CMSC 5718 INTRODUCTION TO COMPUTATIONAL FINANCE

Lecture 10

Outline

- Discussion of professional trading strategies
  - Leveraged Exchange Traded Funds
  - Pairs trading
  - Statistical arbitrage
  - Index arbitrage

Leveraged exchanged traded fund

- Exchange Traded Funds (ETFs) are very popular in many countries
- Leveraged ETFs have been listed in the US markets since 2006
- There had been great mis-understanding about the risk and behavior of this product among many investors, including professional traders and investment advisors
  - Originally supposed to be a product designed for short term traders and hedge funds
- In the US, most of these ETFs underperformed the underlying indices, and some of these funds suffered big (unexpected) losses during the financial crisis in 2008 and early 2009
- In Asia, Japan and South Korea were the earliest markets to introduce listed leveraged ETFs (since around 2007)
  - Turnover have been very active in these countries
  - Other Asian countries where approval has been given include Taiwan, Hong Kong and Singapore
- Early references: Cheng and Madhavan (2009), Avellaneda and Zhang (2009)

Leveraged ETF examples

- ETFs available for sectors including equities, commodities, fixed income, and foreign exchange
- E.g.
  - Proshare UltraPro Dow30 (UDOW): 3x leveraged on Dow Jones Index
  - Proshare UltraPro Short Dow30 (SDOW): –3x leveraged on Dow Jones Index

- Basically, the daily return of the ETF is $R = x \times I$

  where x is the leveraged factor and I is the daily index return
  - x = 2 or 3 (positive leveraged)
  - x = –1, –2, –3 (inverse leveraged)

- In the ETF prospectuses, it is often stated clearly that the return horizon is only 1-day

Example: Fubon SSE 180 ETF

- First listed in the Taiwan Stock Exchange on November 25, 2014, based on the Shanghai Stock Exchange 180 Index (SSE 180)
- Fubon SSE 180 Leveraged 2X Index ETF
  - 2 time the daily return of the SSE 180 index
- Fubon SSE 180 Inverse Index ETF
  - Inverse of the daily return of the SSE 180 index
- Example: SSE 180 index daily return of +1%
  - Leveraged 2X Index ETF: +2% return
  - Inverse Index ETF: –1% return

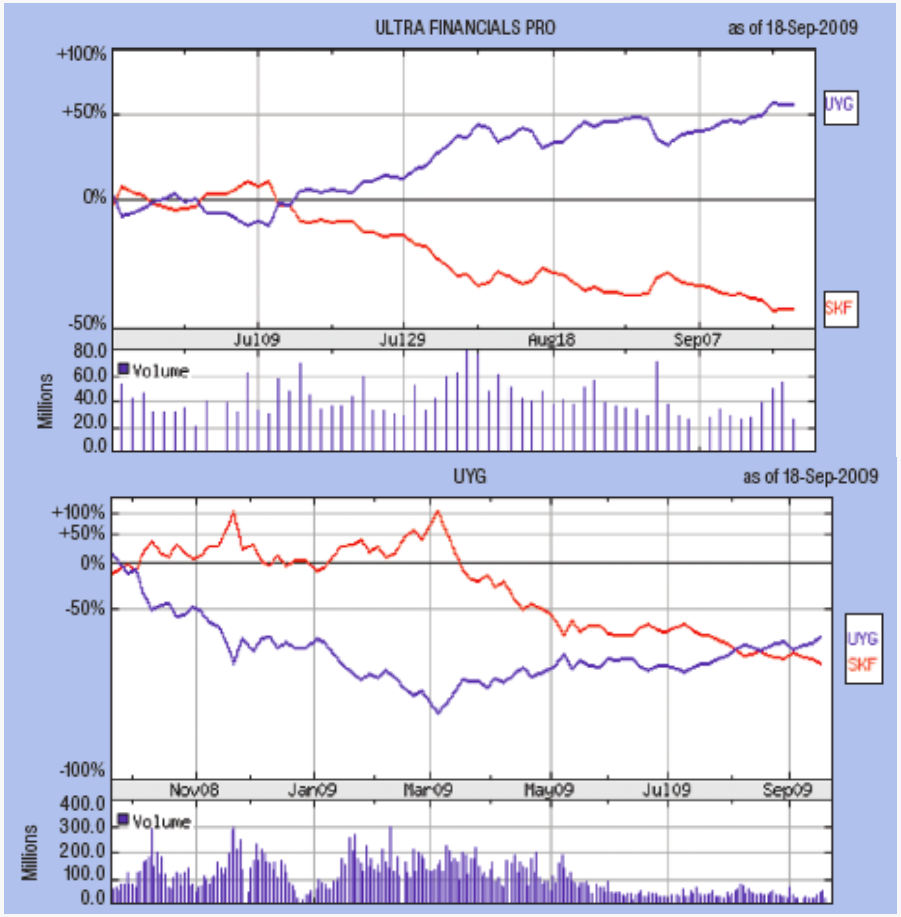
Leveraged ETFs in Hong Kong

- Approval has been given since Feb 2016, with the first fund listed in June 2016

- As of Jan 23, 2017, there are 12 leveraged ETFs listed in the Hong Kong Exchange, based on Kospi 200, Topix, Nifty 50, S&P500, and Nasdaq 100 indices
  - An example is ChinaAMC Direxion NASDAQ-100 Daily (2x) Leveraged Product (stock code 7261)
  - Turnover of these funds have not been too active, probably due to the limited interest in foreign indices

- From Dec 23, 2016, approval has been given to list ETFs based on liquid Hong Kong indices (such as HSI and HSCEI)
  - 16 such products were listed on March 14, 2017, based on HSI 2x, HSCEI 2x, HSI -1x, and HSCEI -1x

