FAS 133 Option Fair Value Hedges: Financial-Engineering and Financial-Accounting Perspectives

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Abstract

Statement of Financial Accounting Standard No. 133 induces time value-related earnings variability for purchased options held to hedge maturity. In response to management's reluctance to report such volatility, for certain cash flow hedges, the Derivatives Implementation Group (DIG) condoned relegating volatility to "Other Comprehensive Income" (OCI), where it does not affect firms' reported earnings per share. However, the DIG solution only applies to certain cash flow hedges. Most importantly, ephemeral volatility still persists for fair value hedges.

We propose two methods of relegating option volatility to OCI. First our "accounting solution" addresses accounting-induced volatility directly, by modifying the accounting for all option hedges. It classifies options used in hedge relationships as "held-to-maturity" securities, which are carried at amortized cost, or "available for sale" securities, which are marked to market through OCI under SFAS 115. Second, our "financial engineering solution" assumes that the conceptually flawed DIG G20 justification will remain in place. We construct a derivative structure for option fair value hedges that effectively converts them to effective cash flow hedges, to which the DIG G-20 approach applies.

We first value SFAS 133-induced earnings volatility, relying on the standard risk-neutral probability or martingale-pricing framework. This exercise highlights a coupled canonical financial engineering innovation for the new accounting standard: Variable Time Value Payment Options (VTVPO) and Time Value Swaps (TVS). By replacing standard cash payment for a hedging option with a VTVPO and a "fixed" TVS, we fix period-to-period time value-related earnings adjustments. The combined VTVPO – TVS structure neutralizes the impact of the new accounting standard on reported quarterly earnings volatility. Under this contract and related swap structure, option time values may, effectively, be amortized as they were amortized before SFAS 133 was introduced.

I. Introduction

Statement of Financial Accounting Standard No. 133 (FASB 1998, henceforth "SFAS 133") recently established accounting and reporting standards for derivative instruments and hedging activities.[1] This article focuses on a controversial consequence of applying the standard to hedges implemented with options: earnings volatility. Prior to SFAS 133, volatility was not a concern because companies generally amortized an option premium, like an insurance premium, over its time to maturity. SFAS 133, however, requires companies to mark *all* derivatives to market, with the balancing entry going to comprehensive income.

To mitigate income statement volatility, a firm must structure an "effective" hedge that qualifies for hedge accounting. Generally, this exercise entails parsing option fair value changes into a time value component and an intrinsic value component. An effective hedge identifies intrinsic value changes as the hedge of changes in the fair value of a hedged item, so that the two changes offset each other. Still, time value is a residual fair value component whose changes generate volatility in comprehensive income. For purchased options held to hedge maturity, financial managers and other interested parties argue that this ephemeral, time value-induced earnings variability misrepresents the results of firms' hedging activities.

In response to those concerns, for certain cash flow hedges, the Derivatives Implementation Group (henceforth "DIG") condoned judging hedge effectiveness on the basis that the "total expected cash flows" of options offset the expected cash flows being hedged, to the extent an option is in the money This DIG concession succeeds in relegating option volatility to other comprehensive income (henceforth, "OCI"), where it does not affect firms' reported earnings per

[1] In this article, references to "SFAS 133" include Statement No. 133 and amending Statements No. 137 (FASB 1999) and 138 (FASB 2000).

share; however, two problems remain. First, the concession is a Band Aid solution because it introduces a conceptual inconsistency between the risk neutral probabilities used to value options and the "true" probabilities used in determining expected cash flows[2]. Second, since it only applies to cash flow hedges, ephemeral volatility persists for fair value hedges. Therefore, a significant fraction of cash flow hedges and all fair value hedges face option time-value induced earnings variability.

We propose two ways of dealing with time value volatility for accounting purposes. First, our "accounting solution" addresses accounting-induced volatility directly, by modifying the accounting standards for all purchased option hedges. We classify purchased options used in hedge relationships as "held-to-maturity" securities, which are carried at amortized cost under SFAS 115 (FASB 1993). This is our preferred accounting solution. Alternatively, we classify them as "available for sale" securities, which are marked to market through OCI under SFAS 115. This solution relegates volatility to OCI but results in recognizing the entire cost of the option when it is exercised.

Second, our "financial engineering solution" assumes that accounting standards for derivatives and hedging will not change and that the conceptually flawed DIG G-20 treatment of effective cash flow hedges will remain in place. We construct a new derivative structure for purchased option fair value hedges. This structure effectively converts them to cash flow hedges, to which the DIG G-20 approach applies.

We first value SFAS 133-induced earnings volatility, relying on the standard risk-neutral probability or martingale-pricing framework. This exercise highlights a canonical financial engineering innovation for the new accounting standard: Time Value Swaps (henceforth "TVS").

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[2] The DIG-20 cash flow hedge effectiveness test procedure mixes expected values and risk-neutral values in its evaluation method. This inconsistency will limit the rule's applicability.

First, we consider a way to lower the time value change impact of a standard cash purchase of a hedging option. A variable TVS reduces the time value-induced earnings changes. More importantly, we suggest a full alternative to purchasing a hedge option for cash. In this alternative, we couple variable time value-based option payments with a “fixed” TVS. In this manner, we can largely fix period-to-period time value-related earnings adjustments, neutralizing the impact of the new accounting standard on reported quarterly earnings volatility. Under this contract and related swap structure, option time values are effectively carried at amortized cost, consistent with our preferred accounting solution, and time value volatility appears in OCI, bypassing earnings per share.

The paper continues as follows. Section II motivates the paper by discussing companies’ aversion to reported earnings volatility and the consequent demand for measures to mitigate it. Section III briefly summarizes SFAS 133 and gives examples of hedge accounting. Section IV presents our proposed accounting solution to the ephemeral volatility problem. Section V shows how one can isolate option time value changes, which produce volatility in earnings, and hedge them with a TVS combined with a variable payment option. This hedging structure effectively “undoes” the volatility that SFAS 133 introduces, spreading changes in option time value smoothly over the life of a hedge. Section V concludes the paper and suggests avenues for future research.

II. Earnings Volatility

Both anecdotal and empirical evidence suggest that managers are averse to reporting earnings volatility introduced by SFAS 133. In a submission opposing the FASB's proposed introduction of SFAS 133, the Institute of Management Accountants stated:

> We continue to object to the notion that recording derivatives on the balance sheet requires the rejection of FASB Statement No. 80's deferral/basis adjustment accounting and the elimination of current synthetic instrument accounting practices…Artificial earnings volatility also will result from the Board's definition of "hedge ineffectiveness," even for fully effective hedges. For example, in most hedging strategies that utilize options when effectiveness is assessed on changes in intrinsic value, the time value component of the option premium payment must be marked-to-market over the life of the option (reflecting changes in volatility and other market factors as well as the passage of time) even though the option premium payment is fixed at inception of the contract and never changes (IMA 1997, p. 1).

Thus, many hedgers object to recognizing time value-related volatility in earnings.

If they must recognize volatility, managers see OCI, a component of comprehensive income, as a more palatable harbor for volatility than earnings for two reasons. First, OCI does not affect earnings per share, a key metric that analysts and investors use to gauge corporate performance. Second, the FASB's financial accounting concepts statements draw a distinction between comprehensive income and earnings (Storey and Storey 1998, p. 150).

