15.997 Practice of Finance: Advanced Corporate Risk Management
Spring 2009

Measuring Risk
– Part A: Exposure

MIT Sloan School of Management
15. 997 Advanced Corporate Risk Management
John E. Parsons

Overview

- Defining and Measuring Exposure
- How Volatile are Companies?
- Decomposing Risk to Factors
- Modeling Exposure
- Total Exposure
- Economic Exposure
- Cash Flow Exposure vs. Value Exposure

2

Defining Exposure

- When we talk about exposure, we are talking about risk. Variables that cause the value of an asset to change are called risk factors. If changes in the factor cause changes in the asset value, then the asset value is exposed to the factor.
- The asset that is exposed could be, for example…
  - the total market value of a company,
  - the market value of a division or a project,
  - the value of a supply contract, or
  - the value of a security such as a stock or option or futures contract.
- One set of risk factors are called market risks and include,
  - exchange rates,
  - general market movements, i.e., stock market indexes,
  - the rate of inflation,
  - interest rates, or
  - the price of oil or other widely traded and quoted commodities.

3

Defining Exposure (cont.)

- Many key risk factors don't have a widely cited or even readily quotable index.
  - The demand for your company's product, product X, can wax and wane and is an important exposure.
  - Technological progress may advantage or disadvantage your product or services.
- And many key risk factors have to do with your own operations.
  - Is your company able to implement an important new plant design?
  - Can you train your staff to operate in a global environment?
  - Is your R&D pipeline going to succeed in generating new, valuable drugs.

4

An Aside

- These are risks that you don't want to hedge. Meaning you don't want to just sell them away. If you do that, you might as well quit the business. If you think this is a business that you should be in, then these are the risks you claim to be able to master. You will profit by taking on these risks and winning at them. This is what you invest your capital in. In order to make a profit, this has to be the gamble you take on.

5

Exposure Measures

- There are many ways to measure exposure or risk.
  - A common measure of risk is volatility, i.e., the standard deviation of the value. We can speak interchangeably about volatility and variance, since variance is the square of the volatility. Therefore, exposure to factor X is the volatility in value due to movements in factor X.
  - There are other measures of risk. A recently popularized measure is the *value at risk* or *VAR*. The *VAR* is the expected loss at a given confidence level, for example, the 5% confidence level.
  - Why are there multiple measures of risk? Because risk is a complicated thing!
  - Only in special cases, such as the normal distribution, can a random variable be summarized by just 2 parameters – expected return and variance. Many key risk factors are not well described by the normal distribution. For example, some have fat tails. And many asset exposures are asymmetric, creating a non-linear relationship between the factor and the asset value so that the distribution of the asset value is highly skewed. Therefore, variance is not a sufficient measure of risk.

6

Exposure Measures (cont.)

- A proper definition of exposure requires that we specify the horizon over which risk is measured.
  - Is the exposure measured over a day, a week, a year?
  - The size of the exposure may be sensitive to the horizon. For example, within a short horizon it may be impossible to close out a position. However, over a long horizon this is possible, and this puts a floor on the downside. The importance of horizon is even greater for analyzing risk at non-financial corporations than at financial corporations.
- Exposures can also be conditioned on key variables.
  - Market depth varies through time and can affect the volatility of a stock or other investment.
  - General GARCH properties. Be careful about observing a simple average across all market conditions and then projecting that forward at a given time.

7

3 Examples of Exposure Calculations

- Exposure of a receivable to a movement in the exchange rate.
- Exposure of a call option to changes in the stock price.
- Exposure of a company's stock price to environmental legislation.

8

Example #1: Exposure of a receivable to a movement in the exchange rate

- An Italian aircraft parts manufacturer has made a sale to a US company. It has delivered a parts shipment invoiced at $3.20 million. The cost of goods sold is €1.95 million. Payment is due in 3 months. The €/$ rate is 0.6842.
- Measured in Euros, the receipt on the transaction are risky. A 1% change in the exchange rate implies a €20,000 change in the Euro denominated value of the receivable.
- The 3-month volatility in the Euro/Dollar exchange rate is 8.9%, i.e., ±8.9% is a one-standard deviation movement in the exchange rate over a 3-month horizon.

9

Example #1: Exposure of a receivable to a movement in the exchange rate (cont.)

Standard Deviations	Percentile	Exchange Rate	Receivable in Euros	Gain or Loss
+2	98%	0.8047	2.58	0.39
+1.65	95%	.7831	2.51	0.32
+1	84%	.7439	2.38	0.19
0 (Mean)	50%	.6831	2.19	0
-1	16%	.6223	1.99	-0.19
-1.65	5%	.5831	1.87	-0.32
-2	2%	.5615	1.80	-0.39

10

Example #2: Exposure of a call option to changes in the stock price

- Using the Black-Scholes formula for a stock with a current price of $100, a strike price of $100, a time to maturity of 2 years, a volatility of 22%, and assuming the risk free rate is 5%: C($100) = $17.1.
- There is significant upside and limited downside. It is a very non-linear exposure.
- At the current price of $100, the option delta is 0.68331. Meaning that a $1 change in the stock price yields an approximately $0.68 change in the call price.
- But clearly for a large move in the stock price up, for example, $100, the change in the call price will be more than $68: C($200)-C($100) = $109.6-$17.1 = $92.5.
- And for a large move down, the change in the call price will be much less. C($0)-C($100)= -$17.1.
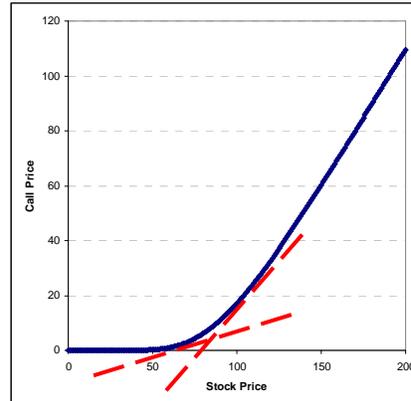
11

