Risk Measurement and Hedging: With and Without Derivatives

Mitchell A. Petersen and S. Ramu Thiagarajan*

This paper examines a setting in which the derivatives strategies of two firms are known, but completely different. One firm aggressively hedges its risk using derivatives. The other firm uses a combination of operating and financial decisions, but no derivatives, to manage its risk. The different choice of methods is a result of different abilities to adjust operating costs and different needs for investment capital. Managerial incentives also play a role. Although risk-averse managers have an incentive to reduce risk, how and how much they hedge depends on how they are compensated.

In the corporate finance literature, research on risk management has focused on the question of why firms should hedge a given risk. The literature makes the important point that measuring risk exposures is an essential component of a firm's risk management strategy. Without knowledge of the primitive risk exposures of a firm, it is not possible to test whether firms are altering their exposures in a manner consistent with theory.

However, the measurement of risk exposures for non-financial firms has received limited research attention. At one level, the measurement of risk exposure seems intuitively obvious and deceptively simple. It is the covariance of the firm's unhedged cash flows, investment opportunities, or asset values with the risk factor. In practice, the problem is more difficult, since risk exposure can only be seen through the firm's financial disclosures, which might not fully reflect the true economic exposure (Beaver and Wolfson, 1995). The measurement problem is even more complex for some variables, such as investment opportunities, where the existence of the empirical relation in the data depends on a firm's risk management strategy. Investment opportunities might truly covary with a risk factor, but such a relation will not appear in the data if market frictions prevent the firm from taking advantage of investment opportunities when they arise.

In this paper, we take a new approach to measuring risk exposures and thus to testing the theory of risk management. We estimate and compare the risk exposures of two firms that are at opposite ends of the derivative-use spectrum, but are similar in that they both operate in the gold mining industry. The two firms we select are American Barrick, which

The views expressed in this paper are those of the authors and do not necessarily reflect the views of the firms or institutions discussed. Comments from Franklin Allen, David Brown, Judy Chevalier, Beverly Clingan, Joel Demski, Stuart Gilson, Rachel Hayes, Robert McDonald, Todd Pulvino, Raghuram Rajan, Lawrence Revsine, Lenny Soffer, Jake Thomas, Beverly Walther, the Editors and two anonymous referees, as well as seminar participants at Carnegie Mellon University, Columbia University, Duke University, Chicago Board of Trade, the London Business School, the London School of Economics, Pennsylvania State University, the Universities of Florida, Iowa, Michigan, Michigan State, Oregon, Washington, Wisconsin, and Vanderbilt University are gratefully acknowledged. Research assistance by Lauren Tan and Spencer Chen made this work possible. The authors thank the Accounting Research Center and the Banking Research Center at Kellogg for support.

**Mitchell A. Petersen is an Associate Professor at the J.L. Kellogg Graduate School of Management of Northwestern University. S. Ramu Thiagarajan is a Director at Mellon Capital Management.*

aggressively hedges its gold price risk with derivatives, and Homestake Mining, which uses no derivatives. By comparing two firms in the same industry, it is possible for us to measure the different dimensions of the firms' risk exposures and how they are altered by the firms' risk management strategies.

Our objective is to understand the way in which firm specific characteristics determine how firms manage risk. The theoretical literature offers many possible objectives for risk management (e.g., operating cash flow, earnings, taxable income, and equity values). The specific objectives that managers choose depend on the fundamental characteristics of the firm. In this paper, we explore how differences in opportunities available to the firms for managing risk (beyond derivatives) and differences in the managerial and firm incentives lead the firms to target different variables for risk reduction and choose different tools for managing their risk exposure.

The paper is organized as follows. Section I reviews the empirical research on derivative use by non-financial firms and describes our research strategy. In Section II, we examine shareholder-based reasons for managing risks. By estimating the sensitivity of the firm's revenues, cash flow, and investment opportunities, we can begin to explain why American Barrick uses derivatives, and Homestake Mining uses changes in its operating decisions to manage risk. Homestake Mining appears to have lower costs of adjusting production, which provides them with an alternative means of reducing the volatility of its cash flow. Since its investment opportunities are more highly correlated with gold prices, this gives them a natural hedge against gold price risk and thus less reason to hedge. In Section III, we focus on managerial incentives for managing risk. By comparing the different ways in which the two firms compensate their managers, we can explain why one firm seems to target equity values and the other targets earnings as their objective for risk reduction. Section IV concludes.

I. The Research Question and Empirical Strategy

The reasons why publicly traded firms manage risk can be divided into two broad categories: risk management can create value for shareholders, or it can increase the welfare of managers. Although risk management does not affect the value of the firm in a frictionless world, in the presence of market frictions, changes in risk can increase firm value.

A. Theoretical Motivations For Risk Management

Which variable should be the target of risk management depends on the hypothesized source of the gain. Reducing the volatility of taxable income can lower the present value of taxes when the tax schedule is convex (Graham and Smith, 1999). Assuring cash flow in bad states of the world can help the firm avoid financial distress (Smith and Stulz, 1985; and Froot, Scharfstein, and Stein, 1993). Since this strategy can increase the firm's debt capacity, it can also raise the value of the firm through an increase in tax shield (Graham and Rogers, 2000). If external capital is costly, the firm can assure its access to capital when it has positive net present value projects by reducing the volatility of net cash flow which we define as cash flow from operations minus net investment (Froot, Scharfstein, and Stein, 1993; Lessard, 1990; and Myers and Majluf, 1984).

Risk management, which reduces the undiversified risk that managers bear, can improve their welfare (Campbell and Kracaw, 1987; Stulz, 1984; and Smith and Stulz, 1985). The manner in which the firm's risk affects managers depends on their compensation contract. For example,

managers who own stock might focus on the volatility of equity values, but managers with earnings based bonuses might focus on earnings volatility (Brown, 2000; Guay and Kothari, 2000; and Tufano, 1996). By examining how firms and their managers choose to manage risk—and which variables they target (e.g., earnings or net cash flow) – we might be able to distinguish among the theories.

B. Previous Empirical Literature

The empirical tests of risk management theory use two distinct approaches. The first measures the effect of derivatives programs on the firm's risk exposures. The second compares the characteristics of derivative users and nonusers.

1. Measuring the Effects of Derivatives

Hentschel and Kothari (2000) identify firms that use derivatives. They compare the risk exposure of derivative users to that of nonusers. They find economically small differences in equity return volatility between derivative users and nonusers. They also find that currency hedging has little effect on the currency exposure of firms' equity, even though derivatives use ranges from 0.6% to 64.2% of the firm's assets. Jorion (1990) examines the currency exposure of US multinationals, not the use of derivatives, but his findings are similar. Guay (1999) extends Hentschel and Kothari by also examining firms that begin using derivatives. He finds a reduction in risk for these firms, but the reduction is not large economically. The volatility of their equity returns drops by approximately two percentage points (Guay, 1999, Table IV).

One possible explanation for these finding is that firms can manage their risks in many ways. Firms that do not use derivatives might reduce their risk through alternative means. This sentiment is echoed by all three papers. Since firms can manage their risk through operational and financial strategies, as well as derivatives choices, there is value to examining how firms choose to manage risk as a function of their objectives and their opportunities.

2. Cross-Sectional Studies

The second branch of the literature examines why firms use derivatives to manage their risks. This literature also classifies firms as either derivative users or nonusers. Francis and Stephan (1990) search financial databases for keywords such as "hedging," "swaps," or "options." Geczy, Minton, and Schrand (1997) look for references to the use of currency derivatives in the financial statements of S&P 500 firms. Mian (1996) examines whether a firm reports using derivatives and if the derivatives receive hedge accounting treatment. These papers then estimate whether the firm is a derivative user as a function of firm characteristics.

Since researchers only observe firms' use of derivatives, it could be difficult to verify whether these firms manage risk in other ways. An example from the gold industry is a gold loan. Instead of borrowing dollars, a firm borrows gold that it then sells to fund its mining operation. At the end of the loan, the firm returns a fixed amount of gold (principal plus interest). A gold loan is economically equivalent to a cash loan plus a series of short positions in the forward gold market. However, accounting disclosures do not uniformly classify this transaction as a hedging instrument similar to a forward contract. American Barrick, which used gold loans widely (especially in the mid and late 80s), initially did not even classify this as debt. Instead it treated this liability as deferred revenue and then made adjustments to its income statement in future years based on the delivery of gold to repay the loans. The two contracts (a gold loan or a cash loan plus a forward contract) are economically identical, but only one is classified as a derivative.

To argue that derivatives are being used to create value by reducing the volatility of the

firm's taxable income, net cash flow, or asset values, the researcher must control for both the magnitude and direction of a firm's underlying risk exposure. Each of the papers in this group of studies recognizes this problem and uses different methods to control for the firm's underlying risk exposure. By including only firms with significant foreign operations, foreign-denominated debt, or a high concentration of foreign competitors, Geczy, Minton, and Schrand's (1997) sample should include only firms with a potential foreign currency exposure. As a cross sectional control for the magnitude of the firm's underlying risk exposure, they also use the fraction of the firm's sales that are foreign.