Comprehensive income reflects *all* changes in the enterprise's command over economic resources during a period, except changes resulting from investments by owners and distributions to owners. It can be computed by merely deducting an enterprise's net assets at the beginning of a period from net assets at the end of the period, after adjusting for owners' investments and distributions. FASB standards, however, are predicated on the assumption that financial statement readers "…are interested in knowing not only that an entity's net assets have increased (or decreased) but also *how* and *why*" (FASB Concepts Statement 6, paragraph 219). Splitting comprehensive income into earnings and OCI components is thought to satisfy this need.

According to FASB concepts statements, earnings, a subset of comprehensive income, is an indicator of performance of an enterprise and its management. OCI, the difference between comprehensive income and earnings, contains items such as foreign currency translation adjustments, adjustments from recognizing certain additional pension liabilities, and changes in the market value of available-for-sale securities. These items "may be partly or wholly beyond the control of individual enterprises and their managements" (Storey and Storey 1998, p. 140). Presumably, investors would assign such items different weights than earnings in assessing the performance of an entity and its management.

Management Aversion to Reporting Earnings Volatility

Accounting researchers are interested in why managers are averse to reporting earnings volatility. Financial economics literature implies that, in perfect capital markets, reported earnings volatility *per se* does not affect firm value if financial statement notes and other sources of information reveal the company's risk management strategies and derivative positions (e.g. DeMarzo and Duffie 1991, Breeden and Viswanathan 1998).[3]

However, accounting literature hypothesizes that investors use reported earnings volatility as a proxy for both expected cash flow volatility and expected earnings volatility, both of which can reduce firm value for the following reasons.

1. Volatile cash flows reduce future investment in value-creating projects in years when cash flows are low and increase bankruptcy costs (Minton & Schrand 1999).
2. Volatile earnings make accounting-based contracting more costly, even if cash flow volatility is not directly affected (Smith and Warner 1979, Leftwich 1981, Lys 1984, Frost and Bernard 1989, DeFond and Jiambalvo 1994).

[3] As indicated by DeMarzo and Duffie 1995, this conclusion is not necessary. One of their primary assumptions is that both the manager and investors are uncertain about the manager's quality type. In certain settings, high quality managers may not reveal their skill by hedging and, instead, add volatility to earnings and cash flows.

3. Firms adopt sub-optimal investment, financing, and risk-management policies to mitigate the preceding two effects. Investors see this, so volatility destroys value (Imhoff and Thomas 1988, Bartov 1993).

4. Investors see more estimation risk in firms' cost of capital when earnings volatility is higher, so they assign a higher cost of capital, decreasing firm value. Or, the market is inefficient, naively translating earnings volatility into higher systematic risk and hence higher cost of capital (Beaver et al. 1970, Stein 1989).

Empirical evidence, particularly germane to this paper, suggests that hedging can increase perceived firm value if it preserves a trend of smoothly increasing earnings. As has long been hypothesized (Hepworth 1953, Gordon 1964, Barnea et al. 1976), Barth et al. (1999) show that firms with sustained periods of zero or positive earnings changes have higher price-earnings ratios than firms that cannot sustain earnings growth. Further, the price-earnings multiple increases monotonically for each consecutive year a firm reports non-decreasing earnings but disappears after just two years of earnings declines.

Other studies (Bartov et al. 2000; Beatty et al. 2000; Myers and Skinner 2001) support this capital market-based incentive. Consistent with Barth et al. (1999), the incentive is increasing in a firm's growth opportunities (Skinner and Sloan 2000). Myers and Skinner (2001) link the duration of consecutive earnings changes to management stock ownership and unexercised stock options, and Ke (2001) finds that growth opportunities and CEO equity and accounting compensation-based incentives are positively related to the duration of a firm's consecutive earnings increases.

From the finance perspective, both better firms and highly risk sensitive firms hedge more. Nance et. al. (1993) were the first to document this phenomenon across forwards, futures, swaps and options and all market risks. Subsequent studies of the gold market by Tufano (1996), foreign exchange by Geczy et. al. (1997), as well as oil and gas by Haushalter (2000) all found that more risky firms hedge more.

In sum, both anecdotal and empirical evidence suggest that managers are averse to reporting earnings volatility because reported volatility is likely to affect investor perceptions of firm risk. To the extent that management wants to reduce this volatility, to dispel such perceptions, we expect to see both a) pressure on the FASB from the corporate sector to get rid of option-induced earnings volatility or at least relegate it to OCI and b) absent any change in accounting standards, a demand for financial instruments whose fair value changes can offset the option-induced earnings volatility that SFAS 133 introduces. Since accounting rules and derivative structures that shift volatility from earnings to OCI would lower U.S. banks' federally mandated capital requirements, we expect to see similar support for our conclusions from lenders and derivative counterparties. Variability in OCI does not enter a bank's market risk aggregate.[4] Therefore when the TVS structure is used for option-based hedges, a fixed level of bank equity may support more transactions. Permitting held-to-maturity or available-for-sale designations of purchased hedging options would have the same effect.

The next section of the article describes hedge accounting under SFAS 133. The succeeding section proposes an accounting solution to ephemeral earnings volatility, while the one after that uses financial engineering to banish earnings volatility to OCI under current accounting principles.

[4] Reporting Forms - FFIEC 031, Consolidated Reports of Condition and Income for a Bank with Domestic and Foreign Offices, http://www.ffiec.gov/forms031.htm, July 2, 2002.

III. Hedge Accounting under SFAS 133

SFAS 133 contains four major provisions. First, all financial derivative values must appear on the balance sheet at fair value. Second, at hedge inception, management must fully document derivative-based hedges and the entity's auditor must deem them "effective" (Finnerty and Grant 2002). Otherwise, the hedge does not qualify for hedge accounting treatment and any derivative fair value volatility appears in quarterly earnings. Third, forecasted transactions and available for sale securities are eligible for cash flow hedge accounting.

For cash flow hedges, instruments such as swaps, forwards, futures, and options can be used to obtain hedge accounting for anticipated and highly likely transactions. Until an anticipated transaction is recognized for accounting purposes, the derivative gains and losses go to OCI, bypassing the income statement and earnings per share, to the extent that they are "effective hedges." Finnerty and Grant (2002) discuss approaches to testing hedge effectiveness under SFAS 133.

The fourth provision is particularly germane to this paper. It stipulates that either option-based hedges must be effective in total (as in the case of embedded options) or the intrinsic value component of an option must be segregated from its time value.[5] The intrinsic value is, effectively, assigned to hedge the underlying (like a forward hedge), and time value (residual) changes go to quarterly earnings. For option fair value hedges, both intrinsic value changes and time value

[5] SFAS 133 (63.b) also permits hedge effectiveness determination based on option "minimum value." For a call, the minimum value is Max[Se^{-yt}-Xe^{-rt},0]. A desirable feature of using minimum value as opposed to intrinsic value is that the residual value or "volatility value" is positive. As we discuss in our modeling section, a shortcoming of using volatility value is model complexity. Nevertheless, the logic of our valuation approach carries through in terms of volatility value, e.g. $V(t_1, t_2) = C(t_1,t_2) - M(t_1,t_2)$, $M(t_1, t_2) = \text{Max}\left(S(t_1)e^{-y(t_2-t_1)} - Xe^{-r(t_2-t_1)}, 0\right)$. As in the case of our initial example, option time value may become negative for calls on high yield underlyings. (The same is true for puts in high interest rate environments.)

changes go to earnings but changes in the value of the hedged item offset intrinsic value changes, leaving only time value changes as the net change in earnings.

