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. The depositary shares issued by FCX illustrate how firms can enhance credit quality through financial engineering without changing the existing priority ordering of their capital structure.

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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. The depositary shares issued by FCX illustrate how firms can enhance credit quality through financial engineering without changing the existing priority ordering of their 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 by committing the firm to a risk management strategy. We also show that the design of the security enabled the firm to target the benefits from a reduction in distress costs to the newly issued securities.

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. 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 has different valuation effects and it overcomes the credibility problem that firms face when they promise bondholders that they will initiate a hedging program to reduce default risk.

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 have important effects on the value of the firm's equity when the firm has debt existing on its balance sheet. The differences between using an implicit hedge through a financially engineered security, such as the gold-denominated depositary shares,

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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.

and explicit hedging at the firm level, arise from differences in the obligations and netting privileges of the derivatives counterparty when the firm is in default. By bundling financing and risk management, the firm issues a security whose value is enhanced during default because the amount owed on the derivative can be netted against the value of the financing instrument. This circumvents the priority structure of the firm's existing capital structure by allowing hedge cash flows to accrue to the most recently issued securities rather than other senior claim holders. We refer to this effect as *targeted risk management.*

A moral hazard problem arises when shareholders promise to use risk-management to reduce default risk of debt holders 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 works 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 would have received 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 <u>taking on new exposure</u>. The reputational

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

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.

The gold-denominated depositary shares also eliminate two other moral hazard problems associated with the use of indexed debt as financing instruments and which have been examined in the literature. Froot, Sharfstein and Stein (1989) show that the manipulation of the index by managers is a potential consideration when output or revenue is used to index the value of debt. It is, therefore, important to use an exogenous variable which is not subject to manipulation by the manager. Gold prices are eminently suitable as they are market determined. McConnell and Schlarbaum (1981) note that in the case of income bonds, i.e. debt linked to firm revenue, there is a potential negative signal because managers have better information than the market on the future value of the index. It is possible to interpret the issue of income bonds as a signal that the managers expect revenues to decease. Gold indexation as used in the depositary share structure avoids the negative signal since managers are unlikely to possess private information about future gold prices, but retains the correlation to the revenues of the firm desired by such revenue-contingent securities. The exogeneity of the indexation measure, such as the gold-link in FCX's depositary shares, is thus an important factor in the design of indexed debt.

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

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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.

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 gold interest rates to calculate the forward rates required to value the swap and the forward components. Data on the implied cost of carry in traded gold futures contracts is used as a proxy for gold interest rates.

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 were reflected in their market price and were captured by the firm's shareholders. In keeping with our argument that it is not in the 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, not well received by the market. FCX 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 of 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

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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.

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-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'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 being 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 the 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 have 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 offsets 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 is levered

In this section, we show that the effect of issuing a commodity-linked bond for a gold mining firm is an implied hedge but retains the benefits of hedging for the newly issued securities. The analogy to hedging arises because the effect on the cash flows to equity 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* and discuss, in this section, the features of the commodity linked-securities which make it feasible. In the next section, we show that the implied hedge reduces the incentives shareholders have for asset substitution, and overcomes the credibility problems confronting a firm that initiates a risk management program to enhance the credit quality of a debt issue.

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. By extending their analysis to the case when the firm is already levered, we show that the mode of risk management affects the division of the benefits among the firm's claim holders. Specifically, we examine through a detailed example the effect on the cash flows to the various claim holders of the firm when hedging explicitly through derivative market contracts and implicitly through financially engineered contracts. We show that the implicit hedge preserves the cash flow benefits for the shareholders, as it eliminates positive transfers to existing bondholders and benefits to newly issued debt is reflected in its pricing.

3.1 Targeted risk management using an indexed instrument

We consider a firm whose only asset is assumed to be its stock of 3 million ounces of gold. 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 its senior debt at a gold price of $183.3 per ounce and on the total debt issued at a gold price of $300 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 compared to Scenario

B where the firm hedges using forward contracts. The junior claim is safer[8] than the junior claims in both Scenario A and Scenario B and it defaults now at a lower gold 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.

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. Therefore, senior bond holders benefit 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, there are no cash flows from the implied derivative contract to the firm when the price of gold decreases, because junior bond holders can default on their implied long forward contract when the assets of the firm are lower than the face value of the total debt of the firm. Therefore, none of the cash flows from the derivatives contract go the firm's senior claim holders.

