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Chapter 2: How Companies Manage Risk

2.1 Everyone is a Risk Manager

The term risk management can mean different things to different people. In the last few decades, with the rise of financial engineering, the term risk management has become strongly associated with the derivatives trading desks of investment banking houses and hedge funds. In a few commodity industries certain firms have developed profitable trading operations built on the same principles. In non-financial corporations, risk management evokes an image of the treasury office buying or selling foreign currency futures to lock in the dollar value of foreign product sales. There is also an entirely distinct discipline that goes by the same label, risk management, and that is involved in identifying and limiting the probability of calamitous events, such as plant explosions or the theft of corporate secrets or the loss of key personnel. Insurance companies both cover and help to manage and minimize these sorts of risks.

In truth, risk management is not a specialized activity properly relegated to any single type of financial institution nor to any single office of the firm. Managers in all parts of a company regularly make all types of decisions involving choices and tradeoffs about risk. The marketing department designs types of contracts for customers that share risk between the firm and its customers. Business unit managers evaluate alternative lines of business with different risk characteristics. Asset development teams alter project designs so as to minimize risk without sacrificing return. Supply chain management regularly evaluates alternative means of sourcing based on risk factors. The tax, legal and accounting departments are concerned with risk, with hedging and with the corporate governance issues. At the highest level of the company key questions about the firm's strategy and its ability to fund its operations must be answered with an eye on the risks of each alternative and strategic decisions that can secure the greatest value for shareholders. Most business decisions involve a choice about risk. Everybody is a risk manager.

Risk management is the science of assessing these tradeoffs involving risk – quantifying the exposure, determining the cost of risk to the activities of your department or business unit or customer, understanding how the marketplace values and prices risk, and using this knowledge to

execute your tasks successfully for the benefit of the business. Risk is an important element of decisions facing managers throughout a company's many departments, and risk management should be everybody's business.

Therefore, this book develops one common toolkit for analyzing risk, and then shows how these tools are used across diverse activities within the business.

The next section of this chapter provides a brief overview of some of the different types of activities and decisions involving risk which arise in various parts of a business. The objective is to give the student a fuller sense of the diverse settings in which a thorough understanding of risk can benefit the business. This overview helps to illustrate that risk management is not a specialized function carried out separate from the other parts of the firm, but instead a general management issue relevant throughout the firm. Throughout the remainder of the course and these lecture notes, we will be going into much more detail on each of these individual problems. By the end of the course, the student should be able to spot and identify the risk management element of each case or story.

2.2 The Different Types of Corporate Risk Management

Although the many different parts of the firm all face problems involving risk, the problems are very different. The problem facing a commodity trader is not the same problem that faces the business unit manager and not the same problem that faces the CFO. To gain a comprehensive view of what risk management is requires a short tour through the various types of problems facing managers who play these different roles within the firm.

Valuation and Pricing

Valuation is central to a wide range of business decisions, from the price to pay for an asset to the price to charge for a product. And risk is central to valuation. Better measurement of risk and better pricing of risk leads to a more accurate valuation. Armed with more accurate valuations, management is able to make better decisions.

The workhorse for valuations is the discounted cash flow (DCF) model. In many cases the DCF model produces a reasonably accurate estimate of the value. This is true because the risk profile fits the usual assumptions employed by the DCF model, at least to the degree of precision at hand in real world cases. But in certain situations the structure of the risk is markedly different from the usual one, and the standard DCF calculation gets the valuation wrong. In these cases, a

more thorough analysis of risk is needed in order to get the valuation right. Amending the DCF model to handle this more complicated risk structure is possible. The tools of risk management show how it can be done.

There are many complicated patterns for which a more careful treatment of risk is needed. However, two very common patterns requiring more careful analysis are:

- Risk is not symmetric; this happens, for example, when risk is truncated by a guarantee clause, by the option to switch or abandon, by floor or ceiling price structures, and so on;
- Risk changes through time; this happens, for example, when the success or failure of a project is decided within a concentrated window of time or when a project goes through markedly different stages during which specific risks become resolved.

Once you start thinking carefully about it, many projects and assets exhibit these features.

Companies often enter into supply agreements with various floor and ceiling price clauses. Supply contracts often have quantity options of various sorts. If the market price of a critical input rise too far, engineers will be put to work to find substitutes or to redesign the product to minimize the amount required. Shutdown of operations, whether at just one plant or of one product line or of an entire business line, is the most drastic “truncation” of all.

Changing risk through time is just as common. For example, companies that develop and operate hotel properties face different amounts and types of risk through the different stages of development. A greenfield development, pre-construction, faces a very different amount of risk than a completed property that has been operated for several years. A wildcat oil exploration project faces a very different amount of risk before and after a successful find. Development of the oil field is still risky, but not to the same degree and in the same way as before the first discovery was made. And once the field has been successfully developed and is simply pumping oil, the risks have changed again. Mature products and new products face different risks.

Here are some examples where companies have exploited the insights of risk management to generate a better valuation:

- The oil major BP is considering adding capacity to a natural gas stabilization plant in East Asia that takes natural gas piped from offshore, processes it, and delivers a pair of end-products: “stabilized gas” and condensate. An alternative design would include a complementary liquified petroleum gas (LPG) extraction facility. Adding this facility requires some incremental capital investment, and would divert some of the pipeline gas to production of this third end-product. Given the average spread of the LPG price, adding this facility doesn’t make any sense—the NPV is negative. But the major benefit of adding the facility is the flexibility it provides. The LPG plant can be operated when LPG prices are high and closed down when they are low. In order to assess the true value

of the incremental expenditure, it is necessary to estimate the distribution of the spread and to identify the size of the tail of the distribution when LPG prices are at a sufficient premium to justify turning on the plant. This requires carefully modeling the volatile oil price process. It also requires estimating an appropriate discount rate to apply to this truncated distribution, one that will be consistent with the company's normal discount rate methodology.¹

