

Who Manages Risk? An Empirical Examination of Risk Management Practices in the Gold Mining Industry

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ABSTRACT

This article examines a new database that details corporate risk management activity in the North American gold mining industry. I find little empirical support for the predictive power of theories that view risk management as a means to maximize shareholder value. However, firms whose managers hold more options manage less gold price risk, and firms whose managers hold more stock manage more gold price risk, suggesting that managerial risk aversion may affect corporate risk management policy. Further, risk management is negatively associated with the tenure of firms' CFOs, perhaps reflecting managerial interests, skills, or preferences.

ACADEMICS KNOW REMARKABLY little about corporate risk management practices, even though almost three-fourths of corporations have adopted at least some financial engineering techniques to control their exposures to interest rates, foreign exchange rates, and commodity prices.¹ While theorists continue to advance new rationales for corporate risk management, empiricists seeking to test if practice is consistent with these theories have been stymied by a lack of meaningful data. Corporations disclose only minimal details of their risk management programs, and, as a result, most empirical analyses have to rely on surveys and relatively coarse data that at best discriminate between firms that do and do not use specific types of derivative instruments. Case studies of individual firms, while providing greater detail on firm practices, typically lack cross-sectional variation to test whether existing theories explain behavior.

As a result of data limitations, for most industries we cannot describe which firms manage more risk than others or whether firms engage in dynamic risk management strategies. More importantly, we cannot reliably test whether

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¹ The Wharton/Chase Derivatives Survey (1995) reports that over 70 percent of firms use derivatives to hedge commitments.

firms' risk management practices conform with existing theories. This article describes risk management practices and tests their conformance with existing theory by analyzing an industry that seems almost tailor-made for academic investigation: the North American gold mining industry.

In the United States and Canada, there are over 50 publicly-traded and closely-watched firms whose exclusive or primary line of business is mining gold. These firms share a common and clear exposure in that their output is a globally-traded, volatile commodity. Firms can manage this exposure using a rich set of instruments, including forward and futures contracts, gold swaps, gold or bullion loans, rolling forward commitments called spot deferred contracts, and options. Perhaps most important, firms in the gold mining industry disclose their risk management activities in great detail. Quarterly reporting provides investors with extensive information on firms' use of forward sales, swaps, gold loans, options, and other explicit or embedded risk management activities, and permits analysts to calculate meaningful measures of the degree of risk management undertaken.

At first glance, one might expect that no firm in the gold mining industry would choose to manage gold price risk. Given an extensive gold derivative market, investors can modify gold price risk almost as well as mining firms can. Given the reasonably transparent nature of the mining industry and the tangible nature of its assets, many rationales for corporate risk management derived from considerations of asymmetric information and deadweight costs of financial distress seem almost irrelevant. Theory might predict that no firms manage gold price risk.

To the contrary, the gold industry has embraced risk management: over 85 percent of the firms in this industry used at least some sort of gold price risk management in 1990–1993. Furthermore, mining firms have adopted very different risk management approaches, ranging from Homestake Mining, which sold all of its production at spot prices and made vigorous pronouncements against gold price management, to American Barrick, which featured its successful hedging program on the cover of its annual report.

Using industry-specific measures for firms' exposures, cost structures, and investment programs, I test whether cross-sectional differences in risk management activity can be explained by academic theory. For example, theory predicts more extensive risk management by firms more likely to face financial distress, which in this industry can be measured by operating costs and leverage. Other theories posit that corporate risk management activities might be linked to risk aversion of corporate managers, and the form in which they hold a stake in the firm. These theories would predict that firms whose managers hold greater equity stakes as a fraction of their private wealth would be more inclined to manage gold price risk, but those whose managers hold options might be less inclined to manage gold price risk. This article tests the predictive (as compared with the prescriptive) power of the various theories, i.e., whether they help describe the choices made by firms.

I find that gold mining firms' risk management decisions are consistent with some of the extant theory. Managerial risk aversion seems particularly rele-

vant; the data bear out Smith and Stulz's (1985) prediction that firms whose managers own more stock options manage less gold price risk, and those whose managers have more wealth invested in common stock manage more gold price risk. These results seem robust under a variety of econometric specifications, and using a number of alternative proxy variables. In contrast, theories that explain risk management as a means to reduce the costs of financial distress, to break the firm's dependence on external financing, or to reduce expected taxes are not supported strongly. I also find that firm risk management levels appear to be higher for firms with smaller outside block holdings and lower cash balances, and whose senior financial managers have shorter job tenures.

The remainder of the article is divided into five sections. Section I describes risk management activities of gold mining firms and develops a measure of the extent of risk management that firms undertake. Section II briefly reviews extant theoretical research on corporate risk management and describes characteristics of gold mining firms that theory would use to explain the cross-sectional disparity in risk management choices. Section III examines the cross-sectional variation in the use of financial risk management practices among gold mining firms, analyzing the relationship between the extent of risk management and firm characteristics using tobit analyses. Section IV more closely investigates the relationship between risk management and managerial traits, testing the robustness of the results in Section III under alternative specifications. Section V concludes the article with a discussion of the implications of the findings for current theory and subsequent research on risk management. In addition, a detailed appendix describes the form of risk management strategies adopted by gold mining firms.

I. Gold Price Risk Management Activities in the Gold Mining Industry

The gold mining industry serves as a strategic research site for a variety of reasons: gold mines face a common, substantial exposure to fluctuating gold prices; gold prices have experienced substantial volatility; capital markets have developed a wide variety of techniques to manage this volatility; firms have adopted a rich variety of policies with respect to gold price management; and finally, implementation of these policies is publicly disclosed in this industry, allowing us to directly observe the financial risk management activities of firms. This section briefly describes the means by which gold mining firms manage gold price risk and proposes a measure of risk management activity.

A. Background on Institutional Practices: Tools to Manage Gold Price Risk²

Firms can manage risk through diversification, hedging, and insurance (Merton (1993)). Most of the 48 North American gold mines studied in this

² For a discussion of gold risk management instruments, see Tufano and Serbin (1993) or Cross (1994). Some of the firms studied here may also manage their interest rate or foreign exchange exposures, but these activities are not studied in this article.

article are not well diversified, thus their gold price risk management involves hedging (the shedding of all exposure through the sale of gold at fixed prices) or insurance (the shedding of downside exposure, for instance through the purchase of put options). Risk management strategies can be implemented using explicit derivative transactions, such as in the forward sale of gold, or they can be combined with financing activities. For example, in borrowing via a gold or bullion loan, a mining firm combines dollar-based-financing with a forward sale of gold.

Hedging instruments include over-the-counter forward sales of gold, exchange-traded futures contracts, gold or bullion loans, gold swaps, and spot deferred contracts (which are economically similar to rolling forward contracts.) Firms wishing to establish *insurance* strategies can use either exchange-traded or over-the-counter gold put options, or can dynamically replicate puts by trading forwards and futures. This article's primary focus is on the *level* of risk management activity chosen by the firm, not the *form* of that activity. An appendix to this article summarizes the types of risk management strategies and instruments used by firms, the practical concerns that affect the choice of instruments, and empirical regularities in firms' use of insurance versus hedging strategies.

The rich menu of risk management instruments gives firms an ability to customize their gold price exposure, and firms have embraced risk management. For example, over four years American Barrick Resources Corporation used put and call options, gold warrants, bullion loans, forward sales, spot deferred contracts, and customized gold-linked equity financings as part of its risk management program (Tufano and Serbin (1993)). Detailed disclosure of gold mining firms' use of the full range of risk management instruments permits analysts to measure the firms' gold price exposure.

B. Constructing a Measure of the Extent of Financial Risk Management Activity

To measure a mining firm's gold price risk management, one would like to know the economic magnitude of risk-modification activities across all types of transactions, scaled by the size of the underlying exposure of the firm. Fortunately, North American mining firms provide exceptionally thorough disclosure of the type, amount, and terms of explicit and financing-related gold price risk management activities, so as to permit the construction of this type of measure. The necessary data has been collected, summarized, and expanded by regular surveys of company hedging activity. These studies were conducted by at least three equity analysts since 1988. This article uses data on gold risk management positions from 1991 through 1993 compiled by Ted Reeve, a Canadian equity analyst who covers precious metals firms.³ These data, which

³ Mr. Reeve published his first survey in February 1990, when he was employed by First Boston Corporation, then continued his quarterly surveys after moving to Sanwa McCarthy Securities Limited (1993) and then Burns Fry Limited (1994). Other surveys have been conducted by analysts at Burns Fry and Nesbitt Research. The Burns Fry surveys were conducted annually

cover the bulk of the mines in North America, were publicly disseminated in Reeve's research reports at First Boston and his successive employers, and were well-known in the gold mining and investing community.⁴

Table I, Panel A shows the data reported in the Reeve survey for one firm. As of March 31, 1991, this firm had committed to sell 96,000 ounces of gold under forward sales commitments through the end of 1991, at an average price of \$443 per ounce. It had commitments to deliver gold under its gold loan agreements shown for each of the three years that the survey covers. It had purchased put options expiring before the end of 1991 with an average strike price of \$425/ounce on 20,000 ounces. Finally, it wrote call options on gold, also for 20,000 ounces, expiring before the end of 1991, with an average strike price of \$455/ounce. One limitation of this data is that commitments beyond three years are not reported.

Rather than analyze each financial contract separately, it is useful to express a firm-wide summary measure of the reported financial risk management portfolio by calculating the portfolio *delta*, a common measure of exposure of investment portfolios. The delta represents the change in the value of a portfolio with respect to a small change in the price of an underlying asset. Through the logic of dynamic replication, the delta also represents the equivalent long or short position in the underlying asset necessary to construct the replicating portfolio. In this case, the portfolio delta represents the ounces of gold that the firm has effectively sold short through its financial risk management activities. It can be estimated with the information from the Reeve surveys and additional market data.⁵ A sample calculation is shown in Table I, Panel B. As of March 31, 1991, this mining firm had a gross short position in gold (through forward sales, gold loans, long puts, and short calls) equal to 226.965 ounces of gold sold. The deltas of its forward and embedded forward positions are equal to 1:0. The puts it bought are substantially in-the-money (exercise price of \$425 while

from 1987, and two surveys were conducted by Nesbitt. I have used the Burns Fry and Nesbitt surveys to test the Reeve data for consistency, but rely on the Reeve surveys because they cover a wider range of hedging instruments and contain quarterly observations. By late 1993, the Reeve surveys were the only ones published, as Nesbitt ceased publication of its hedging report and Reeve subsequently joined Burns Fry and continued his surveys there.

⁴ From their inception, hedging surveys have enjoyed strong cooperation by the participating gold mines. By Reeve's estimate, his 1990 surveys covered firms representing approximately 70 percent of all North American gold production, the 1991-1992 surveys covered approximately 80 percent of all North American production, and the 1993 surveys cover over 90 percent of all production. These self-calculated coverage figures can be verified using industry data from a rival analyst at Nesbitt Thompson. According to Mr. Reeve, North American firms that are not included in the survey (either because they were not polled or refused to answer) tend to be very small producers or privately held firms.

⁵ While deltas are typically reported as the quantity of the long position in the underlying asset, for expositional convenience in this paper, all positive deltas represent the quantity of the underlying (gold) that has been sold *short*.

Table I
Sample Data on One Gold Mining Firm's Risk Management Activities

Panel A: Data from "Global Gold Hedge Survey" for One Gold Firm, as of March 30, 1991^a

	1991			1992			1993		
	Ounces	Price (US\$/Oz.)	% of Production	Ounces	Price (US\$/Oz.)	% of Production	Ounces	Price (US\$/Oz.)	% of Production
Forward sales	96,000	\$443							
Gold loans	22,353	\$476		44,706	\$476		44,706	\$476	
Puts (purchased)	20,000	\$425							
Total	138,353	\$446	61.2	44,706	\$476	10.3	44,706	\$476	11.0
Calls (sold)	20,000	\$455							

Panel B: Delta of Firm's Gold Derivative Portfolio, as of March 30, 1991

Position	Ounces	Delta ^b	Delta-Ounces ^c
Forward sales—1991	96,000	-1.0	-96,000
Gold loans—payable 1991	22,353	-1.0	-22,353
Gold loans—payable 1992	44,706	-1.0	-44,706
Gold loans—payable 1993	44,706	-1.0	-44,706
Put options maturing 1991 ^d	20,000	-0.957	-19,140
Call options maturing 1991 ^d	20,000	-0.003	-60
Aggregate equivalent portfolio position (ounces)			-226,965
Production estimate through 12/93 (ounces) ^e			1,066,524
Delta-percentage = percentage of production accounted for by portfolio delta ^f			21%

^a Source: Ted Reeve, "Global Gold Hedge Survey," First Boston Equity Research (June 10, 1991), p. 11.

