

STRATEGIC HEDGING

*by Antonio S. Mello,
University of Wisconsin, and
John E. Parsons,
Charles River Associates*

Risk management is now a critical task in many corporations. Any number of uncertainties can derail a strategic plan if they have not been anticipated. Sudden shortfalls in cash from operations can undermine a company's ability to follow through on valuable investment programs and force management to take drastic measures. In such cases management will consider emergency plans to raise funds by cutting dividends or turning to creditors and other outside sources. Or it may decide to solve the problem by delaying the launch of projects or reducing their scale—or perhaps even by shelving its strategic plan altogether. All these scenarios can have serious consequences for the company's future competitive position and hence the value of its stock.

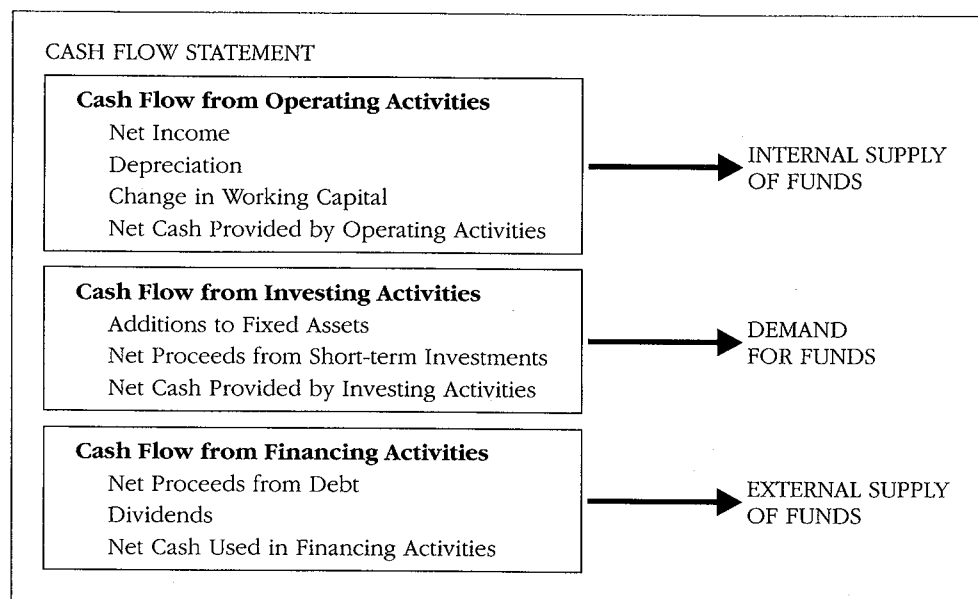
In this paper, we argue that a well-designed hedging program creates value primarily by protecting the company's supply of funds and thus guaranteeing the resources necessary to carry out its strategic plan. But, in order to design an effective risk management program, managers need to address a number of difficult questions: How large is the company's exposure to fluctuations in economic variables? And how will such price movements affect the firm's future investment opportunities and hence its demand for investment capital? Answers to these questions are necessary to enable management to answer the risk management question: How much of its price exposures should be hedged?

In this article, we present a measure of exposure that captures how the company's ability to realize its strategic objectives is affected by changes in fundamental economic variables. In assessing a company's overall exposure, we attempt to determine how price uncertainties facing the company are likely to affect not only its current operating cash flow, but also its strategic investment requirements. Take the case of an oil exploration company. Although a sharp decline in crude prices would reduce the cash flows from current operations, it would also likely reduce its near-term investment requirements. And, to the extent the expected reduction in operating inflows is offset by the reduction in investment outflows, the case for hedging is weakened.

In short, our approach to risk management focuses attention on the strategic value of a hedging program. Besides being strategy-oriented and forward-looking, this approach is simple, transparent, and can easily be implemented by corporate managers. Because it focuses only on the exposures that need protection when regular sources of funds are exhausted, it will generally lead to a more conservative, and therefore less costly, hedging policy. Our measure of exposure is also dynamically interactive in the sense that it uses familiar financial tools to project changes by the firm in response to changes in economic and industry conditions.

In linking risk management directly with corporate strategy, our approach contrasts sharply

FIGURE 1
 DIAGRAM OF CASH FLOW
 STATEMENT IN THREE
 PARTS



with the usual finance textbook cases that demonstrate the hedging of individual transactions. Hedging financial transactions, such as receivables in foreign currency or commodity supply contracts, without considering the firm's total sources and expected uses of funds, is likely to add value only "by accident" because it is disconnected from the firm's true value drivers. And besides failing to contribute to firm value, such "micro" hedging is also hard to monitor and can easily degenerate into speculation. At best, this kind of piecemeal risk management is a waste of management's time and attention.

This article discusses the mechanisms and value of a comprehensive approach to hedging as a strategic foundation for financial risk management. It begins by discussing the three components of a company's risk profile: "internal supply" of funds (or cash flow from operations); "demand" for funds (cash flow from investments), and "external supply" of funds (cash flow from financing activities). It then examines exposure and volatility in each of these areas, the ramifications for potential funding discrepancies, and how hedging can bridge the funding gap. The exposure of a major petrochemical producer is then analyzed in a case study that demonstrates how this approach might be applied. Finally, the article discusses how simulation techniques can provide more realism in the projections used for strategic hedging.