- A pharmaceutical company is a portfolio of pre-product research projects, early stage product development and testing, interim product approval and marketing research, and management of mature products. The evaluation of R&D funds to the various alternative projects requires a differentiated understanding of the risk at the various stages. A study by the MIT Program on the Pharmaceutical Industry finds that investors' required cost of capital moves down a "risk-return staircase" as a given project advances through the stages of development. The right cost of capital for the early stages of clinical testing can be as high as 30%. The floor or bottom step on the staircase is the 10% cost of capital required for mature products. The cost of capital observed from financial market data on pharmaceutical companies is actually an average of these various costs of capital, reflecting the distribution of investments in projects at each of the different developmental stages. The changing cost of capital through the stages of a pharmaceutical project are not a reflection of changing technical risks of success. The risk of success or failure at a given stage for a given drug in development is just the type of risk that portfolio investors can diversify away and that will not add to the cost of capital. Rather, the changing cost of capital reflects the changing operating leverage through time of the project. The early stages of the development process are highly levered with respect to the market risks facing the project, and this leverage gears up the cost of capital. The MIT study shows how the estimates for the cost of capital at different stages are developed.²

Once management becomes aware of how valuation needs to be adjusted to account for complicated patterns of risk, a whole host of management processes and decisions are reshaped. Product pricing is affected.

- Bombardier is a Canadian manufacturer of regional aircraft and business jets, rail transportation equipment and recreational vehicles, including snowmobiles. The marketing department for snowmobiles developed an innovative guarantee to address a number of problems. Sales respond powerfully to snowfall, but in most midwestern U.S. cities there was often insufficient snow in time for Christmas sales. Moreover, many customers are anxious about making a major purchase in the face of risk that they will be able to use it right away. So in a number of cities the company offered a \$1,000 rebate if

¹ Woolley, Simon and Fabio Cannizzo, 2005, Taking Real Options Beyond the Black Box, Journal of Applied Corporate Finance 17(2), 93-98.

² Myers, Stewart C. and Christopher D. Howe, 1997, "A Life-Cycle Financial Model of Pharmaceutical R&D", MIT Sloan School of Management, Program on the Pharmaceutical Industry Working Paper #41-97. See also Myers, Stewart C. and L. Shyam Sunder, 1991, "Cost of Capital Estimates for Investment in Pharmaceutical Research and Development," Contract report prepared for the Office of Technology Assessment, U.S. Congress, Washington DC, and Myers, S. C., and L. Shyam-Sunder. 1996. Measuring Pharmaceutical Industry Risk and the Cost of Capital. in Competitive Strategies in the Pharmaceutical Industry. Ed. Robert B. Helms, The American Enterprise Institute Press, Washington, D.C.

local snowfall was less than half the average of the past three years. While the marketing department could forecast the impact of such a guarantee on sales, the problem was to estimate its cost. What was the probability of paying the rebates? And what was the price of risk? Bombardier didn't actually make this estimate. Instead, it turned to others in the financial market and covered its obligation by purchasing weather derivatives—payments based on the snowfall—for every snowmobile it sold. Bombardier's counterparty at the time was Enron —this was back in 1998—and for each snowmobile sold Bombardier paid a price ranging between \$45 and \$400, depending upon the city. So the cost of the guarantee was determined by the financial markets and Bombardier's sales department simply had to decide if the expected sales warranted the price to be paid. The guarantee was a success, resulting in a 38% increase in sales over the prior year, and Bombardier expanded the program to other cities the next year.³

- A local heating oil company delivers oil to residential and commercial customers under a variety of terms. The basic contract lets the price of oil delivered float with the market. But many residential customers prefer to lock in the price just before the winter heating season begins. They sign a contract to take delivery as needed at a fixed price. Other customers want security, but don't like the high price charged for locking in a single price throughout the full season. They prefer a contract with a cap and a floor, but accept variation in price within that range. How should the company set the fixed price? What is a fair level for the cap and for the floor? If the quantity purchased by each consumer were fixed, these contracts would mimic simple options contracts sold on the major commodity exchanges. But typically the consumer is entitled to these price terms on whatever quantity of oil they actually use in their home that season. And the quantity consumed obviously fluctuates with the severity of the weather, which in turn is correlated to the price level. How should this quantity risk be factored in when setting the fixed price to charge customers?

Operating Decisions and Asset Management

Better valuation tools also empower management to make better operating decisions and manage assets more profitably.

Here are some examples:

- An asset manager at an integrated oil and gas company is responsible for working up the program for development and exploitation of its proven, but undeveloped reserves of oil. At current prices, the NPV of development is positive. But the price of oil is very risky and could fall dramatically so that the low revenues would not repay the sunk development expenditures. Holding the properties undeveloped until the price rises further could be the wiser strategy. The value of these properties is really a call option on the price of oil. When should this option be exercised? How high does the oil price have to be before it makes sense? Solving this development problem requires a sophisticated

³ Many sales arrangements include warranties and other provisions that can be readily modeled as options. In some cases, such as lease agreements, the options are explicit. The value of the cancellation and purchase options in automobile lease contracts is estimated in Giaccotto, Carmelo, Gerson Goldberg and Shantaram Hegde, 2007, The Value of Embedded Real Options: Evidence from Consumer Automobile Lease Contracts, *Journal of Finance* 62(1), 411-445. They show that the penalty provisions included in the lease nullify the value of the cancellation option and that the value of the purchase option is equal to about 16% of the market value of the used car.

understanding of oil price dynamics. It is important to distinguish between short-run, transitory price shocks that one can predict will dissipate relatively quickly, and shocks to the price that are long-lasting. Important information can be gleaned from the term structure of oil futures prices, so that the development decision should depend not just on the current price of oil, but on the full term structure. Finally, the asset manager need to decide what s/he anticipates about the likely evolution of drilling costs and other costs – are they tied to the price of oil or independent of it?⁴

