Two sides of the same coin

Why corporate risk managers and trading risk managers calculate risk differently

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Who am I?

- PhD in Particle Physics and Cosmology from Yale University
- Began my career at Bankers Trust as an IR quant in 1991
- Worked at DLJ, CSFB, HSBC, and as a contractor
- Joined Wells Fargo (Wachovia) in 2005 to run Fixed Income Analytics
- After Wells Fargo acquired Wachovia, was a senior leader in the Traded Markets model development team
- In 2017 became head of the Corporate Risk Model Development CoE
- Co-founder of the Wells Fargo Quant Associate program
- Current member of the Wells Fargo Quantitative Analytics Council

What am I here to talk about?

- (What might I talk about in 30-45 minutes that might actually be useful to you?)
- Trading risk managers and corporate risk managers start from the same place: complex pricing functions
- They have broadly the same goal: to minimize risk
- And yet they wind up with very different tools that work in very different ways, and often don't understand why the other does things the way they do
- This is just a specific instance of a broader fundamental issue: the importance of understanding the details of a problem

❖ When quants fail, it's not usually because they don't understand the math. They fail because they don't understand the business motivation behind the math problem they are trying to solve

Overview of the talk

- Enumerate the specific needs and concerns of trading risk managers versus corporate risk managers
- Provide a quick overview of how derivatives are priced, primarily to define a consistent vocabulary
  - Not the math; just the operational connections that allow a portfolio to be thought of in the abstract as a complex function of market observables
- Describe how trading risk managers calculate risk to address their concerns
- Highlight the difficulties with corporate risk managers applying the same approach
- Describe how corporate risk managers in fact calculate risk
- Questions

Different ways of thinking about risk

Trading Risk Manager	Market Risk Manager
• Used to verify sensitivity to small market moves	• Used to determine the likelihood of portfolio losses based on history, incl. large market moves
• Focus needs to be narrow: an individual trader needs to know his specific risk	• Focus is broad: only care about large-ish risks to the firm
• Answer needs to be precise: even a small systematic loss can get the trader fired	• Precision is not essential
• Needs to care about all risks individually	• Needs to care about impact of risks only in aggregate
• Scope is small, usually a single business	• Scope is wide: needs to worry about cross-asset accumulation of risk

Different ways of thinking about risk, cont'd

Trading Risk Manager	Market Risk Manager
• Used to calculate hedges: a hedged portfolio will not change value under small market moves	• Used to calculate trading limits and to define required capital
• Risk is calculated many times a day for immediate use	• Risk is calculated usually daily, and often with a lag
• Need to worry about stability and convergence	• Need to worry about correlation and idiosyncracy

Pricing derivatives

- A derivative is a financial instrument whose price is derived from another instrument
- The simplest example is a stock option: the option value on expiry is determined by the stock price
- More complex instruments, such as a callable range accrual, have more complicated relationships but are still defined in terms of underlying market observables
  - CRA's are similar to fixed rate callable bonds, but they only accrue interest on days when a reference index is within certain bounds
- It shouldn't be a surprise, then, that pricing models tend to price derivatives using simple market data as a starting point

