

Financial Engineering and Computations

Preliminaries

Course Information

- cameldai@nycu.edu.tw
- 管一422
- 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

Course Information

- 助教：鄭玉琪
- Mail：bischofia891211.mg13@nycu.edu.tw
- 成績：
 - 作業：繳交時間：出作業後一星期（請勿遲交）
 - 期中考
 - 期末term project 或是期末考

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公司為例，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。

於是Laker Airline 以美金購5架DC-10客機，並向客戶收取英鎊。1980年代，美金升值，Laker Airlines 因匯兌損失大筆資金。

保險局證實南山人壽淨值比轉負數剩-0.59% 7家淨值比低於3%

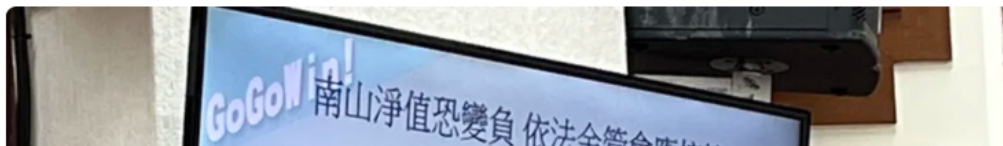


葉憶如 | Yahoo財經特派記者

2022年10月3日



美國聯準會升升不息，壽險業淨值再惡化，南山人壽9月底淨值資產已正式轉為負數，剩下-0.59%！金管會要求各壽險公司周周公布自結數，立委郭國文今（3）日上午強勢要求公布名單，保險局長施瓊華證實南山人壽淨值已轉負數，國泰人壽淨值比也僅剩下2.6%，其他包括第一金人壽、保誠人壽、安聯人壽及三商美邦、宏泰人壽。立委要求金管會應該檢視後要求各壽險業增資，而不是讓他們可以隨意更換會計制度來美化帳面。



U.S. 20 Year Treasury Bond

ADD TO WATCHLIST

4.567 %

▲ 0.007

Last Updated: Feb 20, 2024 4:58 a.m. EST

PREVIOUS CLOSE

4.560%



Financial Engineering

SVB 矽谷銀行破產事件

- SVB（Silicon Valley Bank）矽谷銀行是一家商業銀行，創立於1983年倒閉於2023年3月，總部位於美國加州聖克拉拉市。其專注支持科技新創產業，客戶將近一半來自科技類和生命科學類的初創公司，提供包括商業銀行、投資銀行、資產管理和國際銀行等服務。
- 因疫情重挫經濟，美國聯準會為促興經濟開始發放資金，新創公司在融資或募款活動中從市場上吸收大量現金，SVB 作為新創公司的資金借放處銀行存款量大增。
- SVB 把較多資產部位配置在長期的固定收益產品，但卻忽略長期債券易會隨利率上升的巨大風險。
- 後續聯準會不斷升息，造成債券價格下跌，同時間新創公司在難以募款的背景下，存入銀行的錢變少很多，新創公司儲戶開始領錢，從SVB 撤出的資金不斷擴大。
- 2023年3月，SVB 不得已宣布賣掉手上210 億美元的債券，實現18億美元的虧損，公告一出來後等於SVB 承認自己的流動性危機，大批客戶因不信任開始大量領錢，發生擠兌，有420億美元嘗試被領出，短短48小時之內，SVB 宣告破產。

銀行資產負債表

資產 (Assets)

現金

貸款 (Loans)

投資資產

債券 (Bonds)

股票 (Stocks)

房地產 (Real Estate)

其他投資資產

負債 (Liability)

存款 (Deposits)

活期存款

定期存款

股東權益 (Equity)

準備金 (Reserves)