- The Boeing Company employs risk management financial valuation tools in the evaluation of investments in new aircraft designs. The manufacture of new aircraft involves many critical stages. At each stage different risks are confronted and the development program is either scrapped, delayed, redesigned or continued. Throughout the process the company is receiving information, learning about the market and about the technology, so that the risk distribution it faces is changing. Moreover, the manufacturer often has to choose between different development paths that have different risk profiles. The prudent expenditure of scarce development funds requires assessing the value of information generated. There are choices to be made in the pace of development spending and in the sequencing. Valuing these choices demands a structured model of risk. Boeing's use of a disciplined valuation methodology that accomodates these risks is a useful tool in getting managers to be explicit about a range of future scenarios. It avoids resort to vague claims of 'strategic value' since long-shot game changing designs are readily fit into the valuation model.⁵
- In 2000, Hewlett Packard found itself short of supplies of the flash memory components of its profitable laser printers due to a rapidly expanded use of the component in the cell phone industry. In order to assure production of its printers, HP entered into a long-term contract, but at a higher price. The experience convinced the company to implement a Procurement Risk Management (PRM) program to evaluate its choices in negotiating supplies, including how much to purchase under contract, at what prices, what sort of options to place on future supplies and how large of a premium to pay for the option. HP compares the option premium against the cost of maintaining excess inventory as a hedge. To implement the PRM the company employs the same type of analytic models and software systems that investment banking houses employ at their trading desks. The system requires HP to make a careful assessment of the markets for its supplies, to understand price dynamics and the likely directions of costs. But it also requires HP to understand the internal costs of risk. How much will it lose from a delay in printer shipments? What is the value to the company of its inventory?⁶

⁴ There is a large literature on the valuation of oil properties using option pricing tools. In fact, this example inspired one of the very first papers on 'real options': Siegel, D., J. Smith, and J. Paddock, 1987, Valuing Offshore Oil Properties With Option Pricing Models, *Midland Corporate Finance Journal* 5, 22-30. See also, McCormack, John and Gordon Sick, 2001, Valuing PUD Reserves: A Practical Application of Real Option Techniques, *Journal of Applied Corporate Finance*, Winter, pp. 8-13.

⁵ Matthews, Scott, Vinay Datar and Blake Johnson, 2007, A Practical Method for Valuing Real Options: the Boeing Approach, *Journal of Applied Corporate Finance* 19(2), 96-106. Curiously, Boeing claims to have a patent on this methodology! See also Miller, Bruno and John-Paul Clarke, 2005, Real Options And Strategic Guidance In The Development Of New Aircraft Programs, MIT International Center for Air Transportation.

⁶ Bartholomew, Doug, 2005, "HP Reinvents, Slowly," *CFO.com*, March 15. (accessed from the web in July 2007).

Cash Management and Transaction Hedging

The Finance/Comptroller/Treasury Office is responsible for managing the short-run cash flow of the firm. Uncertainty in the cash inflows and outflows is expensive. The more uncertainty, the larger the reserve of cash and other very liquid, low return assets the Treasury must maintain. Risk management tools can be used to minimize expensive uncertainty in short-term cash flow, lowering the amount of working capital the firm requires. These assets can then be invested in less liquid investments that yield a higher return. Alternatively, the freed up assets are available for major corporate investments or can be returned to shareholders.

This type of hedging—managing the firm’s short-run cash flow—is called transaction hedging. The classic example of transaction hedging is a multinational firm that has made a sale in a foreign currency for which payment will not be received until delivery is complete some months hence. The firm wishes to lock in its domestic currency income and it does so by selling a forward contract on the foreign currency, exchanging future payment of the foreign currency for future payment of the domestic currency.

The right size and structure of a transaction hedge is simplest to assess after the underlying transaction has formally been executed. In many cases, however, it is possible to anticipate with a reasonable degree of certainty many transactions expected in the near term, and the firm may hedge these as well. Most natural resource extraction companies can predict a minimum quantity of production within a term of a number of months or a year. Because these sales have not yet been closed, these sales will be made at whatever turns out to be the market price in the months ahead. Over a longer term the company might want to adjust its production in response to changes in the market price. But in the near term, the volume of production may not vary significantly and the firm simply hedges to reduce the risk of this near term cash flow. A natural gas producer sells forward or futures contracts on its expected production for the next six months. An agricultural commodity producer may similarly sell forward some portion of its expected harvest. A livestock company may sell forward some fraction of the animals it expects to bring to market.

Users of commodities may do the same. Petrochemical refiners may buy forward a portion of the crude oil used to feed their operations over the coming months. Multinational companies may buy currency forward to lock in the domestic currency price they pay on some of their supplies. Each of these is a case of transaction hedging.

Hedging transactions is very different from supply management or product pricing, because hedging is a purely financial action. A transaction hedge does not generate delivery of an input or an output.

Although transaction hedging is the simplest form of hedging, occasionally things don't work out as planned.

- During the winter of 1995 and 1996, several US natural gas producers with fields in east Texas – including Apache, Cabot Oil & Gas, Enserch, Sonat, TransTexas Gas and Union Pacific Resources Group – found that they had rung up big losses on the hedges they had sold on the New York Mercantile Exchange's natural gas futures contract. The NYMEX contract is based on delivery of gas into the Henry Hub in Louisiana, near the starting point of major pipelines heading up the east coast. The losses stemmed from an unprecedented run-up in the futures contract price following a surprise shortage of gas in the northeast US. Unfortunately for these companies, however, prices in east Texas had not increased the same amount since east Texas production traveled up a different set of pipes leading to the US midwest, and the price spike had been localized exclusively to the northeast. So the losses on the hedges were not matched by gains on the underlying sales, and the companies found themselves scrambling to cope with the cash drain. The hedges that were supposed to protect the companies from surprising cash shortfalls had suddenly created a cash shortfall. The companies had not anticipated that such a large differential between east Texas and Louisiana was possible, and going forward they needed to adjust their hedge ratios to accommodate the danger.

Liability Management

On a longer time frame, the firm also worries about risk exposure created by the debt it has issued. Some companies attempt to structure their liabilities to match their assets on various dimensions. For example, companies with long-lived assets may be more willing to issue long-term debt, while companies in a high asset turnover business will choose shorter-term debt that turns over more often. Companies with tangible assets may be willing to borrow more.

Companies also try to match the currency denomination of their debt to the currency of their revenues, avoiding the mismatch in cash flow that can arise if the exchange rate quickly falls. This matching can be done either by issuing the debt in the relevant currency, or by issuing the debt in one currency and supplementing the debt with a hedge. The hedge could be a long-term swap of currencies, or it could be a dynamic portfolio of futures on the two currencies.