For option cash flow hedges, SFAS 133 originally stipulated that time value changes, ineffective by construction for accounting purposes, would go to earnings, while intrinsic value changes would be recorded as changes to accumulated OCI to the extent that they were effective.[6] In the face of mounting opposition to reporting time value changes in earnings, the Derivatives Implementation Group ruled in DIG Issue G-20 that time value changes can go to OCI instead of earnings, on the basis that the "total expected cash flows" of options offset the expected cash flows being hedged, to the extent an option is in the money, and hence such cash flow hedges are effective in total.

This DIG concession succeeds in relegating option volatility to OCI, at the expense of introducing a conceptual inconsistency between the risk neutral probabilities used to value options and the "true" probabilities used in determining expected cash flows. Therefore, it only applies to a subset of all cash flow hedges. Most importantly, ephemeral volatility persists for fair value hedges.

FAS 133 Hedge Example

To illustrate the main ideas in SFAS 133, we assume that the underlying exposure is a 100 Euro unrecognized firm commitment to purchase inventory. With the Euro initially valued at one dollar, the first panel of Figure 1-a) depicts example spot price evolution process. Our two emphasized cases are highlighted in bold. The $1.152 and $1.327 outcomes represent the Euro appreciation case, while the $0.868 and $0.754 outcomes represent the Euro depreciation case.

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[6] Net purchased options or zero-cost collars that are perfectly effective in offsetting the changes in the expected future cash flows on the hedged transaction (that is, for prices above the specified level) have all changes in the option's fair value recorded in OCI. Thus, in that situation, the entity would not recognize any part of the option's gain or loss (that is, change in fair value) in earnings prior to the date that the hedged transaction affects earnings. See Statement 133 Implementation Issue No. G20, Cash Flow Hedges: Assessing and Measuring the Effectiveness of an Option Used in a Cash Flow Hedge, April 2001.

To ease the exposition, we assume that U.S. and Euro interest rates are equivalent and five percent. Therefore, Euro forward prices equal the Euro spot price.[7] For the two-quarter example period, SFAS 133 results in six journal entries. (Initially, the future 100 Euro firm commitment results in no accounting entries because the forward purchase is contracted at the market price, so that the contract value is zero.)

Over the remaining two quarters, changes in the exchange rate induce changes in both the carrying value of the firm commitment and the carrying value of the hedging derivative. The required journal entries in the increasing or decreasing exchange rate scenarios are as follows:

Accounting Entries (I denotes income statement, B denotes balance sheet)	**Currency Up**		**Currency Down**	
	Debit	**Credit**	**Debit**	**Credit**
Beginning of Quarter 1	**None**		**None**	
End of Quarter 1				
Foreign currency forward contract – B	15.00			13.00
Other income/expense – I (earnings component)		15.00	13.00	
Other income/expense – I	15.00			13.00
Change in fair value of foreign currency firm commitment – B		15.00	13.00	
End of Quarter 2				
Foreign currency forward contract – B	17.70			11.60
Other income/expense – I		17.70	11.60	
Other income/expense – I	17.70			11.60
Change in fair value of foreign currency firm commitment – B		17.70	11.60	
Inventory – B	100.00		100.00	
Change in fair value of foreign currency firm commitment – B	32.70			24.60
Foreign currency forward contract – B		32.70	24.60	
Cash – B		100.00		100.00
Cost of goods sold – I	100.00		100.00	
Inventory – B		100.00		100.00

Thus, the net impact of the forward purchase and the underlying unrecognized firm commitment is to fix the cost at the initial forward price level, $100.

[7] Under SFAS 133, hedge effectiveness may be assessed on a forward or a spot basis.

To structure a call option cash flow hedge example, we specify a one-half year maturity, $1.00 strike price and $0.052 premium option. This call option is "at-the-money" (strike price = spot price), so all of its value is time value. The firm buys 100 of these options to hedge the unrecognized Euro firm commitment against dollar depreciation. Management declares that hedge effectiveness shall be assessed on the basis of changes in the intrinsic value of the option. Therefore, in case the Euro appreciates, the changes in the option's intrinsic value will perfectly offset changes in the value of the firm commitment.

Initially, the option premium is credited to cash and debited as an asset. Contingent on the Euro spot price evolution, we assume the call value changes as in Figure 1 – Panel b). The intrinsic value of a call is equal to the maximum of a) the difference between the spot price and the exercise price and b) zero. Changes in intrinsic value conditional on the spot price process are depicted in Figure 1 – Panel c). Finally, and as shown in Figure 1 – Panel d), the time value of the call is equal to the option price less the intrinsic value:[8]

[8] If the Euro appreciates in the first quarter, then the European call time value is negative. The owner of this option would like to exercise the option in this eventuality to capture the 5% Euro yield on the call that is certain to finish no worse than at-the-money. An equivalent American option would be exercised in this eventuality.

Over the half-year of the call option hedge, the following journal entries occur in the increasing and decreasing currency scenarios:

Accounting Entries (I denotes income statement, B denotes balance sheet)	**Currency Up**		**Currency Down**	
	Debit	**Credit**	**Debit**	**Credit**
Beginning of Quarter 1				
Call option (all time value) – B	5.20		5.20	
Cash – B		5.20		5.20
End of Quarter 1				
Other income/expense – I	15.00			
Change in fair value of foreign currency firm commitment – B		15.00		
Call option (intrinsic value portion) – B	15.20			
Other income/expense – I		15.20		
Call option (time value portion) – B		5.40		5.20
Other income/expense – I	5.40		5.20	
End of Quarter 2				
Other income/expense – I	17.70			
Change in fair value of foreign currency firm commitment – B		17.70		
Call option (intrinsic value portion) – B	17.50			
Other income/expense – I		17.50		
Call option (time value portion) – B	0.20			
Other income/expense – I		0.20		
Inventory – B	100.00		75.40	
Change in fair value of foreign currency firm commitment – B	32.70			
Call option – B		32.70		
Cash – B		100.00		75.40
Cost of goods sold – I	100.00		75.40	
Inventory – B		100.00		75.40

There are four key differences between the forward case and the option case:

1. The additional time value entries are necessary to expense the initial "at-the-money" option premium, and the associated time value changes. Recall that because the company specified changes in only the intrinsic value of the option as the basis for judging hedge effectiveness, changes in time value go directly to earnings, as if they were speculative gains and losses.

2. The declining Euro value leads to a much lower cost of goods sold because the call option hedges only appreciation in the value of the Euro. Moreover, changes in the value of the firm commitment are not recognized along this path. That is because the intrinsic value of the option, which was designated as the hedging instrument, never changes.

3. In the case of the appreciating Euro, in closing the first quarter, the call time value becomes negative and the charge to income is greater than the initial option premium. In closing the second quarter, this negative time value gives rise to income when the call option is marked to market. This phenomenon can occur only for a call option close to maturity on relatively high yielding underlying (high interest rate foreign currency.)

4. With the forward hedge, the cost of goods sold was fixed, independent of changes in currency values. In contrast, the option hedge leads to different outcomes depending on changes in currency values. Over the two quarters, in the appreciating currency case, the firm, effectively, locks in a total cost of goods sold of $105.20, which is the option strike price (100) plus the option premium (5.20). In the declining Euro case, the option expires worthless and the total cost of goods sold is $80.60 (cost of 100 Euros at $0.754 per Euro and the $5.20 call option premium.) However, since changes in the option time value are *not* part of the effective hedge relationship, they appear separately in the income statement in the quarter when they occur.

