Financial Engineering and Computations

Preliminaries

Course Information

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- MB313
- 03-5712121#57054
- Suggested reading:
  - Financial Engineering & Computation: Principles, Mathematics, Algorithms. Cambridge University Press, 2002. Lyuu, Yuh-Dauh
  - C++財務程式設計,證基會2005戴天時

What is Financial Engineering

Financial engineering is the process of tailoring financial instruments and organizational structure to improve the profitability of intermediaries' customers.

財務工程的兩個要旨

1. 金融創新
2. 滿足顧客需求

Why Financial Engineering

1.價格波動性增加
2. 金融市場的全球化
3. 租稅的不對稱性
4. 科技的進步
5. 管制放鬆及競爭增加

價格波動性增加

- **Black Monday**: Monday October 19, 1987.
  - Dow Jones Industrial Average fell 22.6%, the largest one-day decline in recorded stock market history.
- 價格大幅波動影響公司及個人的財務,甚至導致破產

價格波動性增加
An Example

以Laker Airlines公司爲例，1970年代因英鎊強勢，英國人到美國渡假的人很多，班機因此經常客滿，Laker Airlines於是購5架DC-10客機。其收入爲英鎊，購機支出則爲美金。1980年代，美金升值，Laker Airlines 因匯兌損失大筆資金。

價格波動性增加

- 如何規避價格風險實屬必須
- 財務工程提供了規避價格風險的解答
- A short example for risk management will be given later.

金融市場的全球化

- 多國籍企業的影響力日增
- 市場改革開放
- 全球產業分工

租稅的不對稱性

- 某些產業在租稅優惠(e.g. 高科技產業、生化產業、孤兒藥製造商)
- 不同國家有不同租稅負擔(e.g. 福利國家(如北歐國家)的稅率通常較高)

租稅的不對稱性
An Example

例：在美國利息收入是必須完全課稅(taxable)的，但在股利收入則可抵免80%。若A公司稅率40%，A公司的借款利率10%，B公司特別股股利率8%，

此時A公司應借錢(e.g. 10millions)買B公司特別股。

租稅的不對稱性
An Example

<u>分析</u>：

無tax asymmetry時⇨do not make sense(借10%，得8%)

tax asymmetry存在時⇨

借款的effective rate＝10%×(1-40%)＝6%

特別股收益的effective rate＝8% ×(1－20% × 40%)＝7.36%

租稅的不對稱性
An Example

<u>進一步分析</u>：

若B公司的稅率爲12%，則A公司可以直接向B公司借錢，B公司發行8%特別股賣給A公司。

B公司的benefits＝利息收益－特別股利支出＝10%×(1－12%)-8%＝0.8%

A公司的benefits＝7.36%－6%＝1.36%

科技的進步

- 電腦、通訊、軟體技術影響最大
- 程序創新上常見(e.g. ATM, e-trading)
- Program trading

管制放鬆及競爭增加

- 產業開放、業務開放(e.g. 加入WTO)
- 提供客戶多樣化服務

A Short Story to Introduce Risk Management

- Foreign exchange rate:
  - The exchange rate between the domestic currency and the foreign currency.
- An example:
  - Sell 1 USD
    - 32.97190 TWDs
  - Buy 1 USD
    - 33.78860 TWDs

美商花旗銀行
台幣對外幣匯率表

幣　別	代號	買入匯率	賣出匯率
澳幣	AUD	25.11950	25.69000
加拿大幣	CAD	24.87430	25.25630
瑞士法郎	CHF	26.30620	26.67230
美金現鈔	CSH	32.97190	33.78860

The exchange rate between TWDs and USDs (between 99'1~99'8)

What Exchange Rate Changes Could Influence

- A Speculator:
  - The USD can be viewed as a stock.
  - A speculator tries to buy at low and sell at high.
  - Ex: Buy at time t with 32 (TWDs/USD), and sell at T with 33.
- Import / Export:
  - A contract is usually quoted in USDs.
  - Assume a 1-million-USD contract is signed at t and the deal is settled at T.
  - An exporter gains as he earns 1 more million TWDs.
  - An importer suffers as he needs to pay one more million TWDs.

A Financial Derivatives (Foreign Exchange Call Option)

- The exchange rate at time s is denoted as Xs.
- Consider a call option as follows:
  - It starts at time t and matures at time T.
  - The strike price is K.
  - That is, the call option allows the holder to buy the underlying asset with price K.
- An example: (Assume K=Xt for convenience.)
  - An option buyer give P (option price) to the seller at t.
    - P is usually much smaller than Xt.
  - At T, Seller should pay max(X_T-Xt,0) to the buyer.

What does this Option Appeal to?

