Capital Expenditures, Financial Constraints, and the Use of Options

Tim Adam*†

M.I.T. - Sloan School of Management

August 2006

Abstract

This paper analyzes the use of options strategies in the North American gold mining industry. I find that firms with large investment programs and firms that focus on gold mining activities only are more likely and more extensive users of options. Among these firms the largest and least financially constrained firms tend to buy put options (insurance strategies), while more financially constrained firms use collar strategies or sell call options. Firms' hedging instrument choices are also correlated with current market conditions. When gold prices decline, firms shift away from hedging with forwards and buy put options instead. When gold prices increase, firms sell more call options on gold.

JEL Classification: G32

Keywords: Risk management, hedging, instrument choice

*I would like to thank Greg Brown, Kalok Chan, Eitan Goldman, Gunter Dufey, Joseph Fan, Chitru Fernando, Charles Hadlock, David Haushalter, Dirk Jenter, Alberto Moel, Tim Opler, John Parsons, Peter Tufano, and seminar participants at the annual meeting of the Western Finance Association, the University of Michigan, University of Oklahoma, the Hong Kong University of Science & Technology, and Nanyang Technological University of Singapore for valuable comments and suggestions. Any remaining errors are my own. I am also grateful to Ted Reeve for providing me with his derivatives surveys.

†Correspondence address: 50 Memorial Drive, E52-401B, Cambridge, MA 02142, USA, Tel.: (617) 253-5123, Fax: (617) 258-6855, E-mail: *tadam@mit.edu*

Capital Expenditures, Financial Constraints, and the Use of Options

Abstract

This paper analyzes the use of options strategies in the North American gold mining industry. I find that firms with large investment programs and firms that focus on gold mining activities only are more likely and more extensive users of options. Among these firms the largest and least financially constrained firms tend to buy put options (insurance strategies), while more financially constrained firms use collar strategies or sell call options. Firms' hedging instrument choices are also correlated with current market conditions. When gold prices decline, firms shift away from hedging with forwards and buy put options instead. When gold prices increase, firms sell more call options on gold.

1 Introduction

The use of options as risk management tools is widespread among corporations. For example, the Wharton/CIBC 1998 risk management survey reports that 68% of non-financial firms that use derivatives also use options. The gold mining industry is no exception: 62% of derivatives users hedge their gold price exposures with options, and the average fraction of the future gold production that has been hedged with options is 33%.

Options positions are clearly an important part of the risk management strategies of many firms. However, our knowledge as to why and how firms use options is limited. To shed light on this area, this paper comprehensively evaluates options strategies in the North American gold mining industry, and focuses on three main questions: First, are there cross-sectional differences between firms that use options strategies and firms that use linear hedging strategies? Second, among option users why do some firms buy options while others sell options? Third, do market conditions affect firms' hedging instrument choices?

There are several theoretical models that predict when firms should use options to hedge their risk exposures. For example, Froot, Scharfstein, and Stein (1993) show that if a firm is financially constrained and if its future capital expenditures are a non-linear function of some risk exposure, then options can be necessary to achieve the value-maximizing hedge. Adam (2002) extends the Froot, Scharfstein, and Stein (1993) model to an inter-temporal setting, and shows that financially less constrained firms tend to buy options, while financially more constrained firms tend to sell options. Adler and Detemple (1988) show that borrowing and short-selling constraints can cause exposures to be non-linear and hence create a demand for options. Stulz (1996) argues that large, financially stable firms are the most likely to

incorporate market views into their hedging programs. Since options strategies allow a hedger to maintain significant exposures, firms that incorporate their market views could find options strategies particularly useful.

In addition to these financial constraints-based theories, a few authors have examined the impact of non-hedgeable risks and real options on the demand for options. Adler and Detemple (1988), and Moschini and Lapan (1995) show that the optimal hedging portfolio contains options if hedgeable and non-hedgeable risks are correlated. Brown and Toft (2002) show that this result can hold even if hedgeable and non-hedgeable risks are uncorrelated. Finally, Moschini and Lapan (1992) consider a firm's option to choose certain production parameters after product prices are observed. Assuming hedging is desirable, hedging this production flexibility (a real option) optimally requires non-linear hedging instruments, i.e., options. Common to all of the above theories is the general insight that if the exposure is non-linear then the optimal hedging strategy is also non-linear.

In order to test the empirical relevance of the above theories, I examine the use of options strategies in the North American gold mining industry over a 10-year horizon, between 1989 and 1999. The gold mining industry represents an excellent laboratory for studying hedging instrument choices because gold mining firms share a relatively simple risk exposure, the future price of gold, while employing a range of different hedging strategies.[1] Therefore, differences in hedging strategies are more likely the result of differences in certain firm-specific characteristics rather than differences in exposures. Furthermore, to my knowledge no other industry reveals similarly detailed information about their derivatives portfolios that would allow a detailed study of instrument choice.

[1] The four primary hedging strategies are: selling forwards, buying put options (insurance strategies), buying collars, and selling call options.

I find that gold mining firms with higher capital expenditures are more likely to hedge their future gold sales using options strategies. They also use options to a larger extent. These results support the Froot Scharfstein, and Stein (1993) model, in which financially constrained firms hedge in order to match their cash inflows with their cash outflows (capital expenditures), which can be non-linear functions of the future gold price. In addition, I find that financially constrained firms tend to sell options while financially unconstrained tend to buy options, which is consistent with Adam's (2002) extension of the FSS model. Thus, while both financially constrained and unconstrained firms can have incentives to use options, they use different options strategies.

I also find that the use of options strategies is significantly more prevalent among firms that focus on gold mining activities only than among diversified firms. This could be due to an investor clientele effect. Some investors, often referred to as "gold bugs," hold gold mining stocks primarily to gain gold price exposure. Firms that focus exclusively on mining for gold would be the primary targets for these investors.[2] The existence of a gold investor clientele can cause a firm to use options strategies, because options allow the firm to hedge while at the same time maintain significant exposure to gold prices. Insurance strategies (long put positions) maintain the most upside exposure, but require the up-front payment of the insurance (option) premium. I find that the largest and least financially constrained firms are the most extensive users of insurance strategies. Firms that appear somewhat more financially constrained are more likely to hedge using collars, i.e., finance the puts by selling calls.

I find no evidence that uncertainty of the exposure (presence of production risks)

[2]Recently, a number of investment funds have been set up, which target this gold investor clientele. According to the fund prospectuses these funds invest most of their assets in companies that are "predominantly involved in the mining and processing of gold."

or the existence of real options (production flexibility) motivate firms to use options strategies. However, I find that firms' hedging instrument choices are correlated with current market conditions. When gold prices decline, firms reduce their use of linear hedging strategies (forwards) and switch towards options strategies instead. In particular, they hedge their future gold sales by buying put options. When gold prices increase, firms increase their short call positions. These results are consistent with a belief that the gold price is mean-reverting. When gold prices decline firms prefer not to lock in the relatively low price with a forward contract, but hedge the downside risk with a put option in order to maintain the upside potential.[3] When gold prices rise firms sell calls in the hope that they will expire worthless.

There are no comprehensive studies on the corporate use of options as hedging instruments. Tufano (1996) describes the different risk management strategies used by gold mining firms. Consistent with the results in this paper he finds that large firms are more likely to use options. A couple of papers examine other types of derivatives used as part of their analyses. For example, Geczy, Minton, and Schrand (1997) find that firms are more likely to use currency swaps if they have more foreign-denominated debt, while they are more likely to use other foreign currency derivatives (such as forwards, futures and options) if they receive more income from foreign sources. In a clinical study of a durable goods manufacturer Brown (2001) finds that concerns about accounting treatments and the firm's competitive position affect its hedging instrument choices.[4] Consistent with the impact of market conditions on

[3]This rationale is also cited by Merck & Co., Inc. "Given the possibility of exchange rate movements in either direction, we were unwilling to forgo the potential gains if the dollar weakened; so options were strictly preferred." (see Lewent and Kearney, 1990, pp. 26-27)

[4]Under the new derivatives accounting standards FAS 133 and IAS 39, adopted in 1998, only a portion of an option hedge qualifies for hedge accounting, while forward positions can qualify up to 100%. These new regulations should reduce the attractiveness of hedging with options.

A recent survey, the Global Survey of Corporate Financial Policies and Practices, conducted by Henry Servaes and Peter Tufano, and published by Deutsche Bank, reveals that 71% of metals & mining firms expect no impact on their commodities derivatives strategies. If an impact is expected

instrument choices, Chernenko, Faulkender, and Milbourn (2006) find that the use of swaps is affected by the shape of the yield curve.

In contrast to the lack of studies on hedging instrument choices, there are several studies that examine hedging strategies in the gold mining industry. Tufano (1996) analyzes the determinants of the decision and the extent of hedging. He finds that hedge ratios are higher among firms that keep less liquidity and lower among firms that reward their executives with more stock options but less shares of the company. In a second paper, Tufano (1998) studies the gold price exposures of a cross-section of gold mining firms, and finds that hedging has only a marginal effect on a firm's stock price sensitivity to gold prices. Petersen and Thiagarajan (2000) argue that differences in operating cost structures can lead some firms to use financial hedges and others to use operational hedges to mitigate gold price risk. Chidambaran, Fernando, and Spindt (2001) show that the gold and copper producer, Freeport-McMoRan, was able to obtain better financing terms by issuing gold-linked notes rather than regular debt. Brown, Crabb, and Haushalter (2006) examine whether gold mining firms adjust their hedge ratios due to their expectations about future gold prices, and find some supporting evidence. Finally, Adam and Fernando (2006) find that gold mining firms earn significantly positive cash flows from their derivatives transactions, which they link to the existence of a risk or forward premium in the gold market.

The rest of the paper is organized as follows. Section 2 describes the sample and risk management strategies in the gold mining industry. Section 3 summarizes the theoretical foundations of why firms should or should not use options. Section 4 presents the empirical results, and Section 5 concludes.

it is more likely to be negative than positive, and affects options positions more than linear positions (forwards/futures/swaps). However, even among firms that use OTC options, only 15% state that they will decrease their reliance on options. The largest impact is expected on exchange-traded derivatives, which mining companies rarely use. Thus, the impact of the new accounting standards is likely to be small in the gold mining industry.

2 Sample

The sample firms are those included in the *Gold & Silver Hedge Outlook*, a quarterly survey conducted by Ted Reeve of Scotia Capital from 1989 to 1999. The survey contains information on the gold derivatives positions of 118 gold mining companies, which represent most firms in the North American gold mining industry. Firms that are not included tend to be small and privately held corporations. The appendix provides an example of the survey data.[5]

Quarterly financial data are obtained from the Active, Canadian, and Research tapes of the Compustat database. Financial data of firms included in the survey but not covered by Compustat are collected by hand from firms' annual reports and 10-K forms. Operational data, such as metals production and cash production costs are also collected by hand from firms' annual reports and 10-K forms. Financial market data, such as gold prices, futures prices, and interest rates, are obtained from Datastream. The regressors and data definitions are summarized in Table 1.