IV. Accounting Solution

Though SFAS 133 permits dynamic hedging strategies, buyers of options for hedging purposes will not, generally, undertake dynamic trading strategies. Instead, option hedgers will purchase options with roughly the same maturity as the hedge exposure and hold the options through maturity. SFAS 115 (FASB 1993), which was effective for fiscal years beginning after December 15, 1993, provides a framework for accommodating such hedges.

SFAS 115 addresses the accounting and reporting for investments in equity securities that have readily determinable fair values and for all investments in debt securities. Those investments are to be classified in three categories and accounted for as follows: 1) Debt securities that the enterprise has the positive intent and ability to hold to maturity are classified as *held-to-maturity securities* and reported at amortized cost. 2) Debt and equity securities that are bought and held principally for the purpose of selling them in the near term are classified as *trading securities* and reported at fair value, with unrealized gains and losses included in earnings. 3) Debt and equity securities not classified as either held-to-maturity securities or trading securities are classified as *available-for-sale securities* and reported at fair value, with unrealized gains and losses excluded from earnings and reported in accumulated OIC, a separate component of shareholders' equity. When such securities are sold, their lifetime gains or losses are recycled through earnings: i.e., the unrealized gains are removed from accumulated OCI and shunted through earnings.

It is reasonable to seek ways of accounting for option-based hedges that convey their economic import. Generally, the buyer of a held-to-maturity option hedge is acquiring the option for a purpose other than short-term profit potential. As the quote from AIMR in section II of the paper suggests, hedgers tend to see the cost of a held-to-maturity option as an insurance premium to be amortized over the life of the option. Moreover, recent empirical research suggests that hedging can increase perceived firm value by preserving a trend of smoothly increasing earnings (Barth et al. 1999, Allayannis and Weston 2001). Thus, it seems perverse to introduce option-induced earnings volatility in a situation where management clearly sees the option as a risk-reducing hedge.

Such considerations lead us to view hedging options as held-to-maturity and/or available-for-sale securities. Therefore, we look to SFAS 115 for accounting procedures that can amortize option premia smoothly over time or shunt option volatility to OCI without the need to engage in financial engineering.

Our preferred accounting alternative would simply classify hedging options as “held to maturity” if management credibly signaled the ability and intent to hold the options to maturity. In this case, the option premium would be entered on the balance sheet at inception of a hedge. SFAS 133’s parsing of intrinsic value to the effective hedge and time value as a residual value would be maintained. However, the time value associated cost would be amortized to earnings over the life of the option. Since time value is zero at maturity, all of time value would be amortized over the life of the asset under a held to maturity classification. As we show in the next section of the paper, this result is already achievable through financial engineering.

A second alternative is also related to SFAS 115 and is, in a sense, a hybrid of the held-to-maturity and available-for-sale classifications. Any deviation of time value change from amortization would be an adjustment to OCI. Since the total time value change equals the total amortization, there would be nothing left to recycle through earnings at hedge maturity. A related accounting remedy to volatility aversion would permit full available-for-sale treatment for a purchased hedging option. The effect of this treatment would be to shunt the entire option premium to OCI over the life of the option; each quarterly charge would be equal to the change in time value.

Then, the entire cost of the option would be recycled through earnings or added to the cost of the hedged item in the quarter when the hedge was realized.

If SFAS 133 and the DIG G-20 interpretation are allowed to stand without further revision, we expect that managers will demand financial engineering products to remove volatility from earnings and relegate it to OCI. The next section of the paper outlines such a product.

V. Financial Engineering Solution

As SFAS 133 is currently implemented, standard option-based risk management techniques can provide 100% "hedge effectiveness." To receive this treatment, a hedging option's intrinsic value is the effective hedge component. Throughout the life of the hedge, any negative changes in the hedged item's value will be offset by intrinsic value changes. However, the remaining time value of the option is not allocated to the hedge. Instead, changes in option time value are marked-to-market in earnings. This outcome is at variance with our argument that purchased hedging options should be treated as "held-to-maturity" positions. Since SFAS-133 may not be amended in any of the ways we suggest, we develop a new valuation and risk management structure that attains the same end.

This structure works as follows: 1) Instead of paying cash for a hedging option, agree to make payment over time and contingent on the underlying price outcomes. This option is a fair value hedge of underlying price risk and qualifies for hedge accounting. 2) Agree through another transaction to swap all the state and time contingent payments for the option into a fixed payment stream. This swap, a cash flow hedge of the latter instrument, also qualifies for hedge accounting. Furthermore, because the swap is a cash flow hedge, its fair value changes are accounted for in OCI and not earnings.

We illustrate these concepts and definitions in the three parts of our financial engineering discussion: 1) An example method for estimating the cost and cash flows of option time value and SFAS 133 earnings adjustments; 2) time value swap responses to the rule in the example context; and 3) a general treatment of these two points.

A Specific Binomial Process Example

As is standard in the derivatives literature, we construct a binomial spot price process and its associated call option value process or "binomial tree." Subsequently, we parse the spot price contingent call option values into the main quantities of interest: intrinsic value and time value.

The business context of this example is an underlying short exposure. Short exposures arise from foreign currency denominated transactions, unrecognized firm commitments and available for sale securities.[9] More generally, short exposures stem from owing anything that will have to repaid or be repurchased on a future date.[10]

Our example parameters are the following: spot exposure value (S_0) 100, exercise price (X) 100, interest rate (r) 5%, yield (y) 5%, volatility (σ) 20%, maturity (t) 0.75. For the binomial process, we have six (N) approximating periods, and the associated time interval is 0.125 (h=t/N).[11] Figure 2 depicts the end-of-quarter outcomes for six periods of spot price evolution. In Figure 2 – Panel a), the spot price moves up or down in proportion to the factors $u\left(=e^{\sigma\sqrt{h}}=1.073\right)$ or $d\left(=e^{-\sigma\sqrt{h}}=0.932\right)$, respectively. A particular spot price outcome reflects its associated total number of up (m) and down (n) moves, $Su^m d^n$. The at-the-money call option price process and current value are derived by backward induction through the standard binomial hedging procedure from spot values at the option maturity (t=0.75). The end-of-quarter call value process is presented in Figure 2 – Panel b).[12]

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9 The changes in the fair value of the hedged component of a foreign currency denominated available for sale security is reported in earnings and not other comprehensive income. SFAS 133 changes this component of SFAS 115. The unhedged fair value changes are reported as adjustments to other comprehensive income.

10 This example is converted to the long-receivable-own exposure case by treating the associated put option.

11 Consistent with our example, the $100 total exposure is based on a $1.00 Euro spot currency price and a 100 Euro firm commitment.

12 This concept and technique are fully developed in Cox-Ross-Rubinstein (1979), Jarrow-Rudd (1983) , Cox-Rubninstein (1985), Bodurtha-Courtadon (1987), Jennergren-Naslund (1993) and Hull (2000).

In the example, the initial at-the-money call option value is 6.38. Call price outcomes are associated with the spot price process up and down moves, $Cu^m d^n$

The quantities of major concern are calculated by splitting the call option value into two components: intrinsic value and time value. The time value and intrinsic value processes are shown together in Figure 2 – Panel c). Time value, $Tu^m d^n$, is defined as option value in excess of intrinsic value, $Iu^m d^n$:

$$Tu^m d^n = Cu^m d^n - Iu^m d^n, \; Iu^m d^n = Max\left(Su^m d^n - X, 0\right) \qquad 1)$$

The superscripts m and n indicate the number of cumulative up and down spot price movements, respectively.