It is also instructive to examine the differences in the cash flows to the junior debt in Scenarios B and C from another viewpoint. Consider a portfolio of a straight bond and a long forward contract. When the price of gold is below the forward price, the forward contract has a negative cash flow and the value of the portfolio is lower than the value of the straight bond.

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[8] The price of gold at which junior debt defaults in Scenario C decreases for two reasons. First, the face value of junior debt is lower than the face value of junior debt in Scenario A - $300 million at current gold prices v.s. $400 million. Second the value of the firm decreases at a lower rate as a function of gold prices after the implied hedge in Scenario C as compared to the face value of the junior debt. If the firm had issued straight junior debt of face value $300 million, default would have occurred at a gold price of $266.67. The difference from the price at which gold-linked debt of face value $300 million at current gold prices defaults, captures the magnitude of the second effect.

However, if an investor in such a portfolio is allowed to *net* the value of the two securities then it is important to first evaluate whether the firm is in default when the price of gold is below the forward price. Any shortfall on bond proceeds when the firm is under default can be made up by not paying the amount due on the forward contract. The gold-linked bond represent exactly such an ability to net the potential losses on the bond against amount due on the long forward position. In the framework of our example, consider a portfolio of a straight bond of face value $300 million and a long forward contract with a forward price of $300. When the price of gold is $250, the bond holder can only recover $250 million from the firm's assets after paying off senior debt, representing a potential loss of $50 million. The amount due on the gold forward is $50 million. If the investor can net the two components of the portfolio, then the amount due on the portfolio is only $250 million and the firm has enough assets to pay of the portfolio. From Scenario 3 in Table 4 , we can see that this is exactly the case of the gold-linked bond when the gold price is at $250 and the firm is not in default.

The ability to net the obligations on the derivative contract against amounts due from the firm is therefore a critical advantage of a financially engineered security such as the gold-linked depositary shares. Note that the derivatives counterparty has no netting privileges when the firm hedges by trading in the derivatives market. Coupled with the priority structure that allows senior bond-holders to claim the cash flows from the derivatives counter-party, the implied hedge is more advantageous to the junior bondholders in comparison to hedging explicitly using the derivatives market. The security design therefore has the effect of targeting hedging benefits to the junior bondholders.

The only range of gold prices for which the junior bond holders lose on the implied forward contract is when the gold price is less than the implied forward price and the value of the firm's assets after paying the senior bond holders is sufficient to pay off the gold-linked debt. This potential loss is more than offset by the gains when the price of gold is higher than the forward price. The pricing of the junior debt reflects the option to default on the forward contract and the netting benefits, 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.

The effect on equity holders of issuing the gold-linked securities is similar to hedging, since it reduces the sensitivity of equity to gold prices and decreases default risk. However, the valuation effects are very different. It does not affect the value of senior debt, thereby completely eliminating the wealth transfer to senior bondholders associated with conventional risk management. It is also possible for shareholders to benefit from a reduction in the firm's distress costs as less junior debt has to be issued to finance investment needs if the pricing in the market reflects the credit enhancement of the bond's cashflows. Although the value of the firm remains substantively the same, the two approaches discussed above partition the value of the firm differently, permitting equity holders to realize the benefit of their actions. This example clearly 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.

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 additional incentive to unhedge, in order to recover the wealth transfer to senior bondholders.

There is, however, a lack of symmetry between initiating and unwinding an embedded hedge, i.e. a hysteresis effect, on 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 million and the value of the newly issued bondholders decreases by $26 million. Shareholders gain by $49.4 million 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 million 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 the forward transaction has a short position and is exposed to the probability that the firm will 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 upfront 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 out of the firm's current cash flows also affects the probability of default. We solve the problem for the parameters described in Scenario E to be equal to $49.6 million and verify it by calculating the expected cash flows to the counter-party to be equal to -$49.6 million. The value of senior debt decreases by $11.4 million and that of junior debt decreases by $12.8 million, which is a smaller change as compared to the value changes in Scenario D. The increase in the value of Equity is $20 million, 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 once again the treatment of the derivatives counterparty when the firm is in default. 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.

The residual 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 greatly increase the reputation problem as it is more transparent to the market and it is less easy for shareholders to justify an act of commission in increasing the cash flow risk compared to an act of omission as in a failure to hedge.