Table 2 provides descriptive statistics of the 96 sample firms for which financial data was available. The distributions of the market and book values of assets are highly skewed, and indicate that the gold mining industry consists primarily of small firms and a few large producers. The market value of assets ranges from $3 million to about $12 billion, while the mean and median values are $1,370 million and $438 million respectively. The two Herfindahl indices show that most gold mining firms do not operate in other business segments, and exclusively mine for gold. The mean Herfindahl index based on asset segments is 0.93, while the mean Herfindahl index based on metals production is 0.86.[6]

[5] Firms also report their derivatives positions in the footnotes to their financial statements. This alternative source provided a way to check the accuracy of the survey data.

[6] In fact, 88% of firms focus exclusively on gold mining, and 57% do not extract any metal other than gold. The most common non-gold business segments are extraction of silver, base metals,

In the 1990's, the average profit margin over cash production costs (excluding non-cash items such as depreciation, amortization and depletion) was only 47%, and some companies were not even able to recover their cash production costs. The high risk nature of gold mining, the little diversification, and slim profit margins argue for conservative financial policies. Indeed, most gold producers maintain very low leverage levels, and pay no dividends. The median leverage ratio is only 18%. If dividends are paid, the payout ratios are generally low: 12% of the operating cash flow on average. Furthermore, most gold mining firms have no credit rating (76%), and if a rating exists it tends to be below investment grade. The fact that most firms have little debt outstanding indicates that most firms are not sufficiently credit worthy to attract significant amounts of debt. In fact, a relatively high debt level signals that a firm's cash flows are sufficiently stable to support debt. It is typically the largest firms, which operate many different mines, and hence have the most predictable cash flows, that also have the highest debt levels. Cases of overleveraged companies are less common in the gold mining industry.

Firms' investment programs are substantial. The average firm spends 24% of its invested capital or 50% of its sales (not reported) on capital expenditures each year.

In summary, a typical gold mining firm is a fairly small enterprise, which focuses exclusively on gold mining and operates under a slim profit margin. To support its investment program it raises external financing mostly in form of equity. The average firm pursues a conservative financial policy, has no public debt outstanding, and pays no dividends.

industrial chemicals & minerals, and smelting-refining activities.

2.1 Risk management in the gold mining industry

Gold mining companies face two principal risk exposures: Gold price risk, which arises from the firms' major asset: the gold reserves in the ground, and production risk. In contrast to price risk, production risk is usually not hedgeable or insurable due to moral hazard or adverse selection. Gold price risk can be hedged, however, and the hedging of it is widespread. Between 1989 and 1999, on average 70% of gold mining companies used derivatives. Despite relatively similar risk exposures hedging strategies differ significantly. To manage gold price risk mining firms have been using forwards, spot-deferred contracts, gold loans, put and call options.[7] Fig. 1 shows that options are an important part of firms' derivatives portfolios, constituting approximately 40% of all outstanding derivatives positions.[8] Table 2 shows that about 62% of firms that use derivatives use options. The average fraction of the future gold production that has been hedged with options is 33%.

Option usage is not a recent phenomenon. Fig. 2 shows that the fraction of firms that use both options and linear strategies has increased from 30% in 1989 to 55% in 1999, while the fraction of firms that use linear strategies only has been generally declining.

There are four principal risk management strategies in the North American gold mining industry: selling linear contracts (forwards, spot-deferred contracts and gold loans), buying puts, buying collars, and selling calls. The resulting payoff profiles are linear, convex, concave, or both convex and concave (collars). In order to derive

[7] A spot-deferred contract is similar to a forward contract except that if the contract is rolled over, the loss/gain is factored into the new delivery price. Thus, there is no cash flow when a spot-deferred contract is rolled over.

A gold loan is economically equivalent to a cash loan and a portfolio of short forward contracts.

[8] The aggregate risk management portfolio consists of the derivatives positions of all firms in the sample. Its characteristics differ from the sample statistics because the aggregate portfolio is skewed towards the larger hedgers.

testable predictions, it is important to understand the major differences between these four risk management strategies. Each strategy has different implications with respect to the elimination of downside risk and upside potential, the initial cash flow impact, and the flexibility in structuring the hedge. For example, while selling a forward contract fully eliminates both the downside risk and the upside potential, buying an (out-of-the-money) put option only partially hedges the downside, while it maintains all of the upside. Selling an (out-of-the-money) call option hedges none of the downside risk, but eliminates part of the upside. Buying a collar partially eliminates both the downside risk and the upside potential. Thus, options strategies allow the hedger to maintain exposure to the gold price to varying degrees. A firm that uses puts or calls maintains most exposure, while a firm that uses forwards eliminates all exposure (on a per ounce of gold hedged basis). Firms that use collars maintain some exposure to gold prices.

The four strategies also differ in terms of their initial cash flow impacts. While a forward strategy is self-financing, buying puts requires a cash payment, and selling calls yields a cash inflow. Buying collars can be self-financing, depending on the choice of strike prices and the number of options involved. Thus, a firm that uses options strategies shifts cash flows not only across states of nature, but also across time periods. It makes both intra-temporal and inter-temporal decisions and therefore must consider the marginal benefit of funds across states *and* across time.

Finally, options strategies provide more flexibility in structuring a hedge than linear strategies, because options are available for many different strike prices, and allow the separation of managing downside and upside risk. This is why options are more suitable to hedge non-linear exposures. Table 3 summarizes the characteristics of the four primary hedging instruments.

3 Should firms use options?

There are several theories as to why firms should hedge with options. Common to all theories is the general insight that if the exposure to be hedged is non-linear, then non-linear instruments, i.e., options, are necessary to obtain the optimal hedge. This section reviews the relevant literature, and derives testable predictions, which are summarized in Table 4.

Froot, Scharfstein, and Stein (1993) argue that firms, which are financially constrained, have an incentive to hedge their future capital expenditures, so as to reduce their dependence on external capital markets. If firms' capital expenditures are non-linear then the optimal hedging strategy may require non-linear instruments.[9] Fig. 3 illustrates an example similar to Table 1 in Froot, Scharfstein, and Stein (1993). It depicts a firm's operating cash flow and its capital expenditures as functions of the gold price. If the gold price drops below x, then the firm's internal cash is insufficient to finance its capital expenditures. Given a forward price of F the funding risk cannot be fully hedged with a linear strategy, as shown in Panel A. However, it can be hedged with an options strategy (a put or an asymmetric collar), as shown in Panel B. Had the capital expenditures been generally lower, then a linear strategy could have sufficed. Thus, based on the Froot, Scharfstein, and Stein (1993) model, we should expect that firms with large investment programs are more likely to use options strategies, especially those that involve put options.

The following statement in the 2001 annual report of Randgold Resources Corp. demonstrates a relationship between capital expenditures and options strategies. "In

[9] MacKay (2006) has shown that production costs in the oil industry are a non-linear function of the oil price. In the gold mining industry investment expenditures are likely to be non-linear also. Consider a mining company, which would develop an existing gold reserve only if the gold price were to rise above some threshold. The firm would need to raise capital to build the mining facilities, etc. only if the gold price rose above that threshold, but would have no financing needs if gold prices remained low. Thus, the firm's capital requirement is a step function.

periods of capital expenditure or loan finance, the Company secures a floor price through simple forward contracts and options whilst maintaining significant exposure to spot prices."

Chacko, Tufano, and Verter (2001) discuss an example of hedging future capital expenditures at Cephalon, Inc. The firm was waiting for approval to market a particular drug. If approval were granted, the firm would face significant cash needs. Management expected that approval would cause the firm's share price to rise significantly. To guarantee sufficient funds should the approval for the drug be granted, Cephalon's management decided to purchase call options on its own stock. The options would payoff handsomely should approval be obtained and Cephalon's share price rise.

Adam (2002) extends the Froot, Scharfstein, and Stein (1993) model to an inter-temporal setting in order to capture the fact that options strategies affect cash flows in multiple periods. In his model firms equalize the marginal values of cash by shifting cash flows not only across states of nature but also across time periods. A financially constrained firm is characterized by a currently high marginal value of funds. It will shift cash flows from future states, in which the marginal value of cash is low, to the present. For a gold mining firm this objective can be achieved by selling calls on gold. A financially unconstrained firm is characterized by a currently low marginal value of funds. It will shift cash flows from the present to future states, in which the marginal value of cash is high. For a gold mining firm this objective can be achieved by buying puts on gold. If the marginal value of cash is already equalized across time, then firms shift cash flows only across states of nature by using standard forwards or zero-cost collars.

Why is it optimal for firms to shift cash flows inter-temporally using options rather than using traditional forms of borrowing and lending? This is because with state-

contingent contracts the marginal values of funds can be equalized more efficiently. For example, state-contingent debt (e.g. selling call options) can reduce credit risk and hence offer a cheaper form of funding for a financially constrained firm than regular debt. An example of such case is discussed by Chidambaran, Fernando, and Spindt (2001). Similarly, it is more efficient for a financially constrained firm to shift cash flows only to those states in the future, in which the marginal value of cash is high, e.g., by buying put options. Regular lending would shift cash flows to all states in the future. Thus, the model by Adam (2002) predicts that financially less constrained firms buy (put) options, while financially more constrained firms sell (call) options. Average firms use either collar or linear strategies.

Stulz (1996) argues that large, financially stable companies have a comparative advantage in bearing certain financial risks. For example, a firm that believes it has an information advantage could decide to maintain some exposure if its financial condition is sufficiently stable so that a negative outcome would not jeopardize its operations. As discussed in the previous section, options strategies allow the hedger to maintain varying degrees of exposures. Most exposure to gold prices is maintained if firms use either puts or calls. Less exposure is maintained if a firm uses collars, and no exposure is maintained if a firm used linear hedging strategies. Thus, Stulz's (1996) model would predict that large, financially unconstrained firms buy puts or sell calls, medium sized firms use collars, and the smallest and most financially constrained firms use linear hedging strategies.

Adler and Detemple (1988) show that in a portfolio context borrowing and short-selling constraints can cause exposures to be non-linear, and thus create a demand for options. In a corporate context such constraints could be represented more generally by financial constraints. Thus, their model would predict that financially constrained firms are more likely to choose options strategies.

A number of authors explore the effects of non-hedgeable risks on options strategies. Moschini and Lapan (1995) show that if hedgeable and non-hedgeable risks are correlated, then the optimal hedging portfolio is non-linear. Unfortunately, gold prices and production risks (non-hedgeable risks) tend to be uncorrelated, because the gold production of an individual firm has no measurable impact on the gold price, which is determined by world demand and supply. Thus, there must be other reasons as to why gold mining firms use options. However, Brown and Toft (2002) extend Moschini and Lapan's (1995) work and show that the mere *existence* of non-hedgeable risks can cause an exposure to be non-linear. This result is similar to the typical textbook recommendation to hedge an uncertain exposure with options. The greater the magnitude of non-hedgeable risks, the greater would be the incentive to use options.[10]

Franke, Stapelton, and Subrahmanyam (1998) show that in the presence of non-hedgeable risks risk-averse investors prefer to buy options, while in the absence of such risks investors prefer to sell options. The intuition is similar to Leland (1980), who shows that agents whose risk tolerance increases with income purchase portfolio insurance from agents whose risk tolerance increases less rapidly. Since shareholders do not necessarily act in a risk-averse manner, it is not clear whether this theory applies in a corporate context. If it does apply, their model would predict that firms that are exposed to high production uncertainty buy put options, while firms that are exposed to little production risk sell call options.