An interesting example of liability risk matching is the issuance of commodity linked debt by companies who mine and sell the commodity.

- Freeport McMoRan is one of the world's largest producers of gold. It operates the Grasberg mine in the Papua province of Indonesia. In the early 1990s it wanted to expand

the mine from 52,000 metric tons of ore per day to 90,000 tons, at a cost of \$545 million. A second expansion to 118,000 metric tons would cost even more. The company was already highly levered. In 1990 its book leverage ratio was 66%. Between 1991 and 1993 it issued \$157 million in long-term bank debt, \$219 million in LYONs, a specialized debt instrument with an equity option, \$560 million in convertible preferreds, and \$174 million in equity. The company was constrained by a number of debt covenants and probably had no more capacity to issue traditional debt. In August 1993, however, the company issued a gold note. Both the quarterly dividend and the principal value of the note were indexed to the price of gold – if the gold price went up, the company would pay a larger dividend, and ultimately a larger principal payment, and vice-versa. The company issued a second gold linked note in January 1994 and a silver note in July 1995. The total raised on the three issuances was \$450 million. By linking the payments on the debt to match the risk profile of the company's underlying production, the company may have expanded its debt capacity and made the expansion possible.⁷

Interest rate risk is also an important element of this long range liability risk management. Smaller companies often find it easier or cheaper to borrow directly from banks than to borrow by issuing a bond. But bank debt is typically floating rate. Many companies use the interest rate swap market in order to convert their floating rate bank debt into a fixed rate exposure.

Not all firms may be trying to lower their risk when managing their liabilities. Some may actually be trying to play the market, using their balance sheet to make a bet on the direction of interest rates – WalMart, for example. A recent study found evidence that the corporate use of interest rate swaps seems motivated by the desire to 'ride the yield curve' – i.e., benefit in the short run from low short run interest rates and avoid, in the short run, the higher fixed rate – and that WalMart may be a prime example. "... at the end of Wal-Mart's 2001 fiscal year, during which the yield curve was inverted on average (specifically the average 1-year Treasury yield was higher than the average 10-year Treasury yield by 9.5 basis points), they had swapped only 3.9% of their debt from a fixed to a floating interest rate exposure, resulting in an overall floating debt exposure of 18.7%. During the 2002 fiscal year, the average Treasury yield spread (the 10-year Treasury yield minus the 1-year Treasury yield) had risen to 1.75% and Wal-Mart commensurately increased their use of pay-floating interest rate swaps to 17.3% of debt, bringing 25.3% of their debt to a floating exposure. Finally, during the 2003 fiscal year, the Treasury yield spread had risen further to an average of 2.59%, and Wal-Mart again increased their use of pay-floating interest rate swaps to 32.6% of total debt, leaving 40.8% of their debt with a floating exposure. At the culmination of these swap activities, Wal-Mart noted in their 2003 annual report

⁷ Chidambaran, Fernando & Spindt, 2001, Credit enhancement through financial engineering: Freeport McMoRan's gold-denominated depository shares *Journal of Financial Economics* 60, 487-528.

that “interest costs on debt and capital leases ... as a percentage of net sales [decreased] 0.17% when compared to fiscal 2002.” In fact, their interest expense fell by \$269 million (18.5%) even though their total debt increased by \$3.5 billion (16.1%).”⁸

Financial Policy and Strategic Management

A company’s financial needs are dynamic and respond to changes in the key risk factors shaping the company’s cash flow. The changing marketplace for its products has repercussions for the company’s investments in future product development. Some products reach maturity and require little incremental investment and the product margin is free cash flow to the firm. Other product lines enter into a stage of transition and face new competitive pressures, so that additional investments in those lines are a drain on free cash flow. Changes in macro variables such as exchange rates, interest rates, commodity prices shape the timing of these developments and the size of the cash flow freed up or the investments demanded.

The company’s financial policy, therefore, needs to be dynamic. The policy needs to be designed in anticipation of these risky developments and cash flow needs. Risk management is about shaping the company’s relationship to external capital markets through time and in response to these exogenous factors. A company may wish to tailor the dynamic risk profile of its sources of cash so that they match the company’s strategy and match the risk profile of its investment plans, or so that they give the company a competitive boost when it is most valuable against its competitors.

The pharmaceutical firm Merck noticed that it was significantly exposed to currency risk. It had a mismatch between the currencies in which it earned its revenues and in which it paid its costs. Currency risk in and of itself was not Merck’s concern, however. It’s shareholders could absorb this risk as a part of their overall portfolios. But in studying it’s past behavior, Merck took note of the fact that fluctuations in the dollar value of earnings had been translated into its investment decisions. Low earnings from a strong dollar meant a cutback in research and

⁸ Chernenko, Sergey, Michael Faulkender, and Todd Milbourn, 2006, Why are Firms Using Interest Rate Swaps to Time the Yield Curve?, Working Paper. This type of speculation appears to be quite widespread. Faulkender studied 133 firms in the chemical industry, analyzing 275 debt issuances over a period six years from 1994 through 1999, and finds that firms are more likely to choose floating rate debt if the yield spread is large (i.e., the short rate is below the long rate. The data incorporates the exposure at issuance, but including any swapping of exposure from fixed to floating or vice-versa. A one standard deviation in the yield spread, 44.5 basis points, increases the probability of floating from 30% to 41%.

development spending. Merck decided this was hurting its value. It needed to manage its foreign exchange risk in order to protect its R&D investments and the future growth value of the firm.⁹

Companies often take extreme opposite positions on the contribution hedging can make to shareholder value. Famously, many small gold mining companies believe that many of their shareholders own the shares in order to gain exposure to gold price risk – the so-called ‘gold bugs’. These companies don’t want to hedge gold price risk because it will drive away a sizeable clientele for their stock. Others in the industry view hedging as essential to their growth strategy. During the early 1990’s the two largest North American producers pursued diametrically opposed strategies: Homestake Mining vociferously proclaimed its decision to remain exposed, while American Barrick advertised how its hedging strategy enabled its swift expansion. The different strategies could reflect the two managements’ different assessments of the relevant factors. Or, the two companies may have faced very different strategic situations that called for different solutions.¹⁰

Having sampled a broad range of risk management problems, we now turn to providing a more comprehensive picture of whether and how firms manage risk.