THE THREE PARTS OF A COMPANY'S RISK PROFILE

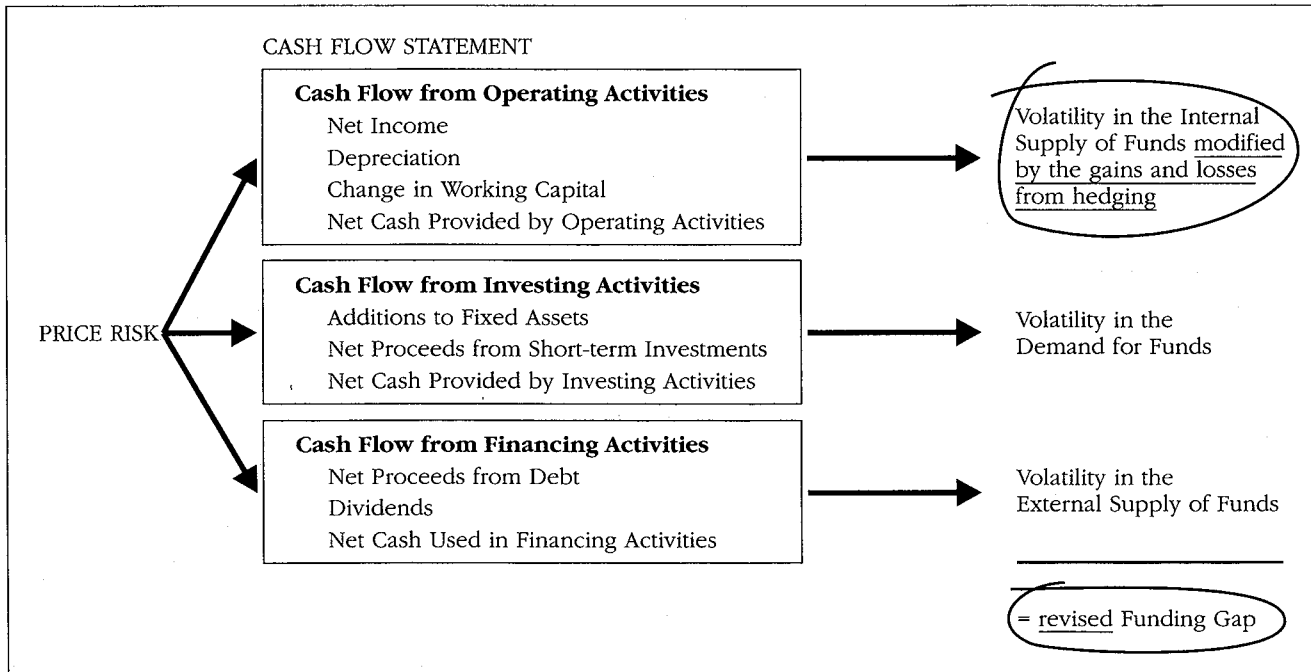
A company's cash flow statement provides the ideal structure within which to understand the goal of a well-designed hedging strategy. There are three parts to the cash flow statement: (1) cash flows from operating activities, which can be thought of as the "internal supply" of funds; (2) cash flows from investing activities, or the "demand" for funds; and (3) cash flows from financing activities, or the "external supply" of funds. The financial manager's job—and, as we will argue, the primary aim of corporate risk management—is to ensure that the internal and external supplies of funds are sufficient to cover the demand for funds.

Fluctuations in macroeconomic variables create volatility in each of these different parts of the cash flow statement. In certain circumstances, this volatility may threaten the company's ability to supply the funds demanded by its strategy. To design a hedging strategy that will protect the firm's supply of funds, it is necessary to understand how each of these three cash flow components is exposed to risk.

The first and most obvious exposure is volatility in operating income. Fluctuations in the price of a company's products or in the cost of its inputs have an immediate and readily measurable impact on cash flow from operating activities. And since operating income is a company's basic source of cash for future

A well-designed hedging program creates value primarily by protecting the company's supply of funds and thus guaranteeing the resources necessary to carry out its strategic plan.

FIGURE 2 ■ DIAGRAM OF CASH FLOW STATEMENT WITH EFFECT OF HEDGING



growth, volatility here can threaten a company's strategic plans by jeopardizing its supply of funds.

Risk also affects a company's investment plans. This is an often overlooked aspect of risk exposure. A sharp and lasting increase in the price of a company's product may encourage expansion and the purchase of new assets. Conversely, permanent increases in the cost of a company's inputs may force a cutback in planned expansions. Because investing activities are one of the major uses of cash, risk also means volatility in the *demand* for funds, which is measured by the company's net cash flow from investing activities.

Finally, there is almost certainly exposure in the external supply of funds. Turning to outside sources for capital—by issuing new debt, for example—can be an expensive proposition if the company's output price is depressed or if costs are running high.

The financial manager's job is to put together information about each of these components. Does the company's supply of funds match its demand? Is

the supply adequate only when prices increase as expected? If prices fall, does the supply of funds drop faster than the demand? How big is the gap? If the company has the financial capacity to cover the gaps, there may be little cause for concern. But if not, the company's growth plans may be undermined. Scenario analysis can reveal whether price risk exposes the company to a large gap between the supply and demand.

Hedging can improve a company's ability to cover the gap. Hedge gains are a substitute supply of funds that allows a company to maintain its growth plan in the face of a temporarily low price for its product. Of course, the firm may just as well incur losses on the hedge if prices are temporarily high. But if the firm incurs these losses when it otherwise has a surplus of internal cash flow, the strategic cost may be minimal. And if the gains fund profitable investments the firm would otherwise be forced to abandon, the hedge adds to shareholder value overall.¹

1. This paper focuses on one corporate motive for hedging: ensuring the firm has sufficient cash flow to fund future investments. This rationale for corporate risk management is presented in Kenneth A. Froot, David S. Scharfstein, and Jeremy C. Stein, "Risk Management: Coordinating Corporate Investment and Financing,"

Journal of Finance, vol. 48, pp. 1629-1658 (1993). However, our methodology for identifying the sources of exposure through the different components of the cash flow statement can be used to assess the value of other benefits from hedging.