Example #2: Exposure of a call option to changes in the stock price

- The volatility of the option can also be calculated from the volatility of the stock:

$$\sigma_{call} = \sigma_{stock} |\Omega| = \sigma_{stock} \frac{S\Delta}{C}$$

- At S=$100, so that Δ=0.68331 and C=$17.13, we have Ω=3.99. Therefore, the call volatility is 88%.
- This is just the local volatility. At a higher stock price the volatility is smaller, at a lower stock price, it is greater.
- This is also local in the sense that it shows changes in the call value today as a function of changing the stock price today…not the changes in the call value at various horizons in the future.
- What is the VAR for the call at a 5% confidence interval?

12

6
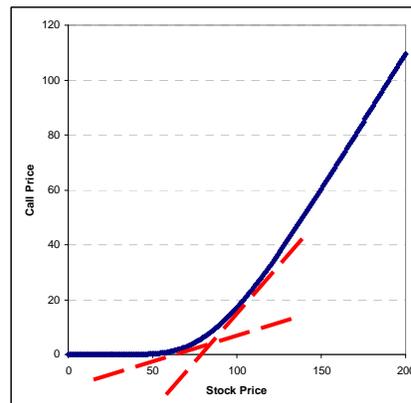
Example #3: Exposure of a company's stock price to environmental legislation

- A company's stock price is exposed to many risk factors. Corporate 10Ks traditionally list the major exposures or risk factors, providing a qualitative, but not quantitative statement.
- Some examples from Peabody Energy Co's 2006 10K are…
  - *If a substantial portion of our long-term coal supply agreements terminate, our revenues and operating profits could suffer if we were unable to find alternate buyers willing to purchase our coal on comparable terms to those in our contracts.*
  - *If transportation for our coal becomes unavailable or uneconomic for our customers, our ability to sell coal could suffer.*
  - *Our mining operations are extensively regulated, which imposes significant costs on us, and future regulations and developments could increase those costs or limit our ability to produce coal. …Legislation was introduced in Congress in 2006 to reduce greenhouse gas emissions in the United States. Such or similar federal legislative action could be taken in 2007 or later years. Further developments in connection with legislation, regulations or other limits on greenhouse emissions, both in the United States and in other countries where we sell coal, could have a material adverse effect on our financial condition or results of operations.*
- Stock analysts and other researches attempt to quantify these exposures in various ways…

13

Example #3: Exposure of a company's stock price to environmental legislation (cont.)

- Robert Repetto of Stratus Consulting produced this analysis of the Kyoto Protocol adoption on the stock prices of various oil cos:

Image removed due to copyright restrictions.

- Hugh Wynne, a Senior Research Analyst at Bernstein Research, has a very insightful breakdown of how passage of the Lieberman-Warner or like carbon legislation would impact different electric utilities in the US. Some gain and some lose. Why?

14

Example #3: Exposure of a company's stock price to environmental legislation (cont.)

- The adequacy of corporate disclosures with respect to climate legislation exposures has been a pressure point of late, both for regulators and for active shareholder groups.

15

Total Exposures of Exchange Traded Corporations

- A study by Andersen et al. (2000) estimated the volatility of the 30 individual stocks in the DJIA (not the portfolio) during 1993-1998…
  - median annual volatility of 28%,
  - high of 42% for Walmart, and low of 22% for United Technologies.
  - As a comparison, the annual standard deviation for a broad market portfolio was approximately 11% in the 1990s. (figure from Campbell et al. 2000)
- Probably varies cross sectionally – across countries, industries.

16

Total Exposures of Exchange Traded Corporations (cont.)

- Annual volatility of the market as a whole shows no consistent trend. There have been periods of markedly higher and periods of markedly lower volatility.

Standard deviation of value-weighted stock index. The standard deviation of monthly returns within each year is shown for the period from 1926 to 1997.
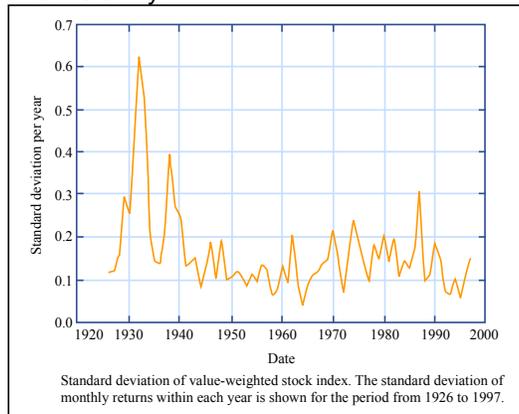
Image by MIT OpenCourseWare. Adpated from Figure 1 in Campbell, J. Y., M. Lettau, B. G. Markiel, and Y. Xu. "Have Individual Stocks Become More Volatile? An Empirical Investigation of Idiosyncratic Risk." *Journal of Finance* 56 (2001): 1-43.

17

Total Exposures of Exchange Traded Corporations (cont.)