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.[9] Indeed, Smithson and Chew (1992) argue that firms may be using hybrid securities to "complete" the

[9] 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.[10]

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 less likely 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

The use of indexed debt as financing instruments has been examined previously in the literature and two potential agency problems have been identified. First, the ability of managers to manipulate the variable chosen as the index is an issue and second, there is the possibility of a negative signal when the manager has private information about the variable chosen as the index. In this section we discuss the advantages of the depositary shares structure used by FCX that arises from the use of a market determined variable (gold price) as the index, thereby incorporating the solution to these potential agency problems.

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 avoid moral hazard problems, since debtors can at least partially influence endogenous variables such as the level of output.

McConnell and Schlarbaum (1981) examine income bonds, used by railroad companies during their restructuring, and attribute their lack of popularity bonds to the "smell of death"

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

associated with their usage.[11] Income bonds allow a company to forego interest payments during times of low earnings and their issue could represent a negative signal as managers have private information about future earnings. Since FCX is unlikely to have private information about gold prices, such negative signaling consequences do not result from gold-indexation. 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 the income bonds.

5. Valuation of the FCX commodity-linked depositary shares

To determine whether FCX was able to achieve credit enhancement on its gold-linked depositary shares, we need to compare the implied nominal yield with the yield that they would have paid on a straight bond. We can use the market rate for equivalently rated securities as a proxy for the yield that FCX would have received if it had issued straight bonds. The implied nominal yield on the depositary shares, however, needs to be estimated using a replicating portfolio approach, and we describe the procedure in this section.

Figure 2 shows the payoffs to the commodity denominated depositary shares, in terms of ounces of gold and also the dollar equivalent. The dollar equivalents are calculated by multiplying the ounces of gold paid by the price of gold at the time of the payment. Since the issue price in gold is equal to the face value of the depositary shares in gold ounces, the real yield on the commodity linked depositary shares is equal to the coupon rate on the date of the issue.

[Place Figure 2 about here]

Consider a portfolio of the following three securities: 1) A straight bond that pays $C * S_0$ on each date that the gold-denominated depositary share pays a coupon, and $M * S_0$ on the maturity date of the gold-denominated depositary shares, where C is the coupon payment in gold, M is the face value in gold, and S_0 is the gold price on the day of issue; 2) A fixed-for-

[11] 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.

floating gold swap such that the cash inflow is C * S_t and the cash outflow is fixed at C * S_0 where S_t , $t \in (1, T)$, is the gold price on all dates corresponding to the payment dates on the contract; and 3) A forward contract which matures on T, with a forward price of M * S_0. Figure 3 shows the cash flows to the replicating portfolio. Comparing with Figure 2, we see that the portfolio indeed has exactly the same payout as the gold-denominated depositary shares.

[Place Figure 3 about here]

Since the issue price of the gold denominated depositary shares is known in dollar terms, we can calculate the implied yield on the depositary shares by calculating the present value of the cash flows to the three components of the replicating portfolio. The implied yield on the straight debt component of the depositary shares should 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. Since the fixed payment on the swap is the current gold price, all the expected cash flows are paid to the investor by FCX. Further, the cash flows include an exchange based on the face value of the depositary shares. This makes counter-party credit risk an important element in determining their value. Therefore, we use the same risk-adjusted yield measure as that used for the straight bond when calculating the present value of the cash flows to the swap and the forward.

5.1 The term structure of gold interest rates

We need a model for pricing the embedded gold swap and forward contract as an intermediate step in calculating the value of the depositary shares. We develop an empirical pricing model using the implied net-cost-of-carry from the gold futures market to proxy for the implied interest rate for lending gold and to detract from convenience yield issues in a theoretical futures pricing model.[12] The gold futures market is, however, not complete and data is not available for maturities beyond five years. Further, the cash flows do not exactly match the expiration dates on the available futures contracts. Therefore, we also need to use an interpolation and extrapolation method to calculate the gold interest rates for maturities that

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[12] McDonald and Shimko (1998) find that the convenience yield on gold is generally positive in the period 1980 - 1998, but is time varying.

cannot be inferred directly from the futures markets. We achieve this by fitting a Vasicek model to the term structure of gold rates.

