Credit enhancement through targeted risk management: Freeport-McMoRan's gold-denominated depositary shares

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Abstract

In 1993 and early 1994, Freeport McMoRan Copper and Gold (FCX), a mining company, issued two series of gold-denominated depositary shares to raise 430 million dollars for expansion of their mining capacity in Indonesia. We price the depositary shares using a term structure model for the forward rates implied by gold futures and we show that FCX successfully enhanced the credit quality of the issue. This credit enhancement is achieved because the effect of linking the payoff of the depositary shares to gold reduces default risk and is similar to conventional risk management. The bundling of financing and risk management however allows the firm to target hedging benefits only to the newly issued securities. The design of the security overcomes the asset substitution problem and credibly commits the firm to hedging. FCX was thus able to enhance the credit quality of its new liabilities without changing the existing priority ordering of its capital structure.

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In 1993 and early 1994, Freeport McMoRan Copper and Gold (FCX), a mining company, issued two series of gold-denominated depositary shares to raise 430 million dollars for expansion of their mining capacity in Indonesia. We price the depositary shares using a term structure model for the forward rates implied by gold futures and we show that FCX successfully enhanced the credit quality of the issue. This credit enhancement is achieved because the effect of linking the payoff of the depositary shares to gold reduces default risk and is similar to conventional risk management. The bundling of financing and risk management however allows the firm to target hedging benefits only to the newly issued securities. The design of the security overcomes the asset substitution problem and credibly commits the firm to hedging. FCX was thus able to enhance the credit quality of its new liabilities without changing the existing priority ordering of its capital structure.

1. Introduction

In 1993 and early 1994, Freeport-McMoRan Copper and Gold Inc. (ticker symbol FCX) faced a substantial financing problem for the expansion of its Grasberg gold and copper mine in Indonesia, the world's largest gold reserve and one of the world's largest copper reserves. FCX needed to invest heavily in order to expand mine capacity and achieve the economies of scale required to be competitive. Despite a heavy debt burden and a stock that was trading below book value, FCX successfully raised $430 million through two series of gold-linked depositary shares at a cost below or equal to that of its existing debt. We show that the credit enhancement was achieved because the link to gold prices credibly reduced default risk and targeted the benefits from the implicit hedge to the new securities issued.

The gold depositary shares issued by FCX have all interest and principal repayments denominated in gold. The use of these hybrid instruments creates a liability that has a positive correlation with the company's revenues, thereby reducing the probability of default and the associated deadweight costs of financial distress. The effect of this structure on the cash flows to the firm's shareholders is equivalent to FCX issuing a fixed-rate bond and simultaneously initiating a risk management program to hedge its exposure to gold price risk.[1] We show however that combining the bond and the hedge into one security differs from traditional risk management in that it mitigates the asset substitution problem which arises because shareholders have an incentive to unwind the hedge after the debt is issued.

Smith and Stulz (1985) examine the interaction of debt financing and hedging policies of the firm and demonstrate that hedging can reduce expected financial distress costs, thereby increasing firm value. We extend their analysis to the case of levered firms and show that alternate approaches to risk management has important effects on the value of the firm's equity when the firm has debt existing on its balance sheet. Hedging at the firm level reduces bankruptcy costs and improves cash flows to the firm's existing debt and to its newly issued debt.

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[1] Other gold-mining companies have also employed gold-linked financing to combine financing and risk management needs. See Tufano and Serbin (1993) for a general description, and the activities of American Barrick in particular. Tufano (1996) provides a detailed study of the risk management practices of North American gold mining companies.

Implicit hedging through indexing of the firm's newly issued securities, however, preserves the hedge cash flows for the new securities and minimizes the positive externalities to the firm's existing debt. We refer to this effect as *targeted risk management*.

A moral hazard problem arises, however, since asset substitution through the unwinding of the hedge, i.e. an "un-hedge," would result in a transfer of wealth from bondholders to shareholders. Therefore, for shareholders to capture the benefits of hedging ex-ante, the firm must be able to "convince potential bondholders that it will hedge after the bond sale" (Smith and Stulz (1985)). The problem is exacerbated when the firm has existing leverage on its balance sheet, as hedging to satisfy new bondholders has the unintended consequence of enhancing the value of existing bondholders. Therefore, existing leverage makes it even more difficult for shareholders to make a credible commitment to hedging, even though the reduction in financial distress costs increases with leverage.

We argue that the use of indexed instruments, such as the ones adopted by FCX, has three key advantages that mitigate these problems and seems to work in practice: 1) the derivative counterparty in an un-hedge will be an unsecured creditor junior to existing bondholders and through their pricing of the derivative contract and/or collateral requirements, will expropriate much of the benefit that shareholders receive from unwinding the hedge.[2] 2) it locks in the risk management for the duration of the debt, making it easier for the company to credibly commit to maintaining its position; and 3) it provides a bigger incentive for the firm to establish a reputation to hedge (Boot, Greenbaum, and Thakor (1993)) . The only way in which the firm can undo the effects of this hedge is by actually taking on new exposure. The reputational consequences of taking on naked exposure are likely to be much more severe than those of failing to hedge, and firms could see a greater benefit to maintaining an existing hedge.

Another benefit of denominating the value of the depositary shares in terms of gold is that it provides a link to an exogenous measure that is not subject to manipulation by the manager. Froot, Sharfstein and Stein (1989) note that a potential for manipulation by managers is an important consideration when debt is indexed to measures such output or revenue. Moreover,

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[2] See Tucker (1991) and Foster (1995) for a discussion of the treatment of derivatives in bankruptcy.

since FCX is unlikely to possess superior information about future gold prices, gold indexation also avoids the negative signal associated with the issue of revenue-contingent instruments such as income bonds (McConnell and Schlarbaum, 1981). The exogeneity of the gold-link in FCX's depositary shares, thus eliminates other potential moral hazard problems.

We show that FCX was able to reduce its financing cost as a result of the hybrid financing structure.[3] It sold its BB- Gold Series I depositary shares at a yield of 8.08%, which is 26 basis points lower than the market rate of 8.34% on BB3[4] instruments and its BB- rated Gold Series II depositary shares at a yield of 8.09%, which is 19 basis points lower than the market rate of 8.28% on BB3 rated instruments. We priced the depositary shares by benchmarking to a combination of a straight fixed rate instrument, a gold swap that exchanges the fixed coupon payments for floating gold payments, and a forward contract that exchanges the dollar face value for a fixed quantity of gold. We use the term structure of implied gold interest rates to calculate the forward rates required to value the swap and the forward components. The term structure of gold interest rates is extracted from data on the implied cost of carry in traded futures contracts.

We thus conclude that shareholders can capture risk management benefits if it is appropriately implemented. Further, when the firm has existing leverage, it is possible to minimize the benefits of risk management for existing debtholders, thereby maximizing the benefits to the shareholders. FCX was able to credibly commit to risk management and enhance the credit quality of the depositary shares because of the structure of its newly issued liabilities. The improvements in the cash flows to the new securities was reflected in its market price and was captured by the firm's shareholders. In keeping with our argument that it is not in the

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[3] It is possible that a part of the cost saving may have come from "gold-bugs" who paid a premium for these instruments. Indeed, this argument may have motivated the design of the security in the first place. However, our failure to detect a similar effect with the silver denominated depositary shares, as discussed later in the paper, weakens this argument.

[4] BB- is the rating given by Standard & Poors. Benchmark market rates for corresponding dates and credit quality were obtained from Bloomberg for BB3 rated instruments. Bloomberg's BB3 rating is its equivalent to the BB- rating of Standard & Poors and the Ba3 rating of Moody's.

shareholders' interest for the firm to un-hedge, we found no evidence that FCX took naked long positions in gold derivative instruments to offset the effects of the gold hedge created through its gold-linked financing.

