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Journal of Multinational Financial Management
10 (2000) 237–255

Journal of
MULTINATIONAL
FINANCIAL
MANAGEMENT

www.elsevier.com/locate/econbase

An innovative analysis of taxes and corporate hedging

Latha Shanker *

Department of Finance, Concordia University, 1455 de Maisonneuve Blvd. West, Montreal, Quebec, Canada H3G 1M8

Received 15 July 1999; accepted 18 February 2000

Abstract

Theoretical research predicted that firms with convex tax schedules would hedge to minimize expected taxes. However, previous empirical research did not detect a relationship between derivative use and tax losses carry forward, which contribute to tax schedule convexity. This study aims to show that the tax incentive to hedge depends on tax losses carry forward and the ability of the firm to carry losses forward and back, which depends on the distribution of taxable income. A new measure of the tax incentive to hedge, which incorporates this, will be proposed. Hedging could be accomplished by methods other than by using derivatives. Measures of hedging activity which incorporates the effect of all methods of hedging, and which are consistent with previous theoretical research, will also be proposed. Using the new measures of the tax incentive to hedge and hedging activity, the firm's tax incentive to hedge will be empirically established to significantly influence its hedging activity[1]. © 2000 Elsevier Science B.V. All rights reserved.

Keywords: Hedging; Taxes

1. Introduction

Theoretical research on the tax motivation for corporate hedging (Smith and Stulz, 1985) showed that firms would hedge, if they face a tax schedule that is a convex function of the pre-tax value of the firm. If the firm faces a convex tax

* Tel.: +1-514-8482791; fax: +1-514-8484500.
E-mail address: latha@vax2.concordia.ca (L. Shanker).

[1] JEL classification: H25, G31, G33

PII: S1042-444X(00)00027-X

function, it could minimize its expected taxes by hedging the volatility of its pre-tax value and thereby maximize its post-tax value. The firm would face a convex tax function, if its pre-tax income was in the progressive range of the corporate income tax code (between $0 and $100 000) or if it had tax preference items such as investment tax credits or net operating losses carry forward.

Since most publicly traded firms have a range of pre-tax income which lies above the range of progressivity in the corporate income tax code and the Tax Reform Act of 1986 eliminated investment tax credits for property put into place after 1985, most recent empirical research on the tax incentive to hedge has focussed on the effect of net operating losses carry forward.

Previous empirical research on the motivation for corporate hedging or corporate use of derivatives has measured the tax incentive to hedge by the following variables: (1) the unscaled value of tax losses carry forward (Nance et al., 1993); (2) a binary 0-1 variable, which is assigned a value 1 in the presence of tax losses carry forward and 0 otherwise (Mian, 1996); (3) the value of tax losses carry forward scaled by the size of the firm (Tufano, 1996; Géczy et al., 1997; Gay and Nam, 1998). All of these empirical studies did not detect any relationship between corporate hedging or corporate use of derivatives and the tax loss carry forward variable.

This study shows analytically that while the magnitude of tax losses carry forward is important, the tax incentive to hedge depends upon the firm's ability to use tax losses as well as carry losses forward and back, which depends upon the distribution of its taxable income. The analysis identifies the types of firms that would have an incentive to hedge to reduce expected taxes and proposes a new variable that measures the tax incentive to hedge more accurately. This analysis owes its inspiration to Shevlin (1990), in which Shevlin shows that the marginal tax rates of firms depend not just on the presence or absence of net operating losses carry forward, but also upon future realizations of taxable income.

Nance et al. (1993) and Mian (1996) classified firms as hedgers if they used derivatives such as forwards, futures and swaps, and as non-hedgers if they did not use derivatives. Tufano (1996) focussed on the management of gold price risk by gold mining firms, which was done primarily through the use of gold derivatives or gold loans. Géczy et al. (1997) investigated firms' use of currency derivatives, while Gay and Nam (1998) studied corporations' use of currency, interest-rate and commodity derivatives.

There are some limitations in attempts to infer what motivates corporations to hedge, from the results of the above empirical research. First, while corporations may hedge risks by using derivative contracts, they may also hedge these risks by using other methods. For example, firms may hedge risks by entering into guaranteed price contracts with their suppliers or customers, by merging with other firms, by diversifying across industries or by purchasing insurance. For the above reason, the reported use or non-use of derivatives would not present an accurate measure of corporate hedging activity. Tufano (1996) points out that his measure of risk management does not take into account the gold mining firm's ability to manage risk through its operating risk management activities. Second, firms that report the

use of derivatives in their financial statements, do not always distinguish between derivatives used for hedging and those used for speculation, as Mian (1996) observes. Thus, some firms may be classified as hedgers if they report usage of derivatives, while they could be using derivatives to speculate. Third, firms may elect to hedge some risks and not others. By focussing on one risk alone, a firm may be erroneously classified as a non-hedger. For example, a gold mining firm may not hedge its gold price risk, but may elect to hedge interest rate risk or foreign currency risk. The focus on gold price risk management may understate such a firm's hedging activities (Tufano, 1996).