In Moschini and Lapan (1992) a firm is given the option to choose certain production parameters *after* product prices are observed. Assuming hedging is desirable (the authors assume that the firm is risk-averse), hedging this production flexibility option

[10]Brown and Toft (2002) further show that firms should buy options if price and quantity risks are negatively correlated, and sell options if price and quantity risks are positively correlated. Unfortunately, this idea fails to explain risk management choices in the gold mining industry. As argued previously, gold price risk is uncorrelated with firms' production risks, but the use of options is widespread.

(a real option) optimally requires non-linear instruments, i.e., options. In particular, to hedge the convexity of a real option, a firm would need to sell convexity, i.e., sell call options. Thus, Moschini and Lapan's (1992) model implies that the selling of calls might be related to a firm's production flexibility.

In contrast to the theories of option usage stands the possibility that options are used to implement managers' market views. For example, a manager who must hedge but believes that the gold price will likely raise might decide to purchase puts rather than sell forwards in order to maintain the upside potential. Indeed, I conducted a survey among 30 gold mining companies, which revealed that after 'size of exposure' the most important determinants of instrument choice are market conditions, such as volatility, expected future spot prices, and liquidity of contracts.[11] I will therefore test to what extent market conditions, such as gold prices and the gold price volatility, affect option strategies.

4 Results

The discussion in the previous section revealed that the use of non-linear (options) hedging strategies should be correlated with firms' investment expenditures, financial constraints, non-hedgeable risks, production flexibility (real options), and market conditions. The construction of most variables is standard and summarized in Table 1.

To measure the magnitude of firms' investment expenditures, I define the ratio of capital expenditures over net plant property and equipment (CAPX/PPE).[12] To

[11] See page 28 for more details.

[12] In an earlier draft I also used the ratio of exploration expenditures (expensed and capitalized) over sales. However, exploration expenditures likely covary positively with the gold price and hence firms' revenues. Thus, the hedging of these expenditures makes little sense. Not surprisingly, exploration expenditures never turned out to be significant in the prior analysis. Since it significantly reduced the sample size, I have dropped it from the analysis.

proxy for financial constraints I follow the existing empirical literature and use variables such as firm size, diversification, leverage, dividend policy, the existence of a credit rating, and a firm's profit margin. Diversification is measured by two Herfindahl indices, one based on the value of assets allocated to different business segments, the other based on the value of different metals that a firm produces. The main metals produced by gold mining firms are (in order of importance): gold, silver, copper, zinc, lead, and nickel. As explained in the introduction asset diversification can also inversely proxy for a gold investor clientele: Investors that seek exposure to the gold price prefer to invest in companies that predominantly engage in the production of gold.[13]

As pointed out previously, leverage levels in the gold mining industry are characteristically low. The fact that a firm has debt outstanding often indicates that it was sufficiently creditworthy to attract debt. In the mining industry leverage is positively correlated with firm size, business diversification, the dividend payout ratio, and the existence of a credit rating. In fact, it is typically the largest firms, which operate many different mines, and hence have the most predictable cash flows, that have the highest debt levels. The case of overleveraged firms is less common in the gold mining industry. Thus, *low* leverage should be interpreted as a sign of financial constraints.

To capture the magnitude of non-hedgeable risks, I calculate the mean-squared production forecast error defined by

$$MSE_t \equiv \frac{1}{k} \sum_{i=1}^{k} \left(\frac{\hat{y}_{t,t+i} - y_{t+i}}{y_{t+i}} \right)^2,$$

where $\hat{y}_{t,t+i}$ denotes the production forecast of year $t+i$ at time t, and y_{t+i} denotes

[13] Alternatively, investors could hold physical or synthetic gold (gold accounts, derivatives, structured products) in order to gain exposure to the gold price. Holding physical gold causes high transaction costs and is expensive for investors who cannot participate in the gold leasing market. Synthetic gold investments were relatively rare in the past, and gold derivatives are not available to all investors. For these reasons, gold investors have been holding shares of gold mining companies, which can be traded easily and cheaply.

the actual gold production in year $t+i$.[14] Production risk is a classic example of a non-hedgeable risk.

The existence of real options is measured by two variables: the number of mines in operation, and the standard deviation of mine production costs. The more mines a firm operates, the more it is able to shift production from one mine to another in response to changes in market conditions. Thus, such a firm should enjoy more production flexibility (real options). Of course, if all mines had the same production costs, then this production flexibility would be less valuable. I therefore include the dispersion in mine production costs as an additional regressor. Firms that operate mines with different unit extraction costs benefit from volatility in gold prices because they can adjust their production costs by shifting production from low-cost mines to high-cost mines and vice versa.

The remainder of this section is organized as follows. Section 4.1 presents the univariate results. Section 4.2 examines differences between firms that use options strategies in general and firms that use linear hedging strategies. Sections 4.3, 4.4, and 4.5 focus on strategies involving the use of insurance (long puts), collars, and short call option positions respectively, and compare their users with firms that hedge with linear strategies. Section 4.6 compares firms that buy options with firms that sell options, and Section 4.7 evaluates to what extent market conditions affect the use of options strategies.

[14] Gold mining companies report these production forecasts in the derivatives surveys conducted by Ted Reeve from Scotia Capital. There are up to k production forecasts available at each point in time ($k_{\max} = 4$).

4.1 Univariate results

Table 5 shows descriptive statistics of the sample firms by hedging strategy. There are 192 firm-strategy observations,[15] creating the following distribution of strategies: 35% linear strategies (forwards, sport-deferred contracts, and/or gold loans), 19% insurance strategies (long puts), 29% collar strategies, and 16% short call strategies.

The univariate comparisons demonstrate some significant differences between the firms in each category, especially between option buyers and option sellers. Firms that buy options are the largest in the industry (based on both market and book values of assets as well as the number of mines in operation), are among the most diversified firms in the industry, and operate under the highest profit margins. They are the most likely to pay dividends, maintain the highest leverage levels, and are the most likely to have a credit rating. In short, these firms appear to be the industry leaders, and probably face the lowest financial constraints of all firms in the gold mining industry.

In contrast, firms that sell options tend to be on the other end of the spectrum. Most firms in this category are among the smallest in the industry, operate the fewest mines, and are the least diversified. They are the least likely to pay dividends, and if dividends are paid, offer the lowest payout ratios. They maintain the lowest leverage levels, and are unlikely to have a credit rating. Thus, option sellers appear to be among the most financially constrained firms in the industry. The last column of Table 5 shows t-statistics and z-scores for a univariate comparison between option buyers and option sellers. Although not all differences are statistically significant, all signs are consistent and tell the same story.

Firms that use linear hedging strategies and firms that use collar strategies are

[15] Some firms pursued more than one strategy during the sample period. Therefore, the number of firm-strategy observations is larger than the number of firms in the sample.

somewhere in the middle between the two extremes. In many respects linear and collar hedgers are quite similar. These results support Adam's (2002) extension of the Froot, Scharfstein, and Stein (1993) model, which stipulated that financially unconstrained firms buy options in order to hedge their future investments, while financially constrained firms sell options in order to fund their current investments. With respect to capital expenditures differences do not appear to be large, although firms that choose insurance and collar hedging strategies, appear to maintain the largest investment programs. Thus, the use of options, especially puts appears to be related to the size of firms' investment programs.

Production uncertainty is similar across firms, except that sellers of options either are subject to the lowest production risks, or alternatively, are the most accurate in forecasting their future gold production. Thus, non-hedgeable risks such as production risks do not appear to motivate the use of option strategies in the mining industry. Rather the opposite seems to apply. Firms that sell claims against their future gold production, i.e., call options, could be required to forecast their future production more accurately than other hedgers.

Real options (production flexibility), as predicted by Moschini and Lapan (1992) also do not seem to motivate the selling of call options. Firms that sell options operate the fewest mines and also exhibit relatively low dispersion in production costs, which is opposite to the prediction.

4.2 Why firms use options

Table 6 contains probit estimations of the decision to use options strategies, and tobit estimations of the fraction of gold hedged with options. Since most firms that hedge with options also hedge with linear contracts, the tobit estimations provide useful robustness checks. To account for the panel nature of the data set, I estimate both

random-effects and population-averaged probit models.[16] Furthermore, due to the high correlation among some of the regressors only a subset of variables is included in the multivariate analysis.[17]

The theories presented in Section 3 predict that firms that use options strategies have larger investment programs, and are subject to more production uncertainty. With respect to firm size and financial constraints, the predictions are ambiguous. Stulz (1996) predicts that option users are larger and less financially constrained than linear hedgers, while Adler and Detemple (1988) predict the opposite. Adam (2002) predicts that both constrained and unconstrained firms hedge with options, but use different options strategies.

The multivariate results show that firms with larger investment programs are more likely to use options strategies and use options to a larger extent. The coefficients imply that an investment intensive firm (one that spends at least 7.6% of its net PP&E on capital expenditures per quarter) is ceteris paribus 6% more likely to hedge with options and hedges 4% more with options than an investment unintensive firm (one that spends less than 2.5% of its net PP&E on capital expenditures per quarter).[18] This result supports the hypothesis that firms hedge their capital expenditures and that options best approximate the optimal hedging strategy if cash outflows are large

[16] I also estimated logit models but found no significant differences in the estimation results.

[17] One caveat in this study is that the sample is relatively small due to the industry focus. Therefore the results are potentially more sensitive to changes in the sample size than in large sample studies. I address this problem in three ways. (i) All tests are performed with and without trimmed outliers. Outliers are defined as the extreme 1% of values for each variable. (ii) Variables that reduce the sample size significantly are excluded in robustness checks. (iii) All tests are performed on the full sample and a subsample which excludes marginal hedgers (firms that hedge less than 10% of output). Whenever a change in the sample size significantly affected the results, all results are reported.

[18] The change in probability due to a change in the value of regressor x_i ($\Delta x_i = x_{i2} - x_{i1}$) is calculated as follows.

$$\frac{\Delta P(y=1)}{\Delta x_i} \approx \Phi(\bar{x}b + x_{i2}b_i) - \Phi(\bar{x}b + x_{i1}b_i)$$

Estimates are based on the population-averaged probit models. In most cases, $x_{i1}$and x_{i2} are the first and third quartiles of the sample distribution of x_i.

relative to cash inflows. Contrary to the prediction, however, production uncertainty appears to be negatively correlated with the extent of options usage. Thus, production risk does not appear to motivate the use of options. Rather, the opposite seems to hold. Production risk reduces the use of options strategies.