Possibly with the intention of building on the success of the gold issues, FCX also issued a series of silver-denominated shares. These BB- Silver Series I depositary shares were, however, less well received by the market – it sold these shares at a yield of 11.04%, which is 116 basis points higher than the market rate of 9.88% on BB3 rated instruments. While the silver-denominated shares were structured similarly to the gold-denominated securities, and were, therefore, thought to have the same advantages, FCX's exposure to gold and silver prices was sharply different. For FCX, silver is a byproduct of their gold mining operations and a very small part of total revenue. Hence, the default risk on its silver-denominated depositary shares is not closely correlated with silver prices. The different receptions by the market to the gold and silver issues, further validate our model of targeted risk management.

The rest of the paper is organized as follows. In section 2, we describe FCX's operations and its need for new financing. This section also discusses the role of gold-linked securities in financing, especially in the context of risk management. In section 3, we present a detailed example illustrating how a gold-indexed financing instrument issued by a gold mining company can overcome wealth transfer issues associated with conventional risk management. In section 4, we discuss why the bundling financing and risk-management mitigates the asset substitution problem and enhances the credibility of the hedge. Section 5 develops a methodology for valuing gold-indexed bonds, which is then applied to value FCX's gold and silver-denominated issues. Section 6 concludes.

2. Freeport-McMoRan Copper and Gold: operations and financing

FCX was formed in 1988 when Freeport McMoRan Inc's (FTX) copper and gold operations were spun-off into a separate company.[5] FTX retained 73.2% ownership in FCX. FCX's principal operating subsidiary is P.T. Freeport Indonesia (PT-FI) which engages in the exploration and development of mining and processing of copper, gold and silver in Indonesia, and in the marketing of concentrates containing such metals worldwide. FCX owns 80% of the outstanding common stock of PT-FI, with the remaining 20% split equally between the Government of Indonesia and an Indonesian corporation, P.T. Indocopper Investama Corporation.

2.1 FCX's mining operations and the Grasberg Mine expansion

Figure 1 shows FCX's reserves of copper, gold, and silver, for the three years 1992-1994. Copper is by far FCX's major product but FCX also produces substantial amounts of gold. Silver, however, is more of a byproduct for the company. Mining operations in Indonesia commenced in 1967 with the discovery of the Ertzberg mineral reserve on the Indonesian island of Irian Jaya.. The Grasberg mineral reserve, currently the world's largest single gold reserve and one of the world's three largest open pit copper reserves, was discovered in 1988.

FCX's stated corporate philosophy was to enhance shareholder value by becoming an efficient mining company. Being a low-cost producer was thought to be the most effective way to survive the major price swings that the industry often experienced, since price drops force high-

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[5] FTX came into existence in 1981 following the merger of Freeport Minerals Co. and McMoRan Oil and Gas Co. The former began operations in 1912 in Texas as the Freeport Sulphur Company to develop a newly discovered sulphur field on the Texas Gulf Coast. The latter was founded in 1969 in Utah as McMoRan Explorations Co. to undertake oil exploration. Following the 1981 merger, FTX began acquiring oil and gas assets, geothermal properties and phosphate mines in a $1 billion program to diversify away from the sulfur business which was then in decline. In 1987 Freeport-McMoRan Copper & Gold Inc. and Freeport-McMoRan Resource Partners Inc. were formed as subsidiaries of Freeport McMoRan Inc. The year 1988 was very significant for the company with two huge discoveries -- the Main Pass sulfur deposit in the Gulf of Mexico and gold, silver and copper deposit in the Indonesian province of Irian Jaya. Given the mammoth capital costs associated with developing these deposits, FTX reversed its earlier acquisition spree and spun-off its subsidiaries.

cost producers out of the market, making way for a quick recovery and return to higher profits for those that remain. The discovery of the Grasberg mine was seen as an opportunity for the company to substantially increase throughput of its mining operations in Indonesia and reduce mining costs.

The implementation of this low-cost philosophy through increased capacity called for $2 billion in capital investments to expand mining operations at the Grasberg mine and for accompanying infrastructure development projects such as power, housing, transportation, hospitals, and communications. In 1989, FCX initiated the first capacity expansion from 20,000 MTPD to 52,000 MTPD. Capital expenditure for the expansion was estimated at $507 million. In August 1992, FCX approved a plan to expand production to 90,000 MTPD at an estimated cost of $545 million. The third and final phase expanded production to 118,000 MTPD. The burden of operating in an uncertain political environment, coupled with the large amounts of money needed, caused FCX to explore various avenues for raising the capital required and led them to issue financially engineered products.

2.2 Financing strategy and capital structure

Table 1 presents the securities FCX issued to raise a total of $1.2 billion to meet the costs for the first phase of the Grasberg expansion and reduce its dependence on short term funds.

[Place Table 1 about here]

FCX has two classes of common stock outstanding - Class A held by the general public and Class B which is wholly owned by FTX. Through May 1, 1993, Class A common stockholders received cumulative quarterly dividends of 10.25 cents per share before payment of any dividends on Class B common stock. On the debt side, FCX has traditionally used short-

term debt financing.[6] The company's management was dissatisfied with its dependence on short term financing because of its cost and concerns about refinancing risk, especially as banks were nervous about the political risk associated with Indonesia. FCX initiated new rounds of financing, seeking longer maturities to eliminate refunding risk and obtain a capital structure more in keeping with the long-term nature of their business. In the process, they also sought to free themselves from the restrictive covenants attached to existing debt.

The political uncertainty in Indonesia and the enormous amount of capital already raised by FCX made it difficult for them to tap the traditional sources of capital for the second and third phases of the expansion. FCX's management did not want to issue new equity, since they felt that the stock was undervalued. On the other hand, its existing subordinated debt was already rated at a low BB-, and further debt issues would put further pressure on FCX's debt rating. In this environment, FCX proposed and issued the commodity-linked depositary shares, getting much needed credit enhancement for these securities and raising capital for its investment needs.

FCX raised over $500 million dollars through three issues of commodity linked depositary shares as reported in Table 2. The first series of 3.5% gold-denominated depositary shares was issued in August 1993 and had a maturity of 10 years. The proceeds of $221 million were used to fund the 90,000 MTPD expansion plan. The second series of 3.125% gold-denominated depositary shares was issued in January 1994 and had a maturity of 12 years. The third series was denominated in silver and was issued in July 1994 at a yield of 4.125%. The $250 million raised through the latter two issues was used to fund the 118K expansion. All the depositary shares were backed by preferred stock held in trust and carried a BB- rating. FCX was able to raise these funds in spite of being placed under a credit watch with negative implications by the rating agencies at the time of the issue.

[Place Table 2 about here]

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[6] In 1989, the company obtained a line of credit to provide project financing up to $550 million to finance capital expenditure. In 1991, the company converted the floating rate line of credit into a fixed rate loan by entering into an interest rate swap agreement, resulting in a fixed rate of 8.3 percent on $100 million of debt through December 1999. In June 1993, the $550 million credit agreement was restructured as a three year revolving line of credit followed by a three-and-a-half year reducing revolver.

2.3 Risk management at FCX

As shown later in the paper, an important aspect of the commodity-linked depositary shares, is their embedded hedge of FCX's exposure to gold prices. FCX had already issued other exotic securities that combine financing and risk management, such as LYONs and step-up convertible preferred stock, prior to their decision to issue gold and silver linked depositary shares. FCX's policy towards hedging gold price risk appears to have varied over time. The company implemented risk management in the early 1980s but reversed its policy in the latter half of the 1980s on the premise that shareholders wanted the gold exposure. FCX reinstated its risk management program in the 1990s, adopting the objective of "separating good management from gold price risk." The hedge embedded in these securities was consistent with the policy of offering good management to their shareholders and be the low cost producer in the gold market.

