How Much do Firms Hedge with Derivatives?

Wayne Guay
The Wharton School
University of Pennsylvania
2400 Steinberg-Dietrich Hall
Philadelphia, PA 19104-6365
(215) 898-7775
guay@wharton.upenn.edu

and

S.P. Kothari
Sloan School of Management, E52-325
Massachusetts Institute of Technology
50 Memorial Drive,
Cambridge, MA 02142
(617) 253-0994
kothari@mit.edu

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Abstract

Previous research offers little large-sample evidence on the magnitude of non-financial firms' risk exposure hedged by financial derivatives. In a sample of 234 large non-financial corporations that use derivatives, we find that if the median firm simultaneously experiences a three standard deviation change in interest rates, currency exchange rates, and commodity prices, it will collect $15 million of cash from its entire derivatives portfolio and that the entire derivatives portfolio will rise in value by $31 million. These dollar amounts are modest relative to firm size, operating cash flows, investing cash flows and other firm benchmarks. The findings raise questions about the role of derivatives securities held by non-financial firms.

1. Introduction

Corporate risk management is thought to be an important element of a firm's overall business strategy. Stulz (1996, pp. 23-24) draws upon extant theories of corporate risk management to argue "the primary goal of risk management is to eliminate the probability of costly lower-tail outcomes – those that would cause financial distress or make a company unable to carry out its investment strategy."[1] Financial derivatives – currency, interest rate, and commodity derivatives – are one means of managing risks facing corporations. If a firm's derivative positions generate positive cash flows or value in periods of economic adversity, then those derivatives are deemed to hedge the firm's risk.

Previous research presents mixed evidence that corporate uses of financial derivatives are consistent with the extant theories of corporate hedging. With the exception of industry studies like Tufano (1996) and a detailed case study like Brown (2001), previous research analyzes categorical data on whether corporations use financial derivatives, or data on the notional principal of corporate derivative positions to test whether corporate uses of derivatives accord with the corporate risk management theories.[2] However, none of the previous studies documents large-sample evidence on the *magnitude* of risk hedged by the firms' financial derivatives. The primary objective of our study is to provide insight into the importance of corporations' financial derivatives portfolios in managing risk.

For a random sample of 234 large non-financial corporations, we present detailed evidence on the cash flow and market value sensitivities of financial derivative portfolios to extreme changes in the underlying assets' prices. That is, for simultaneous extreme changes in

[1] See Stulz (1984), Smith and Stulz (1985), DeMarzo and Duffie (1991), Froot, Scharfstein, and Stein (1993), Smith (1995), Ross (1997), and Leland (1998), among others.

[2] See Nance, Smith, and Smithson (1993), Dolde ((1995), Berkman and Bradbury (1996), Mian (1996), Tufano (1996), Geczy, Minton, and Schrand (1997 and 1999), Petersen and Thiagarajan (1997), Allaynnis and Ofek (1998), Haushalter (2000), Brown (2001), Gay and Nam (1999), Guay (1999), Howton and Perfect (1999), Rajgopal and Shevlin (1999), Loderer and Pichler (2000), Hentschel and Kothari (2001), and Graham and Rogers (2000).

interest rates, exchange rates, and commodity prices, we estimate (i) the dollar cash flow that a firm would derive from its derivatives portfolio, referred to as the cash flow sensitivity; and (ii) the change in the market value of the firm's derivatives portfolio, referred to as the market value sensitivity. For each sample firm, we estimate the derivatives portfolio's cash flow and market value sensitivities using corporate disclosures about the types of interest rate, currency, and commodity derivative securities held by a firm, the notional principals of each type of security, and the derivatives' remaining time to maturity. Information about corporate derivative positions is gathered from firms' Form 10-K filings with the Securities and Exchange Commission (SEC) for the fiscal year 1997.

In estimating the magnitude of risk hedged by a firm's derivatives portfolio, we make three assumptions intended to ensure that we do not underestimate the importance of derivatives securities in firms' hedging programs. First, we assume each firm's entire derivatives portfolio hedges its downside risk exposure (i.e., the cash flow generated by each derivative security is perfectly negatively correlated with the firm's unhedged cash flow). Second, we estimate the sensitivity of each firm's derivatives positions to extreme changes in the underlying asset prices (i.e., interest rates, currency exchange rates, or commodity prices), where we define an extreme change as three times the annual standard deviation of the historical time series of movements in the asset prices. Finally, we assume that the prices of all three underlying assets simultaneously experience a three standard deviation change, and that the effects of these price movements on the cash flows and value of firms' derivatives positions are perfectly positively correlated.

Summary of results. The median derivatives user's derivatives portfolio consists of interest rate derivatives with a notional principal of $200 million, currency derivatives with a notional principal of $123 million, and commodity derivatives with a notional principal of $51 million. The median (75th percentile) firm's derivative cash flow sensitivity is $15 ($85) million, and the market value sensitivity is $31 ($129) million. That is, when the median derivatives user firm simultaneously experiences a three standard deviation change in interest rates, currency exchange rates, and commodity prices, the entire derivatives portfolio rises in value by $31 million, with $15 million of this amount coming as cash flow in the current period. As indicated above, our calculations are generous in that we assume the underlying assets' price changes are all in the direction that would generate cash inflow from each firm's interest rate, currency, and commodity derivatives positions.

For most of the sample firms, the cash flow and market value sensitivities are small relative to the magnitudes of operating and investing cash flows, absolute values of the changes in operating cash flows, and measures of economic exposures. For example, the median derivatives user's annual operating cash flow and investing cash outflow are $178 and $178 million, respectively. As another example, our regression estimates of the sensitivity of the median firm's equity value to a three standard deviation change in interest rates and currency exchange rates is $825 million and $458 million, respectively. We reach similar conclusions when the cash flow and market value sensitivities are compared to the firms' other economic characteristics, such as firm size, cash holdings, PPE expenditures, and absolute changes in operating cash flow or accounting income.

In addition to reporting average magnitudes of cash flow and market value sensitivities for the derivatives users, we examine whether the firms that theory predicts to benefit most from hedging hold derivatives positions with relatively larger cash flow and market value sensitivities. For example, corporate hedging theories suggest that high volatility of firm value and cash flows, the presence of investment opportunities, and high leverage should incline firms to engage in hedging activities. We also consider agency theory predictions that managers might hedge to reduce contracting costs. For example, firms may allow CEOs with earnings- and stock-based compensation contracts to remove uncontrollable market risks, or may allow managers in a multi-divisional firm to hedge away market exposures in their respective performance. We find some evidence of increased use of derivatives for larger firms and firms with greater investment opportunities, as well as for more geographically diverse firms and when CEOs have a greater sensitivity of wealth to stock price. However, the magnitudes of the derivatives positions are quite small for all partitions of the data. For example, the quintile of firms with largest market-to-book ratios would receive 17% of its annual investing cash flow from its derivatives portfolio in the event of a simultaneous three standard deviation change in interest rates, currency exchange rates, and commodity prices. Further, several of the firm characteristics are correlated, and multivariate tests indicate that only geographic diversification consistently explains firms' hedging intensity.

In summary, the results suggest most firms hold derivatives positions that are small in magnitude relative to their typical investment cash flows or market value sensitivities. Maintaining an economically small derivatives program is potentially consistent with firms: i) using derivatives to "fine tune" their overall risk-management program that likely includes other means of hedging (e.g., operational hedges through diversified manufacturing sites),[3] ii) making decentralized decisions on derivatives use (e.g., divisional decision making) for internal budgeting or performance evaluation purposes,[4] or iii) using derivatives for purposes other than risk-management (e.g., to speculate on asset prices).

Outline of the paper. Section 2 reviews the theories of corporate risk management. Section 3 describes sample selection and presents descriptive statistics on the economic characteristics of sample firms and their derivative positions. The main results of the paper appear in Section 4. We report the sample firms' cash flow and market value sensitivities in the event of extreme changes in the underlying assets' prices. Section 4 also reports descriptive

[3] If this conclusion is valid, it emphasizes the importance of considering corporate derivatives use within the context of a much larger hedging program in empirical studies of corporate risk management. One potential driver of this finding is that much of the overall risk facing firms (e.g., operating risk) cannot be managed through the use of standard derivatives contracts written over assets prices such as interest rates, exchange rates and commodity prices. Further, some firms may restrict their use of derivatives to transaction-based hedging, such as managing the risk inherent in foreign sales/purchases or specific interest-bearing debt securities.

[4] Brown (2001) reaches some similar conclusions using extensive transaction-level derivatives data for one large multinational corporation. Specifically, he finds that the impact of the derivatives instruments has a limited effect on the firm's cash flows, and that internal budgeting and performance evaluation play a substantial part with respect to the objectives of the derivatives program.

statistics for the sensitivities as a fraction of the sample firms' economic exposures in the event of extreme movements in the underlying assets' prices and their historical average cash flow variability. We summarize the paper and offer conclusions in section 5.

2. Hypothesis development and risk management theory

In the absence of market imperfections, hedging does not affect firm value (Modigliani and Miller, 1958). The theory of corporate risk management identifies several market imperfections that can make volatility costly. These imperfections can be broadly summarized as: (i) financial distress costs (Myers, 1977; Smith and Stulz, 1985); (ii) costly external financing (Froot, Scharfstein, and Stein, 1993); (iii) taxes (Smith and Stulz, 1985); and (iv) costs of managerial risk aversion (Stulz, 1984; Smith and Stulz, 1985).

While all of the risk management theories posit that hedging can increase firm value, the type of firm risk targeted by the theories varies. The financial distress cost arguments generally point toward volatility of firm value as the risk measure to be hedged. Smith and Stulz (1985) argue that hedging can increase the value of a levered firm when the expected costs of financial distress are decreasing in firm-value. By narrowing the distribution of firm-value outcomes, hedging reduces the expected costs of financial distress. Myers (1977) demonstrates that financial distress can provide equityholders with incentives to forgo positive net-present-value projects if the gains accrue primarily to fixed claimholders. Hedging firm value reduces the probability of distress and the likelihood that equityholders will find it beneficial to pass up valuable projects.

