Morgan Stanley

Journal of Applied Corporate Finance

WINTER 1995 VOLUME 7.4

Metallgesellschaft and the Economics of Synthetic Storage

by Christopher L. Culp and Merton H. Miller,
University of Chicago

METALLGESELLSCHAFT AND THE ECONOMICS OF SYNTHETIC STORAGE

*by Christopher L. Culp and Merton H. Miller, University of Chicago**

INTRODUCTION

MG Refining & Marketing, Inc. (MGRM), a U.S. subsidiary of the German industrial conglomerate Metallgesellschaft AG (MG AG), is a contender for the world's record in derivatives-related losses—$1.3 billion by press accounts at year-end 1993. Unlike many of its rivals for that record, however, MGRM was not using derivatives as part of a treasury function, with a view to enhancing the return on an investment portfolio or to lowering the firm's interest expense.

MGRM's derivatives were part and parcel of its *marketing* program, under which it offered long-term customers firm price guarantees for up to ten years on gasoline, heating oil, and diesel fuel purchased from MGRM. The firm hedged its resulting exposure to spot price increases to a considerable extent with futures contracts. Because futures contracts must be marked to market daily, cash drains must be incurred to meet variation margin payments when futures prices fall. After several consecutive months of falling prices in the autumn of 1993, MGRM's German parent reacted to the substantial margin calls by liquidating the hedge.

The top management of the parent corporation has yet to make clear why it chose to unwind the futures leg of the hedge while the fixed-price contracts were still in force. That MGRM had no way of financing the margin payments, except on distress terms, cannot be the explanation. Even if MGRM had been locked out of public capital markets, it hardly needed to go "hat-in-hand" to strangers unfamiliar with its strategy. Over 100 of the world's leading banks were *already* creditors to MG AG; and Deutsche Bank, one of the world's largest financial institutions, was both a major creditor *and* a major stockholder of MGRM's parent. If new sources of outside credit had to be tapped, the program should have been "self-financing" because the flow contracts increased in expected value as oil prices fell. Other ways of staunching the cash drains on

*For comments on earlier drafts (under various titles), we owe thanks to Malcolm Basing, Halsey Bullen, Don Chew, George Constantinides, Kent Daniel, Dean Furbush, Ken French, Steve Hanke, Steve Kaplan, Randy Kroszner, Bill Margrabe, Mark Mitchell, Todd Petzel, Richard Roll, José Scheinkman, Charles Smithson, and to a number of industry and derivatives specialists, many of whom prefer to remain anonymous (even those who agree with us!). Special thanks are due to Barbara Kavanagh for helpful discussions on credit risk and funding risk.

the futures, while still remaining hedged, were also available had the firm really been facing a binding cash constraint.

Perhaps the supervisory board of the parent believed that MGRM was not hedging, but "speculating" on oil prices. The team the supervisory board called in to liquidate the futures positions, after all, had resolved an earlier oil derivatives fiasco for Deutsche Bank—the notorious Klöckner speculative episode of some six years before.[1] Possibly the supervisory board of the parent misinterpreted the appeals by its MGRM subsidiary for more cash as "doubling-up" or, at the least, as the telltale sign of a business failure in the making. Or perhaps the supervisory board had other corporate motives of its own for ending the program.[2]

Whatever the reason, the decision to liquidate the futures leg proved unfortunate on several counts, turning "paper losses" into realized losses, sending a distress signal to MGRM's over-the-counter (OTC) derivatives counterparties, and leaving MGRM exposed to rising prices on its remaining fixed-price contracts.

In this article we explore in more detail the economics of MGRM's delivery/hedging program, a strategy aptly dubbed "synthetic storage."[3] But despite the frequent references throughout to MGRM, this article is not a case study in the usual sense. Too many essential facts about the program and its liquidation have still not been made public and perhaps never will be, given that one of the key lawsuits in the case has been sent to private arbitration.[4] Our focus here will be mainly on the economic logic underlying a synthetic storage program like MGRM's. In particular, we show such a strategy is neither inherently unprofitable nor fatally flawed, *provided* top management understands the program and the long-term funding commitments necessary to make it work.

DID MGRM'S MARKETING/HEDGING PROGRAM MAKE ECONOMIC SENSE?

MG's Marketing Program

MG AG is a 112-year-old enterprise owned largely by institutional investors, including Deutsche Bank AG, Dresdner Bank AG, Daimler-Benz, Allianz, and the Kuwait Investment Authority. At the end of 1992, MG AG had 251 subsidiaries with activities ranging over trade, engineering, and financial services. Its subsidiary responsible for U.S. petroleum marketing was MGRM.

In December 1991, MGRM recruited from Louis Dreyfus Energy Corporation Arthur Benson and his management team, whose key marketing strategy was to offer long-term customers firm price guarantees for five, and in some cases up to ten, years on gasoline, heating oil, and diesel fuel purchased from MGRM. So successful, apparently, were these marketing efforts that by September 1993 MGRM had sold forward the equivalent of over 150 million barrels (bbls.) of petroleum products in its flagship, long-term "flow delivery" contracts.[5] In conjunction with those forward short positions, MGRM entered long into futures and OTC derivatives, such as commodity swaps.

MGRM's derivatives positions protected the firm and its creditors against the *principal* risk the program faced—that is, the risk that rising spot prices would erode the gross profit margins on its fixed-price forward sales. Price protection *per se*, however, need not be presumed the primary motivation for the hedging. The combined delivery/hedging strategy was intended to maximize the expected profits from marketing and storing oil products, a field in which MGRM possessed special expertise and superior information, without having to gamble on directional movements in spot prices, an activity in which MGRM had no such comparative advantage.[6]

1. *See* Kenneth Gilpin, "Trying to Rescue a Soured Oil Bet," *New York Times* (March 9, 1994):D1.

2. For an account of the internal politics behind the liquidation decision, *see* Jens Eckhardt and Thomas Knipp, "Das Protokoll einer vermeidbaren Krise," *Handelsblatt* (November 4, 1994):28-29. We thank our colleague Rudi Schadt for his help in translating this very revealing article. *See also Heinz Schimmelbusch v. Ronaldo Schmitz, Deutsche Bank AG, and Metallgesellschaft AG*, Civ. Act. No. 94-134662, Supreme Court of the State of New York (December 16, 1994).

3. MGRM also engaged in "synthetic refining" by going long crude oil and short refined oil product futures (or vice versa)—in industry parlance, trading the "crack spread." (*See* Robert C. Merton, "Financial Innovation and the Management and Regulation of Financial Institutions," *Journal of Banking and Finance*, Vol. 19, No. 1 (1995 forthcoming).) To keep the story uncluttered, however, we will focus here mainly on MGRM's long-term flow contract and synthetic storage program.

4. Press accounts and statements from the new management of MG AG, possibly self-serving, have raised questions about the role MGRM's "offtake agreements" with Castle Energy might have played in the decision to liquidate MGRM's futures hedge. Because the public record on this matter is far from complete, however, we shall here and throughout be treating MGRM's combined delivery/hedging program as independent of the Castle Energy program.

5. *W. Arthur Benson v. Metallgesellschaft Corp. et. al.*, Civ. Act. No. JFM-94-484, U.S.D.C.D. Md. (1994):5.

6. MGRM's program is squarely in the tradition of Holbrook Working rather than in the these-days more familiar context of "variance-minimizing hedging." Stated differently, MGRM might be considered as effectively "risk-neutral" with little concern for the expected costs of bankruptcy given the financing commitments it believed it had from its parent and deep-pocketed shareholder/creditors. Much of the discussion of hedging in the finance and trade literatures is thus applicable only peripherally to our analysis of MGRM.

The bulk of MGRM's futures positions were on the New York Mercantile Exchange (NYMEX) in the most liquid contracts of between one and three months to maturity based on New York harbor regular unleaded gasoline, New York harbor No. 2 heating oil, and West Texas Intermediate (WTI) grade light, sweet crude oil.[7,8] Liquidity was an important consideration in MGRM's overall strategy, because it lowered the cost of managing its positions to meet seasonal changes in the demand and supply of heating oil and gasoline.[9]

Most of MGRM's fixed-price contracts also contained an "option" clause allowing counterparties to terminate their contracts early if market prices surged above the fixed price at which MGRM was selling the oil product. Why MGRM included these sell-back options in the first place will become clearer later. But because contingent liabilities of that kind can raise the specter of "runs" on a supplier, MGRM sought to reassure its customers by contractually agreeing to remain fully hedged[10]—a policy it was prepared to follow for the separate reasons already noted.