Therefore, two measures of hedging activity are proposed here which incorporate the effects of all of the firm's various hedging activities. The first measure used here is the standard deviation of the net operating income of the firm over a future period. This measure is consistent with the minimum variance hedge ratio model of Ederington (1979), which focuses on hedging the firm's profits. The second measure used here is the standard deviation of the market value of the firm over a future period. This measure is consistent with Smith and Stulz (1985) who define hedging as hedging the value of the firm. Since these variables may be impacted by the hedging activity of the firm, as well as by industry effects, these effects are controlled for in the empirical research.

The relationship between corporate hedging activity and the tax incentive to hedge as well as other firm characteristics is empirically analysed for all firms for which data is available on the Compustat tapes. The results show that the tax incentive to hedge is a significant determinant of corporate hedging activity.

The remainder of this paper is organized as follows. Section 2 models the tax incentive to hedge. Section 3 describes the measures of corporate hedging activity. Section 4 describes other motivators of corporate hedging. Section 5 describes the methodology of the empirical research and presents the findings. Section 6 concludes the paper.

2. A model of the tax incentive to hedge

Assume that there are two possible states of the world, State 1, which is labelled a 'good' state and State 2, which is labelled a 'bad' state, with an equal probability of occurrence of 0.5. All firms face the same statutory tax rate, which is equal to 34%. Interest rates are constant at 10% per year. The definition of hedging that is used here is minimizing variability of income. The measure of the tax incentive to hedge that is used here is termed TIH. Four possible cases are analysed in what follows.

2.1. Zero net operating losses from previous years and zero probability of a tax loss in current year

Consider Firm A, which has no net operating losses from previous years. Firm A expects that its taxable income in the current year will be \$200 in State 1 and \$100

in State 2. Its expected taxable income is \$150 and the standard deviation of its taxable income is \$50. At a 34% tax rate, its tax liability is \$68 in State 1 and \$34 in State 2. Its expected tax liability is \$51.

Firm A cannot reduce its expected tax liability by hedging. If Firm A hedges the variability of its taxable income, so that its taxable income is \$175 in State 1 and \$125 in State 2, its expected taxable income is \$150 and its standard deviation of taxable income is reduced to \$25. Its tax liability is \$59.50 in State 1 and \$42.50 in State 2. Its expected tax liability is \$51, which is the same as its expected tax liability if it did not hedge.

Firms such as firm A, with zero net operating losses from previous years and a zero probability of a tax loss in the current year, have no tax incentive to hedge and TIH is assigned a value of 0. This situation corresponds to situation 1, summarized in row 1 of Table 1.

2.2. Zero net operating losses from previous years and a probability of tax losses in the current year

Consider Firm B, which has no net operating losses carry forward from previous years. Firm B expects to have taxable income of \$400 in State 1 and tax losses of \$100 in State 2. Its expected taxable income is \$150. Its standard deviation of taxable income is \$250. Its tax liability in State 1 is \$136. If the tax loss of \$100 in State 2 is carried back to reduce taxes in the previous three years at the rate of 34%, its tax reduction in State 2 is \$34 and its expected tax liability is \$51.

Firm B cannot reduce its expected tax liability by hedging, if tax losses are carried back fully. Suppose Firm B hedges, so that its taxable income in State 1 is \$350 and its tax loss in State 2 is \$50. Its expected taxable income is \$150 and the standard deviation of its taxable income is \$200. Its tax liability in State 1 is \$119. If the tax loss in State 2 is carried back to reduce taxes in the previous 3 years at the rate of 34%, its tax reduction in State 2 is \$17 and its expected tax liability is \$51, thus leading to no reduction in expected taxes.

If the tax losses of the current year can be fully utilised to reduce taxable income of the previous 3 years, the firm will have no tax incentive to hedge and the variable TIH will have a value 0. This situation corresponds to situation 2, which is summarized in row 2 of Table 1.

If, however, there is a positive probability that the firm will not be able to fully use up its tax losses through offset of its taxable income of the past 3 years, but will have to carry its tax losses forward to future years, there will be a tax incentive to hedge, as is shown in the following sub-section. Such firms have zero net operating losses from previous years, a probability (<1) of having a tax loss in the current year and a probability that the tax loss in the current year is greater than the sum of the taxable income in the last 3 years, so that the tax losses have to be carried forward. For these firms, the tax incentive to hedge TIH is given by:

$$P(\text{Tax loss in current year} < \text{sum of taxable income of last 3 years})$$

Table 1
Summary of possible situations faced by a firm[a]

Situation	Net operating losses from previous year	*P*(Taxable income of current year < 0)	Use of tax losses	Tax incentive to hedge TIH	Number/percentage of firm-year observations	Mean/S.D. of TIH
1	Zero	Zero	–	0	128 1.91%	0 0
2	Zero	Non-zero	Carried back	0	1834 27.34%	0 0
3	Zero	Non-zero	Carried forward	*P*(Tax loss in current year < sum of taxable income of last 3 years)	3254 48.51%	0.169 0.327
4	Non-zero	Zero or non-zero	Carried forward	*P*(Taxable income in current year < net operating losses of previous years)	1395 20.80%	0.735 0.322
5	Non-zero	Zero	Used in current year	0	0 0%	–
6	Non-zero	1	Carried forward	0	97 1.45%	0 0

[a] Corresponding values of the tax incentive to hedge variable TIH and mean and standard deviation of TIH for 6708 firm-year observations over 1986–1990.