The hedging theories that emphasize costly external financing focus on the volatility of cash flows as the risk measure to be hedged. For example, Froot, Scharfstein, and Stein (1993) hypothesize that if external financing is more costly than internal financing, hedging can be a value-increasing activity if it more closely matches fund inflows with outflows, thereby lowering the probability that a firm needs to access the capital markets. With respect to tax motivations for hedging, Smith and Stulz (1985) demonstrate that a reduction in the volatility of taxable income can lower expected taxes for firms with convex effective tax functions.[5] Finally, when managers are risk averse and under-diversified with respect to their compensation and firm-specific wealth, they are likely to require extra compensation to bear this risk. Thus, managers have an incentive to reduce firm risk and hedging can potentially reduce the required risk premium (Stulz, 1984 and Smith and Stulz, 1985). However, the type of risk targeted for hedging, be it cash flow, earnings, or stock price volatility, is likely to depend on the nature of the managers' compensation contract and firm-specific wealth.

The risk management theories are relevant to this study because our goal is to examine the extent to which firms hedge their risk exposures with derivative securities. The risk management theories described above point to at least three risk exposures of interest: (i) volatility of firm value; (ii) volatility of cash flows; and (iii) volatility of income. Because it is not possible to identify a single risk measure that fully captures a firm's motivation for using derivatives, we examine the magnitude of firms' derivatives positions relative to each of these risk measures for all sample firms.

To gain additional perspective on firms' risk management practices, we also examine the magnitude of risk hedged by the derivatives positions relative to other firm characteristics:

(i) Firm size measured as market value of equity, book value of assets, cash flow from operations, net income, and absolute values of the changes in operating cash flows and net income;

(ii) Investing activities measured as PPE expenditures and cash flow from investing activities;

(iii) Liquidity measured as cash and marketable securities;

(iv) Interest expense for firms that use interest-rate derivatives; and

[5] Although we do examine income volatility as a potential determinant of derivatives use, we do not conduct a detailed analysis of tax convexity as a determinant of derivatives use. Graham and Smith (1999) find that tax convexity is not large for most firms and Graham and Rogers (2000) find that tax convexity is not an important determinant of derivatives use.

(v) Exposures of stock returns to financial prices, such as interest rates for firms that use interest-rate derivatives and exchange rates for firms that use exchange-rate derivatives.

The preceding discussion focuses on firms' risk management incentives under the assumption that managers' incentives are aligned with the shareholders. However, agency considerations might motivate managers to use derivatives to further their self-interest. Managers of large firms with diversified business segment operations and geographically diverse operations might engage in hedging to smooth out their divisional performance. In addition, risk averse managers might seek to smooth out their divisional or firm-level earnings performance through derivatives because they are compensated based in part on their accounting performance. We use several proxies to capture managers' agency incentives for using derivatives and test whether these are correlated with the firms' intensity of derivatives use.

3. Sample selection and descriptive statistics

Section 3.1 describes our sample selection procedure and the derivatives variables for which we gather information from firms' financial filings. In section 3.2 we present descriptive statistics on a number of economic characteristics of the sample firms that are useful in assessing the degree to which firms' derivatives positions might hedge potential risks facing the firms. Section 3.3 explains the procedure we employ to calculate cash flow and market value sensitivities using information about firms' derivatives positions and extreme movements in the underlying asset prices.

3.1 Sample selection

We use the Compustat Annual database to identify an initial sample of the 1,000 largest market valued stocks as of the end of 1995. We also require that these stocks have return data on the Center for Research in Security Prices (CRSP) tapes and that they have a December fiscal year-end for financial reporting purposes. We focus on large stocks because previous evidence shows that large firms are more likely derivatives users (see, for example, Nance, Smith, and

Smithson, 1993, Graham and Rogers, 2000, and Hentschel and Kothari, 2000). Another reason is that the largest 1,000 firms represent a large fraction of the value-weighted portfolio of the U.S. stocks and thus are economically important. Availability of return data on CRSP enables us to estimate firms' economic exposures and market value sensitivities. Finally, restricting the sample to December year-end firms facilitates data analysis by allowing consistent assumptions about prevailing interest rates, exchange rates and commodity prices when we estimate cash flow and market value sensitivities.

From the initial sample of 1,000 largest firms, we select every other firm and reduce the sample to 500 firms. The reason for this reduction is to facilitate our hand collection of a significant quantity of information about each firm's derivative positions as of December 1997 from Form 10-K filings with the SEC for fiscal year 1997.[6] Of the 500 sample firms, 73 firms merged or went out of business between the sample selection year, 1995, and the year the derivatives data are collected, 1997. This attrition is more common among the smaller firms in the sample. We exclude firms if the Form 10-K filings indicate that derivatives are used for trading purposes as opposed to hedging purposes. We drop 15 firms that state trading as the purpose for at least a portion of their use of derivatives.

For each firm, we collect FYE 1997 information on the types of derivative securities held, the notional principal of each derivative instrument held, the remaining time-to-maturity of each instrument held, and whether the firm uses derivatives for trading purposes. Fiscal year 1997 is the latest year for which data were available at the time we began gathering data for this study. For 1997, GAAP pertaining to disclosure about financial derivatives is contained in Financial Accounting Standard No. 119, "Disclosure about derivative financial instruments and

[6] Even though we gather derivatives data for 1997, we select the sample from 1,000 largest firms as of 1995, not 1997. The reason is that market value is positively correlated with immediate past performance (i.e., largest firms are likely to have experienced good past performance and smallest firms bad performance). If firms' use of derivatives at the end of a period is correlated with past performance, use of 1997 market value rankings might have confounded with the analysis. To avoid this danger, we sample firms from amongst the 1,000 largest firms as of the end of 1995.

fair value of financial instruments," which was released in 1994. Appendix A contains a sample of derivatives disclosure according to SFAS 119 for Intel Corporation in its 1997 Form 10-K filing with the SEC.

3.2 Descriptive characteristics

In Table 1, we present means and medians of firm size and a number of operating flow variables, including three-year average cash flow from operations and average absolute change in cash flow from operations, average net income, and average property, plant, and equipment expenditures, etc. We select these variables because corporate hedging theories argue that risk management programs are designed to either make-up potential shortfalls in cash flows from operations to be used for investment purposes or to hedge against a drop in firm value. Later analysis calibrates changes in the market value of firms' derivatives positions against firm size, and cash flow from firms' derivative positions against operating flow variables and against absolute values of the changes in the flow variables. Such comparisons are one means of examining the extent to which firms' derivatives positions hedge market values, operating flows, and shocks to operating flows in the event of extreme changes in the underlying assets' prices.

For each descriptive variable, Columns 1 and 2 of Table 1 report mean and median values for the aggregate sample; the next two columns provide descriptive statistics separately for derivatives users and the last two columns contain data for derivatives non-users. Firms reporting derivative positions at fiscal year-end 1997 are users and non-users report no derivative positions. There are 234 (56.7%) derivatives users out of the aggregate sample of 413 firms and the remaining 179 (43.3%) firms are non-users of derivatives. We mainly discuss the descriptive statistics for the derivatives users because the analysis examining the extent to which derivatives are used for risk management pertains to derivatives users. While the average market value of $5.9 billion for the aggregate sample is large because of our sample selection criterion, the derivatives users are the relatively larger firms with an average market value of $8.6 billion, compared to $2.4 billion for the non-users. Market value as well as all other variables in Table 1 exhibit right skewness in that the medians are considerably lower than the means, but even the median firm is quite large.

[Table 1]

The flow variables in Table 1 are three-year annual averages using data from 1995 to 1997. The descriptive statistics suggest derivatives users generally have large positive operating cash flows, net incomes, and investment cash flows. Average annual cash flow from operations for the users is $735 million and these firms on average invest $454 million in property, plant, and equipment annually. The firms are highly profitable in that derivatives users' mean (median) average annual net income is $318 million ($74 million). As an indication of the cash flow shocks the derivative users experience, we report the three-year average absolute change in annual cash flow from operations and net income, as well as the maximum absolute change in annual cash flow from operations and net income during the years 1995-1997. The average (maximum) absolute change in cash flow from operations is $194 million ($349 million) for the derivatives users and the corresponding numbers for net income changes are $139 million ($230 million).

3.3 Derivatives data and descriptive statistics

Table 2 presents descriptive statistics on the notional principal of the derivatives positions as reported in the firms' Form 10-K filings at the 1997 fiscal year end. The information applies only to the 234 derivatives user sample firms. We partition the derivatives into foreign exchange, interest-rate, and commodity instruments. In each category, we further partition the instruments by type, e.g., swaps, forwards, and options. For each firm, we sum the notional principal for each type of security held in each category. The first column in Table 2 reports the number of firms that hold each type of security, and the next seven columns provide descriptive statistics for the outstanding notional principal calculated using data for the firms that hold those securities. The last two columns provide the mean and standard deviation of time-to-maturity for each category of securities held by the firms. Note that these descriptive statistics describe the reported derivatives positions held by the firms at fiscal year end and may differ somewhat from the average derivatives positions held by the firms during the year.

Consistent with the findings in previous research, Table 2 reveals that foreign exchange (FX) and interest rate (IR) derivatives constitute the bulk of the activity both in terms of the number of users and the amount of derivatives used. Within the FX derivatives category, 124 of the 143 users have positions in forwards and futures, whereas only 33 firms have FX swaps and 27 have FX options. Median notional principal of the FX forwards and futures users is $68 million and ranges from $0.6 million to $9.5 billion. The median notional principals are substantially greater for FX swap and option users at $243 million and $203 million, respectively. Of the 143 firms that hold IR derivatives, swaps are the most popular securities (137 users), whereas IR caps and forwards are used by only a handful of firms (24 users). The median firm's IR swap position, however, is only $180 million of notional principal. Thirty-six firms use commodity derivatives with a median notional principal of $40 million across all three instruments – forwards and futures, swaps, and options.[7]

[Table 2]

The average time-to-maturity of the FX and IR swaps is about 5 years compared to about 1-2 years for commodity derivatives and FX and IR forwards and options. This is not surprising because swap contracts are typically designed to hedge periodic cash flows over long horizons (e.g., bond interest payments), whereas long-horizon forwards and options contracts are extremely illiquid or non-existent.