Tufano (1996) and Haushalter (2000) give a more precise version of these tests. Using derivatives is not a binary decision, but a continuous one. A firm that hedges a small portion of its risk with derivatives is closer to a nonuser of derivatives than to one that hedges most of its risk. Using survey data, Tufano calculates the change in the value of the gold mining firm's derivative portfolio with respect to gold prices. Higher deltas (i.e., greater sensitivity of the firm's derivative portfolio to gold price changes) imply that the firm has hedged more of its risk. Haushalter uses the fraction of the current year's production that has been hedged with derivatives as a dependent variable. Both papers find the continuous dependent variable contains significantly more information than does a binary dependent variable. A bigger innovation is the way in which both studies control for a firm's underlying risk exposure. Since both papers restrict their samples to firms from a single industry (gold or oil), the authors can argue the risk exposure of the firm's revenue is the same across firms.

C. Research Design

We examine how firms manage risk by taking the logic of Tufano (1996) and Haushalter (2000) one step further. We examine in detail two gold mining firms, American Barrick and Homestake Mining. Our strategy is similar to that of Brown (2000), who examines the derivative choices of a single firm. Brown has the advantage of comparing actual derivative trades to the statements made by management.

1. Explaining Different Methods of Risk Management

We choose gold mining firms because the demand for investment capital and the supply of operating cash flows depends primarily on a single easily measurable economic variable, the price of gold. Gold is a commodity with little variation in quality, so the market for gold is arguably competitive. Being competitive, the sale price of the product is beyond the control of any individual firm. Unless they contractually lock in the price of gold, the price of their output will move with the market price of gold. Further, the market for gold derivatives is well developed. There is a variety of available instruments, ranging from forwards and options to spot deferred contracts and gold bullion loans (Tufano, 1995).

The two firms we examine have well articulated derivative strategies that are diametrically opposed.[1]

[1]Through 1994, the two firms had stable derivative use policies. Starting in 1994 this changed, which is why we end our analysis in 1994. In 1995, American Barrick scaled back its use of derivatives (Farnsworth, 1996). A shortage raised the lease rate on gold sixfold. American Barrick cited the increase in borrowing cost as the reason for reducing its derivative portfolio by a third (Gooding, 1996). Homestake Mining decided to start using derivatives to manage its gold price risk, (McGee, 1995; *The Economist*, 1996). Homestake Mining's decision was motivated in part by a desire to protect its earnings. Homestake had a high-cost mine which would have required a write down had gold prices fallen. The management of Homestake also believed that investors purchased their stock to obtain gold price exposure. This belief began to evolve in 1995, when Homestake's managers expressed a belief that a correctly executed derivative strategy could maintain the upside in gold prices that their investors desired while protecting the firm from a drop in the price of gold. As a result, their hedging had risen to approximately 80% of annual production by 1999 (Homestake Mining Annual Report, 1999).

American Barrick aggressively hedges its gold price risk exposure. According to American Barrick's chairman, Peter Munk, "Through its gold hedging program, Barrick has demonstrated that it can manage the gold price risk... At current gold prices, Barrick could almost be fully hedged until 1995 at a gold price of approximately $440 per ounce." (American Barrick Annual Report, 1990). It was American Barrick's policy to hedge nearly all of its production for the next three years and 50% of its production in years four through six. Because American Barrick is the most aggressive gold mining firm in its use of derivatives it is a good polar case for our analysis (Tufano, 1996).

Homestake Mining's approach to derivative use is at the other extreme. Homestake's explicit corporate policy is to avoid derivatives when managing its risk. "In order to maintain the maximum upside potential for gold, ...Homestake does not hedge or use other methods to sell forward its future gold production. As a result, Homestake's earnings fluctuate with changes in the price of gold along with other factors including total production costs.[2]

2. Are the Two Firms Identical?

On the surface, the two firms appear identical. Both firms mine and sell gold, so the price of their output will fluctuate with the market price of gold if they do not contractually lock it in. The fact, however, that two firms in the same industry, exposed to the same risk factors, choose diametrically opposite approaches to derivatives strongly suggests that the firms are not identical. And in fact, Table I shows the firms are similar, but not identical. American Barrick and Homestake Mining are similar in size in the later half of the sample. Homestake's sales and production (in ounces) are larger, but American Barrick has greater reserves and market capitalization, both indicative of greater future growth.

American Barrick was not always large. The firm was formed in the mid 80s and has grown very rapidly, mainly through acquisitions. Homestake Mining is a much older firm. It has grown internally through exploration and the growth of its sales has been correspondingly smaller than that of American Barrick (9.3% versus 36.7% – see Table I). Homestake's internal approach to growth also means it has been less reliant on the capital markets. This difference in investment opportunities is one factor that influences the firms' choice of risk management strategies (Froot, Scharfstein, and Stein, 1993 and Lessard, 1990).

Our objective in examining these two firms is to identify which characteristics—different opportunities the firms face, different objectives that they pursue, or both—lead the firms to choose such different approaches to derivative use and risk management. With our data, we can estimate how American Barrick's and Homestake Mining's revenues, cash flow, investment opportunities, and equity values fluctuate with the price of gold. This enables us to describe the firms' risk exposures, and study the ways in which firms differ. By examining the operational, investment, financial, and accounting decisions of American Barrick and Homestake Mining, we can determine the factors that cause the firms to choose different risk management approaches.

II. Estimated Risk Exposures, Risk Management, Shareholder Value

In this section, we examine the building blocks underlying the effects of risk management

[2]Homestake Mining Annual Report, 1992. To verify the firm's use or lack of use of derivatives, we read the annual reports for our sample period. Where necessary, we contacted the managers. Homestake Mining did report outstanding gold loans in its 1992 and 1993 annual reports. Homestake assumed these loans when it acquired Corona Corporation in July 1992. The loan represents less than 3% of Homestake's reserves and the current portion less than 3.5% of Homestake's 1992 production. The loans were paid off in June of 1993 (Homestake Mining Annual Report, 1993). Adjusting our estimates for these loans did not alter them materially.

Table I. Summary Statistics for American Barrick and Homestake Mining

The table contains summary statistics for American Barrick (Derivative User) and Homestake Mining (Derivative Nonuser). We report means for the full sample (1976-94) for Homestake and the common period (1986-94) for both firms. Reserves are reported in millions of ounces as are the firms' estimates of proven and probable gold reserves. Production is the number of ounces (in 1,000s) that were mined during the year. The net debt ratio reduces debt by the firm's cash and marketable securities. Data on managerial equity ownership is available from 1989-1994.

	American Barrick (Derivative User)	Homestake Mining (Derivative Nonuser)	
	1986-1994	1986-1994	1976-1994
Reserves (M oz)	20.7	14.1	9.6
Production (K oz)	876.6	1,202.6	757.7
Sales ($M)	361.7	457.2	281.1
Sales Growth (%)	36.7%	7.6%	9.3%
Market Capitalization ($B)	3.0	1.7	1.2
Debt Ratio (%)	16.8%	7.7%	4.4%
Net Debt Ratio (%)	6.3%	-4.5%	-7.6%
Managerial Equity Ownership (%)	23.0%	9.0%	

on shareholder wealth.

A. Operating Cash Flows

Risk management can increase shareholder wealth and improve the welfare of managers. Shareholder wealth can be increased by reducing the volatility of taxable income or net cash flow (operating cash flow minus net investment). We begin with the primitive building blocks of a firm's cash flow (revenues and costs) and examine how each of these elements vary with the underlying risk factor (gold prices). We can then understand the different methods of managing risk that the two firms choose, show how the firms are fundamentally different, and why this leads to their different approaches.

We estimate gold price sensitivities by regressing the percentage change in the chosen variable on the percentage change in gold prices. We calculate percentage changes as the difference in the natural log of the variable. We estimate gold price exposures two ways: the percentage change in the year-end gold price and the percentage change in the average price. The average price is the average of the 12 month-end prices. Which gold price measure is correct depends on the chosen variable. For variables that depend on the path of gold prices throughout the year (e.g., revenue), the average price is the correct measure. For changes in stock variables (e.g., equity returns) or flow variables that change slowly (e.g., possibly operating costs), changes in year-end prices might be more informative.

1. Sales Revenue

All the performance variables that a firm can target (net cash flow, taxable income, earnings) depend on the firm's operating cash flow. There are two reasons to estimate the risk exposure

of revenues and costs as well as operating cash flows. Operating cash flows could be uncorrelated with a risk factor either because revenues and costs are not correlated with the risk factor, or because both revenues and operating costs are highly correlated with the risk factor, but their difference is not. Since firms can manage risks through the use of operating leverage, it is important to know how both costs and revenues move with the risk factor (Petersen, 1994).[3]

Another reason to examine revenues and costs instead of cash flow or earnings is that the latter variables can be and are negative in the sample. Percentage changes are meaningless in such situations. Consistent with intuition, Homestake Mining, which does not use derivatives, is more likely to experience negative operating cash flow (defined as earnings before interest, taxes, depreciation, and amortization). Homestake Mining's operating cash flow is negative 10% of the time; American Barrick's is never negative.