- A speculator:
  - He earns money by predicting the future.
  - Buy USD at t and sell at T.
    - Earns (33-32)/33=3%.
  - Buy an exchange rate call option
    - Earns (33-32)/P>>3% (As we know P <<32)
  - Maximum loss: P dollars.
  - (High leverage) A speculator would like to buy a call option for higher return.

What does this Option Appeal to?

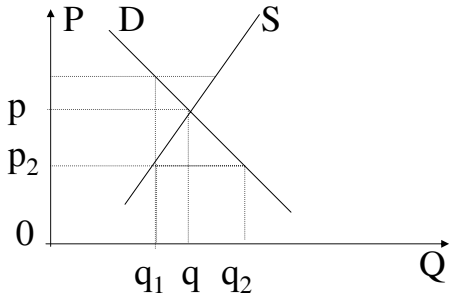
- Importer may want to avoid the exchange rate risk.
  - Consider 1-million-USD contract mentioned before.
    - Exchange rate 32=> 33
    - One more million TWDs is required to buy the USDs.
  - If the importer buy one million units call options.
    - At maturity, he receives (33-32)* 1 million
    - His loss is covered by the gain of the option.
    - We call this ***"hedge"*** .

Review of the Above Mentioned Option

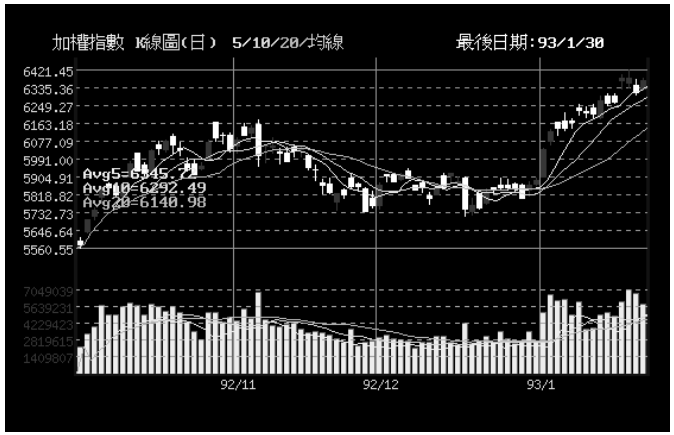
- Initiates at time t, and matures at time T.
- The strike price is Xt (32).
- At time t, the option buyer will pay *P* to get the option.
- At time T, the option seller needs to pay max(X_T-Xt,0) to buyer.
- How can we determine the fair price of P.

How to Determine the Option Price Economics

- The price is determined by the intersection of demand and the supply curves.

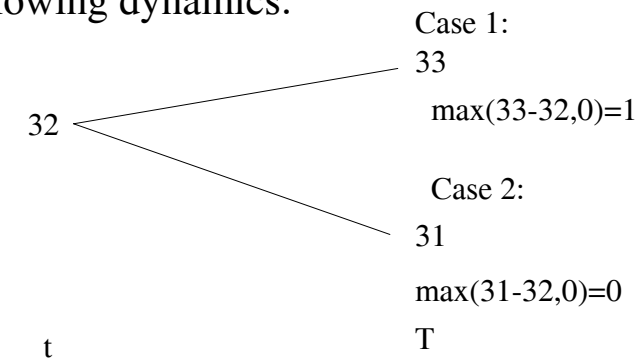


How to Determine the Option Price (技術指標)



How to Determine the Option Price (Arbitrage-Base Pricing Theorem)

- Assume that the exchange rate follows the following dynamics:



Arbitrage-Base Pricing Theorem

Replicate the Option

- Replicate: Construct a portfolio so that it has the same payoff as the option in the future.
- This call option can be replicated as follows:
  - We buy x TWDs and y USDs to at time t
  - We hope that this portfolio generates the same payoff as the option at time T.
  - At case 1: $x + 33y = 1$
  - At case 2: $x + 31y = 0$
  - Solve the equations, we have x=-15.5, y=0.5

Arbitrage-Base Pricing Theorem

Replicate the Option and Determine the Option Price

- A foreign exchange option can be constructed as follows:
  - Borrow 15.5 TWDs,
  - Buy 0.5 USDs.
  - The total cost=-15.5+0.5*32=0.5 (TWDs)
- At case 1:
  - The value of portfolio=-15.5+0.5*33=1 (TWDs)
- At case 2:
  - The Value of portfolio= -15.5+0.5*31=0 (TWDs)
- Can we say the value of the option is 0.5 (TWDs)?

Arbitrage-Base Pricing Theorem

Introduction of Arbitrage

- Arbitrage: A trading that get ***extra returns*** without suffering risk.
  - Counter example:
    - Deposit: Earn normal return risklessly.
    - Gamble: Earn extra return by taking risk.
  - Example:
    - Cheat in gamble: In the case that you are sure to win.
- Arbitrage opportunity is assumed not to exist for long in the financial market.