With respect to financial constraints the evidence is mixed. Larger firms are more likely to use options strategies. In particular, a relatively large firm (book value of assets > \$1 billion) is ceteris paribus 24% more likely to use options and hedges 28% more with options than a small firm (book value of assets < \$100 million). On the other hand, option users are less diversified and are less likely to pay dividends. A firm that pays no dividends is ceteris paribus 26% more likely to use options and hedges 30% more with options than a firm that makes dividend payments. A firm that focuses on gold mining only is 28% more likely to use options and hedges 18% more with options than a diversified firm (Herfindahl index = 0.58 = the sample average of diversified firms). Given the univariate results, this ambiguity is not surprising as option users comprise some of the most and least financially constrained firms in the industry.

The finding that focused firms are more likely and more extensive users of options can also be explained by a gold investor clientele effect. As explained previously, firms that concentrate on gold mining only are the most likely investment vehicles for investors who hold gold mining stock primarily to gain exposure to the gold price. A strong clientele effect can cause a dilemma. On the one hand a firm may need to hedge its gold exposure to relax certain constraints. On the other hand, the firm's shareholders prefer the firm to remain unhedged. Options provide a solution. With options a firm can hedge its downside risk while at the same time maintain some or all of its upside exposure to the gold price.[19]

[19] Homestake Mining is a case in point. Petersen and Thiagarajan (2000) report, "The management

While this section considered all option strategies together, the next three subsections evaluate the determinants of particular options strategies: insurance, collars, and the selling of (call) options.

4.3 Insurance versus hedging strategies

According to the theories presented in Section 3 the size of a firm's investment program, financial constraints, and production risks can affect the choice between insurance and hedging strategies. Table 7 presents the multivariate comparisons between firms that use insurance strategies and firms that use linear hedging strategies. The results show that larger firms, and firms that concentrate on gold mining only rely more on insurance strategies than hedging strategies to hedge their gold price exposures. In particular, large firms (as defined in the previous section) are ceteris paribus 18% more likely to use insurance strategies than small firms, while pure gold mining firms are 21% more likely to use insurance strategies than diversified firms. Investment programs are also significantly larger at firms that use insurance strategies than linear hedgers. Investment intensive firms are ceteris paribus 7% more likely to choose insurance strategies than investment unintensive firms, and an increase in investment spending by 10% increases the fraction hedged with insurance strategies by more than 3%. Production uncertainty, on the other hand, does not seem to have an impact on the decision to use insurance strategies. Dividend and leverage policies also appear to be similar among linear and insurance hedgers.

The finding that large and non-diversified firms are more likely to hedge with insurance strategies is consistent with Stulz (1996) and the existence of a shareholder clientele effect. Focused firms prefer insurance strategies in order to maintain upside

of Homestake also believed that investors purchased their stock to obtain gold price exposure. This belief began to evolve in 1995, when Homestake's managers expressed a belief that a correctly executed derivative strategy could maintain the upside in gold prices that their investors desired while protecting the firm from a drop in the price of gold."

exposure to the gold price while at the same time satisfy their hedging needs. However, only larger firms have the financial resources to pay for a hedging premium (the put premium) up-front, or, as Stulz (1996) points out, have a higher capacity to bear risks.[20] Thus, we see predominantly large firms among the insurance hedgers. Firms that cannot afford the payment of an up-front hedging premium, however, use linear hedges, or other options strategies, as will be shown in the next section.

4.4 Collar versus hedging strategies

Collar strategies are similar to insurance strategies except that the purchase of the puts is (partially) financed by the sale of calls. Thus, a firm, which needs to serve a gold investor clientele but does not have the financial resources for a pure insurance strategy, could choose a collar hedging strategy instead in order to maintain some upside potential. The results in Table 8 are consistent with this hypothesis.

As with insurance hedgers, firms that use collars tend to be more focused on gold mining activities only than linear hedgers. In particular, focused firms are ceteris paribus 21% more likely to choose a collar strategy and hedge 19% more using collars than diversified firms. Thus, a gold investor clientele among collar hedgers is likely. In contrast to insurance hedgers, however, firms that hedge with collars are more likely to face financing constraints. Collar hedgers are less likely to pay cash dividends than linear hedgers. In fact, a non-dividend paying firm is 20% more likely to choose a collar hedging strategy than a linear strategy and hedges 18% more with collars than a dividend paying firm. Although collar hedgers appear to be larger than linear hedgers this result disappears when marginal hedgers (those that hedge less than 10% of their next year's gold production) are excluded from the analysis. Thus, the results suggest that firms, which need to maintain upside potential but lack the

[20] Insurance strategies are typically implemented with out-of-the-money puts, leaving considerable downside exposure with the firm.

financial resources for an insurance strategy, hedge with collars.

Furthermore, investment intensive firms are ceteris paribus 7% more likely to hedge with collars than investment unintensive firms. This result is similar to that of insurance hedgers, and supports the hypothesis that option strategies enable a more effective matching of cash inflows with cash outflows, which is non-trivial when cash outflows, such as capital expenditures, are large.

Production uncertainty is uncorrelated with the use of and the extent of using collar strategies. Thus, production uncertainty does not appear to motivate the use of collar strategies.

4.5 Selling calls versus hedging strategies

According to Adam (2002), firms that sell options should be the most financially constrained. Illustrating this prediction, Chidambaran, Fernando, and Spindt (2001) discuss the case of the gold and copper producer Freeport-McMoRan, which sold gold-indexed notes to finance the expansion of the Grasberg mine at a time Freeport had little financial flexibility. The embedded call options on gold lowered the credit risk of the note and provided more attractive financing terms for Freeport-McMoRan. It is possible that gold mining firms sell calls to raise low-cost financing.[21] On the other hand, Stulz (1996) predicts that sellers of calls are larger and less financially constrained than linear hedgers, because short call positions retain significant exposure to the gold price. Only large, financially sound firms should be expected to maintain significant downside exposure. Finally, if firms hedge their real options, as in Moschini and Lapan (1992), then one would expect a positive correlation between selling calls and proxies for real options.

The univariate results in Table 5 already showed that firms that sell calls on gold

[21] The calls are essentially collateralized by a firm's gold reserves in the ground and hence require no credit risk premium.

tend to be the most financially constrained firms in the industry. Most of these firms are very small (market value of assets less than $160 million), pay no dividends, and maintain little debt. However, there are also a number of very large firms among option sellers, as indicated by the large difference between the mean and median values for firm size. Thus, Stulz's prediction also appears relevant.

The multivariate analysis, presented in Table 9, is consistent with the univariate results.[22] Confirming Stulz's (1996) prediction, larger firms are more likely and more extensive sellers of options. In particular, a large firm is ceteris paribus 19% more likely to sell call options than a small firm. This is despite the fact that most options sellers are small firms. Consistent with this result, diversification, leverage and dividend policy indicate that financially constrained firms are more likely to sell options than to choose linear hedging strategies. In particular, firms that are undiversified are ceteris paribus 17% more likely to sell calls than diversified firms. Firms that pay no dividends are ceteris paribus 37% more likely to sell calls than firms that pay dividends, and unlevered firms are ceteris paribus 16% more likely to sell calls than levered firms (firms with a leverage ratio of 34%). Thus, there appear to be two motivations for gold mining firms to sell calls. First, some financially constrained firms sell options possibly in order to raise low-cost financing, as in the case of Freeport-McMoRan. Second, large firms sell calls possibly in the hope that the calls will expire worthless. Such speculative gamble would be consistent with Stulz (1996), who argued that large firms have a comparative advantage in bearing risk and hence are the most likely to speculate.

Interestingly, production uncertainty is negatively correlated with selling calls. Thus, firms that sell claims against their future gold production either face little

[22] The panel data models did not converge when the sample size dropped to 120 observations. To facilitate comparison across model specifications, I report probit/tobit models and heteroskedasticity-robust standard errors that are adjusted for the interdependence within firm-quarter observations.

production risk or are able to forecast their future production more accurately. Less production uncertainty or production forecast error could be a requirement imposed by the counterparty of the derivative contract. However, the magnitude of this effect is small. An increase in the production risk by 10% reduces the likelihood of selling calls only by 0.2%.

Finally, the dispersion in production costs (differences in production costs across several operating mines) also appears to be negatively correlated with the selling of calls. The magnitude of this effect is larger. An increase in the standard deviation of production costs by 10% reduces the likelihood of selling calls by 2%. This result is contrary to the prediction that firms sell calls to "hedge" their real options. Thus, here too, no evidence could be found that real options matter in firms' hedging instrument choices.

To summarize, the results presented so far show that diversified firms are more likely to hedge with simple linear strategies, while focused firms are more likely to choose options strategies (puts, calls, or collars). This could be due to a shareholder clientele effect. Investors who hold gold mining stocks primarily to gain exposure to the gold price, are more likely to invest in focused than diversified firms. To serve both such shareholder clientele and their hedging needs, focused firms choose to hedge with options strategies because options allow firms to hedge their downside risk while at the same time maintain some upside exposure. A pure insurance strategy would best satisfy these two goals. However, it requires the payment of a premium (the put premium) up front. Only large, financially unconstrained firms are able or willing to pay that premium. More constrained firms choose to finance the purchase of the puts by selling calls, and thus hedge with collar strategies.

A second reason to use options strategies (puts and collars) are high capital expenditures, i.e., high cash outflows relative to inflows. If capital expenditures are

large and a non-linear function of the gold price, then a simple forward strategy may not provide an adequate hedge. The fact that options are available at many different strike prices implies that a firm can more effectively match its cash inflows with its cash outflows, and thus increase the likelihood that investments can be financed internally.

This evidence is also consistent with a survey of all gold mining companies in the sample, which I conducted in 2000.[23] Of the 118 sample companies, 30 returned the survey, and of those, 14 stated to have adopted a financial risk management program. The responses revealed that cash flows, profitability, and capital expenditures are at the center of their risk management programs. Out of 12 companies, 8 stated that "Reducing volatility in cash flows" was a primary objective of their risk management. For 7 out of 13 companies "Ensuring that operations remain profitable even if metal prices decline" was another primary objective. "Ensuring that internal cash is sufficient to finance capital expenditures" was a primary risk management objective for 5 out of 13 firms. Consistent with these responses all responding firms reduce the volatility in operating net cash flows and free cash flows in order to achieve their primary risk management objectives.

Regarding instrument choice, the survey asked, "Why would you prefer to hedge an exposure with options rather than with forward contracts?" The two most important reasons were: "Options allow one to protect the downside while maintaining some upside potential," cited by 7 out of 12 firms as a very important reason, and "Options offer more flexibility in designing an optimal hedge," cited by 4 out of 11 firms as a very important reason. Interestingly, all firms that cite the above reasons as very important focus exclusively on gold mining. The one firm that considers the

[23] The survey questionnaire as well as a summary of firms' responses are available from the author upon request.

downside risk / upside potential reason as only somewhat important is a diversified firm. These responses are consistent with the empirical results, which showed that firms that are more likely to have a gold investor clientele, and firms that have larger investment programs, and thus face more difficulty in matching cash inflows with cash outflows as demonstrated in Fig. 3, prefer to hedge using options strategies.