^b Delta equal to -1.0 for short forward and embedded forward positions.

^c Delta times number of ounces.

^d Assuming that the options mature on the final day of the period and are structured as European-style options that can be exercised only on the expiration date. Uses risk-free rate and gold lease rate as of March 30, 1991 as inputs to Black-Scholes-Merton model. As of this date, the appropriate risk-free rate was 5.9 percent and the gold lease rate was 0.83 percent per annum. The price of gold was \$367.10/oz. and the volatility of gold over the prior 90 days was 9.6 percent per annum.

^e Implied by Panel A.

^f Equals equivalent portfolio position divided by production estimate. While these numbers are negative for all the firms in the database, their absolute values are reported throughout the study. Greater delta-percentage indicates a larger amount of production has been hedged through equivalent short-sales.

the gold price is \$367), and thus have deltas almost equal to 1.0.⁶ The calls which it sold are substantially out-of-the-money, and have deltas of nearly zero. In the aggregate, for a \$1 drop in the gold price, the market value of the firm's gold derivative portfolio should rise by \$226,965.

⁶ This calculation assumes that the options expire at the end of the year shown. The other information needed to calculate the delta include the risk-free rate (calculated using Treasury rates), the volatility of gold (calculated using the historical volatility over the prior 90 days), and the gold lease rate (supplied by Jessica Cross and Morgan Stanley). The gold lease rate is the interest rate paid on borrowings of gold.

Because it includes all financial risk management activities, the delta is not subject to the inaccurate categorization of functionally-equivalent financial positions. In turn, this permits an analyst to disentangle derivatives activity from risk management activity, which is a major advantage of the dataset. In a majority of the earlier empirical research on risk management, researchers measured "risk management" by using a dichotomous variable that equaled one if the firm used derivatives and zero otherwise.⁷ Unfortunately, these methodologies cannot directly distinguish between derivatives use and risk management. For instance, two firms may consciously manage their interest rate exposure, one firm using swaps, futures, or options, while its more traditional counterpart selects the type of debt it issues, incorporating embedded interest rate derivatives (like call features) into debt issues. By equating "risk manager" with "derivative user," the former would be characterized as a "hedger" and the latter, while functionally equivalent, a "non-hedger." With the more detailed data in the gold mining industry, one can add together on- and off-balance sheet risk management activity so as to avoid this incorrect distinction. Thus, the delta represents a summary measure of all financial risk management activity.⁸

It is necessary to scale the firm's financial risk management portfolio against its natural exposure to understand its economic importance.⁹ I define a mine's *delta-percentage* as the delta of the portfolio divided by the amount of gold the Reeve report shows as expected to be produced over the three years, the same period over which risk management data is reported. In the example given above, 226,965 ounces of gold sold short equals 21 percent of the firm's estimated production through the end of 1993. In managerial terms, 21 percent of the gold to be produced over the next three years has been sold forward, and that portion of the mine's production has no gold price exposure.

Were information available on the firm's financial risk management positions for *all* maturities, the risk management portfolio delta could be scaled by

⁷ In seven related empirical studies of corporate risk management, researchers classify firms into two groups on the basis of their use of particular types of derivatives, as determined by surveys or by inspection of financial statements. In four studies, authors surveyed firms, asking respondents whether their firm used selected derivative instruments (Booth, Smith, and Stolz (1984), Block and Gallagher (1986), Houston and Mueller (1988), Nance, Smith and Smithson (1993)). Three studies search financial statements or the National Automated Accounting Research System (NAARS) database, and define as risk managers firms whose financial reports included references to terms including "hedge" or to particular instruments, such as "interest rate swaps" (Wall and Pringle (1989), Francis and Stephan (1990), Geczy, Minton, and Schrand (1995)).

⁸ The delta-percentage ignores *operating* risk management activities, including the real options to change the rate of production, exploration, and acquisition. Unfortunately, there is no easy way to measure this type of operating flexibility.

⁹ In this spirit, three sets of empirical papers use continuous measures of risk management activity scaled by a measure of firm exposure. Mayers and Smith (1990) collected information on the percentage of insurance premiums ceded through reinsurance, a measure of the amount of risk shed by insurers. Dolde (1993, 1995) surveyed finance managers, asking them to estimate what "percentage of inherent exposure from operations (their firms) attempt to offset, on average." Schrand and Unal (1995) use thrifts' net one-year maturity gap as a measure of total interest rate exposure.

the "value delta" of the mine's unhedged operations. This "value" delta would reflect the change in the *value* of the unhedged firm for a small change in gold price, which would equal the change in value of the entire production profile reflecting all reserves, as well as the change in value of the real options in production, development, acquisition, and exploration. As information on financial risk management activities is available only over a three-year horizon, the relevant measure of underlying gold price exposure is the expected ounces of production over this same horizon.

Apart from this practical limitation, there are two additional reasons for scaling the delta by production, which reflects the short-term cash flow to be produced by the mine. First, much risk management theory, such as Froot, Scharfstein, and Stein (1993), is defined in terms of firms' cash flow exposures, as compared with their total value exposure. Second, gold mining managers also focus on cash flow exposure; the percentage of near-term production hedged is the common metric that managers of gold mines use to set and describe risk management policy. For example, when Battle Mountain Gold announced its decision to hedge, it expressed its risk management policy in terms of the percentage of the next year's production it committed to hedge.

C. Sample Construction

The above example demonstrates the type of information available on the financial risk management activities of North American mines. The database of mining firms studied in this article were those 48 firms that met the following three criteria:

- (1) The firm's risk management activities were reported in the "Global Gold Hedge Survey" or the succeeding publications by Mr. Reeve;
- (2) The firm had common shares whose price and dividend history were reported by Reuters, in its ReuterLink database of U.S. and Canadian exchanges; and
- (3) The firm was covered by COMPUSTAT.

For each firm-quarter, I calculate a delta-percentage, the percentage of the following three calendar years' estimated production that has been effectively short-sold. The effective short-sale amount is the calculated delta of the firm's reported hedging and option transactions (expressed in ounces) where the delta of the option transactions is found using the Black-Scholes-Merton model, taking as inputs the spot gold price (COMEX), the gold lease rate (reflecting the relevant cost-of-carry), annualized volatility of gold prices estimated from the prior 90 trading days' prices, and the appropriate treasury rate. Because firm data is available only on an annual basis, I use the annual delta-percentage by averaging the firms' delta-percentages over the year.¹⁰

¹⁰ Analyses using year-end delta-percentage were run, and do not differ materially from those reported.

Table II
Distribution of Risk Management Activity in the North American Gold Mining Industry, 1990-1993

For each firm and quarter, financial risk management transactions for the remainder of the current year and the subsequent two calendar years are aggregated to form a portfolio delta or equivalent short position in ounces of gold. This equivalent short position is divided by the firm's estimated production over the same time period, to form delta-percentage, a variable that represents the percentage of production over the following three calendar years that is covered by risk management activities. These delta-percentage figures are averaged over the 16 quarters for each firm, and the distribution of firm observations is reported using equal weighting for each firm and weighing each firm by their proven and probable reserves.

Firm Delta-Percentage (average 1990-1993)	Percentage of:	
	Firms	Industry Reserves
Exactly 0	14.6	14.8
0.1-10	14.6	11.3
10-20	14.6	25.2
20-30	14.6	6.4
30-40	25.0	22.7
40-50	2.1	1.9
50-60	4.2	4.1
60-70	4.2	1.0
70-80	4.2	0.7
80-90 ^a	2.1	12.0
Mean	25.6	
Median	22.9	
Standard deviation	22.4	
Minimum	0.0	
Maximum	85.9	

^a These represent averages over the four year period 1990-1993. For any one quarter or year, a firm may have had a delta-percentage exceeding 100 percent; the maximum quarterly delta-percentage is 146 percent.

Table II reports the level of risk management activity entered into by the firms in the sample between 1990 and 1993, reported as the firm's average delta-percentage—the percentage of the following three years' worth of projected production that had been effectively sold short. The table gives the distribution of risk management activity, weighing each firm equally as well as by proven and probable reserves. Looking at the distribution, it is apparent that firms have adopted diverse practices, with 14.6 percent selling all of their output at spot prices and 16.8 percent of firms shedding 40 percent or more of the price risk of their projected three-year output forward. The median firm in the sample shed 22.9 percent of its output over the multiple-year period shown in the table. There are no firms that used these financial transactions to increase gold price exposure; thus, it appears that the financial risk management programs produce risk reduction, rather than risk enhancement (or speculation).

Because the gold mining industry offers us detailed risk management data that exhibit large differences in firm behavior, we are naturally led to theory to help us explain these differences. The following section discusses those characteristics of gold mines that theory suggests should affect the level of corporate risk management.

II. Empirical Implications of Theories of Corporate Risk Management

Theorists have constructed two classes of explanations for managers' choices of risk management activities on behalf of their firms. One class of explanations focuses on risk management as a means to maximize shareholder value, and the second focuses on risk management as a means to maximize managers' private utility. This section briefly describes these theories, and the characteristics of gold mining firms that theories predict will be related to the level of risk management. Table III summarizes the hypotheses tested, definitions of the variables examined, and sources of information.

A. Shareholder Maximization Hypotheses

A.1. Financial distress

Financial distress arguments for risk management, developed by Smith and Stulz (1985), hold that by reducing the likelihood of costly financial distress, risk management can increase the expected value of the firm. This increase in value comes from the reduction in deadweight costs, and an increase in debt capacity, which in turn can benefit the firm through valuable tax shields or reductions in agency costs of excess free cash flow. Shapiro and Titman (1986) extend the costs of financial distress to include the deterioration of valuable relationships with buyers and suppliers who value long-term access to the firm, for example to provide ongoing service.

Gold mining firms encounter financial distress if the price of gold falls below their costs to produce gold and make fixed financial payments. To measure the relative likelihood of financial distress, I collect data on firms' *cash costs* and *leverage*. Cash costs are per ounce costs of producing gold, excluding non-cash items such as depreciation, depletion, and amortization as well as financing costs. Cash costs vary with the quality of ore deposits and operating efficiencies; in the short-term they reflect the firm's fixed production technology. Leverage is measured as the book value of debt divided by the total market value of financial claims (market value of equity plus book value of preferred stock and debt.) Theory predicts a positive relationship between the delta-percentage and both cash costs and leverage.