Performances of 2 ETFs in 2008/9



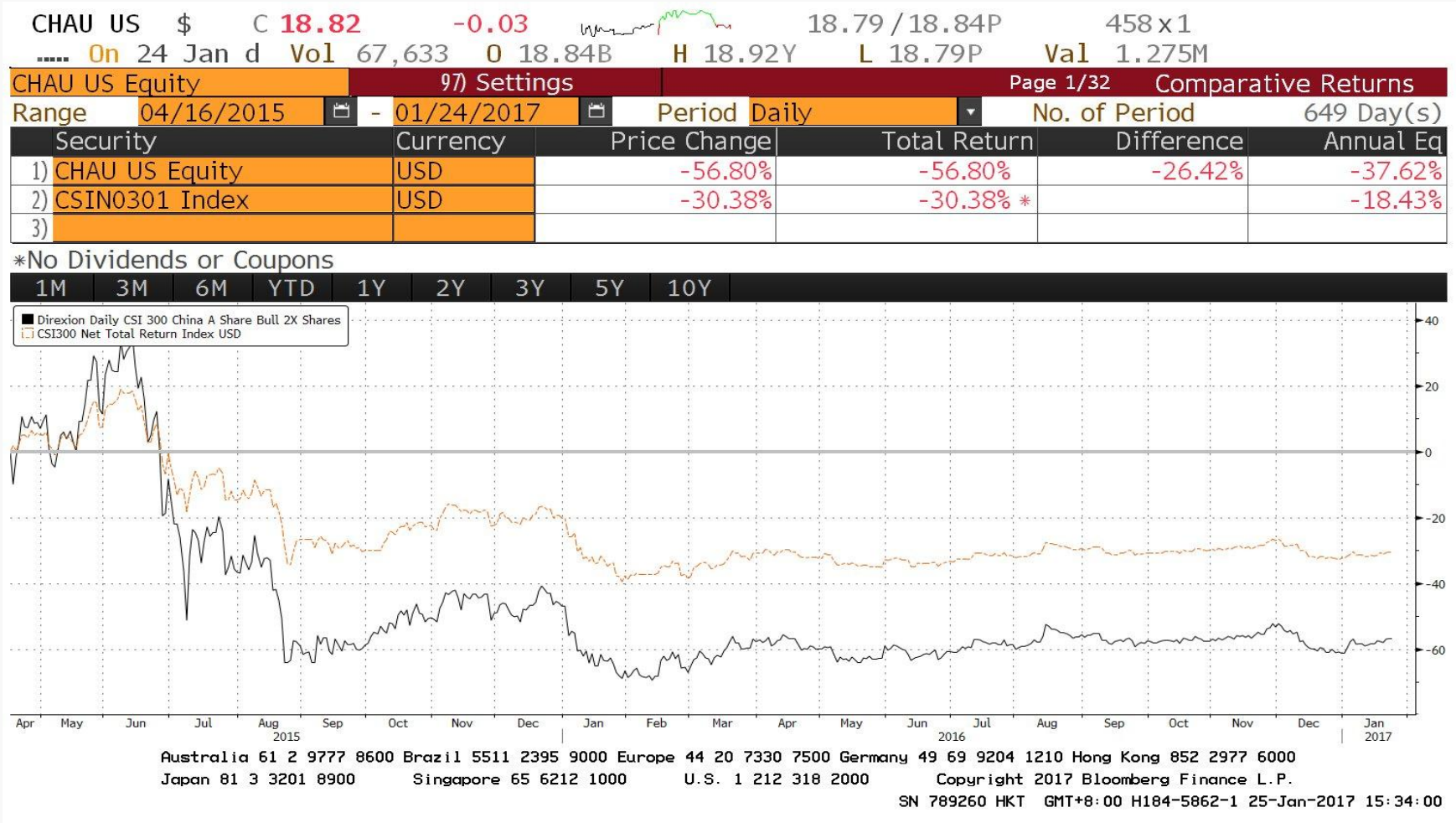
- Performances of two funds tracking the Dow Jones Financial index offered by Proshares (UYG and SKF); one is 2x, the other is -2x
- Source: Avellaneda and Zhang (2010)

Examples of performance

- Three funds based on the Russell 2000 index, showing the performance between Jan 2008 and Dec 2009

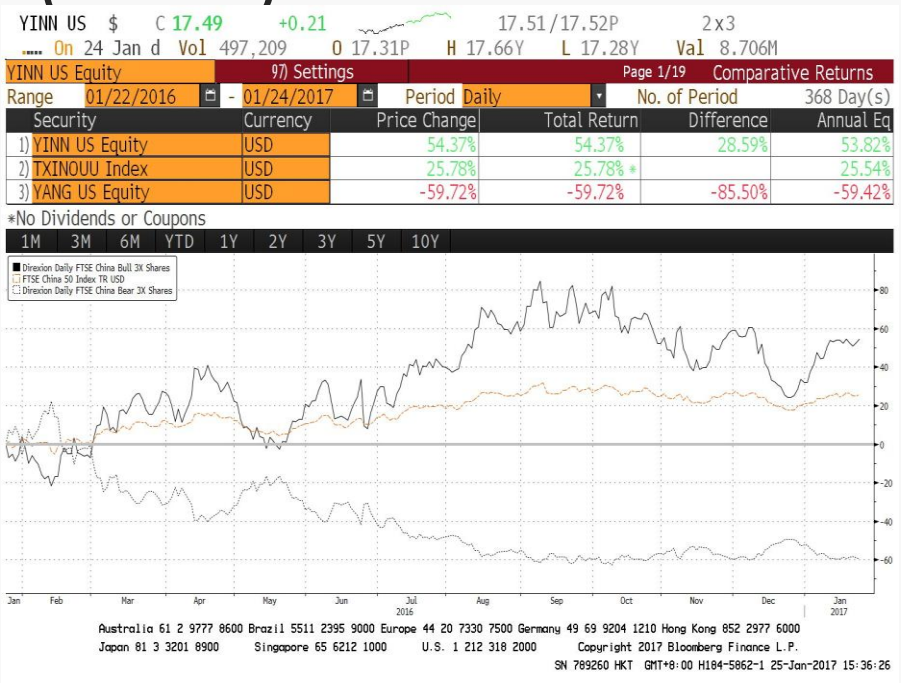
	Naïve return expectation	Actual return	Difference
Russell 2000 index (RTY)	−15.8%	−15.8%	
Russell 2000 Ultra Long 2x (UWM)	−15.8%x2 = −31.6%	−52.7%	−21.1%
Russell 2000 Short (RWM)	+15.8%	−16.5%	−32.3%
Russell 2000 Ultra Short 2x (TWM)	+31.6%	−51.3%	−82.9%