FCX's risk management operations in the early 1990s involved buying large positions in gold and copper puts to set a price floor for their output. They used sequenced trades (rolling) to minimize price impacts of their participation in this market. In their 1993 annual report they disclosed that -- "PT-FI has a price protection program for virtually all of its estimated copper sales to be priced in 1994 at an average floor price of $0.90 per pound, while allowing full benefit from prices above that amount." This hedging program cost $6 million in 1993. FCX's Spanish subsidiary used forward contracts for approximately 61% of its gold production and 38% of its silver production in 1994 and 1995. It also reported a policy of hedging the purchases of concentrate for its smelter through the use of forward contracts.

The lack of consistency in FCX's risk management program is not at odds with the findings of Tufano (1996), in his extensive study of the risk management practices of 48 publicly traded North American gold mining companies. Tufano (1996) shows that there is considerable variation in the hedging practices of gold mining firms. For example, Homestake Mining sells all its production in the spot market and has taken a public position against gold price risk management, while American Barrick is a strong adherent to the policy of separating good management from gold price risk, and makes its hedging program an integral part of its business (See also Tufano and Serbin, 1993).

2.4 Gold-linked securities

Gold and gold securities are valued by investors as a hedge against inflation. There are also "goldbugs", i.e. investors who simply like to invest in gold. Gold-linked securities fill an important niche in completing the market for securities through which investors can get gold exposure. Markets for spot gold and gold derivatives are incomplete reflecting the finite supply of the commodity, the control of central banks on the mined supply of gold, and the lack of liquidity of long-term derivatives.

World production of gold is dominated by a few major players in US, Russia, South Africa and Indonesia. Central banks generally control most of the world's mined gold supply which they hold as security for financial transactions. The supply of gold is thus affected by the activities of central banks. While there has been a lot of recent activity in gold loans, the supply of gold to lend is limited by the willingness of central banks to make their gold stocks available to the market.

Gold-linked debt securities of the type issued by FCX, offer long-term exposure to gold without taking a position in the spot market and are popular with investors who look to the derivative markets to get exposure to gold price risk. [7] Active derivative markets do exist for short-term gold derivatives, but trading to get long-term exposure is limited by the contract maturities currently available. The derivatives embedded in the gold-linked securities tend to be relatively long-term and fulfill the market niche for such contracts.

Table 3 shows a sample of gold-linked securities that have been offered in the market and which has greatly expanded avenues available to investors to get an exposure to gold. These gold-linked bonds have been issued primarily in Switzerland, historically the center for trading in gold, and the Swiss bond market has been a source of many of the innovations in this market.

[Place Table 3 about here]

[7] FCX's gold and silver-linked financing are similar to the extensive gold financing undertaken by American Barrick in the 1980's. See Tufano and Serbin (1993) for a discussion of American Barrick's gold financing program.

2.5 Credit risk considerations

Gold-linked bond issuers are of two types -- those who have natural exposure to gold, such as gold mining companies, and can back the issue with their gold reserves; and those who are not naturally long in gold. Many industrial companies issue bonds with attached gold-linked warrants to take advantage of a "hot"gold market, despite not having a natural exposure to gold.

As with all bonds, buyers of these securities have to be concerned about default risk. However, the default risk of these securities is a function of the correlation between gold prices and the revenues of the firm which depends on whether or not the issuer has natural exposure to gold. The revenue and profitability of issuers who are exposed to gold price risk, such as mining companies, are increasing in the gold price. If gold prices drop, the issuer's profits will also drop making the issuer more vulnerable to financial distress. However, this is partially offset by the reduction in the issuer's liability on the bond. On the other hand, if gold prices rise, the value of the issuer's liability is greater, but the issuer is more able to meet its liabilities as its revenues and profitability are also greater. Therefore, the default risk for the gold-linked security issued by a gold mining company is lower than for an otherwise equivalent plain-vanilla debt instrument

However, when the issuer's profits are unrelated to the gold price the opposite is true and the gold-link can significantly increase the default risk. Budd (1983) discusses the striking case of the gold-linked bonds ("Giscards") issued by the French government in 1973, with the gold link apparently being added to "sweeten" the issue. Due to the dramatic escalation in the price of gold, the bond appreciated more than ten-fold over a ten year period. The French government did not have a gold reserve to offset the exposure and the gold price escalation led to speculation that the government might have to renegotiate the gold clause.

In the next section we compare the credit enhancement achieved through debt indexation with that achieved through traditional risk management and show that there are important differences. It is also important to consider whether the issuer of these securities offset the exposure to gold embedded in the gold-linked security in order to counteract the above effects. We also evaluate the feasibility of such offset trades and the analogy to traditional risk management in subsequent sections.

3. Targeted risk management when a firm has existing leverage

In this section, we show that the effect of issuing a commodity-linked bond for a gold mining firm is an implied hedge and decreases default risk. The effect is similar to issuing a fixed-rate bond and simultaneously initiating a risk management program to hedge its exposure to commodity price risk. The implied hedge through the commodity link, however, permits shareholders to allocate the benefits of risk management only to the new bond issue. We refer to this effect as targeted risk management. In the next section, we also show that the implied hedge reduces the incentives shareholders have for asset substitution and credibly commits the firm to a risk management program.

In their analysis of the determinants of a firm's hedging policy, Smith and Stulz (1985) show that risk management could increase the value of the firm by reducing expected bankruptcy costs. A key issue that arises in the implementation of a risk management program is the division of the resulting surplus between stockholders and bondholders. We extend their analysis to the case when the firm has existing leverage on its balance sheet and show that the mode of risk management affects the division of the benefits among the firm's claim holders. Specifically, we illustrate through a detailed example, how the use of an indexed instrument permits the benefits of risk management to be targeted to the new bondholders, thereby eliminating positive transfers to existing bondholders.

3.1 Targeted risk management using an indexed instrument

We consider a firm whose assets are assumed to be its stock of 3 million ounces of gold in entirety. Hence, the value of the firm will be linearly increasing in the price of gold, and we assume that gold prices (in $/ounce) are distributed uniformly over the range[100, 500]. The firm currently has senior debt with a face value of $500 million and is proposing to raise $251 million of new (junior) debt. We also assume that the firm faces bankruptcy costs of $50 million if it were to default on either category of debt. Stakeholders are assumed to be risk neutral and the discount rate to be zero. Table 4 examines three different risk management and financing scenarios for such a firm.

[Place Table 4 about here]

In Scenario A, the firm does not manage its gold price risk. Raising $251 million in the junior debt requires issuing debt with a face value of $400 million. The firm will default on this junior debt at a gold price of $300 per ounce and on its senior debt at a gold price of $183.3 per ounce. The value of the firm is $875 million while the values of senior debt and of equity are $474 million and $150 million, respectively.

In Scenario B, the firm manages the price risk associated with a third of its gold reserves, i.e. one million ounces. Ignoring carrying costs, this fixes the price on one million ounces of its reserves at $300/oz. The reduced sensitivity of firm value to the gold price has several consequences. First, because junior debt is now safer (it defaults at a lower gold price of $272.9), less face value of junior debt needs to be sold ($345.9 million) to raise the required $251 million. Second, the existing senior debt also becomes safer (it defaults at the lower gold price of $125), increasing the value of the senior debt to $498.4 million. The value of the firm rises to $878.4 million, reflecting the reduction in expected bankruptcy costs. Shareholders do not benefit, however, as this increase is more than offset by the wealth transfer to the senior bondholders, and the value of equity drops to $128.9 million from the $150 million in Scenario A. The entire benefit of risk management is expropriated by senior bondholders. Thus, the firm has no incentive to hedge the gold price risk ex-post, and indeed shareholders will attempt to unwind the hedge after the bond issue.