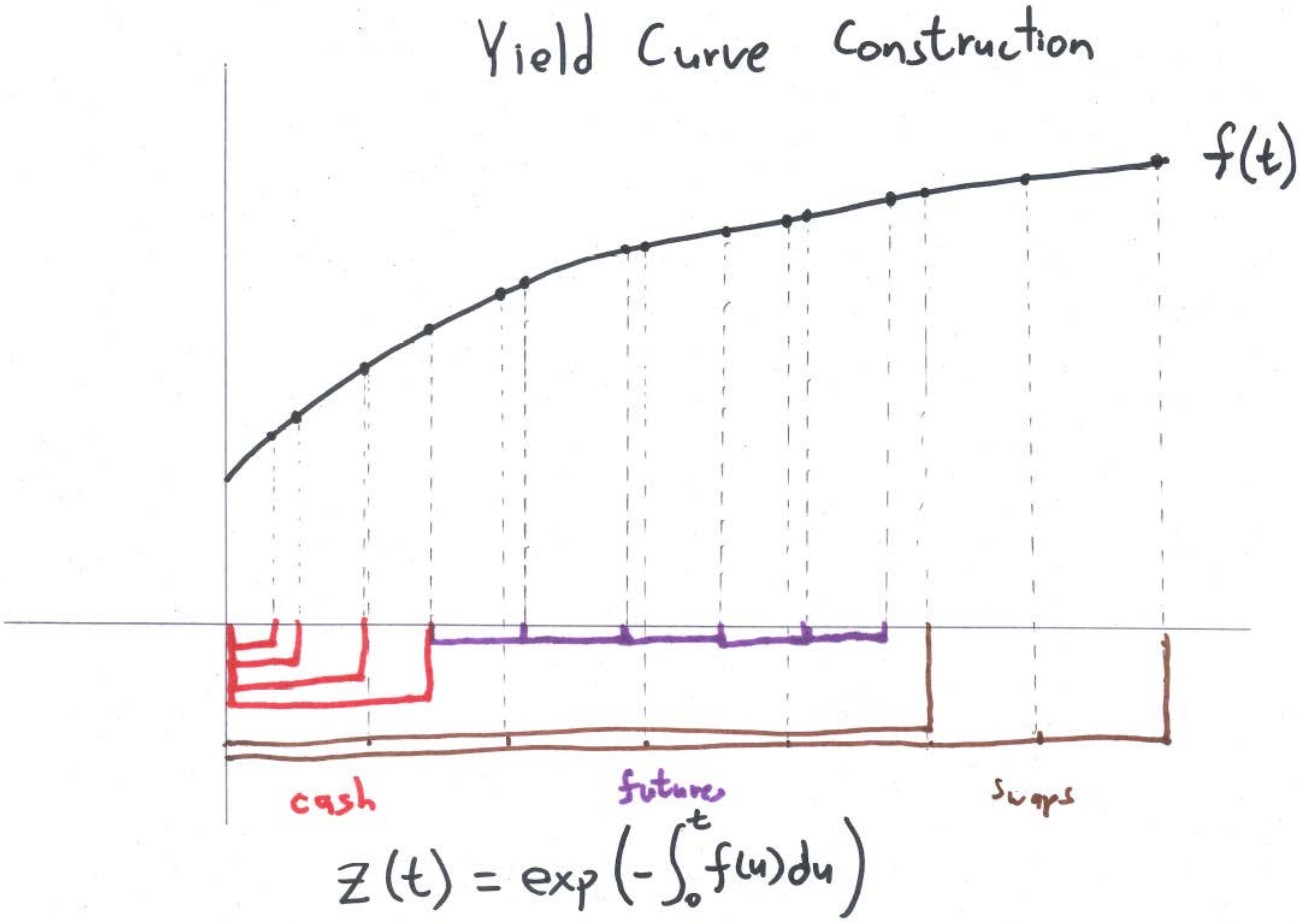
Pricing derivatives, cont'd

- Typically this takes place in several stages:
  - Market data (along with additional parameters) is used to define market data objects
  - Market data often nests, where more complex market data objects take in simpler market data objects
  - Market data objects plus other parameters in turn define the dynamics of fundamental processes
  - Those fundamental processes are used to price the complex instruments

Market data object example 1: Yield Curve

- The yield curve is the most fundamental market data object for pricing rate-sensitive instruments
- It is a tool that allows a riskless discount factor to be calculated to any maturity
- With this, the riskless forward rate over any forward period can be calculated, including cash, forward, and par swap rates
- It is constructed using highly liquid, very observable reference rates: cash deposit rates, future rates, and swap rates
- This method of calibration is usually referred to as “bootstrapping”
- It typically has the characteristic that output values produce smooth derivatives under deformation of the inputs – generally a requirement for how they will be used, as we will see

Yield Curve construction



MDO example 2: Interest Rate Volatility Surface

- The purpose of an IRVS is to produce a Black volatility for all simple European options on interest rates
- IRVS + YC allow all simple European instruments to be priced
- ATM options are liquid, but not options in the wings, so not enough information to calibrate daily
- Typically, a parametric form is assumed, such as the SABR model
- ATM vols are updated daily using market information, as are reference rates in the form of yield curves
- Other parameters are set by hand, usually monthly or less frequently, to be consistent with infrequently observed prices