Hedging Long-dated Obligations with Short-dated Futures[11]

Borrowing short and lending long is an oft-cited recipe for financial disaster. But for MGRM, unlike, say, the S&Ls of the 1980s, or the more recent episode in Orange County, California—an episode purportedly surpassing even MGRM in losses incurred—maturity mismatch was not the real culprit.

Counter-intuitive as it may seem, a firm *can* use short-dated futures to hedge its long-term delivery commitments against spot oil price increases simply by purchasing a "stack" of short-dated futures equivalent to its remaining delivery obligations. Note, in this connection, that we are not here saying (nor have we ever said) that such a stacked hedge is a *perfect* hedge, whatever that may mean.[12] The strategy involves risks other than the principal one of market price risk, and those additional risks will be considered in due course later.

The mechanics of a stacked hedging strategy are straightforward. On the first delivery date, the firm buys in the spot market for delivery, offsets all its maturing futures contracts, and re-establishes a long position in the new front-month (i.e., one-month) futures contract—this time, though, with its long futures positions reduced by the amount delivered on its flow contracts. On the next settlement date, the hedger again decreases the size of its futures position by the amount delivered and rolls the rest forward to the next maturing one-month futures contract. And so on, month by month.[13,14]

A Three-Period Example. To convince yourself that such a stacked hedging strategy can protect a firm's gross profit margin, consider the following three-period example in which a firm enters fixed-price flow contracts to sell 1,000X bbls. of oil monthly for $20/bbl.[15] Suppose prices happen to rise over time as follows:

$$S_0 = \$17 \qquad S_1 = \$18 \qquad S_2 = \$19 \qquad S_3 = \$20$$

7. Under NYMEX rules, MGRM had been granted a "hedging exemption," allowing it to hold total futures positions of 55 million bbls. (25 million bbls. of WTI crude, 15 million bbls. of gasoline, and 15 million bbls. of heating oil). NYMEX rules also limit substantially the amount held in the front or delivery month contract. For simplicity of exposition, however, we assume throughout that the entire position was in the front-month futures contract even though, as will become clearer later, this assumption exaggerates some of the costs of managing the program.

8. The major portion of MGRM's hedge was actually in "over-the-counter" (OTC) derivatives, including commodity swaps and forwards. If it hedged a total of 150 million bbls., its OTC position would have been on the order of 95 million bbls. These OTC positions, rarely more than three months to maturity, were functionally equivalent to the futures MGRM held, so that, for simplicity, we proceed as if MGRM's entire hedge was in futures. MGRM's OTC position is discussed in Appendix 1.

9. For an account of how futures may be used in seasonal inventory management, *see* Holbrook Working, "Futures Trading and Hedging," *American Economic Review* (June 1953):314-43, and Holbrook Working, "New Concepts Concerning Futures Markets and Prices," *American Economic Review* (June 1962):432-59.

10. Just how to interpret that contractual obligation to remain hedged is precisely the issue in one prominent and highly contentious court case. *See Thornton Oil Corp. v. MG Refining and Marketing, Inc*. Civ. Act. No. 94-CI-01653, Jefferson Circuit Court Div. Five, Ky. (March 29, 1994).

11. Portions of this section are based on Christopher L. Culp and Merton H. Miller, "Hedging a Flow of Commodity Deliveries with Futures: Lessons from Metallgesellschaft," *Derivatives Quarterly* Vol. 1, No. 1 (Fall 1994).

12. The only perfect hedge can be found in a Japanese garden, as accountants often quip. Certainly the so-called "variance-minimizing hedge," which would presumably involve a smaller stack, does not meet the test of perfection in this context for a variety of reasons. The key coefficients underlying the "optimal" hedge ratio can only be estimated from past data subject to considerable error. A hedge designed solely to minimize the variance of net cash flows in the face of price changes, moreover, need not be maximizing expected returns to the firm. Important managerial and control motivations for corporate hedging also exist that are not always well-captured by a variance-minimizing approach. We will deal with some of these issues in a subsequent paper.

13. Because futures contracts, unlike forward contracts, are marked to market daily, normal market practice is to reduce the size of a hedge by "tailing." (*See, for example,* Ira G. Kawaller, "Comparing Eurodollar Strips to Interest Rate Swaps," *Journal of Derivatives* Vol. 2, No. 1 (Fall 1994):67-79, and the references therein.) We ignore this adjustment in our examples for simplicity.

14. Note that while the policy is dynamic in the sense that the number of contracts in the stack changes over time, the policy is not appropriately described as "dynamic hedging." Unlike true dynamic hedging, the synthetic storage stack adjusts not to changes in *prices*, but only to the quantities actually delivered. MGRM, it is true, might well have increased its expected long-run profits by dynamic hedging—increasing the stack as prices rise, and decreasing it as prices fall. But there are no free lunches. Catastrophic losses can result if prices gap unexpectedly and adversely while the futures portfolio is being rebalanced—as dynamic hedgers in a variety of contexts have learned to their sorrow over the years.

15. Crude oil is used in the examples because prices and the quantities for crude are denominated in more tractable units than heating oil and gasoline.

The combined delivery/hedging strategy was intended to maximize the expected profits from marketing and storing oil products, a field in which MGRM possessed special expertise and superior information, without having to gamble on directional movements in spot prices, an activity in which MGRM had no such comparative advantage.

TABLE 1
HEDGING LONG-DATED OBLIGATIONS WITH SHORT-DATED FUTURES

	Cash Flows			Income		
Month	(1) Spot[a]	(2) Futures[b]	(3) Net Cash Flow	(4) Gross Flow Contract Income[c]	(5) Net Cost of Carry[d]	(6) Net Income
1	\$2,000X	\$3,000X	\$5,000X	\$3,000X	0X	\$3,000X
2	\$1,000X	\$1,420X	\$2,420X	\$3,000X	(\$580X)	\$2,420X
3	\$0X	\$560X	\$560X	\$3,000X	(\$440X)	\$2,560X
TOTAL	\$3,000X	\$4,980X	\$7,980X	\$9,000X	(\$1,020X)	\$7,980X

a. $1000X \bullet (20 - S_t)$
b. (# contracts) $\bullet$ X $\bullet$ 1000 $\bullet$ $(F_{t,t} - F_{t-1,t})$
c. $1000X \bullet (20 - S_0)$
d. (# contracts) $\bullet$ X $\bullet$ 1000 $\bullet$ $(S_{t-1} - F_{t-1,t})$

where S_t denotes the spot price at time t. Given those prices, we can approximate the time t prices of the futures contract in the stack by invoking the familiar "cost of carry" formula:[16]

$$F_{t,t+1} = S_t[1 + b_{t,t+1}] = S_t[1 + r_{t,t+1} + z_{t,t+1} - d_{t,t+1}]$$

where the one-period "basis," $b_{t,t+1}$, includes the interest cost of physical storage $r_{t,t+1}$, the physical cost of storage $z_{t,t+1}$, and the "convenience yield" of having physical inventories on hand $d_{t,t+1}$—all assumed known at the start of period t and all expressed as a fraction of the time t spot price.

Suppose further that the current one-period interest rate, storage cost, and convenience yield are

$$r_{0,1} = 0.005 \qquad z_{0,1} = 0.01 \qquad d_{0,1} = 0.015$$

and that those values happen to change over time as follows:

$$r_{1,2} = 0.008 \qquad r_{2,3} = 0.01$$
$$z_{1,2} = 0.015 \qquad z_{2,3} = 0.02$$
$$d_{1,2} = d_{2,3} = 0.007$$

Given these values for the above variables and the assumed path for spot prices, the one-period futures prices and bases will evolve as follows:

$$F_{0,1} = \$17.00 \qquad F_{1,2} = \$18.29 \qquad F_{2,3} = \$19.44$$
$$b_{0,1} = 0.0 \qquad b_{1,2} = 0.016 \qquad b_{2,3} = 0.023$$

When the basis is positive and thus the current futures price is higher than the current spot price, the market is said to be in "contango" for that period. Although not typical of oil markets, we are assuming in this example, to make the role of storage costs stand out most sharply, that the market moves unexpectedly into contango at time 1 and stays there.

Table 1 shows the cash flow and income statements over the three periods for a firm selling 1000X bbls. of oil each period for \$20/bbl. The firm holds initially three futures maturing at month 1, then rolls into two contracts maturing at month 2, and finally into one contract maturing at month 3.