EXPOSURE AND THE FUNDING GAP

Operating Exposure—Volatility in the Internal Supply of Funds

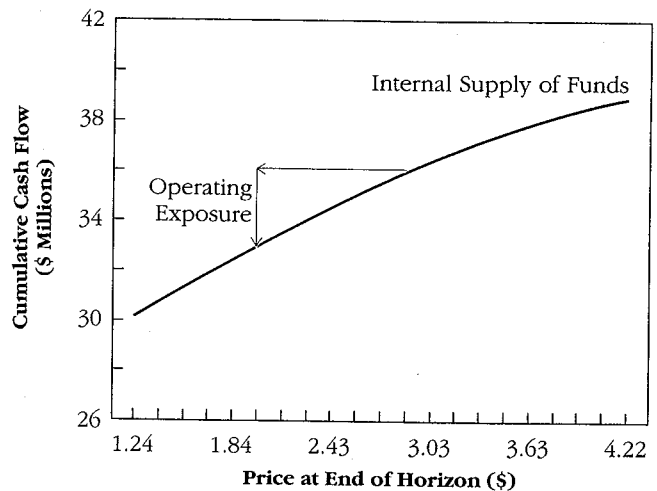
Operating exposure to changes in a key economic variable—say, interest rates, exchange rates, or the price of a critical commodity—is the most readily identifiable and measurable risk facing the firm. It is measured using a simulation of the firm's cash flow from operations under alternative scenarios for future price movements. Under each scenario, the simulation calculates the aggregate cash flow from operating activities—what we are calling the firm's internal supply of funds. The calculation is repeated for many alternative scenarios to demonstrate how the firm's supply of funds varies with the price risk it faces.

Figure 3 gives an example of how the firm's internal supply of funds might vary under different future price scenarios. The horizontal axis shows the price at the end of the horizon in each alternative scenario, while the vertical axis shows the cumulative cash flow from operations over the horizon. The graph records the cumulative cash flow or supply of funds corresponding to each different possible price scenario. The greater the price increases within the horizon, the higher the supply of funds accumulated.

The slope of the line measures the firm's operating exposure to price changes. Although many corporate managers understand that the firm is sensitive to risks, the method used to quantify this sensitivity is often a "black box" that seems wholly disconnected from the company's operations. Relying on commonly used financial tools to measure exposure brings corporate management closer to the issues at hand and ensures that risk management plans are integrated with the company's strategy.

Unfortunately many risk analyses stop here in the mistaken belief that operating exposure tells the whole story. For example, the "Value at Risk" measures recently developed for non-financial companies typically address only operating exposure. Many companies with high operating exposure, however, may find hedging unnecessary and expensive, while other companies with relatively modest operating exposures may find hedging to be a critical part of the firm's overall strategy. Volatility in the supply of funds is just half the story—it is also important to look at how the firm's need for cash may vary.

FIGURE 3
INTERNAL SUPPLY OF FUNDS, BY PRICE SCENARIO



Investment Exposure—Volatility in the Demand for Funds

The demand for funds is also affected by the risks and uncertainties facing the firm. How should a company's investment program change with key variables such as the price of its products? If a fall in price means new investments should be delayed, the company's demand for funds is very *elastic*—that is, highly sensitive to price changes. But if large short-run swings in price have little impact on new investments and other capital expenses, the company's demand for funds is relatively *inelastic*. Investment exposure differs dramatically across companies and the exposure of any given company could also shift dramatically over time as its growth prospects develop or change.

Figure 4 shows a graph of the demand for funds as a function of the different possible price scenarios. The lower the price, the lower the demand for funds. The slope of the line measures the firm's investment exposure. In the case illustrated in the figure the exposure is very slight.

The Internal Funding Deficit

Is the internal supply of funds sufficient to meet demand in all cases? Figure 5 overlays the supply of funds schedule and the demand for funds schedule. For low price scenarios there is an internal funding deficit: the internal supply of funds generated from operations over this horizon

By integrating the risk management function with corporate strategy, strategic hedging should enable companies to avoid the excessive and costly “micro” hedging of individual transactions.