4.6 Who buys and who sells options

Adam (2002) predicts that financially unconstrained firms are more likely to buy options, while financially constrained firms are more likely to sell options. Thus, both constrained and unconstrained firms have incentives to use options, but use different options strategies, which explains why option users as a group do not appear more or less financially constrained than linear hedgers (see Section 4.2). In addition, Franke, Stapelton, and Subrahmanyam (1998) predict that firms that face more production risk are more likely to buy options while firms that face less production risk are more likely to sell options. To test these hypotheses, I compare options buyers with options sellers.

The univariate tests in Table 5 show that on average sellers of options are more financially constrained than buyers of options. While buyers of options also seem to be exposed to more production uncertainty than sellers, the difference is not statistically significant. The multivariate results, reported in Table 10, allow similar conclusions. Firms that buy options are more diversified, maintain higher leverage levels, and are more likely to pay dividends than firms that sell options. In particular, diversified firms are ceteris paribus 19% more likely to buy options than focused firms, levered firms are 33% more likely to buy options than unlevered firms, and dividend paying firms are 21% more likely to buy options than firms that do not pay dividends. Thus, overall, option buyers appear to be less financially constrained than option sellers.

Both univariate and multivariate results indicate that production uncertainty is similar among firms that buy and firms that sell options. Thus, the model by Franke, Stapleton, and Subrahmanyam (1998) does not appear to apply in a corporate setting such as the gold mining industry.

4.7 Do market conditions affect options strategies?

> Which instruments we use is influenced by market conditions (contango, volatility levels, spot market trends and forecasts), as well as by our shareholders." Christopher Hill, Vice President & Treasurer of Kinross Gold Corporation, 2002.

Apart from hedging considerations and investor clientele effects, market conditions could also influence how managers hedge their exposures as the above quote indicates. For example, when the gold price declines, firms may be more reluctant to lock in the new, relatively low gold price with a forward contract, and hedge instead by purchasing put options so as to maintain the upside potential. When the gold price volatility is high, managers may refrain from buying options because options appear expensive. In fact, the previously mentioned survey revealed that after "size of exposure" and "volatility of risk to be hedged" the third most important factor when deciding whether to hedge an exposure with forwards, spot-deferred contracts or options is a firm's expectation about future spot prices. Finally, it is often heard from practitioners that selling gold forward it more profitable when the gold contango or basis (difference between the forward on spot price of gold) is large.

The quarterly nature of the data set allows a limited time-series analysis to examine how changing market conditions affect firms' hedging instrument choices. To characterize the structure of firms' derivatives portfolios, I use two variables that have been used in the previous analysis. The fraction of gold hedged with options measures

the extent of option usage, while the net option position, defined by $\frac{\text{puts - calls}}{\text{puts + calls}}$, measures the size of the put position relative to the call position. It is bounded between 1 (100% puts) and -1 (100% calls).

The time-series graphs of the two measures are shown in Fig. 4 for the aggregate industry derivatives portfolio.[24] While there is no discernible trend in the extent of options strategies (fraction of gold hedged with options) in general, the gold mining industry has clearly shifted from net buying of options to net selling of options between 1989 and 1999. Over the same sample horizon, the gold price generally declined. In order to remove the obvious time trends in the data the following analysis is based on changes in all variables.

Table 11 presents time-series regressions for the above two variables on the gold price, the gold price volatility, and the basis. All regressions are estimated by OLS including fixed-effects. I also estimate two separate models for the largest 10% of firms (in terms of market values) and the smallest 90% of firms in order to test whether large firms speculate more than small firms.

The results in Panel A show that the fraction hedged with options is negatively correlated with the gold price. In particular, when gold prices decline by \$10, firms increase the fraction of gold hedged with options by about 1%. Thus, when gold prices decline, firms prefer not to lock in the relatively low gold price with forward contracts, but choose options strategies instead, which allow the firm to maintain some exposure. Interestingly, it is not the large firms that respond to changing market conditions, but the small firms.

Panel B shows that the net option position is negatively correlated with the gold price but uncorrelated with the gold price volatility and the basis. These results

[24]The aggregate industry derivatives portfolio consists of the derivatives portfolios of all firms in the sample, and is therefore skewed towards large firms.

imply that when the gold price declines firms predominantly shift towards buying put options. When the gold price increases, firms increase their short call positions. One interpretation of these phenomena is that when the gold price declines hedging needs become more pressing, but firms hesitate to lock in a relatively low gold price with a forward contract. Instead, they choose to hedge with put options, and thus maintain the upside potential. When gold prices increase, protecting the downside becomes relatively less important. Firms then sell their upside potential, possibly hoping that prices are more likely to decline than to increase further. The economic significance is larger than in the previous case. When gold prices decline by $10, firms increase the size of the their put positions relative to the size of their call positions by about 3%. Again, these results do not apply to the largest 10% of firms.

In summary, the time-series results document a link between current market conditions and the derivatives instruments firms choose to hedge their exposures. When gold prices decline firms shift away from selling forwards to purchasing put options. While these results do not prove a causal link between market conditions and instrument choices, they document stylized facts that are consistent with anecdotal evidence on how firms hedge.

5 Conclusion

The use of options as risk management tools is widespread among corporations. Instrument choice is an important question within corporate risk management, but our knowledge as to why and how firms use options is limited. To shed light on this question this study comprehensively evaluates the use of options strategies in the North American gold mining industry.

I find that firms with large investment programs are more likely and more exten-

sive users of options strategies. They use predominantly insurance and collar strategies. Given that capital expenditures are often non-linear in nature, these results are consistent with Froot, Scharfstein, and Stein (1996), who argue that financially constrained firms have an incentive to match cash inflows with cash outflows.

I also find that firms, which focus on gold mining only, rely more on options strategies than diversified firms. Focused firms are more likely to have a gold investor clientele among their shareholders and therefore prefer options strategies because they allow a firm to hedge the downside risk while at the same time maintain some exposure to the gold price. The largest and least financially constrained firms are the most extensive users of insurance strategies (put options). Buying puts maintains all of the upside potential to the gold price, but requires an up-front premium. Not all firms are willing or able to pay the up-front option premium. More financially constrained firms finance the puts by selling calls, i.e., they use collar strategies.

Most firms that sell options are among the smallest in the industry and appear to face the largest financial constraints. These firms may sell call options as a way to obtain low-cost financing, as the calls are fully collateralized by the gold reserves in the ground. However, there are also some very large firms among option sellers. These firms may sell options simply in the hope that they will expire worthless.

I find no evidence that uncertainty in the exposure, e.g., production risks, or the existence of real options (production flexibility) motivate firms to use options strategies. However, I do find that market conditions are correlated with firms' hedging instrument choices. In particular, when gold prices decline mining firms shift away from selling forwards to purchasing put options. This result is consistent with anecdotal evidence that firms prefer options because options protect the downside while maintaining the upside potential. Maintaining the upside potential would be desirable when prices are relatively low.

References

[1] Adam, T., 2002. Risk Management and the Credit Risk Premium. *Journal of Banking & Finance* 26, 243-269.

[2] Adam, T., Fernando, C., 2006. Hedging, Speculation and Shareholder Value. *Journal of Financial Economics* 81, 283-309.

[3] Adler M., Detemple, J.B., 1988. Hedging with Futures and Options. *Studies in Banking and Finance* 5, 181-197.

[4] Altman, E.I., 1968. Financial Ratios, Discriminant Analysis and the Prediction of Corporate Bankruptcy. *Journal of Finance* 23, 589-609.

[5] Bessembinder, H., Coughenour, J.F., Seguin, P.J, Smoller, M.M., 1995. Mean Reversion in Equilibrium Asset Prices: Evidence from the Futures Term Structure. *Journal of Finance* 50, 361-375.

[6] Bodnar, G.M., Hayt, G.S., Marston, R.C., Smithson, C.W., 1996. Wharton Survey of Derivatives Usage by U.S. Non-Financial Firms. *Financial Management* 25, 113-133.

[7] Bodnar, G.M., Hayt, G.S., Marston, R.C., 1998. 1998 Survey of Financial Risk Management by U.S. Non-Financial Firms. *Financial Management* 27, 70-91

[8] Brown, G.W., 2001. Managing Foreign Exchange Risk with Derivatives. *Journal of Financial Economics* 60, 401-448.

[9] Brown, G.W., Crabb, P.R., Haushalter, D., 2006. Are Firms Successful at Selective Hedging? *Journal of Business* forthcoming.

[10] Brown, G.W., Toft, K.B., 2002. How Firms Should Hedge. *Review of Financial Studies* 15, 1283-1324.

[11] Chidambaran, N.K., Fernando C., Spindt, P., 2001. Credit enhancement through financial engineering: Freeport-McMoRan's gold-denominated depositary shares. *Journal of Financial Economics* 60, 487-528.

[12] Chacko, G., Tufano, P., Verter, G., 2001. Cephalon, Inc. Taking Risk Management Theory Seriously. *Journal of Financial Economics* 60, 449-485.

[13] Chernenko, S., Faulkender, M., Milbourn, T., 2006. Why are Firms Using Interest Rate Swaps to Time the Yield Curve? Unpublished working paper. Washington University.

[14] Franke, G., Stapleton, R.C., Subrahmanyam, M.G., 1998. Who Buys and Who Sells Options: The Role of Options in an Economy with Background Risk. *Journal of Economic Theory* 82, 89-109.

[15] Froot, K.A., Scharfstein, D.S., Stein, J.C., 1993. Risk Management: Coordinating Corporate Investment and Financing Policies. *Journal of Finance* 48, 1629-1658.

[16] Géczy, C., Minton, B.A., Schrand. C., 1997. Why Firms Use Currency Derivatives. *Journal of Finance* 52, 132-154.

[17] Leland, H.E., 1980. Who Should Buy Portfolio Insurance? *Journal of Finance* 35, 581-594.

[18] Lewent, J., Kearney, A.J., 1990. Indentifying, measuring, and hedging currency risk at Merck. *Journal of Applied Corporate Finance*, 19-28.

[19] MacKay, P., Moeller, S.B., 2006. The Value of Corporate Risk Management. *Journal of Finance* forthcoming.

[20] Moschini, G., Lapan, H., 1992. Hedging Price Risk with Options and Futures for the Competitive Firm with Production Flexibility. *International Economic Review* 33, 607-618.

[21] Moschini, G., Lapan, H., 1995. The Hedging Role of Options and Futures under Joint Price, Basis, and Production Risk. *International Economic Review* 36, 1025-1049.

[22] Petersen, M.A., Thiagarajan, S.R., 2000. Risk Measurement and Hedging: With and Without Derivatives. *Financial Management* 29, 5-30.

[23] Servaes, H., Tufano, P., 2006. Global Survey of Corporate Financial Policies and Practices. Deutsche Bank AG.

[24] Stulz, R.M., 1996. Rethinking Risk Management. *Journal of Applied Corporate Finance* 9, 8-24.