A.2. Investment Policy

A set of articles, including Stulz (1990), Lessard (1990), and Froot, Scharfstein, and Stein (1993) argue that without risk management, firms will be

Table III
Hypothesized Relations Between Firm Characteristics and Extent of Risk Management Activities

Hypothesis	Variable	Sign	Data Description (Source)
Financial distress	Cash costs	+	Cash costs include all direct and indirect costs of mining, crushing, processing and general and administrative expenses of the mine, including royalties and mining taxes. Cash costs exclude noncash items, such as depreciation, depletion, and amortization, as well as interest expense, corporate SG & A, exploration, and extraordinary costs. Reported in US\$. (Annual reports and 10Ks.)
	Leverage	+	Long-term debt scaled by firm size (3-year average), ending with the current year. (COMPUSTAT.)
Disruption of investment opportunities	Exploration Activities	+	Exploration expenditures and expenses scaled by firm value. (Annual reports and 10Ks.)
	Acquisition Activities	+	Dollar value of attempted acquisitions attempted over prior 3 years scaled by firm value. (Securities Data Corp., Mergers and Acquisitions database.)
Firm size (costs of external financing)	Firm value	-	Annual average of daily market value of equity plus book value of preferred stock plus book value of long term and current debt: US\$, millions. Reuters, COMPUSTAT.)
	Reserves	-	Proven and Probable Reserves (Mil. oz) (Annual reports and 10Ks.)
Tax savings	Tax loss carry forwards	-	Tax loss carry forwards scaled by firm value. (COMPUSTAT and annual reports.)
Risk aversion	Officers' and directors share ownership	+	Log of the value of common shares owned (excluding options) at average annual share price—value in US\$, millions. (Proxy statements (US), management information circulars (CDN), and 10-K filings. Share price information from Reuters.)
	Officers' and directors option holdings	-	Number of options outstanding held by officers and directors in millions. (Proxy statements (US), management information circulars (CDN), and 10-K filings.)
	Large nonmanagerial blocks	?	Percentage of common shares owned by large block-holders (% ownership at least 10%), excluding officers and directors. (Proxy statements (US), management information circulars (CDN), and 10-K filings.)
Alternative financial policies	Diversification	-	Percentage of assets engaged in nonmining operations. (COMPUSTAT segment reporting, annual reports, 10Ks)
	Cash balances	-	Quick ratio—3 year average, ending with current year. (COMPUSTAT, annual reports.)

forced to pursue *suboptimal investment policies*. Most of these articles posit a strong link between cash flow and investment due to capital market imperfections, typically information asymmetries. When the firm's cash flows are low, obtaining additional financing is very costly, inducing the firm to scale

back value-maximizing investments. Risk management programs that break this dependence of investment on cash flow can maximize firm value. Froot, Scharfstein, and Stein's theory suggests that firms with key planned investment programs and costly external financing would be inclined to use risk management to avert the need to access costly external financing to continue these programs.

A drop in gold prices and cash flow could bring to a halt the major investment programs of mining firms: exploration and acquisition. To measure the importance of these activities to the firm, I collect information on the magnitude of firms' annual *exploration expenditures* and their *acquisition activities* (dollar value of attempted acquisitions as an acquirer over the prior three years), both scaled by the market value of the firm (the average daily market value of the firm's equity plus the book value of preferred stock and debt).¹¹ If risk management is used to protect the continued funding of these programs, theory predicts a positive relationship between these measures of investment spending and the delta-percentage.

The Froot, Scharfstein, and Stein argument hinges on costly external financing, and predicts that firms for which external financing is more costly would be more likely to use risk management. It is reasonable to suspect that information asymmetries or transaction costs for small firms are greater than for larger mines—at least for financing activities. If so, theory predicts an inverse relationship between firm size and delta-percentage; smaller mines might engage in greater risk management so as to avoid having to seek costly external financing. Firm size is measured in two ways: as the total *market value of financial claims* (the average of daily market values of equity plus book value of preferred stock and debt), and as the number of ounces of proven and probable *reserves*. Reserves are a common measure of firm size in the gold mining industry; validated by engineering reports, they represent the assets which mining firms can pledge as collateral for borrowing and posting margin.

A.3. Taxes

The tax-induced explanation for risk management, formalized by Smith and Stulz (1985) holds that in the presence of a convex tax schedule, firms would reduce expected taxes by using risk management to fix the level of taxable earnings. Greater convexity of the tax schedule should lead to more risk management. Nance, Smith, and Smithson (1993) use COMPUSTAT data to construct three variables to measure a firm's effective tax function: tax loss carry forwards, investment tax credits, and a binary variable that indicates whether the variation in the firm's historical pretax income makes it likely that it would be in the convex region of the tax code.

¹¹ These variables are scaled by the firm's value to reflect the magnitude of the programs relative to the firm's full resources. Were they scaled by a measure of the firm's current sales or income, which are direct functions of risk management policy because hedging activities directly affect the realized sales price of gold, by construction we would induce a relationship between these investment activities and the degree of risk management.

Among the 48 gold mining firms in this sample, the only one of these three variables for which there was any cross sectional dispersion was the *tax loss carry-forward* measure scaled by the firm value. Theory predicts that firms with greater tax loss carry-forwards, and hence more convex tax schedules, would have higher delta-percentages.

B. Managerial Utility Maximization Hypotheses

B.1. Managerial Risk Aversion

Smith and Stulz (1985) and Stulz (1984) focus on *managerial risk aversion* as a driver of corporate risk management. Managers whose human capital and wealth are poorly diversified strongly prefer to reduce the risk to which they are exposed. If managers judge that it will be less costly (to them) for the firm to manage this risk than to manage it on their own account, they will direct their firms to engage in risk management.

Smith and Stulz's (1985) model predicts that managers with greater stock ownership would prefer more risk management, while those with greater option holdings would prefer less risk management, because stocks provide linear payoffs as a function of stock prices whereas options provide convex payoffs.¹² The global convexity of the option contract may induce managers to take on *greater* risk, because lower risk would reduce the volatility and hence the value of the expected utility of their option contracts. Figure 1 shows how the structure of payoffs might lead the risk-averse manager holding stock to prefer to engage in risk management, but the risk-averse manager holding options to prefer no risk management.

To analyze whether the level and form of managerial equity stakes affect the degree to which gold mining firms engage in risk management, I collect from the footnotes in proxy statements the number of shares and the number of options owned by officers and directors.¹³ For shares, I calculate a dollar value, and I use *the log of the dollar value of shares owned* in these tests.¹⁴ I test whether firms whose managers collectively own greater equity interests in firms tend to be more extensive managers of risk, and I use a log specification to reflect that while always positive, risk aversion should decline as wealth increases.

For options, one would like to calculate the convexity of the portfolio of executive stock options, but exercise prices or maturity dates of options outstanding are not reported. Given this data limitation, I use the *number of*

¹² Equity can also be thought of as a call option on the value of the firm with an exercise price equal to the face value of debt claims. The implications of this proposition are examined in Section IV.

¹³ Proxies often report "beneficial share ownership" which includes share ownership and options exercisable within a few months. From footnotes, I collect information on actual share ownership, excluding options.

¹⁴ In Section IV, I consider alternative specifications of stock holdings to test the robustness of the results.

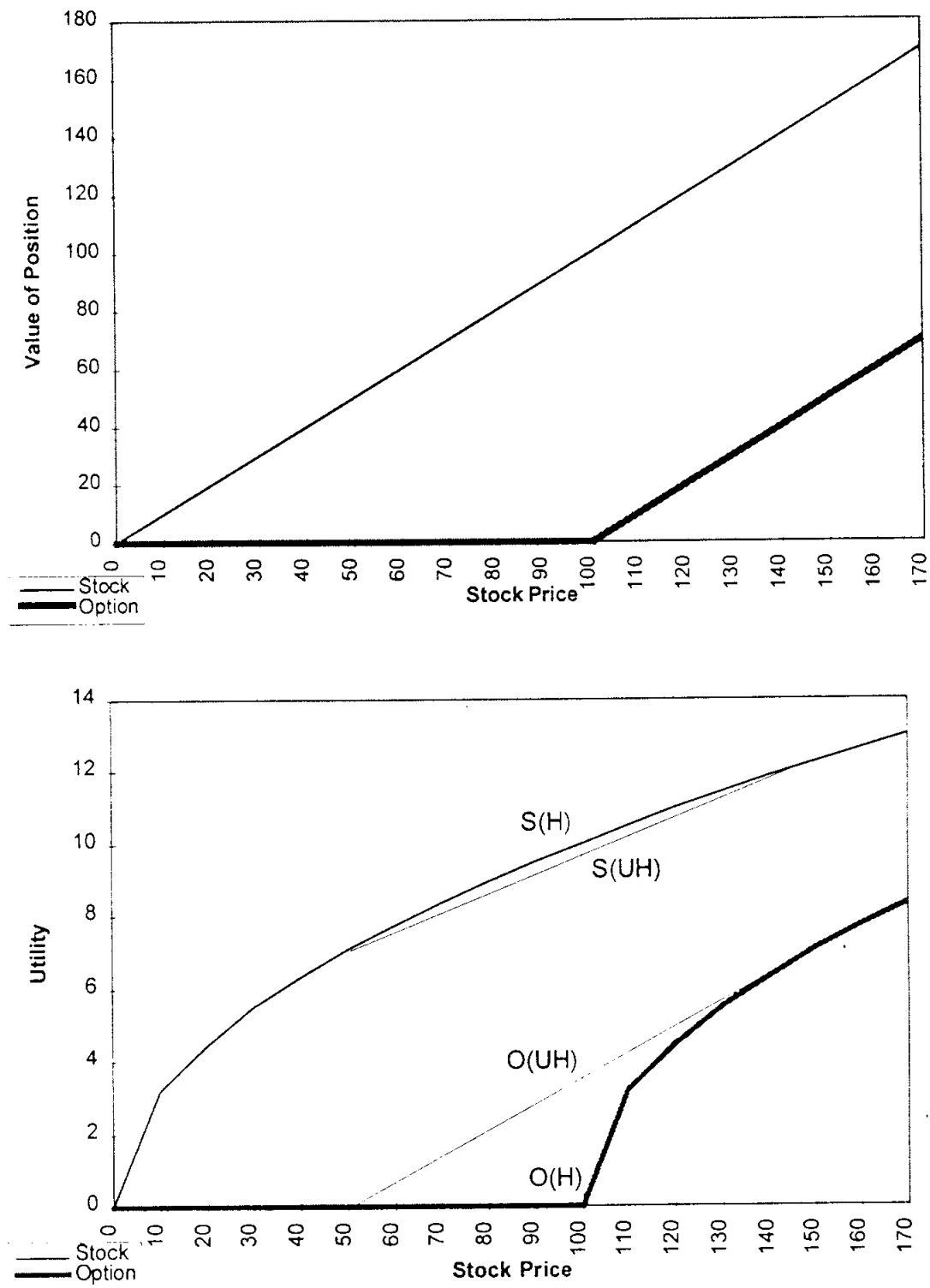


Figure 1. The value and utility of stock and option positions, as a function of firm stock price. The top panel shows the value of a share of stock and the intrinsic value of a call option with an exercise price of \$100, as a function of the stock price. The bottom panel shows the expected utility of the two values, using a utility function of $U = W^{1/2}$. Suppose the stock could take one of two values, 50 or 150, each with equal probability, and the firm could enter into a hedging contract that locked-in a value of 100. $S(UH)$ and $O(UH)$ represent the expected utility of the unhedged stock and option positions. $S(H)$ and $O(H)$ represent the expected utility of the hedged stock and option positions. The risk averse holder of stock may prefer to hedge, but the risk averse holder of an option may not.

options outstanding to measure the extent of options ownership, given that an increase in the number of options granted tends to increase the convexity of the overall payoff facing the manager.¹⁵ For risk averse managers, having greater stock holdings should be associated with more risk management, but greater option holdings should be associated with less risk management.¹⁶ In addition, to test whether risk management is an outgrowth of *poorly diversified* managers holding large equity stakes, rather than large equity stakes alone, I include a control variable in the empirical specifications that measures large block holdings by investors who are not officers and directors. This variable is measured by *large block ownership*, the percentage of the firm held by parties who each own at least 10 percent shares in the firm, excluding officers and directors. I would expect that outside blockholders, which include mutual funds, hedge funds, and private investors, would be better diversified than managers, and thus greater large block ownership should be less positively associated with risk management (if at all) than would be managerial stock ownership.

B.2. Signaling Managerial Skill

An alternative managerial explanation is advanced by Breeden and Viswanathan (1996) and DeMarzo and Duffie (1995), who focus on *managers' reputations*. In these models, outsiders cannot observe managerial quality, nor can they disentangle profits due to managerial quality as compared to exogenous market stocks. As a result, managers may prefer to engage in risk management so as to better communicate their skills to the labor market.

Models where managers use hedging to signal their abilities presume that investors cannot separate results attributable to risk management from those attributable to ability. In the gold mining industry, at least some firms measure managerial performance using operating measures like cash costs, yield per ton of ore, additions to reserves, accident records, etc.¹⁷ While much of managerial reputation may be transparent in this industry, this subject will be treated in more depth later in Section IV.