Direxion Daily CSI 300 China A-shares Bull 2X ETF (CHAU)



Source: Bloomberg LP

Direxion Daily FTSE China Bull 3X Shares ETF (YINN), Bear 3X Shares ETF (YANG)



- Tracks the FTSE China Index, which consists of 50 Chinese stocks listed in HK, with +3 and –3 times leverage
- The ETFs were listed in New York since Dec 2009
- The left diagram shows a 1 year performance, right diagram shows a 5-year performance (source: Bloomberg)

Examples of performance

Date	FXI	FXI return	FXP	FXP return
10/27/2008	19.29		183.01	
10/28/2008	23.15	20.0%	118.70	-35.1%
10/29/2008	22.34	-3.50%	115.48	-2.71%
10/30/2008	25.48	14.06%	87.03	-24.64%
10/31/2008	24.99	-1.92%	89.00	2.26%
11/3/2008	25.28	1.16%	86.00	-3.37%
11/4/2008	27.02	6.88%	75.20	-12.56%
11/5/2008	24.48	-9.40%	87.00	15.69%
11/6/2008	22.54	-7.92%	101.99	17.23%
11/7/2008	25.43	12.82%	76.32	-25.17%
11/10/2008	26.43	3.93%	69.50	-8.94%
11/11/2008	24.88	-5.86%	76.66	10.30%
11/12/2008	23.92	-3.86%	82.58	7.72%
11/13/2008	27.47	14.84%	60.40	-26.86%
11/14/2008	24.98	-9.06%	69.68	15.36%
11/17/2008	24.93	-0.20%	69.96	0.40%
11/18/2008	24.11	-3.29%	74.61	6.65%
11/19/2008	22.13	-8.21%	86.23	15.57%
11/20/2008	21.02	-5.02%	93.00	7.85%

- FXI tracks the FTSE/Xinhua China 25 Index, FXP is –2x this index
- Note that while FXI total return is about 9% throughout this period (from 19.29 to 21.02), FXP's return is –49.2%
- Source: Euan Sinclair, Volatility Trading, 2nd ed. (2013), p.232

Daily hedging demand

- It may be against intuition that the hedging that needs to be carried out would be in the same direction no matter whether it is leveraged or inverse leveraged
  - This is analogous to the case for options, where both in the case of short call or short put, the position is short gamma

- Assume that the NAV of a fund at time t_n is $A(t_n)$ with leverage x (which means that original exposure $L(t_n)$ is $xA(t_n)$), and the return for the period between t_n and t_{n+1} is r_n

Daily hedging demand

- Before re-hedging (at time t_{n+1}), the exposure is

$$L_{BR}(t_{n+1}) = L(t_n)\,[1 + r_n] = xA(t_n)[1 + r_n]$$

whereas the NAV of the fund

$$A(t_{n+1}) = A(t_n)[1 + xr_n]$$

which would require a new exposure of

$$L(t_{n+1}) = xA(t_n)[1 + xr_n]$$

- Therefore the re-hedging that needs to be carried out

$$\begin{aligned}\Delta(t_n) &= L(t_{n+1}) - L_{BR}(t_{n+1}) \\ &= xA(t_n)[1 + xr_n] - xA(t_n)[1 + r_n] = (x^2 - x)A(t_n)r_n\end{aligned}$$

Daily hedging demand

Case 1	$S(t_n)$	$A(t_n)$	$L(t_n)$	$L_{BR}(t_n)$	$\Delta(t_n)$
n=0	100	100	200		
n=1	90	80	160	180	−20
n=2	99	96	192	176	+16
Case 2					
n=0	100	100	−100		
n=1	90	110	−110	−90	−20
n=2	99	99	−99	−121	+22
Case 3					
n=0	100	100	−200		
n=1	90	120	−240	−180	−60
n=2	99	96	−192	−264	+72

- Case 1: $x = 2$
- Case 2: $x = -1$
- Case 3: $x = -2$
- index returns on day 1 and 2 are −10% and +10%
- It is noted that the term $(x^2 - x)$ is always positive for any integer x if x is not equal to 1
- Therefore, no matter whether the fund has positive leverage or inverse leverage, the hedging action is the same, i.e. increase exposure on a day when the index goes up, and decrease exposure on a day when the index goes down

Volatility drag

- Assume we have an ETF that pays the return of the index with an initial price of 100
- Assume that the return of the index is down 10% on day 1, up 10% on day 2
  - Thus the index levels on days 0 to 2 are: 100, 90, 99
- With two equal % moves, the ETF loses 1% over 2 days
  - If there is an ETF that has a leverage of +2, it would have lost 4%
- Simply, $(1-x)(1+x) = 1-x^2 < 1$ where x is the daily return

Path dependency on returns

Path 1	$S(t_n)$	$A(t_n)$	$L(t_n)$	$L_{BR}(t_n)$	$\Delta(t_n)$
n=0	100	100	200		
n=1	90	80	160	180	−20
n=2	99	96	192	176	+16
Path 2					
n=0	100	100	200		
n=1	100	100	200	200	0
n=2	99	98	196	198	−2

- In this example, the leverage of the fund x = 2
- For derivation, see Cheng and Madhavan (2009)

- In both these paths, the index level ends at 99, but the NAVs of the fund are different (96 and 98)
- If the index follows a geometric Brownian motion, it can be shown that over a period of time t_n, the return of the fund's NAV is given by

$$\frac{A(t_n)}{A(t_0)} = C\left[\frac{S(t_n)}{S(t_0)}\right]^x, \; C = \exp\left[\frac{(x-x^2)\sigma^2 t_n}{2}\right]$$

- Note that the scaling factor C is less than one as $(x - x^2) < 0$, but will never be negative, i.e. the fund's NAV will not drop below 0

