Capital Expenditures, Financial Constraints, and the Use of Options

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Abstract

This paper analyzes why gold mining firms use options rather than linear strategies to hedge their gold price risk. Consistent with financial constraints-based theories, I find that the largest and least financially constrained firms are the most likely to hedge with insurance strategies (put options), while more constrained firms finance the purchase of puts by selling calls (collars). The most financially constrained firms use strategies that involve selling calls. Firms with large investment programs are also more likely to use insurance rather than linear strategies. Firms' hedging instrument choices are also correlated with current market conditions, suggesting that managers' market views partially drive hedging instrument choices.

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Abstract

This paper analyzes why gold mining firms use options rather than linear strategies to hedge their gold price risk. Consistent with financial constraints-based theories, I find that the largest and least financially constrained firms are the most likely to hedge with insurance strategies (put options), while more constrained firms finance the purchase of puts by selling calls (collars). The most financially constrained firms use strategies that involve selling calls. Firms with large investment programs are also more likely to use insurance rather than linear strategies. Firms' hedging instrument choices are also correlated with current market conditions, suggesting that managers' market views partially drive hedging instrument choices.

1 Introduction

Options positions are an important part of the risk management strategies of many firms. For example, the Wharton/CIBC 1998 risk management survey reports that among derivatives users 68% of firms use options. However, our knowledge as to why and how non-financial firms use options rather than linear strategies (e.g. forwards) is limited. Hedging instrument choice is clearly an important question for any firm that hedges, and understanding how firms hedge can provide indirect evidence as to why firms hedge. To shed light on this area, this paper comprehensively evaluates options strategies in the North American gold mining industry.

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 buy options, while financially more constrained firms 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.

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, in Moschini and Lapan (1992) the optimal hedging strategy requires non-linear instruments, i.e., options, if a risk-averse firm can choose certain production parameters after product prices are observed. 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 hedging instrument choice.

I find that firms that have relatively high investment expenditures are more likely and more extensive users of insurance (put options) rather than linear strategies. This result is consistent with the Froot Scharfstein, and Stein (1993) model, in which financially constrained firms hedge in order to match their cash inflows with their cash outflows (fixed capital expenditures). If capital expenditures are sufficiently large and a non-linear function of the future gold price then an options strategy involving puts would provide a better hedge than a linear strategy.

In addition, the largest and least financially constrained firms are the most likely to hedge their price risk by buying puts, while more financially constrained firms finance the purchase of puts by selling calls, and thus hedge with collar strategies. The most financially constrained firms use strategies that involve selling calls (with-

[1] The four primary hedging strategies are: selling forwards, buying put options (insurance strategies), buying collars, and selling call options. Further details are given in Section 2.1.

out purchasing puts). These results are consistent with Adam's (2002) extension of the FSS model, which predicts that financially unconstrained firms buy options while financially constrained firms sell options. Overall, the use of options strategies indicates that financial constraints are an important determinant for corporate derivatives usage in the gold mining industry.

I find no evidence that the uncertainty of the exposure (presence of production risks) motivates firms to use options strategies. However, I find that firms' hedging instrument choices are 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 tend to sell more calls. In the presence of a requirement to hedge, which is independent of a manager's market view, these results could arise from a belief that the gold price is mean-reverting. When gold prices decline managers 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.[2] When gold prices rise managers sell calls possibly 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

[2] 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)

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.[3] Consistent with the impact of market conditions on instrument choices, Chernenko, Faulkender, and Milbourn (2007) 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

[3] Under the new derivatives accounting standards FAS 133 and IAS 39, adopted in 1998, only a portion of option positions qualify for hedge accounting, while forward positions can qualify up to 100%, which should reduce the attractiveness of hedging with options. In the Global Survey of Corporate Financial Policies and Practices, however, Servaes and Tufano (2006) report that 71% of metals & mining firms expect no impact on their commodities derivatives strategies. If an impact is expected 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.

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.

2 Sample

As discussed before, the gold mining industry represents an excellent laboratory for studying hedging instrument choices as this industry is relatively homogeneous but employs a variety of different hedging strategies. 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. This survey contains information on the gold derivatives positions of 111 gold mining companies, which represent most firms in the North American gold mining industry during the sample period. Firms that are not included tend to be small and privately held corporations.

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 variables and data sources 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 $2.85 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. 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, industrial chemicals & minerals, and smelting-refining activities.