4. Results: Derivative positions' market value and cash flow sensitivities

In this section, we present evidence on the cash flow and market value sensitivities of the derivatives positions to extreme changes in the underlying asset prices. We begin by describing

[7] For reporting purposes, certain types of commodity positions are not considered derivative instruments. For example, long-term purchase or sales contracts that fix commodity prices are not considered derivatives for reporting purposes if they are expected to settle in units of the commodity as opposed to cash.

how we calculate the sensitivities for each derivative security. We then examine the extent to which the derivative positions can potentially hedge firms' market values or operating flows in the event of extreme asset price movements. At the end of this section we explore whether the sensitivities of the derivatives positions are relatively larger for subsamples of firms with greater expected incentives to hedge. We also examine whether additional variables chosen to proxy for managers' agency-theory-based incentives to hedge (e.g., earnings smoothing and hedging in a multi-divisional firm) explain cross-sectional variation in the intensity of firms' hedging activities.

4.1 Estimation procedure for derivative sensitivities

We estimate the cash flow and market value sensitivities of each firm's aggregate derivatives portfolio position at 1997 fiscal year end. Cash flow sensitivity is defined as the change in the annual cash flow resulting from each derivative security in the portfolio for a three standard deviation annual change in the price of underlying asset (i.e., change in interest rates, exchange rates, or commodity prices). Similarly, we define market value sensitivity as the change in the value of each derivative security for a three standard deviation annual change in the prices of underlying assets. We assume that the cash flow and change in value are perfectly positively correlated within each class of derivative security (i.e., none of the positions are offsetting). Graham and Rogers (2000) report that, on average, after netting out offsetting long and short derivatives positions, firms' net notional principal is only 50% of gross notional principal. This finding suggests our measures of firms' gross derivative sensitivities are likely to substantially overstate firms' net derivative sensitivities. We estimate cash flow (market value) sensitivities for each firm as the sum of cash flow (market value) sensitivities across all the derivative securities in the portfolio.[8]

[8] We recognize that shocks to asset prices are not necessarily normally distributed, and as such, the probability of a three standard deviation change can be greater than that suggested by the normal distribution. Our choice of three standard deviations is simply intended to represent a low probability event.

The market value sensitivity measure is relevant to assessing the derivatives portfolio's importance for risk management if firms use derivatives to hedge firm value. For example, firms may wish to mitigate stock price exposure to changes in interest rates, exchange rates, or commodity prices to reduce the probability and costs of financial distress and underinvestment problems. The cash flow sensitivity measure is useful in gauging the importance of derivatives for risk management if firms use derivatives to hedge cash flows or income. For example, firms may use derivatives to dampen cash flow volatility to reduce the likelihood that they incur the costs of accessing external capital markets to undertake valuable investment opportunities.

We illustrate our estimation of the cash flow and market value sensitivities below using foreign exchange forwards and then discuss the estimation of interest rate and commodity derivative sensitivities. Similar details for other FX derivatives instruments, e.g., swaps and options, and for interest rate and commodity derivatives appear in Appendix B, with only a summary of the salient issues pertaining to the estimation procedure in the text below.

Cash flow and market value sensitivity of FX forwards. The cash flow sensitivity (market value sensitivity) of FX derivatives to exchange rate movements is measured as the estimated change in FX derivatives' annual cash flows (value) for a simultaneous, perfectly positively correlated 33% change in the currency exchange rates underlying the FX derivatives. We use 33% because it equals three times the average historical standard deviation of annualized percentage changes in the US dollar exchange rates for the ten most heavily weighted currencies in the Federal Reserve's Nominal Major Currencies Dollar Index. The annualized standard deviations are computed using quarterly observations over the 10-yr period from 1988 through 1997.[9]

[9] To annualize the exchange rate, interest rate and commodity price standard deviations, we multiply the quarterly standards deviations by the square root of 4. This procedure assumes independence across the quarterly changes. Empirically the autocorrelations across quarterly changes are small, ranging from -0.12 for our commodity price index to +0.14 for interest rate series.

The cash flow sensitivity of an FX forward contract to a three standard deviation change in the currency exchange rate is estimated as

($ notional principal) x 33%.

Because FX forwards almost invariably have maturities of a year or less, we assume the market value and cash flow sensitivities to be the same. For longer duration derivatives, such as swaps, the market value and cash flow sensitivities will be different, often substantially so. Even if the forward contract matures in less than one year, we assume a 33% rate change, which is greater than a three standard deviation change for a horizon of only a fraction of one year.

Interest rate and commodity derivatives. We measure market value (cash flow) sensitivity of IR derivatives to interest rate movements as the estimated change in IR derivatives' value (annual cash flow) for a 3.4 percentage point change in the 6-month yield on T-bills. The choice of 3.4 percentage points reflects a 3 standard deviation change in the annualized percentage point change in the 6-month T-bill yield using quarterly observations over the 10-yr period from January 1988 through December 1997.

We estimate commodity derivatives' sensitivity to a 37% change in the underlying commodity price. For our sample firms, a majority of the commodity derivatives are written over some form of fuel-related resource, e.g., petroleum and natural gas. The choice of 37% reflects a three-standard-deviation change in the annualized percentage return on the quarterly Producer Price Index for Fuel over the 10-yr period from January 1988 through December 1997. An alternative choice for the commodity index would be a more general index, such as the Producer Price Index for All Commodities. However, because this index reflects a portfolio of commodity prices, its volatility is far lower than the volatility of a single commodity index. For example, the annualized standard deviation of the All Commodities Index is 2% versus 12.5% for the Fuel Index, though the correlation between these two indexes is high at 0.81. Therefore, we choose the more volatile Fuel Index to avoid underestimating the sensitivity of the commodity derivatives positions.

4.2 Descriptive statistics on sensitivities

Table 3 reports descriptive data on cash flow and market value sensitivities for the derivatives users' aggregate derivatives portfolios and also by type of derivative security. The mean and median market value sensitivities for the firms' aggregate derivatives portfolios are $158 million and $31 million, respectively. The corresponding mean and median aggregate cash flow sensitivities are $112 million and $15 million. The disparity between the mean and median underscores the influence of a relatively few intensive derivatives users (e.g., the largest market value and cash flow sensitivities are $3.4 billion and $3.2 billion, respectively). On average, FX derivatives make a larger contribution to cash flow sensitivity than IR derivatives. However, because the average time to maturity for IR derivatives is considerably longer than that of FX derivatives, the contribution of IR and FX derivatives to market value sensitivity is roughly equal. For most firms, commodity derivatives contribute substantially less sensitivity than either FX or IR derivatives.

[Table 3]

In interpreting the sensitivities reported in Table 3, note that our assumptions in estimating aggregate sensitivity measures are extremely generous in the following respects: i) For each firm, all derivative securities of the same type are assumed to have payoffs that are perfectly positively correlated. For example, if a firm holds ten different FX contracts on ten different currencies, the value of all the contracts are assumed to move together. Similarly, if a firm holds a combination of IR swaps, caps, and forwards, the values of all the securities are assumed to move together with interest rates. ii) All option-like securities are assumed to be deep in the money, thereby we assume the maximum sensitivity. iii) The aggregate sensitivity is an estimate of the change in the value of a firm's derivative securities assuming a three standard shock simultaneously occurs for interest rates, exchange rates, and commodity prices. Further, we assume that the cash flow and value implications of all three shocks are perfectly positively correlated across all types of derivatives held.

To determine the likely implications of this third assumption for our results, we examine the correlation structure across interest-rate, exchange-rate and commodity (PPI) price indices for the period January 1988 to December 1997. The indices exhibit moderate cross-correlations, ranging from 0.23 to -0.40. To explore the extent to which our assumption of perfect positive correlation across the indices overstates the sensitivities in Table 3, we estimate the expected change in any two of the indices when the third index experiences a three standard deviation change. To do this, we first standardize the three time-series to have the same standard deviation in price changes and then estimate pair-wise regressions between each of the indices. The regression coefficients reflect the expected change in an index (measured in standard deviations) for a one standard deviation change in another index. Extrapolating these coefficients to a three standard deviation change yields the following table:

Three standard deviation change in:	Expected change in interest rates (in standard deviations)	Expected change in exchange rates (in standard deviations)	Expected change in commodity prices (in standard deviations)
Interest rates	3.0	0.8	0.4
Exchange rates	0.8	3.0	1.0
Commodity prices	0.4	1.0	3.0

The above table suggests that the probability of a simultaneous three standard deviation change in all three indices is much less likely than a three standard deviation change in any one index. Further, conditional on a three standard deviation change in one index, the expected change in the other two indices is considerably smaller than three standard deviations. This analysis suggests that our estimates substantially overestimate the aggregate cash flow and market value sensitivities of the derivatives positions in the event of a large shock to any one of the underlying asset prices.

4.3 Scaled sensitivities

If derivative securities are an important component of risk management programs designed to increase firm value, the potential change in the value of a firm's derivatives positions should be economically significant when compared to potential hedging objectives, such as firm value, operating flows, and/or the firm's underlying risk exposures. Since the appropriate comparison depends upon the objective of the risk management program and theories of risk management, we report results comparing firms' derivative positions' sensitivities to a variety of firm characteristics.

