Financial Risk Management

Analysis of financial instruments

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Lecture 9

Learning objectives

- Classify financial risks
- Analyse and measure financial risks
- Describe and analyse operational risk
- Describe Basel accords and their role in risk management
- Describe and analyse the difference between VaR and CVaR/ETL
- Describe and analyse the use of rating matrices in credit-risk
- **Describe and analyse different financial instruments in a market risk perspective**
- Explain some lessons learned from some well known financial crisis

Preparation for today

- 4th edition: Chapter 14.4-14.6 (uploaded)
- The Delta-Normal Approach (uploaded)

Extenting the Model Based Approach

- The Model Based Approach quickly becomes tricky, when the portfolio is complex, for instance
  - Many assets – the covariance matrix becomes large and difficult to estimate $((N \times (N+1)/2)$
  - Consists of or contains many bonds – it's not possible to use each bond as a factor
  - Contains non-linear product like options
  - Contains different futures, forwards or swaps – again not possible to use each of them as a factor
- Solution: Mapping

Investment in one foreign stock 1/2

- Imagine a portfolio consisting N USD invested in one asset traded in a foreign currency
- Before we handled this by estimating the standard deviation of the asset's return when measured in the domestic currency (see equation 14.1)

$$\Delta P = N \frac{X_t P_t - X_{t-1} P_{t-1}}{X_{t-1} P_{t-1}}$$

Investment in one foreign stock 2/2

- Now: Express this in terms of the asset returns in it's foreign currency and the return of the exchange rate

$$
\begin{aligned}
\Delta P &= N \frac{X_t P_t - X_{t-1} P_{t-1}}{X_{t-1} P_{t-1}} \\
&\approx N \left(\log\left(X_t P_t\right) - \log\left(X_{t-1} P_{t-1}\right) \right) \\
&= N \left(\log\left(X_t\right) - \log\left(X_{t-1}\right) + \left(P_t\right) - \log\left(P_{t-1}\right) \right) \\
&\approx N \left(\underbrace{\frac{X_t - X_{t-1}}{X_{t-1}}}_{\text{return on foreign currency}} + \underbrace{\frac{P_t - P_{t-1}}{P_{t-1}}}_{\text{return on asset measured in foreign currency}} \right)
\end{aligned}
$$

Example

- GlaxoSmithKline closed at 1,190.80 on Friday and at 1.216,00 on Thursday
- The GBPUSD exchange rate was 1.4008 on Friday and 1.4148 on Thursday
- Calculate the P&L from investing 1000 USD from Thursday to Friday using the two approaches from the previous slide

Benefit of mapping

- In the example, we could see that 1/3 of the P&L came from FX and 2/3 of risk came from equity
- This information is very relevant when holding a complex portfolio or running a complex business
- In this example, the investor could have traded in financial instruments (for instance a FX forward or option), if he did not like the FX risk and only wanted the equity risk
- In a more general context, the portfolio can be split into different areas – equity, commodity, FX, interest rate – and we can then use this for assigning a risk mandate to every trading desk
- We will not cover decomposition of risk in detail, but here are some keywords if you are curious: Stand-alone VaR, systematic vs unsystematic VaR, marginal VaR

Mapping Approach

- Imagine we have invested in many foreign types of assets in possibly many different currencies

- If a group of assets is closely related to the same factor – for instance a stock market index, the portfolio can end up being described in terms of chosen risk factors and exposures will be related to amounts invested, exchange rates, stocks' betas etc.:

$$\Delta P = \sum_{i=1}^{n} w_i r^i$$

  where w_i describes the exposure to risk factor i and r^i the return on risk factor i.

- In the example above $w_1 = w_2 = N$ and r^1 expresses the return on the currency and r^2 the return on the asset measured in its' own currency

Further on obtaining and using the portfolio mapping

- Going from portfolio composition to values for exposures w relative to risk factors can be cumbersome for a complex portfolio, so an alternative is to construct historical returns/changes and regress on chosen risk factors and obtain a suitable description of the portfolio based on a reasonable number of chosen risk factors.
- It's also possible to use statistical methods to derive risk factors – the so-called Principal Components Analysis. We will not cover PCA in this course.
- Regardless of how the exposures are obtained, it's straightforward to apply the model based approach to get VaR-estimates – it's just a matter of using the variance and exposures in the MBA-expressions

Portfolio of bonds

- It's not feasible to add every single bond as a risk factor
- One approach is to derive transform cash flows from the bonds considered into cash flows from a set of fixed bonds:
  - Find cash flow of bond(s) [time and amount]
  - Find zero coupon bond yields for each time (by e.g., interpolation) and compute present value of cash flows
  - Use a zero-coupon with shorter and one with longer maturity than the timing of each cash flow and find a combination that matches the interpolated volatility
  - Calculate amounts invested in each bond
  - Calculate VaR by the MBA using the set of fixed bonds as risk factors and the amounts calculated as exposures

Note: Instead of matching volatility, another option is to match duration of the portfolio like in PR's note.

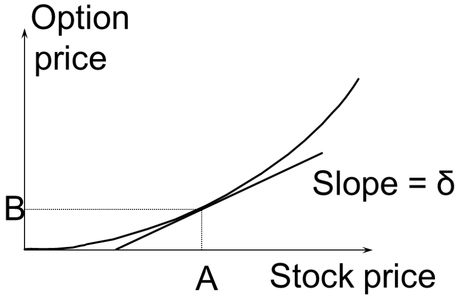
Portfolios with derivatives

- Options – put or calls
- Swaps – often currency or interest rate swaps
- Futures or forwards

How do you think these can be handled using the described approach?

Example: One call option 1/2

- Assume you hold a portfolio consisting of one call option
- A call option gives you the rigth, but not the obligation to buy an underlying asset at time T at a pre-determined price K
- This corresponds to a payoff of $\max(S_T - K, 0)$, i.e., a non-linear function of S. The value is also a non-linear function of S.



Example: One call option 2/2

- The change in option value (and here also our portfolio value) can be approximated by

$$\Delta P = \delta \Delta S$$

  where δ is the option's delta, i.e., the sensitivity to underlying price as illustrated in the previous figure.

- Knowing delta, it can just be viewed as the exposure and the standard VaR approach can be applied
- We will not cover how to obtain deltas – this is covered in e.g., Financial Products
- This is only an approximation and deltas change over time, so they need to be dynamically updated

Example: One forward on underlying asset

- A forward contract is the obligation to buy or sell an asset at future time T at a pre-specified price F
- Contrary to a option, there is an obligation
- In the simplest world possible, the price F is given by $F = (1+r)^{(T-t)} S_t$, where S_t is the price of the underlying at time t
- The exposure of a long forward is then simply $(1+r)^{(T-t)}$
- And this might be mapped further into an index like in Example 11

Example: Interest Rate Swaps

- In an interest swap, one party pays a fixed interest rate on a principal
- The other party pays a floating interest rate on the same principal
- Payments can therefore be made both ways
- Adding the principal to both sides, the cash flows can from either side be seen as the cashflow from bonds – one with a floating rate and one with a fixed rate
- Bonds can be handled via cash flow mapping