FIGURE 4
DEMAND FOR FUNDS, BY PRICE SCENARIO

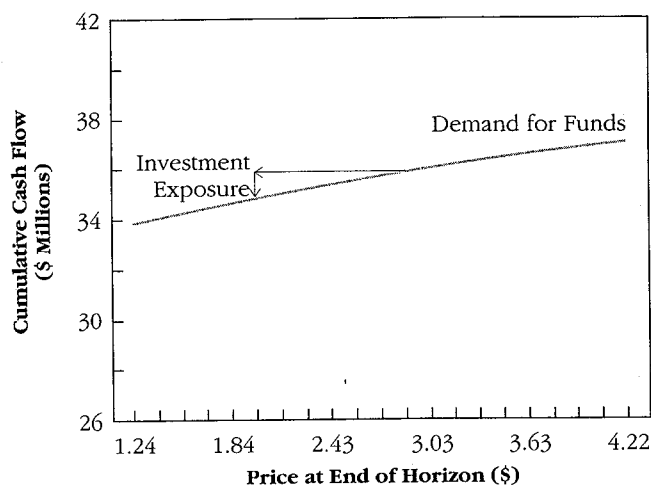
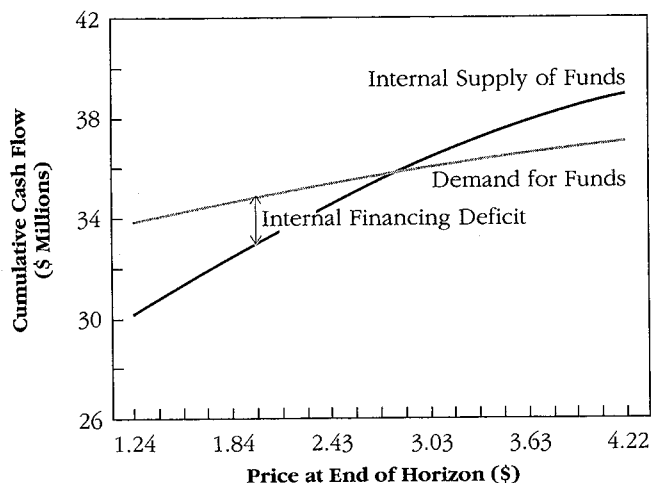


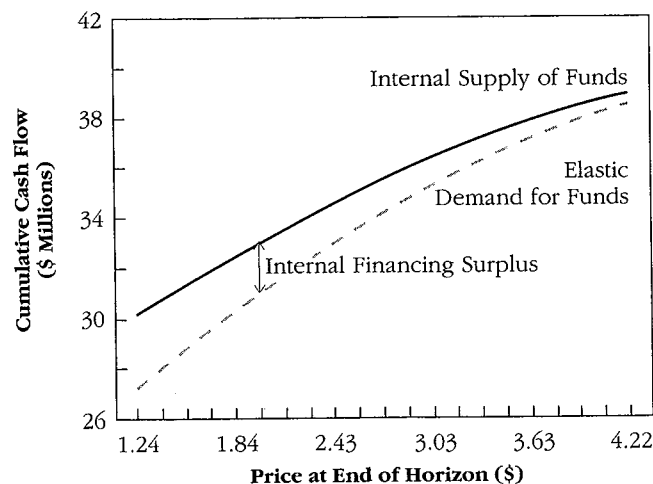
FIGURE 5
OVERLAY OF INTERNAL SUPPLY AND DEMAND FOR FUNDS, BY PRICE SCENARIO



is inadequate to meet the demand for funds in the company’s strategy. At high price scenarios there is an adequate internal supply.

Figure 6 shows why it is important to examine both the operating exposure and the investment exposure. The figure shows the same internal supply schedule as in Figure 5, but superimposes a more elastic demand schedule. Although the firm has significant operating exposure to price risk, it does not have an internal funding deficit under any price scenario. As prices decline and the supply of funds is reduced, the demand for funds is also reduced. Volatility in operating cash flow does not disrupt this firm’s investment strategy, and the firm will not benefit from reducing this volatility.

FIGURE 6
OVERLAY OF INTERNAL SUPPLY AND INCREASED ELASTIC DEMAND FOR FUNDS, BY PRICE SCENARIO



Financial Exposure—Volatility in the External Supply of Funds

There are a number of ways the firm can meet an internal funding deficit. For example, it can issue more debt to finance new capital expenditures. A proper evaluation of the firm’s total supply of funds must include these external financing sources. Figure 7 shows how external financing sources augment the internal supply of funds.

Determining the size of the external financing capacity is critical. Many firms have significant reserves in the form of unused debt capacity, and a shortfall in the internal supply of funds will not disrupt the investment strategy of these firms. But

calculating financial reserves is a more complicated matter than determining the internal supply of funds from operations. The company’s actual debt capacity is a product of many factors, some of which are not easily reduced to simple rules ready-made for entering into a spreadsheet. More difficult still is determining how this external financing capacity is likely to change under alternative price scenarios. It may be easy to float additional debt when output prices are high, but will it be so easy when margins are squeezed over a long period of time?

FIGURE 7
CONTRIBUTION OF EXTERNAL FINANCIAL ACTIVITY TO
TOTAL SUPPLY OF FUNDS, BY PRICE SCENARIO

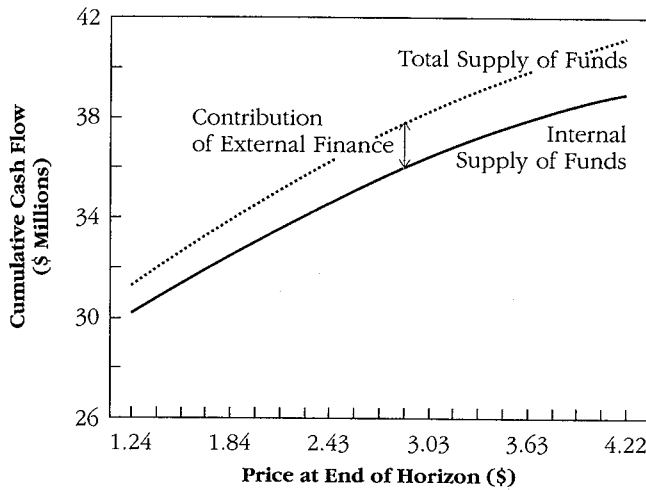
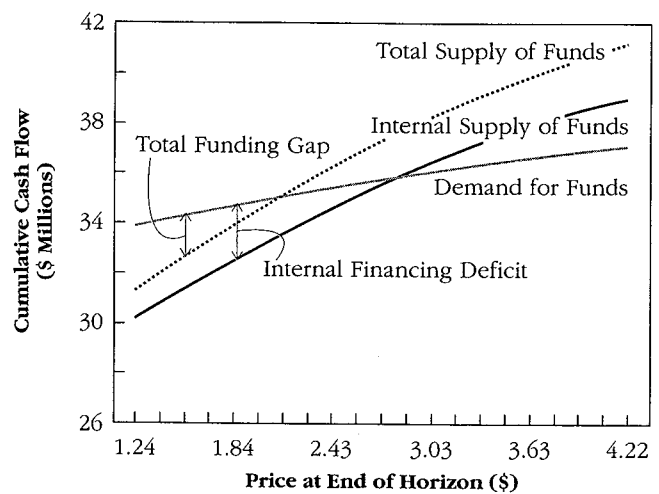