In Scenario C, the firm issues a gold-linked bond junior to existing debt but does not otherwise manage its exposure to gold price risk. We assume that the face value of the junior debt is equal to 1 million oz of gold, which is set such that junior debt is once again worth $251 million. The issue of the gold linked junior debt does not reduce the sensitivity of firm value to the gold price, but does decrease the sensitivity of equity to gold prices as in Scenario B where the firm hedges using forward contracts. The junior claim is safer than the junior claim in both Scenario A and Scenario B (it defaults now at a lower price of $250). Because junior debt is now safer, less face value of junior debt needs to be sold ($300 million equivalent at today's gold prices) to raise the required $251 million. However, the senior claim defaults at the same point as the senior claim in Scenario A. The value of the senior debt remains unchanged at $474 million. The value of the firm rises to $881.3 million, reflecting the reduction in expected

bankruptcy costs. Shareholders benefit, as some of the reduction in bankruptcy costs is directly captured by them, and the value of equity increases to $156.3 million from the $150 million in Scenario A.

Because it reduces the sensitivity of equity to gold prices and decreases default risk, the issue of the gold-linked securities is similar to hedging. However, the valuation effects on the firm's claim holders are very different and this approach to risk management and financing has several consequences. First, it is targeted only on the junior claims. Unlike in Scenario B, it does not affect the value of senior debt, thereby completely eliminating the wealth transfer to senior bondholders associated with conventional risk management. Second, shareholders can benefit from a reduction in the firm's distress costs.

The valuation effects in Scenarios B and C arise because of the differences in how cash flow from the derivative transaction is handled. In Scenario B, cash flows for the derivative transaction affect the overall cash flows of the firm and the allocation to the various claim holders is according to the seniority structure, that is first to senior debt, then to junior debt, and then to equity. Senior bond holders therefore benefit, for example, when gold prices are low and the firm is in default as the firm receives a cash inflow from the forward contract. In Scenario B, the cash flows from the implied derivative contract accrue to the junior bond holders directly and are not subject to the priority ordering of the firm's existing claim holders. Thus, the cash inflows from the implied forward contract benefit the junior bondholders and not the senior bondholders. The pricing of the junior debt reflects the superior cash flows, thereby lowering the overall amount that has to be issued to raise the same amount of funds as in the no-hedge case, and some of the reduction in distress costs also accrue to the shareholders.

This example illustrates the superiority, from the standpoint of equity holders, of using gold-linked junior debt compared to using plain-vanilla debt coupled with conventional financial risk management. Although the value of the firm remains substantively the same, these two approaches partition the value of the firm differently, permitting equity holders to realize the benefit of their actions.

4. Asset substitution and manipulation

We show in this section, that the gold-linked structure adopted by FCX also ameliorates the asset substitution problem associated with risk management (Smith and Stulz (1985)). We also show that the linkage to gold avoids some of the problems associated with other kinds of debt indexation that allow the manager to manipulate the value of the firm's liabilities.

4.1 Asset substitution

In the Smith and Stulz (1985) framework, firms issuing debt must convince incoming bondholders that they will hedge after the bond sale for prices to reflect the lower risk of default and allow shareholders to capture the benefits of hedging. The comparison of Scenarios A and B in Table 4 illustrates the point made by Smith and Stulz (1985), that by reneging on a commitment to hedge or unwinding an existing hedge, equityholders in a levered firm can be made considerably better off. The problem is exacerbated when the firm is already levered, as shareholders have an incentive to unhedge and recover the wealth transfers to existing senior bondholders.

The incentive to unhedge can be overcome by reputational concerns as shown by Boot, Greenbaum and Thakor (1993), especially for companies undertaking capital-intensive projects which require frequent refinancing. Unwinding an embedded hedge also requires the firm to initiate a derivatives transaction that actually increases the exposure of the firm's cash flows. This is less easier to justify compared to a failure to hedge and will greatly increase the reputation problem.

Furthermore, unwinding a long-term hedge of the sort embedded in FCX's gold-linked instruments is also likely to be constrained by the lack of availability of appropriate hedging instruments and the high costs associated with creating an equivalent off-setting hedge.[8] Indeed, Smithson and Chew (1992) argue that firms may be using hybrid securities to "complete" the

[8] Merton (1990) advances this argument as a rationale for financial innovation.

market and thereby capture a surplus when the underlying components are not individually available in the market.[9]

Another less obvious aspect of unwinding an embedded hedge is the lack of symmetry between initiating and unwinding an hedge (i.e. a hysteresis effect) in the division of firm value among its stakeholders. We illustrate this in Table 5 by comparing the impact on equityholders of unwinding the hedge through a derivative market transaction for the hedge established in Scenarios B and C of Table 4. In both cases, the firm takes a long forward position in gold to offset the exposure arising from the previously established short position or an embedded short position.

[Place Table 5 about here]

From Table 5, Scenario D, unwinding the traditional hedge increases the default risk for both classes of bondholders and makes them substantially worse off. The value of senior bondholders decreases by $24.5 and the value of the newly issued bondholders decreases by $26. Shareholders gain by $49.4 because of the higher cash flows that accrue to them in states where the firm is solvent, and illustrates the classical asset substitution problem. Firm value decreases by $1.1 because of the increase in distress costs associated with an increase in default risk.

The effect of unwinding the targeted risk management established by the gold-linked bond is more complex. The counterparty in forward transaction has a short position and is exposed to the probability that the firm does not meet its obligations when cash flows of the firm are lower than the promised payments on the firm's debt. That is, shareholders have the option to default on payments to the counterparty. The counterparty will ask for compensation through an up front premium for the default option. We incorporate this amount as an initial cash outflow from the firm.

The cash flow and valuation effects of unwinding the targeted risk management is shown in Table 5, Scenario E. The calculation of the premium for the default option on the derivatives transaction is endogenous, as the payment of a premium also affects the probability of default. We solve the problem for the parameters described in Scenario E to be equal to $49.6 and verify

[9] See Van Horne (1985) for a discussion of the market completion rationale for financial innovation.

it by calculating the expected cash flows to the counter-party to be equal to -$49.6. The value of senior debt decreases by $11.4 and that of junior debt decreases by $12.8, which is a smaller change as compared to the value changes in Scenario D. The increase in the value of Equity is $20, which is smaller than the increases in Scenario D. Thus, the wealth transfers are considerably reduced when shareholders attempt to unwind the targeted risk management as compared to conventional risk management.

The key difference between the cash flow effects in the two scenarios is the treatment of derivatives positions when the firm is bankrupt. In Scenario D, we assume that the counterparty holds both the long position in the transaction where the hedge was initiated and the short position in the unwinding transaction. This allows the counterparty to simply net the two positions and achieve priority over the firm's senior debtholders under default as is possible under current bankruptcy regulations (See Tucker (1991) and Foster (1995)) . The counterparty that has the short forward position, therefore, does not lose when the firm goes bankrupt and demands no additional compensation. In Scenario D, the counterparty has a naked short position and its claims are junior if the firm were to default. Payments to the derivative counterparty to offset this risk reduces the gains that equity holders can realize.

While the incentives to unwind the risk management are not completely removed when the firm hedges using a targeted hedge, they are smaller and make it unlikely that the firm will unhedge given the reputational and cost concerns. We show in the next section that in the case of FCX, these considerations were enough for the bond markets to act as if the firm would maintain the hedge and enhanced the credit quality of the issue. We also do not find any evidence that the firm unhedged ex-post.