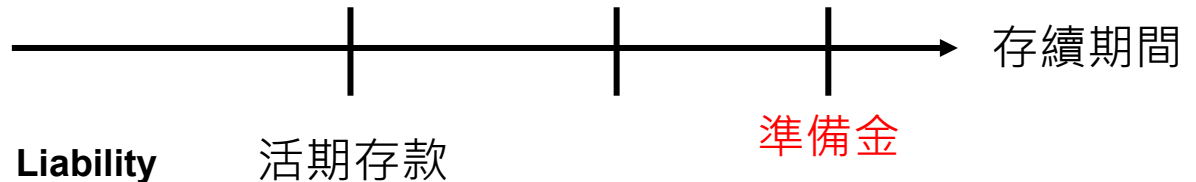
保單責任準備金

未決賠款準備金

保險公司

Asset

長天期債券



存續期間

Liability

活期存款

準備金

● 若債券利率上升，導致債券價值下降，

● 長天期債券所受影響 > 活期存款所受影響，銀行可能提前賣出債券。

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 8%，此時 A 公司應借錢(e.g. 10 millions)買 B 公司特別股。

租稅的不對稱性

An Example

分析：

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

tax asymmetry存在時 \Rightarrow

借款的effective rate $= 10\% \times (1 - 40\%) = 6\%$

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

租稅的不對稱性

An Example

進一步分析：

若B公司稅率為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。

$$\begin{aligned}\text{B公司的benefits} &= \text{利息收益} - \text{特別股利支出} \\ &= 10\% \times (1 - 12\%) - 8\% = 0.8\%\end{aligned}$$