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 low 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 book leverage ratio is only 18%. If a firm pays dividends, the payout ratio is 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.

2.1 *Risk management in the gold mining industry*

Gold mining companies face two principal risk exposures: price and quantity risk. Gold price risk arises from selling gold at market prices, while quantity risk consists of production risk (uncertainty about the actual gold production due to temporary output fluctuations) and reserve risk (uncertainty about the true gold reserve in the ground). While there are various business strategies to manage quantity risks, many are not hedgeable or insurable due to moral hazard or adverse selection. Gold price risk, on the other hand, can be hedged, and the hedging of it is widespread. Between 1989 and 1999, on average 70% of gold mining companies used derivatives. In comparison, only 50% of firms in the Wharton/CIBC 1998 risk management survey 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.[4] Fig. 1 shows that options are an important part of firms' derivatives portfolios, constituting approximately 40% of all outstanding derivatives positions.[5] Table 2 shows that about 62% of firms that use derivatives use

[4] 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 functionally equivalent to a cash loan and a portfolio of short forward contracts.

[5] The aggregate risk management portfolio consists of the derivatives positions of all firms in the

options. This fraction has increased from 30% in 1989 to 55% in 1999. The average fraction of the future gold production that has been hedged with options is 33%.

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 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 maintaining 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 only puts or calls maintains most exposure, while a firm that uses forwards eliminates all exposure (on a per ounce of gold hedged basis).

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

sample. Its characteristics differ from the sample statistics because the aggregate portfolio is skewed towards firms with larger hedge books.

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.

3 Should firms hedge with options?

There are several theories of why firms should hedge but relatively few that explain under what additional conditions firms should hedge with options. For hedging to increase shareholder value ex ante a firm's profit function must be concave, which can be achieved by convexity in costs, e.g., bankruptcy costs, taxes, costs of raising external finance, or by introducing managerial risk-aversion into the model. If the exposure is linear in prices, then a linear hedging strategy is sufficient to attain the optimal hedge. If the exposure is non-linear in prices, then a non-linear hedging strategy, i.e., one that contains options, may be optimal. To illustrate this requirement, this section reviews the relevant literature, and derives testable predictions that are summarized in Table 3.

Froot, Scharfstein, and Stein (1993) argue that firms, which face convex costs of raising external financing, have an incentive to hedge their future capital expenditures, so as to reduce their dependence on external capital markets.[6] If firms' capital expenditures are a linear function of some exposure, then a linear hedging strategy would be sufficient. If firms' capital expenditures are non-linear and sufficiently large,

[6] 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.

however, then the optimal hedging strategy requires non-linear instruments. Fig. 2 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 (using a put or an asymmetric collar), as shown in Panel B. Had the capital expenditure schedule been 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 (insurance and collar strategies).[7]

Adam (2002) extends the Froot, Scharfstein, and Stein (1993) model to an intertemporal 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 lower, 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 higher. For a gold mining firm this objective can be

[7] MacKay and Moeller (2006) have 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.

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 financially constrained firms than regular debt. An example of such case is discussed by Chidambaran, Fernando, and Spindt (2001). Similarly, it is more efficient for financially constrained firms 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.

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. However, 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. 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. This idea does not 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.

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 those same 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. In a corporate setting the Franke, Stapelton, and Subrahmanyam (1998) model would predict that firms that are exposed to more non-hedgeable risks, e.g., production risks, buy options, while firms that are exposed to less non-hedgeable risks sell options.

In contrast to the theories of option usage stands the possibility that the use options is motivated by speculative considerations and thus depends on managers' market views. For example, a manager who must hedge but believes that the gold price will rise might decide to purchase puts rather than sell forwards in order to maintain the upside potential. Similarly, a manager might sell calls purely because he expects the option to expire out-of-the-money. Indeed, I conducted a survey among 30 gold mining companies, which revealed that after 'size of exposure' the most important determinants of instrument choice were market conditions, such as volatility, expected future spot prices, and liquidity of contracts.[8] I will therefore test to what extent market conditions, such as gold prices, the gold price volatility, and the gold basis are correlated with option strategies.

4 Results

The theoretical models reviewed in the previous section predict that the use of non-linear (options) strategies is correlated with firms' investment expenditures, financial constraints, the magnitude of non-hedgeable risks, and possibly market conditions. To measure the magnitude of firms' investment expenditures, I define the ratio of capital expenditures over net plant property and equipment (CAPX/PPE).[9] To 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 the various 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. A firm's profit margin is defined as the relative difference between gold spot price and the cash production costs per ounce of gold.