Under SFAS 133, quarterly changes in option time value will either be marked-to-market or marked-to-model in the case of non-traded options. In our example context, Figure 3 enumerates all quarterly time-value changes. The table also links the risk-neutral probability of each time-value change with the associated outcome. Although most time-value changes are negative, a significant number of time-value changes are positive. The positive changes result when a sizable up or down price movement in the underlying is followed by a reversal back to the initial underlying price level. Thus, volatility for accounting purposes can encompass recognizing not just irregular amounts of expenses over the life of the option but also income.

The earliest time-value changes have the largest expected values. Therefore, expenses are likely to be largest in the initial stages of the option's life. Figure 3 indicates both the variability and complexity of time value changes. The most variable transition is highlighted in bold and evolves as follows: Two periods of downward underlying price moves are followed by two upward movements that are, in turn, followed by two upward price moves. In this case, a first quarter 5.58 decrease in earnings is followed by a second quarter 2.94 increase, only to be followed by a final third quarter decrease of 3.49. As a proportion of the initial option price, these moves are material: –87%, +46% and –55%, respectively. Finally, time value changes are non-linear in the underlying price. This non-linearity induces the income volatility associated with SFAS-133 option hedges.[13]

These time value-related earnings entries roughly represent value. Using standard risk-neutral valuation methods in our example, the fair value of the time value changes is 6.25, which is slightly less than the associated 6.38 option value.[14] The time value changes only sum to $6.25 because all cash flows from time value changes are paid in arrears and do not include the time value of money.

In the context of this example, we use the methods of financial engineering to define an alternative variable payment structure for option time value changes. Importantly, no cash is paid for the option on its purchase. Subsequently, we generalize this hedging and valuation exercise.

From our previous discussion, it is clear that simply agreeing to pay the option writer future time value changes is not sufficient to pay the option fair value. However, simply structuring cash outflows to equal the forward value of time value changes does result in a random set of future payments that equal the option fair value. Without interest rate risk (which is the case that we assume), the forward price of any cash flow is equal to the expected value under the risk-neutral probability measure. Therefore, an agreement to pay the forward value of any time value change results in a set of random cash flows that equal the initial option time value.

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[13] This issue is of paramount concern for firms that hedge longer-term transactions. MacKay-Niedzielski (2000). It is interesting to us that the oscillating earnings phenomenon that has been depicted arises predominantly for option hedges of three quarters or more. For shorter terms and for options that are initiated near-the-money, earnings adjustments will mostly be negative and the SFAS 133 rule only reallocates these costs across time and state.

[14] In the zero interest rate case, the changes in time value indexed forward from time zero to t are equal to the changes in option "time decay" running backward from the maturity date to the present. Since the interest rate is non-zero in our example, the option fair value (6.38) and the fair value of the time value changes (6.25) are not equal. See Carr-Jarrow (1990) for a theoretical treatment of the decomposition of option value into its intrinsic and time value components. See Hull (2000) pages 308-310 for a heuristic discussion of an associated intrinsic value-based (stop-loss) hedging scheme.

This observation leads us to propose an alternative option payment mechanism. Instead of paying cash for an option, the option buyer promises a future, random and time-value contingent stream of cash flows. We call this structure the variable time value payment option ("VTVPO").

Figure 4 depicts the VTVPO cash flows. Relative to the time value changes of Figure 3, the absolute value of all of the cash flows prior to maturity are increased by the forward value factor for each quarter.[15] In Figure 4, we have listed the contingent values of the forward time value changes as well as the exercise values of the option. In the structure and instead of paying cash for the option, the option buyer promises a future, random and time-value contingent stream of cash flows against receipt of option intrinsic value at maturity. In the example case of upward movement in the underlying at the end of the first quarter, the negative 5.83 time value change is multiplied by the forward time value of a dollar over the first quarter, $e^{0.05/4} = 1.0126$. Therefore, the associated forward time value change absolute value is 5.90. Over the full set of cashflows, a VTVPO pays variable future time payments to receive future intrinsic value.

Since the fair value of the VTVPO cash flows will equal the fair value of the option exercise (intrinsic) values, the initial net cost for this structure is zero. Under SFAS 133, no initial journal entry is needed to indicate the underlying hedged item, the option intrinsic value, or the option time value.

In subsequent reporting periods, this contract payment structure does not eliminate option time value-induced earnings variability. However, structuring a cash flow hedge of the **forecasted** and variable time value change contingent payments for the VTVPO will do so. Such a cash flow hedge shifts the random cash flows to a fixed value. Furthermore, changes in the "ineffective" component

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[15] The factor is the inverse of the associated maturity discount factor. In our 5% interest rate example, the forward value factors are 1.0126, 1.0253, 1.0382 for the first, second and third quarters, respectively.

of this cash flow hedge will appear in OCI and not earnings. In this manner, we believe that any earnings-related option time value changes may be "engineered" into a fixed or amortized expense.

Time Value Swaps – Binomial Process Example

As a method to eliminate fair value option hedge earnings variability, we propose both fixed and floating time value swap (TVS) contracts. Our discussion so far has pointed toward the fixed TVS and we will treat this structure first. The floating TVS is a simple quarter by quarter shifting of each random time value change to an end of quarter net payment that is known at the beginning of each quarter. By structuring a new floating TVS contract from one quarter to the next, time value change induced earnings variability is reduced but not eliminated. SFAS 133 reporting is not required for the floating TVS (unless another reporting event occurs.)

A Fixed Time Value Swap

Figure 5 depicts the fixed TVS cash flows and the associated probability of each outcome. Among the cash flows, the first number is the negative of the forward time value changes that were variable time value option payments shown in Figure 4.

Within the time value swap structure, these forward time value changes represent time-value change rebates. In our example, the fair value of the time value rebates is equivalent to fixed quarterly payments of $2.18. Therefore, the second negative number for all time value swap payments is the fixed $2.18 payment.

The last three lines of Figure 5 sum up the expected and discounted expected values of the time value swap cash flows. The initial net value of the swap is zero, as it must be. The condition is satisfied by appropriately choosing the fixed swap payment. Relative to the option payment in cash

[16] The factor is the inverse of the associated maturity discount factor. In our 5% interest rate example, the forward value factors are 1.0126, 1.0253, 1.0382 for the first, second and third quarters, respectively.

or payment by the time value change payment structure, the fixed TVS shifts payments toward the maturity date. Importantly, all three of the payment structures have fair values that equal the fair value of the option exercise proceeds.

Two salient features of this swap are its constant payment and its reallocation of value to the first quarter in which the negative time value earnings adjustments are largest. The income statement accounting for the overall structure is straightforward. The floating time value change-related payments offset the time value payment option expenses and cash flows one for one. The net expense is the fixed swap payment.

The balance sheet and equity aspects of the net transaction are more complicated. As always under SFAS 133, the hedging option asset is carried on the balance sheet at fair value. However, the TVS cash flow hedge structure implies that unrecognized changes in the hedge value are accounted for as adjustments to OCI, which are, generally, negative. At the end of the first quarter, risk neutral pricing of the remaining TVS cash flows results in the following value adjustments: underlying currency up to 115.2 (u2) is a 3.73 OCI decrease; underlying currency unchanged at 100 (ud) is a 2.21 OCI increase; and underlying currency down to 86.8 (d2) is a 5.64 OCI decrease. Hence, the integrated TVS structure moves earnings variability to OCI variability.