This situation corresponds to situation 3, which is summarized in row 3 of Table 1.

2.3. Non-zero net operating losses from previous years and a zero or non-zero ($\neq 1$) probability of a tax loss in the current year

Consider Firm C which has net operating losses carry forward from the previous year of \$150. It expects to have taxable income of \$200 in State 1 and \$100 in State 2. Its expected taxable income is \$150 and the standard deviation of its taxable income is \$50. After considering the effect of net operating losses carry forward, Firm C's taxable income in State 1 is \$50 and its taxable income in State 2 is $-$\$50. Its tax liability in State 1 is \$17.

If the effective net operating loss carry forward of \$50 in State 2 is used in the next period to reduce taxes at the rate of 34%, its tax reduction in the next period would be \$17 and the present value of this tax reduction in the current period would be \$15.45, since the interest rate is 10%. This gives rise to an expected tax liability of \$0.77.

Firm C could reduce its expected tax liability by hedging. Suppose Firm C hedges the variability of its taxable income, so that its taxable income in State 1 is \$175, its taxable income in State 2 is \$125, its expected taxable income remains the same but the standard deviation (S.D.) of its taxable income reduces to \$25. After considering the effect of net operating losses carry forward, Firm C's taxable income is \$25 in State 1 and -\$25 in State 2. Its tax liability in State 1 is \$8.50. If the effective net operating loss carry forward of \$25 in State 2 is used in the next period to reduce taxes at the rate of 34%, its taxes payable in the next period would be reduced by \$8.50 and the present value of this tax reduction in the current period would be \$7.73, giving rise to an expected tax liability of \$0.38. Thus, a reduction of expected taxes by \$0.39 (from \$0.77 to \$0.38) is achieved by hedging.

If firms have non-zero net operating losses carry forward from the previous period, which are larger than taxable income in some possible states of the world, so that the tax losses have to be carried forward, then these firms will have an incentive to hedge. In this case, the tax incentive to hedge TIH is assigned the value:

$$P(\text{Taxable income in the current year} < \text{net operating losses carry forward})$$

This situation corresponds to situation 4, which is summarized in row 4 of Table 1.

In the above example, the firm expected to have a positive taxable income in each state, before application of the net operating losses carry forward. The results are valid even if the firm expects a tax loss in one state, before application of the net operating losses carry forward.

If the net operating loss is not sufficient to cause the taxable income to become negative in some states of the world, then the net operating losses will be used up in the current year. The situation will be similar to that of Firm A and there will be no reduction of expected taxes accomplished by hedging. In this case, the tax

incentive to hedge will be assigned the value of 0. This situation corresponds to situation 5, which is summarized in row 5 of Table 1.

2.4. Non-zero net operating losses from previous years and certainty of a tax loss in the current year

Consider Firm D, which has a net operating loss carry forward of \$1 from the previous year. It expects to have a tax loss of \$100 in State 1 and a tax loss of \$200 in State 2. Its expected taxable income is $-$\$150 and the standard deviation of its taxable income is \$50. If its effective tax losses of \$101 and \$201 in States 1 and 2 respectively are carried forward to reduce taxes in the next period at the rate of 34%, the present value of the tax reductions in the current period would be \$31.22 and \$62.13 in States 1 and 2 respectively and its expected tax reduction would be \$46.67 in the current period.

Firm D cannot reduce its tax liability by hedging. Suppose Firm D hedges, so that its tax loss in State 1 is \$125 and its tax loss in State 2 is \$175, its expected taxable income is $-$\$150 and the standard deviation of its taxable income is \$25. If its net tax losses of \$126 and \$176 in States 1 and 2 respectively are used up in the next period to reduce taxes at the rate of 34%, the present value of the tax reductions in the current period would be \$38.94 and \$54.40 in States 1 and 2 respectively and its expected tax reduction would be \$46.67. Thus, no reduction in expected taxes is achieved by hedging.

Firms with non-zero net operating losses from previous periods and a certainty that the taxable income in the current year will be less than 0, have no incentive to hedge to reduce expected taxes. For these firms, TIH is assigned a value of 0. This situation corresponds to situation 6, which is summarized in row 6 of Table 1.

2.5. Estimation of the tax incentive to hedge TIH

As seen in Table 1, three probabilities are to be calculated in order to assign a value to TIH. These are: P(Taxable income in current year < 0), P(Tax loss in the current year $<$ sum of taxable income in the last 3 years) and P(Taxable income in the current year $<$ net operating losses carry forward from previous years).

It is assumed that the distribution of the taxable income of the firm in the current year, prior to hedging, is the same as the distribution of taxable income in the last 5 years. The mean values of taxable income and the standard deviation of taxable income are calculated for each firm for each year in the period 1986 through 1990 using data on taxable income for the 5 previous years. As in Shevlin (1990), the taxable income is defined as the firm's reported pre-tax book income less the change in its deferred tax account which has been grossed up by the top statutory tax rate. Pre-tax book income is the sum of income before extraordinary items, income taxes, minority interest and extraordinary items and discontinued operations. The probabilities used in Table 1 are then calculated, by standardizing the taxable income in the current year by using the estimated mean and standard deviation and then using the tables of the standard normal probability distribution.