FIGURE 8
TOTAL FUNDING GAP



In sum, the supply of external financing may also be exposed to price risk. Identifying the true sensitivity of available financing to the company's price risk is a critical task, and a difficult one requiring a good degree of judgment.

The Total Funding Gap

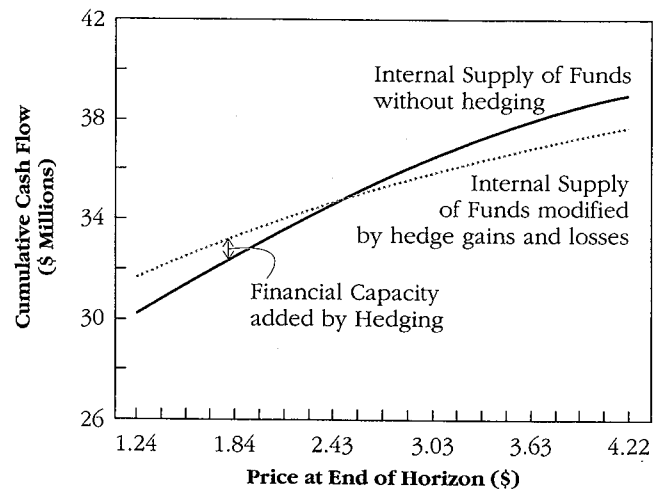
Combining the internal supply of funds and the external funds available from financing gives a total supply of funds. This is compared with the demand for funds schedule, as shown in Figure 8, to reveal the total funding gap. The total funding gap is significantly smaller than the internal financing deficit. However, the firm's available financing capacity still falls short of its demand for funds in some price scenarios. In these cases the company may be forced into an untimely sale of stock or a cutback of its investment program. Both alternatives are costly and reduce shareholder value.

What can the company do when it does not have sufficient financial slack in the form of excess cash or unused debt capacity? Hedging addresses the disparity.

HOW HEDGING CAN BRIDGE THE GAP

The scenario analysis reveals a wide range of price movements for which the company's demand for funds exceeds its supply. Of course there is an even wider range over which the supply of funds

FIGURE 9
EFFECT OF HEDGING ON FINANCIAL SLACK



substantially exceeds the demand. Hedging is ideal for using surplus cash in one range of price movements to cover a deficit of cash over another range. In effect, the firm sells some of its "upside" surplus of funds in exchange for a cash infusion on the "downside." If the downside cash infusion protects the firm's central strategy, the exchange can raise shareholder value overall.

The simplest hedge is a sale of a set of forward contracts. The seller earns hedge gains in the event of a price fall and records hedge losses in the event of a price decline. The company's financial slack is ad-

Most of the firm's *available* and untapped sources of external financing do not show up on a standard pro forma cash flow statement—they need to be identified and put on the statement.

TABLE 1
CALCULATING THE SUPPLY OF FUNDS FROM A PRO FORMA CASH FLOW STATEMENT (ETHYLENE PRICE SCENARIO: 4% ANNUAL INCREASE)

	1997	1998	1999	2000	2001	2002
Forecasted ethylene price (¢/lb.)	22.64	23.55	24.49	25.47	26.49	27.55
Cash flow from operating activities						
Net income	221	217	217	281	353	380
Depreciation	108	127	147	154	160	167
Change in working capital	(40)	(7)	(1)	(9)	(9)	(3)
Deferred taxes	8	8	9	9	10	10
Other	(23)	(7)	(11)	(8)	(9)	(12)
Net cash provided by operating activities	274	337	360	427	505	542
Cumulative net cash provided by operating activities — the supply of funds	274	625	1,017	1,494	2,074	2,720

TABLE 2
SUPPLY OF FUNDS FOR A PESSIMISTIC PRICE SCENARIO (ETHYLENE PRICE SCENARIO: 8% ANNUAL DECREASE)

	1997	1998	1999	2000	2001	2002
Forecasted ethylene price (¢/lb.)	20.03	18.43	16.95	15.60	14.35	13.20
Cash flow from operating activities						
Net income	205	180	161	195	241	241
Depreciation	107	125	144	151	158	164
Change in working capital	(38)	(5)	1	(5)	(6)	(0)
Deferred taxes	8	8	9	9	10	10
Other	(24)	(9)	(12)	(10)	(10)	(14)
Net cash provided by operating activities	259	300	303	340	392	401
Cumulative net cash provided by operating activities — the supply of funds	259	572	904	1,289	1,745	2,233

justed as a result of the hedge. This is shown in Figure 9, where the previous estimate of financial slack is revised to incorporate the result of adding a hedge of forward contracts with various maturities. As a result of the hedge, the company's financial slack is raised when the price declines, and lowered when the price increases. Because there was no funding gap at high prices, this reduction in financial slack is not costly to the firm. At the same time, it buys a very valuable increase in financial slack at those critical low price levels, enabling the firm to cover the remaining gap and avoid costly cutbacks in valuable investments.