- Volatility can be measured in different ways: for example, using recent historical returns, or using implied volatilities. These are 2 techniques ostensibly for measuring the same thing.
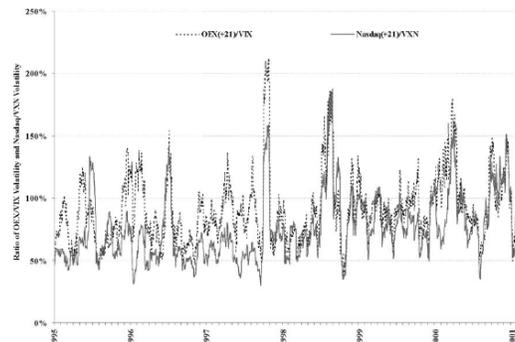

Fig. 4. Ratio of the historical volatility of the S&P 100 (OEX) portfolio for the next 21 trading days (about one month) to the implied volatility of the S&P 100 portfolio (VIX) from CBOE options prices. Also, the ratio of the historical volatility of the Nasdaq portfolio for the next 21 trading days to the implied volatility of the Nasdaq 100 portfolio (VXN) from CBOE options prices. January 1995 through June 25, 2001.

G. William Schwert / Journal of Monetary Economics 49 (2002) 3–26

18

Courtesy Elseviver, Inc., http://www.siencedirect.com. Used with permission.

Total Exposures of Exchange Traded Corporations (cont.)

- Volatility is measured under an assumption of a given model. Classic assumption is normality – or lognormality – and an unchanging distribution through time. This yields the standard formula for estimating the standard deviation.
  - GARCH models.
  - Mixing of normals yields fat tails.
  - How relevant are these to the corporate context?

Decomposing Stock Volatility Into Risk Factors

- The Market Risk Factor – CAPM's Beta
  - The Market Index Model decomposes a company's stock price movements into 2 parts.
  - One part is the movements associated with general stock market movements. This is the systematic component.
  - The second part is the residual or unaccounted for movements. This is the non-systematic component.

$$R_{it} = \alpha_i + \beta_{im} R_{mt} + \varepsilon_{it}$$

- The regression R^2 tells us the portion of the volatility that is accounted for by general market movements.

Decomposing Stock Volatility Into Risk Factors (cont.)

Beta = 1.16

R-squared = 0.575
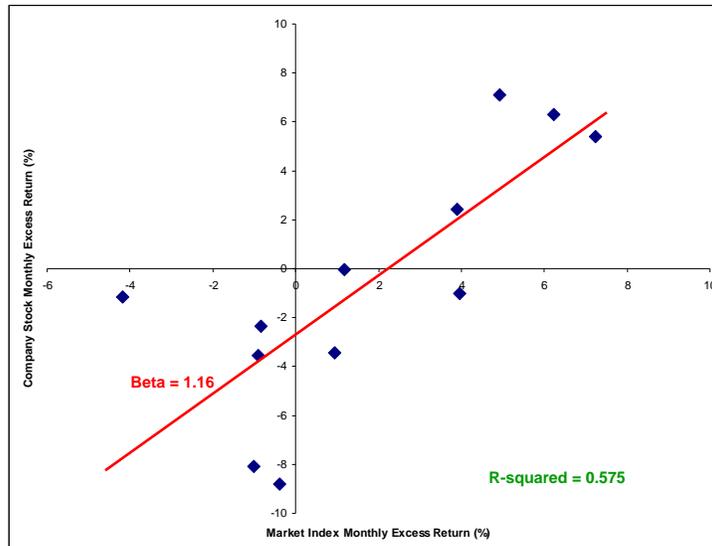
Adapted from Bodie, Kane & Marcus, Investments.

21

Decomposing Stock Volatility Into Risk Factors (cont.)

- Maybe there is more than just one factor? This is the rationale for models such as the APT. Other macroeconomic factors that have been considered are…
  - the long- short-term yield spread
  - real GNP
  - inflation
- Each of these macroeconomic factors will account for some portion of the volatility of a given stock, and we can determine these fractions.
- Other models include Fama-French 3-factor model, and more.

22

11

Decomposing Stock Volatility Into Risk Factors (cont.)

- The Industry Index Model is a popular tool for dividing the volatility of a firm's return into 3 components…
  - the market component,
  - the industry component, and
  - the firm specific component.
- It is exactly like the CAPM's market model, except with an additional regressor, the performance of an index of comparable companies:

$$R_{it} = \alpha_i + \beta_{im} R_{mt} + \beta_{i,comp} R_{comp,t} + \varepsilon_{it}$$

- We can attribute a portion of the stock's movements to each of the three components.

23

Example #1: Performance Evaluation at Ralston Purina

- Campbell and Wasley, 1999, Stock-based incentive contracts and managerial performance: the case of Ralston Purina Company, Journal of Financial Economics 51, 195-217.
- In 1986 Ralston Purina adopted a new incentive contract for its management, giving them $49.1 million in stock within 10 years if the stock price closed above $100 for 10 consecutive days. At the time of adoption, the price was $63.375.
- By February 1991 this hurdle had been reached.
- Campbell and Wasley calculate an industry index model of returns during this period.

24

Example #1: Performance Evaluation at Ralston Purina (cont.)

Image removed due to copyright restrictions.

Example #1: Performance Evaluation at Ralston Purina (cont.)

- From 1986 to 1991, the entire industry had been outperforming the market. Relative to its peers, Ralston Purina performed very poorly. Unadjusted, Ralston's shareholder value increased $3,111 million. But industry adjusted the change is negative… -$2,072 million.
- Campbell and Wasley perform a number of other tests and analyses. Their conclusion is that the incentive contract was badly designed.