Arbitrage-Based Pricing Theorem

Condition of Arbitrage Opportunity

- Arbitrage opportunity exists if the option value is ***not*** 0.5 TWDs.
- Let the option value P>0.5.
  - Sell a call option for P dollars.
  - Construct a replication portfolio
    - Borrow 15.5 TWDs and buy 0.5 USDs.
    - Benefit at time t = P – 0.5>0.
    - No loss will be introduced at either case.

	TWDs	USDs	Option	Total
Case 1	-15.5	33/2	-1	0
Case 2	-15.5	31/2	0	0

Arbitrage-Based Pricing Theorem

Determine the Option Value by No Arbitrage Assumption

- Similar case is applied for the case option value P<0.5
  - Buy a call option for P dollars.
  - Construct a replication portfolio
    - Borrow 0.5 USDs and buy 15.5 TWDs
    - Benefit at time t = 0.5-P>0.
    - No loss will be introduced at either case.

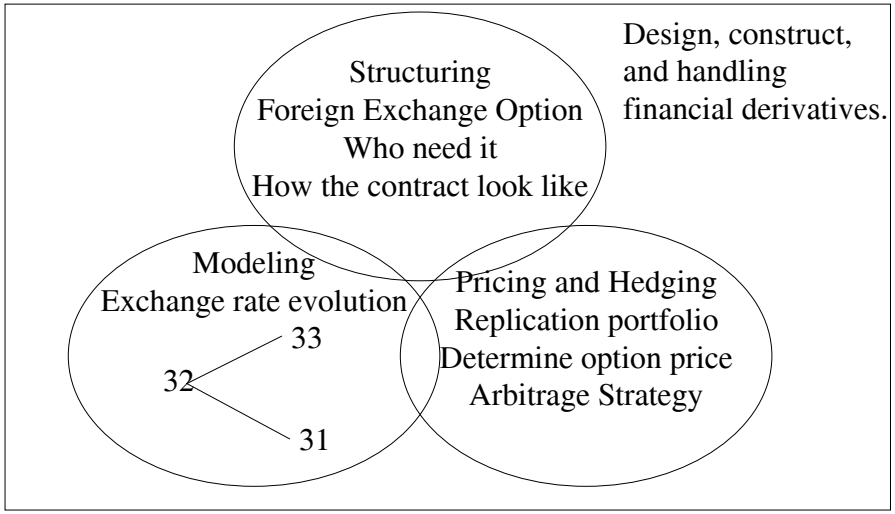
	TWDs	USDs	Option	Total
Case 1	15.5	-33/2	1	0
Case 2	15.5	-31/2	0	0

Arbitrage-Based Pricing Theorem

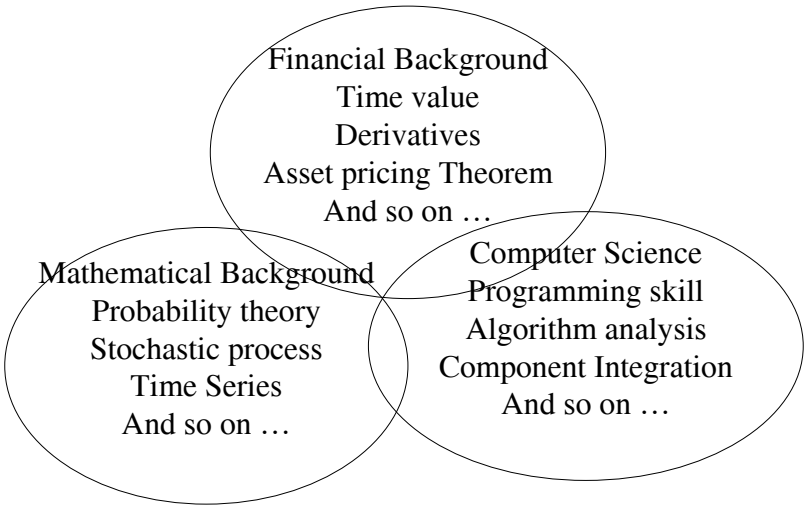
Determine the Option Value by No Arbitrage Assumption

- Since the arbitrage opportunity exists if P>0.5 or P<0.5, the option value should be 0.5 in this case.
- Details for option pricing will be introduced later.

A Simple Overview of Financial Engineering



What Knowledge is Involved



Job Opportunity

- Risk management
  - Risk control
  - Programming and system maintenance
- Trading
  - Trading and hedging the financial assets
- Structuring
  - Design new derivatives and its trading strategies.

What This Course Might Teach

- Financial background knowledge
  - Designed for beginner.
- Basic mathematical background
  - Knowledge involved in the pricing model.
- Learn to use existing packages.
  http://www.csie.ntu.edu.tw/~lyuu/Capitals/capitals.htm
- Computer science
  - Numerical pricing model and special skills,
- Team work
  - A team of members from different background.