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

[8]See page 21 for further details about this survey.

[9]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, which would reduce the necessity to hedge these expenditures. Not surprisingly, exploration expenditures never turned out to be significant in the prior analysis. Since it significantly reduced the sample size, I have dropped this variable from the analysis.

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 the actual gold production in year $t+i$. The production forecast error is subject to both production and reserve risk, which are classic examples of non-hedgeable risks.[10] The construction of the remaining variables is standard and summarized in Table 1.

4.1 *Univariate analysis*

Table 4 shows descriptive statistics of the sample firms by hedging strategy. There are a total of 192 firm-strategy observations,[11] showing 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 reveal some significant differences between the firms in each category, especially between option buyers and option sellers. Firms that buy

[10] If firms were to adjust their gold production in response to changes in the gold price, then the production forecast error would be a function of future gold prices. This would cause the production forecast error to be correlated across firms. To examine this possibility, I regressed changes in the forecast error on changes in future gold prices, but could not detect any significant correlations. This result implies that the actual gold production is not sensitive to gold price movements in the short to medium term. One possible explanation is that firms always operate their existing mines near capacity as long as the gold price does not drop below a threshold. I thank the referee for bringing this issue to my attention.

[11] 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.

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 small, operate the fewest mines, and are the least diversified. They are also 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 4 shows t-statistics and z-scores for univariate comparisons between option buyers and option sellers. Although not all differences are statistically significant, all signs are consistent and tell the same story. These results support Adam's (2002) extension of the FSS model, which predicts that financially unconstrained firms buy options while financially constrained firms sell options.

With respect to capital expenditures differences across the four strategy groups do not appear to be large, although firms that choose insurance and collar strategies maintain the largest investment programs on average. Thus, the use of options, especially puts appears to be weakly related to the size of firms' investment expenditures.

Production uncertainty (the production forecast error) is similar across firms, except that sellers of options either are subject to the lowest production uncertainty, or alternatively, are the most accurate in forecasting their future gold production. Thus, in general 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 using call options, could be required to forecast their future production more accurately than other hedgers.

4.2 *Multivariate analysis*

Table 5 contains a multinomial logit estimation of the decision to select one of the four principal hedging strategies: linear, insurance (long puts), collars and short calls. Since the main focus is on why firms use options, linear strategies are chosen as the base case. Thus, all results have to be interpreted relative to choosing a linear hedging strategy. Due to the high correlation among some of the regressors only a subset of variables is included in the multivariate analysis. One caveat in this study is that due to the industry focus the sample is relatively small. 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.

The results show that the use of put options is positively correlated with firms' capital expenditures. Firms with large investment programs are more likely to hedge with insurance or collar strategies rather than linear strategies. In particular, investment intensive firms (those that spend at least 7.6% of their net PP&E on capital expenditures per quarter) are ceteris paribus 3% more likely to choose insurance or collar strategies than investment unintensive firms. This result is consistent with the hypothesis that firms hedge their capital expenditures, as in FSS (1993), and that options best approximate the optimal hedging portfolio if cash outflows are large relative to cash inflows.[12] Not surprisingly, call option sellers do not have higher capital expenditures on average, as selling calls does not hedge the risk of a future cash shortfall.

The results further show that firms using options are generally larger and more focused than firms using only linear strategies. In particular, a large firm (book value of assets > \$1 billion) is ceteris paribus 24% more likely to use options than a small firm (book value of assets < \$100 million). A firm that focuses on gold mining only is 30% more likely to use options strategies than a diversified firm (Herfindahl index = 0.58 = the sample average of diversified firms). The implication with respect to financial constraints is unclear. While the size result indicates that option users are less financially constrained, the diversification result indicates the opposite.