Table 1 shows the number as well as the percentage of the 6708 firm-year observations which fall within each of the six different possible situations. Note that 48.51% of the observations have a tax incentive to hedge arising from the probability that tax losses in the current year will have to be carried forward to future years. The tax incentive to hedge TIH for these observations has a mean of 0.169 and a standard deviation of 0.327. A total of 20.80% of the observations have a tax incentive to hedge due to the probability that net operating losses of previous years will have to be carried forward to future years. The tax incentive to hedge TIH is higher for these observations, with a mean of 0.735 and a standard deviation of 0.322. In comparison, Graham and Smith (1999), who simulated the tax function for firms using observations on taxable income over 1980–1994, concluded that in 50% of the observations, the firms had a convex tax function, and therefore, had a tax incentive to hedge.

If, as theory predicts, the tax incentive to hedge influences the corporation's hedging decision, TIH should be positively related to the firm's degree of hedging.

3. Measures of corporate hedging activity

3.1. Different methods of hedging used by firms

Measurement of the degree of hedging by a corporation is complicated by several factors. Hedging may be accomplished by a corporation in several different ways. Uncertainty in the costs of inputs used in the production process may be reduced by using commodity futures contracts. However, the uncertainty may also be reduced by entering into contracts with suppliers, which are valid for specified periods of time, in which the price of the input is fixed (or lies within a narrow price range). Uncertainty in the prices of outputs may similarly be hedged by using commodity futures contracts or by entering into guaranteed-price contracts with customers. These contracts, which are forward contracts in spirit, would not be included in the company's reported use of off-balance-sheet hedging instruments. There are other methods that the company could employ to reduce risk. These include diversifying its investments across industries and countries, buying insurance, managing the maturity structure of its debt, using natural hedges such as borrowing in the foreign currency to offset the exchange rate risk associated with cash inflows which are denominated in a foreign currency, using its customers' credit history to only deal with those who are good credit risks, as well as entering into forward, futures, options and swap contracts to manage commodity, interest rate and exchange rate risks.

3.2. Accounting reporting guidelines on derivative use

Nance et al. (1993) used the results of a survey to classify companies as hedgers (104 firms) or non-hedgers (65 firms) based on the companies' reported usage or non-usage of forwards, futures, options and swaps in 1986. Mian (1996) used

disclosures provided in the footnotes to annual reports by 3022 firms in 1992 to classify them into hedgers (771 firms) and non-hedgers (2251 firms). These disclosures were mandated by the Statement of the Financial Accounting Standards Board 105 (SFAS 105) issued by the Financial Accounting Standards Board (FASB) in March 1990 (FASB, 1990). SFAS 105 governed the disclosure of information about financial instruments with off-balance-sheet risks and concentrations of credit risk. The information provided under SFAS 105 related principally to the use of derivative financial instruments, whether for hedging or for speculative purposes.

SFAS 119 was issued by the FASB in October 1994 (FASB, 1994). It sought to improve upon the disclosures provided under SFAS 105 by requiring that companies distinguish between those derivatives used for hedging and those used for trading purposes. SFAS 119 was to be effective for fiscal years ending after December 1994 for companies with $150 million or more in total assets and one year later for smaller companies.

3.3. Limitations of using reported derivative usage to measure hedging activity

There are limitations in using the information provided under the above statements to discern the company's degree of hedging activity. Under the disclosures mandated by SFAS 105, it would be difficult to differentiate between derivative usage for hedging purposes and derivative usage for speculative purposes. Under the disclosures mandated by SFAS 119, it would be possible to differentiate between hedging and speculative use of derivatives by all companies, but only for fiscal years ending after December 1995.

Further, SFAS 105 and SFAS 119 only mandate disclosure on the use of derivative financial instruments. Therefore, while it may be correct to classify a firm as a hedger if it discloses that it uses derivatives, it would be incorrect to classify a firm as a non-hedger if it does not use derivatives, simply because it may hedge risk by using methods that do not involve the use of derivatives. Examples of such methods have been pointed out earlier in this section. In further support, Belk and Glaum (1990) concluded from a study of the management of foreign exchange risk by UK multinationals, that balance sheet exposure to this risk was managed by cash market hedges, namely, by adjusting the currencies of lending and borrowing, while transaction exposures were managed by using foreign exchange derivatives.

Further proposals to strengthen the disclosure of derivative use were released by the Securities and Exchange Commission (SEC) in December 1995 (Higgins, 1996). Higgins reported that the US Treasury Management Association (TMA) pointed out in its reply to the SEC, that its proposals would require release of quantitative information by companies that used derivatives to hedge their risk, but would not be required of companies that hedged their risk by other means. As an illustration, the TMA argued that a grain miller that hedged its wheat price exposures with wheat futures would be forced to disclose this, while a grain miller that hedged its wheat purchase by buying a farm would make no disclosure under the SEC's proposals.

Even if the firm used derivatives solely for hedging purposes and it hedged only through the use of derivatives and by no other method, it would still be incorrect to use the firm's reported use of derivatives as a measure of the degree of its hedging activity, as the following example illustrates.