C. Alternatives to Risk Management as Controls

Instead of managing risk with the financial contracts studied here, firms could pursue alternative activities that substitute for financial risk manage-

¹⁵ In all cases, either the outstanding option figure was reported for each year, or could be constructed from the prior or subsequent disclosure of outstanding options along with information on annual exercises, new grants, and expirations. Firms in the sample did not routinely report the exercise dates or strike prices of executive options; were they revealed, I could use this information to create finer tests of the incentives of managers.

¹⁶ Holding constant the wealth invested in the firm, greater risk aversion should lead to greater risk management. In Section IV, I report on managerial age as a potential measure of risk aversion.

¹⁷ Most firms state that compensation is based on "firm performance," but do not elaborate on the specific aspect of performance monitored closely. However, a few explicitly specify the basis for bonus awards, and mention these types of operating measures.

ment strategies. They could diversify instead of hedging or insuring, or they could adopt conservative financial policies such as maintaining low leverage or carrying large cash balances to protect themselves against potential hardship (a form of negative leverage). Greater use of these substitute risk management activities should be associated with less financial risk management and a lower delta-percentage. These are not so much explanations for financial risk management, but rather controls for substitute forms of risk management.

To measure the existence of these alternatives, I collect information on the degree of *diversification*, firm *leverage*, and firm *cash balances*. The degree of diversification is measured as the percentage of firm assets outside the mining sector, as collected from segment reporting in COMPUSTAT. Leverage is defined as the book value of debt divided by the total market value of financial claims (market value of common equity plus book value of preferred stock and debt.) To collect the degree of available cash balances in excess of current needs, I measure the firm's quick ratio, which is defined as (cash and cash equivalents + receivables) divided by current liabilities.

III. Explaining the Extent of Risk Management Activity

In this Section, I relate the key empirical results: I report univariate tests of differences among firms employing different levels of risk management, discuss the appropriate and feasible methodology for conducting multivariate tests, and detail the findings of these multivariate tests.

A. Univariate Results

A quick inspection of Table II suggests a natural grouping of the firms in the gold mining industry. The extreme ends of the risk management spectrum are represented by the 14.6 percent of firms that use no financial risk management techniques and the 16.8 percent of firms who manage more than 40 percent of their three year production. Table IV reports descriptive statistics for the gold mining firms in the sample, breaking the sample into firm-year observations where firms engage in no risk management (delta-percentage = 0), some risk management (delta-percentage between 0 and 40 percent), and extensive risk management (delta-percentage exceeding 40 percent). The table reports a *t*-test of the differences in the means of these groups, as well as a nonparametric Wilcoxon signed-rank test of the differences between the distributions.

The univariate analysis of means suggests that firms employing no risk management are barely distinguishable from those employing moderate levels of risk management, apart from carrying higher cash balances (as predicted) and being less diversified (contrary to our predictions). The Wilcoxon signed-rank test suggests that the non-users might be less levered and explore less than users, both consistent with predictions.

Firms employing extensive risk management differ from those employing moderate levels of risk management along a variety of dimensions. Their managers hold greater equity stakes in the firm (as predicted), but hold more

Table IV

Characteristics of North American Gold Mining Firms, Conditioned on the Level of Financial Risk Management Employed, 1991–1993

Characteristics of firm-year observations of North American gold mining firms segmented by the degree of risk management employed. All variables are defined in Table III. Firms are partitioned on the basis of their delta-percentage in each year (no risk management (delta-percentage = 0), some risk management ($0 < \text{delta-percentage} < 40$ percent), and extensive risk management (delta-percentage ≥ 40 percent)). The table reports the prior year's firm characteristics, conditioned on the level of financial risk management activity. Mean, standard deviation, and medians are reported. The pairs of *p*-values reported to the far right represent the *t*-tests of the differences of means and the significance level of the Wilcoxon sign-rank test. *p*-values less than 0.10 are shown in boldface type.

	Values of Firm-Year Characteristics by Level of Risk Management Activity												p-Values of Differences			
	None (0%)				Some (between 0–40%)				Extensive ($\geq 40\%$)				None vs. Some		Some vs. Extensive	
	N	Mean	Std. Dev.	Med.	N	Mean	Std. Dev.	Med.	N	Mean	Std. Dev.	Med.	Mean	Med.	Mean	Med.
Delta-percentage	32	0%	0%	0%	71	21%	11%	22%	28	62%	24%	53%				
Cash Costs (\$US/oz.)	23	248	73	239	64	239	59	235	25	252	65	236	0.61	0.85	0.39	0.54
Leverage (%)	32	13	18	5	70	15	11	14	28	18	15	14	0.55	0.03	0.31	0.79
Exploration activities (%)	30	2.9	5.9	1.1	70	3.3	4.4	1.9	27	1.7	2.6	0.6	0.58	0.05	0.02	0.00
Acquisition activities (%)	32	0.2	0.2	0.1	70	0.1	0.3	0.0	28	0.1	0.2	0.0	0.57	0.15	0.70	0.83
Tax loss carry forwards (%)	32	10.7	2146	0.0	68	15.3	34.2	1.2	28	5.3	9.9	0.2	0.42	0.46	0.03	0.35
Firm value (\$US mil)	32	653	1241	162	70	721	1026	241	28	1144	1487	203	0.77	0.83	0.17	0.76
Reserves (oz. mil.)	32	3.9	6.2	1.3	70	4.7	5.6	2.4	28	4.7	7.2	1.7	0.49	0.23	0.99	0.47
Managerial stock ownership (\$US mil)	32	8.3	15.4	2.2	71	7.2	15	2.5	28	86.9	233.1	5.3	0.73	0.83	0.08	0.07
Managerial option holdings (No. in mil)	32	0.68	0.95	0.33	71	0.49	0.49	0.35	28	0.92	1.27	0.56	0.29	0.83	0.09	0.09
Large block ownership (%)	32	34.9	33.4	22.2	70	32.9	29.6	35.6	28	22.8	22.4	21.8	0.76	0.82	0.08	0.13
Quick ratio	32	5.8	10.0	2.4	70	2.1	2.4	1.4	28	1.9	1.4	1.8	0.05	0.14	0.65	0.54
Diversification (%)	25	1.4	7.0	0.0	68	7.5	17.8	0.0	26	18.1	37.8	0.0	0.02	0.07	0.18	0.68

options (contrary to our predictions). They explore less, not more as anticipated. Finally, large block holdings are smaller among the extensive risk managers.

Given the correlations among the different firm characteristics, these univariate tests cannot reveal significant differences in firm traits, holding other firm attributes constant. Thus multivariate tests are necessary. These data also reveal that grouping together all firms engaging in some risk management conceals substantial differences, motivating use of a continuous measure of risk management activity.

B. Methodology

From Table II, one can observe two features of the distribution of delta-percentages. First, there is a mass of firms whose delta-percentages exactly equal zero. Second, there are no firms in any period with negative delta-percentages, i.e., firms using financial contracts to increase gold price exposure. These features of the data strongly suggest that delta-percentage is a censored variable as described by Maddala (1991). Below certain threshold levels, firms choose not to use financial contracts to reduce their gold price exposure, and we observe a zero delta-percentage. While they may seek to augment their gold exposure, they appear to execute this choice using operating decisions (increasing the rate of production, exploration, or acquisition) instead of using financial transactions. This type of data is typically analyzed using tobit analysis, the method employed here.

I employ a one-sided tobit model, regressing the extent of risk management activities (the annual delta-percentage) against the lagged firm characteristics discussed in Section II. In light of the fact that one firm (American Barrick) by policy manages the risk associated with 100 percent of its three-year production, and is known to be an outlier on other dimensions as well, the tobit analysis is shown for samples both including and excluding this firm. In total there are 105 usable firm-year observations in the pooled sample, excluding American Barrick.¹⁸

There are at least three potential econometric challenges that the research design must address: heteroscedasticity, potential serial correlation of the error terms, and small sample size. A priori, one might suspect that firm size is related to the variance of the residual terms in the tobit analysis, if larger firms have greater latitude in their choice of risk management strategies. A subsequent visual inspection of the residuals and formal tests for the existence of heteroscedasticity (Green (1993), pp. 698–700) suggested that this concern was merited.¹⁹ Therefore, for the pooled model, I also report a specification in

¹⁸ Only risk management data from 1991–1993 are used, with a maximum of $48 \times 3 = 144$ observations in the pooled sample. Of these 132 have hedging data in Reeve's reports, and our inability to collect other information for firm-years, especially cash cost data, reduces the sample to 108 firm-year observations, including American Barrick.

¹⁹ Specifically, one can test whether the log likelihood of the restricted (homoscedastic) specification is significantly different from that of the unrestricted (heteroscedastic) specification.

which the variance of the error term is a linear function of lagged firm value (the log of the market value of the firm).

The data include observations on an unbalanced panel of 35–38 firms per year for three years. Pooling firm-year observations treats each observation as independent, which tends to underestimate standard errors and overstate reported p -values to the extent that firm values are correlated from year to year. A common solution to this problem is to analyze each year's data separately, where the individual annual results are not affected by serial correlation, as the panel structure is dismantled. Therefore, I also report the tobit analyses year-by-year. Conducting the analysis year-by-year uses only 35 to 38 firm observations to fit 12 independent variables, which naturally produces higher standard errors and less significant p -values, as it effectively ignores all information from the remainder of the pooled sample. However, the significance levels of these annual tests are not inflated by non-independent observations.

More formal techniques exist to handle estimation of panel tobit models and the potential overestimation of p -values due to serially-correlated errors. If the true model specification was one in which error terms systematically varied from firm-to-firm, it would be appropriate to use a variant of random-effects tobit model, for example, as implemented by the technique discussed in Avery, Hansen, and Hotz (1983) or Maddala (1991). Unfortunately, the third challenge of this data—small sample size—makes the implementation of this solution not feasible. Given the small number of observations in this data set, estimation of the random effects model will not converge on the pooled sample, let alone a more complex model incorporating both random effects and heteroscedasticity. Nor is it possible to estimate a convergent model with explicit treatment of heteroscedasticity with the three annual samples. However, the three sets of results reported (pooled, pooled with heteroscedasticity correction, and annual specifications) should allow the reader to gauge the robustness of the findings to alternative econometric specifications.

C. Multivariate Results

The results of the tobit regressions are shown in Table V. Panel A reports the pooled specifications, with American Barrick (column 1), without American Barrick (column 2), and without American Barrick while incorporating heteroscedastic error terms modeled as a linear function of firm size (column 3). Panel B reports the three annual specifications (American Barrick excluded, without heteroscedasticity correction), along with various summary measures of the three years' results. In both panels, the slopes represent the marginal

Using this test, one can reject the restricted model in favor of an unrestricted model in which the error terms are a function of firm size. Re-estimating the model using $\ln(\text{firm size})$ does not eliminate this heteroscedasticity, nor does a multivariate specification of the heteroscedasticity have any additional explanatory power over the univariate specification of variance in the form of $\sigma_i^2 = \exp(\alpha \text{lagged firm value})$.

Table V

Determinants of the Degree to Which North American Gold Mining Firms Engage in Price Risk Management Using Financial Contracts

The dependent variable for each firm-year observation (1991 through 1993) is the average delta-percentage, the percentage of the estimated production (over the next three calendar years) that has effectively been sold short through financial contracts. The independent variables are defined in Table III, and represent values for the calendar year prior to the year in which the risk management information is revealed. This analysis uses a one-sided tobit model. In Panel A, the analysis is conducted on a pooled data set including all firm-year observations (column 1), and all firms except American Barrick (columns 2 and 3). The third set of columns of Panel A represents an alternative specification correcting for heteroscedasticity, which models the variance of the error term as a function of lagged firm value. Panel B reports the results of year-by-year estimation of the base model, (excluding American Barrick and without modeling the error term as heteroscedastic), along with summary statistics of the three years' results. *p*-values less than 0.10 are shown in boldface type.