We have identified three option purchase methods: 1) cash; 2) variable time value-contingent cash flows, or 3) variable time value-contingent cash flows offset with fixed time value swap cash flows. In all three cases, the net balance sheet effects are the same, and the option and underlying hedge item entries are the same. Cash and time value option payment have roughly the same earnings impact with the only difference being the time value of money. Combining the time value option payment structure with a time value swap shifts variable earnings adjustments to a predictable income statement cost, albeit with variable OCI.

A Floating Time Value Swap

Simple inspection of potential option time value changes indicates that their average is more stable than the individual outcomes. Furthermore, the sum of all changes must net to zero at the option hedge maturity date. The fixed TVS shifts highly variable cash flow streams to a single "average," and this average is the fixed TVS rebate.

An alternative short-term structure completely bypasses SFAS 133. This floating time value swap only averages time value option payment cash flows within a single quarter. The application is straightforward. At the example initiation date in Figure 3, consider the potential first quarter time-value related earnings impacts. Across the up (110.52 – u2), stable (100.0 - ud) and down (86.82 – d2) spot price outcomes, the possible time value charges are 5.83, 1.21 and 5.58, respectively. The expected value of these charges is 3.45.

The initial floating time value swap is the agreement to receive the floating time value change cash flow at quarter end and pay the expected value of these changes. The net value of the floating TVS is zero. Since this swap matures before the end of the accounting period, no additional entries are required. The net effect in every accounting period is to have time value changes offset by the floating swap payment. In this case, the average time value change is the actual cost.

General Case

As indicated by our previous discussion, changes in option time values may be priced within the standard risk-neutral valuation method. With this method, the risk-neutral expectation of derivative cash flows is calculated. Then, this expectation is discounted at the riskless rate to determine the derivative value.

Though our binomial example indicates that changes in option time value are both time-dependent and underlying price path-dependent, changes in option time values may be determined with a simple formula. Importantly, the formula will hold for fairly general distributions.

First, define $C(t_k, t_n)$ to be the value of the $t_n - t_k$ maturity option at time t_k, and define $I(t_k)$ to be the intrinsic value of this option at time t_k. Note that both of these quantities are also dependent on the underlying price and, thus, are random variables (unless $t_k = t_0 = 0$.)[17]

We define time value at time t_k and an associated state to be the following:

$$T(t_k, t_n) = C(t_k, t_n) - I(t_k) \qquad 2)$$

The sequence of time value changes has the following discounted risk-neutral measure expected value:

$$\begin{aligned} R(0,t_n) = {} & e^{-rt_1}\left(T(0,t_n) - \hat{E}_0\left[T(t_1, t_n)\right]\right) + e^{-rt_2}\left(\hat{E}_0\left[T(t_1, t_n)\right] - \hat{E}_0\left[T(t_2, t_n)\right]\right) \\ & + \ldots + e^{-rt_n}\left(\hat{E}_0\left[T(t_{n-1}, t_n)\right] - \hat{E}_0\left[T(t_n, t_n)\right]\right) \end{aligned} \qquad 3)$$

Under the standard assumption of no interest rate risk, we may solve directly for this discounted risk-neutral measure expected value: We do so by substituting forward option prices for all risk-neutral expectations.[18] Therefore, the t_m maturity risk-neutral expected option time value equals the forward value of the t_m maturity option: $\hat{E}_0\left[T(t_k, t_m)\right] = \left[C(0, t_m) - C(0, t_k)\right] / D_k$; and

[17] SFAS 133 also permits hedge effectiveness tests based on option "minimum value." When option hedge effectiveness is calculated based on minimum value, the ineffective residual is called "volatility value." We emphasize option time value in our SFAS-133 treatment because the resulting time value swap valuation formula is stated in terms of a relatively homogeneous set of option values. Though an analogous volatility value swap (VVS) may be structured, its statement is more complex. A closed form valuation formula for the VVS is available from the authors on request. Since our objective is to permit the amortization of the residual time or volatility value component of an option premium, either method will suffice.

[18] The time zero option value is equal to its risk-neutral expected value discounted by the associated risk less discount factor: $C(0,t_m) = e^{-rt_m}\hat{E}_0\left[I(t_m)\right] = e^{-rt_m}\hat{E}_0\left[C(t_m, t_m)\right] = e^{-rt_k}\hat{E}_0\left[C(t_k, t_m)\right]$. Therefore, risk-neutral expected option values are forward values of current option prices: $\hat{E}_0\left[I(t_m)\right] = e^{rt_m}C(0,t_m)$, and $\hat{E}_0\left[C(t_k, t_m)\right] = e^{rt_k}C(0,t_m)$

$D_k = e^{-rt_k}$ is the t_k maturity discount factor.[19] We also define quarterly time intervals: $\tau_k = t_k - t_{k-1}$. Making these substitutions, we have the present and risk-adjusted cost of the time-value changes:

$$R(0,t_n) = e^{-r\tau_n} C(0,t_n) - e^{-r\tau_1} I(0) + \sum_{k=1}^{n-1} \left(e^{-r\tau_k} - 1\right)\left[C(0,t_n) - C(0,t_k)\right] \qquad 4)$$

In most cases, this total cost of time-value changes will be negative. In the case of zero interest rates, this quantity is current option time value. Higher interest rates lower this cost. With a yield on the underlying, the sign of the cost is undetermined because European option time values may become negative (though for most relevant cases the cost remains positive.) In the usual cases that longer maturity and/or higher volatility increase option values, the cost of option time-value changes will also rise with maturity and/or volatility increases.

As illustrated with our example, valuation of expected time-value changes provides a useful by-product. The valuation formula also provides the fair value of SFAS 133-induced earnings variability. From our binomial example in the previous section, this value was $6.25.

Our final task is to shift the value of future time value changes so that the aggregate value of these changes equals option time value. We define the forward time value change to be $\hat{F}_0\left[\Delta T(t_k,t_m)\right] = \left(\left[\hat{E}_0\left[T(t_{k-1},t_m)\right] - \hat{E}_0\left[T(t_k,t_m)\right]\right]\right) \big/ D_k$. Analogous to equation 3), we have the following stochastic cash flow stream value:

$$T(0,t_n) = e^{-rt_1}\hat{F}_0\left[\Delta T(t_1,t_n)\right] + e^{-rt_2}\hat{F}_0\left[\Delta T(t_2,t_n)\right] + \ldots + e^{-rt_n}\hat{F}_0\left[\Delta T(t_n,t_n)\right] \qquad 5)$$

Option time value equals the value of forward time value changes. Given this relationship, we propose the general discounted time value option payment mechanism. An option buyer pays cash

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[19] The forward factor is the inverse discount factor. Following FASB Concept #7, the discount factor may be stated equivalently as $D_k = \frac{1}{(1+R/n)^{n\,t_k}} = e^{-rt_k}$. R is the n-period compounded t_k-maturity bond-equivalent rate: $R = n\left(e^{r/n} - 1\right)$.

for intrinsic value and agrees to pay the forward value of subsequent quarter time value changes. The contract writer will receive these payments plus initial intrinsic value against the potential of having to pay intrinsic value on the option's maturity date (and the value of these final cash flows is total initial option value.)