[25] Tufano, P., 1996. Who Manages Risk? An Empirical Examination of Risk Management Practices in the Gold Mining Industry. *Journal of Finance* 51, 1097-1137.

[26] Tufano, P., 1998. The Determinants of Stock Price Exposure: Financial Engineering and the Gold Mining Industry. *Journal of Finance* 53, 1051-1052.

[27] Whited, T.M., 1992. Debt, Liquidity Constraints, and Corporate Investment: Evidence from Panel Data. *Journal of Finance* 47, 1425-1460.

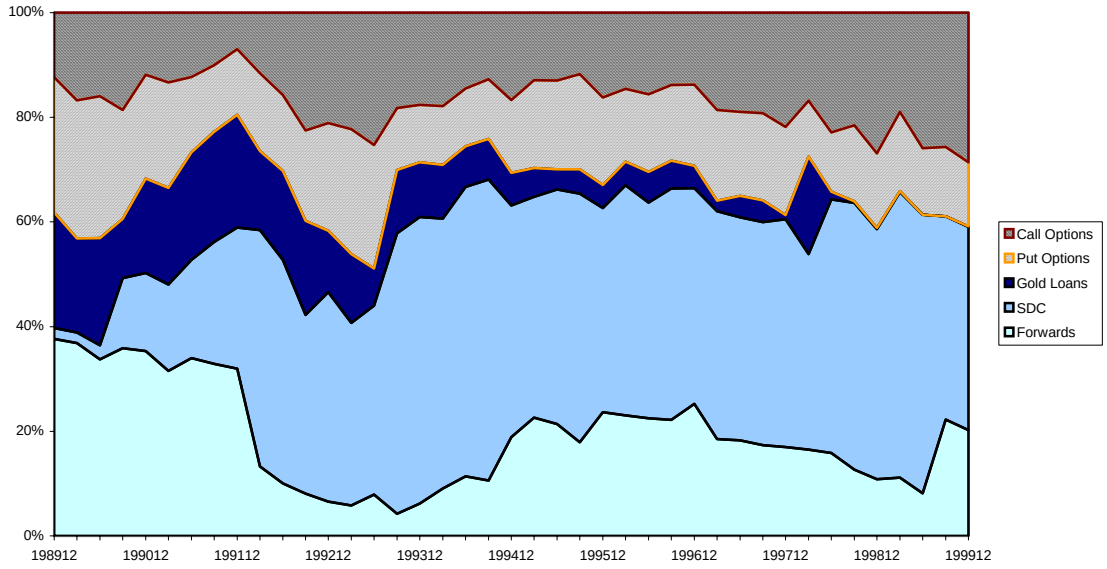

Fig. 1. This graph shows the main derivatives instruments used by gold mining firms in North America to hedge gold price risk, and how the composition of the aggregate derivatives portfolio evolved over time. The aggregate derivatives portfolio is calculated by summing all derivatives positions of the sample firms. Percentages refer to the notional principal of the derivatives positions. SDC stands for spot-deferred contracts, which are similar to forward contracts except that delivery of the underlying asset can be deferred.

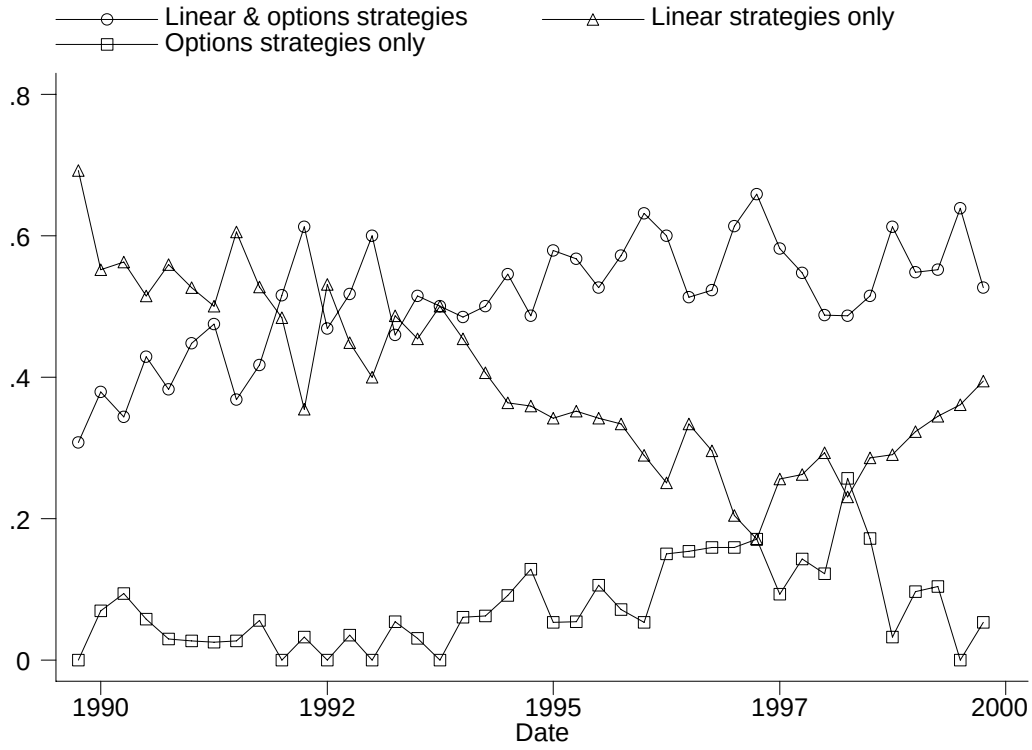

Fig. 2. This figure shows the fraction of firms (among derivatives users), which use only linear strategies (forwards, spot-deferred contracts, and gold loans), only options strategies, and both linear and options strategies.

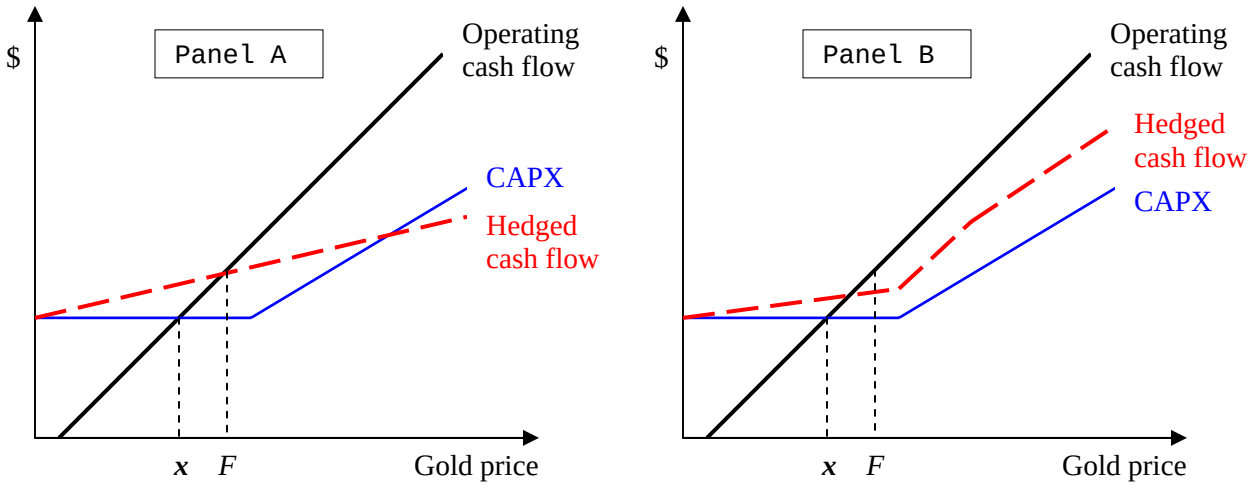

Fig. 3. This figure compares the effectiveness of linear with options hedging strategies. The graphs depict a firm's operating cash flow and its capital expenditures (CAPX) as functions of the gold price. If the gold price falls below the threshold *x*, the firm would need to raise external funds in order to close the funding shortfall. To hedge this funding risk a firm could short forward contracts (Panel A) or purchase an asymmetric collar (Panel B). Given the current forward price *F*, a simple forward strategy cannot fully hedge the risk of a funding shortfall, while with an asymmetric collar the risk of a funding shortfall can be fully hedged.

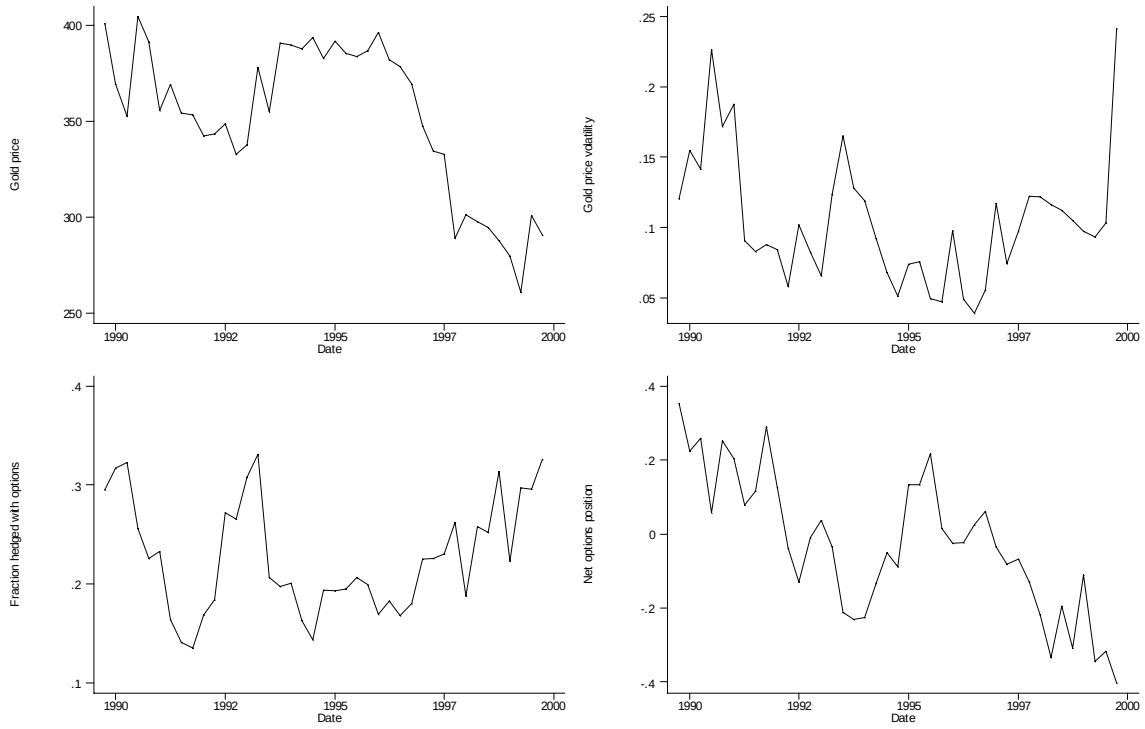

Fig. 4. This figure shows the time-series characteristics of the aggregate derivatives portfolio. The first two graphs depict the gold price and the gold price volatility during the sample period. The gold price is given in US$/oz of gold. The gold price volatility is the annualized standard deviation of daily gold price returns over the previous 60 trading days. The 'fraction hedged with options' is defined as the number of ounces of gold hedged with options divided by the total number of ounces of gold hedged. The 'net option position' is defined by $\frac{\text{puts} - \text{calls}}{\text{puts} + \text{calls}}$, and measures whether the derivatives portfolio consists predominantly of puts or of calls. This measure is bounded between 1 (100% puts) and -1 (100% calls). Definitions of these variables can be found in Table 1.