Table 4 scales firms' aggregate derivatives portfolios' cash flow and market value sensitivities by the sample characteristics in Table 1.[10] In interpreting the scaled sensitivities, we assume that the derivative securities' value is perfectly negatively correlated with the scaling variable, i.e., the derivatives are perfect hedges. To the extent that the derivatives are not a perfect hedge (and it is inconceivable that they are a perfect hedge for all of the scaling variables), the reported scaled sensitivities overstate the potential impact of the derivatives positions on the firms' risk management program. Also, note that, unlike the numerators in the scaled sensitivities, the data from the denominators are simply taken from the three most recent years, 1995-1997, and are not selected to reflect extreme realizations. Further, some of the scaling variables, such as cash flows, income and assets, are influenced by the cash flow realizations from firms' derivative positions. The extent to which our scaling variables reflect "normal" years and are affected by realizations from derivatives positions depends in part on whether movements in interest rates, exchange rates and commodity prices were "unusual" during the 1995-1997 period. An analysis comparing price movements during the 1995-1997

[10] The scaling variables measure firm characteristics that could potentially be targeted for hedging and are not direct measures of firms' risk exposures. It is possible that many of the firms' assets and cash flows are not highly sensitive to changes in interest rates, exchange rates and commodity prices. For these firms, the derivatives sensitivities are expected to be small relative to the firm characteristics, even if the firms are using derivatives to fully hedge their core exposures. However, in these cases, one would still conclude that derivatives use is not an economically important component of a risk management program designed to increase firm value.

period with price movements during the longer 1988-1997 period indicates that the 1995-1997 period was not unusual. Interest rate, exchange rate and commodity price volatilities were slightly lower during 1995-1997 compared to 1988-1997, and the 1997 levels of these asset prices were not substantially different from the 1995 levels.

Even with these and earlier discussed generous assumptions, the results in Table 4 suggest that for most firms, the sensitivities are not a large fraction of the scaling variables. For example, the market value sensitivity as a fraction of the market value of equity averages 0.04, the median is 0.01, and the 75th percentile is 0.04. Thus for three quarters of the sample firms, in the event of extreme simultaneous movements in interest rates, currency exchange rates, and commodity prices, the generously estimated change in the value of the firms' aggregate derivatives portfolio is no greater than 4% of their current equity market values.

[Table 4]

Average values of the cash flow sensitivities as a fraction of the firms' operating flow variables are quite large (e.g., 0.58 when the scale is three-year average CFO), but are driven by extreme observations (e.g., the maximum is 30.23), generally resulting from small denominators, i.e., low average flow values. The median scaled values are between 0.10 and 0.30 for most of the variables. For example, the estimated values suggest that the cash flow from the derivatives portfolio would be 9% of the three-year average investing cash flow in the event of extreme movements in the underlying asset prices. Considered in isolation, this increment to a firm's cash flows under extreme circumstances seems low, especially in light of the generous assumptions we make in estimating the sensitivities. The extent to which shocks to operating cash flows are hedged can be inferred from the cash flow sensitivity scaled by the three-year average of the absolute changes in operating cash flow or the three-year maximum absolute cash flow change. The median ratios of these two variables are 0.18 and 0.33. Overall, the evidence suggests either derivatives constitute a small fraction of a firm's overall risk-management program and/or firms leave a large portion of their financial risks unhedged, and/or derivatives securities are frequently used for purposes other than hedging entity-level risk.

The preceding analysis examines derivatives portfolios' sensitivities as a fraction of firm characteristics that proxy for the potential hedging needs of a firm. For another perspective on this issue, we next directly estimate firms' market value exposures to interest rates and currency exchange rates, and examine the extent to which firms' derivatives portfolios potentially hedge these exposures. We report estimated market-based exposures in Table 5 and scaled sensitivities in Table 6. The analysis below ignores exposure to commodity prices because a relatively small fraction of the sample firms uses commodity derivatives and firms do not consistently report all of the commodity prices to which they face risk exposure.

Table 5 reports sample firms' market-based exposures to interest rates and exchange rates, and volatility of market value of equity. To estimate interest-rate and exchange-rate exposures, we regress monthly stock returns on the monthly change in the 6-month T-bill yield, the monthly percentage change in the Federal Reserve's Nominal Major Currencies Dollar Index, and the monthly return on the CRSP value-weighted market index (for similar procedures, see Wong, 2000; Guay, 1999; and Hentschel and Kothari, 2001). We estimate the regressions separately for each sample firm using data for the 3 years ending December 1997. We define estimated interest rate exposure as the product of the absolute value of the regression coefficient on the interest rate variable multiplied by a 3.4 percentage point change in the 6-month T-bill yield, which serves as an extreme change in the interest rate. Since the regression coefficient is estimated using firms' stock returns as the dependent variable, the exposure calculated as above is denominated in percentage of the market value of equity, i.e., stock return. Similarly, the FX exposure is the absolute value of the regression coefficient on the FX variable times 33% change in the Federal Reserve's Nominal Major Currencies Dollar Index. In addition to return exposures, we also report dollar exposures. Dollar exposures are equal to the return exposures multiplied by the market value of equity at December 1997.

Results in Table 5 reveal that the sample firms' median market-based exposure to a three standard deviation change in interest rates is quite substantial at 25%, or in dollar terms, $0.83 billion. The firms' FX exposures are smaller than the interest rate exposures, but nevertheless quite substantial. The median FX exposure is 17% of the market value of equity or $0.46 billion. Note that because the estimates of interest-rate and FX exposures are net of any hedging activities, our measures underestimate the firms' core exposures to interest rates and exchange rates. We recognize that our tests may be hampered by estimation error in our measures of interest rate and exchange rate exposures. To examine the severity of this concern, we perform two sensitivity tests: (i) using only firms with statistically significant interest rate and exchange rate exposures, and (ii) using only firms with exposure coefficients that are in the top quartile with respect to the precision of the estimates (i.e., regression coefficients with standard errors in the lowest quartile). The inference from these sensitivity tests is the same as the inference from the reported results.

[Table 5]

We define firms' exposure to stock-return volatility as the annualized standard deviation of firms' monthly stock returns over the 3-year period ending December 1997. The dollar stock-return volatility is the annualized standard deviation of monthly returns multiplied by the market value of equity at December 1997. Table 5 shows that the sample firms' exposures measured in terms of stock-return volatility are comparable to interest-rate exposures. Firms' annualized stock-return volatility is on average 30% and the median is 26%.

Table 6 scales the market value sensitivities of the firms' derivative securities by the estimated dollar exposures to interest rates and exchange rates, and the dollar volatility of market value of equity. The median scaled sensitivities to IR and FX exposures are 0.03 and 0.06, respectively. The scaled sensitivities reflect the fraction of the change in stockholder value that would be offset by derivatives in the event of a shock to asset prices. For the scaled interest rate measure, the numerator includes only the market value sensitivity from interest rate derivatives.

Similarly, for the scaled exchange rate measure, the numerator includes only the market value sensitivity from FX derivatives. The market value sensitivity for all derivative securities are included in the numerator of the scaled market value of equity volatility measure.

As mentioned above, since estimated exposures are net exposures as opposed to core exposures, they impart an upward bias into the scaled sensitivities. The reason is that, assuming market efficiency, net exposures are smaller than core exposures because they already reflect the hedging consequences of the firms' derivatives portfolio. In spite of this bias in favor of the magnitudes of scaled sensitivities, the scaled sensitivities are small for most of the sample firms. These findings suggest that derivative securities are unlikely to have a significant impact on entity level interest-rate exposures, the exchange-rate exposures, or the stock return volatility.

Note that our inference is with respect to *entity-level* exposures as opposed to *transaction-level* exposures. Entity-level risk exposures subsume transaction-level exposures but also include operational risk exposures such as supply, demand and competitive effects related to changes in interest rates or exchange rates. We make no statements about the portion of a particular type of transaction-based exposure that is hedged, such as the fraction of foreign sales hedged with exchange rate derivatives or the portion of variable-rate debt that is hedged with interest rate derivatives. It is possible that contracting costs or the desire to qualify for hedge accounting treatment drive some firms to engage in transaction-level hedging. Our data simply suggest that if firms do hedge a large portion of these transaction-level exposures, then the transaction-level exposures make up a relatively small fraction of firms' overall market value exposures to interest rates, exchange rates and commodity prices.[11]

[Table 6]

[11] For example, Allayannis and Weston (2001) use the notional amount of foreign currency derivatives scaled by foreign sales as a proxy for the amount of exchange-rate exposure hedged by their sample firms. They find that this ratio averages 22%. Our results suggest that this hedge ratio overstates the amount exchange rate risk that firm hedge with exchange rate derivatives, in large part because foreign sales fail to capture important elements of entity-level exchange-rate exposure.

4.4 Risk-management theories and cross-sectional variation in scaled sensitivities

In this section we examine cross-sectional variation in the intensity of derivatives use. Evidence in the preceding sections indicate that most firms' derivatives positions are unlikely to significantly reduce the volatility of firm value or cash flows. However, it is possible that the intensity of derivatives use is economically large for firms with the greatest incentives to hedge according to risk-management theories. We therefore analyze the relation between variables that proxy for the determinants of hedging and firms' scaled cash flow and market value sensitivities. We also entertain the possibility that derivatives are used by firms for other purposes, such as to smooth income and/or to reduce contracting costs between the firm and risk-averse employees. An important feature of our inference that differs from previous research is that we emphasize the magnitude, not simply the statistical significance of the relation between derivatives use and determinants of hedging.

Proxy variables for determinants of hedging. Based on the risk-management theories discussed in section 2, we expect cash flow volatility, growth opportunities, and leverage to proxy for firms' incentives to hedge. We measure cash flow volatility as the average absolute change in the ratio of annual cash flow from operations to assets from 1994-1997. We also use an earnings-based volatility measure, calculated similar to the cash-flow-based measure, on the premise that earnings represent a forecast of a firm's future cash flow generating ability (see, e.g., Dechow, Kothari, and Watts, 1998). The market-to-book ratio of assets captures a firm's growth opportunities. Leverage is calculated as the ratio of debt to the market value of assets and serves as a proxy for the probability of financial distress.

We also examine firm size, segment diversification and geographic diversification. Firm size, measured as book value of assets, proxies for the potentially greater benefits of hedging for smaller firms because the direct costs of distress do not increase proportionately with firm size (Warner, 1977). In addition, previous research shows that small firms' earnings and cash flows are more volatile than those of large firms. Segment and geographic diversification are crude proxies for the degree of diversification of the sources of cash flows to the firm, suggesting a negative correlation between these variables and the demand for hedging. We estimate segment diversification with an entropy measure of total product diversification calculated from data on the Compustat Industry Segments File and is defined as $\Sigma P_i ln(1/P_i)$ where P_i is dollar sales of principal product *i* scaled by total firm sales. Geographic diversification is also an entropy measure calculated from data on the Compustat Geographic Segments File and equal to $\Sigma G_i ln(1/G_i)$ where G_i is dollar sales represented by geographic segment *i* scaled by total firm sales. We also include the cash and marketable securities variable described in Table 2. Substantial holdings of cash and marketable securities can act as alternative means of risk management by providing the firm with a buffer against cash shortfalls.