However, collar hedgers appear to be somewhat more constrained than linear hedgers as they are less likely to make dividend payments. In fact, a non-dividend paying firm is 21% more likely to choose a collar hedging strategy than a linear strategy. Call option sellers appear to be the most financially constrained firms. Although these firms are larger than linear hedgers on average, they are less likely to pay dividends, maintain lower leverage levels, and are less diversified. The positive coefficient on firm size can be explained by the univariate results in Table 4. Although most option sellers are very small firms, there are also some very large companies among them, as indicated by the large difference between the mean and median values for firm size (\$1,171 million versus \$163 million). Thus, the positive correlation between firm size and the use of short call strategies is driven by these outliers. These

[12] The following statement also demonstrates a relationship between capital expenditures and options strategies. "In 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." (Randgold Resources Corp., 2001 annual report)

results suggest that there are two distinct types of firms that sell calls: very small firms with significant financial constraints, and very large firms without significant financial constraints.

With respect to production uncertainty there appear to be no significant differences between option users and linear hedgers. Thus, production risk does not appear to motivate the use of options.

The results in Table 5 suggest significant differences between option buyers and option sellers. Table 6 contains logit regressions comparing option buyers with option sellers. The results show that 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 27% more likely to buy options than focused firms, levered firms are 56% more likely to buy options than unlevered firms, and dividend paying firms are 40% more likely to buy options than firms that do not pay dividends.[13] Thus, option sellers are likely to be more financially constrained than option buyers, which supports Adam's (2002) model. Inconsistent with this conclusion is that firms that sell options are larger on average than firms that buy options. This result is again due to outliers, however. Once the largest 10% or largest 25% of firms are excluded from the analysis, the regression results show that option sellers are smaller on average than option buyers, and a large firm is 37% more likely than a small firm to buy than to sell options.

Why there are a number of very large companies among option sellers is puzzling, as these firms are unlikely to face significant financial constraints. Possibly, these

[13] 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.

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

In most cases, x_{i1} and x_{i2} are the first and third quartiles of the sample distribution of x_i.

firms sell calls simply 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.

The empirical evidence is also consistent with survey responses of the gold mining companies in the sample. The survey questionnaire was sent to the 111 sample companies in 2000, of which 30 returned the survey, and 14 stated to have adopted a financial risk management program.[14] 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 firms' 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. This flexibility may be important for firms that have larger investment programs, and thus face more difficulty in matching cash inflows with cash outflows as demonstrated in Fig. 2, generating the positive correlation between capital expenditures and the use of puts.

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

4.2.1 *Robustness: The extent of using options*

The previous results were based on logit regressions in which each firm was allocated to a particular hedging strategy, irrespective of the size of the options position. Thus, even if a firm's option position was small relative to its linear position, it was classified as an options strategy user. To check the robustness of the results, I define three continuous measures of the extent of using options strategies: the extent of using insurance strategies, the extent of using collar strategies, and the extent of selling calls. To account for the panel nature of the data, I estimate random-effects tobit models since unconditional fixed-effects tobit models yield biased estimates.

The results, reported in Table 7, are very similar to the multi-nomial logit results of Table 5. Larger and more focused firms use options strategies to a larger extent than small or diversified firms. High capital expenditures increase the use of insurance (put) strategies, while financial constraints are positively correlated with the extent to which firms sell call options.

While the logit regressions in Tables 5 and 6 revealed no significant differences in production uncertainty among any of the four strategy groups, the tobit results show that production uncertainty is negatively correlated with the extent of selling calls. This is contrary to Franke, Stapelton, and Subrahmanyam (1998), who predict that (risk-averse) firms that face more production uncertainty are more likely to buy options while (risk-averse) firms that face less production uncertainty are more likely to sell options. Thus, their model does not appear to apply in a corporate setting such as the gold mining industry. The negative correlation between production uncertainty and the selling of calls suggests that there could be a supply effect: Firms that sell claims against their future gold production could be required by the counterparty of the derivative contract to either ensure low production uncertainty or to be able to forecast future production more accurately. However, the magnitude of this effect is small.

4.3 *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, market conditions could also influence how managers hedge their exposures as the above quote indicates. For example, when the gold price is relatively low, managers may be reluctant to lock in the current 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 is more profitable when the gold basis (difference between the forward and the 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 define the net option position by $\frac{\text{puts - calls}}{\text{puts + calls}}$, which measures the size of the put position relative to the call position. This variable measures the convexity/concavity of the overall risk management portfolio, and is bounded between 1 (100% puts) and -1 (100% calls).