Using a model for the term structure of gold rates on the day FCX issued the depositary shares, we determine forward rates for maturities corresponding to the gold payment dates of the shares and calculate the expected dollar equivalent of all the gold cash flows. The forward rates are used to calculate the dollar equivalent of all the gold payments. The final step is to discount the expected cash flows and the nominal yield is calculated such that the present value of the expected payments to the replicating portfolio is equal to the initial dollar equivalent price of the depositary shares. 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.

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. Table 6 also reports gold futures prices on August 5, 1993 traded on NYMEX and the implied cost-of-carry. Figure 4 plots the data and the fitted model, and reports the parameters of the model fitted to the rates shown in Table 6.[13] We assume that these parameters also apply to the London P.M. fixing gold prices.

[Place Table 6 and Figure 4 about here]

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

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[13] 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.

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.

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 preferred stock structure also makes these securities junior to their currently outstanding debt. The positive markets reception for the gold-linked depositary shares indicates that these concerns were secondary to the advantages and FCX was able to successfully use financially engineered securities to reduce the cost of raising funds in the capital markets.

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 second series of 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 gold-denominated depositary shares to price the silver 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 4.125%, 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 graphs the term structure.

[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 is 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 financial engineering 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 only to the newly issued securities. Our analysis indicates that the reduction in borrowing cost was achieved because the structure of the depositary shares credibly committed the firm to hedging in order to enhanced their credit quality.

One of the important contributions of our paper is to extend the analysis 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 in the presence of existing debt, 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 embedded derivatives versus derivatives market contracts when the firm is in default. With appropriate security design it is possible for firms to implement a risk management program that avoids positive externalities to senior bondholders. When hedging is credible and benefits are targeted on the newly issued securities, the increase in value is reflected in their pricing. Shareholders, therefore, are able to capture hedging benefits. The depositary share issue by FCX is an example of such security design, and their pricing indicates that the firm was able to issue the securities at an enhanced value.

We also show that financially engineered securities are able to overcome the asset substitution problem associated with risk management and the moral hazard problems associated with debt indexation. Specifically: 1) FCX was able to credibly commit to risk management, even though shareholders have an incentive to un-hedge after the debt issue resolving the asset substitution problem raised by 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 resolving the moral hazard problem raised by 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)).

Our results have broader implications for situations other than those examined in this paper. Our conclusions imply that alternate methods of implementing a risk management program are not equivalent in general, and that financial engineering impacts the valuation of the firm's other outstanding liabilities. These issues are important, for example, for firms which are considering the issue of floating rate debt or foreign exchange denominated debt. Issuing floating rate debt or FX denominated debt is not always equivalent to issuing fixed rate debt and entering into a fixed-for-floating dollar swap or fixed-for-floating FX swap. It is important to take into account any differences in how obligations of the derivatives counterparty are treated when the firm is in default especially when the cash flows on the derivative contract are correlated with the cash flows of the firm.

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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**[14] 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

[14] 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 $500.0 million

	Min	Sr Debt -> Paid	Jr Debt -> Paid <- Default	Max	**Expected Value**
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 <- Default	Max	**Expected Value**
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 <- Default	Max	**Expected Value**
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)

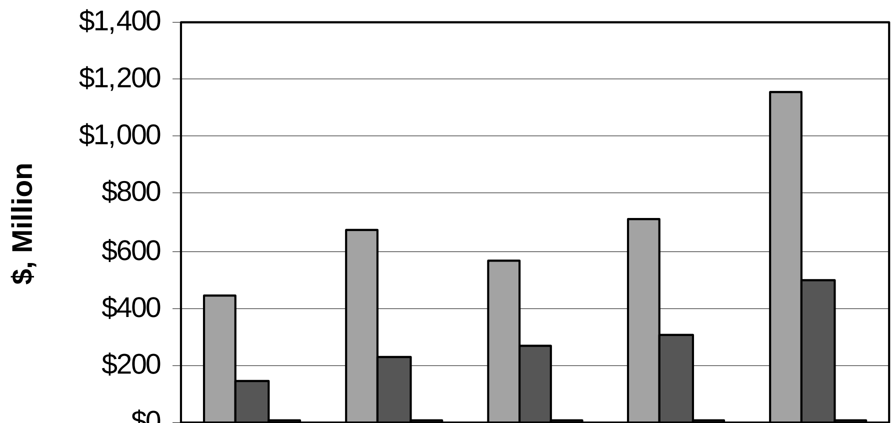
Contract Month		Settle	Change (1 day)	Open Interest	Implied Rate
JUL	94	525.7	+ 3.0	145	-
SEP	94	528.0	+ 2.8	78,569	-
DEC	94	535.3	+ 2.8	24,450	3.59%
MAR	95	543.4	+ 2.8	6,633	4.49%
MAY	95	548.8	+ 2.8	3,618	4.77%
JUL	95	554.7	+ 2.8	3,102	5.04%
SEP	95	560.8	+ 2.8	548	5.25%
DEC	95	570.1	+ 2.8	2,098	5.48%
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