$$\text{A公司的benefits} = 7.36\% - 6\% = 1.36\%$$

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

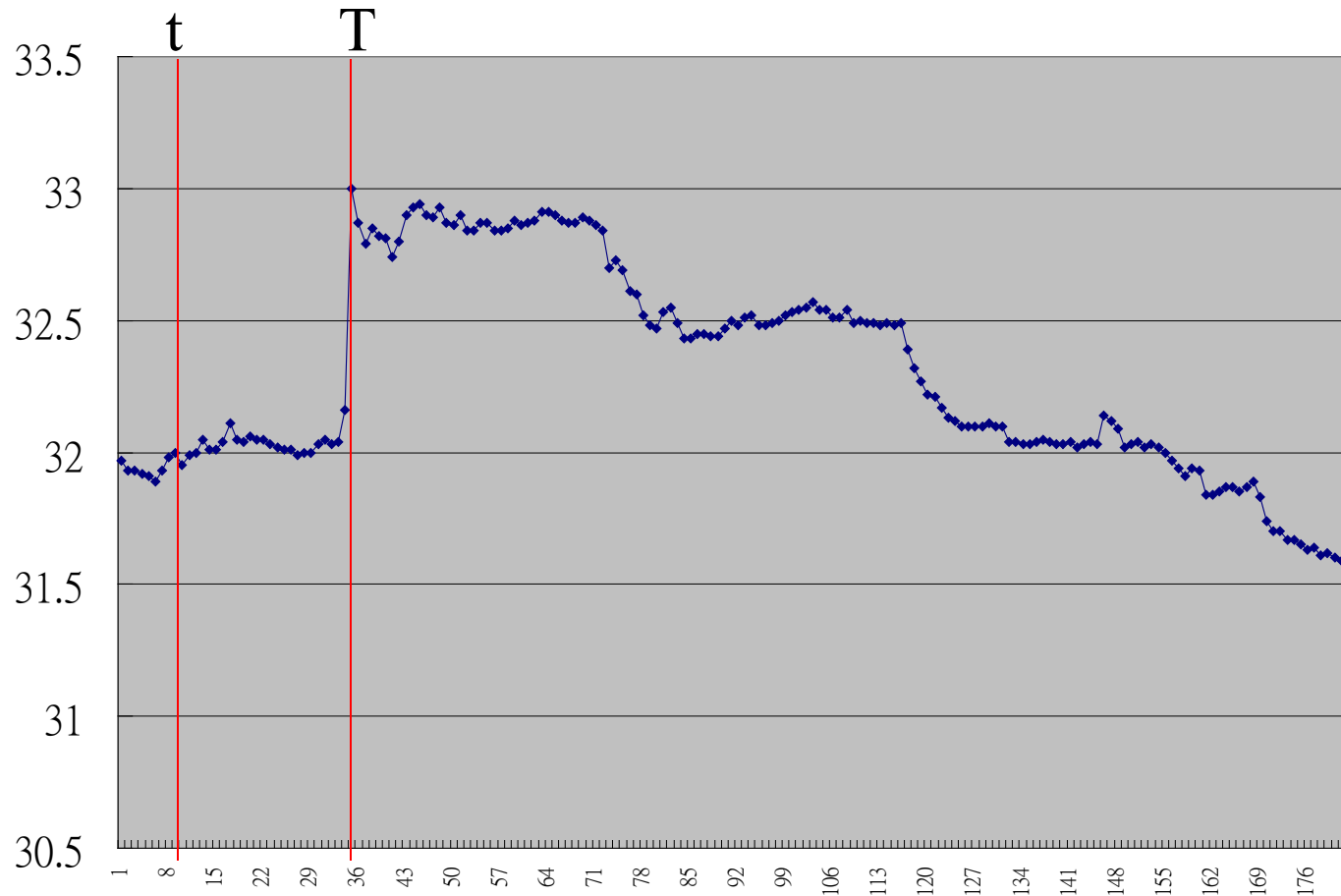
A Short Story on Risk Management

- 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 the Changes of Exchange Rate Could Influence

- A Speculator:
 - view USD as a stock.
 - buy at low and sell at high.
 - Ex: Buy at time t with 32 (TWDs/USD), and sell at T with 33.
- Importer / Exporter:
 - A contract is usually quoted in USDs.
 - 1-million-USD contract signed at t and delivered 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)

- X_s : the exchange rate at time s .
- Consider a call option as follows:
 - It starts at time t and matures at time T .
 - The strike price is K .
 - Allows the holder to buy the underlying asset with K .
- An example: (Assume $K=X_t$ for convenience.)
 - An option buyer give P (option price) to the seller at t .
(P is usually much smaller than X_t .)
 - At T , Seller should pay $\max(X_T - X_t, 0)$ 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 $(33-32)/32=3\%$.
 - Buy an exchange rate call option
 - Earns $(33-32)/P \gg 3\%$ (As we know $P \ll 32$)
 - Maximum loss: P dollars.
 - (High leverage) A speculator would like to buy a call option for higher return.

What does this Option Appeal to?

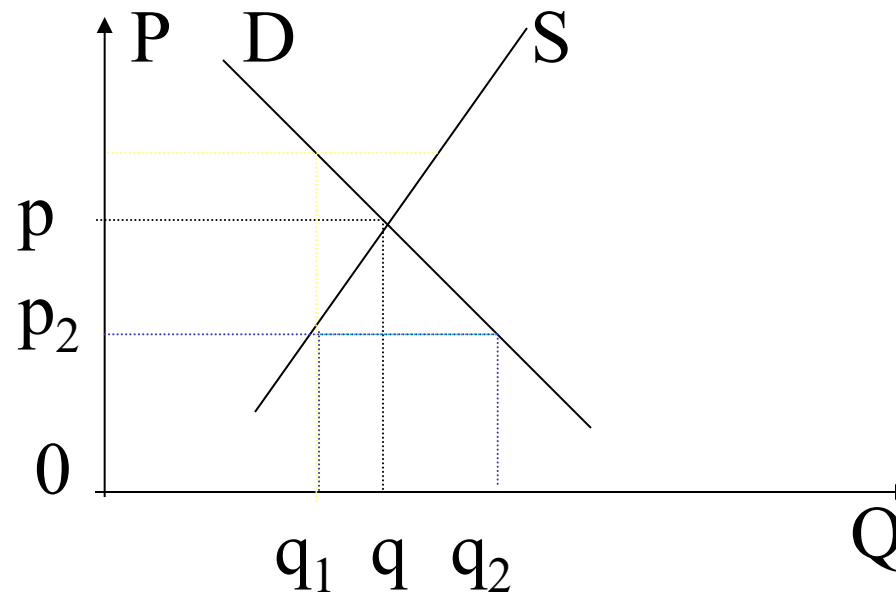
- Importer may want to avoid the exchange rate risk.
 - Consider 1-million-USD contract mentioned before.
 - Exchange rate $32 \Rightarrow 33$
 - One more million TWDs is required to buy the USDs.
 - If the importer buy one million units call options.
 - At maturity, he receives $(33-32) * 1$ million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