The average sales price received by Homestake Mining, which does not use derivatives, rises and falls one for one with the average price of gold, so there is little unexplained variation in Homestake's sales price (R^2 = 0.977—see Table II, Panel B). The sales price reported by American Barrick includes the effects of its derivatives program. American Barrick's risk exposure is therefore dramatically smaller. The average sales price for American Barrick increases 3.3% for every 10% increase in the price of gold. Given the short sample, we re-estimated this coefficient using quarterly data. The coefficient estimate is slightly smaller at 0.28 (regression not reported) and still statistically significant (t=2.0) With an R^2 of 40%, a portion of American Barrick's sales is still exposed to changes in the average gold price. If we estimate it using the change in year-end prices, American Barrick's sales price has no risk exposure (ß = 0.122 and t-statistic = 0.8). Since the year-end price and average price are not perfectly correlated, hedging an average price (Asian) exposure with year-end derivatives (European), does not completely eliminate the exposure.

Consistent with our expectations, the different approaches to derivative use dramatically reduce the volatility of American Barrick's sales revenue. Over our sample period, the average price each firm receives for its gold increases at almost the same rate as the market price of gold (1.7% per year). The price American Barrick receives for its gold rises an average of 1.5% per year compared to an average of 2.1% per year for Homestake Mining. However, the variability around this mean is twice as large for Homestake Mining as it is for American Barrick.

2. Operating Costs

Since firms mine gold in a world where gold prices fluctuate, they might change their mining strategy as a function of the price of gold. Both companies extract gold from many mines with different extraction costs. For example, in 1994, the average extraction costs across Homestake's mines varied from a low of $211 per ounce (at its David Bell mine) to a high of $416 per ounce (at its El Hueso mine). Furthermore, because the concentration of ore varies within a mine, the cost per ounce will also vary within a given mine. As the gold price declines, these firms can mine lower-cost ore, reduce output from mines, or shut down a mine completely (Tufano, 1998b; and Tufano and Moel, 1999). Such a mining strategy would create costs that vary positively with the price of gold and thus provide a mining firm with a natural hedge. Hence, as gold prices rise, the firm's marginal and average costs rise, making operating cash flows and earnings less sensitive to gold prices.

[3]For both American Barrick and Homestake Mining, the number of ounces of gold they sell is not correlated with the price of gold. The R^2s never rise above 15% and the coefficients are never statistically significant, even after allowing past prices to affect current unit sales (regressions available from authors). Since including quantities in our regressions only adds noise, we report regressions based on per ounce data for sales, costs, and cash flow.

Table II. Sensitivity of Operating Cash Flow and its Components to Gold Prices

The table contains coefficients from the regression of the percentage change in the dependent variable (average sales price per ounce, average cost per ounce, and average operating cash flow per ounce) on the percent change in the price of gold. We calculate the percentage changes as the difference in the log of the variable. We base our regressions on annual numbers collected from the American Barrick and Homestake Mining annual reports. Unit Costs are the cost per ounce of mining the gold including stripping costs, depreciation and amortization. Since 1977 is the first year for which cost data is available, 1978 is the first year for which we can calculate a percentage change in costs per ounce for Homestake Mining. We calculate the percentage change in the gold price two ways. The first method is to calculate a percentage change based on the year-end price of gold. The second method is the percentage change in the average gold price during the year. We calculate the average gold price for the year as the average of the 12 month-end prices. Due to the negative values, the operating cash flow regressions exclude 1991-92 for Homestake Mining. The last row specifies which version of the percent change in gold prices was used in each regression. Standard errors are in parentheses. Superscripts denote two-tailed significance levels.

	Average Price			Unit Costs			Operating Cash Flow		
Panel A. American Barrick - Derivative User (1986-1994)									
Intercept	0.013	0.005	0.008	-0.034	-0.046	-0.038	0.040	0.044	0.043
	(0.019)	(0.013)	(0.015)	(0.065)	(0.067)	(0.065)	(0.105)	(0.116)	(0.106)
Gold Price Change$_t$	0.122	0.090	0.331*	0.199	0.149	0.360	-0.363	-0.350	-0.154
	(0.146)	(0.102)	(0.153)	(0.058)	(0.518)	(0.649)	(0.918)	(1.002)	(1.140)
Gold Price Change$_{t-1}$		0.297**			0.466			-0.198	
		(0.102)			(0.517)			(0.854)	
R^2	0.091	0.622	0.400	0.022	0.138	0.042	0.025	0.036	0.003
Panel B. Homestake Mining - Derivative Nonuser (1976-1994)									
Intercept	0.018	0.001	0.004	-0.036	0.021	0.027	0.013	-0.061	-0.045
	(0.044)	(0.020)	(0.009)	(0.028)	(0.020)	(0.023)	(0.127)	(0.097)	(0.079)
Gold Price Change$_t$	0.611***	0.449***	0.998***	0.237**	0.162**	0.367***	1.272***	1.009***	2.036***
	(0.170)	(0.078)	(0.038)	(0.103)	(0.075)	(0.097)	(0.446)	(0.341)	(0.311)
Gold Price Change$_{t-1}$		0.629***			0.296***			1.147***	
		(0.075)			(0.075)			(0.338)	
R^2	0.432	0.895	0.977	0.281	0.651	0.488	0.385	0.687	0.768
Model	Year End	Year End	Average	Year End	Year End	Average	Year End	Year End	Average

***Significant at the 0.01 level.
**Significant at the 0.05 level.
*Significant at the 0.10 level.

a. Empirical Differences in Estimated Sensitivities

We regress changes in the log of total cost per ounce on changes in the log of the gold price to estimate the sensitivity of each firm's costs to gold prices. We can thus test whether changes in their costs hedge risk. We use the year-end gold price in our regressions and include several lags to account for the fact that adjusting mining operations is not instantaneous.

For Homestake Mining, operating costs fluctuate with the price of gold. A 10% fall in the price of gold during the year is associated with a 2.4% decrease in its extraction costs (see Table II, Panel B). When we include the gold price change and its two lags, only the current gold price change and its first lag are statistically different from zero. The long-term adjustment in costs to changes in gold prices is sizeable. A 10% decrease in gold prices leads to an eventual decrease in the average extraction cost of 4.6%, with approximately two thirds of the adjustment occurring in the following year. We also report estimates based on changes in the average gold price, but they provide the same intuition. Since we are measuring changes in average cost, the changes in marginal cost would be even more dramatic.

The estimated sensitivity of American Barrick's operating costs to changes in gold prices is approximately as large as it is for Homestake Mining. Measuring gold price using year-end prices, the estimated sensitivity is 0.24 (t=2.4) for Homestake compared to 0.20 (t=0.4) for American Barrick (Table II). Current gold price change explains 28% of the variation in Homestake Mining's operating costs, but only 2% of the variation in American Barrick's costs. This is why the American Barrick coefficients are estimated with very little precision. The short time series for American Barrick limits our ability to determine if the coefficient is truly economically significant or only large by chance.

To increase our statistical power, we collect quarterly data from as far back as reported and re-estimate the coefficient. Using quarterly data, the sensitivity of total costs to gold price changes is small (ß=0.02) and still statistically insignificant (t=0.1) (regression not reported). More importantly, when we examine the sensitivity of operating cash flow to gold price movements, the results indicate that American Barrick's costs do not fluctuate with gold prices.

b. Different Cost Structures

The results in Table II suggest that the marginal costs of adjusting mining output might be higher for American Barrick. If this is true, we should see less adjustment in their production. However, since American Barrick and Homestake Mining are growing at very different rates, looking at the average variation in production might be misleading. Over the sample period, which is longer for Homestake Mining, Homestake Mining's production grew at 11% per year compared to 32% for American Barrick.

To compare the variation in production around the trend growth rate, we regressed the log of production on a time trend. The slopes are the average growth rates in production. The standard deviation of production around the trend growth rate (the error term) is significantly higher for Homestake Mining (21%) than for American Barrick (7%). This difference is statistically significant (p = 0.003). If the costs of adjusting production are linear or convex in the adjustment, this would suggest lower costs of adjustment for Homestake Mining.

The one problem with this approach is that it is indirect. Ideally, we would like to measure the costs of altering production as a response to changing gold prices. Since this information is unavailable, we asked the managers of the two firms how costly they considered changes in production in response to changes in gold prices. The managers of American Barrick view changes in the mining plan as very costly and any changes are considered permanent.[4] Both

[4]Discussion with Jamie C. Sokalsky, Treasurer, American Barrick, October 14, 1997.

their labor and the capital are specialized and, given the widespread locations of their mines, are costly to reallocate. American Barrick forecasts how many ounces will be extracted from each mine per year and then does not significantly alter production, because the adjustment costs are high. This would explain why we do not find changes in operating costs that are correlated with changes in gold prices, or significant variation in production around the trend growth rate.