CASE STUDY—A PETROCHEMICAL PRODUCER

We applied these tools to an analysis of the exposure of a major petrochemical producer. The firm faces significant risk from fluctuating prices for a number of its products—most significantly, ethylene. Concerned that this volatility could reduce margins and threaten its expansion plans, the company wanted to measure its exposure and evaluate alternative hedging programs.

We started with a set of pro forma financial projections for the firm. Table 1 shows the projected cash flow from operations over the next six years. Operating cash flows come from oil refinery operations and from production of a number of petrochemicals. The tables below evaluate the company's exposure to volatility in ethylene prices. We begin with a baseline forecast of a 4% annual average increase in ethylene prices over the six-year horizon. The bottom row of Table 1 shows the cumulative net cash provided by operating activities over the six years. This is the internal supply of funds.

Since operating exposure is the volatility in the cumulative cash flow from operations, how will temporarily depressed product prices cut into the firm's supply of funds? We selected a set of possible scenarios for how the firm's product prices might move over the next five years. For example, the company could consider the consequences of cumulative annual price changes in ethylene ranging from +12% to -8%. For each of these scenarios we constructed a set of pro forma financial projections and calculated the cumulative cash flow from operating activities. Table 2 shows the supply of funds for the scenario in which ethylene prices fall by 8% per year.

TABLE 3
SUPPLY OF FUNDS FOR A
RANGE OF SCENARIOS

Price Scenario	12%	6%	4%	-2%	-8%
Supply of Funds (\$ millions)	\$ 3,179	\$2,838	\$2,720	\$2,452	\$2,233

TABLE 4
CALCULATING THE
DEMAND FOR FUNDS
FROM A PRO FORMA CASH
FLOW STATEMENT
(ETHYLENE PRICE
SCENARIO: 4% ANNUAL
INCREASE)

	1997	1998	1999	2000	2001	2002
Forecasted ethylene price (¢/lb.)	22.64	23.55	24.49	25.47	26.49	27.55
Cash flow from investing activities						
Additions to fixed assets	(429)	(470)	(505)	(169)	(169)	(169)
Purchases of short-term investments	0	0	0	0	0	0
Proceeds from the sale of investments	0	0	0	0	0	0
Net cash provided by investing activities	(429)	(470)	(505)	(169)	(169)	(169)
Cumulative net cash provided by investing activities — the demand for funds	(429)	(920)	(1,471)	(1,713)	(1,968)	(2,235)

TABLE 5
CALCULATING THE
DEMAND FOR FUNDS IN A
PESSIMISTIC PRICE
SCENARIO (ETHYLENE
PRICE SCENARIO: 8%
ANNUAL DECREASE)

	1997	1998	1999	2000	2001	2002
Forecasted ethylene price (¢/lb.)	20.03	18.43	16.95	15.60	14.35	13.20
Cash flow from investing activities						
Additions to fixed assets	(409)	(449)	(483)	(165)	(165)	(165)
Purchases of short-term investments	0	0	0	0	0	0
Proceeds from the sale of investments	0	0	0	0	0	0
Net cash provided by investing activities	(409)	(449)	(483)	(165)	(165)	(165)
Cumulative net cash provided by investing activities — the demand for funds	(409)	(878)	(1,405)	(1,640)	(1,886)	(2,145)

TABLE 6
DEMAND FOR FUNDS FOR
A RANGE OF SCENARIOS

Price Scenario	12%	6%	4%	-2%	-8%
Demand for Funds (\$ millions)	\$(2,302)	\$(2,279)	\$(2,235)	\$(2,190)	\$(2,145)

Repeating this exercise for a wide range of scenarios produces a schedule of the supply of funds as a function of the cumulative price changes over the horizon analyzed. Table 3 shows the total internal supply of funds at the end of a six-year horizon as a function of the different scenarios for annual price changes in ethylene.

Table 4 shows the pro forma cash flow from investment activities. The bottom row is the cumulative cash flow from investing activities, i.e., the firm's demand for funds. Table 5 shows the demand for funds under a pessimistic scenario for ethylene prices. By comparing the demand for funds from Tables 4 and 5, one can see that this firm's investments are only marginally affected by the decline in price and total demand for funds changes very little. The expected significant short-run volatility in the ethylene price has little impact

on the profitability of future investments in ethylene capacity. Consequently, the firm's demand for funds is not significantly reduced in these low price scenarios. Table 6 shows the demand for funds over a range of price scenarios.

In the base case of a gradual 4% annual increase in ethylene prices, the supply of funds at the end of 1999 is \$1.017 billion while the demand for funds is \$1.471 billion. This leaves an internal funding deficit of \$454 million. Moreover, in the event of an annual ethylene price decline of 8%, the supply of funds at the end of 1999 would only be \$904 million while the demand for funds would be \$1.405 billion. As a result there would be a deficit of more than \$500 million that would have to be covered if the planned investment program were to be completed as scheduled. The funding deficit for this pessimistic price scenario is shown in Table 7.

One important insight from this case study is that more aggressive hedging would yield further losses and possibly create a deficit in these optimistic scenarios.