In month 1, for example, the firm delivers 1000X bbls. at \$20/bbl. on its flow contract, obtaining that oil by buying in the spot market at \$18/bbl. Its spot cash flow (Column (1)) thus is \$2,000X. At the same time, the firm offsets the three futures it had previously initiated in month 0 at a price of \$17.00/bbl., re-establishing at \$18.29/bbl. two new long positions maturing in month 2. Because spot and futures prices must be equal at maturity, its month 1 futures cash flow (Column (2)) is \$3,000X=3X•1000•[18–17].

Column (4) shows the gross margin on the flow contract. Because the firm hedged when the spot price was \$17/bbl., it "locks in" a gross margin per period of \$3,000X. The net cost of carry (Column (5)) reflects the storage costs the firm effectively pays each month when it rolls over its stack of futures. At the end of month 1, for example, the firm offsets its

16. For a succinct explanation of the cost of carry formula, *see* Merton H. Miller, "Equilibrium Relations Between Cash and Futures Markets," in *Financial Innovations and Market Volatility* (Cambridge: Blackwell, 1991).

three futures at \$18/bbl. and re-establishes a position of two futures at \$18.29/bbl. Its implicit storage cost for the second month thus is \$580X = 2X•1000•[18–18.29]. The *net* margin for the hedger (Column (6)) is thus its gross margin from the fixed-price deliveries less the implicit cost of storing oil using futures.

Note also that while the hedger's monthly net margin over the entire period need not equal its monthly net cash flow, the firm's *total* net margin equals the *total* net cash flow, regardless of spot price movements. In this sense, the firm's net worth is indeed fully hedged against spot price risk.

The Benefits and Costs of Synthetic Storage

Our example above has been constructed deliberately with the basis positive and rising. In oil markets, however, unlike most commodity markets, the basis is typically *negative*; that is, the spot price is greater than the futures price because the convenience yield often exceeds the cost of physical storage plus the interest cost of storage. In the case of crude oil, for example, the front-month basis, defined as $F_{t,t+1} - S_t / S_t$, averaged –.0082 over the period May 1983 to September 1994; and for heating oil, the proportional basis averaged –.0096 from January 1980 to September 1994.[17]

The negative basis, usually referred to as "backwardation," occurs when the current demand for oil is high relative to current supply. Because firms may need physical oil on hand to avoid inventory stock-outs, spot prices rise above futures prices to reward firms for "lending" their inventory to the current spot market, as it were.[18] When the market is in backwardation, a stacked hedger remains hedged against spot price changes, but its net margin is *higher* than the gross margin to reflect the negative net cost of carry. The firm is still paying the cost of storage, of course, but the presence of those costs is masked by the high convenience yield.

The stacked hedging strategy of synthetic oil storage does differ from actual physical storage in some important respects, however. In the physical storage strategy, the firm pays its own marginal costs of storage and receives its own marginal convenience yield. By contrast, under the synthetic storage strategy, the firm pays the marginal storage cost net of the convenience yield for the marginal physical storer. A firm expecting its own marginal cost of storage to be higher than the marginal cost of storage in the futures price would thus be better off *ex ante* hedging with futures rather than physical storage. By the same token, fully-integrated producing firms with lower marginal costs of storage—such as Exxon with tank farms around the world—typically find it more efficient to store physically rather than synthetically.

Were "Rollover Costs" a Basic Flaw in the Strategy?

Critics have argued that "the crushing impact of [MGRM's] monthly rollover costs"[19] made MGRM's hedging method a "basically flawed trading strategy."[20] The rollover cost is the difference between the price of the maturing futures contract and the price at which the new futures position is established times the size of the stack. As long as the rollovers are in front-month contracts and occur near the maturity date, the price of the expiring futures contract is essentially the spot price because the two must converge at maturity. The rollover cost is thus just the basis expressed as a lump-sum dollar value. In our previous illustration, for example, the time 1 rollover cost per contract would be $F_{1,1} - F_{1,2} = S_1 - F_{1,2}$ = \$18 – \$18.29, or a cost of \$0.29. (Adjusted for the size of the stack, this total rollover cost of \$580X appears in Column (5) of Table 1 in the row corresponding to Month 2.)

Because the front-month rollover cost per contract is simply the basis in another form, expected rollover costs are quite literally the marginal expected implicit costs of interest and physical storage less the convenience yield built into futures prices. As noted earlier, the one-month net cost of storage and interest *averaged* less than zero over the last ten years. Even so, some critics believe the decision to liquidate MGRM's futures hedge was justified because those costs were becoming excessive in the autumn of

17. Past results, of course, are no guarantee of future performance—a phrase familiar enough from mutual fund prospectuses—but ample theoretical grounds exist for believing that the numbers above are not just sample-dependent flukes. *See* Robert H. Litzenberger and Nir Rabinowitz, "Backwardation in Oil Futures Markets: Theory and Empirical Evidence," Working Paper, The Wharton School (April 11, 1994).

18. *See* Jeffrey Williams, *The Economic Function of Futures Markets* (Cambridge: Cambridge University Press, 1986), and the references therein.

19. Michael J. Hutchinson, "The Metallgesellschaft Affair: Risk Management in the Real World," Memorandum (October 10, 1994):3. Hutchinson was a member of the management team that took over in December 1993 and unwound MGRM's futures positions.

20. William Falloon, "The Market Responds," *Risk* Vol.7, No. 10 (October 1994):29.

The liquidation of the hedge, though relieving MGRM of the net costs of oil storage, exposed it instead to spot price risk on its still-outstanding flow contracts. And spot price risk is huge relative to basis risk.

1993.[21] And indeed, by historical standards, the rollover costs then may well have been perceived as unusually high. For crude oil, the November 1993 mid-month rollover cost was \$0.33/bbl. compared to a mean over the entire sample of –\$0.2091/bbl., placing that month in the 86th percentile of the historical sample. For heating oil, the corresponding values were \$0.0021/gal., –\$.0076/gal., and the 56th percentile; and for gasoline, \$.0187/gal., –\$.0082/gal., and the 89th percentile.[22] (See Appendix 2.)

We remind readers, however, that the liquidation of the hedge, though relieving MGRM of the net costs of oil storage, exposed it instead to spot price risk on its still-outstanding flow contracts. And spot price risk is huge relative to basis risk. In a regression of front-month futures prices ($F_{t,t+1}$) on the contemporaneous spot price S_t, the value of R^2 will measure the fraction of the variance in futures prices explained by the variation in spot prices. For crude oil (May 1983 to February 1994), the R^2 was .99, for heating oil (January 1980 to September 1994) the value was .96, and for gasoline (December 1984 to September 1994) the value was .95. Or, to put it the other way around, no more than one to five per cent of the historical variation in futures prices can be traced to variations over time in the basis.[23]

Not only do variations in the basis thus account for little of the intertemporal variation in futures prices, but we also know that the lump-sum dollar basis (i.e., the rollover cost) varies inversely with spot prices. For WTI crude, heating oil, and gasoline, the simple correlation coefficients of each basis with spot prices were –0.359, –0.091, and –0.453, respectively, for the sample periods noted above. If, therefore, the supervisory board's decision to liquidate the hedge in mid-December 1993 was done to avoid rollover costs, that decision turned out to be doubly-cursed when crude and heating oil prices rose *and* rollover costs fell in early 1994—triply-cursed, in fact, because the futures positions were unwound in mid-December 1993 *after* the December rollovers had already occurred.

Finally, critics of MGRM rarely seem to recognize that rollover costs by themselves tell us nothing about the profitability of a *combined* delivery/hedging strategy. A combined delivery/hedging program of the kind MGRM was following must not be judged by the storage or related costs it happens to incur *over any short interval of time.* What counts, rather, is the program's profit potential over the long haul or, as finance specialists might prefer to put it, its expected net present value. How to compute the requisite net present value for a *hedged* delivery program is far from obvious, but we sketch out the method for doing so in the next section, leaving the mathematical details to a separate paper.[24]

The Marketing/Hedging Decision as a Capital Budgeting Problem

Calculating the net present value of a combined delivery/hedging program would be simplicity itself, of course, in a futures market with a complete set of contracts covering every maturity for which the flow commitments had been made. As long as the fixed price for deliveries in period T exceeds the current T-period futures price, the locked-in *net* profit on the period T delivery is precisely the difference between the two prices. By going long X T-period futures contracts for each 1,000X bbls. of period T delivery commitments, MGRM would both have hedged the delivery commitments *and* reduced basis or rollover risk (but, by the same token, also giving up any rollover gains). The set of futures contracts actually available, however, is *not* rich enough to support such a strategy—a pure "strip," as it is called in the trade. The NYMEX has no liquid contracts for crude beyond 18 months to maturity and a year to maturity in heating oil.[25]

Though futures contracts are not available for all maturities, their prices can be approximated by repeated application of the cost of carry formula. In particular, the presumptive basis for a T-period

21. *See, for example,* Hutchinson, cited previously, and Falloon, cited previously.

