such a fashion that the commodity that is used as a reference point is not replicable by an alternative basket. This would prohibit the construction of an arbitrage portfolio, and hence eliminate the fundamental basis for constructing a model for valuing an option. In general, option-pricing models depend on the ability to replicate the behaviour of the option by constructing a replicating portfolio that *can* be priced. As Campbell, Lo and MacKinlay state[8]:

> The option price must equal the cost of the dynamic trading strategy that replicates the option's payoff. ...but the derivative security may not be replicated by any dynamic strategy ...

In the latter case, the fundamental principles permitting the formation of analytical models of the valuation of such options would fail. The presence of transactions costs for replication strategies has similar implications.

The implications of these aspects of option pricing for the auditor of an estimated valuation for a derivative contract should be clear. To estimate the value of an option, one must assume that it is possible to dynamically replicate the process that determines the option's payoff. One must also assume that the processes by which price formation occurs is known and well-specified. It would appear that an auditor would need to document these attributes in order to maintain that one had sufficient appropriate audit evidence.

Additional complications are presented by the requirement to estimate the parameters of models with sufficient accuracy so as not to generate a material estimation error. For example, it has been shown that if one uses an estimate of the volatility in the Black-Scholes model of 30%, when the true value is in fact 26.8%, the value of a one year $35 call option on a $40 stock (with other appropriate assumptions) is misspecified as $8.48 instead of $8.10.[9] In the aggregate such specification errors can result in material errors. They may result in incorrect trades, and losses, depending on the margins available in the business. It should also be noted that these kinds of problems are also found in classical valuation methods, and derivatives may not be that different on that account.

When the scope of option-like arrangements is extended to include real assets, it is clear that there are significant difficulties in assembling sufficient appropriate audit evidence to support estimated fair values for contracts. For example, the valuation of assets in an industry with significant technological change must recognize the need for a high continuing level of investment in new technology, with an appropriately high expected rate of return, to maintain the productivity of any capital asset. The valuation of such assets is further complicated by the fact that the failure to invest in any one future period may eliminate the possibility of any further returns from the asset. This makes the valuation of such assets similar to the valuation of barrier or path-dependent options. These are quite complicated, to say the least.

One conclusion might be that this approach is practically infeasible. This would lead to the conclusion that if the asset or

contract has certain option-like features that make valuation difficult, it cannot be valued because of those features. This seems like an inadequate response to an admittedly difficult situation. The solution cannot be to run away from the difficulties presented by the intellectual technology of derivatives pricing and to simply rely upon classical valuation models. The solution requires enhancing the abilities of auditors to analyze and understand the parameters of the process, and the underlying assumptions that make option-pricing models valid or otherwise.

IMPLICATIONS FOR THE AUDIT PROCESS

The audit process, particularly (but not exclusively) the external audit process, generally relies on the processes collectively known as "internal controls" to gather the sufficient appropriate audit evidence with the minimum of disruption to the enterprise's operations, and at a minimal cost. Thus there is a significant attempt to rely upon those processes which an enterprise uses to control its own activities as a source of audit evidence. The observations made above thus have significant implications for internal control processes as well as for external audit processes.

Control processes are supplemented for both internal and external purposes by testing and by analytical review. However, such tests are a secondary source of assurance about the day to day operations of an enterprise, which generally span extended periods involving many individual transactions and/or valuations. Auditing such streams of transactions by replicating the valuation is often much more difficult than auditing a one-time balance sheet position.

This is particularly the case in the valuation of derivative contracts that are marked to market frequently (often daily) and for which the change in market value is included in income on the same basis.[10] The significance of controls naturally depends, in part, on the type of valuation employed in the financial statements. If assets and liabilities are recorded at market, the process should be quite simple. An appropriate quotation is identified (e.g. last trade for the day) and is used to mark to market. It is understood that this approach is to be employed literally and without exception, regardless of the quotes that models might produce. The reason for this rigor is that models, particularly those involving volatility estimates

cannot predict the one-time calendar pricing events (elections, Y2K) that affect market prices.