Long term erosion of return of the leveraged ETF

- The leveraged ETF will outperform the static ETF only when volatility is low and the underlying asset (or index) moves in a constant trend
  - E.g. when the index goes up, the re-balancing of the ETF effectively means that the exposure would be rising in a rising market, hence it will outperform the ETF which is not re-balanced
  - $[S(t_n)/S(t_0)]^x$ tends to dominate, and this is a convex relationship

- However, as shown in the previous slides, the leveraged ETF cannot track index returns for periods longer than one day, and the leveraged ETF almost certainly underperforms the index / asset in the long run
  - Even ignoring tracking errors and transaction costs, the return depends on the index volatility and the time horizon
  - E.g. if $x = -2$, $\sigma = 30\%$, $t_n = 5$, index return is -10%, $C = 0.259$, the fund value is only 32% of its original value

Options on leveraged ETFs

- Given the popularity of leveraged ETFs, options on certain leveraged ETFs are also available in the market
- For an option based on a leveraged ETF on the S&P 500 index, clearly the implied volatility should somehow be linked to the volatility of a non-leveraged ETF on the same index
- Empirically, the connection is not very obvious, as the market does not seem to be efficient
- For a detail study, refer to Ahn, Haugh and Jain (2014), Leung and Sircar (2014)

The power of leverage

- If we can only invest with full amount, the return can be limited
  - E.g. you have $10000 to buy shares; if share price goes up by 10%, your return is 10%
- If you can borrow money to invest, your potential return is much higher
  - E.g. you have $10000, but someone lend you an additional $40000, so that you bought $50000 worth of shares
  - If share price goes up by 10%, your profit is $5000, and this represents 50% of your original investment

Leverage examples

- Margin accounts (stocks, FX)
  - Need to maintain minimum margin level, otherwise forced termination of position
- Futures and options
  - E.g. For HSI futures, we are paying the equivalent of 1365 index points in margin (as of Jan 3, 2017) to control an asset which is roughly equal to 23000 points
- Long/short trades (pairs trading)
  - Very high leverage attainable because it can require very little initial investment

Market neutral strategies

- Does not make assumption as to whether market will rise or fall
- Trading strategy is based on how two assets will move relative to each other
- Typical strategies are called pairs trading
  - E.g. long 1000 shares of stock A at $10 per share, short stock 2000 shares of stock B at $5 per share on trade date, so that no initial investment is required (other than margins)
  - If share price of A goes up by 10% and share price of B goes up 5%, a total profit of $1000 – $500 = $500 is made
  - As long as the relative performance of A is better than B, a profit is earned (e.g. both stocks can go down, but still a profit is possible)

Pairs trading

- Sometimes known as "relative-value" trading
- The methodology is heavily based on whether two securities revert back to an underlying long-term relationship between them (a **"mean-reverting"** behaviour)
- Need to consider the cost and possibility of short selling in these strategies
  - regulatory issues
  - ease of stock borrowing

Selection criteria for equity pairs

- Different classes of security for the same company, e.g.
  - Swire Pacific 'A' (0019) vs Swire Pacific 'B' (0087)
    - Note that Swire Pacific 'B' is no longer eligible for short selling
  - Different listing e.g. Wipro ADR vs Wipro in India (ADR premiums due to foreign ownership rule)
  - Dual listing: HSBC listed in both Hong Kong and London
  - Chinese companies with A shares (listed in China) and H shares listed in Hong Kong

- Fundamental analysis, e.g.
  - Hang Lung Group (0010) vs Hang Lung Properties (0101)
  - Hutchison (0013) vs Cheung Kong Infrastructure (1038) (before 2015)
  - Outperformance trades

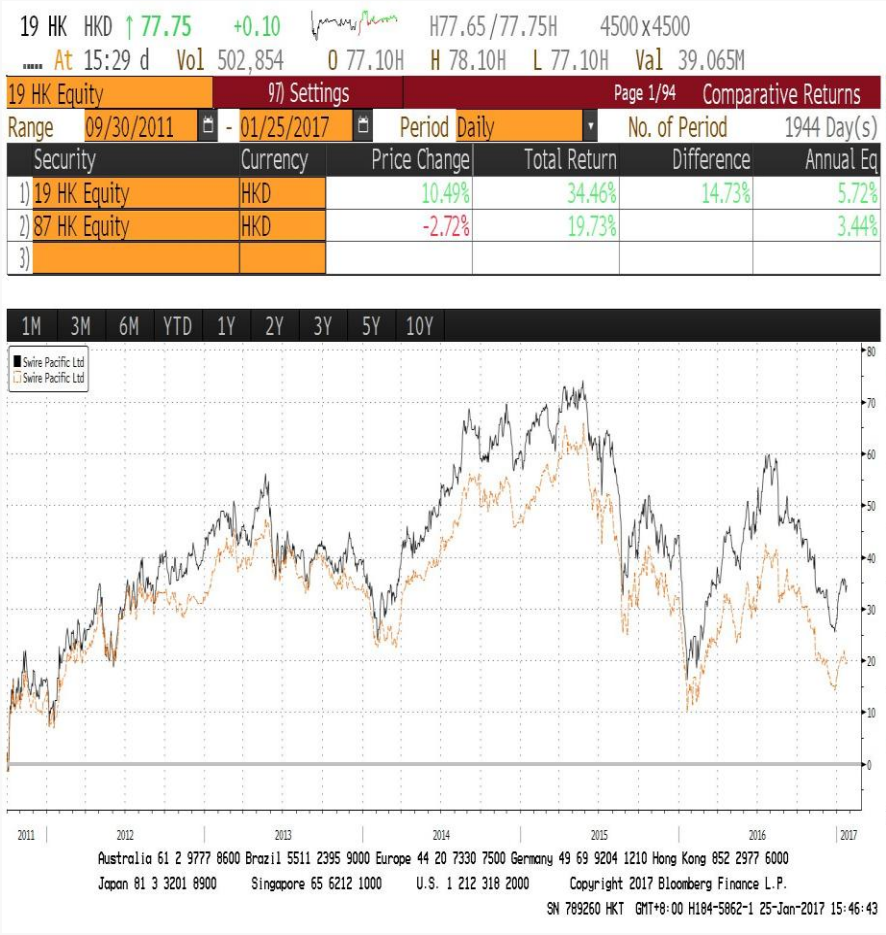
- Statistical arbitrage
  - Time series properties

Similar class

- Swire Pacific ‘A’ (0019) and Swire Pacific ‘B’ (0087) differ in voting rights and dividend policy
- Liquidity of Swire Pacific ‘B’ is much lower since it is largely owned by the majority shareholder
- Dividend yield of Swire Pacific ‘B’ is often higher than Swire Pacific ‘A’
- Should the total return converge?