To argue that American Barrick never changes its production decisions in response to changes in the price of gold—no matter how extreme—would be wrong. Extreme changes in gold prices must affect a firm's operating decisions. However, given the cost structure faced by the managers of American Barrick, changes in mining decisions are permanent. In the industry, 88% of mine closings are permanent (Tufano and Moel, 1999). Barrick's decision to close five mines in response to low gold prices in 1997 is an example. The mines in question were near the end of their useful life and had operating costs above the current price of gold. Thus, shutting them down permanently reduced the firm losses with little chance that future profits would also be lost (Heinzl, 1997).

The managers of Homestake Mining also viewed shutting down mines as a permanent decision. However, Homestake's managers consider it less costly to vary the mix of ore extracted, which changes the average extraction cost. Therefore, we find that production (as measured in ounces) falls only slightly and production (as measured in tons of rock) rises when gold prices rise (regressions not reported). Although costs cannot be shifted over long periods of time, over a period of a year or so, costs can be moved by altering the quality of ore that is mined.[5] The lower costs of altering the grade of ore extracted over the short term is consistent with the empirical results in Table II, which imply that Homestake Mining varies operating costs to dampen the effect of gold prices on their operating cash flows.

3. Operating Cash Flow

Combining our results on revenues and costs, we expect that American Barrick has eliminated the exposure of its operating cash flow to gold prices (see Table II, Panel A). No matter how we measure gold price changes, American Barrick's operating cash flow is independent of gold prices.

Homestake Mining significantly reduces, but has not eliminated, its exposure. Based on the average gold price regression, the elasticity of Homestake's cash flow to gold prices is approximately two.[6] Due to operating leverage, this elasticity is greater than one. When costs do not rise proportionally with revenues, a given percentage increase in revenues causes an even greater percentage increase in cash flow. However, the fact that Homestake's costs rise with gold prices reduces this elasticity. If its costs did not fluctuate with gold prices, the elasticity of cash flows to gold prices would be almost three times greater. To illustrate: Homestake's average operating margin ",P-C/P. " is 18%. If its costs did not move with the price of gold, then a 1% increase in the price of gold (and revenues) would raise its profit margin to 19%, an elasticity of almost 6 ([(0.19-0.18)/0.18] / 0.01).

Given their different abilities to adjust costs, the two firms have both reduced the volatility of their operating cash flows, but they have done so in different ways and to different degrees. We examine the objectives behind this reduction next. The reason for hedging operating cash flows could be to hedge net cash flows or taxable income, both of which can

[5]Discussion with Mike Carroll, Comptroller, Homestake Mining and Dan Ankuda, President, Metals Marketing, Homestake Mining, on October 15, 1997.

[6]Due to negative cash flows, we lose two observations from our Homestake sample. Thus, these estimates are not directly comparable to the above results and should be interpreted with caution.

increase shareholder wealth, or to hedge accounting earnings, which can improve managerial welfare–depending on how managers are compensated.

B.Taxable Income

If volatile taxable income creates losses that can not be completely carried back, then it provides an incentive for a firm to manage risk (Graham and Smith, 1999; Berkman and Bradbury, 1996). The two firms might hedge their operating cash flows to hedge their taxable income and thus reduce the present value of taxes. Approximately half of the firms studied by Graham and Smith (1999) are able to reduce the present value of their taxes by reducing the volatility of their taxable income. Based on estimates of the firms' marginal tax rates, we are able to simulate the tax savings from further reductions or increases in a firm's taxable income.[7] The estimated marginal tax rate for American Barrick is consistently close to the statutory rate, which implies that the potential savings from additional hedging are essentially zero. Given their derivatives program and the results in Table II, this isn't surprising.

Homestake Mining's estimated marginal tax rate is more volatile, fluctuating from a high of 46% (the statutory rate) in 1980 to a low of less than 1% in 1992. For Homestake Mining, reductions in the volatility of taxable income are value enhancing. An additional 5% reduction in the volatility of taxable income is estimated to reduce taxes by an average of 3% over the 1980-1994 period. Graham and Rogers (2000) find that "...firms do not hedge in response to convexity because the incentive is small relative to other hedging incentives." For Homestake, a 3% savings would amount to approximately a quarter of a million dollars or 0.2% of income on average between 1980 and 1994. This is smaller than the cost of setting up a derivative program as reported in Brown (2000). Bodnar, Hayt, and Marson (1996, 1998) find that the second most common reason for not using derivatives is the cost of establishing and maintaining a derivatives program. Consistent with the finding of Graham and Rogers (2000), the magnitude of the tax savings for Homestake is probably small.

C. Investment Opportunities

American Barrick reduces the gold price sensitivity of its current cash flow significantly more than Homestake Mining. This difference can be consistent with each firm maximizing shareholder value if the exposure of their investment opportunities to gold price risk differs (Froot, Scharfstein, and Stein, 1993; and Lessard, 1990). Hedging is value increasing if it takes cash away when cash has (relatively) low value and returns cash when cash has high value. When external capital is expensive, cash has high value when internal cash flow is low and investment opportunities are high. Thus, if we are to determine if the reductions in the firm's operating cash flow volatility reduce the volatility of net cash flow (operating cash flow minus desired net investment), we must describe how investment opportunities covary with gold prices (Gay and Nam, 1998).

1. Variability in Investment Opportunities

In theory, investment opportunities can covary positively or negatively with gold prices. The major investment expenditure for gold firms is procuring unmined gold. This can be done by exploring for gold on properties they already own. If exploration costs (capital and labor) are not highly correlated with the price of gold, the desirability of exploring for gold

[7]See Graham (1996) and Graham and Smith (1999) for a description of this methodology. We thank John Graham for calculating the marginal tax rates and projected savings from hedging for us.

will positively covary with the price of gold. Alternatively, firms can acquire gold reserves through acquisitions. Unlike exploration, the profitability of purchasing gold mines could rise when gold prices are low (Ortega, 1997). If distressed firms are forced to sell properties at bargain prices when gold prices are low, then a firm with excess cash would find its investment (buying) opportunities are high when gold prices are low (Shleifer and Vishny, 1992). The publicly traded gold firms are not usually highly levered. Over the 1985 to 1994 period, the average debt to asset ratio for the gold industry is 11%. However, since the debt ratios are highly correlated with gold prices (ρ = -0.74), periods of low gold prices might create the opportunity to purchase distressed assets at favorable prices.

2. Different Investment Strategies

Even though the two firms are in the same industry, they pursue very different investment strategies. The different investment strategies lead to demand for capital in different states of the world and thus to different needs for managing risk. Homestake Mining, started in 1877, has been steadily growing but at a slower pace than American Barrick. Their reserves have grown 4% a year over our sample period. American Barrick's reserves have grown 45% per year from 1984 to 1994. The different growth rates illustrate the different ways the firms have chosen to invest.

Homestake Mining has focused on developing its own properties and thus spends significantly more on exploration expense than does American Barrick. Between 1986 and 1994, Homestake Mining's exploration costs relative to its operating income has been almost five times larger than American Barrick's (3.4% compared to 0.7%). If Homestake's exploration outlays are highest when internally generated cash flow is highest, the value of smoothing net operating cash flow is low. In addition, its strategy has been to carry a significant amount of cash, so that it always has sufficient capital to explore and develop mines. Homestake Mining's cash has averaged 12% of its assets (market value of equity plus book value of debt and preferred equity). Therefore, Homestake Mining has accessed the public capital markets infrequently. Its net equity issues (equity issues minus equity repurchases) as a percent of outstanding equity has been near zero over the 1984-1994 period, and has never exceeded 1% of outstanding equity.

American Barrick's strategy has been one of rapid growth through acquisition of gold mines. American Barrick spent approximately $1.6B on acquiring gold mines between 1984 and 1994. By comparison, Homestake spent only $0.6B. Since Homestake was a larger firm for most of this period, on a percentage basis the difference is even greater. American Barrick's acquisition strategy and more rapid growth has meant it has had a greater demand for external capital and has therefore accessed the capital markets more often. Its net issues of equity relative to outstanding equity have averaged 4.4% per year over our sample period. The different investment strategies and thus different reliance on external capital makes reductions in volatility of operating cash flows more valuable for American Barrick.

3. Empirical Investment Risk Exposures

To empirically examine the two firms' investment strategies and capital requirements, we estimate the risk exposure of each firm's investment opportunities. We note that we are measuring actual investment, not desired investment. We look at both variations in exploration costs and the growth in their reserves (ounces of unmined gold) as it correlates with gold prices.

Homestake Mining, whose focus is exploring for gold, does alter its exploration expense with the price of gold (Table III, Panel B). Although current changes in the gold price do not have a statistically significant effect on its current exploration costs, a 10% rise in gold prices this year is followed by a 4.5% rise in exploration spending the following year (t = 1.7).