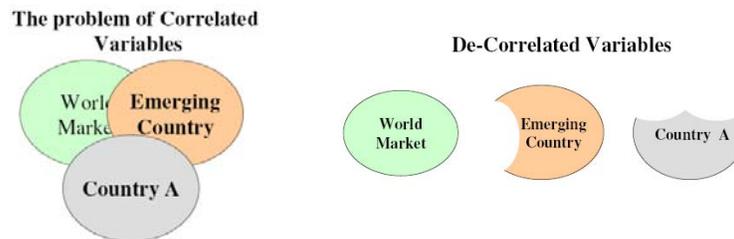## Example #2: Identifying Exposures of Latin American Firms

- Sergio Pernice, Mariano Fernandez and María A. Alegre,Quantifying Latin American firms' exposure to external factors, Universidad del CEMA Working Paper
- Decompose the returns of various companies headquartered in Latin America on…
    - the global market, proxied by the S&P500
    - the regional market, using an index of all of the companies
    - its country specific market, using an index of companies in its same country
    - its industry, using an index of companies in that industry
    - and the company specific risk, which is just the residual volatility

$$R_{i,t} = \alpha_i + \beta_{im} R_{mt} + \beta_{i,region} R_{region,t} + \beta_{i,country} R_{country,t} + \beta_{i,industry} R_{industry,t} + \varepsilon_{it}$$
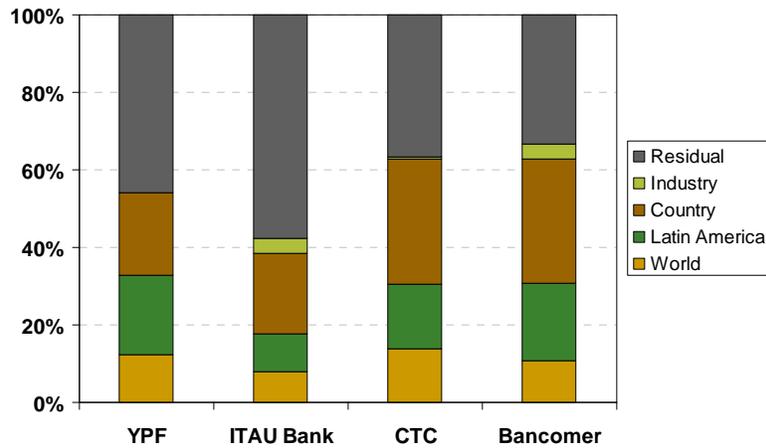
27

Example #2: Identifying Exposures of Latin American Firms (cont.)

- Highlights the problem of having many factors, some of which may be highly correlated with one another, muddying up the statistical validity of the estimation or the meaning of the coefficients. This problem can be resolved, however.

28

14

Example #2: Identifying Exposures of Latin American Firms (cont.)

29

Factor Weights Appear To Be Changing Over Time

Panel B: Average R^2 statistics of market model for individual stocks

Average correlations and R^2 statistics of market model for individual stocks. The top panel reports the equally weighted average pairwise correlation across stock traded on the NYSE, AMEX, and Nasdq. The solid line is the average correlation over the past 60 months of monthly data, and the dotted line is the average correlation over the past 12 months of daily data. The bottom panel reports the equally weighted average R^2 statistic of a market model, estimated using the past 60 months of monthly data (solid line) or the past 12 months of daily data (dotted line). Stocks included in the calculation at each point in time are required to have a complete return history over the past 60 months (solid line) or 12 months (dotted line).
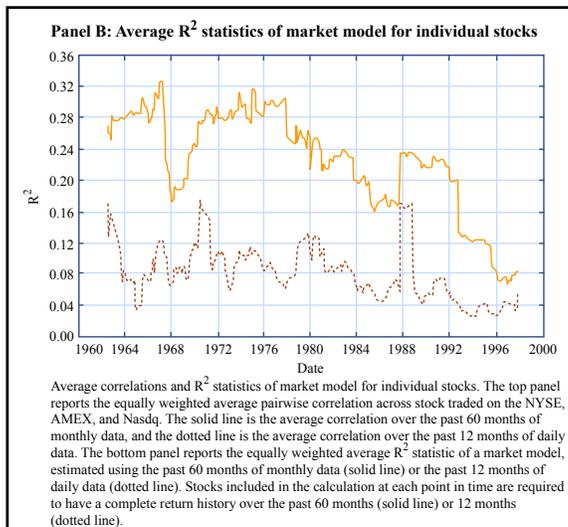
Figure by MIT OpenCourseWare. Adpated from Figure 1 in Campbell, J. Y., M. Lettau, B. G. Markiel, Y. Xu. "Have Individual Stocks Become More Volatile? An Empirical Investigation of Idiosyncratic Risk." *Journal of Finance* 56 (2001): 1-43.

30

15

Decomposing Stock Volatility Into Risk Factors (cont.)

- The extra risk factor in the model needn't be an industry index. It can be a commodity price or the exchange rate.
- For example, to measure a gold mining company's exposure to gold prices as well as to the market index, you expand the usual CAPM regression to include the returns to gold as one of the independent variables:

$$R_{it} = \alpha_i + \beta_{ig} \, R_{gt} + \beta_{im} \, R_{mt} + \varepsilon_{it}$$

- It is important to get a complete measure of returns. In the case of gold this means measuring the lease rate as well as changes in the price, much as with stocks we need to account for dividends.