4.2 Exogenous vs endogenous indexation of debt securities

Another advantage of gold-linked debt is that it links the value of the liabilities to an exogenous measure which is nonetheless correlated with the revenues of the firm. Froot, Sharfstein and Stein (1989) examine the issue of indexing debt to observable variables in the context of their study of LDC debt. They contrast two schemes of indexation -- (a) indexing debt to endogenous variables such as output or revenue, and (b) indexing debt to exogenous variables

such as the price of commodities. They conclude that indexing debt to exogenous variables will mitigate potential moral hazard problems, since debtors can at least partially influence endogenous variables such as the level of output.

Despite providing FCX the ability to defer dividend payments in times of earnings difficulty (the depositary shares are backed by FCX gold preferred stock), there is no negative signal associated with the issue of the gold depositary shares, unlike income bonds which are also linked to firm revenues. Income bonds, used by railroad companies during their restructuring, allow a company to forego interest payments during times of low earnings. McConnell and Schlarbaum (1981) attribute the lack of popularity of income bonds to the "smell of death" associated with their usage.[10] Since FCX is unlikely to have superior information about gold prices, such negative signaling consequences do not result from gold-indexation.

5. Valuation of the FCX commodity-linked depositary shares

The real yield on the commodity linked depositary shares is equal to the rate that equates the present value of its future payments to its initial value, with all cash flow in terms of gold. Figure 2 shows the payoffs to the commodity denominated depositary shares, in terms of ounces of the commodity, which is used to calculate the real yield. Figure 2 also shows the cash flows in terms of equivalent dollar payments calculated by multiplying the ounces of the commodity paid multiplied by the price of the commodity. Given that there are no other outstanding issues by FCX that are gold-linked, there is no obvious benchmark to use for calculating nominal yields. We can, however, use the no-arbitrage pricing principle to price an equivalent "portfolio" of traded securities that gives the same cash flows as the gold-linked depositary shares. Abstracting from any adjustments for credit risk differentials, the value of the depositary shares is simply equal to that of the replicating portfolio.

[Place Figure 2 about here]

[10] As in the case examined by Froot, Sharfstein and Stein (1989), income bonds can also be the cause for earnings manipulation by stockholders to the detriment of bondholders. However, McConnell and Schlarbaum (1981) argue that the potential for such conflicts can be easily eliminated and dismiss this as an explanation for the dearth of income bonds.

5.1 The replicating portfolio

The depositary shares have a sequence of T dividend payments of *C* oz of gold plus an additional payment of M oz at maturity. The dollar value of that payment is equal to the price of an ounce of gold at that time multiplied by *C* oz, the amount of gold received. Consider a portfolio of the following three securities:

1) A straight bond that pays -
   a) $C * S_0$ on each date that the gold-denominated depositary share pays a coupon, and
   b) $M * S_0$ on the maturity date of the gold-denominated depositary shares.
2) A sequence of forward contracts, i.e. a swap, for each of the coupon dates defined as follows. The first forward contract matures on t_1, the first time that the bond pays a coupon and has a forward price equal to $C * S_0$. The last forward contract matures on T, the maturity date of the depositary shares, and has a forward price equal to $C * S_0$. The forward contracts each have a payout equal to $C * (S_t - S_0)$, for t 0 (1, T), that is, on every date that the gold-denominated depositary share pays a coupon,
3) A forward contract which matures on T, with a forward price of $M * S_0$. The forward contract has a payout of $M * (S_T - S_0)$ where S_T is the price of gold on the maturity of the date of the depositary shares.

Figure 3 shows the cash flows to the replicating portfolio. Comparing with Figure 2, we see that the portfolio has exactly the same payout as the gold-denominated depositary shares. Since the issue price of the gold/silver denominated depositary shares is known, we can calculate the implied yield on the depositary shares.

[Place Figure 3 about here]

The implied yield on the straight debt component of the depositary shares will reflect the default risk of FCX. For valuing the cash flows to the swap and the forward, the risk free rate is normally used as credit risk considerations are secondary to a fair value swap. However, all the cash flows as described above would be paid to the investor by FCX. Further, the cash flows correspond to an exchange based on the final face of the depositary shares. This makes counter-

party credit risk an important element in determining their value. We account for the counter party credit risk by using the same risk-adjusted yield measure as that used for the straight bond when calculating the value of the cash flows to the swap and the forward.

5.2 Pricing the first series of gold-denominated depositary shares

FCX issued its first series of gold-denominated depositary shares on August 5, 1993. From Table 2, the coupon rate on the first gold-denominated preferred shares is 3.5% and has a face value equal to 0.1 oz. The maturity date is August 1, 2003, a maturity period of approximately 10 years. Coupons are paid quarterly with the first coupon of 0.000825 oz paid on November 1, 1993 and the last coupon paid on August 1, 2003. The issue price is 0.1 oz and the implied real yield is therefore 3.5% compounded quarterly.

Table 6 reports gold prices in London and New York. The London P.M. fixing gold price is the benchmark used for pricing the gold depositary shares, which was $387.75 on August 5, 1993, implying a price of $38.77 per depositary share.

[Place Table 6 about here]

The nominal yield is set equal to the rate which equates the initial dollar equivalent price of the shares to the present value of the expected payments to the straight bond, the swap, and the forward contract. As discussed before, we use the same yield for discounting the cash flows to the swap and the forward as that used for discounting the cash flows to the straight bond.

We calculate the expected dollar value of the cash flows to the swap and the forward using a model for forward rates on August 5, 1993. Table 6 also reports gold futures prices on August 5, 1993 traded on NYMEX and the implied cost-of-carry. Unfortunately, the gold futures market is not complete and data is not available beyond five years. Further, the cash flows do not exactly match the expiration dates on the available futures contracts. We, therefore, need to use an interpolation/extrapolation method to analyze the value of the embedded forward contracts.

We fit a Vasicek model to determine the term structure of gold rates, where the instantaneous gold rate follows a mean reverting process,

$$dr = a(b-r) + s\,dz \qquad (1)$$

with *a* being the speed of adjustment, *b* the long term gold rate, and *s* the volatility of the short rate. Vasicek (1977) shows that the process above gives the following result for the interest rate on a zero coupon instrument that has maturity T:

$$R(T) = -\frac{1}{T} A(T) + \frac{1}{T} B(T)\, r \qquad (2)$$

where,

$$B(T) = \frac{1-\exp(-aT)}{a} \qquad \cdots\cdots \quad a \neq 0 \qquad (3)$$

$$A(T) = \exp\left[\frac{\{B(T) - T\}(a^2 b) - s^2/2}{a^2} + \frac{s^2 B(T)^2}{4a} \right] \quad \cdots \quad a \neq 0 \qquad (4)$$

If a = 0 then, B(t,T) = T and A(T) = exp[$s^2 T^3$ /6].

Figure 4 plots the data and the fitted model, and reports the parameters of the model fitted to the rates shown in Table 6.[11] We assume that these parameters also apply to the London P.M. fixing gold prices.

[Place Figure 4 about here]

Using the term structure model, we determine forward rates for maturities corresponding to the gold payment dates of the gold-denominated preferred shares and calculate the expected dollar equivalent of all the gold cash flows. The final step is to discount the expected cash flows and determine the rate at which the present value of cash flows equals the issue price. At a yield of 8.08%, the value of the straight bond is equal to $26.52 and the value of the swap and forward contracts is equal to 12.25 giving a total value of $38.77 for the depositary shares.