This forward time value payment structure does not, however, reduce variability of SFAS 133-related time value earnings entries. In fact, this payment stream simply substitutes for an initial cash payment for the option asset. To eliminate earnings variability, the random forward time value cash flows must be swapped against a fixed payment. The associated time-value swap fixed payment is calculated as the root, V, of the following equation:

$$0 = -T(0,t_n) - \sum_{k=1}^{n} e^{-rt_k} V \qquad 6)$$

On net, the swap buyer receives the negative time value change as a rebate against his time-value change dependent payments and the call option exercise value at maturity. In return, the swap buyer must make fixed payments quarterly, V. Since this swap is a hedge of forecasted cash flows, it is *not* a fair value hedge. It is a cash flow hedge, so that changes in its fair value appear as adjustments to OCI, not earnings.

Both the forward time value payment options and the TVS have complicated path-dependent payment streams, and are "exotic" derivative structures. Nevertheless, both our binomial example and general case treatments may be extended to show how a derivative dealer may hedge the contracts. For our at-the-money example, time-value changes are smallest if the end-of-quarter spot price ends up at-the-money. The largest time value losses occur with extreme movements in the underlying. However, these losses are (except for slight underlying yield concerns) bounded by the initial option time value. Therefore, a first approximation to at-the-money time value change is a butterfly.

A butterfly is constructed with a purchased strangle and sold straddle. The straddle is composed of an at-the-money put and call. A strangle is constructed with two out-of-the-money options. One strangle component is a call option with its strike price set at the current spot price plus option time value. The other strangle component is a put with its strike price set at the current spot price minus the option time value. Since the butterfly roughly matches the end of quarter time value changes of an at the money option, the hedge of these value changes is a short butterfly.

For options that are not at the money, time value changes have roughly the same outcome domain as at-the-money options. However, the range of the outcomes is shifted right or left, dependent on whether the option is a call or put and based on the degree to which the option is in- or out-of- the money. As in the case of at-the-money options, time value changes are bounded. Again as an approximation, time value changes are in rough correspondence with a butterfly. As a general comment across time value changes, the associated hedges are butterflies with their apex roughly centered over the option exercise price.

Of course, hedging efficacy under the risk-neutral pricing approach will be, at best, approximate. Therefore, the dealer hedging activity, risks and, hence, pricing of the structures that we propose may be high. Alternatively, the structure may provide a nice offset to some outstanding risk and be priced well.

In either event, we do not motivate our developments as alternative trading methods for held-to-maturity option hedges. Instead, we advocate a change in SFAS-133 that is zero cost and results in the same outcome as our approach. Clearly, management will support a change in accounting rules that permits held-to-maturity hedge option time values to be amortized in earnings. Otherwise, we do predict demand for TVS-type products.

VI. Conclusion

We have analyzed SFAS 133 fair value option hedges, emphasizing concern for earnings volatility related to purchased, effective and held-to-maturity and option hedges. We suggest that SFAS 115 provides an accounting framework for amending SFAS 133's treatment of such options. Our preferred alternative is to invoke SFAS 115's "held to maturity" classification, which would allow the amortization of option time values over their lives. However, the difference between time value changes and the amortized cost could, consistent with available for sale security treatment, be recorded in other comprehensive income (OCI). Alternatively, all time value changes could go to OCI and then be recycled to earnings or inventory costs at hedge maturity. To the extent that hedgers prefer to relegate reported volatility to OCI, as opposed to earnings, such proposals would receive strong corporate support, and obviate the need for financial engineering products designed to dampen reported earnings volatility.

We have also shown how, if SFAS 133 remains in place, financial engineering techniques can effectively shunt option volatility to OCI for accounting purposes. Specifically, we developed two derivative structures that, together, should permit straight-line amortization of option time value in earnings. The first structure is a variable time value change-based method of paying for an option. The second structure is a time value swap (TVS) that exchanges a fixed quarterly payment for the variable and forecasted time value changes. By combining these two structures, variable time value change earnings entries are eliminated; OCI bears the brunt of volatility for accounting purposes.

Finally, the cost of SFAS 133's treatment of held-to-maturity option time values is not only one of earnings variability and financial structuring. Since bank capital must be allocated against earnings variability related to market risks, accounting for purchased hedge option time value changes in earnings has raised U.S. banks' cost of capital. Either our advocated held-to-maturity treatment of hedging option time values or use of time value swap structures would lower this cost.

VII. References

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Figure 1: Example Evolution of Euro Spot Prices, Initially At-the-Money Call Prices, and the Associated Intrinsic and Time Values

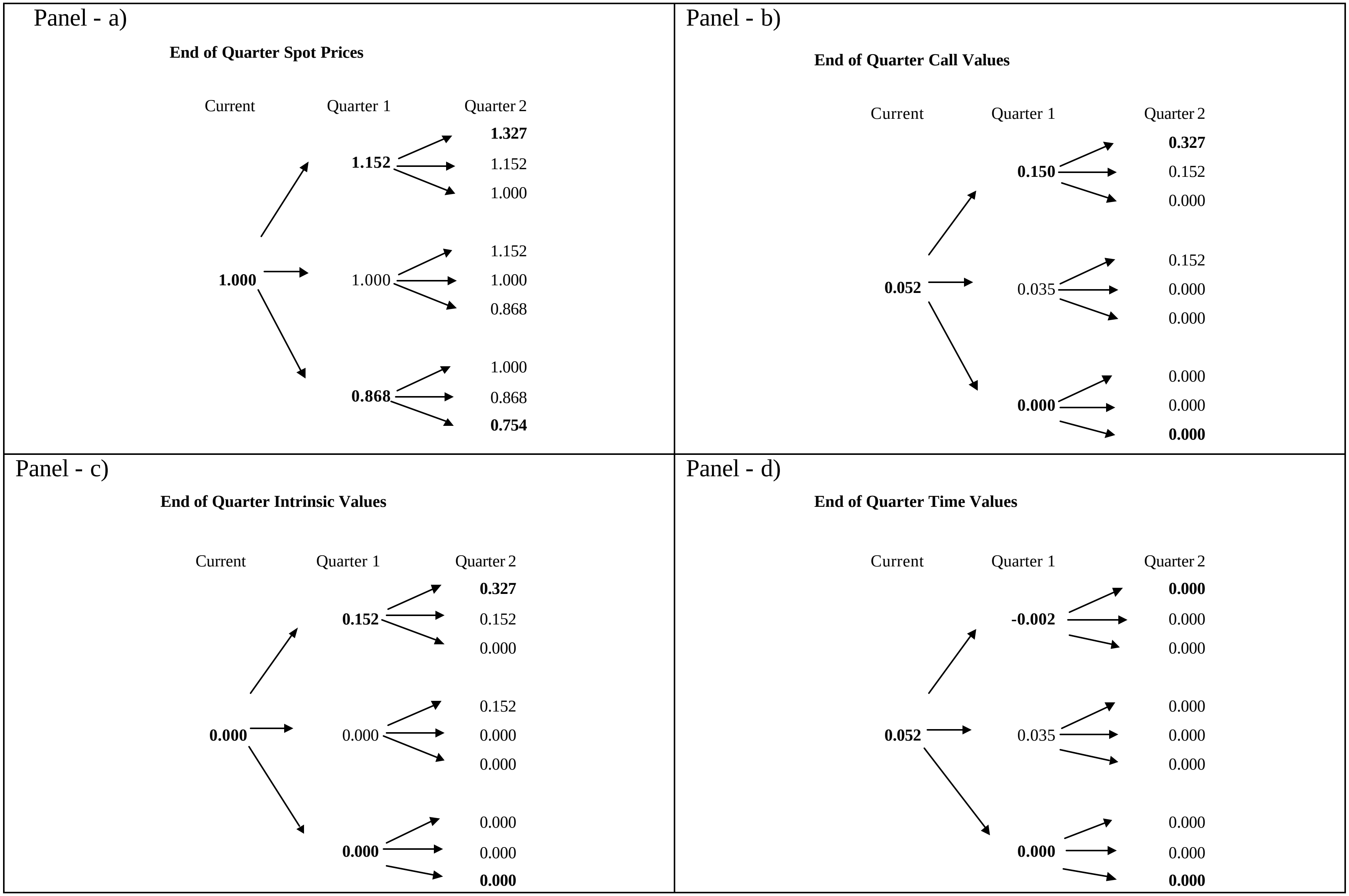

Figure 2

Panel a) **Spot Price Process Evolution**

0	0.25	0.5	0.75
			Su6= 152.85
		Su4= 132.69	Su5d= 132.69
	Su2= 115.19	Su3d= 115.19	Su4d2= 115.19
S0= 100.00	Sud= 100.00	Su2d2= 100.00	Su3d3= 100.00
	Sd2= 86.81	Sud3= 86.81	Su2d4= 86.81
		Sd4= 75.36	Sud5= 75.36
			Sd6= 65.43