Consider a firm which desires to hedge the interest rate risk exposure caused by a commercial paper portfolio with a face value of $1 million. Its hedging choices are 90 day Tbill futures contracts or 90 day Eurodollar futures contracts, with sizes equal to $1 million face value of the underlying instrument. Suppose the firm uses Ederington's minimum variance hedge ratio model to determine its optimal position in the futures contracts. The hedge ratio is given by cov (ΔS,ΔF)/V(ΔF), where ΔS and ΔF are the corresponding changes in the spot and futures prices respectively. Suppose the model yields a hedge ratio of 0.8 (0.6) when Tbill (Eurodollar) futures are used as the hedging instrument. This difference in hedge ratios could be due to differences in the covariances between the changes in the futures prices and the spot price and/or differences in the variances of the futures prices. Suppose the futures prices are $95 ($90) per $100 of face value for the Tbill (Eurodollar) futures contract. If the value of futures contracts is reported in the firm's financial statements, then the reported value of futures when Tbill futures are used to hedge would be $760 000 ($0.8 \times \$1$ million $\times 0.95$) and the reported value of futures contracts when Eurodollar futures are used to hedge would be $540 000 ($0.6 \times \$1$ million $\times 0.90$). If the reported value of derivative contracts is used as a measure of hedging activity, then, for a firm with a given incentive to hedge, its degree of hedging activity would seem to be lower if it used Eurodollar futures to hedge rather than Tbill futures. Extending this example further, two firms with the same risks and the same incentives to hedge may seem to have different hedging activity as measured by the reported value of futures contracts, if one used Tbill futures and the other used Eurodollar futures to hedge.

Thus, as in Nance et al. (1993) and Mian (1996), the most that can be done with the firm's reported use of derivatives is to use a binary 1-0 classification of the firm as a hedger or a non-hedger. This classification is not very informative and cannot distinguish between firms on the basis of the degree to which they are hedged, which should surely vary with the magnitude of the incentives to hedge.

3.4. Proposed measures of hedging activity

The degree of hedging by a corporation in a given year is therefore estimated in this paper by the corporation's desired risk level in a future period. This is estimated by two measures. The first measure, SIGOI, is the standard deviation of the firm's net operating income measured over the next 5 years. Using the standard deviation of net operating income is consistent with Ederington's minimum variance hedge ratio model, which focuses on minimizing variance of hedged profits. A second measure of hedging activity that is used is the standard deviation of the market value of the firm over the next 5 years, which is termed SIGMV. The market value of the firm that is used here is the sum of the book values of debt and preferred stock and the market value of common equity. This measure is used, since

the theoretical model of Smith and Stulz (1985) defines hedging as hedging the value of the firm.

These measures should incorporate the effects of all of the corporation's hedging activities, whether accomplished through the use of off-balance-sheet financial instruments or through the investment, production or marketing processes. Using these measures for this purpose assumes that the degree of risk attained in the future is synonymous with the degree of risk sought. The higher SIGOI or SIGMV, the lower the degree of hedging activity by the firm.

The limitation associated with using these variables as measures of the hedging activity of the firm, is that they may be impacted by other factors, such as the nature of the industry. For example, the uncertainty in net operating income may be higher for the mining industry than for the service industry. The industry effects are controlled for in the empirical research, by using industry dummy variables as control variables.

4. Other variables that influence corporate hedging activity

The hedging activity of the firm could also be influenced by the firm's objective to minimize the expected costs of financial distress, the underinvestment problem, which arises from the presence of agency costs and external financing costs, and hedging costs.

4.1. Costs of financial distress

Smith and Stulz (1985) argued that hedging could reduce the probability that the firm would find itself in financial distress and thereby could increase firm value by decreasing its expected costs of financial distress. The decrease in the expected costs of financial distress depends on the probability of financial distress and the costs that the firm would face if it encountered financial distress.

The greater the proportion of fixed claims in the firms' capital structure, the greater the probability that the firm would encounter financial distress. As in Nance et al. (1993), Géczy et al. (1997), Gay and Nam (1998), the probability of financial distress is measured by the interest coverage ratio and the debt ratio. The interest coverage ratio, termed INTCOV, is the ratio of the firm's earnings before interest and taxes to its interest expense. The higher this is, the lower the probability that the firm would find itself in financial distress. INTCOV should be negatively related to hedging activity. The debt ratio, termed DEBTR, is the ratio of the book value of debt to the market value of the firm. The market value of the firm is measured by the sum of the book value of debt and preferred stock and the market value of common equity. The higher the debt ratio, the more likely that the firm will encounter financial distress and DEBTR should be positively related with hedging activity.

Smith and Stulz (1985) cite Warner (1977), who found that the direct costs of financial distress are less than proportional to firm size, to argue that small firms

would have more to gain from hedging than large firms. The size of the firm is measured by LSIZE, which is the natural logarithm of the sum of the book value of debt and preferred stock and the market value of common equity. LSIZE should be negatively related with hedging activity.

4.2. The underinvestment problem

Agency costs arise due to conflicts between bondholders and shareholders. External financing costs are costs associated with raising funds from external sources, which make these more expensive than internally generated funds.

Myers (1977) showed that shareholders would not invest in profitable investment projects, if the gains from these projects would go primarily to the bondholders. This is known as the underinvestment problem. Since bondholders would be aware of this possibility, they would incorporate it into the price of the firm's bonds, which would make it more costly for the firm to raise debt. The firm could alleviate the negative effects of the underinvestment problem, by hedging and thereby, decreasing the probability associated with states in which gains from profitable projects would go primarily to the bondholders.