The time-series graphs of the industry average of the net option position as well as the gold price, the gold price volatility, and the gold basis are shown in Fig. 3.[15] Between 1989 and 1999, the gold mining industry has shifted from net buying of options to net selling of options. Over the same sample period, 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 8 presents OLS regressions of changes in firms' net option positions on changes in the gold price, the gold price volatility, and the basis. All regressions are estimated with and without fixed-effects. I also estimate two separate models for large and small firms (above and below median in terms of market values) in order to test whether large firms speculate more than small firms as suggested by Stulz (1996).

The results show that the net option position is negatively correlated with the gold price but uncorrelated with the gold price volatility and the basis. These results imply that when the gold price declines firms shift towards buying put options, while when the gold price increases firms increase their short call positions. In particular, when the gold price declines by \$10, firms increase the size of the their put positions relative to the size of their call positions by about 3%. Large firms display a lower sensitivity than small firms, but the difference in coefficients is not statistically significant.

One interpretation of these results is that when the gold price declines hedging needs become more pressing, but managers hesitate to lock in the relatively low gold price with a forward contract. Instead, they choose to hedge with put options in order to maintain the upside potential. When gold prices increase, protecting the downside becomes relatively less important. Firms then sell their upside potential,

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

possibly hoping that prices are more likely to decline than to increase further.

In summary, the time-series results document a link between current market conditions and the derivatives instruments firms choose to hedge their exposures. 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

Options constitute a significant part in the risk management portfolios of many firms, but our knowledge as to why firms hedge with options rather than with simpler, linear contracts is limited. This study analyzes options strategies in the North American gold mining industry, which, due to the diversity of hedging strategies but homogeneity of the primary risk exposures, is an excellent laboratory for the study of hedging instrument choices.

I find that the use of options is consistent with models using financial constraints as a motive for corporate risk management as advanced by Froot, Scharfstein and Stein (1993) and Adam (2002). In particular, I find that the use of insurance (put) strategies is positively correlated with firms' capital expenditures, suggesting that firms hedge a fixed portion of their capital expenditures. As hedging with puts requires the up-front payment of the put premium, however, only the larger and least financially constrained firms are willing or able to use this strategy. More financially constrained firms finance the puts by selling call options, and thus hedge using collar strategies. The most financially constrained firms choose hedging strategies that involve the sale of call options. Selling options may be a way to obtain low-cost financing, as the calls are essentially collateralized by the firms' gold reserves in the ground. However, some of the largest firms in the gold mining industry also sell calls. These firms are unlikely to be financially constrained, and may sell options simply in the hope that they will expire worthless.

While I find no evidence that the uncertainty of the exposure (non-hedgeable risks) motivates firms to use options strategies, market conditions are correlated with firms' hedging instrument choices. In particular, when gold prices decline mining firms purchase more puts, while when gold prices rise firms sell more calls. This result suggests that firms use options not only to hedge, but also to speculate.

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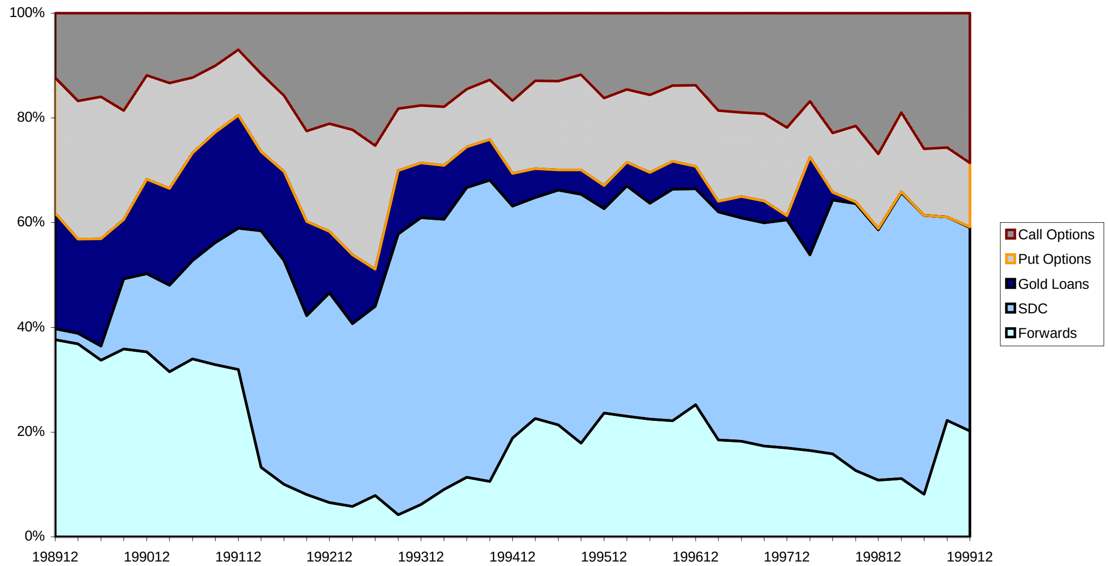