Review of the Above Mentioned Option

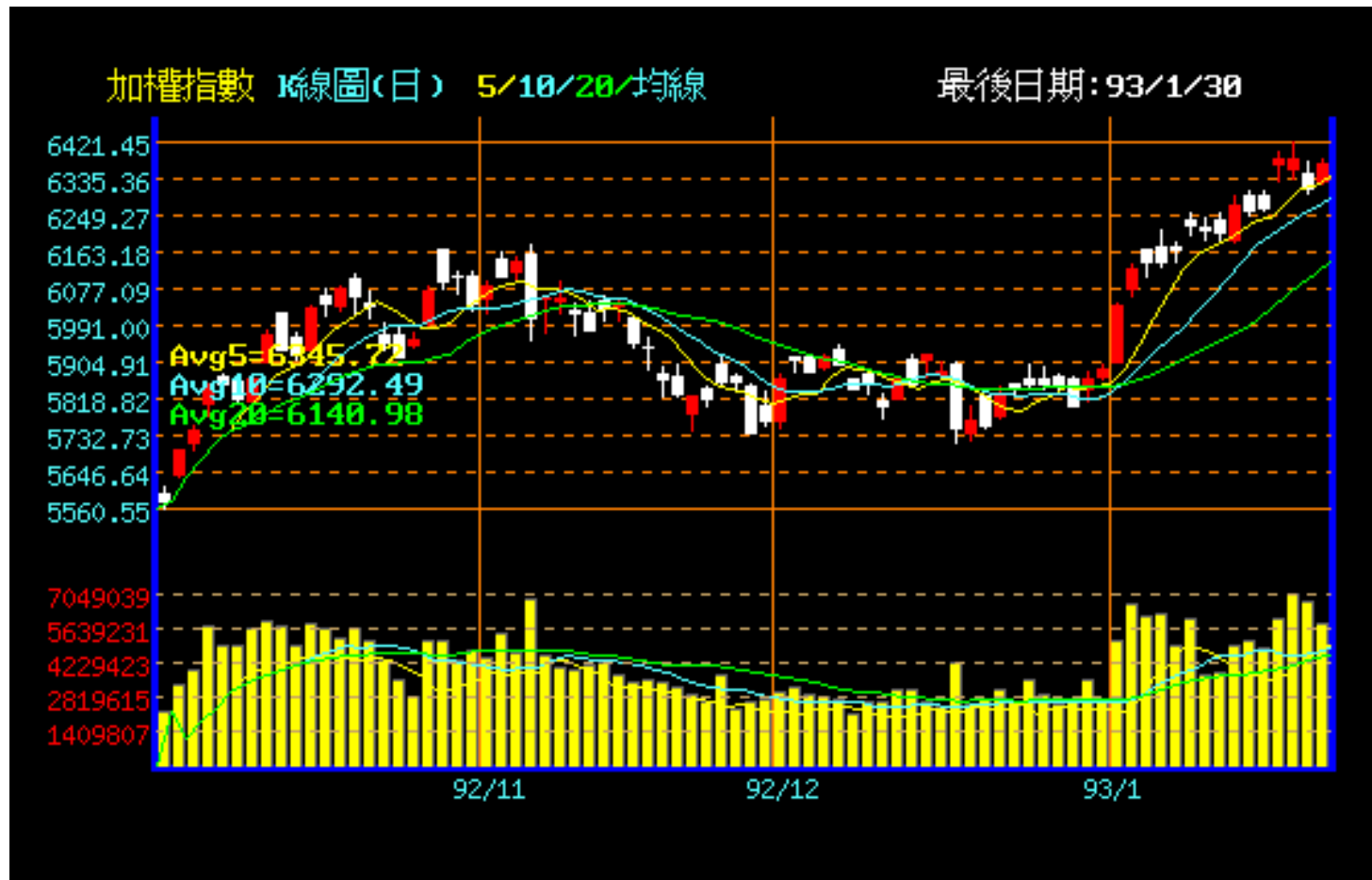
- Initiates at time t , and matures at time T .
- The strike price is $K=X_t$ (32).
- At time t , the option buyer will pay P to get the option.
- At time T , the option seller needs to pay $\max(X_T-X_t,0)$ to buyer.
- How can we determine the fair price of P .