TABLE 7

CALCULATING THE FUNDING DEFICIT IN A PESSIMISTIC SCENARIO (ETHYLENE PRICE SCENARIO: 8% ANNUAL DECREASE)

	1997	1998	1999	2000	2001	2002
Cumulative net cash provided by operating activities — the supply of funds	259	572	904	1,289	1,745	2,233
Cumulative net cash provided by investing activities — the demand for funds	(409)	(878)	(1,405)	(1,640)	(1,886)	(2,145)
Internal funding deficit	(150)	(306)	(501)	(351)	(141)	88

TABLE 8

CALCULATING THE EXTERNAL SUPPLY OF FUNDS (ETHYLENE PRICE SCENARIO: 4% ANNUAL INCREASE)

	1997	1998	1999	2000	2001	2002
Forecasted ethylene price (¢/lb.)	22.64	23.55	24.49	25.47	26.49	27.55
Cash flow from financing activities						
Minority owner contribution	0	0	0	0	0	0
Net proceeds from short-term debt	0	0	0	0	0	0
Proceeds from long-term debt	29	0	162	459	22	20
Repayments of long-term debt	(112)	(32)	(150)	(492)	(90)	(90)
Repayment of capitalized leases	0	0	0	0	0	0
Dividends paid	(75)	(75)	(75)	(75)	(75)	(75)
Net cash provided by financing activities	(158)	(107)	(63)	(108)	(143)	(145)
Cumulative net cash provided by financing activities — the external supply of funds	(158)	(265)	(328)	(437)	(580)	(725)

TABLE 9

CALCULATING UNUSED DEBT CAPACITY AND THE TOTAL AVAILABLE EXTERNAL SUPPLY OF FUNDS (ETHYLENE PRICE SCENARIO: 4% ANNUAL INCREASE)

	1997	1998	1999	2000	2001	2002
Assets less deferred charges	3,335	3,676	4,002	4,031	4,060	4,061
Aggregate debt capacity	1,668	1,838	2,001	2,016	2,030	2,030
Existing debt	1,283	1,251	1,263	1,229	1,161	1,091
Unused debt capacity	385	587	738	786	869	940
Total available external supply of funds	227	322	410	350	289	214

The third section of the cash flow statement calculates the external supply of funds. Table 8 shows the petrochemical company's pro forma statement of cash flow from financing activities. The pro forma statement reflects the anticipated proceeds from new issues of long-term debt, as well as the scheduled repayments on existing debt and the anticipated dividend stream. The net cash provided by these sources is the external supply of funds.

Because the petrochemical company forecasts expansion of facilities, this pro forma statement shows a negative external supply of funds. But most of the firm's *available* and untapped sources of external financing do not show up on a standard pro forma cash flow statement—they need to be identified and put on the statement. Calculating financial reserves is a more complicated matter than calculating the

internal supply of funds from operations, but the company must make some assessment of its capacity. For example, a starting point may be to set debt capacity at, say, 50% of book value of the assets, if that is the level that is customary in the industry. Using this rule produces the schedule of unused debt capacity shown in Table 9. The starting point for the table is the entry "assets less deferred charges," which is taken from the company's pro forma balance sheet. The simple rule applied here is that one-half of this number is the "aggregate debt capacity." By subtracting from this the "existing debt" as shown on the pro forma balance sheet, we arrive at "unused debt capacity." By adding unused debt capacity to the external supply of funds calculated in Table 8, we arrive at the "total available external supply of funds."

Once the total available external supply of funds has been calculated, we can return to the

TABLE 10
CALCULATING THE TOTAL
FUNDING GAP (ETHYLENE
PRICE SCENARIO: 8%
ANNUAL DECREASE)

	1997	1998	1999	2000	2001	2002
Cumulative net cash provided by operating activities—the internal supply of funds	259	572	904	1,289	1,745	2,233
Cumulative net cash provided by available financing activities—the external supply of funds	227	322	410	350	289	214
Net supply	486	894	1,313	1,638	2,034	2,447
Cumulative net cash provided by investing activities—the demand for funds	(409)	(878)	(1,405)	(1,640)	(1,886)	(2,145)
Total funding gap	77	16	(91)	(1)	148	302

TABLE 11
HEDGING FILLS THE
FUNDING GAP (ETHYLENE
PRICE SCENARIO: 8%
ANNUAL DECREASE)

	1997	1998	1999	2000	2001	2002
The internal supply of funds without hedging	259	572	904	1,289	1,745	2,233
Additions from hedging	16	47	95	99	104	110
Cumulative net cash provided by available financing activities—the external supply of funds	227	322	410	350	289	214
Net supply	501	941	1,408	1,738	2,139	2,557
Cumulative net cash provided by investing activities—the demand for funds	(409)	(878)	(1,405)	(1,640)	(1,886)	(2,145)
Total funding gap	92	63	3	98	252	412

question of whether the supply of funds is always adequate to meet the demand. Table 10 shows the total funding gap under the pessimistic price scenario.

Table 11 shows how a properly designed hedging strategy can fill the funding gap. The strategy in this case involves selling forward contracts on ethylene. The company sells contracts for 10 million pounds of ethylene due in 1997 at a forward price of \$22.64/lb, for a second 10 million pounds of ethylene due in 1998 at a forward price of \$23.55/lb, and for a final 10 million pounds of ethylene due in 1999 at a forward price of \$24.49/lb. Of course the prices at which the forward contracts can be sold are determined in the marketplace and the company's only decision is how much to sell. At these forward prices the company's hedge would break even when the actual ethylene price climbs by 4% per year.