Panel A: Pooled Results						
	ABX Included		ABX Excluded		ABX Excluded Heteroscedastic	
	Slope	<i>p</i> -value	Slope	<i>p</i> -value	Slope	<i>p</i> -value
Intercept	0.1652	(0.15)	0.3715	(0.01)	0.5240	(0.00)
Cash costs	0.0001	(0.79)	0.0002	(0.76)	-0.0007	(0.19)
Leverage	0.0026	(0.23)	0.0035	(0.14)	0.0107	(0.00)
Exploration activities	-0.0091	(0.09)	-0.0117	(0.04)	-0.0119	(0.19)
Acquisition activities	0.0177	(0.81)	-0.0368	(0.65)	0.0854	(0.55)
Firm value	0.0001	(0.24)	0.00004	(0.37)	0.00003	(0.94)
Reserves	-0.0101	(0.19)	-0.0144	(0.09)	-0.0016	(0.81)
Tax loss carryforwards	0.0001	(0.88)	0.0002	(0.82)	0.0002	(0.92)
Managerial stock ownership	0.0184	(0.00)	0.0140	(0.04)	0.0188	(0.03)
Options held by officers and directors	0.0349	(0.23)	-0.1266	(0.01)	-0.1960	(0.00)
Large outside block percentage	-0.0009	(0.23)	-0.0022	(0.01)	-0.0035	(0.00)
Cash balances	0.0083	(0.45)	-0.0238	(0.04)	-0.0335	(0.02)
Diversification	-0.0004	(0.80)	0.0002	(0.92)	0.0005	(0.59)
Number of observations	108		105		105	
Chi-squared	26.0		30.4		43.4	
<i>p</i> -value	0.02		0.00		0.00	

Panel B: Annual Results ABX Excluded									
	1991		1992		1993		Summary		
	Slope	<i>p</i> -value	Slope	<i>p</i> -value	Slope	<i>p</i> -value	Average Slope	Average <i>p</i> -value	Median <i>p</i> -value
Intercept	0.4832	(0.10)	0.4797	(0.01)	0.2643	(0.28)	0.4091	0.1296	(0.10)
Cash costs	0.0002	(0.88)	0.0015	(0.06)	0.0002	(0.82)	0.0006	0.5847	(0.82)
Leverage	0.0014	(0.82)	0.0022	(0.51)	0.0068	(0.14)	0.0020	0.4854	(0.51)
Exploration activities	0.0051	(0.77)	0.0345	(0.01)	-0.0122	(0.05)	-0.0139	0.2748	(0.05)
Acquisition activities	0.0197	(0.88)	0.0500	(0.71)	-0.4050	(0.16)	-0.1451	0.5832	(0.71)
Firm value	0.0002	(0.12)	0.00005	(0.52)	-0.00001	(0.89)	0.0001	0.5100	(0.52)
Reserves	0.0439	(0.05)	0.0201	(0.09)	0.0002	(0.99)	0.0212	0.3774	(0.09)
Tax loss carryforwards	-0.0002	(0.95)	0.0003	(0.78)	0.000	(1.00)	0.0002	0.9088	(0.95)
Managerial stock ownership	0.0124	(0.18)	0.0187	(0.23)	0.0280	(0.08)	0.0197	0.1651	(0.18)
Options held by officers and directors	-0.1262	(0.23)	-0.2821	(0.01)	-0.1478	(0.07)	-0.1853	0.1020	(0.07)
Large outside block percentage	-0.0036	(0.03)	-0.0041	(0.00)	-0.0008	(0.56)	-0.0028	0.1992	(0.03)
Cash balances	-0.0492	(0.07)	0.0987	(0.00)	0.0036	(0.82)	-0.0481	0.2955	(0.07)
Diversification	-0.0005	(0.91)	0.0004	(0.86)	-0.0012	(0.66)	-0.0004	0.8098	(0.86)
Number of observations	34		34		37		35		
Chi-squared	17.6		25.8		13.0		18.8		
<i>p</i> -value	0.17		0.02		0.45		0.21		

effects reported evaluated at the means of the variables.²⁰ The different results when including and excluding American Barrick reflect the unique characteristics of the firm, and its disproportionate effect on the results. Therefore, I focus on the results excluding the firm.

C.1. Shareholder-Maximization Hypotheses

Table V suggests that shareholder maximization notions of corporate risk management have relatively little predictive power in this industry. There is no observable relationship between the extent of risk management undertaken by gold mining firms and either the likelihood of financial distress (as measured by cash costs),²¹ the degree to which they face convexities in their tax schedules,²² or the portion of investment opportunities represented by the firms' acquisition programs. Contrary to the simple notion that firms might set up risk management programs to protect large on-going investment programs, there is a *negative* relationship between historical exploration activities and risk management.²³ However, in economic terms, this effect is small. Were the mean firm in the sample to double its exploration activity, this would be

²⁰ Tobit coefficients represent the change in the latent or index variable with respect to the independent variables. To convert these into slope coefficients which represent the marginal effect of the independent variables on the observed variables, one evaluates the function which represents the conditional change in the observed dependent variable as a function of the vector of the independent variables, at the sample mean values for the independent variables (Greene 1993, pp. 694–695).

²¹ Financial distress may be less of a driver of risk management activity in the gold mining industry because deadweight costs of bankruptcy may be small. Firms can shut-in production, exercising the real option to temporarily stop production. Furthermore, gold mines own tangible assets that produce an unbranded commodity product with no after-market service, leading to little loss of franchise value in times of financial distress. The failure to find a relationship between risk management and cash costs is inconsistent with Dolde (1995), who finds that firms with higher primitive risk hedge more. Dolde measures primitive risk as the standard deviation of the ratio of operating income before depreciation to book value of assets. In the gold industry, risk management contracts would affect operating income (e.g., sales would be a function of the delivered price of gold), thus this measure would not be appropriate.

²² Previous empirical research has found no consistent relationship between measures of the convexity of tax schedules and the degree of derivative use. Nance, Smith, and Smithson (1993) find a positive relationship, but Géczy, Minton, and Schrand (1995) do not.

²³ This interpretation is correct if a firm's demand for funds for exploration was invariant to the price of gold, and therefore could be extrapolated from prior exploration activities. However, this result could still be consistent with the notion of protecting investment programs if there was an *inverse* relationship between historical investment activities and unobservable planned investment activities conditional on low future gold prices. For example, firms that conducted larger exploration programs might be more likely to scale them back if gold prices fell, especially if in low gold price environments, the marginal value of finding additional gold declined. The inverse relationship between exploration and hedging could also be attributable to an omitted-variable error. Firms whose managers had a bullish view of future gold prices might consistently manage less risk and explore more. If we could develop an instrument to detect this unobserved managerial trait, we could test whether this hypothesis was correct. Unfortunately, it is not apparent how to construct this instrument. Nevertheless, anecdotal evidence suggests that there may be merit in this supposition. American Barrick, whose policies dictate full hedging of three years of production, appears to micro-manage their hedging program on the basis of gold price expectations, as

associated with a reduction in delta-percentage of only 2 percentage points, based on the tobit slope coefficients.

At first glance the theory that firms may use risk management to protect themselves from costly external financing seems supported, in that smaller firms (i.e., those with smaller reserves) manage more risk. However, when controlling for heteroscedasticity with the error terms being a function of firm size, this result vanishes, suggesting it may have been a spurious econometric result.

There is some evidence of a positive relationship between leverage and risk management activity, as predicted by theory.²⁴ In the pooled sample (excluding American Barrick), as well as in the annual analysis of 1993 data, it appears as if higher levered firms engage in greater risk management. The mean firm in the sample has leverage equal to approximately 15 percent of total capital; were the leverage to be 10 percentage points higher (25 percent), the tobit slope coefficients suggest that the delta-percentage would rise by 2 to 10 percentage points, depending on the specification chosen. However, the lack of any meaningful relationship in two of the years shown in Panel B of Table V raises concerns about the strength of this result. Overall, it seems fair to conclude that initial predictions of shareholder maximization hypotheses are not well supported by the data.

C.2. Managerial Utility Maximization Hypotheses

All three equity ownership variables are associated with the degree of risk management, in varying degrees of significance. As predicted by Smith and Stulz (1985), firms whose management teams hold more options—and hence face greater convexity in payoffs—tend to manage less gold price risk. Excluding American Barrick, this result seems robust across the pooled, pooled/heteroscedastic, and two of three annual specifications. In addition, as predicted, firms whose managers have more wealth invested in the firm's stock manage more gold price risk. This latter result is somewhat weaker across the board, especially in the annual specifications.²⁵

To gauge the economic materiality of the association between stock and option holdings and risk management decisions, I calculate both the predicted delta-percentage (conditional on the firm undertaking some risk management) and the probability that the firm will undertake some risk management, conditional on the level of share and option ownership.²⁶ Figure 2 graphs these relationships, plotting the predicted level and probability of risk management

witnessed by the fact that the firm sold forward approximately one years' worth of production in one hour on the evening of the Desert Storm invasion in January 1991 (Tufano and Serbin (1993)).

²⁴ A positive relationship between leverage and derivative use is also shown by Géczy, Minton, and Schrand (1995) and by Dolde (1995).

²⁵ Géczy, Minton, and Schrand (1995) find no relationship between beneficial ownership and derivative use, however, the result in this article has also been found by Schrand and Unal (1995). They find that thrift institutions whose managers hold more stock hedge more and those with options hedge less.

²⁶ For a discussion of this technique, see Maddala (1991) and McDonald and Moffitt (1980).

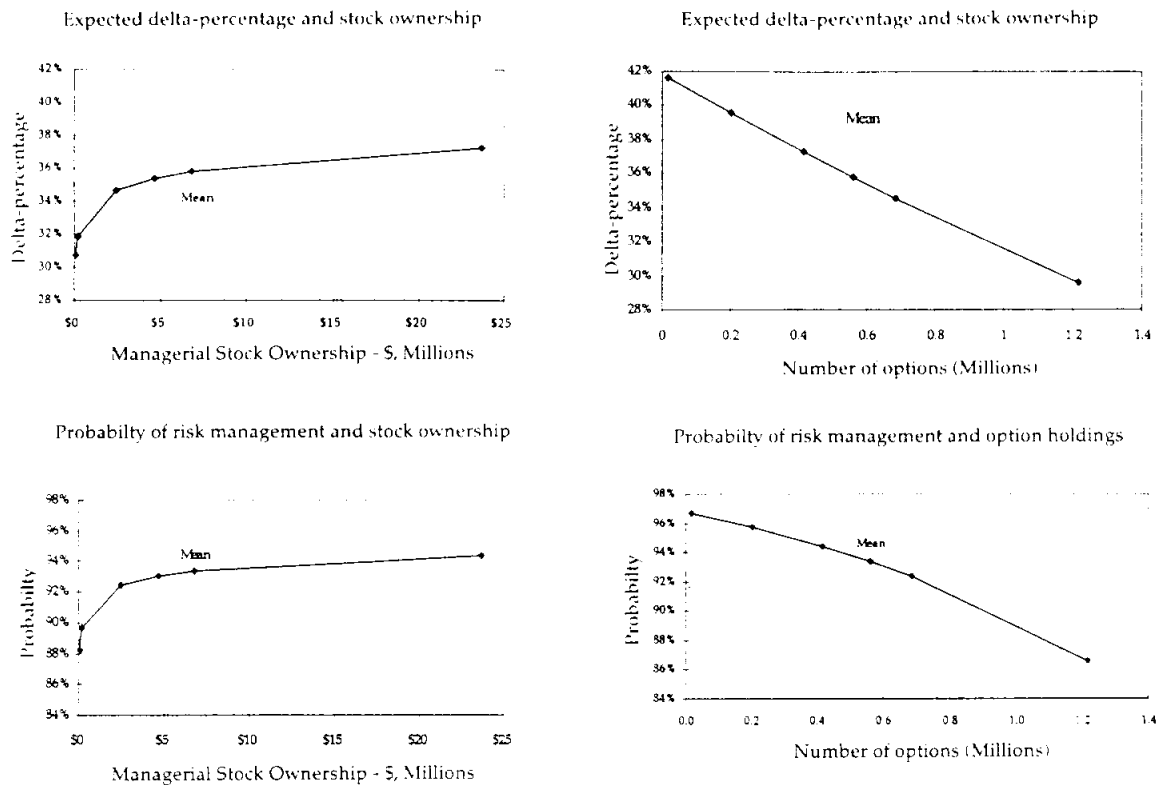


Figure 2. The predicted level of risk management and the predicted probability of the firm entering into some risk management as a function of the dollar value of managerial stock ownership and number of options held by officers and directors. Both sets of graphs evaluate these probabilities at the means of all of the other reported variables and at different levels of managerial stock ownership and option holdings using the pooled estimates from Table V, excluding American Barrick. The plot points marked on the graphs represent the 10th, 25th, 50th, 75th, and 90th percentile levels for stock and options ownership, as well as the mean value, which is marked. The top graphs show the predicted level of risk management (delta-percentage) as a function of the level of managerial holdings (conditional on the firm entering into some risk management.) The bottom graphs show the probability that the firm will enter into some risk management as a function of the level of holdings. See McDonald and Moffitt (1980) for a discussion of this type of decomposition of tobit results.

for mean stock and option holdings as well as holdings at the 10th, 25th, 50th, 75th, and 90th percentiles. In the gold mining industry, absolute differences in risk management policy arising from cross-sectional differences in option holdings are twice as large as those associated with the comparable cross-sectional differences in stock ownership. Specifically, based on the tobit estimates, moving from the 10th to 90th percentile level of option holdings is associated with a 11 percent change in the probability of undertaking some risk management, and a 12 percentage point decrease in the level of delta-percentage. By contrast, moving from the 10th to 90th percentile in the level of stock holding is associated with only a 5 percent change in the probability of undertaking some risk management, and only a 6 percentage point increase in the level of delta-percentage.