2.3 Evidence on How Firms Manage Risk

Evidence on how firms manage risk comes in several different forms. Knowledge of cases such as those discussed above is one form. A broad acquaintance with the diverse practices of various companies is certainly an important perspective on the question of how firms manage risk. A second form is a survey about specific practices. A survey can be conducted through a questionnaire, or by analyzing corporate financial reports. Surveys have been made about the capital budgeting tools firms use – for example, do they limit themselves to traditional DCF, do they employ the Real Options method? Surveys have also been made about whether and how companies used derivative securities for hedging exposures. In fact, recently adopted accounting rules (starting in the 1990s) require companies to disclose information about their portfolios of derivative securities, and so this data provides a window on companies’ hedging activities. A third form of data is the indirect empirical evidence that identifies how risk management practices

⁹ Lewent, Judy C. and A. John Kearney, 1990, Identifying, Measuring, And Hedging Currency Risk At Merck, *Journal of Applied Corporate Finance* 2(4), 19-28.

¹⁰ An early paper on hedging in the gold industry is Tufano, Peter, 1996, Who Manages Risk? An Empirical Examination of Risk Management Practices in the Gold Mining Industry, *Journal of Finance* 51(4), 1097-1137. A large literature has followed.

impact other observable variables, such as market values of certain assets or the operating actions of firms.

Many, many interesting analyses of firm risk management have been published. We review just a few of these here.

Case Studies

Gregory Brown conducted a very detailed case study of foreign exchange risk management at a large US multinational industrial firm with more than \$10 billion in sales.¹¹ He spent three months in the Spring of 1998 in the treasury department of the company, examining each of the company's foreign currency trades, observing the company's decision making and operations, and interviewing management. The company had foreign exchange derivatives written on 24 currencies. The notional value of foreign exchange derivatives at year end was approximately \$3 billion, and the notional value of transactions made during the year was over \$15 billion. Foreign exchange hedging is handled by a management team of 4 persons with a total of 11 full-time employees and at an administrative cost of about \$1.5 million, with roughly half the cost being employee compensation. Transactions costs, usually in the form of bid-ask spreads, average \$2.3 million, annually.

The firm's hedging focused on a very short horizon of less than a year. The company maintains a set of maximum and minimum hedge ratios for transactions by quarter horizon as follows:

¹¹ Brown, Gregory, 2001, Managing Foreign Exchange Risk With Derivatives, Journal of Financial Economics 60, 401-448.

Expected time to exposure	Minimum Hedge	Maximum Hedge
Current quarter	60%	90%
1 quarter	40%	90%
2 quarters	25%	85%
3 quarters	0%	85%
4 quarters	0%	85%

Hedging exposures more than four quarters out was possible only with special approval. Similarly exceptions could be made to the hedge ratio bounds with special approval or under specified circumstances.

Reducing the volatility of a firm's cash flow is often thought to be the major role of hedging, and so Brown analyzed the impact of the firm's hedging on this variable. He had access to the full transaction level detail on the company's portfolio, and so could presumably measure the impact of the firm's hedging better than many other studies which attempt to do the same analysis using the courser set of information available in financial statements. Brown found that hedging reduced the volatility of annual cash flow and earnings by approximately 10%. In dollar terms, this amounted to a reduction in annual changes of about \$4 million on mean earnings of \$170 million – a surprisingly low number given the cost of running the program.

Perhaps the most important finding in Brown's study is the fact that foreign exchange risk management was primarily an element of the company's short-run budgeting and planning function. The risk management process is focused on developing a set of short-run exchange rates that everyone must employ in planning and evaluating short-run decisions – setting annual budgets, sales targets etc. Foreign business units use a treasury forecast of their foreign exchange exposure together with the hedge rate in developing their business plans. "A treasury training manual states, 'the primary currency risk management directives are (1) to increase the certainty of operating margins by supporting planning and pricing decisions with expected rates and by hedging forecasted exposures and (2) to reduce negative impacts from currency movements on competitiveness by continuously managing forecasted transactions and by providing competitive information to senior management.'"

Surveys

As the sketch of risk management problems opening this chapter suggests, the use of derivatives is only one element of risk management at corporations. But since derivatives are clearly an important element of active financial management of a firm's exposures, observations

about how they are used are important. Studies quantifying the use of derivatives can be broken into two groups. First, are those which study use by a broad sample of companies across many industries and focusing on portfolios of foreign currency and interest rate derivatives. Since many types of firms are exposed to exchange rate and interest rate risk, it makes sense to cast the net wide and include companies from various industries. Second, are those which focus on companies in a single industry exposed to a common commodity price risk for which there exist tradeable financial securities. For example, in North America there are many companies whose primary business is mining gold, and the price of gold is a clear and dominant risk for the revenue of these companies, and gold futures and many other related financial instruments are readily available. Similarly, there are many oil producing firms with revenues tied to the price of oil, and other industries, such as airlines, for which fuel is a major operating cost. The oil futures and options markets are among the deepest in the world, and so analyzing the hedging practices of firms on both sides of the oil price seems natural. Agriculture is another industry for which one might extract some lessons by observing how firms make use of derivatives, especially since agricultural commodities played a central role in the original development of organized futures and options exchanges.

To give a very broad summary of the results, we can say that:

- Derivative use is focused equally on foreign currency and interest rate risk and to a significantly smaller degree on a few key commodities such as oil, natural gas, and metals.
- Aggregate exposures currently hedged by these financial portfolios seem relatively small. Hedging is focused on relatively short maturities, although for foreign exchange and interest rates, the maturities can go out to a few years. For other risks the focus is on one to three years at most.
- There is a great diversity in financial hedging activities. A few firms hedge a lot, while many firms do not hedge at all. Firms often change their financial hedging strategies markedly in time. Larger companies make more use of derivatives, as it is costly to set up a hedging capability.
- There is some evidence that the use of derivatives is tied to identifiable features of the firm's business or financial structure, but this is still a murky area.
- The use of financial derivatives is clearly growing.