Fig. 1. The aggregate derivatives portfolio. This graph shows the main derivatives instruments used by gold mining firms in North America to hedge gold price risk, and how the composition of the aggregate derivatives portfolio evolved over time. The aggregate derivatives portfolio is calculated by summing 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.

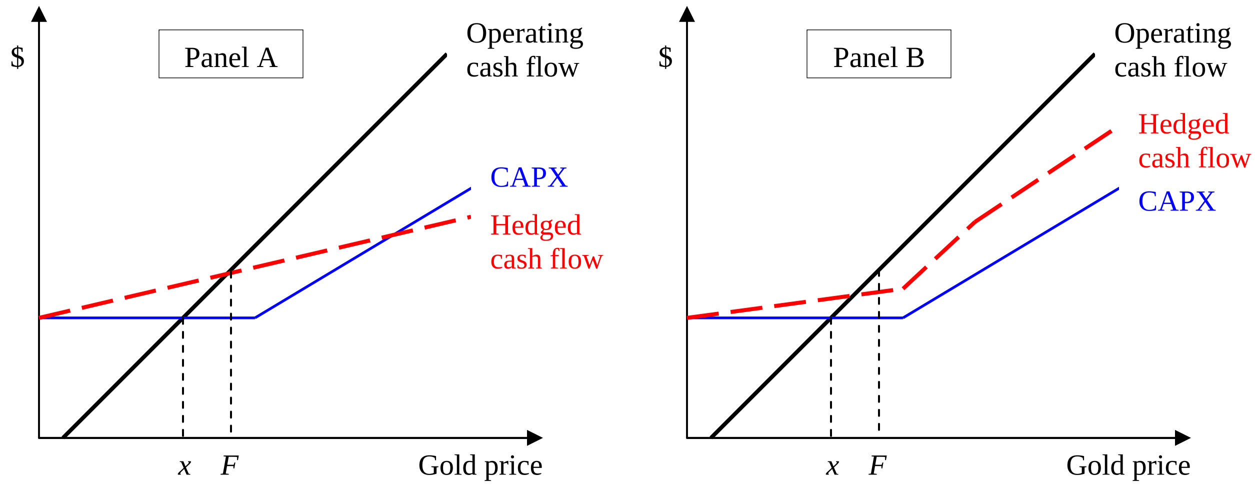

Fig. 2. Hedging a non-linear exposure. This figure compares the effectiveness of linear with options hedging strategies. The graphs depict a firm's operating cash flow and its capital expenditures (CAPX) as functions of the gold price. If the gold price falls below the threshold *x*, the firm would need 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.