Panel b) **Call Option Value Process Evolution**

0	0.25	0.5	0.75
			52.85
		32.28	32.69
	15.74	15.00	15.19
6.38	5.17	3.49	0.00
	0.80	0.00	0.00
		0.00	0.00
			0.00

Panel c) **Option Time Value (T)** and Intrinsic Value (I) **Process Evolution**

0	0.25	0.5	0.75
			0.00 52.85
		-0.41 32.69	0.00 32.69
	0.55 15.19	-0.19 15.19	0.00 15.19
6.38 0.00	5.17 0.00	3.49 0.00	0.00 0.00
	0.80 0.00	0.00 0.00	0.00 0.00
		0.00 0.00	0.00 0.00
			0.00 0.00

Our example parameter values are r=5%, y=5%, s=20%, t=0.75, h=0.125, u=1.073=$e^{\sigma\sqrt{h}}$, u=1.073=$e^{-\sigma\sqrt{h}}$, Sumdn=S0*u^m*d^n. As standard, the risk neutral probability and call values are p=48.23%=$\left(e^{(r-y)h}-e^{-\sigma\sqrt{h}}\right)\Big/\left(e^{\sigma\sqrt{h}}-e^{-\sigma\sqrt{h}}\right)$ and $Cu^m d^n=\left(pCu^{m+1}d^n+(1-p)Cu^m d^{n+1}\right)e^{-rh}$, respectively. Time value is call value less intrinsic value: $Tu^m d^n = Cu^m d^n - Iu^m d^n$, $Iu^m d^n = \mathrm{Max}\left[Su^m d^n - X, 0\right]$

Figure 3

Risk-Neutral Probabilities of Occurance and Associated Changes in Option Time Value

(that Will Be Booked to Quarterly Earnings under FAS-133 with a standard hedge option purchase)

	0.25	0.5	0.75
			1.26% * 0.41
			5.41% * 0.19
		5.41% * -0.95	8.70% * -3.49
		11.62% * -5.36	6.23% * 0.00
	23.26% * -5.83	6.23% * 2.69	1.67% * 0.00
			2.70% * 0.41
			11.60% * 0.19
		11.62% * -0.74	**18.68% * -3.49**
		24.94% * -1.68	13.37% * 0.00
	49.94% * -1.21	13.38% * -0.80	3.59% * 0.00
			1.45% * 0.41
			6.23% * 0.19
		6.23% * 2.94	10.02% * -3.49
		13.38% * -5.17	7.17% * 0.00
	26.80% * -5.58	7.18% * -0.80	1.92% * 0.00
Expected Values =	-3.45	-1.68	-1.24
Discounted Expected Values =	-3.41	-1.64	-1.19

Discounted Expected Time Value Changes = -6.25

Path-dependent time-value evolution follows from Figure 2. $Tu^n d^m - Tu^i d^j$, is the time value change associated with a spot price move from $Su^i d^j$ to $Su^n d^m$

Figure 4

Variable Time Value Payment Option (VTVPO) Cashflows and Value

(Value of $1 Contingent on each outcome is multipllied by the associated changes in forward option time value.
These forward time value change cashflows equal the option value and roughly match FAS-133 quarterly earnings adjustments.)

	Changes in Forward Option Time Value			Option Exercise Value
	0.25	0.5	0.75	0.75
			$0.012 * 0.42	$0.012 * 52.85
			$0.052 * 0.20	$0.052 * 32.69
		$0.055 * -0.98	$0.084 * -3.62	$0.084 * 0.00
		$0.119 * -5.49	$0.060 * 0.00	$0.060 * 0.00
	$0.230 * -5.90	$0.061 * 2.76	$0.016 * 0.00	$0.016 * 0.00
			$0.026 * 0.42	$0.026 * 32.69
			$0.112 * 0.20	$0.112 * 15.19
		$0.113 * -0.76	$0.180 * -3.62	$0.180 * 0.00
		$0.243 * -1.72	$0.129 * 0.00	$0.129 * 0.00
	$0.493 * -1.22	$0.131 * -0.82	$0.035 * 0.00	$0.035 * 0.00
			$0.014 * 0.42	$0.014 * 15.19
			$0.060 * 0.20	$0.060 * 0.00
		$0.061 * 3.02	$0.097 * -3.62	$0.097 * 0.00
		$0.131 * -5.30	$0.069 * 0.00	$0.069 * 0.00
	$0.265 * -5.65	$0.070 * -0.82	$0.019 * 0.00	$0.019 * 0.00
Quarterly fair values =	-$3.45	-$1.68	-$1.24	$6.38

Time Value Contingent Cash Flow Fair Values = -$6.38

Fair Value of Option Exercise Cash Flows at Maturity = $6.38

Net Initial Option Fair Value with Time Value Option Payment Structure = $0.00

Figure 5

Forward Price Contingent Cashflows of a Fixed Option Time Value Cash Flow Swap

[forward time value rebate - fixed (swap) **+ option** (@ maturity)**]**

	0.25	0.5	0.75
			(-0.42 - 2.18)*1.26%
			(-0.20 - 2.18)*5.41%
		(0.98 - 2.18)*5.41%	(3.62 - 2.18)*8.70%
		(0.00 - 2.18)*11.62%	(0.00 - 2.18)*6.23%
	(5.90 - 2.18)*23.26%	(-2.76 - 2.18)*6.23%	(0.00 - 2.18)*1.67%
			(-0.42 - 2.18)*2.70%
			(-0.20 - 2.18)*11.60%
		(0.76 - 2.18)*11.62%	(3.62 - 2.18)*18.68%
		(1.72 - 2.18)*24.94%	(0.00 - 2.18)*13.37%
	(1.22 - 2.18)*49.94%	(0.82 - 2.18)*13.38%	(0.00 - 2.18)*3.59%
			(-0.42 - 2.18)*1.45%
			(-0.20 - 2.18)*6.23%
		(-3.02 - 2.18)*6.23%	(3.62 - 2.18)*10.02%
		(5.30 - 2.18)*13.38%	(0.00 - 2.18)*7.17%
	(5.65 - 2.18)*26.80%	(0.82 - 2.18)*7.18%	(0.00 - 2.18)*1.92%
RN Expected Values =	1.32	-0.45	-0.89
Discounted RN Expected Values =	1.30	-0.44	-0.86

Discounted RN Expected Value of Net Time Value Rebate less Swap Payment (2.18) = 0.00