Firm size, segment diversification, and geographic diversification might also spur the demand for derivatives by managers because of contracting reasons. Large, diversified firms are more likely to be multi-divisional. At the divisional level, variation in profits or revenues due to variation in financial prices may be uninformative about managers' performance. If the costs of writing contracts to remove this variation are large, firms might rationally allow lower-level managers to smooth performance with derivatives, even though these positions are not large enough to significantly hedge entity-level risk. These firms' managers might engage in hedging to smooth out their divisional performance. Thus, whereas diversified sources of cash flows for these firms would suggest less intensive demand for derivatives, agency considerations would predict these firms to use derivatives more intensively.

A related contracting argument also applies to top executives, such as the CEO. Optimal contracts written between firms and their executives often impose risk on the executive through stock-based and accounting-based performance measures. The cost of these contracts to the firm increases with the noise in the performance measures. To reduce contracting costs, firms may allow executives to remove uncontrollable market risks through hedging with derivatives. We use two proxies to capture executives' incentives to mitigate uncontrollable market risks through hedging with derivatives. The first variable is a measure of stock-based incentives computed as the sensitivity of the value of a CEO's stock and option portfolio to a one percent change in stock price. We estimate the sensitivity of the CEO's option portfolio to stock price using the method described in Core and Guay (2000) and data from the Execucomp database. The second variable is a measure of the CEO's incentives from annual bonuses. This variable is defined as total cash bonus paid to the CEO over the previous three years as a fraction of the total pay to the CEO over the same period.[12] Total pay includes cash pay plus grants of restricted stock, options and other annual compensation, and is calculated using data from the Execucomp database and from proxy statements for firms not listed on Execucomp.

Evidence on cross-sectional variation in hedging intensity.

To explore how the intensity of derivatives use varies with hypothesized determinants, we partition the firms that use derivatives into quintiles based on the proxy variables described above. Table 7 reports median scaled sensitivities for the first, third, and fifth quintiles of the proxy variables. Although we report results for only three of the scaled sensitivities (i.e., market value sensitivity scaled by assets, cash flow sensitivity scaled by three year average investing cash flows, and cash flow sensitivity scaled by the largest absolute change in net income during the previous three years), the results are similar for the remaining scaled sensitivity measures.

[Table 7]

Table 7 indicates that the scaled sensitivities are not large for most of the quintile rankings. In no quintile does the median firm's market value sensitivity exceed 3.2% of assets. In the columns where hedging intensity is defined as scaled cash flow sensitivity, the median values are generally small, in most cases less than 0.30. Some of the hedging proxy variables are correlated with derivatives intensity in the direction predicted by theory. For example, hedging intensity increases with the ratio of market value to book value of assets across the quintiles.

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[12] We recognize that this variable measures managers' incentives to smooth earnings with error because it does not incorporate the influence of non-linearities in the shape of the bonus scheme.

However, while a positive *correlation* between hedging intensity and proxies for the incentives to hedge is consistent with risk management theory, such a finding is not sufficient to conclude that derivative securities are an economically important component of firms' hedging programs.

The largest median scaled cash flow sensitivity in Table 7 is 0.47 for the quintile of firms with the greatest geographic diversification (when the scaling variable is the largest absolute change in net income during the previous three years). In fact, geographic diversification exhibits the strongest and most consistent relation with derivatives intensity across the columns in Table 7. A potential confounding issue is that firm size also exhibits a consistent positive relation with derivatives intensity and larger firms are expected to be more diversified. In Table 8, we rank firms first into quintiles by size, and then within each size quintile by above and below median geographic diversification to explore whether firm size influences the observed relation between diversification and derivatives intensity. The results clearly suggest that geographic diversification, and not size, is strongly positively related to derivatives intensity. In each size quintile, firms with above median geographic diversification exhibit significantly higher derivatives intensity, and in several cases, the magnitude of the median firm's derivatives intensity is quite large.

[Table 8]

Multivariate regressions of derivatives intensity on the proxies for hedging incentives in Table 9 support the observed importance of geographic diversification in explaining derivatives intensity. These regressions use cash flow and market value sensitivities scaled by assets as the dependent variables. In each specification, geographic diversification is the only variable with a coefficient that is significantly different from zero. The coefficients on cash and marketable securities and the sensitivity of CEO wealth to stock price are in the predicted direction and marginally significant. Alternative regression specifications that use other scaled sensitivities from Table 4 as the dependent variable yield similar results. The results are also similar for a tobit specification that includes the non derivatives users as a way to control for self-selection issues. When the interest rate and exchange rate exposures reported in Table 5 are included as independent variables, their coefficients are generally *negative* and marginally significant, suggesting that firms with greater exposure to interest rates and exchange rates have *lower* derivatives intensity. However, none of the other results are altered when these variables are included.

[Table 9]

5. Summary and conclusions

In this paper, we examine the hypothesis that financial derivatives are an economically important component of corporate risk management. While previous research explores whether the corporate use of derivatives is consistent with theories of hedging, none of the previous studies documents large-sample evidence on the magnitude of a firm's risk exposure hedged by the financial derivatives. Absent such evidence, it is difficult to assess the importance of corporations' financial derivatives portfolios in managing risk.

For a random sample of 234 large non-financial corporations, we present detailed evidence on the cash flow and market value sensitivities of financial derivative portfolios to extreme changes in the underlying assets' prices. That is, for simultaneous extreme changes in interest rates, exchange rates, or commodity prices, we estimate (i) the dollar amount of cash flow that a firm would derive from its derivatives portfolio; and (ii) the change in the market value of the firm's derivatives portfolio. The median (75th percentile) firm's cash flow sensitivity to extreme changes in the underlying assets' prices is $15 ($85) million, and the market value sensitivity is $31 ($129) million. For most of the sample firms, these cash flow and market value sensitivities are small relative to the magnitude of traditional measures of economic exposures, or operating and investing cash flow measures. For example, the median firm holds derivative securities that, even under very generous assumptions, could hedge only 3% to 6% of its aggregate interest-rate and currency exchange rate exposures. Our inferences in this respect are broadly consistent across a variety of economic measures that capture different aspects of firms risk exposures.

Our results suggest that the magnitude of the derivatives positions taken by most firms is economically small in relation to their typical risk exposures. Maintaining an economically small derivatives program is potentially consistent with firms: i) using derivatives to "fine tune" their overall risk-management program that likely includes other means of hedging (e.g., operational hedges through diversified manufacturing sites), ii) making decentralized decisions on derivatives use (e.g., divisional decision making) for internal budgeting or performance evaluation purposes, or iii) using derivatives for purposes other than risk-management (e.g., to speculate on asset prices).

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Appendix A

Intel Corporation, Footnotes to Financial Statements for 1997

Derivative financial instruments

Outstanding notional amounts for derivative financial instruments at fiscal year-ends were as follows:

In millions)	1997	1996
Swaps hedging investments in debt securities	$ 2,017	$ 900
Swaps hedging investments in equity securities	$ 604	$ 918
Swaps hedging debt	$ 155	$ 456
Currency forward contracts	$ 1,724	$ 1,499
Currency options	$ 55	$ 94
Options hedging investments in marketable equity securities	$ --	$ 82

While the contract or notional amounts provide one measure of the volume of these transactions, they do not represent the amount of the Company's exposure to credit risk. The amounts potentially subject to credit risk arising from the possible inability of counterparties to meet the terms of their contracts) are generally limited to the amounts, if any, by which the counterparties' obligations exceed the obligations of the Company. The Company controls credit risk through credit approvals, limits and monitoring procedures. Credit rating criteria for off-balance-sheet transactions are similar to those for investments.

Swap agreements. The Company utilizes swap agreements to exchange the foreign currency, equity and interest rate returns of its investment and debt portfolios for floating U.S. dollar interest rate based returns. The floating rates on swaps are based primarily on U.S. dollar LIBOR and are reset on a monthly, quarterly or semiannual basis.

Pay rates on swaps hedging investments in debt securities match the yields on the underlying investments they hedge. Payments on swaps hedging investments in equity securities match the equity returns on the underlying investments they hedge. Receive rates on swaps hedging debt match the expense on the underlying debt they hedge. Maturity dates of swaps match those of the underlying investment or the debt they hedge. There is approximately a one-to-one matching of swaps to investments and debt. Swap agreements remain in effect until expiration.

Weighted average pay and receive rates, average maturities and range of maturities on swaps at December 27, 1997 were as follows:

	Weighted average pay rate	Weighted average receive rate	Weighted average maturity	Range of maturities
Swaps hedging investments in U.S. dollar debt securities	6.1%	5.8%	.9 years	0-3 years
Swaps hedging investments in foreign currency debt securities	6.3%	5.9%	1.0 years	0-3 years
Swaps hedging investments in equity securities	N/A	5.7%	.6 years	0-2 years
Swaps hedging debt	5.9%	5.2%	1.6 years	0-4 years

Note: Pay and receive rates are based on the reset rates that were in effect at December 27, 1997.

Other foreign currency instruments. Intel transacts business in various foreign currencies, primarily Japanese yen and certain other Asian and European currencies. The Company has established revenue and balance sheet hedging programs to protect against reductions in value and volatility of future cash flows caused by changes in foreign exchange rates. The Company utilizes currency forward contracts and currency options in these hedging programs. The maturities on these instruments are less than 12 months. Deferred gains or losses attributable to foreign currency instruments are not material.