22. Some critics of MGRM have argued that MGRM's position in the oil market was so large by November that its very presence kept the market in contango, presumably because prices were bid up by other traders on the contracts into which they knew MGRM had to roll each month and bid down on the contracts MGRM was offsetting. Assuming MGRM held as many futures contracts as the NYMEX allowed firms with a hedge exemption, MGRM would have held 25,000 WTI crude futures, 15,000 gasoline futures, and 15,000 heating oil futures. Those amounts would have constituted 6.32%, 11.06%, and 7.88% of the total NYMEX open interest in December 1993 in those products—hardly numbers to suggest MGRM was driving the market. Note also that crude oil, at least, remained in contango as late as March, long after MGRM's futures liquidation.

23. No evidence of which we are aware supports the notion that a structural change in market conditions occurred in 1993. Although realized rollover costs were high, the coefficients of determination of futures prices regressed on spot prices in 1993 are virtually the same as those for the full sample.

24. *See* Christopher L. Culp and Merton H. Miller, "The Net Present Value of Hedged Commodity Contracts," mimeo, The University of Chicago, Graduate School of Business (forthcoming, 1995).

25. WTI crude futures are also listed for maturities of 21, 24, 30, and 36 months to maturity, but those contracts are relatively illiquid.

futures contract would be the *expected* value of the storage and interest cost net of convenience yield over T periods. If the cash receipt on a period-T fixed-price delivery discounted at that expected basis exceeds the current price of oil, the program has a positive *expected* net present value.[26] Stated more formally, a firm will enter into a hedged N-period fixed-price delivery program to sell one unit of oil each period if the program has a positive expected NPV at time t=0—that is, if

$$E_t(NPV_t) = \sum_{j=t+1}^{N} \frac{K_j}{1 + E_t(b_{t,j})} - (N - t)\bullet S_t > 0 \qquad (1)$$

where K_j is the fixed price of a time j delivery, S_t is the time-t spot price, and $E_t(b_{t,j})$ is the basis expected to prevail from time t to j evaluated with information available at time t.

Although different hedging strategies may have different values for the $E_t(b_{t,j})$ terms in equation (1), we show elsewhere that under plausible assumptions about equilibrium futures pricing, MGRM's strategy must have the same *expected* NPV at time 0 as a pure strip.[27] *Realized* outcomes may differ from their expectations, however. Some strategies may thus have higher or lower net profits *ex post*, depending on how the bases happen to evolve over time relative to initial conditional expectations.

That the expected NPV might be positive for MGRM does not mean, of course, that the expected NPV is necessarily negative for MGRM's customers. MGRM's customers, almost by definition, have very high marginal storage costs and place a high value on security of delivery.[28] Those customers might have opted for synthetic storage themselves, of course, but as episodic "do-it-yourself" users of derivatives have come to recognize, risk management professionals have a considerable comparative advantage in those matters.

The Economic Function of the Sell-back Options

The expected value of the program can be recalculated each period to reflect the arrival of new information. In the example above, we assumed that the market moved at time 1 unexpectedly into contango, which would change the discount rates used in expected NPV calculations *after* time 0. Using the value of $b_{1,2}$ realized at time 1 for $E_1(b_{1,2})$, 0.016, and assuming $E_1(b_{1,3})$ = 0.032 = 2•0.016, the expected NPV of the program *conditional* on information available at time 1 is

$$E_1(NPV_1) = [(\frac{20}{1.016} + \frac{20}{1.032}) - 18 \bullet 2] \bullet 1{,}000X = \$3065X$$

The conditional expected NPV at time 2 using the still-higher one-period basis prevailing then is \$550X. Despite the two unexpected increases in the basis, the conditional expected NPV of the program is positive at the beginning of all three periods.

Now suppose instead that spot prices beyond period 0 were to increase more rapidly than before, say, as

$$S_0 = \$17 \qquad S_1 = \$19 \qquad S_2 = \$21 \qquad S_3 = \$23$$

The initial expected NPV of the program would still be positive (\$9,000X), and hence a rational corporation would again accept the policy at time 0. The conditional expected NPV is also positive at time 1 (\$1,065X). But now the conditional expected NPV of the program would be negative at time 2 (–\$1,550X). A firm committed to the combined delivery/hedging program at time 0, though still technically hedged, would then seem to be profiting handsomely on the stack of futures but "losing money" on the flow contracts. If the firm could possibly end the program by "buying out its customers" for *less* than it expects to pay for servicing them, it would.

Bilaterally-negotiated contracts cannot be unwound at zero cost, however, especially on favorable terms. Getting out of such contracts means negotiating their unwinding with customers on a case-by-case basis. The Master Agreements of the International Swaps and Derivatives Association (ISDA), for example, allow counterparties to choose a method of calculating "close-out settlement values" in the event OTC derivatives terminate early. In the absence of an "event of termination or

26. For a detailed proof, *see* Culp and Miller, mimeo, cited previously.
27. Culp and Miller, mimeo, cited previously.
28. The Chrysler Corp., for example, had a policy of putting five gallons of gasoline into every completed car coming off its assembly lines. Failure to have gasoline on-hand could mean shutting down the whole assembly line.

As a substitute for negotiated unwinds under a master agreement, MGRM chose to add the early exercise options to its flow contracts.

default," the unwinding counterparty must obtain the consent of the other party and negotiate the terms of the unwind, not always an easy or inexpensive task.[29,30]

As a substitute for negotiated unwinds under a master agreement, MGRM chose to add the early exercise options to its flow contracts. These options take effect when the front-month futures price rises above the fixed delivery price in the flow contract. On exercising their options, customers receive a pre-specified monetary payment equal to one-half the difference between the front-month futures price and the fixed price in the flow contract times the total volume remaining on the flow contract. The sell-back options thus not only specify in advance the method of calculating a "close-out price," but also eliminate the need for negotiating the close-out itself.

Although customers might wish to exercise their sell-back options if they expect spot prices in the future to fall, they might well wish to do so even if they regarded a surge in spot prices as permanent. Remember that they must compare the immediate cash payment on exercise with the *present value* of expected future differences between spot prices and the delivery prices over the remaining life of the contract. And if the customers, unlike MGRM, are neither hedged nor otherwise well-diversified corporations, their discount rates must reflect the risk of changing spot prices as well as their own time-value of money. In any event, the likelihood that customers will exercise their buy-back options at some time in the life of their contracts cannot be ignored in appraising MGRM's synthetic storage program. Computing the exact present value to MGRM of those embedded "reverse options" is a task of great technical difficulty, but whether the exercise rights rested with MGRM or its customers, the value of those options would clearly be substantial in a world in which spot prices are highly volatile. By the same token, the presence of the options substantially reduces the effective tenor of the flow delivery contracts.[31]

The Expected Net Present Value When Prices Fall

When prices fall, a repeat of the previous calculations holding the expected bases constant would find the conditional expected net present value for MGRM actually rising, suggesting that a company in MGRM's position should be even more anxious to continue the program. This may seem paradoxical, of course, because of cash drains on the futures stack and management's possible reaction to them. Those cash drains, however, are essentially *sunk costs* at this point and, as such, should have no effect on current decisions about whether to *continue* the program. And because the firm is still hedged, those costs are not even sunk irrevocably but will eventually be recovered by the fixed-price deliveries over time.

Calculating the conditional expected NPV for MGRM when prices fall *and* the bases change is more difficult, because the effects are at least partially offsetting. To separate the effects, suppose first the term structure undergoes a uniform, parallel downward shift as spot prices fall. The discount rate in equation (1) would be unaffected, and the expected net present value would rise one-for-one with the fall in the spot price. When prices fall, however, prices of short-term futures typically will fall by more than deferred prices, giving rise to the "horizontal tornadoes" or "diving boards" about which oil derivatives specialists never cease to prattle. But precisely because these effects are concentrated at the short end, their impact on the conditional expected NPV is limited. They show up essentially as a temporary rise in *expected* rollover costs, thus reducing the gross present value of *near-term* deliveries. If the basis were assumed to remain at its high throughout the life of the contracts, the discounting effect would eventually overwhelm the spot-price effect for deliveries as well. But more reasonable estimates of the expected bases for deferred deliveries, calculated from historical market norms, would leave the expected NPV for the deferred deliveries and the program as a whole positive.[32]

29. For a discussion of the costs of unwinding, *see* Christopher L. Culp and Barbara T. Kavanagh, "Methods of Unwinding Over-the-Counter Derivatives Contracts in Failed Depository Institutions: Federal Banking Law Restrictions on Regulators," *Futures International Law Letter* 14(3-4) (May/June 1994):1-19.