❖ Fun fact: IRVS + YC price >90% of the volume of IR derivatives trades

Pricing models

- Market data objects and other parameters are used in the creation of more complex pricing models
- The dynamics of complex models (such as the LIBOR Market Model, LMM) are specified in the abstract
- LMM drivers are simple forward rates, similar to 3M LIBOR, which follow a relatively simple process, e.g. shifted lognormal
- Many of the parameters can be fit very easily from market data objects
- Other factors, such as correlation, are calibrated to more complex market observables, such as swaptions, possibly using approximations
- Pricers incorporate these parameters into standardized approaches, such as American Monte Carlo

Summary of all model-based pricing in one slide

- The value of a portfolio can be calculated through the chain:

[market observables+parameters]

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market data objects

↓

pricing models

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portfolio value

- The portfolio value can be written abstractly as a function of a vector of market observables and parameters, which we will collectively call “market factors”:

*portfolio value=V(**MF**)*

How trading risk managers calculate risk

- The risk in a specific market factor MF_i is equal to the numerical derivative of the portfolio value to the change in the market factor:

$$\text{Risk}_i = \frac{V(\boldsymbol{MF} + \Delta MF_i) - V(\boldsymbol{MF})}{\Delta MF_i}$$

- The trading risk manager’s goal is to make all such risks 0 by buying/selling sufficient amounts of the market factor
- Generally don’t need special functions for this: risk is calculated by bumping market data inputs directly, and then using the same chain of functions to price the instrument
- Risk can generally be calculated very quickly, to allow the portfolio to be rebalanced multiple times throughout the day

Can corporate risk managers use the same approach?

- Hard to combine into a true portfolio view
  - How do different but strongly related sensitivities interact with one another?
  - How can they be combined?
- Hard to relate to historical moves
- Hard to turn into useful measures for limit setting, etc.
- Many, many moving parts: somehow aggregate all sensitivities for a large portfolio

Can corporate risk managers use the same approach, cont'd?

- One half-way proposal: use historical data for market factors to create hypothetical one-day shifts and apply them:

$$\Delta MF_i = MF_i(T_{j+1}) - MF_i(T_j)$$

- Problem 1: Existence of historical data for "real" financial instruments
  - The last future has only been traded for less than three months
- Problem 2: applying historical information to current inputs to market data object calibrators can fail pretty easily
  - A -50 BP shift applied to a 25 BP rate can fail

❖ Corporate risk managers spend as much time (or more) worrying about data as models

How corporate risk managers calculate risk

- Use an automatically aggregated view: VaR
- Abstract the market moves away from market factors into “risk factors”
- Apply risk factor bumps directly to built market data objects, rather than to inputs