The first row of Table 11 shows the internal supply of funds without any hedging contracts. This row is taken from Table 2. The second row shows the gains on the hedging contracts. Since we are showing the pessimistic scenario in which prices fall, the firm that has sold forward contracts earns profits on those forward contracts in this scenario. The third row shows the external supply of funds from Table

9. Combining these three rows yields a net supply of funds that is always sufficient to cover the demand for funds. Thus, there is no funding gap (as can be seen in the last row of Table 11).

Of course, the same contracts would earn a loss in more optimistic scenarios. Table 12 shows how these losses reduce the funding surplus in such optimistic scenarios. As one can see in the last row of the table, because of the losses from hedging over the first three years, the cumulative funding surplus falls to only \$3 million in 1999 before increasing again. One important insight from this exercise is that more aggressive hedging would yield further losses and possibly create a deficit in these optimistic scenarios!

BRINGING MORE REALISM TO YOUR PROJECTIONS

To illustrate the role of hedging, a small number of scenarios was sufficient. To describe uncertainty more realistically, however, it is necessary to consider all possible occurrences. In statistical terms this is equivalent to getting the distribution of possible outcomes by giving the proper weight to each possible outcome according to its probability of occurrence. This can be done using simula-

**Simulation handles multiple sources of uncertainty in a much better way, provided
the correct parameters are used in generating the
joint distribution of the uncertainties.**

TABLE 12
THE DRAIN FROM
HEDGING ON THE UPSIDE
(ETHYLENE PRICE
SCENARIO: 12% ANNUAL
INCREASE)

	1997	1998	1999	2000	2001	2002
The internal supply of funds without hedging	285	663	1,104	1,664	2,366	3,179
Additions from hedging	(10)	(34)	(72)	(75)	(79)	(83)
Cumulative net cash provided by available financing activities—the external supply of funds	250	398	491	441	437	434
Net supply	524	1,028	1,523	2,029	2,723	3,530
Cumulative net cash provided by investing activities—the demand for funds	(445)	(952)	(1,521)	(1,768)	(2,028)	(2,302)
Total funding gap	80	76	3	261	695	1,229

tion techniques. Although they may appear technically complex, these tools are straightforward to apply and are often available with modern spreadsheet applications.

As in any model of reality, however, these simulations must be fed the right parameters. Inflation-adjusted prices of many commodities appear to revert to a long-term mean. However, in their convergence to the long-term mean, prices are often subjected to random shocks. Deviations from the path to convergence depend on the volatility of the price. Therefore, to generate sequences of future prices it is necessary to input into the simulation algorithm sensible values for the long-term price level, speed of adjustment, and volatility. These three parameters suffice to describe the distribution of prices at any future date, provided a sufficiently large number of iterations are produced with the help of the spreadsheet's random number generator.²

Greater realism can be gained when the company faces multiple sources of uncertainty because it has different product lines or because a portion of its production costs are tied to some commodity price. For example, the company in the case study produces polypropylene as well as ethylene, and the price of polypropylene does not move exactly in concert with the price of ethylene. Intuition suggests that more degrees of uncertainty may not mean more uncertainty overall. The company's total exposure can be reduced by operating in two different product markets instead of just one. And although the cumulative funding requirements of two divisions are higher than those of a single

division, it is possible that the strategic investments do not all occur simultaneously. What needs to be assessed is how the prices of the two olefins move together.

As in the previous case, scenarios for the two individual cases can be constructed. However, if done arbitrarily, these often miss the true link that exists between the prices of the commodities. Again, simulation handles multiple sources of uncertainty in a much better way, provided the correct parameters are used in generating the joint distribution of the uncertainties. The greater the number of uncertainties the company faces, the more important it is to do risk management that relies on exposures that accurately reflect the comovement of the various uncertainties. Simple scenario analysis loses important information for correct decision-making.

CONCLUSION

In this article we present a new approach to financial risk management that we call strategic hedging. The primary objective of strategic hedging is to ensure that companies have sufficient internal funds and access to outside capital to carry out their strategic investments.

The foundation of this approach is a comprehensive measure of the firm's exposure that views the firm as a collection of current cash-generating assets and future investment opportunities. Assets in use, together with unused debt capacity, are the company's main source of funds

2. If one carefully follows a particular simulated trajectory for the price, one will notice that prices go up and down at random from one period to the next. Also, it is easy to verify that in any given future year certain price ranges are more frequently obtained than others. This would demonstrate that the frequency distribution of the prices on a given date is not constant. Consequently, the average price on that date is not just the simple average, but rather the weighted average,

with the weights reflecting the relative frequencies of each price. These weighted average prices are better forecasts than the simple projections used in the above illustration, and therefore should give better estimates of the exposures and the financial gap as well as the right amount to hedge. Finally, it must be kept in mind that the averages computed are in real dollars, so they must be converted to nominal prices by compounding at the forecasted rate of inflation.

while future investments are the expected net users of funds. Exposure is a measure of how changes in fundamental economic variables can threaten the firm's ability to realize its strategic objectives. Therefore, exposure measures how both income earned from current operations and investment needs for future operations are influenced by changes in economic variables.

This focus allows risk managers to concentrate on the implications of the hedging program for the company's strategic plan and shareholder value. By integrating the risk management function with corporate strategy, strategic hedging should enable companies to avoid the excessive and costly "micro" hedging of individual transactions—an approach that can easily degenerate into speculation.

■ ANTONIO MELLO

is Associate Professor of Finance at the University of Wisconsin's School of Business.

■ JOHN PARSONS

is a Vice-President of Charles River Associates.