30. *See* the ISDA Master Agreements (1992), §5-6 (events which trigger terminations of the Agreements), §7 (restrictions on transfers), and §6(e)(i)-(ii) (method of payment for close-out netting after a default or early termination). The ISDA Master Agreements are not the only master agreements, but they are the most widely used for common OTC derivatives contracts.

31. The uncertainty about the true tenor of the flow contracts will also seriously complicate the calculation of the size of the appropriate tail. *See* our earlier reference to tailing.

32. An upward-sloping term structure, moreover, implies a market expectation of rising spot prices and, hence, a declining basis. *See, for example,* Eugene F. Fama and Kenneth R. French, "Commodity Futures Prices: Some Evidence on Forecast Power, Premiums, and the Theory of Storage," *Journal of Business*, Vol. 60 (January 1987):55-74.

Customer Incentives and Credit Risk

Though MGRM would have no obvious incentive to terminate its flow contracts early when prices fall, its *customers* might. The sell-back options, however, specify no termination rights in the event of price *declines*. Customers could unwind their contracts after a price decline only by buying their way out; but they would have no positive incentive to do so unless MGRM offered to settle for less than the present value of the customers' purchase obligations. And indeed, that appears exactly what MGRM did in January 1994 when a new management awakened only belatedly to its naked price exposure following the futures liquidation. Despite the positive gross present value of the flow contracts to MGRM, it offered customers the right to terminate their contracts *with no close-out payment to MGRM*—"leaving money on the table," as they say on Wall Street.[33] How much money new management effectively burned in this fashion was still unknown at the time of this writing, but the cancelled contracts could have been for as much as 60 million bbls.[34]

Although some customers not released from their contracts might well have had incentives to "walk away" when prices fell, we remain unconvinced that customer credit risk could justify the draconian relief strategy of liquidating the futures hedge. Even in the face of price declines in 1993, no customer defaults have been documented. MGRM had stipulated in its flow contracts that none of its smaller customers could rely on MGRM for more than 20%—usually only 5-10%—of their annual required input purchases. Because MGRM was the only firm selling long-dated fixed-price delivery contracts, this ensured that at least 80% of the input purchases by those firms were being made at *variable* prices. Many of these smaller firms, moreover, were selling oil products at retail prices—far slower to adjust to market conditions than their wholesale input purchase prices.[35] Consequently, the smaller customers would be losing money on and thus might want to exit their flow contracts precisely when they are *making* money from the more than 80% of variable inputs purchased at the lower spot price. Nor should it be assumed in assessing the credit risks in MGRM's strategy that MGRM's customers were all of the "mom and pop" variety. MGRM's customer base also included large firms, Chrysler Corp., Browning-Ferris Industries Corp., and Thornton Oil Corp. among them.

Should MGRM Have Used Long-dated Futures?

Exactly as in the short-dated stacked hedging strategy, MGRM could have held an amount of futures always equal to its remaining delivery obligations, but this time in contract months with deferred maturity dates. As before, MGRM would have to roll over its hedge every month. This time, however, the current position would be rolled into the new *deferred* contract. This strategy, like MGRM's, would have protected the firm against the risk of rising spot prices.[36]

But the long-dated futures strategy was not obviously a superior alternative for a program as large as MGRM's. Volume and open interest are lower for longer-dated commodity futures contracts, so longer-dated futures would have had substantially higher transaction costs. Lower relative liquidity would also have made it difficult and much costlier for MGRM to switch its hedge between heating oil, gasoline, and crude as seasonal conditions dictated. A long-dated stack would also still have to be rolled each month, often a costly and challenging task in a relatively illiquid contract.

Because long-dated futures prices are imperfectly correlated with front-month prices, moreover, using long-dated futures would have exposed MGRM to basis risk on its customer sell-back options—that is, when the customers exercised their options, the long-dated contract price might not have risen as much as the front-month price on which the options were written. Of course, one might imagine that MGRM might then have based the settlement value of the sell-back options on the deferred futures

33. Plaintiff W. Arthur Benson's Reply to Defendants MG Corp. and MGR&M's Memorandum in Opposition to Plaintiff's *Motion for Permission to Depose MG Corp.'s Former General Counsel, W. Arthur Benson v. Metallgesellschaft Corp. et. al.*, Civ. Act. No. JFM-94-484, U.S.D.C.D. Md. (October 1994):3.

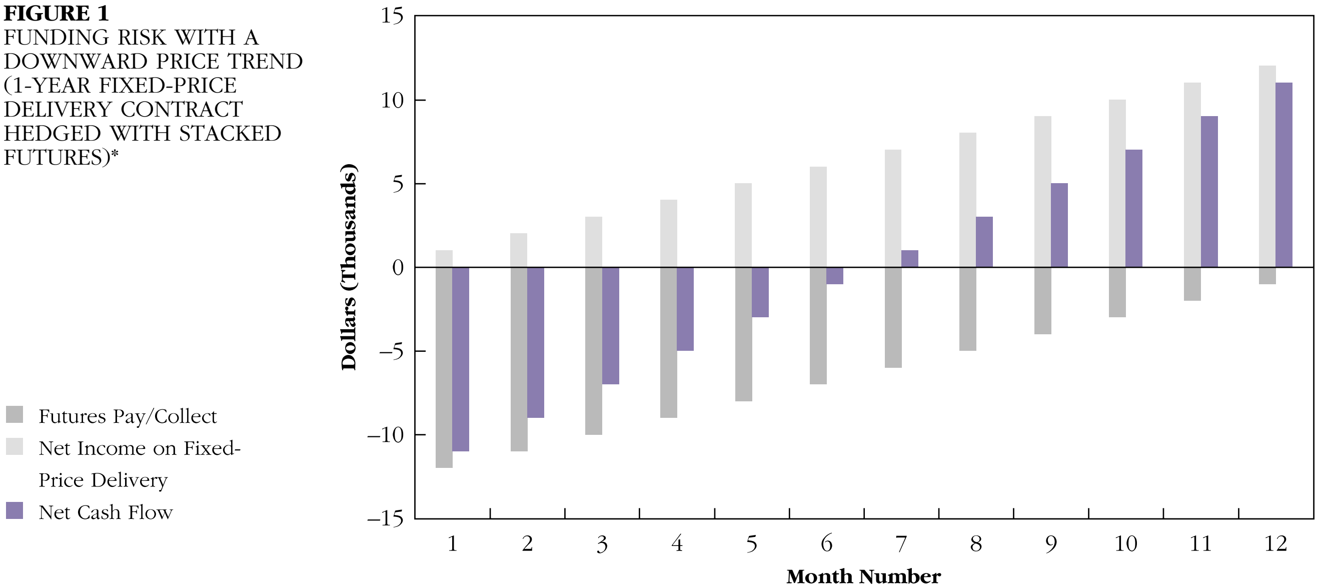
34. *See* Christopher L. Culp and Merton H. Miller, "Auditing the MG Shareholders' Audit," mimeo, The University of Chicago, Graduate School of Business (March 1995).

35. Note that the sluggishness of retail price adjustment works in the opposite way when wholesale prices rise. As retail prices rise more slowly, MGRM's customers might well welcome the immediate cash payment from MGRM in return for terminating their long-term flow contracts.

36. MGRM also might have employed several variations of this strategy, such as combining it with a strip for listed contract months—that is, matching futures maturities to flow contract deliveries for the listed futures contracts and stacking in the most deferred futures contract to hedge deliveries beyond that maturity. For a flow contract with five or 10 years to maturity, however, this strip and stack would be closer to a long-dated stack than a strip for most of the contract's tenor.

Although some customers not released from their contracts might well have had incentives to "walk away" when prices fell, we remain unconvinced that customer credit risk could justify the draconian relief strategy of liquidating the futures hedge.