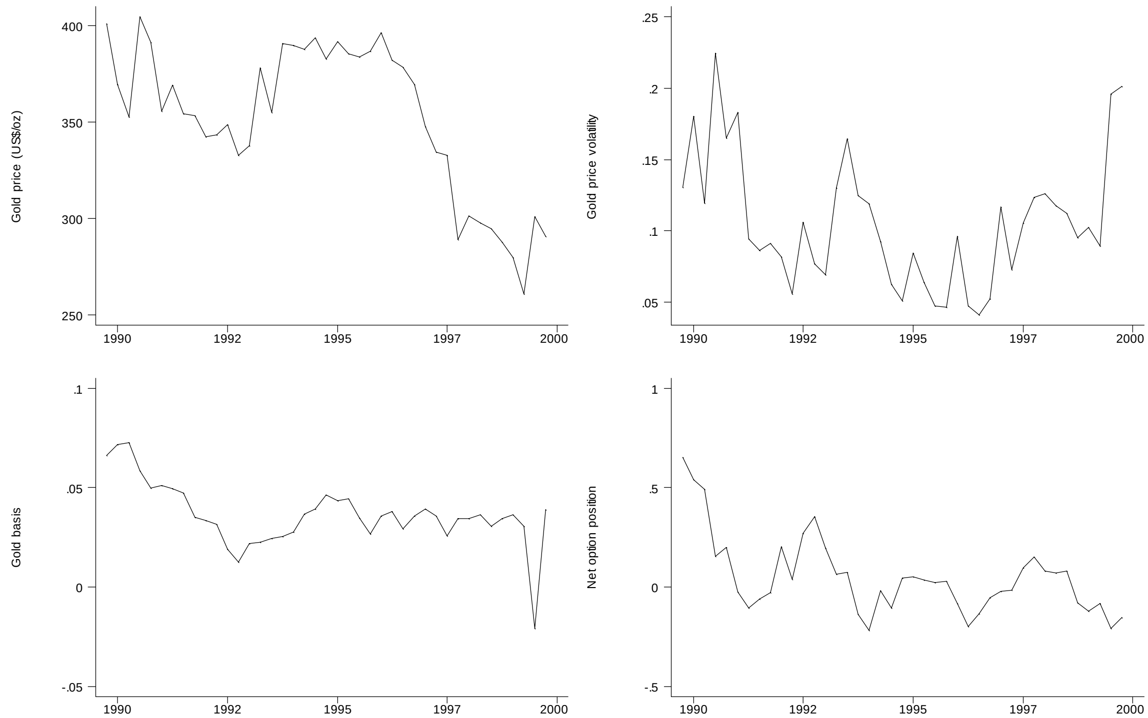

Fig. 3. The net option position and market conditions. The first two graphs depict the gold price and the gold price volatility during the sample period. The gold price volatility is the annualized standard deviation of daily gold price returns over the previous 60 trading days. The third graph depicts the gold basis, i.e., the difference between the 1-year forward and the current spot price of gold. The fourth graph depicts the industry average of firms' net option positions, defined by (puts – calls) / (puts + calls). It measures the size of the put position relative to the call position, and is bounded between 1 (100% puts) and -1 (100% calls).

Table 1
Construction of variables

This table lists the 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, from the Bureau of Labor Statistics, is used to deflate nominal figures.
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)	The Herfindahl index is 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)	The Herfindahl index is 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* are 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. Annually reported observations are repeated for each quarter of the same fiscal year.
Number of operating mines	Number of operating mines per firm. Annually reported 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.

Variable	Construction of variable
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 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 years). 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.

Table 2
Descriptive statistics

This table reports standard sample statistics for 111 gold mining firms in North America between 1989 and 1999. The *Use of derivatives* dummy variable equals one if a firm had outstanding derivatives positions at quarter end and zero otherwise. The *Use of options* dummy variable equals one if a firm had option positions and zero if the firm had non-option derivatives positions outstanding at quarter end. Definitions of all other variables can be found in Table 1.

	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
Number of operating mines	4.10	3	3.20	1	18	866	52
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
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

Table 3
Summary of empirical predictions

This table summarizes the empirical predictions for each of the four principal hedging strategies in the North American gold mining industry.

	Derivatives strategy			
	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
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

Table 4
Univariate analysis

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. 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.

	I	II	III	IV	II vs. IV
	Linear contracts only	Long puts & linear contracts	Collars & linear contracts	Short calls & linear contracts	t-statistics z-scores
Firm-strategy observations	68	37	56	31	
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*
Number of operating mines	3.86 3	5.50 4.5	4.15 3	3.74 3	1.602 1.902*
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*

	I	II	III	IV	II vs. IV
	Linear contracts only	Long puts & linear contracts	Collars & linear contracts	Short calls & linear contracts	t-statistics z-scores
Firm-strategy observations	68	37	56	31	
Credit rating dummy	0.142 0	0.258 0	0.196 0	0.179 0	0.748 0.813
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

Table 5
Determinants of derivative instrument choice

This table presents multi-nomial logit regression results of the decision to select one of the four hedging strategies listed in Table 5 (linear, put, collar, and call strategies). The base category are linear strategies. 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.