Performance of Swire ‘A’ vs ‘B’

(source: Bloomberg LP)

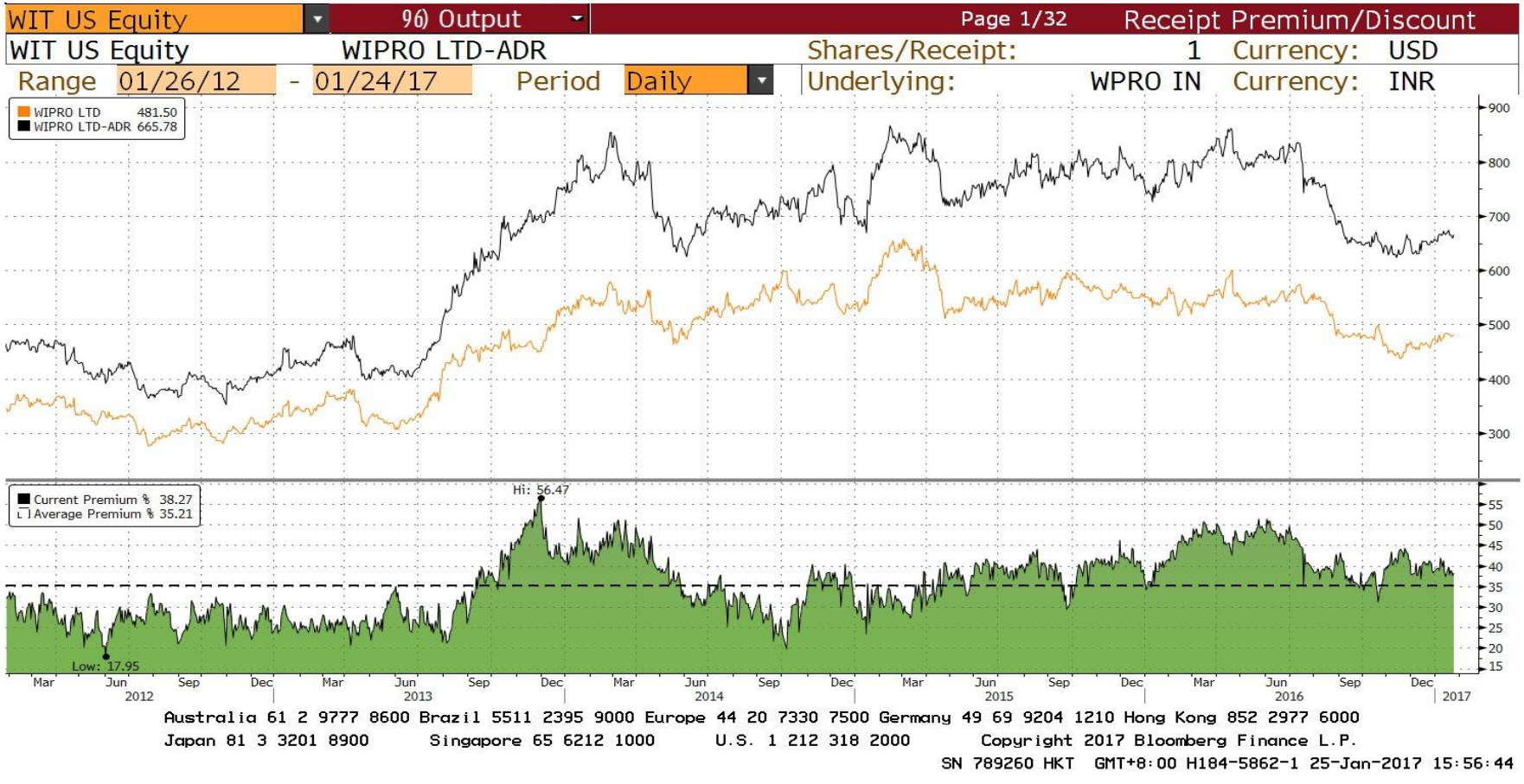


Long/short example: premium extraction trade

- Wipro ADR (listed in New York) is usually trading at a premium to the local Indian stock (due to foreign ownership rules), but the premium level keeps changing
- If it is anticipated that the premium will trade higher, one strategy is to
  - borrow the local stock and sell it
  - Convert the INR to USD
  - Use the proceeds to buy the ADR

Wipro ADR vs local stock

(source: Bloomberg LP)



Long/short example: related companies

- Hutchison (0013) owns 76.4% of Cheung Kong Infrastructure (1038) (before 2015)
- Some financial characteristics (as in Jan 2014):
  - 0013: P/E = 17x, Market Cap = HKD 450 Billion
  - 1038: P/E = 12.8x, Market Cap = HKD 117 Billion
- Trade idea: long 2.5 share of CKI and short 1 share of Hutchison

Leverage effect of pairs trading strategies

- Let's say you put on the trade on May 31, 2011, when the price of Hutchison was HK$ 90.00 and the price of CKI was HK$ 36.75
- Cost of trading = HK$ 2.50 x 36.75 – 90 = $1.875
- Other transaction costs include the borrowing fee for Hutchison, stamp duty, funding cost etc.
- In this example, ignoring transaction costs, if CKI price moves up by 1% (0.3675), the portfolio return is 0.3675/1.875 = 19.6%, i.e. a leverage of 19.6x
- Sometimes it is even possible to construct a zero cost strategy (other than the transaction costs), so that an extremely high leverage could be attained
- On Sep 30, 2011, the spread was worth $55.80
- As of Nov 4, 2014, the spread was worth $41.775 (Hutchison's price was $97.10, CKI's price was $55.55)