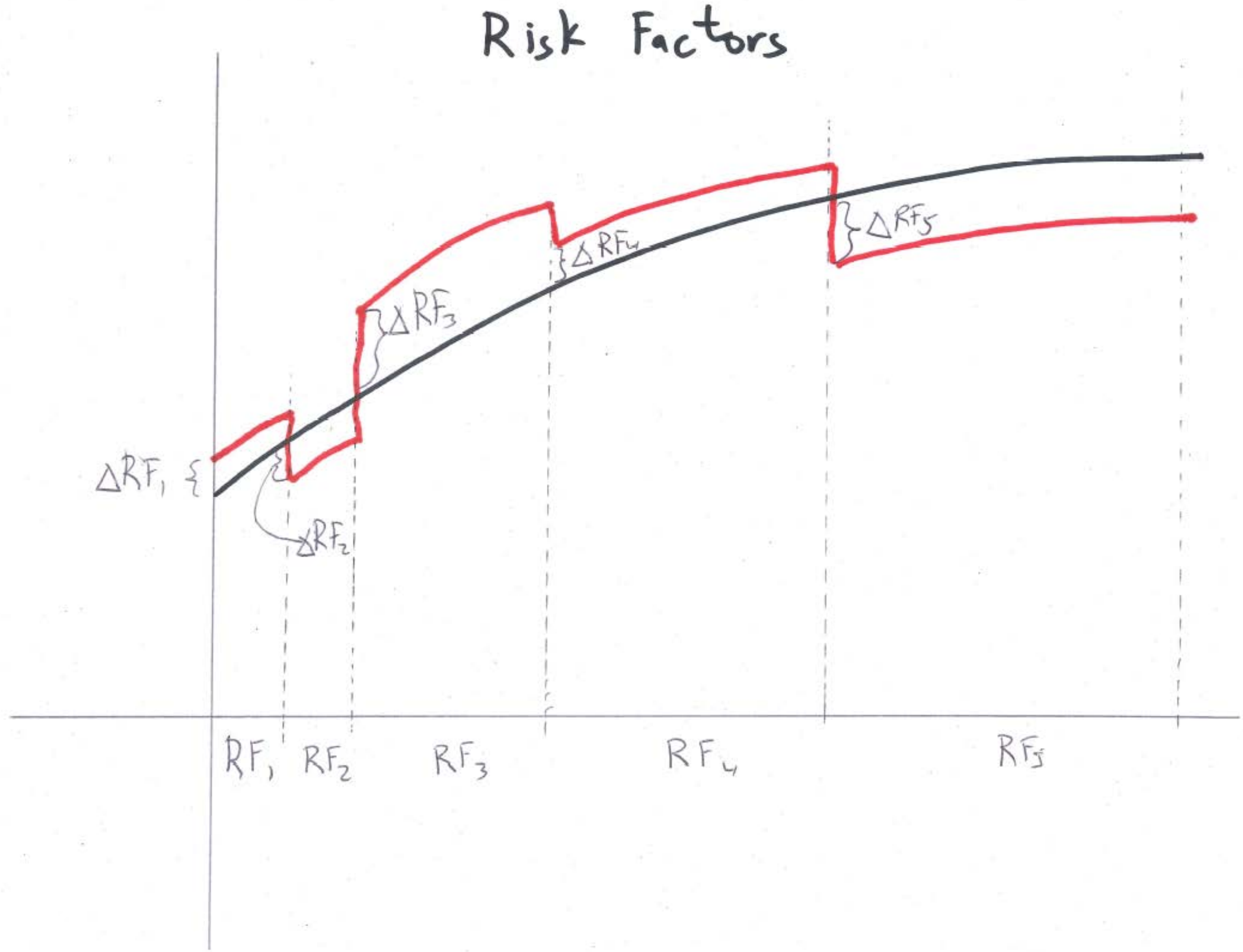
Value at Risk (VaR)

- VaR has been one of the main measures used by corporate market risk managers to evaluate potential losses in portfolios
- Historical moves are applied to a portfolio to calculate a profit or loss (more on this later): the output is not sensitivities but projected P&L
- The VaR is then some worst percentile loss
  - One standard approach it to take the second-worst loss over a year of trading; with 252 trading days, this is ~99% worst loss
- Historical VaR is trivially aggregated: apply all market moves from a single day to all assets, and add up the P&L
- Can be based on most recent market moves, or from a stressed period, or from a blend of the two
- VaR can be used to set unambiguous risk limits at multiple levels

Risk factors

- Risk factors are a way of describing the important changes to market data objects, without regard to how those market data objects are created
- They can be defined in such a way that there is no problem with historical data
- They can be tailored to focus the risk view where it has the biggest impact, allowing for fewer risk factors
- Historical risk factors need to be calculated from historical market data objects

Risk factor example: Yield Curve



Applying risk factors to generate P&L

- Recall how we abstracted market pricing:

[market observables+parameters]

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market data objects

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pricing models

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portfolio value

*portfolio value=V(**MF**)*

$$\text{Risk}_i = \frac{V(\boldsymbol{MF} + \Delta MF_i) - V(\boldsymbol{MF})}{\Delta MF_i}$$

Applying risk factors to generate P&L, cont'd

- We can instead define the portfolio value as a function of market data objects:

$$portfolio\ value = V(\boldsymbol{MDO})$$

- We can calculate the historical change from T_j to T_{j+1} for each risk factor as

$$\Delta RF_i = RF_i(T_{j+1}) - RF_i(T_j)$$

- If we define all bumps for all risk factors on a single day in a vector, then the P&L impact is

$$\text{P\&L} = V(\boldsymbol{MDO} + \Delta\boldsymbol{RF}) - V(\boldsymbol{MDO})$$

- Note that applying risk factor bumps to existing market data objects generally requires new functions, which can be quite complex

Conclusion

- A reasonable way for trading risk managers to calculate risk is by calculating sensitivities to inputs to market data objects
- A reasonable way for corporate risk managers to calculate risk is by bumping abstract risk factors that are added to market data objects, and using that in a VaR calculation
- Understanding the detailed needs of each type of risk manager make the reasons for the different approaches clear

Questions?