FIGURE 1
FUNDING RISK WITH A DOWNWARD PRICE TREND (1-YEAR FIXED-PRICE DELIVERY CONTRACT HEDGED WITH STACKED FUTURES)*



*Assume an initial price of $20/bbl. and a $1 price decline each month. The fixed-price delivery involves the monthly sale of 1000 bbls. of oil at $20/bbl. for 12 months. The futures position is a stacked hedge beginning with 12,000 bbls. and declining by 1000 bbls. each month.

contract, but that would be to miss the point of those options. As with other options, the sell-back options are most valuable when prices are more volatile. In one sense, the spot price itself would have been the ideal asset on which to write the sell-back options, if indeed the concept of the "spot price" were better defined. Given the complexities of delivery grades, geography, liquidity, and the like, however, using the front-month futures contract here, as elsewhere in commodity markets, is the best approach to defining the "spot commodity."

WAS FUNDING RISK TO BLAME?

"Funding risk," or liquidity risk, has been defined as "[t]he inability to meet cash flow obligations at an acceptable price as they become due..."[37] Funding risk is a natural suspect for MGRM's problems because futures hedging programs can require substantial infusions of cash to meet variation margin calls when prices are falling. In 1993, oil and oil product prices fell precipitously after OPEC failed to reach agreements on its production quotas, and substantial margin payments were due from MGRM to the NYMEX.

The Funding Risk of a Marketing Program Hedged with Futures

In Figure 1 we illustrate the funding risk that a stacked hedger faces when prices fall in a 12-month example (with a zero basis for simplicity). Assume the price of oil falls steadily from $20/bbl. by $1 every month, and that margin calls are monthly. The cash flows are for a single flow contract to sell 1,000 bbls. of WTI crude each month at $20/bbl, and for a futures hedge of 12 contracts in the first month declining by one contract each subsequent month.

Note first that stacking creates a cash flow asymmetry over time between futures pays and collects and the net income on the fixed-price contract. Each $1 oil price decrease (increase) between settlement dates triggers a pay (collect) on the futures position that is 12-t+1 times larger than the net inflow (outflow) on the 12-month fixed-price contract, where t is the settlement month number. Thus, the cash requirements are largest in the early part of the program when the stack is large and reverse later as deliveries occur.

Although Figure 1 is designed to depict the funding risk of stacked futures, it is important to keep

37. Office of the Comptroller of the Currency, "Risk Management of Financial Derivatives," *Banking Circular No. 277* (October 27, 1993).

in mind that cash flows of the same order of magnitude would be required on *any* futures strategy in which the entire remaining delivery commitment is hedged. The only difference is the less than perfect correlation between futures prices of all maturities. Because short-dated futures are more volatile than long-dated futures, the cash inflows and outflows on a short-dated stack may be larger than those on a long-dated stack, but only marginally so.

The large cash infusions the stacked hedging program would require if prices fell can hardly have come as a surprise to the original management team at MGRM. You don't have to be a rocket scientist, after all, to prepare something like Figure 1. Given those likely cash drains, the team at MGRM would presumably not have maintained or expanded its program in the summer and autumn of 1993 unless it thought it had firm assurances from its parent and bank creditors that a secure line of credit was there on which to draw. As things turned out, MGRM had no such firm commitment, though the reasons why are still in dispute (and in litigation).

How Might the Cash Needs Have Been Financed at the Time?

The evidence suggests that funding risk alone was not responsible for the untimely end of MGRM's futures hedge; alternatives *were* available. That MGRM had no access to external financing, except on ruinous, distress terms, cannot be taken seriously. Even if MGRM had been locked out of public capital markets, it hardly needed to go "hat-in-hand" to strangers unfamiliar with its strategy. Over 100 of the world's leading banks were *already* creditors to MG AG; and Deutsche Bank and Dresdner Bank, two of the world's largest financial institutions, were both major creditors *and* major stockholders of MGRM's parent. And those very same creditors did agree, after all, on January 15, 1994, to a \$1.9 billion capital infusion to MG AG, raising the perplexing question of why that step was taken to cover the liquidation of the hedge rather than to continue financing it.[38]

If the expected net present value of the program was positive and substantial, moreover, the program as a whole should have been viewed as an asset by *any* would-be lenders.[39] Indeed, because the intrinsic asset value of the combined program was locked-in, the program was "self-financing" in the sense that the accreting gains on the flow contracts as oil prices fell should, in principle, have provided the economic equivalent of at least partial collateral to finance margin calls on the futures leg. Press accounts indicate that several banking institutions, including Chemical Bank and J.P. Morgan, made just such an offer to MGRM but were rebuffed by the new management team.[40] The puzzle thus remains as to why alternative sources of financing could not have been arranged.

Several authorities with whom we have discussed the possibility of collateralizing the margin loan have expressed concerns that the flow contracts alone might not have been usable as collateral because of the inability to "perfect a lien" on forward contracts. If the contracts could not serve directly as collateral, an obvious alternative for firms like MGRM (assuming existing debt covenants allowed it) would be to sell the program as a whole, as was done when the Development Finance Corp. of New Zealand failed;[41] or, to spin off the *combined* delivery/hedging program into a new subsidiary, as is routinely done with accounts receivable subsidiaries or issuers of "securitized products."[42] The stock of the new subsidiary could then be posted as collateral for the loan, with the additional covenant that the subsidiary remain hedged at all times.[43]

If the new affiliate remained hedged, it could continue to service its obligations to the bank no matter how much prices rose. Both firms would benefit from this arrangement; the new subsidiary obtains the funding it needs to continue its hedging/delivery program, thus earning the gross profit locked-in by hedging, and the bank earns interest on its loan.

38. Some believe that the liquidation of MGRM's program was inevitable once press reports of liquidity problems at MGRM appeared in early December, 1993. It is hard to believe, however, that a reassuring statement from Deutsche Bank at that point would not have quieted those concerns.

39. If lenders perceived, however, that MGRM itself as a company had a negative present value (as some have suggested because of the offtake agreements with Castle Energy mentioned earlier), even secured lending might have been problematic.

40. *See* Eckhardt and Knipp, cited previously, and *Schimmelbusch v. Schmitz et. al.*, cited previously. The precise details of those offers, however, have not been made clear.

41. *See* Culp and Kavanagh, cited previously.

42. For an example, *see* Barbara Kavanagh, Thomas R. Boemio, and Gerald A. Edwards, Jr., "Asset-Backed Commercial Paper Programs," *Federal Reserve Bulletin*, Vol. 78, No. 2 (February 1992):107-118.

43. If existing covenants preclude splitting off the delivery/hedging program, the funds would have to be provided by an equity infusion or additional subordinated debt. When MG AG was restructured in January 1994, additional equity and subordinated debt were indeed added.

MGRM faced operational risk, to be sure, but the opposite of that assumed by the GAO and many others: the supervisory board may not have understood that MGRM was hedging and not speculating.

Note in this connection that under these circumstances, the bank has no need to insist on a variance-minimizing hedge. The function of the variance-minimizing hedge is usually taken to be reducing a firm's reliance on the capital market for external financing by lowering the variance of the firm's cash flows. But what sense does a variance-minimizing hedge at the new subsidiary make for a bank that is *supplying* (at a price) the external financing the variance-minimizing hedge is intended to reduce?

MGRM might also have been able to staunch the cash drains on its futures positions if prices fell further by purchasing futures puts. Such an emergency strategy was in fact suggested by Benson and his team to the new MGRM management but was rejected. To the new team, still concerned about MGRM's cash drain on its futures position, Benson's suggestion must have seemed a classic "hair of the dog" remedy—in which a badly hung-over drunk proposes to start off the day with a double shot of whisky.[44]

Managing Funding Risk *Ex Ante*

Admittedly, arrangements like those above can be difficult to negotiate quickly and under duress, even when not embittered by managerial feuds and finger-pointing. Firms hoping to initiate potentially cash-intensive combined delivery/hedging programs like MGRM's might be well advised, therefore, to do an unsecured borrowing *up front* (in presumably calmer waters) equal to the initial face value of its total futures position—a so-called "pure synthetic" strategy. Rather than depositing only the required minimum initial margin with a futures exchange clearinghouse, such firms could give this *total amount* to the clearinghouse in T-bills thus ensuring that no further cash outlays would be required over the life of the hedge, regardless of price movements.[45] It can be argued, of course, that no lender could have assurance that the unsecured loan would in fact be used to purchase T-bills and posted as margin. But this potential agency problem could be solved by requiring the borrower to keep the funds on deposit at the lender bank. The lender bank would then pay all variation margin calls of the borrower by drawing down its margin-equivalent deposit account.[46]

THE REAL CULPRIT

The forced liquidation of MGRM's futures highlights an ill-defined, catch-all risk category dubbed "operational risk" by the Group of Thirty's Global Derivatives Study Group.[47] In the Group's open-ended definition, operational risk is associated with systems failures, natural disasters, or personnel problems. But operational risk also covers unapproved speculative activities by subordinates not detected by the senior management and board until serious losses have occurred.[48] In referring to MGRM, for example, the General Accounting Office states that "[p]oor operations controls were reportedly responsible for allowing losses at this firm to grow to such levels."[49]

A Failure of Understanding?