While *managerial* stock ownership seems positively associated with risk management, the presence of large *outside* block-holders is negatively associ-

ated with risk management, across the pooled and all but one annual specification.²⁷ The mean firm in the sample has large block holders owning 31 percent of the firm; were this stake to be 10 percentage points higher (41 percent), the tobit slope coefficients suggest that the delta percentage would be 2–4 percentage points smaller. Firms with larger *managerial* blocks hedge more, and those with larger *outside* blocks hedge less. A salient difference between these types of block holders is the degree to which they hold diversified portfolios. While I have not collected data on the portfolios of outside block holders, the more recognizable names among this group (Fidelity Management and Research, CREF, and Dimensional Fund Advisors) are well-diversified investors, unlikely to act like risk-averse, poorly diversified investors. This interpretation is consistent with Mayers and Smith (1990), who find that less-widely held insurers—whose owners were less diversified—were more likely to hedge through reinsurance. In addition, institutional investors in gold mines may be buying shares precisely because of their gold price exposure.²⁸

The evidence suggests that risk management policies may be set as if to satisfy the needs of poorly diversified, risk adverse-managers. This interpretation supports the findings of Amihud and Lev (1981). In their study of conglomerate mergers, or risk management through diversification, they found that firms in which managers owned a larger fraction of the stock were more likely to engage in conglomerate mergers, and they conjectured that risk aversion explained this result. It is also consistent with the more recent findings by May (1995), who concluded that acquiring firms whose CEOs had greater wealth invested in their firms were more likely to seek diversifying mergers, a form of risk management.

As a general note, it is important to emphasize that risk management and compensation decisions (along with investment policy and leverage) are set simultaneously by firms. Thus, one can not distinguish whether management teams with more options are less likely to manage price risk, or whether managers of firms with greater risk management are less likely to seek and receive option-based compensation.

²⁷ Including American Barrick in the analysis completely reverses this finding. The firm has both high large block holdings and high levels of risk management.

²⁸ Some have suggested a related interpretation of this finding. If we assume that firms with greater outside block holdings are likely to be managed more in the interests of their shareholders (as compared with their managers), then their practices are more likely to reflect value-maximizing behavior versus utility maximizing behavior by managers. Given this assumption, the lower levels of risk management among firms with large blocks would be consistent with managers choosing too high levels of risk management relative to value maximization. However, to the extent that particular institutional investors were primarily interested in obtaining maximum gold exposure through gold stocks, the different risk management policies of firms with large outside blocks may reflect this clientele's investment goals as opposed to their judgment of optimal risk management practices.

C.3. Controls for Risk Management Substitutes

The results of the tobit analysis are consistent with firms using financial risk management and cash balances as substitutes, in that firms that hold greater cash balances manage less risk. The mean firm in the sample has a quick ratio of approximately 2.0; were this to be 2.5 instead, the tobit analyses suggest that delta-percentage would be 1.2 to 2.4 percentage points lower. As noted above, the data are also consistent with a positive relationship between risk management and leverage; capitalizing the firm with greater equity is another form of financial cushion. However, the data fail to show any negative relationship between the extent of diversification outside the mining industry and the degree of risk management.

IV. A Closer Look at Managerial Traits and Risk Management

In this section, I inspect the robustness of the results obtained in the prior section, using alternative measures of managerial share holdings and managerial risk aversion.

A. Potential Misspecification: The Size of Management Teams

The relation between risk management and the extent of stock and option ownership by the management *team* found in Table V could be due to the fact that some firms have *larger* reported management teams (but not larger holdings per manager). Thus, total managerial stock holdings may be proxying for firm size.²⁹ To address this concern, I relate the extent of risk management activities (delta-percentage) to per capita managerial holdings rather than total stock and option holdings. If the results on Table V with respect to management holdings are due to different size teams, but disappear when analyzed using per capita holdings, this would raise serious doubts about the interpretation of the results.

I would like to identify per capita holdings across a consistent group of top officers and directors at each company. For common shareholdings, this is possible. From proxy statements, one can consistently identify shareholdings by the four individual top officers and directors, and therefore I report the per capita holdings of these four individuals.³⁰ Unfortunately, it is not possible to

²⁹ The relationship between stock ownership and risk management activity could be a statistical artifact of firm size being misspecified. To address this concern, I ran eight additional specifications similar to those in Table V. In four of these, firm value was replaced with the log of firm value, square of firm value, cube of firm value, and inverse of firm value. In the remaining four, reserves were replaced with a similar set of transformed variables. In these eight specifications, the coefficients and p-values of the stock holding and option holdings variables were essentially unchanged. The stability of these coefficients suggests that the results are not the result of misspecification of the firm size variables.

³⁰ Proxies also report total holdings by all officers and directors. Because firms may arbitrarily define the size of this group, it seemed more informative to consistently collect per capita data on a similar number of top executives at each company than to merely divide share holdings by all officers and directors. Among the sample, the average top insider holds stock worth \$1.4 million.

identify outstanding option holdings by individual, especially in earlier proxy statements. Therefore, for option holdings I report the aggregate options outstanding per capita among *all* officers and directors, where the number of reported officers and directors varies between 4 and 32 persons.³¹

Table VI, column (a) reports the results of this analysis of per capita holdings. Table VI shows the results of pooled, pooled with heteroscedasticity correction, and annual results. Firms with greater per capita shareholdings among the top officers manage more risk, and those with greater per capita option holdings among all managers and directors manage less risk. There is a significant relationship between per capita holdings and risk management activities, among pooled, pooled/heteroscedasticity, and annual specifications. In fact, there is a stronger association between risk management activities and per capita holdings than total management team holdings, supporting the notion that managers' stock and option holdings are associated with their firm's risk management decisions.

B. Potential Misinterpretation: Percentage Ownership

This study uses the value of executive stock and option holdings to capture managers' private exposures to gold price swings. Theory posits that risk averse managers might act to increase their private utility because of an agency conflict: they disproportionately enjoy the benefits of risk management relative to the portion of the costs that they bear. The percentage of the firm that managers' own is a customary measure of the degree to which their incentives are aligned with those of other shareholders. Were this direct measure of agency costs more closely associated with the firm's risk management choice than the dollar holdings of managers, we might be inclined to believe that agency conflicts, but not risk aversion, were related to corporate risk management choices.

I test whether dollar holdings or percentage ownership is more closely related to corporate risk management in Table VI, column (b), which substitutes percentage ownership by management for the dollar value of managerial stock ownership. Comparing the significance of dollar value and percentage-ownership figures (for both the pooled and average-annual specifications), differences in risk management levels are more closely associated with the former than the latter, consistent with the interpretation of the link between managerial ownership and risk management as a product of risk aversion. This is not to say that agency conflicts may not be at work; rather, the benefit that managers enjoy seems to be related to the dollar holdings of their shares, as would be the case were managerial risk aversion motivating risk management policy.

In the sample, the median group of officers and directors owns 0.7 percent of their firm's shares. To discover if the relationship of stock ownership and risk

The second, third, and fourth inside stock holders have share holdings 34 percent, 17 percent, and 9 percent of the size of the top shareholder's stake.

³¹ In the sample, the mean number of officers and directors is 14.4 and the median is 12 persons.

Table VI
Managerial Characteristics and the Degree to Which North
American Gold Mining Firms Engage in Price Risk Management
Using Financial Contracts, 1991-1993

The dependent variable for each firm-year observation (1991 to 1993) is delta-percentage, the percentage of the estimated production (over the next three calendar years) that was effectively sold short through financial contracts. The independent variables represent values for the calendar year prior to the year in which the risk management information was revealed. In all specifications, all of the variables listed in Table III were included as independent variables, except as explicitly noted here. Reported in the table are the marginal effect slope coefficients and *p*-values for the managerial compensation variables, alternate specifications for these variables, and additional information on managerial traits. Slopes and *p*-values for other variables are not reported here to conserve space, but are available from the author. They do not materially differ from those shown in Table V. All analyses use a one-sided tobit model. Panel A reports results based on a single pooled data set including all firm-year observations excluding American Barrick. Panel B reports the results based on the same pooled data set, with a specification that explicitly models heteroscedasticity of error terms, in which the error term is modeled as a function of lagged firm value. Panel C reports the results of year-by-year estimation excluding American Barrick, (without the heteroscedasticity correction) with the slope coefficients representing the average of the three year's results. Both mean and median *p*-values of the three annual specifications are reported. The first column, marked "Base" repeats the results from Table V to serve as a point of reference against which to compare the other specifications. Column (a) replaces total share and option holdings with per capita share holdings and option holdings. Column (b) replaces the dollar value of officer and director holdings with the percentage ownership of officers and directors. The column marked (c) separates CEO shareholdings from those of all other officers and directors in the firm. Column (d) adds information on the tenure (in years) for the firm's CEO and CFO. *p*-values are reported in parentheses.

	Specification				
	Base	a	b	c	d
Panel A: Pooled Results (ABX excluded)*					
Managerial stock ownership	0.014 (0.04)				0.144 (0.04)
Number of options held officers & directors	-0.127 (0.01)		-0.144 (0.00)	-0.131 (0.01)	-0.053 (0.64)
Per capita officer and director holdings					
Log of per capita holdings by top four executives		0.022 (0.03)			
Per capita options outstanding by all officers and directors		-2.412 (0.00)			
% holdings by officers and directors			0.337 (0.28)		
Dollar shareholdings by rank					
Log of dollar holdings of CEO				-0.005 (0.11)	
Log of dollar holding of other officers				0.021 (0.00)	

Table VI—Continued

	Specification				
	Base	a	b	c	d
Tenure of senior executives					
CEO					-0.013 (0.05)
CFO					-0.020 (0.00)
Number of observations	105	105	105	105	105
Chi-squared	30.4	32.0	27.2	32.6	45.5
p-value	0.00	0.00	0.01	0.00	0.00
Panel B: Pooled Results (ABX excluded, explicit heteroscedasticity term included [*])					
Managerial stock ownership	0.019 (0.03)				0.019 (0.02)
Number of options held officers & directors	-0.196 (0.00)		-0.202 (0.00)	-0.186 (0.00)	-0.117 (0.15)
Per capita officer and director holdings					
Log of per capita holdings by top four executives		0.024 (0.06)			
Per capita options outstanding by all officers and directors		-3.158 (0.00)			
Officer holdings by officers & directors			0.416 (0.91)		
Dollar shareholdings by rank					
Log of dollar holdings of CEO				-0.007 (0.29)	
Log of dollar holdings of other officers				0.024 (0.01)	
Tenure of senior executives					
CEO					-0.006 (0.34)
CFO					-0.024 (0.01)
Number of observations	105	103	105	105	105
Chi-squared	43.4	42.2	37.7	44.9	61.8
p-value	0.00	0.00	0.00	0.00	0.00

Table VI—Continued

Panel C: Average Annual Results (ABX excluded) ^b					
	Specification				
	Base	a	b	c	d
Managerial stock ownership	0.020 (0.17) (0.18)				0.015 (0.29) (0.33)
Number of options held officers and directors	-0.185 (0.10) (0.07)		-0.182 (0.10) (0.07)	-0.189 (0.09) (0.06)	-0.296 (0.36) (0.37)
Per capita officer and director holdings					
Log of per capita holdings by top four executives		0.030 (0.14) (0.16)			
Per capita options outstanding by all officers and directors		-3.691 (0.05) (0.01)			
% holdings by officers and directors			0.351 (0.49) (0.43)		
Dollar shareholdings by rank					
Log of dollar holdings of CEO				-0.005 (0.41) (0.43)	
Log of dollar holdings of other officers				0.026 (0.10) (0.14)	
Tenure of senior executives					
CEO					-0.011 (0.50) (0.58)
CFO					-0.022 (0.09) (0.02)
Average number of observations	35	35	35	35	35
Average chi-squared	18.8	20.8	17.3	19.6	26.0
Average <i>p</i> -value	0.21	0.11	0.30	0.16	0.06

^a Slope (*p*-value).