Foreign Currency Derivatives

In a study of 720 large U.S. corporations, approximately half of which have foreign sales accounting for more than 10% of total sales, and reporting financials from 1990 through 1995, it was found that approximately 37% of the total population of firms had some amount of foreign

currency derivatives (futures, options and swaps). The percentage increases from 32% in 1990 to 40% in 1995. If the sample is restricted to just those with firms with foreign sales, the percentage of those using derivatives is higher, 60%, growing from 55% to 64% between 1990 and 1995. The amount of derivatives used also increases from an average of \$105 million in notional principal to \$279 million, measured across all firms.¹²

	Average 1990-1995	1990	1995
All Firms	37%	32%	40%
Foreign Sales > 0	60%	55%	64%
Foreign Sales = 0	15%		
Average \$ Notional		\$105 million	\$279 million

Interest Rate Risk

A study of 2,600 non-financial corporations and their financials in the years 2000 and 2002 found that 500 reported using derivatives in 2000 and more than 600 in 2002 — i.e., between 20 and 25%.¹³ We can see how diverse was the portion of interest rate risk hedged by reproducing this table from the study:

	# obs.	Swaps as a Fraction of Total Debt*				
		10th	25 th	Median	75th	90 th
2000						
Pay-floating	88	2%	4%	16%	31%	47%
Pay-fixed	369	-5%	-14%	-28%	-51%	-83%
No direction	15					
Unknown	25					
2002						
Pay-floating	201	5%	11%	18%	34%	48%
Pay-fixed	359	-5%	-14%	-32%	-60%	-97%
No direction	23					
Unknown	33					

* Notional value of pay-floating interest rate swaps minus the notional value of pay-fixed interest rate swaps, caps and collars, as a percent of total debt.

¹² Allayanis, George, and James P. Weston, 2001, The Use of Foreign Currency Derivatives and Firm Market Value, Review of Financial Studies 14(1), 243-276. In this study large firms are defined as those with more than \$500 million in sales. A number of firms not reporting any foreign sales also report using foreign currency derivatives—15%. Some of these firms may have had exposures to currency movements due to the use of imported goods as inputs or due to competition from imports.

¹³ Covitz, Daniel, and Steven A. Sharpe, 2005, Do Nonfinancial Firms Use Interest Rate Derivatives To Hedge? Working Paper, Capital Markets Section, Board of Governors of the Federal Reserve System.

According to the study, larger firms are more likely to use interest rate derivatives: derivatives use by size declines from 43%, 28% to 12% in 2000 and from 57%, 36% to 15% in 2002. Likewise, higher rated firms are more likely to use derivatives: falling by rating category from 43%, 38%, 28% to 10% in 2000 and from 58%, 53%, 30% to 12% in 2002. Although large and highly rated firms appear to use derivatives more, the net effect of derivatives on interest rate risk appeared to be greatest for those small, low rated firms who used them. Non-users tended to be companies who had borrowed fixed. Among users of interest rate derivatives, the situation is very different as between large and highly rated companies (over \$5 billion in assets, and A rated or above) and small and poorly rated companies (under \$1 billion in assets, and BB rated or lower, including unrated). For large and highly rated companies there was no discernable pattern of use. Smaller and lower rated firms are more likely to have to turn to banks for credit, as opposed to accessing the bond market. And banks lend short-term and at variable interest rates. Therefore, firms accessing banks and getting variable rate loans turn to the swaps market to convert to fixed rate. Before accounting for their derivative use, these smaller and lower rated firms had a much larger pay-floating exposure than the larger and more highly rated firms, but after accounting for their derivative use the net position of the two groups was indistinguishable.

A study of small, credit constrained firms, shows that these companies consistently prefer fixed-rate loans, and those companies in industries with a greater sensitivity to interest rate shocks are more likely to use fixed rate loans. When these small companies use adjustable rate loans, it is because that is what the market is making available to them – i.e., it is a supply-side phenomenon, not a demand-side one.¹⁴

Earlier in this chapter, we cited a study by Chernenko, Faulkender and Milbourn (2006) that found firms using the interest rate swaps market to ride the yield curve. A closely related study by Faulkender found this type of speculation to be quite widespread, focusing on an analysis of 133 firms in the chemical industry with 275 debt issuances over a period six years from 1994 through 1999. He finds that firms are more likely to choose floating rate debt if the yield spread is large – i.e., the short rate is below the long rate.¹⁵ This appears to argue that firms choose floating in order to ride the yield curve, i.e., benefit in the short run from low short run interest rates and avoid, in the short run, the higher fixed rate. The study also finds that (1) there

¹⁴ Vickrey, James, 2005, How and Why Do Small Firms Manage Interest Rate Risk? Evidence from Commercial Loans, Federal Reserve Bank Working Paper.

¹⁵ Faulkender, Michael, 2005, Hedging or market timing? Selecting the interest rate exposure of corporate debt, *Journal of Finance* 60, 931-962.

is no correlation with the firm's cash flow exposure to interest fluctuations, but that (2) during economic downturns firms are less likely to choose floating – i.e., they look for the safety of fixed to reduce their exposure. The former result is interpreted as arguing against firms using interest rate exposure on their debt to hedge interest rate exposure on their assets. The latter finding is interpreted as suggesting that firms respond to the increased cost of interest rate risk, i.e., the potential probability of default and costs of distress.

Gold Producers

The hedging practices of the North American gold mining industry have received a great amount of attention and analysis. A study by Peter Tufano of HBS analyzed hedging by 48 firms using quarterly data from the four year period 1990-1993.¹⁶ Companies in the industry regularly provide detailed information about their use of a wide array of financial instruments including standard forward, futures and options contracts as well as less familiar tools such as spot deferred contracts, gold loans and gold swaps. The study took advantage of a database of hedging positions compiled by an equity analyst following the industry. One of the most interesting facts to emerge is the great diversity in hedging practices. Defining a company's quarterly hedge position (delta) as the ratio of its effective financial short position (e.g., sales of gold forward) to its forecasted production.¹⁷ In this study, the data includes hedges with a horizon of three years and as well as forecasted production within three years. This quarterly hedge ratio is then averaged for each company over the sixteen quarters studied.