MGRM faced operational risk, to be sure, but the opposite of that assumed by the GAO and many others: the supervisory board may not have understood that MGRM was hedging and not speculating. As noted earlier, the team the supervisory board called in to liquidate the futures positions had also been used to resolve the Klöckner speculative episode for Deutsche Bank.[50] The supervisory board may have interpreted MGRM's appeals for more cash as "doubling-up" or, at the least, as the all-too-typical symptom of an imminent business failure. Or perhaps the supervisory board, in light of the power struggles then going on within MG AG,[51] may have deliberately chosen not to understand MGRM's program.

In any case, unwinding MGRM's futures positions, though widely applauded in some parts of the

44. For an account of the new team's views on liquidation strategy, *see* Gilpin, cited previously.

45. Not the least of the advantages in the notion of a pure synthetic strategy is its putting to rest, once and for all, the widely-held view that the "maturity mismatch" in a long-term delivery program hedged with short-term futures must inevitably give rise to financial distress when prices fall.

46. Either form of the pure synthetic strategy would allow the firm to earn interest on its margin or margin-equivalent deposit. Thus, despite the seemingly large numbers of the *principal* values involved, the total *interest* cost would only be the net difference in interest paid on the loan and the interest earned. If prices fall, of course, the amount of funds on deposit earning interest will fall below the principal on the loan. In this sense, when prices fall there is an additional interest cost to the firm over and above the interest cost built into the basis, but the opposite is also true when prices rise.

47. Global Derivatives Study Group, *Derivatives: Practices and Principles* (Washington, DC: The Group of Thirty, July 1993).

48. *See* Global Derivatives Study Group, cited previously:50-51.

49. General Accounting Office, *Financial Derivatives: Actions Needed to Protect the Financial System*, GAO/GGD-94-133 (May 1994):4.

50. *See* Gilpin, cited previously.

51. *See* Eckhardt and Knipp, cited previously.

press then and now, proved unfortunate on several counts.[52] By the time MGRM began to unwind its positions in mid-December, the price of oil had fallen to its low of roughly $14/bbl. The precipitous liquidation of MGRM's futures hedge thus turned "paper losses" on that leg into realized losses and left MGRM exposed to rising spot prices on its still-outstanding flow delivery contracts. And indeed, as noted earlier, when the new management awakened to its naked price exposure following the liquidation, it began negotiating unwinds of its flow contracts without demanding *any* compensation for its positive expected future cash flows.

In fairness to MG AG, however, ending a combined delivery/hedging program is never costless. As noted earlier, unwinding bilateral contracts may require concessions from the party initiating the unwind. The supervisory board increased the cost of ending the program both by giving *full* concessions to its counterparties and by not following the common practice of unwinding both legs of a hedged transaction as close to simultaneously as possible.

If MGRM had not unwound its futures, the positive daily pays received when prices recovered in 1994 would have given it a substantial positive cash inflow. MGRM's forced liquidation, moreover, sent a signal to MGRM's OTC derivatives counterparties that its credit standing might be in jeopardy, thereby increasing calls for collateral to keep its OTC positions open and making it virtually impossible to establish new OTC positions. (See Appendix 1.)

Accounting and Disclosure

Operational risk can also arise from the accounting and auditing process.[53] Under German accounting rules, assets normally are valued at the lower of historical cost or market value, "LOCOM." The U.S. Generally Accepted Accounting Principles (GAAP), by contrast, allow for "hedge accounting" if a specific hedge transaction can be linked to a specific obligation.[54] Hedge accounting under GAAP then allows the firm to account for the hedge transaction in the same manner as the underlying transaction using either mark-to-market or deferral accounting.

The more conservative German accounting rules thus tend to exaggerate economic losses in hedge operations. In the typical hedge transaction, the profitable leg of the hedge will be valued at cost, thus deferring the gain, while the losing leg of the trade is accounted for at its lower market value, thus recording the loss. By contrast, GAAP would allow both transactions to be deferred or both marked-to-market. Accounting losses under German accounting rules can thus exceed those losses under GAAP for a legitimate hedge transaction.

Whether this difference in accounting treatments was significant in MGRM's case is difficult for outsiders to judge. We do know that Arthur Andersen & Co. had audited MG Corp. and its affiliates through September 30, 1993, and showed a $61 million *profit* under U.S. GAAP before special reserves for MGRM.[55] By contrast, MG's German auditor Klynveld Peat Marwick Goerdeler Deutsche Treuhand Gesellschaft (KPMG) showed an accounting loss of $291 million for the same period for MGRM under German accounting rules, though press accounts suggest that these losses may have been deliberately inflated to discredit the previous management.[56] The discrepancy in the two audits may well have had an unfortunate consequence for MGRM if the accounting loss under German accounting conventions had been perceived as a *real* loss on the combined delivery/hedging program.

That the almost universally cited figure of $1.3 billion for MGRM's loss on oil derivatives might contain "big bath" write-offs seemed likely to us from the publicly available information on the company's positions. But the $1.3 billion figure for *gross* cash losses has since been confirmed in an auditors' report commissioned last year by the shareholders of MG AG.[57] The auditors put the *net*

52. Contrary to many press accounts, the unwinding was *not* undertaken in response to the removal of MGRM's hedging exemption by the NYMEX. In fact, the hedging exemption expired at the end of December 1993, by which time the liquidation of MGRM's hedge was well underway.

53. For another account of how MGRM's problems trace in part to accounting and disclosure rules, *see* Franklin R. Edwards, "Systemic Risk in OTC Derivatives Markets: Much Ado About Not Too Much," presented before the conference on Coping with Financial Fragility: A Global Perspective (Maastricht: September 7-9, 1994):28-29.

54. This is called a "micro hedge." If a hedge transaction cannot be associated with a specific balance sheet entry, it does not necessarily receive hedge accounting treatment under GAAP. *See, for example,* Jennifer Francis, "Accounting for Futures Contracts and the Effect on Earnings Variability," *The Accounting Review* 65(4) (October 1990).

55. *See* Benson, cited previously: 8-9.

56. *See* Eckhardt and Knipp, cited previously.

57. Coopers & Lybrand Treuarbeit Deutsche Revision and Wollert-Elmendorff Treuhand, *Report No. 4011742 RE: The Special Audit in Accordance with Paragraph 142 Section 1 AktG of Metallgesellschaft Aktiengesellschaft Frankfurt am Main* (February 1995).

To avoid being ambushed, top managers and directors of those firms need not become derivatives experts—as some legislators and regulators at the moment seem to be urging—but they must understand the essential logic behind their firms' marketing and hedging strategies and the long-term commitments needed to make the programs work.

loss at $1.0 billion, but only because they grossly underestimate the appreciation in the value of the flow contracts as prices fell. We have estimated the real 1993 net loss in the combined delivery/hedging program to be about $200 million.[58]

CONCLUSION

Why did MGRM's synthetic storage program come to such grief? Was it fatally flawed—an accident waiting to happen? Or was it killed off prematurely? Although we lean to the latter view, we recognize that the deeper issue of the long-run viability of synthetic storage programs like MGRM's cannot yet be settled definitively. The identification problem is insuperable: many contending theories, but only a single observation! We can only hope that other firms, in the petroleum industry or elsewhere, adopt programs similar to MGRM's. If indeed any are willing to follow MGRM's pioneering path, perhaps our account here may at least help show them where they are most likely to run into trouble along the way.

To avoid being ambushed, top managers and directors of those firms need not become derivatives experts—as some legislators and regulators at the moment seem to be urging—but they must understand the essential logic behind their firms' marketing and hedging strategies and the long-term commitments needed to make the programs work. Otherwise, their firms may encounter not the classical gambler's ruin problem—they will be hedging and not gambling, after all—but an insidious new phenomenon of the derivatives age: an economically sound hedging program may be liquidated prematurely because highly visible rollover costs and temporary cash drains may be construed by top management as gambling losses. Perhaps we might call this new phenomenon "hedger's ruin."