	Long puts & linear contracts		Collars & linear contracts		Short calls & linear contracts
ln(CAPX / PPE)	0.344** (2.10)		0.300** (2.24)		-0.118 (-0.62)
ln(book value of assets)	0.483** (2.12)		0.449* (1.69)		0.649*** (2.83)
Herfindahl index (asset segments)	2.649** (2.35)		3.270** (2.52)		3.607** (2.13)
Herfindahl index (metals production)	-1.380 (-1.11)		-1.147 (-0.94)		0.436 (0.26)
Dividend dummy	-0.751 (-1.11)		-1.346** (-2.37)		-2.379*** (-3.75)
Leverage	-1.150 (-0.92)		-1.209 (-1.10)		-3.897* (-1.79)
Production uncertainty	0.005 (0.01)		-0.037 (-0.11)		-1.392 (-1.24)
	Wald test	87.95	Pseudo R^2		0.086
	Significance level	0.000	Obs. / number of firms		706 / 60

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

Table 6
Buying puts versus selling calls

This table presents random-effects logit regressions to evaluate the differences between firms that buy (put) options and firms that sell (call) options. Buy versus sell options is a dummy variable that equals 1 if a firm bought put options, and 0 if a firms sold call options. 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 versus sell options (dummy variable)		
			Excluding the largest 10% firms	Excluding the largest 25% firms
ln(book value of assets)	+	-0.628* (-1.86)	0.271 (0.64)	1.446** (2.03)
Herfindahl index (asset segments)	-	-3.338* (-1.75)	-3.192 (-1.24)	-6.126* (-1.89)
Herfindahl index (metals production)	-	-1.523 (-1.03)	2.777 (1.09)	4.510 (1.40)
Dividend dummy	+	1.780** (2.31)	2.221** (2.39)	3.044** (2.53)
Leverage	+	7.544*** (3.02)	6.087* (1.90)	8.539*** (2.59)
Production uncertainty	+ / -	2.355 (1.44)	1.849 (0.97)	2.761 (0.77)
Wald test		15.52	12.58	13.23
Significance level		0.017	0.050	0.040
Obs. / number of firms		160 / 39	146 / 38	114 / 32

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

Table 7
The extent of using options strategies

This table presents random-effects tobit models, evaluating the determinants of the extent of choosing different options strategies. The dependent variables are defined as follows.

$$\text{Extent of using insurance strategies} = \frac{\text{puts}}{\text{linear contracts} + \text{puts}}$$

$$\text{Extent of using collar strategies} = \frac{\min\{\text{calls, puts}\}}{\text{linear contracts} + \min\{\text{calls, puts}\}}$$

$$\text{Extent of selling calls} = \frac{\text{calls}}{\text{linear contracts} + \text{calls}}$$

All contracts are measured in ounces of gold hedged. 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.

	Extent of using insurance strategies	Extent of using collar strategies	Extent of selling calls
ln(CAPX / PPE)	0.108** (1.99)	0.025 (1.27)	0.012 (0.24)
ln(book value of assets)	0.195*** (3.54)	0.108*** (5.06)	0.155*** (3.48)
Herfindahl index (asset segments)	0.579** (2.02)	0.452*** (3.29)	0.893*** (2.69)
Herfindahl index (metals production)	-0.115 (-0.43)	-0.004 (-0.04)	-0.028 (-0.13)
Dividend dummy	-0.320** (-2.28)	-0.181*** (-3.07)	-0.729*** (-5.16)
Leverage	-0.039 (-0.12)	-0.053 (-0.47)	-1.086*** (-3.91)
Production uncertainty	0.044 (0.26)	-0.069 (-1.45)	-0.662*** (-2.94)
Wald test	24.50	45.80	79.01
Sig. level	0.000	0.000	0.000
Pseudo R^2	0.072	0.064	0.247
Obs. / number of firms	318 / 51	560 / 57	306 / 52

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

Table 8

The impact of market conditions on the use of options strategies

This table evaluates how the use of puts and calls is affected if market conditions, such as the gold price, the gold price volatility, and the gold basis change. The dependent variable, the net options position, is defined by $\frac{\text{puts - calls}}{\text{puts + calls}}$, and measures the size of the put position relative to the call position (see Fig. 3). 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 difference between the 1-year forward price and the current spot price of gold. To eliminate time-trends, all regressions are estimated on changes in all variables.

	Full sample	Top 50% of firms (market value)	Bottom 50% of firms (market value)
Gold price	-0.003*** (-2.70)	-0.002* (-1.79)	-0.004** (-2.00)
Gold price volatility	0.287 (0.69)	0.125 (0.20)	0.224 (0.26)
Basis	-1.379 (-1.10)	-2.128 (-1.65)	-2.105 (-0.95)
Fixed effects	Yes	Yes	Yes
Obs. / number of firms	754 / 63	304 / 31	245 / 31
R^2 (within)	0.011	0.014	0.020