Tufano's figures reveal that 14.6% of the firms did not hedge at all, i.e., sold all of their output at the spot price, while 16.8% of the firms hedged 40% or more of their production. The median hedge ratio was 22.9%. In no case did a firm use its financial portfolio to increase its exposure to gold prices, although in at least one case a firm did have a hedge ratio for a single quarter of 146%. The main variable that Tufano finds to provide at least a partial explanation for the different hedge ratios is managerial stock holdings. When management owns more stock and so is very exposed to gold price risk, the company hedges more. However, when management owns more options which would benefit from volatility, the company appears to hedge less.

¹⁶ Tufano, Peter, 1996, Who Manages Risk? An Empirical Examination Of Risk-Management Practices In The Gold Mining Industry, *Journal of Finance* 51, 1097–1137. Later studies include...

¹⁷ The delta is a sophisticated measure that takes into account the value sensitivity of option contracts that may be in or out of the money and that have a greater or lesser time to maturity. The precise meaning of delta will be given later in the text.

As we will see, the high variability in the size of hedging by different firms is a constant. There is little unanimity about the causes of this. It remains an important puzzle.

Oil and Gas Producers

Haushalter studied 100 independent oil and gas producers and their hedging activity during the years 1992-1994.¹⁸ He, too, finds the amount of hedging is highly variable. Approximately half of the firms did not hedge any production. Among those that did hedge, the average amount hedged was between 24% (median) and 30% (mean) of one year's production, although some hedged more than 70% and one hedged 90%. There seems to be more hedging in the gas portion of the industry than the oil portion. The most widely used hedging tools were oil price swaps, followed by fixed price contracts, followed by forwards and futures contracts. Options were used by a minority of hedging firms—10.5%. Interestingly, even within such a short period of time, companies change their hedging from year to year so that the correlation coefficient between the fraction of production hedged in 1992 and the fraction hedged in 1994 is only 0.582. Larger companies are more likely to have some kind of hedging program in place, although size does not explain the amount of hedging. Companies with more debt and who are financially constrained hedge more. Haushalter's results on managerial stock ownership and option positions are not entirely consistent with Tufano's results for the gold industry: greater option positions do lead to less hedging, but so do greater stock positions. Finally, a key determinant of hedging was geographical basis risk: hedging is more prevalent among companies whose production is located primarily in regions where prices have a high correlation with the prices on which exchange-traded derivatives are based. For these companies the exchange-traded derivatives are more likely to be an effective hedge.

Jin and Jorion studied 119 U.S. oil and gas producers and their hedging activity during the years 1998-2001.¹⁹ Roughly 1/3 of the sample (measured in firm years) is engaged in hedging both oil and gas, and 1/3 in hedging neither. The remaining 1/3 hedges either oil alone or gas alone. Most of the sample, 92 out of 119 firms, reported at least some hedging activity in at least

¹⁸ Haushalter, David, 2000, Financing Policy, Basis Risk, And Corporate Hedging: Evidence From Oil And Gas Producers, *Journal of Finance* 55, 107–152. In limiting the sample exclusively to firms primarily engaged in oil and gas production, the study excludes from the sample firms more popularly thought of as oil firms—such as Exxon and Chevron—which are also engaged in refining and marketing among other things. The pool of firms is therefore smaller than what one might casually think of as “the oil industry.”

¹⁹ Jin, Yanbo and Philippe Jorion, 2006, Firm Value and Hedging: Evidence from U.S. Oil and Gas Producers, *Journal of Finance* 61, 893-919. Compared to Haushalter, this study takes advantage of more detailed risk disclosures required by the SEC in 1997. As with Haushalter, this sample excludes the large oil majors.

one year; 47 reported oil hedging in each year and 68 reported hedging gas in each year. Out of 324 firm years with oil exposure, fewer than half, 146, hedge oil. Among hedging firms, the mean oil hedge ratio was 33% of next year's oil production and 4% of oil reserves: the median values were 24% and 2%. No firm had a negative ratio; i.e., companies did not speculate, but used derivatives to reduce their exposure. Out of 325 firm years with gas exposure, slightly more than half, 174, hedge gas. Among hedging firms, the mean gas hedge ratio was 41% of next year's gas production and 5% of gas reserves: the median values were 33% and 4%. No firm had a negative ratio. Hedging firms are much larger than non-hedgers—on average, two to three times the size.²⁰

Airlines

The airline industry represents a nice counterpart to the oil and gas producing industry since for airlines the price of jet fuel is a major cost of production—approximately 14% of revenues. Carter, Rogers and Simkins studied the hedging strategies of 28 US and US based airlines over the period of 1992-2003.²¹ The average hedge ratio, comparing financial securities locking in the price of fuel with one year's consumption, was 15%. But this ratio varied between 0% for several firms, to 80% for Southwest Airlines. Ten of the 28 airlines—more than one-third—did not hedge in any of the years. The major airlines were the most likely to hedge, and the smaller airlines the least likely.

Southwest Airlines considered its hedging strategy to be integral to its competitive strategy. The 2005 10K report trumpets the company's successful performance: "This performance was driven primarily by strong revenue growth, as the Company grew capacity, and effective cost control measures, including a successful fuel hedge program." And, in the words of Scott Topping, Southwest's vice president and treasurer, "Fuel hedging will continue to play a strategic role in the industry and be a potential source of competitive advantage."

²⁰ See also Chang Dan, Hong Gu and Kuan Xu, *The Impact of Hedging on Stock Return and Firm Value: New Evidence from Canadian Oil and Gas Companies*, Working Paper, 2005. "In this paper we analyze the impact of hedging activities of large Canadian oil and gas companies on their stock return and firm value. Differing from the existing literature this research pays particular attention to possible nonlinear payoffs of hedging activities, which may not be fully revealed in the traditional linear framework. By using generalized additive models, we find that the factors that affect stock return and firm value are indeed nonlinear. The large Canadian oil and gas firms are able to hedge against downside risk induced by unfavorable oil and gas price changes. But gas hedging appears to be more effective than oil hedging when downside risk presents. In addition, oil reserves tend to have a positive (negative) impact on stock returns when the oil prices are increasing (decreasing). Finally, hedging, in particular hedging for gas, together with profitability, leverage and reserves, has a significant impact on firm value."