The gold-denominated depositary shares are rated BB- by Standard and Poors and B1 by Moodys. At the time of issue, FCX was also under a credit watch by Moodys. From the credit spreads reported in Table 6, the implied yield on the depositary shares represents an improvement of 26 BP over the BB3 rate of is 8.34%, reflecting the higher credit quality of the depositary shares.

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[11] We use a modified Simplex method to calculate the parameter values that minimize the sum of squared deviations from observed gold rates for different maturities.

5.3 Pricing the second series of gold-denominated depositary shares

FCX issued a second series of gold-denominated depositary shares on January 13, 1994. We use a procedure similar to that described above for the first series. From Table 2, the coupon on the second gold-denominated preferred shares is 3.25% and it has a face value equal to 0.1 oz. The maturity date is February 1, 2006, a maturity period of approximately 12 years. Coupons are paid quarterly with the first coupon of 0.0008125 oz paid on May 1, 1994 and the last coupon paid on February 1, 2006. The issue price is 0.1 oz and the implied real yield is therefore 3.25%, compounded quarterly.

From Table 7, the London P.M. fixing gold price on January 13, 1993 is $388.75, implying a price of $38.875 per depositary share. Table 7 also reports gold futures prices on January 13, 1994 traded on NYMEX and the implied cost-of-carry. Figure 5 reports the parameters of the fitted Vasicek term structure model, and plots the data and the fitted model.

[Place Table 7 and Figure 5 about here]

At a yield of 8.09%, the value of the straight bond is equal to $24.22 and the value of the swap and forward contracts is equal to 14.63 giving a total value of $38.85 for the depositary share.

The gold-denominated depositary shares are rated BB- by Standard and Poors and B1 by Moodys and FCX was under a credit watch by Moodys. Table 7 reports the credit spreads for January 13, 1994. The 10 year BB3 rate is 8.3% and the 20 year BB3 rate is 8.6% implying a rate of 8.24% for 12 year BB3 securities. The implied yield on the depositary shares represents an improvement of 15 BP over the BB3 rate, once again reflecting the higher credit quality of the depositary shares.

5.4 Pricing the silver-denominated depositary shares

FCX issued its first and only series of silver denominated depositary shares on July 22, 1994. We use a procedure similar to that described for pricing the first series of gold-denominated depositary shares to price the second series. From Table 2, the coupon rate on the silver denominated preferred shares is 4.125% and has a face value equal to 4 oz. The face value

of the bond is paid back in equal installments of 0.5 oz over a period of 8 years from August 1, 1999 to August 1, 2006. Coupons are paid quarterly with the first coupon of 0.04125 oz of silver paid on November 1, 1994. After August 1, 1999, dividends are paid at a rate of 4.125% on the remaining face value of the depositary shares. The last coupon is paid on February 1, 2006. The issue price in silver is equal to 4 oz and the implied real yield is therefore 4.105%, compounded quarterly.

From Table 8, the London P.M. fixing silver price on August 5, 1993 is $5.2525, implying a price of $21.01 per depositary share. It also reports silver futures prices on July 22, 1993 traded on NYMEX and the implied cost-of-carry. Figure 6 reports the parameters of the Vasicek term structure model fitted to the rates shown in Table 8, and plots the data and the fitted model.

[Place Table 8 and Figure 6 about here]

At a yield of 11.04%, the value of the straight bond is equal to $13.06 and the value of the swap and forward contracts is equal to 7.96 giving a total value of $21.02 for the depositary shares. The silver denominated depositary shares are rated BB- by Standard and Poors and B1 by Moodys and at the time of issue FCX was under a credit watch by both Moodys and Standard and Poors with negative implications. Table 8 also reports the credit spreads for July 22, 1994. The 10 year B2 rate is 10.59% and the 10 year B3 rate is 11.15%. The implied yield on the silver denominated depositary shares, is therefore, appropriate for its credit rating and the negative implications of the credit watch by Moodys and Standard and Poors.

Despite the similarities in the structure of the gold and silver denominated depositary shares, the silver denominated securities do not show the credit enhancements associated with the gold securities. The differences in the gold and silver mining operations of FCX account for the poor reception the silver issue received in the market. Silver is a byproduct of FCX's mining operations and the correlation between its revenues and silver prices are low. Further, FCX's silver reserves are much lower than its gold reserves – indeed FCX had to amortize the face value of the issue over eight years to match its silver production schedule. When prices of gold and silver diverge, the value of these securities would be high precisely when the firm's cash flows are low, thus increasing the loss under default. With silver denominated depositary shares as part of

its capital structure, any decrease in the quantity of silver produced would have the effect of giving FCX an exposure to silver rather than reducing existing exposure.

The Silver Series I depositary shares illustrate the importance of the specifics of the commodity linkage and the intricacies of security design. To get credit enhancement results through debt indexation, the value of the commodity linked security should be highly positively correlated with the revenues of the firm.

6. Conclusion

FCX's gold-denominated depositary shares are an excellent example of how firms can lower their borrowing costs through innovation and security design. The linkage to gold prices is equivalent to risk management in its impact on the firm's cash flows, but allows hedging benefits to be targeted to the newly issued securities. We analyze the structure of these securities and show that the reduction in borrowing cost was achieved because the implied hedge enhanced their credit quality.

We have extended the work of Smith and Stulz (1985) on the interaction of debt financing and hedging policies by analyzing the impact of risk management on firms that have existing leverage on their balance sheet. We show that alternate methods of risk management have different effects on the value of a firm and its liabilities because of the differences in the treatment of the cash flows of the firm when it is in default. Firms thus can choose how they should implement a risk management program so that benefits are retained by their equity holders. For example, FCX was able to apportion the hedging gains to the newly issued depositary shares which was reflected in their pricing. We refer to this effect as the gains from *targeted risk management*.

The structure of the gold-linked securities was also able to overcome the asset substitution problem and the moral hazard problems associated with debt indexation: 1) FCX was able to credibly commit to risk management, even though shareholders have an incentive to un-hedge after the debt issue (Smith and Stulz (1985)), 2) the exogenous nature of the gold-link makes it unlikely that the managers can manipulate the value of the claims (Froot, Scharfstein, and Stein (1993)), and 3) since managers are not likely to be able to predict the behavior of gold prices in

the future, there is no negative signal associated with the issue as in the case of income bonds (McConnell and Schlarbaum (1981).

The gold-linked depositary shares were thus a novel way for the company to reduce the cost of borrowing and raise the money needed for financing the expansion of its Grasburg mine. In contrast to equity/equity-linked financing, FCX was far more comfortable giving away gold price risk rather than giving away any upside potential on the stock arising from good management. FCX was also able to increase the menu of alternative investment opportunities available to investors and market its securities to goldbugs. Most gold-linked securities prior to the gold-linked depositary shares were sold primarily in Switzerland and the Euromarkets and FCX was one of the pioneers in marketing such securities to domestic investors. The implicit long-dated futures contracts - which Freeport was able to supply - allowed gold investors to get exposure to gold price risk without incurring FCX's management risk.

It should be kept in mind that the depositary shares structure had preferred stocks as the underlying security. The dividends paid on the depositary shares are, therefore, not tax deductible unlike the interest payments on bonds. The point may be moot for companies that are already using the maximum allowable tax shields and cannot use the additional tax shield. The markets reception of the depositary shares indicate that FCX was able to overcome the disadvantages associated with risk management and debt indexation.