58. See Culp and Miller, "Auditing...," cited previously.

■ CHRISTOPHER CULP

is a financial risk management consultant in Chicago, Senior Fellow in Financial Regulation with the Competitive Enterprise Institute in Washington, D.C., and a doctoral candidate in finance at The University of Chicago's Graduate School of Business.

■ MERTON MILLER

is the Robert R. McCormick Distinguished Service Professor Emeritus at the University of Chicago's Graduate School of Business.

■ APPENDIX 1: OVER-THE-COUNTER DERIVATIVES

MGRM negotiated OTC derivatives contracts largely maturing in three months or less to mimic its futures stack. The OTC positions thus were for all practical purposes indistinguishable from futures—setting credit risk aside. But the OTC products subjected MGRM to some risks that the futures did not, and the premature liquidation of MGRM's hedge transformed these risks into reality. OTC derivatives do not utilize margin explicitly and usually do not involve cash flows other than those occurring on settlement dates. Adverse price movements thus do not *always* precipitate cash flows between OTC derivatives counterparties. But sometimes they do.

Cash flow needs could have arisen on OTC derivatives if MGRM's perceived credit risk changed. "Credit enhancements" are often demanded by counterparties to reduce their credit exposure to institutions with increased default potential. The three most common forms of credit enhancements accepted by dealers are cash collateral, securities collateral, and third-party guarantees of performance. Of the dealers using collateral surveyed by the Group of Thirty, over 70% vary the amount of collateral depending on their exposure to the counterparty. Specifically, at least 55% of those dealers demand additional collateral if their counterparty receives a credit downgrade.[59]

For short-dated OTC contracts, counterparties would use collateral much as exchanges use margin. OTC dealers would simply require advance posting of collateral before rolling into a new OTC contract. MGRM would thus have faced potential funding needs on its OTC contracts if it or its parent experienced a perceived credit deterioration. When the supervisory board of MG began liquidating the futures hedge in full public view, it became apparent that the flow contracts were being "unhedged." This prompted calls for collateral from OTC counterparties and impaired MGRM's ability to roll over the short-dated OTC contracts.

MGRM might have avoided concentrating its OTC hedge in longer-dated OTC derivatives because they can be difficult to liquidate. Master agreements governing most OTC derivatives usually do not allow firms in MGRM's position simply to decide to terminate. On the contrary, adverse credit events give the *non*defaulting counterparties the right to terminate the swap early but do *not* usually give that right to the defaulting counterparty.[60] If, therefore, MGRM's counterparties chose to demand collateral in accordance with negotiated master agreements rather than terminate the contracts, MGRM would either have had to post the collateral, default on the contracts, sell them to another party, or negotiate close outs with the original counterparties—all expensive choices.

Long-term OTC derivatives subject their users to counterparty credit risk. On ten-year commodity swaps, *any* corporation is likely to be perceived as a potential credit risk, making costly credit enhancements or collateral requirements possible. Perhaps more importantly, few OTC derivatives dealers would enter into such a long-dated commodity swap without in turn also hedging that risk.

Dealers virtually always either hedge their exposures directly or enter into offsetting transactions when negotiating a transaction. If a dealer hedges its exposure from entering 10-year commodity swaps, it loads the cost of hedging that contract into the price of the transaction paid by its counterparty. Because a dealer would have to use a strategy such as stacking and rolling, it would in turn presumably pass along those costs (and perhaps add a risk premium) to MGRM. As a large corporation already involved in derivatives, there is no reason to believe MGRM's cost of hedging directly with futures would have been higher than those of an OTC dealer.

59. Group of Thirty Global Derivatives Study Group, *Appendix III: Survey of Industry Practice*, in *Derivatives: Practices and Principles* (Washington, D.C.: The Group of Thirty, March 1994).

60. *See* Culp and Kavanagh, cited previously.

■ APPENDIX 2: DATA

We obtained daily settlement prices for futures contracts of all maturities on NYMEX light, sweet crude oil, New York habor regular unleaded gasoline, and No. 2 New York harbor heating oil from the Futures Industry Institute in Washington, D.C. Spot data were also obtained from FII for crude oil and heating oil but were unavailable for gasoline.

A monthly time series of front-month futures prices was constructed for each commodity based on an assumed rollover date. For light, sweet crude, rollovers are assumed to occur on the 15th of the month or on the first business day preceding the 15th when the 15th is not a business day. For heating oil and gasoline, the front-month contract is rolled over on the last business day of the month.

We define the relation between spot and futures prices in the text in two ways. When we refer to the "basis," we define it as a fraction of the spot price, or

$$b_{t,t+1} = F_{t,t+1} - S_t \,/ S_t$$

measured on the first business day *following* an assumed rollover. The December 1993 heating oil basis, for example, is measured on December 1, 1993, corresponding to the rollover initiated on November 30, 1993.

Because spot prices were unavailable for gasoline, we define the gasoline basis as $F_{t,t+1} - F_{t,t}/F_{t,t}$, or the proportional difference between the one-month futures price and the maturing futures contract price. Spot and futures prices must converge at futures maturity, so this is a reasonable approximation to the actual gasoline spot-futures basis.

Our second measure for the relation between spot and futures prices is the "lump-sum basis," defined as $F_{t,t+1} - S_t$. Like the proportional basis, we measure the lump-sum basis on the first business day following a rollover.

We define "rollover costs" as the difference between the maturing futures contract price and the price of a new one-month futures contract one day hence ($F_{t,t+1} - F_{t,t}$). Because we measure rollover costs near the expiration date of the maturing futures contract, the convergence of spot and futures prices at maturity ensures that the lump-sum basis is closely related to per contract rollover costs. We make the simplifying assumption that rollovers are non-synchronous, so the rollover cost is the difference in the price of the futures contract being offset on the rollover date and the price of the new contract into which the firm rolls *on the next business day*. Rollover costs are thus assumed realized when the new front-month contract price is sampled. As with the basis, the observation for the December 1993 rollover is thus dated December 1, 1993.

In the absence of spot data for gasoline, we assume the lump-sum basis and per contract rollover costs are the same.

Journal of Applied Corporate Finance (ISSN 1078-1196 [print], ISSN 1745-6622 [online]) is published quarterly on behalf of Morgan Stanley by Blackwell Publishing, with offices at 350 Main Street, Malden, MA 02148, USA, and PO Box 1354, 9600 Garsington Road, Oxford OX4 2XG, UK. Call US: (800) 835-6770, UK: +44 1865 778315; fax US: (781) 388-8232, UK: +44 1865 471775, or e-mail: subscrip@bos.blackwellpublishing.com.

Information For Subscribers For new orders, renewals, sample copy requests, claims, changes of address, and all other subscription correspondence, please contact the Customer Service Department at your nearest Blackwell office.

Subscription Rates for Volume 17 (four issues) Institutional Premium Rate* The Americas† $330, Rest of World £201; Commercial Company Premium Rate, The Americas $440, Rest of World £268; Individual Rate, The Americas $95, Rest of World £70, €105‡; Students**, The Americas $50, Rest of World £28, €42.

*Includes print plus premium online access to the current and all available backfiles. Print and online-only rates are also available (see below).

†Customers in Canada should add 7% GST or provide evidence of entitlement to exemption

‡Customers in the UK should add VAT at 5%; customers in the EU should also add VAT at 5%, or provide a VAT registration number or evidence of entitlement to exemption

** Students must present a copy of their student ID card to receive this rate.

For more information about Blackwell Publishing journals, including online access information, terms and conditions, and other pricing options, please visit www.blackwellpublishing.com or contact our customer service department, tel: (800) 835-6770 or +44 1865 778315 (UK office).

Back Issues Back issues are available from the publisher at the current single-issue rate.

Mailing *Journal of Applied Corporate Finance* is mailed Standard Rate. Mailing to rest of world by DHL Smart & Global Mail. Canadian mail is sent by Canadian publications mail agreement number 40573520. **Postmaster** Send all address changes to Journal of Applied Corporate Finance, Blackwell Publishing Inc., Journals Subscription Department, 350 Main St., Malden, MA 02148-5020.

Journal of Applied Corporate Finance is available online through Synergy, Blackwell's online journal service which allows you to:

- Browse tables of contents and abstracts from over 290 professional, science, social science, and medical journals
- Create your own Personal Homepage from which you can access your personal subscriptions, set up e-mail table of contents alerts and run saved searches
- Perform detailed searches across our database of titles and save the search criteria for future use
- Link to and from bibliographic databases such as ISI.

Sign up for free today at http://www.blackwell-synergy.com.