How to Determine the Option Price Economics

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

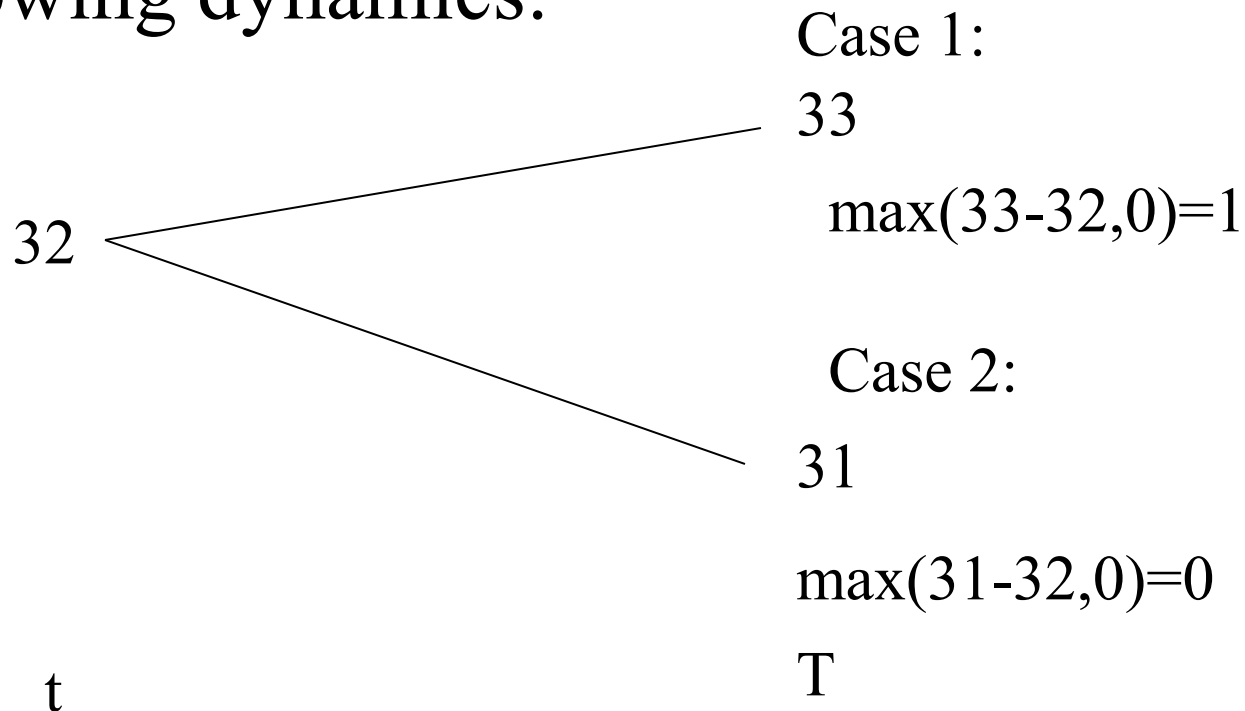


How to Determine the Option Price (技術指標)



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

- Replication: Construct a portfolio that has the same payoff as the option at maturity.
- This call option can be replicated as follows:
 - We buy x TWDs and y USDs at time t
 - We hope that this portfolio generates the same payoff as the option at time T .
 - At case 1: $x + 31y = 0$
 - At case 2: $x + 33y = 1$
 - 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 = $-15.5 + 0.5 \times 32 = 0.5$ (TWDs)
- At case 1:
 - The value of portfolio = $-15.5 + 0.5 \times 33 = 1$ (TWDs)
- At case 2:
 - The Value of portfolio = $-15.5 + 0.5 \times 31 = 0$ (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.