Table III. Sensitivity of Investment Decisions to Gold Prices

The table contains coefficients from the regression of the percentage change in the dependent variable on the percent change in the price of gold. We calculate the percentage changes as differences in the log of the variable. We base our regressions on numbers collected from the American Barrick and Homestake Mining annual reports. Gold reserves are the number of ounces (in millions) that are still unmined. This estimate is based on the existence of the ore and the economic feasibility of extraction. Both production and reserves of Homestake Mining includes those of its affiliate Kalgoorlie Mining Associates in which it had a 48% stake from 1975-1988. "Young firm" for American Barrick is a dummy variable that takes the value of 1 for the years 1985 to 1987. The percentage change in the gold price is based on year-end prices. Standard errors are in parentheses. Superscripts denote two-tailed significance levels.

	Exploration Expenditure		Gold Reserves	
Panel A. American Barrick - Derivative User (1985-1994)				
Intercept	0.036	0.036	0.102	0.099
	(0.184)	(0.197)	(0.112)	(0.119)
Gold Price Change$_t$ (%)	0.879	0.193	-1.885	-1.901
	(1.559)	(1.599)	(1.104)	(1.169)
Gold Price Change$_{t-1}$ (%)		-1.062		-0.277
		(1.367)		(0.721)
Young Firm (Year is 1985-1987)			1.284***	1.293***
			(0.287)	(0.305)
R^2	0.038	0.115	0.748	0.753
Panel B. Homestake Mining - Derivative Nonuser (1976-1994)				
Intercept	0.072	0.059	0.054	0.052
	(0.072)	(0.068)	(0.039)	(0.040)
Gold Price Change$_t$ (%)	0.182	0.065	-0.196	-0.215
	(0.278)	(0.271)	(0.151)	(0.160)
Gold Price Change$_{t-1}$ (%)		0.454*		0.073
		(0.261)		(0.154)
R^2	0.025	0.179	0.089	0.102

***Significant at the 0.01 level.
*Significant at the 0.10 level.

For American Barrick, whose investment focus is on purchasing reserves, there is no relationship between changes in gold prices and changes in its exploration expenditure (Table III, Panel A). The coefficients are statistically indistinguishable from zero and the R^2 is tiny.

To determine if our two firms are expanding their reserves (purchasing mines) when gold prices rise or fall, we regress percent changes in reserves (in millions of ounces) on percent changes in gold prices. Homestake Mining's reserves are barely correlated with changes in the price of gold, even after including lagged changes in the gold prices ($R^2 \leq 10\%$).

We estimate American Barrick's sensitivity in the same manner. Since American Barrick starts from a very small base, its growth rate in the early years is extremely high. The growth of its reserves averages 110% per year between 1984 and 1987, and 18% for the remainder of the sample period. If we do not control for these observations, they act as leverage points that can significantly alter the estimated coefficients. To limit the effect

of these observations, we include a dummy variable for the early years (1985-1987). Given the firm's infancy, the timing of this rapid growth was probably driven by management's desire to grow the firm, rather than opportunistic purchases of mines from distressed firms. The dummy variable controls for this motivation. When the dummy variable is included, changes in reserves are not highly correlated with changes in the price of gold (Table III, Panel A). The negative coefficient implies that American Barrick reserves rise more when gold prices fall. Although large in magnitude, none of the coefficients on gold prices are statistically significant. When we exclude the dummy variable, the coefficients on gold prices are positive, but still insignificantly different from zero.[8]

Given the estimated risk exposures of the two firms' investment opportunities, although the sensitivity of operating cash flow for the two firms is different, it is exactly what theory predicts. Since the firms differ in when they value internal capital the most, they should be expected to hedge their operating cash flow to different degrees. Homestake's greater need for investment capital when gold prices are high makes reductions in the volatility of operating cash flow less valuable to it. Since American Barrick's investment opportunities do not depend on gold prices, its operating cash flow should not either.

D. Equity Risk Exposure

Our next step is to examine how American Barrick's and Homestake Mining's equity and asset values covary with the price of gold. These risk exposures are relevant for two reasons. First, it is a way to test the robustness of the previous results. Since the firm's asset value is the discounted value of its cash flows, strategies that alter the riskiness of the cash flow will appear in both the risk exposure of the firm's assets and its equity. This is one reason the empirical literature has focused on measuring how the risk exposure of firm's equity is altered by hedging (Bartov and Bodnar, 1994; Guay, 1999; Hentschel and Kothari, 2000; and Tufano, 1998b). The equity exposure is also of interest because, depending on their incentives, managers might focus on equity volatility. Shareholders might link managerial compensation to equity values to motivate managers, which in turn might cause managers to hedge the firm's equity exposure.

1. Equity Risk Exposure

We estimate the equity return sensitivity to gold prices by estimating a modified CAPM regression. We obtain the risk exposure of a firm's equity to gold price changes by regressing the firm's excess equity returns on the excess stock market return and the excess gold return:

$$r_{Equity} - r_{Risk\ free} = \beta_0 + \beta_1(r_{Stock\ market} - r_{Risk\ free}) + \beta_2(r_{Gold\ prices} - r_{Risk\ free}) + \varepsilon \quad (1)$$

We measure excess returns as the monthly stock return minus the risk-free rate. We use the return on one-month government T-bills as the risk-free rate. The return on gold is the monthly percentage change in the price of gold, which is the return an investor would earn from holding gold directly. Just as the coefficient on the market return measures the firm's sensitivity to market-wide fluctuations, the coefficient on gold price changes measures the equity's sensitivity to gold price changes. This is the

[8]We also examined acquisitions. Since acquisition expenditures are lumpy and zero in most years, we cannot calculate percentage changes. Instead, we calculated the correlation between gold prices and American Barrick's acquisition expenditure. The correlation is effectively zero (ρ = -0.02).

Table IV. Sensitivity of Equity and Asset Returns to Gold Price Changes

The table contains regressions of asset and equity returns on the equity market and gold return. In column 1, the dependent variable is the monthly excess equity return. The independent variables are the excess return on the market (the return on the value-weighted stock market minus the risk-free rate) and the excess gold return (the percentage change in the price of gold minus the risk free rate) multiplied by the percent of sales from gold. For American Barrick this is always 100%. In column 2, the independent variables are not multiplied by the percent of sales from gold. In column 3, the dependent variable is the excess asset return. The excess asset return is the excess equity return for the month times the market value equity ratio (market value of equity over market value of equity plus book value of debt and preferred equity). Standard errors are in parentheses. Superscripts denote two-tailed significance levels.

Dependent Variable	Equity Returns				Asset Returns	
Sample Period	1/76-12/94	3/87-12/94	1/76-12/94	3/87-12/94	1/78-12/94	3/87-12/94
Panel A. American Barrick - Derivative User						
Model	1	1	2	2	3	3
Intercept		0.027				0.021
		(0.010)				(0.008)
Market Return		1.063***				0.791***
		(0.253)				(0.196)
Gold Return		1.602***				1.306***
		(0.290)				(0.224)
R^2		0.286				0.297
Panel B. Homestake Mining - Derivative Nonuser						
Intercept	0.006	0.009	0.003	0.008	0.006	0.008
	(0.006)	(0.009)	(0.006)	(0.009)	(0.006)	(0.009)
Market Return	0.954***	0.863***	0.844***	0.876***	0.951***	0.811***
	(0.128)	(0.238)	(0.131)	(0.241)	(0.128)	(0.221)
Gold Return	2.053***	1.744***	1.066***	1.605***	1.950***	1.577***
	(0.159)	(0.238)	(0.088)	(0.275)	(0.159)	(0.271)
R^2	0.485	0.299	0.456	0.288	0.479	0.291

***Significant at the 0.01 level.

coefficient that should be altered by the firm's risk management strategy.

When we use the common time period March 1987 to December 1994, the estimated gold sensitivity of American Barrick is only slightly smaller than that of Homestake Mining (Table IV).[9] American Barrick's equity returns rise 16% for every 10% rise in the price of gold (Table IV, Panel A, column 1, t = 5.5). Homestake Mining's gold sensitivity is slightly higher with an

[9]Even though American Barrick has been a public company since 1985 (see page 2, of 1986 Annual report), stock return data is only available on CRSP since February 25, 1987, the day they were listed on the New York Stock Exchange.

estimated coefficient of 1.7 (see Table IV, Panel A, column 1, t=6.0).[10] This result is qualitatively similar to the findings of Hentschel and Kothari (2000) and Guay (1999) and might seem inconsistent with the intuition that derivatives use by American Barrick should reduce its gold price exposure (Tufano, 1998b). However, as our previous discussions point out, American Barrick and Homestake Mining differ in more ways than just their derivatives use. Homestake Mining has also reduced its gold price exposure through operations and through its choice of leverage. To identify the effect of the firm's risk management programs (derivatives or operational decisions), we must examine the difference in the sensitivity of their assets.