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Table 1: **Capital raised by FCX, July 91 - July 93**
(Net proceeds - $ million)

		(Million)
July 91:	**7.75% LYONs** Face Value $1.035 billion, maturing in 2011 Exchangeable for 0.6015 oz of gold or 7.505 shares of FCX Class A common stock Puttable after July 2, 1996	$ 219
July 92:	**Class A Common Shares**[12] 8.5 Million Shares issued	$ 174
	7% Convertible Exchangeable Depositary Shares 8.976 Million Shares. Cumulative Dividends (Quarterly) = $1.75 per year. After 8/1/94, can be exchanged for FCX's 7% Convertible Subordinate Debenture. Redeemable after 8/1/95 at stated prices. Convertible into 0.992 shares of common.	$ 218
March 93:	**PT-FI Alatief joint venture** Sale of residential properties and food service facilities	$ 270
July 93:	**Step-Up Convertible Depositary Shares** 14 Million Shares. Dividends (Quarterly) till 8/1/96 - $1.25 per year Dividends (Quarterly) after 8/1/96 - $1.75 per year Redeemable after 8/1/96 for 0.813 shares subject to price level. After 8/99 redeemable for $25.00 Convertible into 0.813 shares of Common.	$ 341

[12] FCX had planned to issue 10.25 Million shares of Class A shares and 6 million depositary shares but adjusted these amounts because of the large demand for the preference stock. (Bloomberg, 7/14/92)

Table 2: Summary of FCX's commodity-linked preferred stock
(Net proceeds - $ million)

TYPE	ISSUE DATE	COUPON* (Ounces)	FACE (Ounces)	MATURITY (Years)	AMOUNT (Million)
Gold-denominated Preferred I	Aug 5, 93	0.0035	0.1	8/01/03	$221
Gold-denominated Preferred II	Jan 13, 94	0.00325	0.1	2/01/06	$158
Silver-denominated Preferred I	Jul 22, 94	0.165	4.0**	8/01/06	$ 95

* Coupons paid quarterly

** Redemption - Annually, beginning 8/1/99 for 0.5 oz of silver.

Table 3: A sampling of gold and silver-linked financing

Year	Issuer	Amount	Underwriter	Terms
1973	French government	FF 6.5 billion of French domestic bonds	n.a.	Principal and interest payments indexed to market price of gold. Coupon = 7.00%. Maturity 1988.
1980	Sunshine Mining Company	2 issues of silver certificates of US$ 25 million each	Drexel Burnham Lambert	Redemption value indexed to market price of silver subject to a floor of $20 per troy ounce and various redemption provisions. Coupon = 8.50%. Maturity 1995.
1981	Echo Bay Mines Ltd.	C$ 65 million cumulative redeemable preferred shares with gold warrants	Burns Fry, Ltd. Wood Gundy, Ltd.	Each C$50 unit carries 4 warrants to purchase a total of 0.0706 troy ounces of gold at a reference price of $595/ounce, exercisable annually and commencing 1986, ending 1989. Coupon = 6.00%. Maturity 1989.
1981	Refinemet International N.V.	US$ 52 million gold-indexed Eurobonds	Drexel Burnham Lambert and others	Principal and interest payments indexed to market price of gold. Issuer has the option to redeem the bonds after 1986 or if the gold price exceeds $2000 per ounce. Coupon = 3.25%. Maturity 1996.
1987	AT&T Credit Corp.	US$ 100 million Eurobond with gold warrants	Union Bank of Switzerland	Warrants exercisable for one ounce of gold with cash settlement of the difference between market price of gold on exercise date and strike price of $463 per ounce. Coupon = 9.25%. Priced at 112.75. Maturity 1990.
1987	Eastman Kodak	US$ 100 million Eurobond with gold warrants	Union Bank of Switzerland	Structurally identical to AT&T issue. Strike price = $470.6 per ounce. Coupon = 9.00%. Priced at 113.175. Maturity 1990.

Sources: Budd (1983); Wall Street Journal (various issues).

Table 4: The gains from targeted risk management

This table shows the value of the firm and its capital structure components for a gold mining firm that has 3 million ounces of gold in reserves. We assume that the value of the firm is linear in the price of gold and that gold prices ($/oz) are distributed uniformly in [100,500]. The firms has $500 million in senior debt and proposes to raise $251.0 million by issuing junior debt. The firm faces bankruptcy costs of $50 million if it defaults. Three scenarios are analyzed as described in the panel headers.

Scenario A - Gold mining firm with no risk management
Firm issues junior bonds of face value $400.0 million

	Min	Sr Debt -> Paid	Jr Debt -> Paid	Max	**Expected Value**
	|----------|---------- |----------| <- Default				
Gold Price	100.0	183.3	300.0	500.0	
Reserves, million oz	3	3	3	3	
Firm value	250.0	500.0	900.0	1500.0	**$875.0**
Value of senior debt	250.0	500.0	500.0	500.0	**$474.0**
Value of junior debt	0.0	0.0	400.0	400.0	**$251.0**
Value of Equity	0.0	0.0	0.0	600.0	**$150.0**

Scenario B - Gold mining firm with risk management at the firm level
Firm sells junior bonds of face value $345.9 million
Firm hedges by selling a gold forward for 1.0 million oz @ $300/oz

	Min	Sr Debt -> Paid	Jr Debt -> Paid	Max	**Expected Value**
	|----------|---------- |----------| <- Default				
Gold Price	100.0	125.0	272.9	500.0	
Reserves, million oz	3	3	3	3	
Amount managed	1	1	1	1	
Residual exposure, million oz	2	2	2	2	
Firm value	450.0	500.00	845.9	1300.0	**$878.4**
Value of senior debt	450.0	0.0	500.0	500.0	**$498.4**
Value of junior debt	0.0	0.0	345.9	345.9	**$251.0**
Value of Equity	0.0	0.0	0.0	454.1	**$128.9**

Scenario C - Gold mining firm with targeted risk management
Firm sells junior gold-linked bonds of face value 1.0 million oz

	Min	Sr Debt -> Paid	Jr Debt -> Paid	Max	**Expected Value**
	|----------|---------- |----------| <- Default				
Gold price	100.0	183.3	250.0	500.0	
Reserves, million oz	3	3	3	3	
Firm value	250.0	500.0	750.0	1500.0	**$881.3**
Value of senior debt	250.0	500.0	500.0	500.0	**$474.0**
Value of junior gold-linked debt	0.0	0.0	250.0	500.0	**$251.0**
Value of Equity	0.0	0.0	0.0	500.0	**$156.3**

Table 5: Gains from ex-post unwinding of the hedge

The table below shows the value of the firm and its capital structure components for a gold mining firm that has 3 million oz of gold in reserves and buys a forward contract on 1 million oz of gold at the current market price of $300/oz. We assume that the value of the firm is linear in the price of gold and that gold prices ($/oz) are distributed uniformly in [100 ,500]. The firm has $500 million in senior debt and has raised $251.0 by issuing junior debt. The firm faces bankruptcy costs of $50 million if it defaults. Two scenarios are analyzed corresponding to the hedge described in Scenario B and Scenario C of Table 2 as described in the panel headers.