FIGURE 1: FCX's dollar sales of copper, gold, and silver

This graph shows the dollar sales in copper, gold, and silver, for FCX for the five year period 1991-1995. Data are from the firm's annual reports from1992-1996.



	1991	1992	1993	1994	1995
Copper	444.10	671.35	565.92	713.90	1,155.22
Gold	142.75	231.04	265.26	307.04	493.55
Silver	6.27	6.71	6.07	6.74	11.24

Figure 2: Cash flows of the gold/silver denominated depositary shares

GOLD/SILVER PAYMENTS

Depositary Shares
sold for face value M oz

0	1	2	T-1	T
COUPONS (Oz)	C	C	C	C
FACE VALUE (Oz)				M

DOLLAR EQUIVALENT VALUE

Each Depositary Shares
sold for M* $\$S_0$ /oz

0	1	2	T-1	T
COUPONS ($ Equivalent)	$C*S_1$	$C*S_2$	$C*S_{T-1}$	$C*S_T$
FACE VALUE ($ Equivalent)				$M*S_T$

where,	S_t	=	London P.M. fixing price of an ounce of gold at time *t*
			$S_t \in (S_1, S_T)$
	t	=	Time in quarters, $t \in (1, T)$
	C	=	Coupon per quarter in ounces of the commodity
	M	=	Face value in ounces of the commodity

Figure 3 : Cash flows of the replicating portfolio

DOLLAR-DENOMINATED BOND : (Coupon = $C * S_0$, Face Value = $M * S_0$)
\$-denominated
Bond sold for P_0

	0	1	2	∫∫	T-1	T
COUPONS :		$C*S_0$	$C*S_0$		$C*S_0$	$C*S_0$
FACE VALUE :						$M*S_0$

✚ FIXED-FLOATING GOLD SWAP: Fixed Payment = $C * S_0$
Floating Payment = $M * \$S_t$

Value $SWAP_0$

	0	1	2	∫∫	T-1	T
FLOATING :		$C*S_1$	$C*S_2$		$C*S_{T-1}$	$C*S_T$
- FIXED :		$-C*S_0$	$-C*S_0$		$-C*S_0$	$-C*S_0$
NET :		$C* (S_1 - S_0)$	$C * (S_2 - S_0)$		$C * (S_{T-1} - S_0)$	$C * (S_T - S_0)$

✚ FORWARD RATE CONTRACT : (Maturity = T quarters ; Forward Price = $M * S_0$)
Value F_0

	0	1	2	∫∫	T-1	T
PAYOFF						$M* (S_T - S_0)$

≡ PORTFOLIO PAYOFF (= DOLLAR EQUIVALENT VALUE OF GOLD-LINKED DEPOSITARY SHARES)

Portfolio Price = $P_0 + SWAP_0 + F_0$

	0	1	2	∫∫	T-1	T
COUPONS (\$ Equivalent)		$C*S_1$	$C*S_2$		$C*S_{T-1}$	$C*S_T$
FACE VALUE (\$ Equivalent)						$M*S_T$

where, S_t = London P.M. fixing price of an ounce of gold at time t, $t \in (1, T)$
S_0 = London P.M. fixing price of an ounce of gold on t=0

Figure 4: The implied gold yield curve on August 5, 1993

The parameters of the Vasicek (1977) model for the interest rate on a zero coupon instrument that has maturity T given below are: the speed of adjustment, a=0.297, the long term gold rate, b=0.054, the volatility of the short rate, σ =0, and the instantaneous short-term rate, r=0.024. The parameters were estimated using a modified simplex method such that they minimized the squared deviations from observed market rates.