2. Asset Risk Exposure: Leverage Effects

As noted, derivatives use by American Barrick and operational hedging by Homestake Mining reduce the exposure of their assets to gold price fluctuations. However, the estimated equity exposures are a function of these actions as well as of the firm's financial leverage. Risk management and financial policy are joint decisions. Since they are alternative ways to reduce the costs of financial distress, the decisions should be correlated.

Leverage will accentuate the sensitivity of the firm's equity to gold prices. The firm's asset gold betas (sensitivity of its asset to gold prices) is a weighted average of its equity and debt gold betas:

$$\beta_{Assets} = \beta_{Equity} \frac{Equity}{Assets} + \beta_{Debt} \frac{Debt}{Assets} \quad (2)$$

Since the firms have chosen different leverage ratios – American Barrick is 16% debt and Homestake Mining is 4% debt, the equity regressions are not directly comparable. If we assume that the sensitivity of both American Barrick's and Homestake Mining's debt to gold prices is zero, then we can calculate asset returns as equity returns times one minus the debt ratio. This method does not produce the correct asset return, but it will produce the correct covariance between the asset return and gold prices, conditional on the assumption that the debt ß for gold is zero. Given the low leverage, this is probably close to true. The asset gold ß includes both the underlying risk of the firm's assets and any change in this sensitivity due to derivatives use. This is the intuition behind Tufano's (1998b) finding that derivative usage lowers the equity gold ß, all else constant.

We use the debt ratio at the beginning of the previous year to multiply equity returns for the current year. This correction is more important for American Barrick, because its average leverage is higher and because its leverage has changed the most. Its leverage averages 17% over the sample period, but falls from 35% at the beginning of the period to 3% at the end. When we account for the changes in leverage, the explanatory power of the model rises only slightly. This is consistent with Tufano's (1998b) finding that cross-sectional differences in leverage help predict risk exposures, but within-firm variation in leverage does not.

Using these asset returns, we estimate the sensitivity of the firms' asset returns to gold prices (Table IV). The estimated sensitivities fall for both firms, but, consistent with American

[10]Unlike American Barrick, Homestake Mining was not exclusively in the gold mining business at the beginning of our sample. Since they also produced lead, silver, and uranium, gold prices affected only a portion of their business. Without controls, the estimated gold exposures are not comparable. In the absence of market values, we use the fraction of sales that come from each business as an approximation. The excess gold return is multiplied by the fraction of sales from that business unit in the previous year. Therefore, the gold sensitivity we estimate is the sensitivity Homestake Mining would have if it only mined gold. This correction raises the estimated exposure for Homestake Mining (see Table IV, Panel B, column 1 and 2). The effect of this correction is smaller in the more recent period (1987-1994) as Homestake Mining moves toward being a pure-play gold-mining firm.

Barrick's higher leverage, its sensitivity to gold falls by more. American Barrick's assets now rise only 13% for every 10% rise in the price of gold. For Homestake Mining, asset values rise 16% for every 10% increase in gold prices. These estimates imply that American Barrick's assets are 17% less sensitive to gold prices than Homestake Mining's (1-1.306/1.577).

III. Managerial Incentives for Risk Management

The manager's approach to risk management – the decisions on how much and which risks to manage—will depend on the risk they personally bear (Smith and Stulz, 1985). Since markets do not usually compensate investors for idiosyncratic risk, poorly diversified managers might find it costly to bear the idiosyncratic risk of their firm. To know what risks managers face, we need to know their equity ownership and how their annual bonuses are determined (Tufano, 1998a). Here, we compare the compensation approaches of American Barrick and Homestake Mining and examine how compensation policies affect the firms' risk management strategies.

A. Compensation Policy and Managerial Incentives

Both firms pay their managers a combination of salary, bonus, and option grants. Because it was founded by its current managers, American Barrick is closer to the model of an owner managed firm. Its compensation package focuses on stock value as an objective. "Cash bonuses and long-term incentives, which take the form of stock options, are directly linked to increases in the wealth of shareholders and the individuals contribution to that central goal."[11] This policy has resulted in significant equity ownership by the managers of American Barrick. Based on data from Value Line, managers own an average of 23% of the equity over the period for which we have data (1989:Q1 – 1994:Q4).

Homestake Mining also uses option grants to link managerial wealth to shareholder wealth, but the fraction of the firm that is owned by managers is significantly smaller. The Homestake Mining managers owned 9% of the equity during the sample period. The difference in ownership is statistically significant (p-value < 0.01).

The difference in firm size could explain a portion of this difference. Until 1990, American Barrick was smaller than Homestake Mining, and thus we would expect its managers could own a larger fraction of the equity. In fact, we see that managers' equity stake has fallen as American Barrick has grown and as it has raised additional equity from outside investors. However, even in the last year of the sample when American Barrick's equity value exceeds that of Homestake Mining, managerial ownership is twice as high at American Barrick (20.1% versus 10.5%).

Homestake Mining uses its bonus structure to motivate its managers, but its focus is earnings. The annual bonus is used "...to reward performance by paying bonuses when the Company is profitable and when individual performance or other extraordinary circumstances warrant special recognition ...substantial weight is given to profitability ...in determining whether to recommend annual bonuses and the amount of the bonuses."[12] American Barrick has no equivalent profit-based incentive.

Since the compensation structure differs across our two firms, we expect their risk

[11]American Barrick Resources Corporation, Management Information Circular and Proxy Statement, March 9, 1994 and March 9, 1995.

[12]Compensation Report of Homestake, 1993, page 19, and 1994, page 20.

management strategies will also differ. Compensation at American Barrick is equity-value focused, so we would expect its managers to be interested in reducing the volatility of equity returns. Compensation at Homestake Mining is earnings focused, so we expect its managers to be interested in reducing the volatility of earnings.

B. Managerial Incentives to Reduce Equity Volatility

Theory argues that managers of firms like American Barrick would hedge if they are risk averse or would like to more accurately reveal their abilities (DeMarzo and Duffie, 1995; Breeden and Viswanathan, 1998). These issues are probably greatest for start-up firms where managers (founders) can have more wealth in the firm and there is more uncertainty over the managers' abilities. However, these firms are often high-growth firms, so it might not be feasible to hedge a large fraction of the firm's value.

This is the problem for American Barrick's managers. Hedging a large fraction of near-term cash flows doesn't necessarily hedge a large fraction of its asset and equity values. Although American Barrick is already the most aggressive hedger in the gold mining industry (Tufano, 1996), its asset exposure is only 17% less than that of Homestake Mining. Based on a policy of hedging 100% of the next three year's production and 50% of years four through six, we estimate the fraction of American Barrick's reserves which are hedged.

If current production is P and production is assumed to grow at the sample average of 32% per year, then next year's production is 1.32P. In this case, the number of ounces which are hedged is:

$$\text{Ounces Hedged} = P(1 + 1.32 + 1.32^2 + 0.5\,(1.32^3 + 1.32^4 + 1.32^5))$$

Dividing by reserves gives us the percent of reserves which are hedged. This calculation ignores ounces that have not yet been acquired, but which the market might already include in the value of Barrick's assets. Over our sample period, we estimate that American Barrick's derivative strategy hedges 34% of its reserves. This is a large number, given its rapid growth over this period.

Although American Barrick hedges 34% of its reserves, its risk exposure is only 17% smaller than that of Homestake Mining. One reason is Homestake also hedges. The fact that Homestake Mining adjusts its costs along with gold prices means that it also reduces the exposure of its assets to gold prices. However, its operational hedging reduces the gold price risk in assets by less than American Barrick's derivatives program. Not only is this consistent with our cash flow results (Table II), but it is also what we would expect given their different investment opportunities.

C. Managerial Incentives to Reduce Earnings Volatility

Since there is a greater focus on earnings in the compensation structure at Homestake Mining, we would expect its managers to be more concerned with the volatility of earnings. They reduce earnings and cash flow volatility through their operations. However, based on the results in Table II, earnings would still be quite volatile. A firm can also reduce the volatility of reported earnings through its choices of accounting techniques, accounting estimates, and discretionary accruals. For example, a decrease in income resulting from lower gold prices can be offset to some extent by selling beginning inventory carried on the books at a lower cost, or by increasing the estimated useful life of property, plant, and equipment

which lowers depreciation expense. Discretionary accruals such as those relating to lawsuits can also be used to smooth income. Because of the conservative nature of accounting standards, unrealized gains are typically not recognized, but unrealized losses are. Therefore, management could recognize unrealized gains by selling marketable securities in years when income would otherwise be low.

We collect information on accounting choices by reading the footnotes to the annual reports to test whether the firm's compensation plans create incentives to make discretionary accounting decisions that offset fluctuations in the firm's underlying cash flows. Table V reports the changes in accounting choices as well as discretionary accruals made by both American Barrick (Panel A) and Homestake Mining (Panel B). The table also contains the percentage change in the Comex gold price and the average sales price for each firm.