^b Slope (mean *p*-value) (median *p*-value).

management activity differs for those management teams owning a larger and smaller fraction of the firm, I created a percent-ownership dummy variable that equals 1 if percentage-ownership exceeded the median and equals 0 otherwise. This dummy variable was interacted with the log dollar holdings of

all officers and directors, and this interaction term is added to the base specification shown in Table V (which includes the dollar holdings of stock). One might expect that managers who owned a greater percentage of the firm (holding dollar wealth constant), would bear more of the costs of risk management, and therefore hedge less. To conserve space, the full results are not reported in Table VI. The coefficient on this interaction term was consistently negative, as predicted, but insignificant. Thus, one cannot reliably conclude that larger percentage ownership by managers, holding their dollar holdings constant, is associated with the propensity of firms to manage risk.

C. The Option Character of Stock

As noted in Section III, both stock options and common stock are call options, with the former written on the stock price and the latter on the value of the firm. For firms approaching financial distress, the option-like character of common stock becomes more pronounced. Therefore, for firms whose stock is at-the-money (closer to financial distress), managers might act more like option holders and prefer to manage less risk. Yet for stocks far-in-the-money (remote from financial distress), managers will tend to prefer to reduce risk as described in Section III of this article.

To implement this modified test of the incentives of stock holdings, one must identify firms that are closer to distress. I create a dummy variable that equals 1 for firms whose cash costs are in the top quartile in each year, and 0 otherwise, and interact this dummy variable with the log of managerial stock ownership, and add this interaction term to the base model. As managers whose stock is closer to financial distress may choose to manage less risk than others—playing the option embedded in common stock—the coefficient on this interaction term is predicted to be negative.

In all cases the coefficient on the interaction term was positive, contrary to predictions, but insignificant, with p -values never exceeding 0.40. In interpreting these results, it is important to note that even those firms in the top cost-quartile had costs from 18 to 23 percent lower than the market price of gold in the three years studied. Therefore, while these firms were relatively more distressed, on an absolute level even their stocks were likely very much in-the-money.

D. CEO Versus All Officer and Director Holdings

Theoretical models often presume that a single manager runs the firm, and empirical research often defines this manager to be the CEO. Yet, as a practical matter, decision-making authority might be vested in a larger group of persons. To the extent that a CEO has *exclusive* control over firm activities, his or her holdings might be more highly associated with risk management activities than would be the shareholdings of other officers and directors. Alternatively, if risk management policies result from a decision of the full officer and director team, one might expect that the extent of firm risk management decisions would also be related to holdings by officers and directors other than

the CEO. Examining the impact of holdings by rank on the extent of risk management may shed light on the distribution of decision-making rights within the management team.

To address whether shareholdings by the CEO alone or by the entire officer and director group are more likely to be associated with greater risk management, the analysis from Table V has been re-examined, separating CEO stock ownership from stock ownership by the rest of the firm's officers and directors. Table VI, column (c) reports the results. The extent of risk management seems to be *more* closely associated with the shareholdings of the non-CEO officers and directors than with the shareholdings of just the CEO. Firms whose non-CEO management teams have greater stock ownership manage more gold price risk. This result is consistent with risk management policy being set, reviewed, and monitored by a broad group of officers and directors, and is not the province solely of the CEO.³²

E. Officer Age and Tenure

Holding constant the amount of wealth they have invested in the firm, managers who are more risk averse would be more likely to manage risk, because greater risk aversion would be associated with greater concavity of the utility function and thus stronger incentives to manage risk. Unfortunately, there is no direct measure of the degree of risk aversion by managers. Age might serve as a proxy for risk aversion, in that older managers facing imminent retirement might prefer to minimize random fluctuations in their marketable portfolios, and hence more strongly embrace risk management. To the extent this mapping is correct, firms with older managers would be inclined to manage more risk. However, others have argued that the facetious "over-45" factor might apply: older managers might be hesitant to adopt derivatives technologies.³³

Others have noted that managerial tenure might play a similar role, with newcomers more likely to adopt new ideas like derivative-based price risk management. To the extent these conjecture are correct, firms with younger managers, and those whose managers have shorter tenures on the job would be more inclined to manage risk.

I recognize the ad hoc nature of these conjectures, but in the interest of full disclosure, report the impact of age and tenure on the extent of risk management. Specifically, I collect information on the age and tenure of two executive officers: the CEO and CFO of each firm. Tenure is measured as years in this position.³⁴ I add age and tenure variables to the tobit specifications to test if these managerial traits are associated with the level of risk management.

³² As an example of this, see Tufano and Headley (1994), who document the review of risk management policy by the board of directors of Union Carbide Corporation.

³³ A number of practitioners have joked that "No one over 45 can hope to understand derivatives!"

³⁴ In 1993, the average CEO in our sample was 52 years old, while the average CFO was 45, with the age for these two officers ranging from 46–70 and 34–61 respectively. The average CEO had been in office for 5.3 years, while the average CFO had been in this position for 3.7 years. The

To conserve space on Table VI, the age results are not reported. There is no meaningful relationship between CEO and CFO age and the extent of risk management activity, except a negative relationship between CFO age and risk management with the heteroscedastic specification.³⁵ The lack of association between age and risk management might be the result of age acting as a factor that influences both risk aversion and predilection to use sophisticated financial instruments. However, tenure's association with risk management is more strong, as shown by Table VI, column (d). Adding managerial tenure to the tobit analyses materially increases their predictive power, in all specifications. Consistently, firms whose CFOs have fewer years in their current job are more likely to engage in greater risk management activities. The mean CFO in the sample has tenure of 3.4 years; the tobit results suggest that for each year of additional tenure, delta-percentage is lower by 2 to 2.4 percentage points.

It is quite possible that newer executives might simply be more willing to embrace new concepts like risk management, than are their counterparts with long-tenures in office. One reason for this preference is given by Breeden and Viswanathan (1996). In their model, higher-quality managers prefer to hedge to accurately signal their management quality. It is plausible that short-tenure financial managers would have less well-developed reputations than longer-tenure managers, and seek to more accurately signal their quality through hedging. Thus the results can be seen as consistent with their theory. However, their model would seem to apply to CEOs as well as CFOs; the finding that tenure of the CEO is not related to the level of risk management is a warning not to over-interpret these results.

While we lack a compelling explanation of the result that CFO tenure is related to the level of risk management, this finding supports the general contention that managerial motives (or perhaps predilection) may be relevant in setting corporate risk management policy. The results could also simply reflect that firms wishing to do financial risk management tend to hire new financial managers who are skilled with the appropriate tools and techniques.

F. Summary

The association between managerial holdings and risk management activities is robust and not the result of misspecification. The relationship persists when holdings are measured on a per manager basis and when an explicit agency cost specification (percentage ownership) is used. As a measure of risk aversion, managerial age has little descriptive power in assessing the extent of risk management adopted by the firm. We gain additional descriptive insight into the broad-based nature of the corporate decision-making process by learn-

ages and tenures of the two officers are almost uncorrelated with one another (correlations of ages = -0.003 and correlation of tenures = 0.158.)

³⁵ In a tobit analysis including all of the variables in Table V plus the age variables, the coefficients and *p*-values on CEO and CFO age are 0.0018 and 0.0015 (0.46 and 0.50) for the pooled sample, -0.0005 and -0.0057 (0.90 and 0.11) for the pooled-heteroscedasticity specification, and -0.0011 and 0.0003 (avg. 0.42 and 0.56) for the average of the annual samples.

ing that the holdings of not just CEOs, but the entire managerial team, are associated with firms' risk management choices. In a similar descriptive fashion, we learn that job tenure, specifically of CFOs, is associated with the extent to which firms engage in risk management.

V. Conclusion

One must be careful not to over-interpret the results of a single-industry study of a few dozen observations per year. With this caveat in mind, this study suggests that risk management practices in the gold mining industry appear to be associated with both firm and managerial characteristics, although theories of managerial risk aversion seem more informative than those of shareholder value maximization. The evidence shows that the managers who own more options manage less risk, but those who own more shares of stock manage more risk. It finds virtually no relationship between risk management and firm characteristics that value-maximizing risk management theories would predict. In addition, firms with lower cash balances manage more gold price risk; firms with a greater percentage held by outside block holders tend to manage less risk; and firms whose CFOs are newer in their jobs seem to manage a larger proportion of their firm's risks. These latter results are less well grounded in theory.

Marketers of corporate risk management products sometimes attempt to prey upon fear and risk aversion. One risk manager's advertisement, complete with images of stylized crocodiles and leopards, warns potential customers: "In the complex financial jungle, you don't dare to make a move until you are positioned to survive . . . because one false step could risk your entire enterprise." The evidence from the gold mining industry may suggest that some managers may be more receptive to these messages than others. Firms whose managers hold large numbers of shares of stock may be more willing, and those holding options less willing, to commit their firms to higher levels of price risk management, consistent with simple notions of managerial utility maximization. Thus, in this setting, as in those examined by Amihud and Lev (1981) or May (1995), managers' private preferences seem to affect corporate risk management choices. Given the practical limitations of managers eliminating this risk on their own accounts, it appears as if they manage their firms so as to moderate these risks at the corporate level.³⁶

If risk management is costless, allowing managers to reduce private risk using corporate risk management programs is innocuous, and differences among firm's risk management policies unimportant. However, if risk management is costly (in terms of transaction costs), then one must ensure that corporate resources were devoted to value maximization and not managers'

³⁶ These practical limitations include restrictions imposed by certain corporate stock and option grants, tax considerations, cash flow exposure to margin calls on exchange traded futures or to rollovers of option positions, and transaction cost differentials arising from the fact that the average exposure of all officers and directors in the sample is about one-sixtieth that of their firm's exposures.

risk reduction. Many authors have argued that by linking pay with stock price performance, or by increasing the equity component of managerial compensation, firms can align managers' incentives more closely with those of other shareholders.³⁷ This study hints that not only the level of management's equity ownership, but also the form by which that equity stake is held, is related to firms' risk management choices. By inducing greater pay-for-performance through stock and option grants, are firms encouraging managers to move closer to, or farther away from, the "optimal" level of risk management that well-diversified outside shareholders would prefer? Further theoretical and empirical work will hopefully help answer this question.

Appendix: The Form of Risk Management— Linear and Nonlinear Strategies

The manner by which firms manage their risk is perceived to be an important decision by financial executives in the gold mining industry. This Appendix describes alternative strategies that firms have adopted to manage risk, distinguishing between linear and nonlinear risk management strategies. This material is presented in an Appendix because it is largely descriptive, as current theory provides few testable propositions given the practical limitations of this data set.

A. Characterizing Linear and Nonlinear Strategies

One can characterize risk management strategies as either linear, hedging strategies (which eliminate all exposure to price fluctuations) or nonlinear, insurance strategies (which protect firms against falling gold prices only.) In a static world, one can identify whether a firm uses linear or nonlinear strategies by inspecting the type of risk management instruments used. Firms employing forwards, gold loans, swaps, and spot deferred contracts use linear strategies, while firms purchasing put options use nonlinear strategies.³⁸

Choices among instruments are determined by their relative costs (including transaction costs), interim liquidity requirements, accounting and tax implications, and the ability to customize the contract terms. For example, gold mining firms tend to use forward sales instead of futures contracts, at least in part to avoid the cash margin calls which futures transactions might entail. As another example, mining firms' preferences for spot deferred contracts over the functionally equivalent strategy of rolling forward contracts seems to be related to their relatively attractive accounting treatment.³⁹

³⁷ See Jensen and Murphy (1990) or Mehran (1995).