Fair values of financial instruments

The estimated fair values of financial instruments outstanding at fiscal year-ends were as follows:

In millions)	1997 Carrying amount	1997 Estimated fair value	1996 Carrying amount	1996 Estimated fair value
Cash and cash equivalents	$ 4,102	$ 4,102	$ 4,165	$ 4,165
Short-term investments	$ 5,561	$ 5,561	$ 3,736	$ 3,736
Trading assets	$ 195	$ 195	$ 87	$ 87
Long-term investments	$ 1,821	$ 1,821	$ 1,418	$ 1,418
Non-marketable instruments	$ 387	$ 497	$ 119	$ 194
Swaps hedging investments in debt securities	$ 64	$ 64	$ 12)	$ 12)
Swaps hedging investments in equity securities	$ 8	$ 8	$ 27)	$ 27)
Options hedging investments in marketable equity securities	$ --	$ --	$ 25)	$ 25)
Short-term debt	$ 212)	$ 212)	$ 389)	$ 389)
Long-term debt redeemable within one year	$ 110)	$ 109)	$ --	$ --
Long-term debt	$ 448)	$ 448)	$ 728)	$ 731)
Swaps hedging debt	$ --	$ 1)	$ --	$ 13
Currency forward contracts	$ 26	$ 28	$ 5	$ 18
Currency options	$ 1	$ 1	$ --	$ --

Appendix B

For simultaneous extreme changes in interest rates, exchange rates, or commodity prices, we estimate for each sample firm: (i) the dollar amount of cash flow that a firm would derive from its derivatives portfolio, referred to as the cash flow sensitivity; and (ii) the change in the market value of the firm's derivatives portfolio, referred to as the market value sensitivity. We describe this estimation procedure below for each class of derivative security.

Foreign currency derivatives

For foreign currency derivatives, an extreme change is defined as a 33% change in the currency exchange rate. A 33% change equals three times the average historical standard deviation of annualized percentage changes in the US dollar exchange rate for the ten most heavily-weighted currencies in the Federal Reserve's Nominal Major Currencies Dollar Index. The annualized standard deviations are computed using quarterly observations over the 10-yr period from 1988 through 1997.

FX forwards

The cash flow and market value sensitivities of an FX forward contract to a 33% change in the currency exchange rate are estimated as:

($ notional principal) x 33%.

Because FX forwards almost invariably have maturities of a year or less, we assume the market value and cash flow sensitivities to be the same. For forward contracts that mature in less than one year, the assumed 33% change likely overstates a three standard deviation shock to exchange rates.

FX options

Market value sensitivity and cash flow sensitivity of an FX option to a 33% change in currency is estimated as:

($ notional principal) x 33%

Again, because FX options tend to have maturities of a year or less, we assume the market value and cash flow sensitivities to be the same.

Our sensitivity measure overestimates the actual sensitivity of most of the options because the computation assumes that all options are "deep in the money" (i.e., an option delta of one). For example, if the option is substantially out-of-the-money, the dollar sensitivity of option value to exchange rate movements is very small. The sensitivity of an option approaches the sensitivity of a forward contract (i.e., sensitivity of one) in the limit as it moves deep in the money. Because the strike price is rarely disclosed in the Form 10K footnotes, it is not possible to precisely estimate the option sensitivity with public data. While the time-to-maturity of the options is sometimes disclosed, this information alone is not sufficient to accurately estimate option sensitivity. Therefore, we assume all options have the maximum possible sensitivity.

FX swaps

Market value sensitivity of an FX swap to a 33% change in the currency exchange rate is estimated as:

($ notional principal) x 33%

The rationale is as follows. From Hull (1997),

Value of swap = $(S \times B_F) - B_D$

where

S = spot exchange rate expressed as number of units of domestic currency per unit of foreign currency,

B_F = the value, measured in the foreign currency, of the foreign-denominated bond underlying the swap, and

B_D = the value of the U.S. dollar bond underlying the swap.

Therefore, assuming

$B_F = B_D$ = notional principal of the swap in $US,

then

Market value sensitivity of FX swap = ($ notional principal) x 33%

This should roughly be true when the firm first enters into the swap since the interest rates on swaps are likely to be set so that each bond trades at par. However, as exchange rates and interest rates change over time, the above assumption will no longer be valid for all firms. Though, on average, it might still hold approximately.

Cash flow sensitivity of an FX swap to a 33% change in the currency exchange rate is estimated as:

Cash Flow Sensitivity of FX swap = ($ notional principal) x 8% x 33%

In a plain vanilla currency swap, the parties to the swap exchange interest payments in two foreign currencies each period and swap back the principal payments in the two foreign currencies at the maturity of the swap. Therefore, the sensitivity of the annual cash flows from a foreign currency swap to a given change in exchange rates depends on the size of the interest payment and the magnitude of the change in exchange rates. Because the interest rate underlying currency swaps is rarely disclosed in the 10K report, we assume that foreign currencies are swapped by all firms at an interest rate of 8%. This interest rate is larger than the interest rates on Treasury bills and five-year US bonds in effect at 12/31/97 (or at any time in the three-year period leading up to this date), and therefore is not likely to underestimate the cash flow sensitivity of FX swaps held by the sample firms.

We include foreign exchange interest rate swaps in this group. These are currency swaps that also swap fixed for floating interest rates and vice versa, in addition to the swap of currencies. For these swaps, the estimated FX sensitivity is like a comparative static. It measures the sensitivity to exchange rates holding interest rates constant. The sensitivity of this swap to exchange rates is computed just like the standard FX swaps above. However, since the value and cash flows of this type of swap are also sensitive to changes in interest rates, we include them in the IR sensitivity computations below as well.

Interest rate derivatives

We measure market value (cash flow) sensitivity of IR derivatives to interest rate movements as the estimated change in IR derivatives' value (annual cash flow) for a 3.4 percentage point change in the 6-month yield on T-bills. The choice of 3.4 percentage points reflects a 3 standard deviation change in the annualized percentage point change in the 6-month T-bill yield using quarterly observations over the 10-yr period from 1988 through 1997.

IR swaps

Cash flow sensitivity of an IR swap to 3.4% change in interest rates is estimated as:

Cash flow sensitivity of an IR swap = ($ notional principal) x 3.4%.

In a plain vanilla interest rate swap, each party either pays or receives a cash flow equal to a floating interest rate times the notional principal of the swap. Therefore, when interest rates change, the change in periodic cash flows equals the notional principal multiplied by the change in interest rates.

Market value sensitivity of an IR swap to 3.4% change in interest rates is estimated as follows. From Hull (1997),

$$\text{Value of swap} = B_{floating} - B_{fixed}$$

where

$B_{floating}$ = the value of the floating-rate bond underlying the swap, and

B_{fixed} = the value of the fixed-rate bond underlying the swap.

Assume

$B_{floating} = B_{fixed}$ = notional principal of the swap

$B_{floating}$ always equals notional principal immediately after a payment date. Since the swap normally has a value of zero at initiation, B_{fixed} should be equal to notional principal at initiation. Of course, this equality will generally not be true during the life of the swap. Though, on average, it might still hold approximately. Given this assumption,

Market value sensitivity of an IR swap = Change in B_{fixed} for a 3.4% change in interest rates

To compute this sensitivity, we must assume the fixed coupon rate that underlies the swap and the prevailing interest rates that should be used to discount the bond's cash flows. A random sampling of about 150 companies reveals that 40% of the sample firms provide information about the interest rates underlying their swaps. In these cases, the coupon rates almost always fall between 5.5% and 6.5%.

We assume that the coupon rate and discount rate are both equal to 6% for all swaps, all firms, and all maturities. We then perturb the discount rate by ±3.4%, to 2.6% and 9.4%, and compute the aggregate value of each firm's swaps at each of these discount rates. The average absolute value of the outstanding swaps computed at these two discount rates is taken as the interest rate sensitivity of the derivatives.

While most firms disclose the time to maturity of their swaps, some disclose a range of maturities, and others make no disclosure at all. For the firms that report a range of maturities, we take the midpoint of the range as the time-to-maturity. For companies that do not disclose anything, we assume a time-to-maturity of 5 years, which is the average swap maturity for the firms that do provide disclosure.

We also include the IR/FX swaps when computing interest rate sensitivities. As indicated above, these are IR swaps that also swap currencies. Here, as with the FX/IR swap, the sensitivity is like a comparative static. It measures the sensitivity to interest rates holding exchange rates constant. The sensitivity of this swap to exchange rates is computed just like the standard IR swaps above. Since this type of swap is also sensitive to changes in exchange rates, we include them in the FX sensitivity computations above.

IR forwards

We assume each forward contract is written on a 5-yr Treasury note with notional principal equal to the disclosed notional principal. We assume the firm holds the 5 yr note and estimate the cash flow sensitivity of the forward as the cash flow from the forward as a result of a 3.4% change in interest rates. Similar to our computations for interest-rate swaps, we assume that the initial discount rate on the note is 6% for all IR forwards. The initial value of the note is assumed to be equal to [\$ notional principal / $1.06)^5$]. We then perturb the interest rate by ±3.4%, to 2.6% and 9.4%, and compute the change in value of the notes at each of these discount rates. The average absolute change in value for the notes computed at these two discount rates is taken as the interest rate sensitivity of the IR forward derivatives. Because IR forwards held by our sample firms almost invariably mature within a year, we assume the market value and cash flow sensitivities to be the same.

We include the three sample firms with IR options in this group as well. As with the forwards, we assume the options are written on a 5-yr Treasury note. As with the FX options, this sensitivity measure should overestimate the "true" sensitivity because our computation is appropriate only for options that are "deep in the money".

IR Caps, IR Floors, IR Collars

Caps, floors, and collars are similar to swaps except that the swap payments occur only when interest rates are above (caps and collars) or below (floors and collars) some pre-specified interest rate. To compute an upper bound on the cash flow sensitivity, we assume that all caps, floors and collars are deep in the money. Under this assumption, if the interest rate changes by 3.4%, the annual cash flow from the cap changes by [3.4% * $ notional principal]. As such, we estimate the cash flow sensitivity of the cap, floor, or collar as 3.4% * notional principal. The estimation of market value sensitivity is more complicated because caps, floors, and collars are generally bundles of options that have staggered times to maturity. For example, a 5-year cap might be made up of 20 caplet options that expire each quarter. To compute an upper bound on the market value sensitivity, we again assume that all the caplets are deep in the money and that the annual cash flow from the cap changes by [3.4% * $ notional principal] when interest rates change by 3.4%. Thus, the market value sensitivity of the cap is the present value of an annuity, where the cash flow is equal to [3.4% * $ notional principal], and the length of the annuity is the time-to-maturity of the cap, floor, or collar. While a collar is the combination of a put option and a call option and specifies an upper and lower interest rate, only one of the options, either the put or the call, can be deep in-the-money at a given time. Therefore, the method used for caps and floors is a reasonable upper bound on the sensitivity of collars.