Table 1

This table list all regressors used in the analysis and describes their constructions. The principal data sources are Compustat, annual reports and 10-K forms. Market data is obtained from Datastream.

Variable	Construction of variable
CAPX / PPE	The size of the investment program is measured by a firm's quarterly capital expenditures divided by net plant property and equipment at the beginning of the period.
Market value of assets	Real market value of assets, in 1999 dollars. Market value of assets equals book value of assets minus book value of common stock plus market value of equity. The producer price index for commodities is from the Bureau of Labor Statistics.
Book value of assets	Real book value of assets, in 1999 dollars. The producer price index for commodities is from the Bureau of Labor Statistics.
Herfindahl index (asset segments)	Defined by $\sum_{i=1}^{N}\left(\frac{q_i}{q}\right)^2$, where q_i is the book value of assets of industry segment i, and q is the total book value of all reported industry segment assets (non-reported assets such as financial assets are ignored). N is the total number of industry segments. Annual observations are repeated for each quarter of the same fiscal year.
Herfindahl index (metals production)	Defined by $\sum_{i=1}^{N}\left(\frac{s_i}{s}\right)^2$, where s_i is the revenue contribution of each metal (estimated as metal production × spot price), and s is the total metal sales for the year. N is the total number of metals produced by the firm. If metal production is zero, a missing value is assigned. Metal prices are from Datastream. Annual observations are repeated for each quarter of the same fiscal year.
Dividend dummy	Dummy variable that equals one if a firm paid cash dividends during a fiscal year, and zero otherwise.
Dividend payout ratio	Annual cash dividends paid during the fiscal year, divided by the annual operating net cash flow. If the operating net cash flow is negative, a missing value is assigned.
Leverage	Book value of long-term debt divided by the book values of preferred stock, common equity, and long-term debt.
Credit rating dummy	Dummy variable that equals one if a credit rating exists and zero otherwise.
Profit margin	Relative difference between gold spot price and the annually reported cash costs. Cash costs are the per-ounce cash extraction costs of gold. Annual

Variable	Construction of variable
	observations of the reported cash costs are repeated for each quarter of the same fiscal year.
Production uncertainty	Production uncertainty is measured by the mean-squared production forecast error defined by $\frac{1}{n}\sum_{i=1}^{n}\left(\frac{y_{t,t+i}-y_{t+i}}{y_{t+i}}\right)^2$, where y_{t+i} denotes the actual gold production in year $t+i$, and $y_{t,t+i}$ denotes the production forecast for year $t+i$ at time t. There are up to n production forecasts available at each time (n_{max} = 4). Production forecasts are inferred from the Gold and Silver Hedge Outlook (1989 – 1999). Forecast errors > 5 are ignored, as data error is the most likely reason for such large deviations.
Number of operating mines	Number of operating mines per firm. Annual observations are repeated for each quarter of the same fiscal year.
Standard deviation of production costs	Standard deviation of the production costs of each operating mine. Annual observations are repeated for each quarter of the same fiscal year.

Table 2

This table shows standard sample statistics for 111 gold mining firms in North America between 1989 and 1999.

Panel A	***Mean***	***Median***	***Std. dev.***	***Min***	***Max***	***Obs.***	***# of firms***
Use of derivatives (dummy variable)	0.693	1	0.461	0	1	2,098	111
Use of options (dummy variable)	0.616	1	0.487	0	1	1,454	97
Fraction of gold hedged with options	0.333	0.203	0.363	0	1	1,454	97
Extent of using insurance strategies	0.140	0	0.306	0	1	7,39	88
Extent of using collar strategies	0.223	0	0.321	0	1	1,116	94
Extent of selling calls	0.108	0	0.252	0	1	717	84

Panel B	***Mean***	***Median***	***Std. dev.***	***Min***	***Max***	***Obs.***	***# of firms***
CAPX / PPE	0.07	0.04	0.08	0	0.50	1,305	94
Market value of assets (in 1999 $ million)	1,370	438	2,144	2.85	11,619	1,029	93
Book value of assets (in 1999 $ million)	643	219	982	1.91	5,353	1,395	96
Herfindahl index (asset segments)	0.93	1	0.19	0.23	1	1,395	96
Herfindahl index (metals production)	0.86	1	0.21	0.28	1	1,578	86
Dividend (dummy variable)	0.46	0	0.50	0	1	1,372	96
Dividend payout ratio (annual)	0.12	0	0.33	0	2.65	517	96
Leverage	0.22	0.18	0.22	0	1.02	1,302	95
Credit rating (dummy variable)	0.24	0	0.43	0	1	1,395	96
S&P credit rating		BB+		B-	A	334	15
Profit margin	0.47	0.42	0.38	-0.53	1.60	1,611	83
Production uncertainty	0.16	0.03	0.37	0.00	2.45	1,130	69
Number of operating mines	4.10	3	3.20	1	18	866	52
Standard deviation of production costs	65.0	58.6	44.9	4.95	236.2	606	41

Table 3

Characteristics of the primary hedging instruments used by gold mining firms in North America

	Linear contracts (short)	Puts (long)	Collars (long)	Calls (short)
Payoff profile	Linear	Convex	Convex & concave	Concave
Downside risk	Fully hedged	Partially hedged	Partially hedged	Fully exposed
Upside exposure	Fully eliminated	Fully exposed	Partially eliminated	Partially eliminated
Initial cash flow impact	Self-financing	Requires cash payment (option premium)	Can be self-financing	Yields cash inflow (option premium)
Flexibility in structuring the hedge	Low	High	High	High

Table 4

Principal hedging strategies in the North American gold mining industry and testable predictions

	Linear contracts only	Long puts + linear contracts	Collars + linear contracts	Short calls + linear contracts
Froot, Scharfstein and Stein (1993)	Low CAPX	High CAPX	High CAPX	
Adam (2002)	Average financial constraints	Low financial constraints	Average financial constraints	High financial constraints
Stulz (1996)	Small, fin. constrained firms	Large, fin. unconstrained firms	Medium-sized firms	Large, fin. unconstrained firms
Adler and Detemple (1988)	No financial constraints	Financial constraints	Financial constraints	Financial constraints
Brown and Toft (2002)	Low production uncertainty	High production uncertainty	High production uncertainty	High production uncertainty
Franke, Stapelton and Subrahmanyam (1998)		High production uncertainty		Low production uncertainty
Moschini and Lapan (1992)	Low production flexibility			High production flexibility

Table 5

This table lists descriptive statistics of the sample firms by hedging strategy. The top figures in each row represent means, while the bottom figures represent medians. Bold figures indicate statistically significant differences, at least at the 10% level, between option strategy users and firms using linear contracts only. The last column lists t-statistics and z-scores of two-sample tests comparing firms that buy options (Column II) with firms that sell options (Column IV). In order to ensure independent observations in each category, I first calculate time-series averages for each firm-strategy. Variable definitions can be found in Table 1.

	Linear contracts only I	Long puts & linear contracts II	Collars & linear contracts III	Short calls & linear contracts IV	t-statistics z-scores II vs. VI
CAPX / PPE	0.063 0.036	0.068 **0.046**	0.075 0.046	0.053 0.033	0.388 1.354
Market value of assets	979.2 135.7	1,259 **454.7**	761.8 199.2	1,171 163.3	0.155 1.184
Book value of assets	474.4 97.1	584.1 **293.3**	457.1 191.0	573.5 133.1	0.045 1.621
Herfindahl index (asset segments)	0.936 1	0.941 1	0.969 1	0.967 1	-0.665 -0.672
Herfindahl index (metals production)	0.872 1	0.868 1	0.918 1	0.930 1	-1.334 -1.652*
Dividend dummy	0.394 0	0.546 1	0.373 0	0.276 0	2.210* 2.129**
Dividend payout ratio	0.188 0	0.173 0	0.118 0	**0.061** 0	1.356 1.336
Leverage	0.235 0.196	0.251 0.248	0.232 0.230	0.169 0.149	1.826* 1.682*
Credit rating dummy	0.142 0	0.258 0	0.196 0	0.179 0	0.748 0.813

	Linear contracts only I	Long puts & linear contracts II	Collars & linear contracts III	Short calls & linear contracts IV	t-statistics z-scores II vs. VI
Profit margin	0.402 0.338	0.426 0.383	0.391 0.358	0.425 0.326	0.011 0.233
Production uncertainty	0.202 0.021	0.174 0.019	0.150 0.034	**0.067** **0.017**	1.379 0.552
Number of operating mines	3.86 3	5.50 **4.5**	4.15 3	3.74 3	1.602 1.902*
Standard deviation of production costs	70.62 63.56	66.84 59.44	61.34 54.73	54.91 62.45	1.039 0.360
Firm-strategy observations	68	37	56	31	

Table 6

The regression results in this table show the sensitivities between firm-specific characteristics and the use of and the extent of using options strategies. The use of options strategies is a dummy variable that equals 1 if a firm used options, and 0 if it used linear hedging instruments only. A missing value is assigned if a firm did not use any derivatives. The fraction of gold hedged with options is defined by $\frac{\max\{puts, calls\}}{\text{all linear contracts} + \max\{puts, calls\}}$. All positions are measured in ounces of gold. The max function ensures that collar positions, which consist of both puts and calls, are not double counted. Definitions of the regressors can be found in Table 1. The models are estimated with and without trimmed outliers (defined by the extreme 1% of values). Reported results are based on the estimations without outliers. Figures in parentheses denote heteroskedasticity-robust t-statistics.

	Use of options strategies (dummy variable)		Fraction of gold hedged with options
	Random-effects probit model	Population-averaged probit model	Random-effects tobit model
ln(CAPX / PPE)	0.185**	0.149**	0.034*
	(2.39)	(2.52)	(1.90)
ln(book value of assets)	0.323***	0.283*	0.121***
	(3.60)	(1.86)	(6.67)
Herfindahl index (asset segments)	1.769***	1.701*	0.430***
	(3.64)	(1.87)	(2.98)
Herfindahl index (metals production)	-0.343	-0.004	0.050
	(-0.74)	(-0.01)	(0.51)
Dividend dummy	-1.170***	-0.714**	-0.297***
	(-4.52)	(-2.38)	(-6.30)
Leverage	-0.053	-0.253	-0.072
	(-0.13)	(-0.37)	(-0.69)
Production uncertainty	-0.282	-0.147	-0.105**
	(-1.16)	(-0.68)	(-2.02)
Wald test	49.56	19.75	71.02
Sig. level	0.000	0.001	0.000
Pseudo R^2	0.106	0.106	0.074
Obs. / number of firms	706 / 60	706 / 60	706 / 60

Significance at the 1%, 5% and 10% levels is denoted by ***, ** and * respectively.