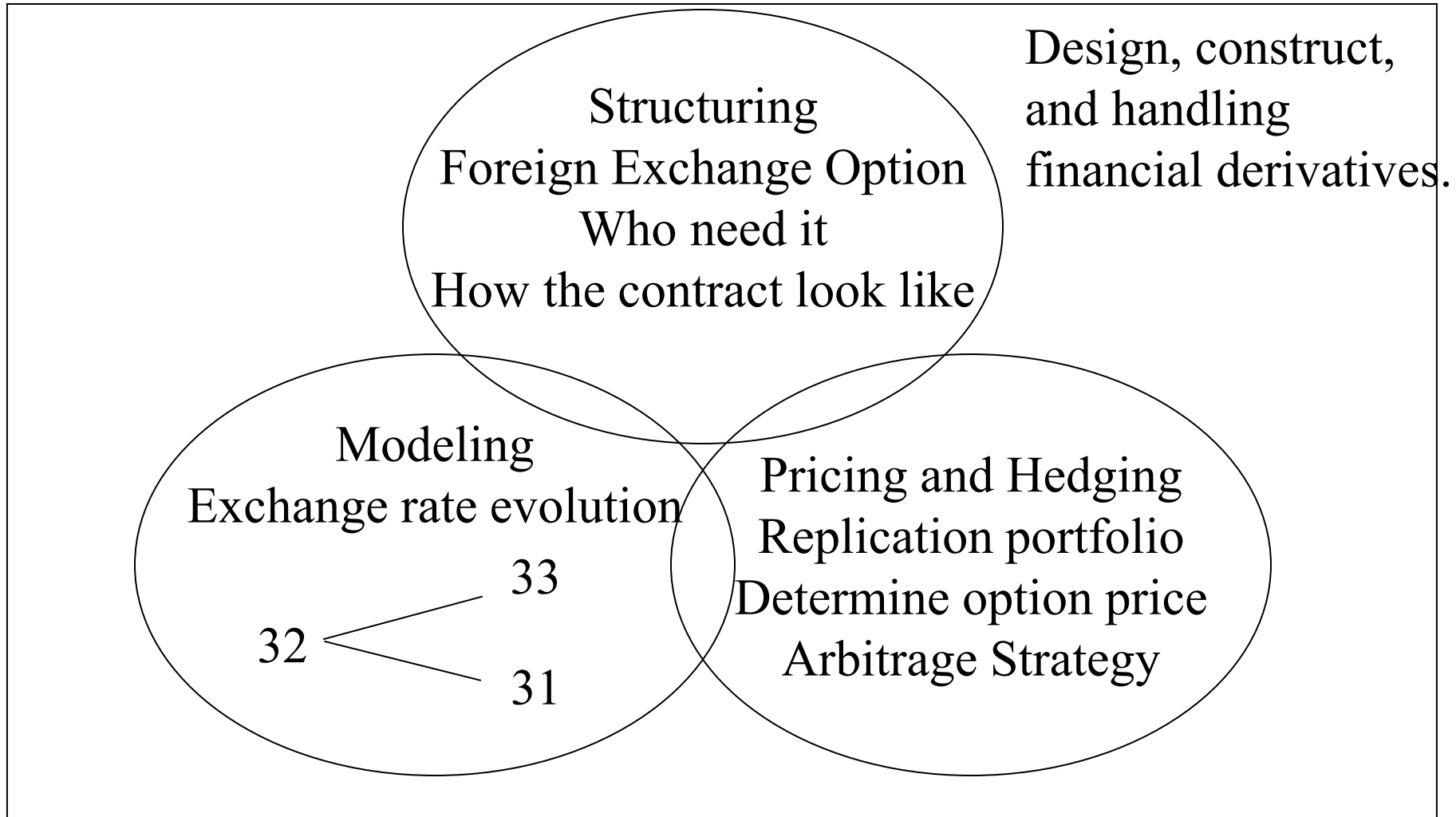
	TWDs	USDs	Option	Total
Case 1	15.5	-33/2	1	0
Case 2	15.5	-31/2	0	0