CKI vs Hutchison (source: Bloomberg LP)

CKI vs Hutchison (source: Bloomberg LP)

- The ratio used here is long 1.33 shares of CKI and short 1 share of Hutchison

Other pairs trading examples

- Outperformance of one company against another within the same sector
  - Within the same country, e.g. China Unicom (0762) vs China Mobile (0941) vs China Telecom (0728)
  - In different countries, e.g. Citibank vs HSBC

Telecom companies in China

(source: Bloomberg LP)

941 HK HKD ↑ 86.75 -0.25 H86.70 / 86.75H 31000 x 21500

At 15:43 d Vol 8,884,176 O 86.40H H 86.80H L 86.20H Val 768.625M

762 HK Equity | 97) Settings | Page 1/54 | Comparative Returns

Range 01/24/2014 - 01/25/2017 Period Daily No. of Period 1097 Day(s)

	Security	Currency	Price Change	Total Return	Difference	Annual Eq
1)	762 HK Equity	HKD	-14.05%	-8.70%	-34.04%	-2.98%
2)	941 HK Equity	HKD	13.92%	25.34%		7.80%
3)	728 HK Equity	HKD	-.54%	6.48%	-18.86%	2.11%

Australia 61 2 9777 8600 Brazil 5511 2395 9000 Europe 44 20 7330 7500 Germany 49 69 9204 1210 Hong Kong 852 2977 6000

Japan 81 3 3201 8900 Singapore 65 6212 1000 U.S. 1 212 318 2000 Copyright 2017 Bloomberg Finance L.P.

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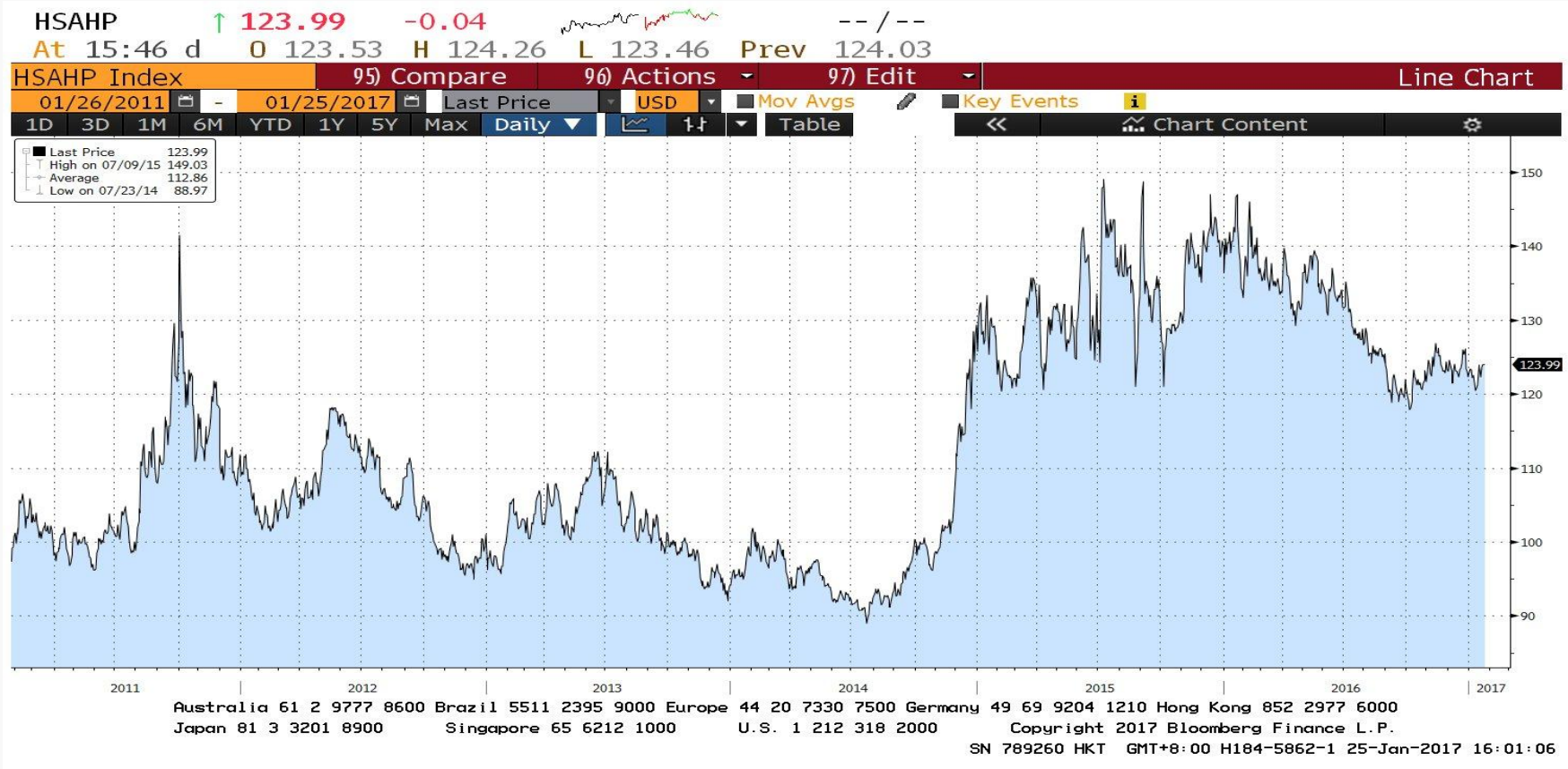
A shares vs H shares

- Many Chinese companies are listed both as A-shares in Shanghai / Shenzhen markets and H-shares in the Hong Kong market
- However, due to regulatory differences and a different investor base, there has been big discrepancies between the share prices for many companies
  - For most companies, Chinese share prices have often shown a premium to Hong Kong share prices
- Given that the share prices should reflect the fundamentals of the companies, there should not be a consistent big difference in their valuation
  - But there seem to be no effective way of arbitrage, even after the introduction of the Shanghai-Hong Kong Stock Connect (滬港通) in Nov 2014 and the Shenzhen-Hong Kong Stock Connect (深港通) in Dec 2016
  - The topic has aroused much research interest