Commodity derivatives

The cash flow sensitivity of commodity derivatives to commodity price movements is measured as the estimated change in commodity derivatives' annual cash flow for a 37% change in the underlying commodity price. A majority of the commodity derivatives used by our sample firms are written over some form of fuel-related resource, e.g., crude oil and natural gas. The choice of 37% reflects a three-standard-deviation change in the annualized percentage return on the quarterly Producer Price Index for Fuel over the 10-yr period from January 1988 through December 1997. An alternative choice for the commodity index would be a more general index, such as the Producer Price Index for All Commodities. However, because this index reflects a portfolio of commodity prices, its volatility is far lower than the volatility of a single commodity index. For example, annualized standard deviation of the All Commodities Index from 1/88 through 12/97 is 2% versus 12.4% for the Fuel Index, though the correlation between these two indexes is high at 0.81. We choose the more volatile Fuel Index to avoid underestimating the sensitivity of the commodity derivatives positions.

Using the same logic described above for FX derivatives, the cash flow sensitivity of the commodity forwards and options for a 37% change in the price of the underlying commodity is estimated as:

Cash flow sensitivity of commodity forward = $ notional principal x 37%.

Because the commodity forwards and options held by our sample firms tend to mature in less than one year, we assume that the market value sensitivity of these securities is the same as their cash flow sensitivity.

For commodity swaps, the disclosed notional principal is the total quantity of the commodity swapped over the duration of the swaps held. The cash flow sensitivity varies somewhat over time depending upon the total quantity of the commodity swapped during each fiscal period. For simplicity, we assume that notional quantity swapped each year is equal to the total notional quantity swapped divided by the number of years until all the swaps mature. Therefore, the cash flow sensitivity of commodity swaps is estimated as:

Cash flow sensitivity of commodity swap = [$ notional principal x 37%] / maturity in years.

Since the notional principal represents the total quantity of commodity swapped over the duration of the swap, the market value sensitivity is estimated as:

Market value sensitivity of commodity swap = [$ notional principal x 37%]

For approximately 35% of the sample firms using commodity derivatives, the notional principal is stated in units of the underlying commodity instead of dollars. Some firms disclose units and price per unit, thus providing sufficient information to compute notional values. If only units are reported, we approximate the notional principal using commodity prices prevailing at the end of 1997.

Table 1
Sample Characteristics

Descriptive statistics on All figures in $millions	**All firms** Mean	Median	**Derivatives users** Mean	Median	**Derivatives non-users** Mean	Median
MV equity	5877	1673	8571	2376	2384	1145
Assets	5224	1496	7226	2050	2632	1118
3-yr avg. CFO	502	127	735	178	201	86
3-yr avg. NI	219	59	318	74	91	52
3-yr avg. cash + mkt. securities	253	55	374	71	93	41
3-yr avg. PPE expenditures	316	91	454	136	138	59
3-yr avg. investing CF	455	135	637	178	221	106
3-yr avg. interest expense	123	33	169	50	61	23
3-yr avg. absolute change in CFO	125	40	194	62	57	30
3-yr max. absolute change in CFO	241	67	349	104	101	48
3-yr avg. absolute change in NI	93	30	139	44	48	17
3-yr max. absolute change in NI	168	44	230	74	88	27
# of firms	413		234		179	

The sample consists of 413 firms selected uniformly from the 1000 largest firms on Compustat, ranked by market value of equity on December 31st, 1995. The descriptive statistics are reported for the fiscal year ending December, 1997. MV Equity is common shares outstanding at year end multiplied by stock price at year end (Compustat #24 x Compustat #25). Assets is book value of assets at year end (Compustat #6). Three-year Avg. (x) is the average of variable x using data for the three years leading up to fiscal year end 1997 when firms' derivatives positions are taken from the Form 10-K filings. CFO is cash from operating activities (Compustat #308). NI is net income before extraordinary items (Compustat #18). Interest Expense is interest expense (Compustat #15). Firms with no interest expense in the year leading up to the date of derivatives measurement i.e., no interest bearing debt in year t) are excluded under the assumption that these firms have no reason to use derivatives to hedge interest expense in year t. Cash +Mkt Securities is cash and short-term investments at year-end (Compustat #1). PPE Expenditures is capital expenditures (Compustat #30). Investing CF is cash flows from investing activities (Compustat #311). Absolute Change in CFO: Change in annual CFO (Compustat #308); three annual absolute changes are calculated using four annual CFO observations leading up to the date of derivatives measurement. Absolute Change in NI is calculated using income before extraordinary items (Compustat #18).

Table 2
Descriptive statistics on derivative positions

		Notional Principal in $million							Maturity in years	
Type of derivative	**# of users**	**Mean**	**Std. Dev.**	**Min**	**Q1**	**Median**	**Q3**	**Max**	**Mean**	**Std. Dev.**
FX derivatives										
FX forwards/futures	124	442.7	1100.5	0.6	12.1	68.4	403.5	9511.0	1.2	0.6
FX swaps	33	428.1	625.7	0.7	65.0	243.1	441.0	2874.0	4.8	4.2
FX options	27	290.5	387.4	6.0	42.8	202.9	354.7	1537.0	1.4	0.8
All FX derivatives	**143**	**537.5**	**1236.7**	**0.6**	**22.1**	**122.0**	**489.8**	**9561.0**	**2.4**	**2.8**
IR derivatives										
IR swaps	137	474.8	697.2	3.8	100.0	180.0	495.0	3678.0	5.0	5.6
IR caps	15	205.0	255.2	17.7	80.0	100.0	200.0	1003.4	4.7	5.2
IR forwards	9	367.8	458.7	50.0	85.0	200.0	350.0	1500.0	1.1	0.2
All IR derivatives	**143**	**499.5**	**746.4**	**3.8**	**100.0**	**200.0**	**500.0**	**3678.0**	**5.4**	**6.2**
Commodity derivatives										
Commodity forwards/futures	25	128.9	186.8	0.5	21.2	39.4	200.0	679.0	1.9	1.4
Commodity swaps	13	189.3	278.6	2.2	23.3	50.0	205.8	974.0	1.8	1.2
Commodity options	8	123.5	223.9	1.4	6.4	41.9	112.9	664.0	1.5	0.8
All Commodity derivatives	**36**	**190.6**	**243.5**	**0.5**	**21.2**	**39.9**	**275.9**	**974.0**	**2.3**	**2.0**

The sample consists of 234 firms that report derivatives use for hedging purposes at fiscal year end 1997. This sample is obtained from a sample of 413 firms selected uniformly from the 1000 largest firms on Compustat, ranked by market value of equity on December 31st, 1995.

Table 3
Cash flow and market value sensitivities of firms' derivatives portfolios at the end of 1997

Type of derivative	Mean	Std. Dev.	Minimum	Q1	Median	Q3	Maximum
Market value sensitivity, $million							
FX derivatives	108.4	330.2	0.0	0.0	3.6	61.1	3155.1
IR derivatives	39.4	88.9	0.0	0.0	4.2	34.1	676.0
Commodity derivatives	10.5	42.7	0.0	0.0	0.0	0.0	360.4
All derivatives	**158.3**	**372.1**	**0.2**	**8.6**	**31.2**	**128.7**	**3422.9**
Cash flow sensitivity, $million							
FX derivatives	90.1	286.8	0.0	0.0	3.0	41.3	3140.0
IR derivatives	11.6	26.3	0.0	0.0	2.3	10.3	244.8
Commodity derivatives	9.9	41.2	0.0	0.0	0.0	0.0	360.4
All derivatives	**111.5**	**299.8**	**0.2**	**4.4**	**15.3**	**84.7**	**3238.8**

Market value sensitivity of a firm's derivatives position is the change in the value of each derivatives security in the portfolio for a given change in the prices of underlying assets. Cash flow sensitivity of a firm's derivatives position is the change in the annual cash flow resulting from each derivative security in the portfolio for a given change in the price of underlying asset (i.e., change in interest rates, exchange rates, or commodity prices). The sum of cash flow sensitivities or market value sensitivities across all the derivative securities yields the cash flow sensitivity and market value sensitivity for the entire derivatives portfolio under the assumption that prices of all the underlying assets simultaneously experience the assumed change (i.e., three standard deviations of annual changes). Details on this procedure are provided in Appendix B.

Table 4
Scaled cash flow and market value sensitivities of firms' derivatives portfolios at the end of 1997
Cash flow sensitivities are scaled by operating flow variables and market value sensitivities are scaled by the market value of equity or the firm's book value of assets

	Mean	Std. Dev.	Minimum	Q1	Median	Q3	Maximum
Mkt. Cap. Sensitivity / MV equity	0.04	0.09	0.00	0.00	0.01	0.04	1.15
Mkt. Cap. Sensitivity / Assets	0.03	0.09	0.00	0.00	0.02	0.04	1.20
CF Sensitivity / 3-yr avg. annual CFO	0.58	2.98	0.00	0.03	0.10	0.27	30.23
CF Sensitivity / 3-yr avg. annual NI	0.84	2.74	0.00	0.07	0.19	0.53	34.95
CF Sens. from IR derivatives / 3-yr avg. interest exp.	0.35	1.07	0.00	0.05	0.12	0.26	11.37
CF Sensitivity / 3-yr avg. Cash + Mkt. Securities	1.18	2.67	0.00	0.06	0.28	1.23	27.37
CF Sensitivity / 3-yr avg. annual PPE expenditures	0.57	1.92	0.00	0.04	0.17	0.48	22.49
CF Sensitivity / 3-yr avg. annual Investing CF	0.40	1.22	0.00	0.03	0.09	0.34	15.08
CF Sensitivity / 3-yr avg. absolute chg. in annual CFO	0.87	1.67	0.01	0.10	0.33	0.88	14.02
CF Sensitivity / 3-yr max. absolute chg. in annual CFO	0.50	0.94	0.00	0.06	0.18	0.53	9.11
CF Sensitivity / 3-yr avg. absolute chg. in annual NI	1.09	1.71	0.00	0.14	0.42	1.27	10.81
CF Sensitivity / 3-yr max. absolute chg. in annual NI	0.65	0.96	0.00	0.09	0.25	0.74	6.46

Market value sensitivity of a firm's derivatives position is the change in the value of each derivatives security in the portfolio for a given change in the prices of underlying assets. Cash flow sensitivity of a firm's derivatives position is the change in the annual cash flow resulting from each derivative security in the portfolio for a given change in the price of underlying asset (i.e., change in interest rates, exchange rates, or commodity prices). The sum of cash flow sensitivities or market value sensitivities across all the derivative securities yields the cash flow sensitivity and market value sensitivity for the entire derivatives portfolio under the assumption that prices of all the underlying assets simultaneously experience the assumed change (i.e., three standard deviations of annual changes). Details on this procedure are provided in Appendix B.