The underinvestment problem would be of more consequence for firms which face many future growth opportunities and face costly external financing. As in Géczy et al. (1997), the presence of future growth options is measured by RDR, which is the ratio of research and development expenses to sales. Gay and Nam (1998) point out that previous research on the effect of future growth options on hedging activity is inconclusive and that firms which have high growth options and have low cash stocks should have the greatest incentive to hedge to alleviate the underinvestment problem. The availability of cash is measured by CASHR, which is the ratio of the firm's cash and short-term investments to current liabilities. A variable, RDCASH, which accounts for the interaction between the presence of growth options and low cash availability, is calculated as the product of RDR and 1/CASHR. This variable should be positively related to the firm's hedging activity.

As in Gay and Nam (1998), other variables are also used to measure the firm's growth options. These are the ratio of the market value of the firm to its book value, termed MVBVR, and the price-earnings ratio of the firm's common stock, termed PER. These are multiplied by 1/CASHR to determine other measures of the interaction between growth options and cash availability. The interaction between the market value to book value ratio and the cash variable is termed MBCASH. The interaction between the price-earnings ratio and the cash variable is termed PECASH. Both these variables should be positively related to the firm's hedging activity.

4.3. Hedging costs

Large firms may face lower hedging costs than small firms, since they may find it easier to hedge using futures and options markets, due to institutional features such as fixed size contracts. Large firms may face lower transactions costs in

hedging in the swaps and forward markets due to discounts on large volume. Thus, large firms would have a greater incentive to hedge. If hedging costs are proportionately lower for large firms, hedging activity should be positively related to the variable LSIZE.

4.4. Industry effects

The measure of hedging activity used in this paper is SIGOI, which is the standard deviation of net operating income over the next 5 years, or SIGMV, which is the standard deviation of the market value of the firm over the same period. These variables may be influenced by industry effects. In order to control for industry effects, dummy variables are used to distinguish between seven broad industry groups. The dummy variables D_1 through D_6 have a value of 1 if the firm belongs to the mining (SIC codes 1000–1500), construction (SIC codes 1501–1800), manufacturing (SIC codes 1801–4000), transportation (SIC codes 4001–4899), wholesale (SIC codes 5000–5199) and retail (SIC codes 5200–5999) groups respectively and 0 otherwise. Firms with 0 values for D_1 through D_6 are in the services industry (SIC codes 7000–9000). The net operating loss carry forward which is used in calculating the tax incentive to hedge is not available for regulated utilities and financial institutions such as banks, life insurance companies and real estate investment trusts. Therefore, regulated utilities and financial institutions are not included in this study.

5. Methodology and results of empirical tests

5.1. Construction of the sample

The sample of firms consists of all firms for which data are available on the Compustat Annual Industrial, Annual Industrial Research, Annual Over-the-Counter and Annual Over-the-Counter Research Tapes between the years 1981 and 1995. Annual data on the firms' total assets, cash and short term investments, current liabilities, long term debt, other liabilities, preferred stock, price of common stock, common shares outstanding, earnings before interest and taxes, interest expense, research and development expenses, sales, earnings per share, net operating losses carry forward from previous years, income before extraordinary items and discontinued operations, minority interest, extraordinary items and discontinued operations and change in the deferred tax account are obtained from the tapes. These data are used to calculate the measures of hedging as well as the tax incentive to hedge and other firm characteristics described in Sections 2–4.

Table 2 shows the mean and standard deviation of the measures of hedging activity, SIGOI and SIGMV, and the variables that affect hedging activity, TIH, DEBTR, INTCOV, LSIZE, RDRCASH, MBCASH and PECASH. While data on firm characteristics are available for the period 1986 through 1995, the dependent variables SIGOI and SIGMV are calculated for each year as the standard deviation

of net operating income or market value over the next 5 years and are therefore only available for the period 1986 through 1990. Thus, there are a total of 6708 firm-year combinations used in the analysis. These include observations on 1233 firms in 1986, 1318 firms in 1987, 1330 firms in 1988, 1390 firms in 1989 and 1437 firms in 1990. Each variable is then standardized, by subtracting the mean from the variable and dividing the result by its standard deviation.

The Pearson correlation coefficients between all the above standardized variables is next calculated. These results are available from the author on request. TIH is significantly positively correlated with DEBTR and significantly negatively correlated with LSIZE. Thus, in the sample of observations, firms with high debt ratios and small firms have a greater tax incentive to hedge. INTCOV and DEBTR are significantly negatively correlated, which would be expected, since they are measures of leverage. RDCASH, MBCASH AND PECASH are significantly positively correlated, which would be expected, since they are measures of the interaction between growth options and cash availability. This could lead to multicollinearity if all of the correlated variables were used simultaneously together in a regression equation to determine the relationship between hedging activity and the motivating variables.