31

Example: Gold Firms

- Tufano, Peter, 1998, The Determinants of Stock Price Exposure: Financial Engineering and the Gold Mining Industry. Journal of Finance 53(3), 1015-1052.
- Typical "gold beta" is around 2
  - a 1% change in the price of gold produces a 2% change in the stock price
  - Raw distribution is very wide: 5th percentile has a gold beta of -0.44 and the 95th percentile a gold beta of 5.68. None of the negative betas, however, are statistically different from zero..
  - Individual company gold betas also change through time. The beta of 2 is an average over companies and quarters through the period 1990-1994.

32

Example: Gold Firms (cont.)

Time series and cross-sectional distribution of Dimson-adjusted gold betas. The top figure plots the quarterly mean and medians of the Dimson-adjusted firm-quarter gold betas for the sample of North American gold-mining firms during the period April 1990 to January 1994. The bottom figures plot the cross-sectional distribution of betas for two quarters, January 1991 and April 1993.
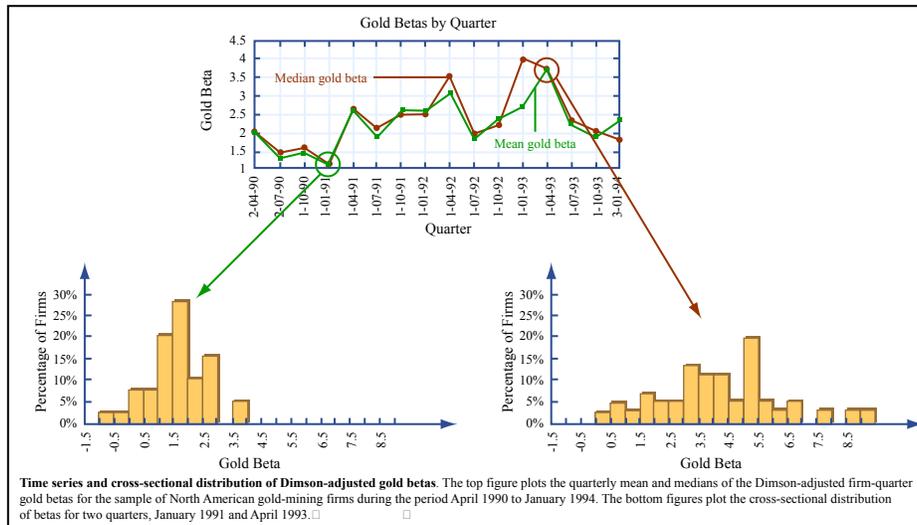
Image by MIT OpenCourseWare. Adapted from Tufano, Peter. "The Determinants of Stock Price Exposure: Financial Engineering and the Gold Mining Industry." *Journal of Finance* 53, no. 3 (1998): 1015-1052.

33

Other Statistical Techniques

- The standard linear regression onto various factors is just one statistical technique. It is appropriate for certain kinds of risk relationships… continuous, linear. There are other techniques that are appropriate to other risk relationships…
  - Probit models for estimating the likelihood of some discrete event.
- And there are techniques for extracting information more efficiently under certain circumstances. What if you need information about the tail, and you are afraid that your distribution assumptions are not correct. Then the classic regression will lead you astray.
- We are not probing this any more deeply here and now. But the point is that this is where more sophisticated statistical analysis would fit in.

34

17

Modeling Exposure

- Step #1: Model the firm's operations and therefore cash flows.
- Step #2: Observe the functional relationship between a given risk factor and the firm's value.
  - This is a classic comparative statics exercise. It involves measuring the sensitivity of the model to variations in an input, i.e., as would produce a tornado diagram.
- Transaction exposure calculation is the classic and simplest example.
- This exercise is also known as a pro-forma exposure calculation.

Modeling Exposure (cont.)

- Example: Measuring the exposure of bitumin supply cost to
  - elements of the discount rate,
  - natural gas prices
  - other, non-fuel, operating costs, such as labor costs, and
  - capital costs.

SAGD in-situ DalBir production
Supply cost of raw bitumen (netback) - Sensitivity analysis

Discount rate (4% - 5% - 8%)

Natural gas (+/- 10%)

Non-fuel operating cost (+/- 10%)

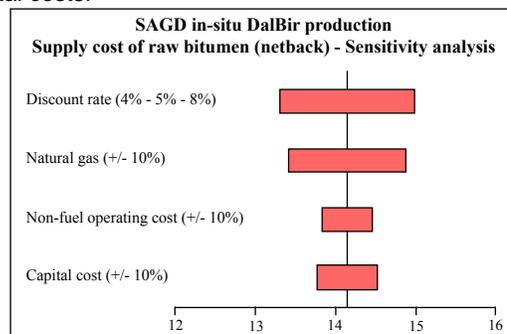Capital cost (+/- 10%)

12   13   14   15   16

Image by MIT OpenCourseWare.