MV Equity is common shares outstanding at year end multiplied by stock price at year end (Compustat #24 x Compustat #25). Assets is book value of assets at year end (Compustat #6). Three-year Avg. (x) is the average of variable x using data for the three years leading up to fiscal year end 1997 when firms' derivatives positions are taken from the Form 10-K filings. CFO is cash from operating activities (Compustat #308). NI is net income before extraordinary items (Compustat #18). Interest Expense is interest expense (Compustat #15). Firms with no interest expense in the year leading up to the date of derivatives measurement i.e., no interest bearing debt in year t) are excluded under the assumption that these firms have no reason to use derivatives to hedge interest expense in year t. Cash +Mkt Securities is cash and short-term investments at year-end (Compustat #1). PPE Expenditures is capital expenditures (Compustat #30). Investing CF is cash flows from investing activities (Compustat #311). Absolute Change in CFO: Change in annual CFO (Compustat #308); three annual absolute changes are calculated using four annual CFO observations leading up to the date of derivatives measurement. Absolute Change in NI is calculated using income before extraordinary items (Compustat #18).

Table 5
Stock-return-based exposures

	Mean	Std. Dev.	Median
Interest rate exposure in percent of market value of equity	0.33	0.29	0.24
Interest rate exposure in dollars of market value of equity	$2939 mil	$8258 mil	$825 mil
FX exposure in percent of market value of equity	0.25	0.25	0.17
FX exposure in dollars of market value of equity	$1748 mil	$3988 mil	$458 mil
Stock-return volatility: annualized standard deviation of monthly returns	0.30	0.15	0.26
Stock-return volatility: expected annualized standard deviation of the market value of equity	$2068 mil	$4746 mil	$627 mil

The regression model for estimating interest rate and exchange rate exposures is $R_{it} = a + b_1 \Delta$ T-Bill $rate_t + b_2 \% \Delta FX_t + b_3 R_{mt} + \varepsilon_{it}$. Interest rate and FX exposures are reported only for those firms holding interest rate and FX derivatives, respectively. Interest rate exposure in percent of market value of equity is the absolute value of the coefficient from a three-year regression of monthly stock returns on the monthly percentage change in the 6-month T-bill rate (b_1 in the regression model) multiplied by a 3.4% change in 6-month T-bill rate. Interest rate exposure in dollars of market value of equity is the interest rate exposure in percent of market value multiplied by the market value of equity at the end of 1997. FX exposure in percent of market value of equity is the absolute value of the coefficient from a three-year regression of monthly stock returns on the monthly percent change in the trade-weighted exchange index (b_2 in the regression model) multiplied by a 33% change in trade-weighted exchange index. FX exposure in dollars of market value of equity is the FX exposure in percent of market value multiplied by the market value of equity at the end of 1997. Stock-return volatility: annualized standard deviation of monthly returns is computed over the three years leading up to December, 1997. Stock-return volatility: expected annualized standard deviation of the market value of equity is the three year annualized standard deviation of monthly returns multiplied by the market value of equity at the end of 1997.

Table 6
Firms' derivative portfolios' market value sensitivities scaled by return-based exposures

	Mean	Std. Dev.	Minimum	Q1	Median	Q3	Maximum
Mkt. Cap. Sensitivity / IR exposure	0.29	1.53	0.00	0.01	0.03	0.12	17.08
Mkt. Cap. Sensitivity / FX exposure	0.95	4.51	0.00	0.02	0.06	0.24	44.17
Mkt. Cap. Sensitivity / Stock-return volatility	0.10	0.19	0.00	0.01	0.04	0.12	1.82

Market value sensitivity of a firm's derivatives position is the change in the value of each derivatives security in the portfolio for a given change in the prices of underlying assets. The sum of market value sensitivities across all the derivative securities yields the market value sensitivity for the entire derivatives portfolio under the assumption that prices of all the underlying assets simultaneously experience the assumed change (i.e., three standard deviations of annual changes). Details on this procedure are provided in Appendix B. IR exposure, FX exposure, and stock-return volatility are the interest rate exposure in dollars of market value of equity, FX exposure in dollars of market value of equity, and the stock-return volatility: expected annualized standard deviation of the market value of equity as described and summarized in Table 5.

Table 7
Median scaled cash flow and market value sensitivities for first, third, and fifth quintiles of firm-year observations ranked independently on determinants of hedging

Measure of hedging → / Quintile of the proxy for determinants of hedging → / Proxy variables for determinants of hedging ↓	Median Mkt. Cap. Sensitivity / Assets			Median CF Sensitivity / 3-yr avg. annual Investing CF			Median CF Sensitivity / Largest absolute chg. in annual NI from previous three years		
	1st	3rd	5th	1st	3rd	5th	1st	3rd	5th
Leverage	0.017	0.015	0.021	0.139	0.084	0.074	0.139	0.178	0.187
Market-to-book assets	0.016	0.015	0.022	0.052	0.111	0.171	0.167	0.187	0.211
3-yr avg. absolute chg. in annual (NI / assets)	0.012	0.019	0.018	0.054	0.093	0.146	0.190	0.254	0.190
3-yr avg. absolute chg. in annual (CFO / assets)	0.012	0.018	0.025	0.081	0.110	0.321	0.411	0.171	0.126
Fraction of total pay as bonus	0.016	0.013	0.013	0.110	0.100	0.078	0.204	0.200	0.363
Cash + marketable securities	0.013	0.017	0.013	0.058	0.079	0.130	0.247	0.213	0.154
Sensitivity of wealth to stock price	0.014	0.011	0.020	0.054	0.104	0.180	0.215	0.249	0.604
Assets	0.013	0.013	0.019	0.093	0.082	0.130	0.146	0.162	0.393
Segment diversification	0.015	0.018	0.013	0.074	0.140	0.110	0.260	0.186	0.166
Geographic diversification	0.010	0.008	0.032	0.045	0.071	0.256	0.113	0.108	0.471

Fraction of total pay as bonus is total cash bonus paid to the CEO over the previous 3 years / total pay to the CEO over the previous 3 years. The sensitivity of wealth to stock price is the sensitivity of the value of a CEO's stock and option portfolio to a one percent change in stock price. Total diversification is an entropy measure of total product diversification calculated from data on the Compustat Industry Segments File and equal to $\Sigma P_i ln(1/P_i)$ where P_i is dollar sales of principal product *i* scaled by total firm sales. Geographic diversification is an entropy measure of geographic diversification calculated from data on the Compustat Geographic Segments File and equal to $\Sigma G_i ln(1/G_i)$ where G_i is dollar sales represented by geographic segment *i* scaled by total firm sales. All other variables are defined in Tables 1 and 4.

Table 8

Discriminating between firm size and geographic diversification as determinants of cash flow and market value sensitivities

Geographic diversification → / Asset quintile ↓	Median Mkt. Cap. Sensitivity / Assets		Median CF Sensitivity / 3-year average annual Investing CF		Median CF Sensitivity / 3-year average absolute change in annual NI		Median CF Sensitivity / Largest absolute change in annual NI from previous three years	
	Below median	**Above median**	**Below median**	**Above median**	**Below median**	**Above median**	**Below median**	**Above median**
Smallest	0.01	0.01	0.07	0.18	0.24	0.54	0.10	0.19
2	0.02	0.02	0.05	0.14	0.44	0.68	0.21	0.41
3	0.01	0.02	0.05	0.15	0.49	0.16	0.14	0.17
4	0.00	0.02	0.03	0.20	0.14	0.58	0.07	0.28
Largest	0.01	0.03	0.07	0.26	0.25	1.32	0.17	0.50

Firms are ranked first into quintiles based on total assets and then ranked within each size quintile into above and below median geographic diversification. All variables are defined in Tables 1, 2 and 7.

Table 9
Regressions of cash flow and market value sensitivities on determinants of derivatives use

Independent variables	**Predicted sign**	**Dependent variable (%)**	
		Cash Flow Sensitivity / Assets	**Mkt. Cap. Sensitivity / Assets**
Intercept		4.37	1.56
		(1.01)	(0.93)
Leverage	+	-2.77	1.43
		(-0.87)	(1.16)
Market-to-book assets	+	-0.43	0.25
		(-0.82)	(1.24)
Log(assets)	-	-0.38	-0.27
		(-0.72)	(-1.31)
Segment diversification	+/-	-1.03	0.08
		(-1.19)	(0.18)
Geographic diversification	+/-	**3.68**	**1.74**
		(2.57)	**(3.13)**
Fraction of total pay as bonus	+	-4.94	-1.31
		(-1.33)	(-0.91)
Sensitivity of wealth to stock price	+	0.65	0.24
		(1.50)	(1.41)
3-yr avg. cash +marketable securities	-	-5.40	-3.21
		(-1.03)	(-1.58)
3-yr avg. absolute chg. in annual (CFO / assets)	+	12.16	5.64
		(0.72)	(0.87)
3-yr avg. absolute chg. in annual (NI / assets)	+	12.16	5.64
		(0.72)	(0.87)
# of observations		223	223
Adjusted R-squared		3.1%	6.1%

t-statistics are in parentheses. All variables are defined in Tables 1, 2 and 7.