In 13 of the 19 years we examine, Homestake Mining's accounting changes move in the opposite direction to gold prices. Accounting changes that raise net income are adopted in years when the price of gold, and thus Homestake's revenues, fall. Gold prices increase dramatically in 1980. This was the year Homestake Mining recognized an $8.1M expense from the settlement of a lawsuit with Westinghouse. They had been vehemently fighting the suit for several years. They also began amortizing prior service cost for its pension over ten years instead of 14 years. This increased the firm's pension expense and thus decreased its income. On the other hand, when the price of gold dropped in 1985, Homestake Mining dipped into LIFO layers, which resulted in an increase of income by $1.7M.[13] Homestake also adopted SFAS 87 early. At the same time the company decided to terminate a contract for the sale of uranium. Together, these actions increased Homestake's net income by $19.2M in a year when profits would have been lower due to lower gold prices.

We estimate an ordered logit model to test the statistical significance of the negative relation between change in the price of gold and the income effect of discretionary accounting choices. The dependent variable is the sign of the accounting change: income increasing, no change, or income decreasing (1,0,-1, see Table V). The percentage change in the average gold price over the year is the explanatory variable. Increases in the price of gold dramatically increase the probability of an income-lowering accounting change by Homestake Mining (p=0.04). When gold prices rise by 10%, the probability of an income reducing accounting change rises by 16% and the probability of an income increasing accounting change drops by 14%.

The negative relation between the gold price change and the accounting choice/ discretionary accrual in Homestake Mining is striking when compared to a similar analysis for American Barrick, where bonuses do not depend on earnings. American Barrick rarely alters its accounting choices. In eight of 11 years, American Barrick discloses no changes in its accounting policies (Table V, Panel A). In years when there are changes, there is only a slight tendency to increase income as gold prices rise. The relation is not statistically significant (p-value = 0.16).

We cannot label a discretionary action taken by the management as being motivated exclusively by a desire to smooth earnings. When gold prices fall, the sale of marketable securities can be motivated by the desire to raise cash instead of, or in addition to, the desire to smooth income. However, we do not find strong evidence to support this alternative explanation. First, Homestake Mining's investment needs fall when gold prices fall. Second,

[13]LIFO inventory accounting assumes the most recent purchases are sold first and thus the oldest inventory remains on the balance sheet. When input prices are rising, the higher costs are expensed in the income statement and the older inventory is carried at lower prices in the balance sheet. Management can dip into old (cheap) LIFO layers and thus lower their costs of goods sold and raise current earnings. The decision to liquidate old layers of inventory is discretionary since this can be avoided by purchasing or manufacturing new inventory at the current prices.

Table V. Hedging of Accounting Income through Discretionary Accruals and Accounting Choices

"Change in the gold price" is the percent change in the price received by the firm during the year. The Comex average is the percent change in the average of month- end gold prices on the Comex. We calculate percent changes as the difference in the log prices. We obtain the detail of accounting choices from the firms' annual reports and their footnotes each year. The table also shows the net effect, on income and cash flow, of the accounting changes and discretionary accruals made during the year. 1986 is the first year for which we were able to secure American Barrick's annual report and thus we only have its realized prices back to 1984.

Panel A. American Barrick - Derivative User

Year	Change in Gold Price		Accounting Effect on		
	Realized Price	Comex Average	Income	Cash Flow	Details of Accounting Choice, Discretionary Accruals, and Changes in Estimates
1984	N/A	-14.8%	Negative	Positive	Wrote down petroleum and natural gas investment. Provision for losses amounted to $10.1M.
1985	-7.0	-11.5%	Zero	Zero	Changed the method of accounting of depreciation from unit of production to straight line with no material changes in the financial statement.
1986	4.4%	14.6%	Zero	Zero	No significant changes
1987	13.0%	19.7%	Positive	Zero	Changed method of depreciation from 3-20 years to 5-25 years for buildings which increased its reported income.
1988	6.2%	-3.5%	Zero	Zero	No significant changes
1989	-2.3%	-13.1%	Zero	Zero	No significant changes
1990	0.2%	0.5%	Positive	Zero	Changed the estimate of useful life on mining equipment from 3-10 to 3-15. Changed the method of accounting for mineral exploration expense. This increased income by $1.4M and decreased PPE by $34.9M and retained earnings by $30.9M.
1991	0.2%	-6.0%	Zero	Zero	No significant changes
1992	-3.7%	-4.6%	Zero	Zero	No significant changes
1993	-3.1%	6.3%	Zero	Zero	No significant changes
1994	-1.7%	4.8%	Zero	Zero	No significant changes

Table V. Hedging of Accounting Income through Discretionary Accruals and Accounting Choices (Continued)

Panel B. Homestake Mining

Year	Change in Gold Price		Accounting Effect on		Details of Accounting Choice, Discretionary Accruals, and Changes in Estimates
	Realized Price	Comex Average	Income	Cash Flow	
1976	-27.1%	-25.5%	Positive	Negative	Dipped into LIFO layers increasing income by $0.04/share. Included unrealized holding gains on marketable securities in net income. Decreased the minimum period for recognition of prior service pension costs from 13 to 14 years.
1977	16.8%	18.7%	Zero	Zero	No significant changes
1978	26.6%	27.6%	Negative	Positive	Recognized permanent impairment in the value of investments.
1979	46.6%	48.9%	Negative	Negative	Recognized losses on metal trading activities.
1980	69.0%	63.5%	Negative	Negative	Settled lawsuit in December taking a charge of $8.1M. Changed assumption for recognition of prior service cost to 10 years from 14 years.
1981	-28.7%	-28.6%	Positive	Zero	Changed assumption for recognition of prior service cost from 10 years to 10-30 years.
1982	-6.2%	-19.3%	Zero	Zero	No changes
1983	12.0%	9.8%	Negative	Zero	Changed useful life of equipment to 5-20 years from 8-20 years.
1984	-15.8%	-14.8%	Positive	Zero	Used pooling method of accounting for acquisition of Felmont Oil Corp acquired in June 1984. This increased net income and revenues by inclusion of Felmont's operations prior to acquisition.
1985	-12.7%	-11.5%	Positive	Positive	LIFO liquidations, which increased income by $1.74M. Adopted SFAS 87 early, which increased income by 3.5M. Adopted an early retirement program which decreased income by 3M. Early termination of uranium sales contract raised income by $19.2M, offset $10M of increase in income by a write down of uranium assets.
1986	13.5%	14.6%	Negative	Negative	Changed the method of depreciation for a particular mine from the "tons milled" basis to "recoverable ounces" basis, resulting in a charge of $4.4M. Incurred shut down expenses on lead business of $5.7M.
1987	20.5%	19.7%	Positive	Zero	Sale of interests in affiliates included in "total revenues." This increased sales by $146.3M. Changed estimates of useful life from 5-8 to 5-10 years.
1988	-2.3%	-3.5%	Positive	Zero	Early adoption of SFAS 96 resulting in a $3.1M increase.

Table V. Hedging of Accounting Income through Discretionary Accruals and Accounting Choices (Continued)

Year	Change in Gold Price		Accounting Effect on		Details of Accounting Choice, Discretionary Accruals, and Changes in Estimates
	Realized Price	Comex Average	Income	Cash Flow	
1989	-13.5%	-13.1%	Positive	Positive	Income from discontinued operations (sale of oil business) amounts to $34.2m arising from sale of oil and gas properties
1990	0.3%	0.5%	Negative	Positive	Wrote off uranium investment. Lowered income by $9.6MChanged pension investment rate of return assumption from 8.0% to 8.5%
1991	-5.9%	-6.0%	Negative	Zero	Changed estimates of useful life from 5-10 to 3-10Early adopted SFAS 106 relating to accrual of post-retirement health benefits, which increased the loss by $28.8M Wrote down exploration properties due to lack of sufficient gold
1992	-7.7%	-4.6%	Negative	Zero	Wrote down mining properties based on low gold prices in the amount of $130M Used the pooling method of accounting for acquisition of International Corona, which increased income marginally
1993	3.1%	6.3%	Net Negative	Negative	LIFO liquidation resulting in a pre-tax profit of $5.2M (NI 52.5M Offered early retirement program and undertook some restructuring, which increased expenses by $7.5M
1994	6.7%	4.8%	Positive	Positive	Recognized income from sale of stock by subsidiary, resulting in additional income of $11.2M Sale of investments resulting in a pre-tax gain of $15.2M

we can directly test this idea by categorizing the accounting choices according to whether they raise, lower, or do not change cash flow. Categorizing accounting choices might be imperfect without access to information on the tax effect of these choices. For example, if Homestake Mining writes down an asset because it becomes permanently impaired, it is not clear from public documents if this is an allowable tax deduction. We make what we believe are reasonable assumptions on the tax impact of these choices. When we test the correlation between gold prices and the cash flow effect of these accounting changes, we find that the firm is more likely to make cash flow increasing changes when the price of gold falls. However, the magnitude of the coefficient is 56% smaller and no longer statistically significant (p=0.16).