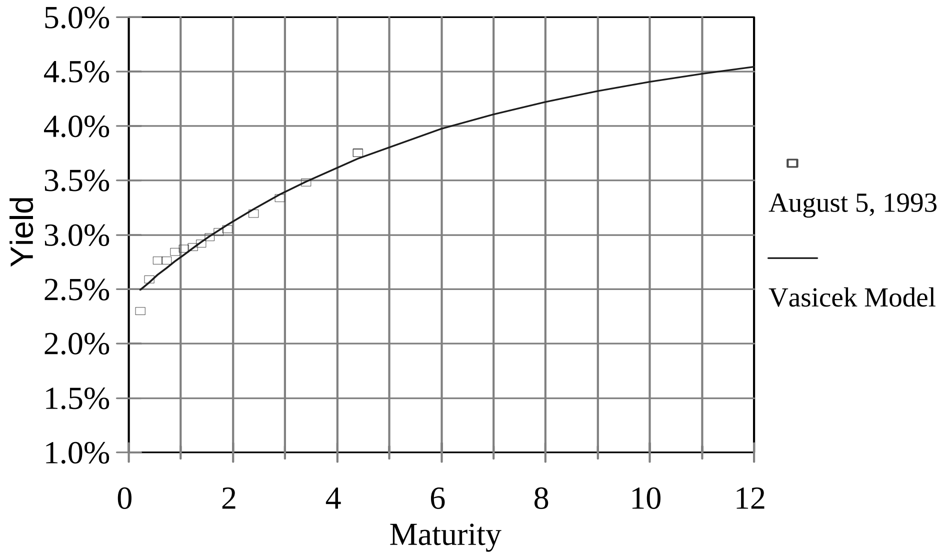


Figure 5: The implied gold yield curve on January 13, 1994

The parameters of the Vasicek (1977) model for the interest rate on a zero coupon instrument that has maturity T given below are: the speed of adjustment, a=0.293, the long term gold rate, b=0.063, the volatility of the short rate, σ =0.013, and the instantaneous short-term rate, r=0.023. The parameters were estimated using a modified simplex method such that they minimized the squared deviations from observed market rates.

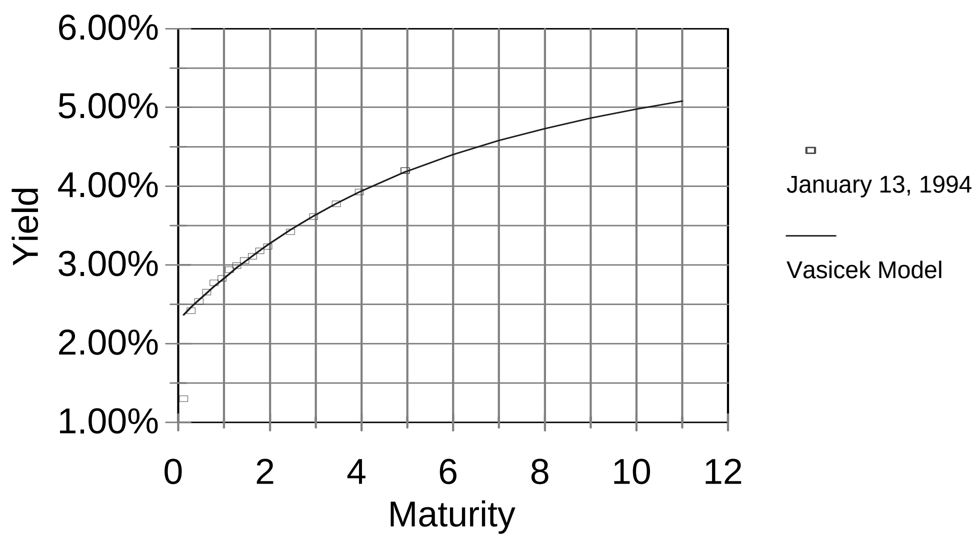


Figure 6: The implied silver yield curve on July 22, 1994

The parameters of the Vasicek (1977) model for the interest rate on a zero coupon instrument that has maturity T given below are: the speed of adjustment, a=2.470, the long term gold rate, b=0.075, the volatility of the short rate, σ =0.219, and the instantaneous short-term rate, r=0.009. The parameters were estimated using a modified simplex method such that they minimized the squared deviations from observed market rates.