5.2. Specification of the empirical relationship

In theory, the relationship between the measure of hedging and the explanatory factors could be analysed by regressing the measure of hedging activity on a set of independent variables, which includes the measure of the tax incentive to hedge, one measure of financial distress costs, one measure of the interaction between

Table 2
Mean and standard deviation of measures of hedging and influencing variables over 1986–1990

Variable	Mean	S.D.
Measures of hedging		
S.D. of net operating income SIGOI ($ millions)	76.663	260.771
S.D. of market value of firm SIGMV ($ millions)	897.463	3196.421
Motivators of hedging		
Reduction in expected taxes		
Tax incentive to hedge TIH	0.235	0.380
Reduction in financial distress costs		
Interest coverage ratio INTCOV	25.684	227.651
Debt ratio DEBTR	0.437	0.243
Alleviation of underinvestment problem		
Interaction between proportionate expenditure on research and development and cash availability RDCASH	0.284	3.848
Interaction between the market-to-book value ratio of firm value and cash availability MBCASH	30.678	221.575
Interaction between price-earnings ratio and cash availability PECASH	239.745	4381.210
Number of observations	6708	

growth options and cash availability and the measure of hedging costs. Since the tax incentive to hedge is significantly negatively related to the size of the firm and significantly positively related to the firm's debt ratio, the variables LSIZE and DEBTR are not included when analysing the relationship between the measure of hedging activity and the tax incentive to hedge. The following empirical relationship between the standardised values of the measure of hedging activity and the standardised values of the independent variables is analysed.

$$\text{Measure of hedging activity} = a_0 + a_1 \cdot \text{TIH} + a_2 \cdot \text{INTCOV} + a_3 \cdot \text{measure of interaction between growth options and cash availability} + a_4 \cdot D_1 + a_5 \cdot D_2 \ldots a_9 \cdot D_6 + \varepsilon \quad (1)$$

a_0 through a_9 are the coefficients of the independent variables and ε is the error term of the regression. Based on the analysis of Sections 2–4, a_1 should be statistically significantly negative if hedging activity is influenced by the tax incentive to hedge. a_2 should be significantly positive, if firms with high costs of financial distress hedge more. a_3 should be significantly negative if firms with high future growth options and low cash availability hedge more.

The measure of hedging activity is either the standardised measure of the standard deviation of future net operating income SIGOI or the standardized measure of the standard deviation of future market value of the firm SIGMV. The measure of interaction between growth options and cash availability is in turn RDCASH, MBCASH and PECASH. Table 3 reports the results of the regression when the measure of interaction between growth options and cash availability is RDCASH. The results when MBCASH and PECASH were used as measures of the interaction between growth options and cash availability are similar to the results using RDCASH and are available from the author on request.

Tests for autocorrelation and heteroscedasticity are conducted. The Durbin–Watson statistic is used to test for autocorrelation and is significant at the 95% confidence level. White's chi-squared test is used to test for heteroscedasticity (White, 1980). The chi-squared statistic indicates the presence of heteroscedasticity in estimating the regressions. The standard errors of the independent variables is estimated with a correction for autocorrelation based on Newey and West (1987) and a correction for heteroscedasticity based on White. The t statistics reported in Table 3 are based on the corrected standard errors.

5.3. Results

Consider the regression in which the standard deviation of future net operating income SIGOI is the dependent variable. This variable is significantly negatively related to the tax incentive to hedge, TIH, the interest coverage ratio, INTCOV, and the wholesale industry dummy D_5. It is significantly positively related to the mining industry dummy D_1, the manufacturing industry dummy D_3 and the transportation industry dummy D_4. Consider the regression in which the standard deviation of future market value of the firm SIGMV is the dependent variable. This

Table 3
Relationship between the standardised measures of hedging activity and standardised explanatory variables over 1986–1990

Independent variable	Dependent variable is the standard deviation of future net operating income SIGOI		Dependent variable is the standard deviation of future market value SIGMV	
	Coefficient	t statistic	Coefficient	t statistic
Tax incentive to hedge TIH	−0.095	−8.487*	−0.099	−9.683*
Interest coverage ratio INTCOV	−0.018	−2.669*	−0.014	−2.129*
Interaction between proportionate expenditure on research and development and cash availability RDCASH	−0.004	−0.890	−0.002	−0.650
Mining industry dummy D_1	0.059	2.581*	−0.017	0.640
Construction industry dummy D_2	−0.009	−0.333	−0.059	−1.899*
Manufacturing industry dummy D_3	0.255	8.090*	0.186	5.737*
Transportation industry dummy D_4	0.233	4.834*	0.182	4.018*
Wholesale industry dummy D_5	−0.059	−3.403*	−0.081	−3.334*
Retail industry dummy D_6	0.041	1.331	0.091	1.602
Constant term	−0.183	−13.458*	−0.126	−6.192*
R^2 of the regression	0.024		0.019	
Durbin–Watson statistic	0.686*		1.060*	
White's chi-squared test for heteroscedasticity	45.480*		14.757*	
Number of observations	6708		6708	

* Significant at the 95% confidence level.

variable is significantly negatively related to the tax incentive to hedge, TIH, the interest coverage ratio, INTCOV, the construction industry dummy D_2 and the wholesale industry dummy D_5. It is significantly positively related to the manufacturing industry dummy D_3 and the transportation industry dummy D_4.

The results show, that as hypothesized, the higher the tax incentive to hedge, the greater the hedging activity of the firm. Recall that previous empirical research did not detect any relationship between the presence of tax losses carry forward and derivative use by the firm.