Lacombe, Romain, and John Parsons, 2007, Technologies, Markets and Challenges for Development of the Canadian Oil Sands Industry, MIT-CEEPR Working Paper 07-006. The spreadsheet model is available at web.mit.edu/ceepr/www/publications/workingpapers/Oil_Sands_Cost_Model_Final_Version_2007-006.xls

Accounting for Flexibility or Dynamic Responses to Changing Risk Factors

- Flexibility should be accommodated, and to some degree can be.
  - With help of computers, decision rules can be input when taking a cash flow model and constructing alternative scenarios or a monte carlo simulation
  - Real option models can be constructed.
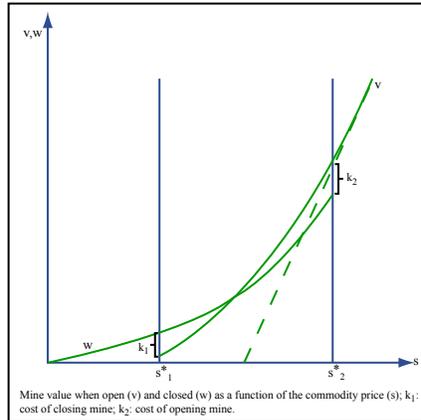- But it's hard.

Image by MIT OpenCourseWare. Adapted from Brennan, Michael J., and Eduardo S. Schwartz. "Evaluating Natural Resource Investments." *The Journal of Business* 58, no. 2 (1985): 135-157.

Mine value when open (v) and closed (w) as a function of the commodity price (s); k_1: cost of closing mine; k_2: cost of opening mine.

37

Example: Comparing Observed vs. Modeled Exposure of Gold Mining Firms

Excerpt from page 1024, Tufano, Peter. "The Determinants of Stock Price Exposure: Financial Engineering and the Gold Mining Industry." *Journal of Finance* 53, no. 3 (1998): 1015-1052. Removed due to copyright restrictions.

38

Example: Comparing Observed vs. Modeled Exposure of Gold Mining Firms (cont.)
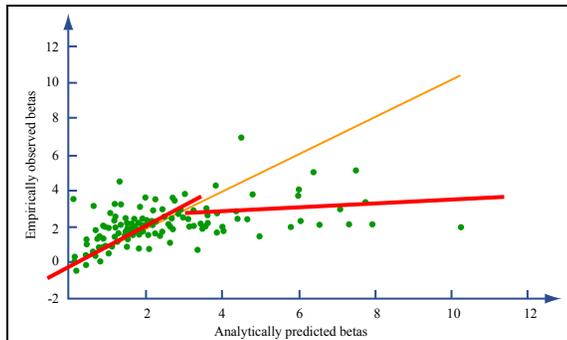
The relationship between empirically observed and analytically predicted betas. This figure plots empirically observed betas and analytically predicted fixed-production betas (β_{ig} and β^*, respectively). The analytically predicted fixed-production betas are calculated annually in the period 1990 to 1993 using accounting and stock price data and equation (10) in the paper. Data constraints limit the sample to 139 useable firm-year observations, reflecting 46 firms. The empirically observed betas β_{ig} are recalculated using the two-factor market model with daily data over the same annual periods. The betas are adjusted for nonsynchronous trading using the method proposed by Dimson (1979) and Fowler and Rorke (1983). The line represents those points where the empirically observed betas and the analytically predicted betas are equal.

Modeled sensitivities (analytically predicted betas) are very high when, for example, the gold price is very low. In this case companies may take managerial actions to change the production rate or otherwise reduce the exposure. These actions are often overlooked in simple models of exposure. The data, however, appears to reflect these reduced exposures.

Image by MIT OpenCourseWare. Adapted from Tufano, Peter. "The Determinants of Stock Price Exposure: Financial Engineering and the Gold Mining Industry." *Journal of Finance* 53, no. 3 (1998): 1015-1052.

39

Final Exposure

- Exposures are sometimes reported as a sensitivity measure like Beta—a 1% change in the underlying risk factor will cause, on average, an X% change in the value of the asset.
- This is not a complete answer, however. If the underlying risk factors itself is not very volatile, then the final exposure will be small, even for a high Beta. If the underlying risk factor is extremely volatile, then a small Beta can be misleading.
- The sensitivity measure must be combined with information about how volatile is the underlying risk factor. This will give the total volatility of the asset value that is likely to be due to the factor.

40

Multiple Factors

- The previous examples have all looked at the exposure to single factors one at a time.
- When there are multiple factors, and these factors often move together, it is important to take into account the correlation between the factors.
  - For example, suppose a US company sells its goods in a variety of other countries… the United Kingdom, France, Germany, Brazil, Mexico.
  - It will have some receivables denominated in each currency.
  - It's exposure to movements in any single exchange rate will be small, simply because only a fraction of its receivables are denominated in that currency.
  - It doesn't make sense to simply add up all of the exchange rate exposures.
  - Its total exposure to exchange rate risk may be larger or smaller than the simple addition tells you, depending upon whether the various exchange rates generally move together or separately, i.e., are correlated or uncorrelated. If they move separately, then diversification reduces the exposure.

41

Economic Exposure

- Many distinct parameters within a model should not be treated as separate risk factors. For modeling and spreadsheet purposes, we can input these as separate factors. But in the real world they may be linked.
- This is especially true of exchange rates and currency denominated selling prices or input prices. The very movement of an exchange rate may change the foreign currency denominated price at which you can sell the commodity in the foreign country.
  - The 2005-2008 run-up in oil prices was very expensive for companies around the world. But because the €/$ exchange rate increased as well during that time, the € cost to European companies was softened. How much of the run-up in the $ denominated oil price is actually just a reflection of the fall in the dollar?
- See the case of Western Mining – a reading in the case packet.