³⁸ A firm could buy puts and simultaneously sell calls to create a synthetic forward.

³⁹ A spot deferred contract (SDC) is a long-term forward sale of gold in which mines can choose on a regular basis (usually annually) whether to deliver against the contract or wait another period to deliver the gold. Ultimately, the gold committed under an SDC must be delivered, but the mine has the option of deciding when to deliver it. If a mine chooses to defer the delivery of gold because spot prices exceed the contract price, a new delivery price is established that incorporates

As a static measure of whether firms utilize hedging or insurance strategies, I calculate the percentage of risk management that is executed using options. Formally, I define option-percent as the delta of the firm's option position (including both puts and calls) expressed as a fraction of the delta of the entire portfolio. This quantity is defined only if the firm engages in some risk management. The panel below reports the distribution of the average option-percentage over the 16 quarters in the period 1990–1993:

Options as a % of delta-percentage	Percentage of firms
Exactly 0	24.4
0–10	24.4
10–20	19.5
20–30	12.2
30–40	4.9
40–50	12.2
Over 50	2.4

Over this period, three-quarters of firms managing some risk use options for at least part of their program. For the average firm managing gold price risk, 16.1 percent of its portfolio delta is contributed through option positions, with the remainder of the effective short-position coming from its forwards, gold loans, and other hedging vehicles. The modest contribution of options to the average firm's portfolio delta is not surprising because firms typically purchase out-of-the-money puts with low deltas.

Distinguishing linear and nonlinear strategies becomes more difficult with dynamic trading. Suppose we observe a firm only selling gold forward. By a static measure, we would conclude that it was hedging. However, as is well known, through dynamic replication, a trader can create a put option by adjusting the amount of gold sold forward. Specifically, as the gold price falls, a dynamic replication strategy would have the firm short-sell more gold. Thus, distinguishing hedging from insurance strategies requires an analysis of the changes in a firm's equivalent short position (or delta-percentage) relative to changes in the price of gold. Formally, using all available quarterly data, I estimate gamma (Γ), the change in the delta of the gold derivatives portfolio, as a function of changes in the price of gold, using the following equation:

$$\Delta\%_{i,t} = \alpha_i + \Gamma_i P_{au,t} + \varepsilon_i \quad (A1)$$

the market forward price plus the loss that the mine would have borne had it delivered against its forward commitment in the prior period. Thus, SDCs are economically equivalent to rolling one-year forward contracts except that the SDC ensures that the mine has long-term access to forward contracting (at market rates) assuming the mine continues to be credit-worthy. In this regard, SDCs reduce a mine's risk of being unable to roll over an existing forward position. If a mine were to rollover a forward contract in which it had a loss, it would have to record the accounting loss on the contract at the rollover. With a SDC, these losses are rolled forward until the ultimate delivery of the gold, and accounting losses may be deferred.

where $\Delta\%$ = delta-percentage (represented as a positive number)

P_{au} = the average gold price over the quarter

If a firm increases its short position as the gold price falls ($\Gamma < 0$), it effectively creates an exposure similar to a purchased put option. A firm whose risk management portfolio is unaffected by the level of the gold price ($\Gamma = 0$) appears to use a hedging strategy (or possibly has purchased put options that remain substantially out-of-the-money.) A firm that reduces its short position as gold price falls ($\Gamma > 0$) is similar to a firm that writes call options (and in conjunction with an underlying long position in gold, this firm would effectively be executing a covered-call strategy.)

Γ is considered to be equal to zero if the two-sided t -test on the coefficient cannot be distinguished from zero at a 90 percent confidence intervals. The table represents the position gamma for all 41 firms engaging in some risk management, and reports separately the gammas for firms that did and did not use options at some period during 1990–1993.

Position Γ	All Firms	Option Users	Non-Option Users
Less than 0	7.3%	10.3%	0%
Zero	75.6%	71.0%	90%
Greater than 0	17.1%	19.4%	10%
Number of firms	41	31	10

Based on this dynamic measure of risk management choices, 75 percent of the risk management strategies were not price-contingent. Among firms employing risk management, 7 percent used dynamic strategies that replicate a purchased put strategy, where the delta rises with a drop in the gold price. 17 percent of the firms employing risk management actually shorted a *larger* fraction of their production when gold prices rose, effectively producing covered-call-writing. Firms using options were more likely to undertake nonlinear strategies, as expected. Option-users were three times more likely than non-users to engage in price-contingent strategies: nearly 30 percent show a non-zero gamma (as compared with 10 percent for non-option users.) Of these 30 percent, one-third replicated purchased puts and the remainder replicated written calls.

B. Theory of Risk Management Strategy Selection

While one can describe the choice of risk management strategy with some precision, extant theory provides few testable predictions as to whether firms should choose linear or nonlinear strategies. Froot *et al.* (1993) explicitly discuss whether firms should choose linear and nonlinear strategies. They argue that the optimal choice of strategies is determined by whether the sensitivity of cash flows and investment costs relative to changes in the underlying macro-variable are equal. If the sensitivities are equal, linear or hedging strategies will be optimal, otherwise firms would prefer to use non-

linear or option strategies. Unfortunately, with only a short time series of annual observations, it is not possible to measure these sensitivities reliably, nor to test the descriptive power of this aspect of this theory.¹⁰

Detemple and Adler (1988) discuss circumstances when poorly-diversified individuals might prefer to use options as part of their risk management portfolio. They analyze a two-period model and find that when the investor faces both quantity and price risk, or when he faces a borrowing constraint, options may be used in addition to futures. It is not apparent how to measure the degree to which mines face quantity risk. However taken literally, the model suggests that firms facing borrowing constraints and those facing higher price risk might be more active users of options. Borrowing constraints might be more severe among firms with high operating costs, small market values, or small reserves; bankers might be reluctant to lend to high-cost producers that may be forced to shut-in production and to smaller firms with less collateral. It is reasonable to suspect that price risk might be more pronounced among mines with higher production costs. The model, when applied to gold mining, might predict that firms with higher cash costs and those with smaller market values and reserves might be more likely to use options or price-contingent nonlinear strategies.

C. The Relationship Between Firm Characteristics and Risk Management Strategies

To describe factors that are associated with the corporate risk management decision, Table A-I examines the characteristics of firms which used options compared to those which did not, and between those that used price-contingent strategies and those that did not. According to Detemple and Adler's model, narrowly interpreted, one would expect a positive relation between option usage and cash costs and a negative relation of option usage with reserves and firm value. As mentioned above, the Froot *et al.* predictions are not testable with the available data.

Contrary to the prediction inferred from Detemple and Adler's model, there are no difference in the cash costs of firms that do and do not use options.

¹⁰ I estimated these sensitivities with the limited annual time series data available in the sample. While I calculated numbers which purport to measure these sensitivities – and found that they had no significant impact on option-percentage – the small amount of data with which these sensitivities were estimated make me uncomfortable presenting the results as testing the Froot *et al.* hypotheses. Details of these tests are available from the author. To estimate *cash flow sensitivity to gold price*, I regressed annual pre-risk-management cash flow on the average annual gold price. Pre-risk-management cash flow was defined as EBIT (constructed from COMPUSTAT) – realized risk management gains + noncash charges (from COMPUSTAT), where realized risk management gains = (realized sale price – average COMEX price) × production quantity. To measure *the sensitivity of investment cost to gold prices*, I regressed the per ounce cost of new reserves against gold price. I defined the per ounce cost of new reserves as (the sum of exploration expenses and acquisitions) divided by additions to reserves. We then compared the two sensitivities and let NONLINEAR = 1 if the coefficients differed from one another (at a 10 percent confidence level) and NONLINEAR = 0 otherwise.

Table A-I—Continued

Panel B

	Values of Average Firm Characteristics by Portfolio Gamma												p-Values of Tests of Differences					
	Negative (Synthetic purchased put)				Zero				Positive (Synthetic covered call)				Negative vs. Zero		Negative vs. Positive		Zero vs. Positive	
	N	Mean	Std. Dev.	Med.	N	Mean	Std. Dev.	Med.	N	Mean	Std. Dev.	Med.	Means	Med.	Means	Med.	Means	Med.
Delta-percentage	3	39%	46%	27%	31	30%	25%	24%	7	27%	21%	22%	0.77	0.99	0.54	0.82	0.71	0.68
Option-percentage	3	24%	22%	17%	30	16%	19%	7%	7	8%	10%	4%	0.47	0.24	0.13	0.25	0.16	0.54
Cash Costs (\$US/oz.)	3	299	44	286	28	255	54	255	7	204	32	197	0.18	0.13	0.04	0.02	0.02	0.03
Leverage (%)	3	14.4	12.1	10.9	31	16.2	12.2	15.1	7	8.4	6.7	7.1	0.81	0.90	0.33	0.65	0.11	0.09
Exploration activities (%)	3	1.2	0.9	1.5	31	3.3	3.6	2.1	7	2.2	1.5	2.0	0.33	0.30	0.32	0.49	0.19	0.88
Acquisition activities (%)	3	0.3	0.1	0.2	31	0.1	0.2	0.0	7	0.1	0.0	0.1	0.40	0.10	0.12	0.02	0.07	0.86
Tax loss carry forwards (%)	3	17.9	30.4	0.8	30	10.5	23.1	1.3	7	27.7	46.0	2.2	0.60	0.87	0.75	0.82	0.37	0.37
Firm value (\$US mil)	3	1778	1733	1774	31	612	983	129	7	775	1201	105	0.07	0.40	0.31	0.49	0.70	0.99
Reserves (oz. mil.)	3	14.7	11.4	18.5	31	3.1	3.9	1.5	7	4.1	6.7	1.3	0.32	0.05	0.10	0.11	0.72	0.79
Managerial stock ownership (\$US mil)	3	248.6	426.2	4.4	31	6.4	12.8	2.7	7	8.0	13.6	3.5	0.43	0.40	0.43	0.65	0.77	0.59
Managerial option ownership (no. in mil)	3	2.1	2.0	1.2	31	0.5	0.4	0.3	7	0.5	0.4	0.4	0.29	0.02	0.29	0.07	0.80	0.71
Large block ownership (%)	3	10.5	18.2	0.0	31	30.8	29.4	24.2	7	36.4	26.3	39.8	0.25	0.22	0.16	0.11	0.64	0.52
Quick ratio	3	2.1	1.4	2.9	31	2.2	2.2	1.3	7	3.6	5.0	2.3	0.93	0.95	0.62	0.99	0.47	0.71
Diversification (%)	3	6.7	11.7	0.0	29	9.1	25.4	0.0	7	7.9	15.1	0.0	0.88	0.54	0.93	0.99	0.88	0.48

Firms that synthetically create call options (positive gamma) tend to have lower, rather than higher, cash costs. Furthermore, firms that use explicit option contracts tend to be larger, as measured by firm value or reserves, rather than smaller (although there is no material difference in the size of firms using price-contingent strategies).

Theory does not suggest reasons why other firm characteristics might be related to the use of options. Nevertheless, for the interest of the reader, the table also reports the breakdown of other firm characteristics. Users of explicit option contracts tend to explore less than firms that do not use options. Firms that synthetically recreated call-writing strategies, i.e., sold away the upside to gold price moves, tended to be less highly levered than firms that did not adjust their delta-percentages with gold prices.

Without a more formal model of the determinants of option-usage, fitting a more structured model on this data would be inappropriate. Nevertheless, it appears as if firm characteristics are associated with the strategies executed by mining firms, whether measured using static or dynamic yardsticks. While these usage patterns are not all predicted with extant theory, they may reflect differences in firm or manager sophistication or preferences, differences in optimal use, or differences in the marketing efforts made by derivative sales people toward larger accounts. The lack of testable theoretical propositions suggests a need for more careful examination of these issues from first principles.

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