Table 7

The regression results in this table evaluate the differences between firms that use insurance strategies and firms that use hedging (linear) strategies only. The use of insurance strategies is a dummy variable that equals 1 if a firm used put options, and 0 if it used linear hedging instruments only. A missing value is assigned if a firm had any calls outstanding or did not use any derivatives. The extent of insurance strategies is defined by $\frac{\text{puts}}{\text{linear contracts} + \text{puts}}$. All positions are measured in ounces of gold.

Definitions of the regressors can be found in Table 1. The models are estimated with and without trimmed outliers (defined by the extreme 1% of values). Reported results are based on the estimations without outliers. Figures in parentheses denote heteroskedasticity-robust t-statistics.

	Use of insurance strategies (dummy variable)		Extent of using insurance strategies
	Random-effects probit model	Population-averaged probit model	Random-effects tobit model
ln(CAPX / PPE)	0.244* (1.91)	0.206** (2.44)	0.108** (1.99)
ln(book value of assets)	0.363*** (2.77)	0.261* (1.78)	0.195*** (3.54)
Herfindahl index (asset segments)	1.921*** (2.72)	1.744** (2.56)	0.579** (2.02)
Herfindahl index (metals production)	-0.862 (-1.24)	-0.642 (-1.05)	-0.115 (-0.43)
Dividend dummy	-0.382 (-1.04)	-0.349 (-1.05)	-0.320** (-2.28)
Leverage	0.077 (0.11)	0.089 (0.12)	-0.039 (-0.12)
Production uncertainty	-0.052 (-0.14)	-0.012 (-0.03)	0.044 (0.26)
Wald test	15.73	18.21	24.50
Sig. level	0.028	0.011	0.000
Pseudo R^2	0.075	0.075	0.072
Obs. / number of firms	318 / 51	318 / 51	318 / 51

Significance at the 1%, 5% and 10% levels is denoted by ***, ** and * respectively.

Table 8

The regression results in this table evaluate the differences between firms that use collar strategies and firms that use hedging (linear) strategies only. The use of collar strategies is a dummy variable that equals 1 if a firm used put and call options, and 0 if it used linear hedging instruments only. A missing value is assigned if a firm used only puts or only calls, or did not use any derivatives. The extent of using collar strategies is defined by $\frac{\min\{\text{calls}, \text{puts}\}}{\text{linear contracts} + \min\{\text{calls}, \text{puts}\}}$. Definitions of the regressors can be found in Table 1. The models are estimated with and without trimmed outliers (defined by the extreme 1% of values). Reported results are based on the estimations without outliers. Figures in parentheses denote heteroskedasticity-robust t-statistics.

	Use of collar strategies (dummy variable)		Extent of using collar strategies
	Random-effects probit model	Population-averaged probit model	Random-effects tobit model
ln(CAPX / PPE)	0.152* (1.95)	0.148** (2.54)	0.025 (1.27)
ln(book value of assets)	0.201** (2.53)	0.209 (1.16)	0.108*** (5.06)
Herfindahl index (asset segments)	1.952*** (4.54)	1.266 (1.20)	0.452*** (3.29)
Herfindahl index (metals production)	0.626 (1.54)	0.497 (0.46)	-0.004 (-0.04)
Dividend dummy	-0.744*** (-3.07)	-0.514 (-1.58)	-0.181*** (-3.07)
Leverage	1.140** (2.32)	0.213 (0.27)	-0.053 (-0.47)
Production uncertainty	-0.143 (-0.64)	-0.073 (-0.32)	-0.069 (-1.45)
Wald test	57.80	15.62	45.80
Sig. level	0.000	0.029	0.000
Pseudo R^2	0.109	0.109	0.064
Obs. / number of firms	560 / 57	560 / 57	560 / 57

Significance at the 1%, 5% and 10% levels is denoted by ***, ** and * respectively.

Table 9

The regression results in this table evaluate the differences between firms that sell call options and firms that use hedging (linear) strategies only. Selling calls vs. linear strategies is a dummy variable that equals 1 if a firm sold call options, and 0 if it used linear hedging instruments only. A missing value is assigned if a firm had any puts outstanding or did not use any derivatives. The extent of selling calls is defined by $\frac{\text{calls}}{\text{linear contracts} + \text{calls}}$. All positions are measured in ounces of gold. Definitions of the regressors can be found in Table 1. The models are estimated with and without trimmed outliers (defined by the extreme 1% of values). Reported results are based on the estimations without outliers. Figures in parentheses denote heteroskedasticity-robust t-statistics.

	Selling calls vs. linear strategies (dummy variable)		Extent of selling calls	
	Probit models		Tobit models	
ln(CAPX / PPE)	-0.003 (-0.02)	0.565*** (2.76)	0.012 (0.24)	0.138 (1.47)
ln(book value of assets)	0.369*** (2.72)	0.314 (0.87)	0.155*** (3.48)	0.165 (1.60)
Herfindahl index (asset segments)	2.121** (2.35)	2.001* (1.66)	0.893*** (2.69)	0.778 (1.52)
Herfindahl index (metals production)	-0.055 (-0.08)	-0.436 (-0.31)	-0.028 (-0.13)	-0.195 (-0.40)
Dividend dummy	-1.565*** (-4.60)	-2.108*** (-3.72)	-0.729*** (-5.16)	-0.778*** (-3.81)
Leverage	-1.827** (-2.18)	-2.352 (-1.50)	-1.086*** (-3.91)	-1.092* (-1.94)
Production uncertainty	-0.934* (-1.79)	-0.498 (-0.34)	-0.662*** (-2.94)	-0.616 (-1.19)
Number of operating mines		-0.109 (-0.83)		-0.070 (-1.63)
Standard deviation of production costs		-0.022*** (-2.89)		-0.006** (-2.22)
Wald test	41.50	38.41	79.01	46.68
Sig. level	0.000	0.000	0.000	0.000
Pseudo R^2	0.234	0.396	0.247	0.492
Obs. / number of firms	306 / 52	120 / 22	306 / 52	120 / 22

Significance at the 1%, 5% and 10% levels is denoted by ***, ** and * respectively.

Table 10

The regression results in this table evaluate the differences between firms that buy (put) options and firms that sell (call) options. Buy vs. sell options is a dummy variable that equals 1 if a firm bought put options only, and 0 if a firms sold call options only. A missing value is assigned if a firm had both puts and calls outstanding, used linear hedging strategies exclusively, or did not use any derivatives. Definitions of the regressors can be found in Table 1. The models are estimated with and without trimmed outliers (defined by the extreme 1% of values). Reported results are based on the estimations without outliers. Figures in parentheses denote heteroskedasticity-robust t-statistics.

	Predicted sign	Buy vs. sell options (dummy variable)	
		Random-effects probit model	Population-averaged probit model
ln(book value of assets)	+	-0.334* (-1.77)	-0.105 (-0.60)
Herfindahl index (asset segments)	-	-1.989* (-1.95)	-1.182* (-1.77)
Herfindahl index (metals production)	-	0.797 (-0.93)	-0.382 (-0.29)
Dividend dummy	+	1.009** (2.37)	0.550* (1.83)
Leverage	+	3.913*** (2.99)	2.527** (1.99)
Production uncertainty	+ / -	1.345 (1.41)	0.682 (1.40)
Wald test		18.93	14.34
Significance level		0.004	0.026
Pseudo R^2		0.149	0.149
Obs. / number of firms		160 / 39	160 / 39

Significance at the 1%, 5% and 10% levels is denoted by ***, ** and * respectively.

Table 11

This table evaluates how option hedging strategies are affected if market conditions, such as the gold price, the gold price volatility, and the gold basis change. The dependent variables are the fraction of gold hedged with options, defined in Table 6. The net options position, defined by (puts – calls) / (puts + calls), measures the size of the put position relative to the call position (see Figure 4). It is bounded between 1 (100% puts) and -1 (100% calls). The gold price is measured in US$/oz, the gold price volatility is the annualized standard deviations of daily gold returns over the previous 60 trading days, and the basis is the percentage difference between the 1-year forward price and the current spot price. To eliminate time-trends, all regressions are estimated on changes in all variables.

Panel A: Dependent variable: Fraction of gold hedged with options

	Full sample	Top 10% of firms (market value)	Bottom 90% of firms (market value)
Gold price	-0.001**	-0.000	-0.001**
	(-2.26)	(-0.21)	(-2.11)
Gold price volatility	-0.135	0.272	0.041
	(-0.90)	(1.58)	(0.15)
Basis	0.457	0.345	-0.217
	(1.01)	(0.76)	(0.73)
Fixed effects	Yes	Yes	Yes
Obs. / number of firms	1,281 / 87	86 / 6	562 / 72
R^2 (within)	0.010	0.035	0.010

Panel B: Dependent variable: Net options position

	Full sample	Top 10% of firms (market value)	Bottom 90% of firms (market value)
Gold price	-0.003***	-0.005	-0.003*
	(-2.70)	(-1.67)	(-1.77)
Gold price volatility	0.287	0.659	0.071
	(0.69)	(0.53)	(0.10)
Basis	-1.379	-3.421	-1.539
	(-1.10)	(-1.29)	(-0.91)
Fixed effects	Yes	Yes	Yes
Obs. / number of firms	754 / 63	45 / 4	351 / 49
R^2 (within)	0.011	0.088	0.011

Appendix

This table lists the hedge positions of Placer Dome as of December 31, 1998. The first column in each panel lists the number of ounces of gold that must be delivered under various contracts. The second column lists the respective delivery prices, and the third column records the percentage of future gold production that has been hedged. The maturity year of all contracts is given on top of each panel. SDC stands for spot-deferred contracts. A spot-deferred contract is like a forward contract except that delivery can be deferred for several years at the discretion of the deliverer. If delivery is deferred, the new delivery price is set to equal the prior contract price plus the current contango premium.

	1999			2000			2001		
	Ounces	Price (US$/oz)	Percent of Prod.	Ounces	Price (US$/oz)	Percent of Prod.	Ounces	Price (US$/oz)	Percent of Prod.
Forwards	649,000	503		213,000	504		188,000	458	
SDC	390,000	397		737,000	440		442,000	441	
Puts	298,000	298		127,000	303				
Total	**1,337,000**		**44.0%**	**1,077,000**		**37.0%**	**630,000**		**23.5%**
Calls	521,000	310		115,000	371		100,000	365	

	2002			2003 and beyond			
	Ounces	Price (US$/oz)	Percent of Prod.	Ounces	Price (US$/oz)	Percent of Prod.	
Forwards	30,000	429					
SDC	886,000	360		886,000	360		
Puts	200,000	300					
Total	**1,116,000**		**40.1%**	**886,000**		**32.3%**	
Calls	200,000	365					

Source: Gold & Silver Hedge Outlook, Fourth Quarter 1998, Scotia Capital Markets