²¹ Carter, David, Daniel Rogers, and Betty Simkins, 2006, *Does Hedging Affect Firm Value? Evidence from the U.S. Airline Industry*, *Financial Management* 35, 53-86. The results of this study have been retold in slightly more popular form in Carter, David, Daniel Rogers, and Betty Simkins, 2006, *Hedging and Value in the U.S. Airline Industry*, *Journal of Applied Corporate Finance* 18(4), 21-33.

Carter et al. (2006) also present some insight into the structure of a hedging program with an illustration from Lufthansa which shows how the hedge ratio and the instruments used vary with the horizon of the exposure being hedged. “Lufthansa hedges up to 90% of its planned fuel requirements on a revolving basis over a period of 24 months ahead. ...[B]eginning 24 months into the future, they start hedging 5% of their requirements using Brent Crude Oil Collars each month, incrementally increasing the level to 90% at seven months into the future. To minimize basis risk (i.e., the price difference between crude oil and kerosene), Lufthansa also hedges using crack spread collars. A crack spread collar involves the use of a pair of options (such as buying a call option and selling a put option where the hedge locks in a price range) on the crack spread (the difference in value between crude oil and the products such as kerosene refined from it). Since hedging kerosene for longer periods is expensive, Lufthansa combines the hedging of crude oil with short-term hedging of the crack spread. Lufthansa starts implementing the crack hedging strategy six months ahead at a monthly rate of 7.5%. As a result, 45% of basis risk is hedged using crack spread collars by the time the fuel is used.

Fingerprint Evidence

In addition to individual case studies on how companies manage risk and how broad samples of companies use derivative securities, there are a miscellany of studies assessing other evidence of the types of risk management being discussed in these lectures. Think of this as a forensic exercise: identifying the fingerprint of risk management.

The first class of studies analyzes whether the market price of certain assets appears to reflect the elements of value highlighted by sophisticated risk evaluation or whether a less differentiated cash flow valuation appears to do the trick. For example, Quigg studied real estate transactions in Seattle between 1976 and 1979, including 3200 developed and 2700 undeveloped investment properties. She calculated an ‘intrinsic value’ (aka a simple DCF) for each undeveloped property and also a valuation that recognized the highly risky upside in undeveloped properties (i.e., the “option value”). She found that market prices for the undeveloped properties contained a premium above the value estimate made using the DCF, and the market price was better predicted by a model that recognized this option value. According to her findings, 6% of the market price was an option premium, with a range of 1%-30%.²²

²² Quigg, Laura, 1993, Empirical testing of real option-pricing models, *Journal of Finance* 48, 621-640.

Berger, Ofek and Swary studied the market value of a large sample of publicly traded companies with data between the years 1984 and 1990. Using analyst forecasts of earnings, they calculate a naïve present value of cash flows. They also calculate a more sophisticated value that recognizes how the ability to liquidate assets of the firm offers some protection on the downside – the abandonment option. The calculation is based off of key line items of each company’s balance sheet and an estimate of the value of these items in liquidation. They find that the market value of the companies are better explained by the more sophisticated – i.e., real option – model of value as opposed to the naïve present value of cash flows.²³

A second class of studies attempts to identify the lessons in risk management not in the prices themselves, but in the asset management decisions of management. For example, Moel and Tufano analyze the opening and closing decisions of 285 North American gold mines during 1988-1997. They focus on “economic” opening and closing decisions – i.e., those not related to factors such as exhaustion of the mine or a strike, and which therefore are likely to have been motivated by movements in the price of gold and the profitability of extraction. As we will show later, the insights of risk management change the recommended mine management rules – how to make open and closure decisions contingent on movements in the price of gold. They found a number of patterns in the opening and closing decisions that are inconsistent with the simplistic DCF model and better explained by a decision model that recognizes the complex risk issues at hand.²⁴

Dikos and Thomakos (2007) document how investments in the oil tanker market matched against charter rates appear inconsistent with a simplistic DCF model and instead reflect the option to wait and delay investment until a later date, a key risk management concept for investment decisions.²⁵

A third type of study looks for “natural experiments” where something is exogenously changed, either in the risks facing the firm or in the marketplace for risk instruments. The researchers then attempt to use this sudden change to identify how companies and managers adjust their risk management behavior. An interesting example is a study by Gron, Beatty and

²³ Berger, Philip G., Eli Ofek and Itzhak Swary, 1996, Investor Valuation of the Abandonment Option, *Journal of Financial Economics* 42, 257-287.

²⁴ Moel, Alberto and Peter Tufano, 2002, When Are Real Options Exercised? An Empirical Study Of Mine Closings, *Review of Financial Studies* 15(1), 35-64.

²⁵ Dikos, George N., and Dimitrios D. Thomakos, 2007, Specification and Estimation of the Real Options Markup: The Case of Tanker Markets, MIT Working Paper.

Jorgenson of the product liability market following the product liability crisis of 1985-86. During these two years the price of product liability insurance increased so dramatically that these researchers use the event as a sort of natural experiment. Not only did the price rise, but insurers lowered coverage limits and charged higher deductibles. The study's authors identify 55 companies who had been insured prior to the dramatic price increase, and follow them through the subsequent years to observe how they respond and what determines the different responses. As certain theories about the interaction between risk management and capital structure would predict, the firms who were most likely to stop purchasing product liability insurance and bear the risk themselves were firms with no debt or otherwise fewer financing constraints. Similarly, the researchers find that when management holds more options, especially out-of-the-money options the firm is more likely to stop purchasing the higher priced insurance. Perhaps most interestingly, the authors document that firms who continue to purchase insurance appear to otherwise adjust their behavior so that the underlying business reflects more risk relative to those who do not continue purchasing the insurance.²⁶

If there are studies that show the irrelevance of risk management, ... well, ... you wouldn't expect to read about them in these notes, would you?

²⁶ Beatty, Anne, Anne Gron, Bjorn Jorgensen, 2003, Corporate Risk Management: Evidence From Product Liability, Working Paper. Published in Journal of Financial Intermediation.