Arbitrage-Based Pricing Theorem

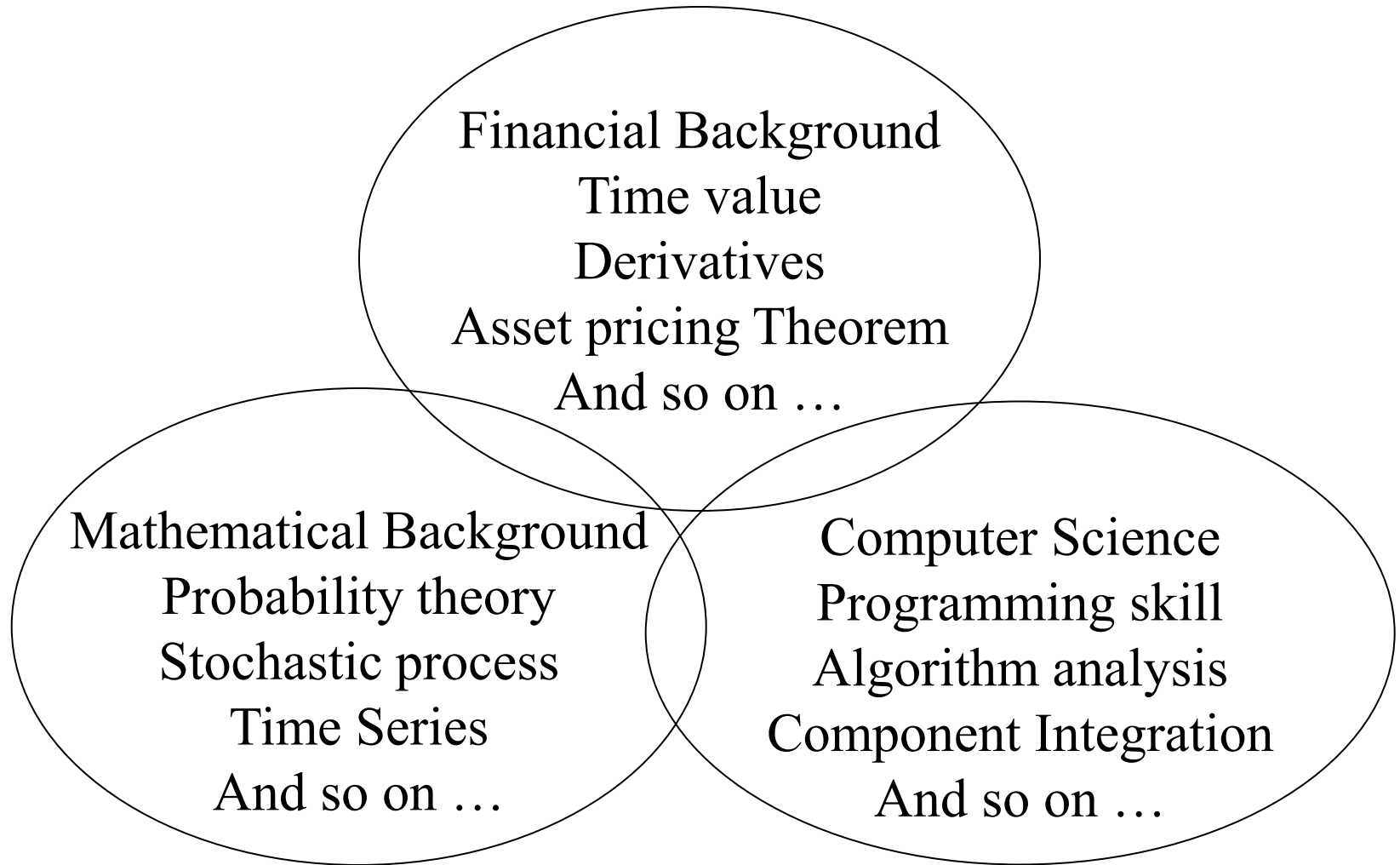
Determine the Option Value by No Arbitrage Assumption

- 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 the Aforementioned Problem



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.