42

Cash Flow Exposure

- Exposure is often defined in terms of a variable's impact on the value of an asset or the value of a company and its stock.
- Exposure can be defined in terms of any parameter that may be affected by the underlying risky variable.
- A popular exposure to calculate is the impact on cash flow. For example, what will be the impact of a change in the exchange rate on next quarter's cash flow.
  - or the cumulative cash flow over the next year.
- The firm's value is the discounted present value of all future cash flows. So properly measured, a firm's cash flow exposures add up to the firm's value exposure.
  - Or, they would in a rational market. Shiller ( ) has argued that stock prices are too volatile compared to the volatility of dividends and ultimately the cash flows of the firm.

43

Why Cash Flow Exposure Matters

- Why cash flow volatility may matter. More on this in later lectures. But a brief allusion now…There are several possible reasons.
- First, the comptroller needs to manage the firm's cash situation so as to minimize transaction costs and so as to minimize the pool of low return, liquid cash equivalents needed. Knowing the potential volatility of short-run cash needs is essential to this task.
- Second, the long-run financial value of the firm can also be critically impacted by short-run cash flow fluctuations…
  - Suppose a firm is long a commodity – as an oil producing firm would be.
  - And suppose the firm hedges its revenue stream with a financial instrument such as an oil futures contract. The hedge appears to be perfect in the sense that the value of the futures contract is perfectly negatively correlated with the value of the anticipated oil revenues.
  - But the futures contract has very different cash flow structure. Gains or losses on the futures contract must be settled up immediately, while anticipated gains or losses on the future oil sales are only realized as production occurs and the sales are made.

44

Why Cash Flow Exposure Matters (cont.)

- There may be a cash flow mismatch even where there appears to be a perfect value hedge. If the value of the anticipated sales is rising, then the futures must be losing money and the company is shelling out cash now, but banking on a larger future revenue stream.
- But how large of a cash shortfall can the firm cope with?
- Are the short-run losses self-financing? Can you borrow to cover the cash drain from the futures? You would appear to have the collateral to borrow, since the future anticipated revenue stream has gone up by as much as the cash drain.
- The answer is, no, the short-run losses on the perfect hedge are not self-financing.
- The hedge is only perfect if we focus narrowly on the revenue exposure. But the company's value is affected by multiple risks. These other risks interfere with the self-financing property of the apparently perfect revenue hedge. And the effect is significant.
- Mello and Parsons, 2000, Hedging and Liquidity, RFS
- The sad tale of Metallgesellschaft. Intermediate cash flows can matter.

45

Total Cash Flow Exposures of Exchange Traded Corporations

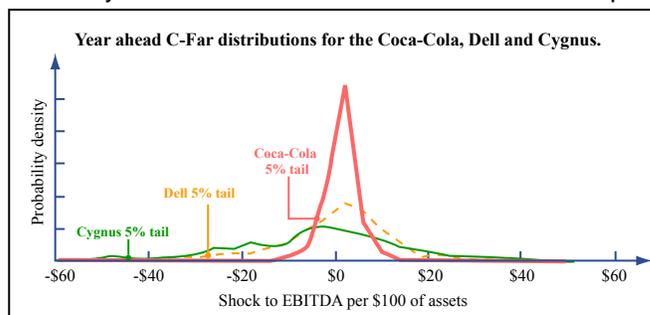- Here is a year-ahead cash flow distribution for 3 companies:

Image by MIT OpenCourseWare. Adapted from Stein, Jeremy, Stephen Usher, Daniel LaGattuta, and Jeff Youngen. "A Comparables Approach to Measuring Cashflow-at-risk for Non-financial Firms." *Journal of Applied Corporate Finance* 13, no. 4 (2001): 100-109.

- These have actually been constructed from comparables.
  - Coca-Cola's distribution represents the sample distribution of cash flow shocks for approximately 1,000 companies like Coca-Cola over the years 1991-1995.
  - The other two distributions are the sample distributions for 50 companies like Dell and another 50 companies like Cygnus.

46

Total Cash Flow Exposures of Exchange Traded Corporations (cont.)

- Data is quarterly EBITDA, a proxy for operating cash flow for approximately 4,000 firms over the years 1991-1995.
- Construct a model of cash flow forecasts in order to center the observed cash flows and identify the error or unexpected component of cash flow.
  - Use an autoregressive model, basing next quarter's forecast on the observed cash flows from the last four quarters.
- Sort the companies into 81 buckets, a low, medium and high value for each of 4 criteria:
  - market capitalization
  - profitability
  - industry risk
  - stock price volatility
- Report the distribution of forecast errors for each of the 81 buckets.
- Find the 5% confidence level for each bucket.

47

Total Cash Flow Exposures of Exchange Traded Corporations (cont.)

Panel A. Quarter-ahead 5% C-far tails[a]										
		Industry Bucket								
		1			2			3		
Stock volatility bucket	Market cap bucket	**EBITDA/Assets Bucket**			**EBITDA/Assets Bucket**			**EBITDA/Assets Bucket**		
		1	2	3	1	2	3	1	2	3
1	1	-7.63	-3.12	-3.32	-10.29	-4.30	-3.84	-11.70	-5.20	-6.15
	2	-1.93	-1.37	-1.69	-6.96	-2.18	-2.77	-8.38	-3.22	-4.49
	3	-1.21	-1.11	-1.46*	-1.16	-1.45	-1.71	-2.52	-2.13	-3.14
2	1	-7.13	-3.99	-3.91	-11.97	-5.49	-5.19	-13.05	-6.51	-6.96
	2	-3.68	-1.76	-2.34	-8.96	-2.48	-4.24	-9.83	-4.81	-6.23
	3	-0.96	-1.14	-1.84	-1.27	-1.19	-2.40	-3.22	-2.12	-3.80
3	1	-7.87	-4.13	-4.94	-11.16	-5.59	-6.09	-12.93	-7.88	-7.56
	2	-6.92	-2.59	-3.09	-11.06	-4.84	-6.05	-14.41***	-6.08	-7.53
	3	-1.51	-1.66	-2.47	-2.65	-2.12	-4.10	-6.05	-3.99	-6.63**

[a]For a firm with $100 in assets, each cell shows how big a negative shock to one-quarter ahead EBITDA (Panel A) or one-year ahead EBITDA (Panel B) occurs with 5% probability.