The negative coefficient of the interest coverage ratio is opposite to what is expected, indicating that firms with a lower probability of financial distress tend to hedge more. Previous research on the effect of financial distress costs and derivative use had mixed results. Gay and Nam (1998) found that the higher the debt ratio, the greater the likelihood that the firm would use derivatives. Tufano (1996) found no significant relationship between hedging by gold firms and their long-term debt ratio, while Géczy et al. (1997) found that there was no relationship between a firm's use of currency derivatives and its long-term debt ratio. Nance et al. (1993) found that in one of their regressions of derivative use on motivating variables, that derivative use was lower, the higher the debt ratio.

The interaction between growth options and cash availability is not significant in either regression. This remains the case, even when MBCASH and PECASH are substituted for RDCASH. In comparison, previous empirical research on the firm's use of derivatives or hedging and growth options had mixed results. While Nance et al. (1993), Géczy et al. (1997) and Gay and Nam (1998) found that firms with higher growth options tended to make more use of derivatives, Tufano (1996) found that gold firms with high growth options hedged less, while Mian (1996) found that firms with more growth options tended to make less use of derivatives.

The industry dummies are used as control variables. The results indicate that the mining industry, manufacturing industry and the transportation industry are characterised by greater volatility of net operating income in comparison to the service industry, while the wholesale industry is characterised by lower volatility of net operating income. The volatility of market value is greater for the construction and manufacturing industry than the service industry and lower for the wholesale industry.

Separate regressions were conducted, in which the tax incentive to hedge TIH was replaced by the debt ratio DEBTR or the size of the firm LSIZE. Hedging activity was significantly lower for firms with high debt ratios and large firms.

6. Conclusions

Although theoretical research on the motivation for firms to hedge, predicted that firms would hedge to reduce expected taxes, previous empirical research failed to show any relationship between firm's use of derivatives, which were assumed to be used for hedging purposes, and proxies for the tax incentive to hedge, which were based on tax losses carry forward. This paper shows analytically that (i) the tax incentive to hedge depends on the magnitude of tax losses carry forward as well

as the firm's distribution of taxable income and its ability to absorb tax losses and carry them forward and back and (ii) the firm's reported value of derivatives is a misleading measure of its hedging activity, because the firm may hedge by using different methods, one of which is the use of derivatives, and, even if the firm hedges only with derivatives, the reported value of derivatives may still be a misleading estimate of its hedging activity. Based on this analysis, the paper proposes more accurate measures of the firm's tax incentive to hedge and hedging activity. The measures of hedging activity used are consistent with previous theoretical research, which focus on hedging firm profits or market value. An empirical analysis is conducted, which analyses the relationship between the firm's hedging activity and its tax incentive to hedge as well as other firm characteristics. The results show that the firm's tax incentive to hedge is a significant determinant of its hedging activity.

Acknowledgements

The author is grateful for research funds provided by the Social Sciences and Humanities Research Council of Canada.

References

Belk, P.A., Glaum, M., 1990. The management of foreign exchange risk. In: UK Multinationals: An Empirical Investigation, Account. Bus. Res., 21, 3–13.

Ederington, L.H., 1979. The hedging performance of the new futures markets. J. Finance 34, 157–170.

Financial Accounting Standards Board of the Financial Accounting Foundation, 1994. Disclosure about derivative financial instruments and fair value of financial instruments. Statement of Financial Accounting Standards No. 119.

Financial Accounting Standards Board of the Financial Accounting Foundation, 1990. Disclosure of information about financial instruments with off-balance-sheet risk and financial instruments with concentrations of credit risk. Statement of Financial Accounting Standards No. 105.

Gay, G.D., Nam, J., 1998. The underinvestment problem and corporate derivative use. Financ. Man. 27, 53–69.

Géczy, C., Minton, B.A., Schrand, C., 1997. Why firms use currency derivatives. J. Finance 52, 1323–1354.

Graham, J.R., Smith, C.W. Jr., 1999. Tax incentives to hedge. J. Finance 54, 2241–2262.

Higgins, K., 1996. Flurry of proposals signals tough disclosure regime. Corp. Finance 101, 27–39.

Mian, S.L., 1996. Evidence on corporate hedging policy. J. Financ. Quantit. Anal. 31, 419–439.

Myers, S.C., 1977. Determinants of corporate borrowing. J. Financ. Econ. 5, 147–175.

Nance, D.R., Smith, C.W. Jr., Smithson, C.W., 1993. On the determinants of corporate hedging. J. Finance 48, 267–284.

Newey, W., West, K., 1987. A simple positive semi-definite, heteroscedasticity and autocorrelation consistent covariance matrix. Econometrica 55, 703–708.

Shevlin, T., 1990. Estimating corporate marginal tax rates with asymmetric tax treatment of gains and losses. J. Am. Tax. Assoc. 11, 51–67.

Smith, C.W. Jr., Stulz, R.M., 1985. The determinants of firms' hedging policies. J. Financ. Quantit. Anal. 20, 391–405.
Tufano, P., 1996. Who manages risk? An empirical examination of risk management practices in the gold mining industry. J. Finance 51, 1097–1137.
Warner, J., 1977. Bankruptcy costs: some evidence. J. Finance 32, 337–348.
White, H., 1980. A heteroscedasticity-consistent covariance matrix estimator and a direct test of heteroscedasticity. Econometrica 48, 817–838.