The establishment of controls over valuations used to test impairment of assets held at cost or amortized cost is much more problematic. Some of the difficulties of testing for impairment under the historical cost have been described above. There are rarely processes in place to continuously evaluate the "real" options embedded in assets. These options may vary by the type of asset, and their pricing should vary depending on the price formation process in the underlying commodity. The structures are usually complicated, involving series of options. The fact that such valuations may be difficult to estimate does not cause any unique difficulty: the valuations produced for most impairment tests involve a significant degree of estimation.

It is difficult in these circumstances for the auditor to do anything but substantively test the valuation. The evidence supporting the specification of the underlying price formation process, particularly if it is assumed to be mean-reverting, should be documented and substantiated. The premiums that must be paid to exercise the optional component must be identified and documented. Such information is usually only prepared on a case-by-case basis, and is not subject to normal internal controls.

In those circumstances where estimates are regularly used to establish values of derivatives, some simple control procedures should exist, in addition to the conventional controls over authorization, confirmation, and independent valuation. Controls should also exist over the choice of underlying pricing models, i.e. if the diffusion process is mean-reverting. Consistent patterns of errors in estimated prices and realizations should be considered examined for evidence of a specification error in the pricing model. Notions such as convergence in the prices of apparently correlated but contractually independent securities should be identified and challenged for their technical validity. For example, while mortgage rates and the interest rates on treasury securities in many countries may be highly correlated, there is no necessary contractual convergence in such rates. Thus highly-leveraged "hedge" positions involving offsetting positions in such securities may be highly sensitive to the non-convergence of these rates. These differences may not in fact be that significant in less leveraged or time-sensitive hedge positions.

In many financial statements, the effects of such errors may not be that material compared to the errors in the estimates of other assets values. For example, depreciation policies for fixed assets are

often only crude estimates. But in those circumstances where large amounts of capital are managed with close tolerances for deviations from benchmark returns, the tolerance for error in estimated values should motivate significant testing over the controls used to establish estimated prices for derivatives and related securities.

Disclosure of the nature of such estimation processes can provide useful information about the nature of the inherent precision in the estimation process.

■ CONCLUDING OBSERVATIONS

Auditing the valuation of derivative contracts might, at first glance, appear to be another common auditing proposition. The widespread use of market values in many circumstances, such as those of pension funds and mutual funds, might suggest there is little to the issue. The reality is, however, that the ubiquitous nature of derivatives, and the sophisticated intellectual process underlying popular models of derivative contract valuation, challenge the auditor's ability to systematically approach derivatives pricing.

The systematic generation of evidence by strictly observing a policy of using market values when available simplifies many issues. If estimates have to be used, however, controls over valuation models, and the choice of models of the underlying price formation process become significant. Even in historical cost situations, significant difficulties exist in determining the effects of option-like attributes in common situations.

The net result is that the revolution in corporate finance driven by the development of sophisticated models of option pricing and other derivatives has not simply passed by the auditing function. If anything, it has raised a bigger challenge of identifying, measuring, and documenting the evidence necessary for an audit involving embedded derivatives such as options. Some may curse this march of technology. The reality is, however, is that it has raised the practice of auditing to a higher analytical plain, and that can only be a good thing.

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Notes

1. F. BLACK and M. SCHOLES, "The Pricing of Options and Corporate Liabilities" *Journal of Political Economy*, May-June 1973, Vol. 81, p. 650.

2. See for example, M. GRINBLATT and S. TITMAN, *Financial Markets and Corporate Strategy* (Boston: Irwin/McGraw Hill: 1998) p. 412-429.

3. See T.A. LUEHRMAN, "Strategy as a portfolio of real options," *Harvard Business Review*, Sept.-Oct. 1998, p. 89-101, for a basic exposition of these issues.

4. For the GAAP definition of asset impairment in Canada, see CICA Handbook section 3060.54.

5. See J.Y. CAMPBELL, A.W. LO, and A.C. MacKinlay, *The Econometrics of Financial Markets* (Princeton: Princeton University Press, 1997), p. 355-382.

6. *Ibid.*, p. 356.

7. *Ibid.*, p. 356.

8. *Ibid.*, p. 391.

9. *Ibid*, p. 362.

10. Note that FAS 115 requires daily mark to market for securities but does not require income recognition for "available for sale securities." The auditing problem is nonetheless the same.