*Bucket containing Coca-Cola. **Bucket containing Dell. ***Bucket containing Cygnus.

48

Total Cash Flow Exposures of Exchange Traded Corporations (cont.)

Panel A. Quarter-ahead 5% C-far tails[a]										
		Industry Bucket								
		1			2			3		
Stock volatility bucket	**Market cap bucket**	**EBITDA/Assets Bucket**			**EBITDA/Assets Bucket**			**EBITDA/Assets Bucket**		
		1	2	3	1	2	3	1	2	3
1	1	-7.63	-3.12	-3.32	-10.29	-4.30	-3.84	-11.70	-5.20	-6.15
	2	-1.93	-1.37	-1.69	-6.96	-2.18	-2.77	-8.38	-3.22	-4.49
	3	-1.21	-1.11	-1.46*	-1.16	-1.45	-1.71	-2.52	-2.13	-3.14
2	1	-7.13	-3.99	-3.91	-11.97	-5.49	-5.19	-13.05	-6.51	-6.96
	2	-3.68	-1.76	-2.34	-8.96	-2.48	-4.24	-9.83	-4.81	-6.23
	3	-0.96	-1.14	-1.84	-1.27	-1.19	-2.40	-3.22	-2.12	-3.80
3	1	-7.87	-4.13	-4.94	-11.16	-5.59	-6.09	-12.93	-7.88	-7.56
	2	-6.92	-2.59	-3.09	-11.06	-4.84	-6.05	-14.41***	-6.08	-7.53
	3	-1.51	-1.66	-2.47	-2.65	-2.12	-4.10	-6.05	-3.99	-6.63**

[a]For a firm with $100 in assets, each cell shows how big a negative shock to one-quarter ahead EBITDA (Panel A) or one-year ahead EBITDA (Panel B) occurs with 5% probability.

*Bucket containing Coca-Cola. **Bucket containing Dell. ***Bucket containing Cygnus.

49

Image by MIT OpenCourseWare. Adapted from Table 2 of Stein, Jeremy, Stephen Usher, Daniel LaGattuta, and Jeff Youngen.
"A Comparables Approach to Measuring Cashflow-at-risk for Non-financial Firms." *Journal of Applied Corporate Finance* 13, no. 4 (2001): 100-109.

Problems

- Accuracy may be exaggerated.
  - assumes sample from a given window of time is fully representative
  - what if the sample period is unrepresentative? what if the population is highly correlated to a given factor and this factor is not adequately sampled? e.g., real estate portfolios
- Cannot use this for management.
  - no analysis of how cash flow exposure is related to specific variables
  - can't say how it will move in response to management actions
- Relevance may be exaggerated. Better to use closer comparables.
  - Members of Dell's bucket included its competitors at the time, Compaq, Gateway and Micron, but also Cisco as well as Bed Bath & Beyond, and Williams Sonoma. Like on some measures, but not full comparables.
  - Repeat the exercise for an industry such as electricity companies…

50

Cash Flow Exposure of Electricity Companies

- SIC codes 4911 and 4931
- 100 companies
  - Segment into 4 buckets on two criteria: low and high profitability and low and high stock price volatility
- Expand time period to 1990-1999
  - divide this into 3 sub-periods

C-Far Analysis of Electricity Industry

Panel A. 5% Year-ahead values per $100 of assets for industry as a whole		
Early '90s (1990Q1-1993Q1)	Mid '90s (1993Q2-1996Q2)	Late '90s (1996Q3-1999Q4)
-1.80	-2.11	-3.30

Panel B. 5% Year-ahead values per $100 of assets for subsamples in late 1990's		
	Low profitability	High pr ofitability
Low stock price volatility	-2.79	-2.34
High stock price volatility	-5.11	-2.67

Image by MIT OpenCourseWare. Adapted from Table 4 of Stein, Jeremy, Stephen Usher, Daniel LaGattuta, and Jeff Youngen. "A Comparables Approach to Measuring Cashflow-at-risk for Non-financial Firms." *Journal of Applied Corporate Finance* 13, no. 4 (2001): 100-109.

- Results show that cash flow-at-risk of electricity companies increased during this period. Interestingly, the median debt-to-assets ratio did not respond to this increase in risk, staying around 39% over this period.

51

Top Down Versus Bottom Up Approaches

- 2 basic approaches…
- Top down:
  - look to the data on actual variability of one or more firms
  - use statistical analyses to try and identify the effect of specific risk factors
- Bottom up:
  - model the project or the firm and how the cash flows respond to one or more risk factors;
  - model the individual risk factors, their correlation and dynamic evolution;
  - evaluate the total project or firm risk profile; typically using scenario analysis or simulation
- Best to try and exploit both; corroborate, integrate results of each into a more precise picture.

52