Scenario D: Unwinding the traditional firm-level risk management
Firm sells junior bonds of face value $345.9 million
Firm hedges by selling a gold forward for 1 million oz
Firm unwinds by buying a gold forward for 1 million oz

	Min	Sr Debt -> Paid	Jr Debt -> Paid	Max	**Expected Value**	**Change due to unwinding**
			<- Default			
Gold price	100.0	183.3	282.0	500.0		
Reserves	3	3	3	3		
Hedge CFs to counter-party	- 200.0	- 116.7	- 18.0	200.0		
Unwinding CFs to counter-party	200.0	116.7	18.0	-200.0	**0**	
Net CFs on the forwards	0.0	0.0	0.0	0.0		
Firm value	250.0	500.0	845.9	1500.0	**877.3**	**(1.1)**
Value of senior debt	250.0	500.0	500.0	500.0	**474.0**	**(24.5)**
Value of junior debt	0.0	0.0	345.9	345.9	**225.0**	**(26.0)**
Equity cash flows	0.0	0.0	0.0	654.1	**178.3**	**49.4**

Scenario E: Unwinding the targeted risk management
Firm sells junior gold-linked bonds of face value 1.0 million oz
Firm unwinds by buying a gold forward for 1.0 million oz and pays $49.6 million

	Min	Sr Debt -> Paid	Jr Debt -> Paid	Max	**Expected Value**	**Change due to unwinding**
			<- Default			
Gold price	100.0	199.9	283.2	500.0		
Reserves	3	3	3	3		
Firm value	200.4	500.0	800.0	1450.4	**877.1**	**(4.2)**
Value of senior debt	200.4	500.0	500.0	500.0	**462.6**	**(11.4)**
Value of junior gold-linked debt	0.0	0.0	283.2	500.0	**238.3**	**(12.8)**
Cash flows after payments to debt holders	0.0	0.0	16.8	450.4		
Cash flows owed to counter-party	200.0	100.1	16.8	-200.0		
Actual cash flows paid to counter-party	0.0	0.0	16.8	-200.0	**-49.6**	
Equity cash flows	0.0	0.0	0.0	650.4	**176.2**	**20.0**

Table 6: Gold futures prices, implied net cost-of-carry, and credit risk spreads for August 5, 1993

This table shows the futures price of gold and the implied net cost-of-carry rate for August 5, 1993, the issue date for FCX's Series 1 gold-linked depositary shares. The London 4pm fixing price was $387.75/oz and New York 4pm spot gold price was at $376.80/oz. The contract size for the NYMEX gold futures contract is 100 oz and the expiration date is the last business day of the contract month.

FUTURES PRICES (Wall Street Journal, August 6, 1993)

Contract Month	Settle	Change (1 day)	Open Interest	Implied Rate
AUG 93	377.20	-22.00	4,995	-
OCT 93	378.80	-22.40	12,169	2.54%
DEC 93	380.70	-22.60	141,176	2.66%
FEB 94	382.70	-22.70	14,324	2.77%
APR 94	384.50	-22.90	5,735	2.83%
JUN 94	386.50	-23.00	7,365	2.94%
AUG 94	388.50	-23.10	3,609	2.99%
OCT 94	390.40	-23.20	2,558	3.06%
DEC 94	392.50	-23.30	10,111	3.11%
FEB 95	394.70	-23.50	1,848	3.18%
APR 95	397.00	-23.70	819	3.24%
JUN 95	399.30	-23.90	2,076	3.42%
DEC 95	406.80	-24.00	1,469	3.61%
JUN 96	415.10	-24.10	694	3.78%
DEC 96	424.20	-24.20	584	3.93%
DEC 97	444.50	-24.40	462	4.20%

CREDIT SPREADS (Bloomberg)

MATURITY	AAA	A3	BBB3	BB2	BB3	B1	B2	B3
5YR	5.48	5.98	6.50	7.26	7.80	8.16	8.58	9.57
7YR	5.88	6.27	6.85	7.90	8.09	8.39	8.84	10.01
10YR	6.26	6.58	7.24	8.29	8.34	8.61	9.12	10.34
20YR	6.76	7.30	7.70	8.54	8.66	8.82	9.41	10.81
30YR	6.89	7.40	7.78	8.57	8.69	8.90	9.48	10.90

Table 7: Gold futures prices, implied net cost-of-carry, and credit risk spreads for January 13, 1994

This table shows the futures price of gold and the implied net cost-of-carry rate for August 5, 1993, the issue date for FCX's Series 1 gold-linked depositary shares. The London 4pm fixing price was $388.75/oz and New York 4pm spot gold price was at $390/oz. The contract size for the NYMEX gold futures contract is 100 oz and the expiration date is the last business day of the contract month.

FUTURES PRICES (Wall Street Journal, January 14, 1994)

Contract Month	Settle	Change (1 day)	Open Interest	Implied Rate
FEB 94	390.60	+ 3.70	78,040	-
APR 94	392.70	+ 3.80	17,844	-
JUN 94	394.50	+ 3.80	23,708	2.54%
AUG 94	396.50	+ 3.80	4,225	2.66%
OCT 94	398.60	+ 3.90	3,236	2.77%
DEC 94	400.70	+ 3.90	11,790	2.83%
FEB 95	403.00	+ 4.00	1,499	2.94%
APR 95	405.30	+ 4.00	2,503	2.99%
JUN 95	407.70	+ 4.10	4,307	3.06%
AUG 95	410.20	+ 4.10	424	3.11%
OCT 95	412.80	+ 4.20	134	3.18%
DEC 95	415.50	+ 4.30	2,334	3.24%
JUN 96	424.20	+ 4.60	828	3.42%
DEC 96	434.00	+ 4.90	1,389	3.61%
JUN 97	444.40	+ 5.20	101	3.78%
DEC 97	455.60	+ 5.50	656	3.93%
DEC 98	480.40	+ 5.50	400	4.20%

CREDIT SPREADS (Bloomberg)

MATURITY	AAA	A3	BBB3	BB2	BB3	B1	B2	B3
5YR	5.30	5.75	5.95	7.23	7.56	8.02	8.84	9.55
7YR	5.67	6.06	6.29	7.62	7.87	8.20	9.03	9.92
10YR	6.02	6.39	6.72	7.95	8.20	8.30	9.24	10.28
20YR	6.66	7.18	7.47	8.47	8.60	8.76	9.64	10.79
30YR	6.77	7.37	7.83	8.83	8.87	9.05	9.81	11.02

Table 8: Silver futures prices, implied net cost-of-carry, and credit risk spreads for July 22, 1994

This table shows the futures price of silver and the implied net cost-of-carry rate for August 5, 1993, the issue date for FCX's Series 1 silver-linked depositary shares. The London 4pm fixing price was $5.2524/oz and New York 4pm spot silver price was at $5.27/oz. The contract size for the NYMEX silver futures contract is 100 oz and the expiration date is the last business day of the contract month.

FUTURES PRICES (Wall Street Journal, July 23, 1994)

Contract Month		Settle	Change (1 day)	Open Interest	Implied Rate
JUL	94	525.7	+ 3.0	145	-
SEP	94	528.0	+ 2.8	78,569	-
DEC	94	535.3	+ 2.8	24,450	3.59%
MAR	95	543.4	+ 2.8	6,633	4.49%
MAY	95	548.8	+ 2.8	3,618	4.77%
JUL	95	554.7	+ 2.8	3,102	5.04%
SEP	95	560.8	+ 2.8	548	5.25%
DEC	95	570.1	+ 2.8	2,098	5.48%
JUL	96	592.7	+ 2.8	943	6.05%
DEC	96	610.6	+ 2.8	1,223	6.04%
JUL	97	637.5	+ 2.8	483	6.30%
DEC	97	658.4	+ 2.8	307	6.47%
DEC	98	707.7	+ 2.8	106	6.64%

CREDIT SPREADS (Bloomberg)

MATURITY	AAA	A3	BBB3	BB2	BB3	B1	B2	B3
5YR	7.17	7.42	7.83	8.91	9.40	9.88	10.12	10.68
7YR	7.40	7.71	8.20	9.12	9.67	10.10	10.41	10.91
10YR	7.67	7.91	8.58	9.34	9.88	10.31	10.59	11.15
20YR	7.95	8.32	8.89	9.64	10.00	10.37	10.69	11.73
30YR	7.96	8.43	8.92	9.82	10.22	10.46	10.79	11.82