IV. Conclusions

We study two gold mining firms that are at opposite ends of the spectrum in their use of financial derivatives. However, the difference between the firms lies not in whether they manage risk, but in the risks they choose to manage and the tools they use. By studying two firms in the same industry that use derivatives so differently, we can examine the fundamental differences that lead them to pursue distinct approaches to managing their gold price risk. In the process, we can obtain a better understanding of why firms manage risk.

Differences in opportunities explain part of the difference in the two companies' risk management strategies. Over short periods of time, Homestake Mining appears to have lower costs of adjusting the quality of ore they extract. Thus Homestake can adjust its costs as a partial hedge against fluctuations in the price of gold. At American Barrick, its cost structure—and thus its opportunity for using operational hedging—is different. American Barrick relies on derivatives to reduce the fluctuations in its revenues and thus its operating cash flows.

Different incentives for risk reduction also play a key role in how these firms manage their gold price risk. Homestake Mining's investment strategy has meant that its need for external capital has been lower, and, given that exploration is most profitable when gold prices are high, its need to completely insulate current cash flow from fluctuations in gold prices has been smaller. In fact, complete hedging would take cash flow away when gold prices are high, just when Homestake's investment opportunity set has expanded. Since American Barrick must be ready to purchase mines whenever they are mispriced, shareholder incentives for smoothing cash flow are greater.

Compensation strategies, which lead to different managerial objectives, also differ between the firms. This is partially due to different histories for the two companies. American Barrick was founded by its managers, and hence their compensation is equity focused. Managers own a significant fraction of the firm and their annual bonuses are linked to stock values. Homestake Mining's managers own a smaller fraction of the firm and their bonuses are linked to firm profitability. These compensation policies create incentives for undiversified managers to hedge their (and the firm's) risk. The different focuses show us the different objectives for each firm's risk management strategy. This helps explain Homestake Mining adjusting its costs and changing their accounting decisions as gold prices rise and fall.

The use of alternative forms of risk management is a conscious choice by firms. This implies that it is as important to study why firms choose a particular method of risk management as it is to find out why they choose to manage risk. Although the focus on derivatives is useful, since they are not the only way for firms to manage risk, it is important to consider the

alternative tools as well. Careful measurement and comparison of a firm's risk exposure, the opportunities available to the firm, and the objectives of the firm is the first step in explaining its risk management behavior. ■

References

Bartov, E. and G. M. Bodnar, 1994, "Firm Valuation, Earnings Expectations, and the Exchange-Rate Exposure Effect," *Journal of Finance* 49(5), 1755-1786.

Berkman, H. and M.E. Bradbury, 1996, "Empirical Evidence on the Corporate Use of Derivatives," *Financial Management* 25(2), 5-13.

Bodnar, G., G. Hayt, and R. Marston, 1996, "1995 Wharton Survey of Derivatives Usage by US Non-Financial Firms," *Financial Management* 25(4), 113-133.

Bodnar, G., G. Hayt, and R. Marston, 1998, "1998 Wharton Survey of Financial Risk Management by US Non-Financial Firms," *Financial Management* 27(4), 70-91.

Beaver, W. and M. A. Wolfson, 1995, "Risk Measurement," in W. Beaver and G. Parks, Eds., *Risk Management: Problems and Solutions*, New York, NY, McGraw-Hill.

Breeden, D. and S. Viswanathan, 1998, "Why Do Firms Hedge? An Asymmetric Information Model," Duke University Working Paper (February).

Brown, G., 2000, "Managing Foreign Exchange Risk with Derivatives," *Journal of Financial Economics*, forthcoming.

Campbell, T.S. and W.A. Kracaw, 1987, "Optimal Managerial Incentive Contracts and the Value of Corporate Insurance," *Journal of Financial and Quantitative Analysis* 22(3), 315-328.

DeMarzo, P.M. and D. Duffie, 1995, "Corporate Incentives for Hedging and Hedge Accounting," *Review of Financial Studies* 8(3), 743-771.

The Economist, 1996, "Gold: A Flash in the Pan" (February 3) 65.

Farnsworth, Clyde H. 1996, "Barrick Move Could Increase Price of Gold" *New York Times* (January 31), D5.

Francis, J. and J. Stephan, 1990, "Characteristics of Hedging Firms: An Empirical Examination," in R.J. Schwartz and C.W. Smith, Jr., Eds., *Advanced Strategies in Financial Risk Management*, Englewood Cliffs, NJ, New York Institute of Finance.

Froot, K.A., D.S. Scharfstein, and J.C. Stein, 1993, "Risk Management: Coordinating Corporate Investment and Financing Policies," *The Journal of Finance* 48(5), 1629-1658.

Gay, G. and J. Nam, 1998, "The Underinvestment Problem and Corporate Derivative Use," *Financial Management* 27(4), 53-69.

Geczy, C., B.A. Minton, and C. Schrand, 1997, "Why Firms Use Currency Derivatives," *Journal of Finance* 52(4), 1323-1354.

Gooding, Kenneth, "All the Gold That's Fit to Hedge" *Financial Post* (February 15), 28.

Graham, J., 1996, "Debt and the Marginal Tax Rate," *Journal of Financial Economics* 41(3), 41-73.

Graham, J. and D. Rogers, 2000, "Do Firms Hedge in Response to Tax Incentives?," Duke University Working Paper, (July).

Graham, J. and C. Smith, 1999, "Tax Incentives to Hedge," *Journal of Finance* 54(6), 2241-2262.

Guay, W. R., 1999, "The Impact of Derivatives on Firm Risk: An Empirical Examination of New Derivative Users," *Journal of Accounting and Economics* 26(1/3), 319-351.

Guay, W. R. and S.P. Kothari, 2000, "The Magnitude of Exposure Hedged by Non-Financial Firm's Derivative Positions," Massachusetts Institute of Technology Working Paper (June).

Haushalter, D.G., 2000, "Financing Policy, Basis Risk, and Corporate Hedging: Evidence from Oil and Gas Producers," *Journal of Finance* 55(1), 107-152.

Heinzl, Mark, 1997, "Barrick Will Close 5 Mines Because of Gold's Plunge," *Wall Street Journal Interactive Edition* (September 10).

Hentschel, L. and S.P. Kothari, 2000, "Are Corporations Reducing or Taking Risks with Derivatives?" Massachusetts Institute of Technology Working Paper (July).

Jorion, P., 1990, "The Exchange-Rate Exposure of US Multinationals," *Journal of Business* 63(3), 331-345.

Lessard, D., 1990, "Global Competition and Corporate Finance in the 1990s," *Continental Bank Journal of Applied Corporate Finance* 3(4), 59-72.

McGee, Suzanne, 1995, "Volatility Is Making Hedges Grow," *Wall Street Journal* (June 12), C1.

Mian, S., 1996, "Evidence on Corporate Hedging Policy," *Journal of Financial and Quantitative Analysis* 31(3), 419-439.

Myers, S.C. and N.S. Majluf, 1984, "Corporate Financing and Investment Decisions When Firms Have Information That Investors Do Not Have," *Journal of Financial Economics* 13(2), 187-221.

Ortega, Robert, 1997, "A Depressed Market Offers Chance to Snap Up Reserves and Cut Costs" *Wall Street Journal* (December 29), A2.

Petersen, M., 1994, "Cash Flow Variability and a Firm's Pension Choice: A Role for Operating Leverage," *Journal of Financial Economics* 36(3), 269-292.

Shleifer, A. and R. Vishny, 1992, "Liquidation Values and Debt Capacity: A Market Equilibrium Approach," *Journal of Finance* 47(4), 1342-1366.

Smith, C. and R. Stulz, 1985, "The Determinants of Firms' Hedging Policies," *The Journal of Financial and Quantitative Analysis* 28, 391-405.

Stulz, R., 1984, "Optimal Hedging Policies," *Journal of Financial and Quantitative Analysis* 19(2), 127-140.

Tufano, P., 1995, "American Barrick Resources Corporation: Managing Gold Price Risk" in S. Mason, R. Merton, A. Perold, and P. Tufano, Eds., *Cases in Financial Engineering,* Englewood Cliffs, NJ, Prentice Hall, 609-644.

Tufano, P., 1996, "Who Manages Risk? An Empirical Examination of Risk Management Practices in the Gold Mining Industry," *Journal of Finance* 51(4), 1097-1137.

Tufano, P., 1998a, "Agency Costs of Corporate Risk Management," *Financial Management* 27(1), 67-77.

Tufano, P., 1998b, "The Determinants of Stock Price Exposure: Financial Engineering and the Gold Mining Industry," *Journal of Finance* 53(3), 1015-1052.

Tufano, P. and A. Moel, 1999, "When are Real Options Exercised? An Empirical Study of Mine Closings," Harvard Business School Working Paper, (April).