Hang Seng AH Premium Index

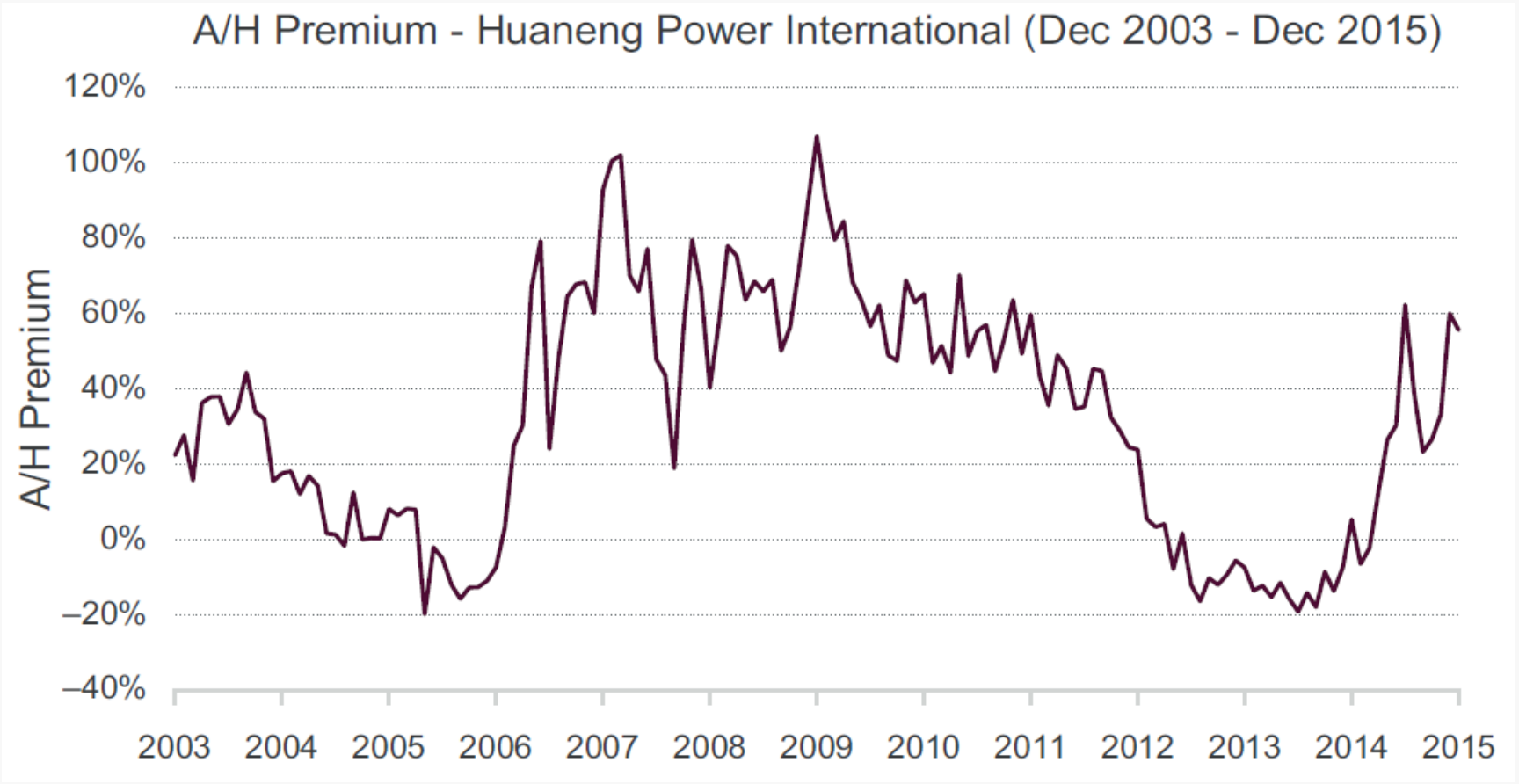


- 100 means that A-share is trading at par with H-share; a number above 100 indicates that A-share is trading at a premium to the H-share
- Source: Bloomberg LP

A vs H example: Yanzhou Coal Mining

- Left: 3-years; Right: 1-year. (Source: Bloomberg LP)

A vs H example: Huaneng Power International



- Source: FTSE Russell report (2016)

Statistical arbitrage

- Arbitrage is supposed to mean that a riskless strategy is conducted by simultaneously trading different assets
- Statistical arbitrage uses time series techniques to determine trading signals
- Based on the concept of **mean reversion**
  - relationship between two securities fluctuates around a constant mean
  - the relative behaviour between the two securities may deviate from the mean temporarily but will return to normal after a certain time

Statistical arbitrage

- Typical methods include
  - Measuring the spread or ratio between two securities
  - regression-based methods
  - Co-integration
- Need to use advanced methods to select pairs of securities which show mean reverting behaviour
- There is no guarantee that the relationship must revert back to normal levels; **it is not a real "arbitrage"!**

Statistical arbitrage example

- Define the log spread as:

$$s_t = \ln(y_t) - \ln(x_t)$$

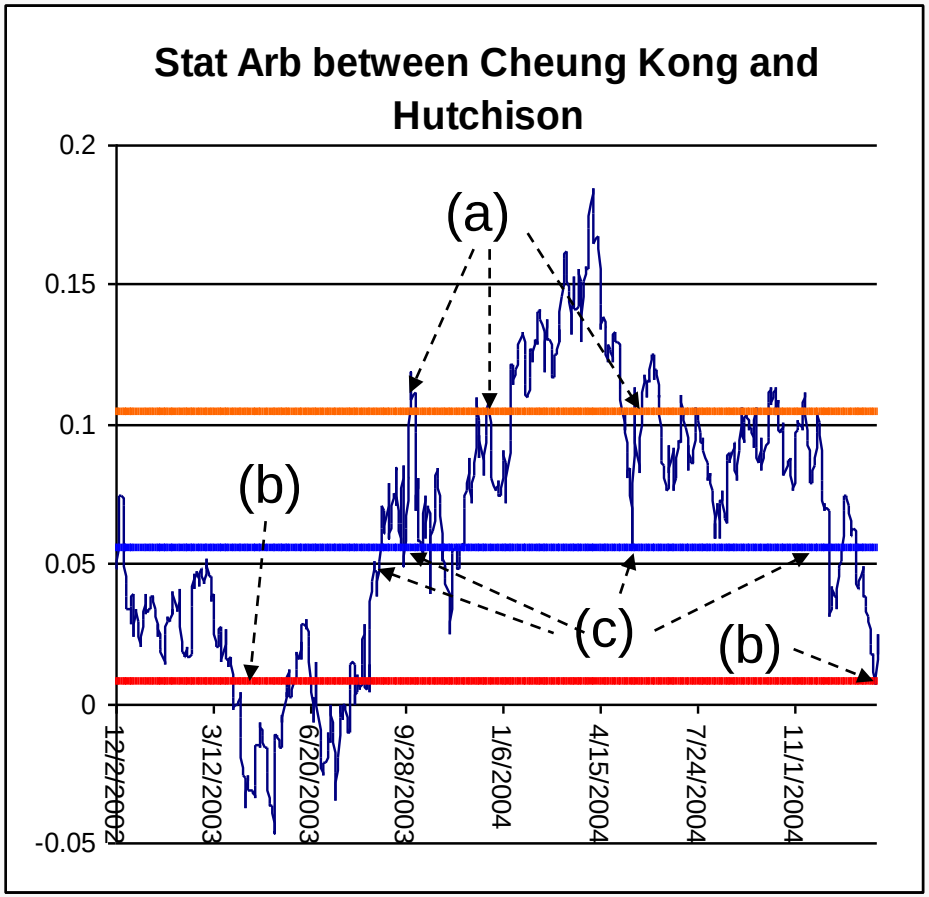
  where x_t and y_t are the prices of the two stocks at time t

- The mean and variance are defined by

$$\bar{s} = \frac{1}{T}\sum_{t=1}^{T} s_t,\ \sigma_s^2 = \frac{1}{T-1}\sum_{t=1}^{T}(s_t - \bar{s})^2$$

- Simple trading rules can be set up, for example
  - If $s_t > \bar{s} + k\sigma_s$, go short in stock y and long in stock x
  - If $s_t < \bar{s} - k\sigma_s$, go long in stock y and short in stock x
  - when s_t returns to $\bar{s}$ close out of position

Statistical arbitrage example



- k has been chosen to be 1.8
- (a) - sell Cheung Kong and buy Hutchison
- (b) - buy Cheung Kong and sell Hutchison
- (c) - close out
- Profit: HKD 18,900 for 1000 shares each (before transaction cost)

Co-integrated time series

- Stock prices are often modelled as a random walk process, which is non-stationary
- For two non-stationary time series x_t and y_t , there may be some kind of relationship between the two: if a specific linear combination becomes a stationary series (say $y_t - \gamma x_t$), the two original series are known as co-integrated
  - Cliver Ranger and Robert Engle proposed the idea in 1987; subsequently they were awarded the Nobel prize in 2003
- If ε_{xt} and ε_{yt} are white noise processes,

$$y_t = \alpha_y (y_{t-1} - \gamma x_{t-1}) + \varepsilon_{yt}$$

$$x_t = \alpha_x (y_{t-1} - \gamma x_{t-1}) + \varepsilon_{xt}$$

Common trends model

- An alternative representation from Stock and Watson

$$y_t = n_{yt} + \varepsilon_{yt}$$

$$x_t = n_{xt} + \varepsilon_{xt}$$

  where n_{xt} and n_{yt} are the non-stationary components of the time series and ε_{xt} and ε_{yt} are the stationary components

- We can write the cointegrating combination as

$$y_t - \gamma x_t = (n_{yt} - \gamma n_{xt}) + (\varepsilon_{yt} - \gamma \varepsilon_{xt})$$

- Since this combination is stationary, it means that the non-stationary component must be 0, thus

$$n_{yt} - \gamma n_{xt} = 0 \text{ or } n_{yt} = \gamma n_{xt}$$

Strategy design

- Identify stock pairs that could potentially be cointegrated
  - c.f. the APT model, where stocks can be related to common factors
- Test of cointegration: determine the cointegration coefficient γ and examine the spread series to ensure it is stationary and mean-reverting
- Set up trading rules by defining the entry and exit levels, taking into account of trading costs and anticipated slippage due to market factors

Statistical analysis

- Need extensive back-testing of models using historical data

- Pay attention to data quality
  - Make adjustments due to corporate actions
  - Make adjustments due to different market hours and holidays (if in different countries)

Regulatory concerns

- Short selling may not be allowed for every stock
  - for example, check the "Designated securities eligible for Short Selling" in http://www.hkex.com.hk under "Market Operations / Securities Trading Information"
- MPF ordinance
  - Funds cannot be leveraged
  - Similar regulations in many countries
- Capital Adequacy Ratios (CARs) for banks
  - 8% of Tier 1 capital is the global standard
- Un-regulated hedge funds are not subject to these restrictions

Index arbitrage

- Also known as cash-and-carry arbitrage
- Fair value of the index

$$F=(I–D)\ \text{x}(1+rt)$$

Where I=current index, D=dividends,

r = interest rate, t = time to maturity

- If the futures contract is trading above or below F, arbitrage opportunity exists
  - This is a real arbitrage, if the unwinding of the trades at maturity can be conducted without slippage

Regular/reverse arbitrage

- If futures is trading above F (i.e. futures trading "at a premium"), the strategy is known as *regular arbitrage*:
  - Sell futures, borrow money at rate r, buy stock basket (index)

- If futures is trading below F (i.e. futures trading "at a discount"), the strategy is known as *reverse arbitrage*:
  - Buy futures, borrow stock basket and sell, lend money at rate r

- *Remember to compare the futures price against the fair value F, not the spot index level I*
  - e.g. spot index 22620, expected dividends 100 points, current futures price 22580 – futures is trading at a premium

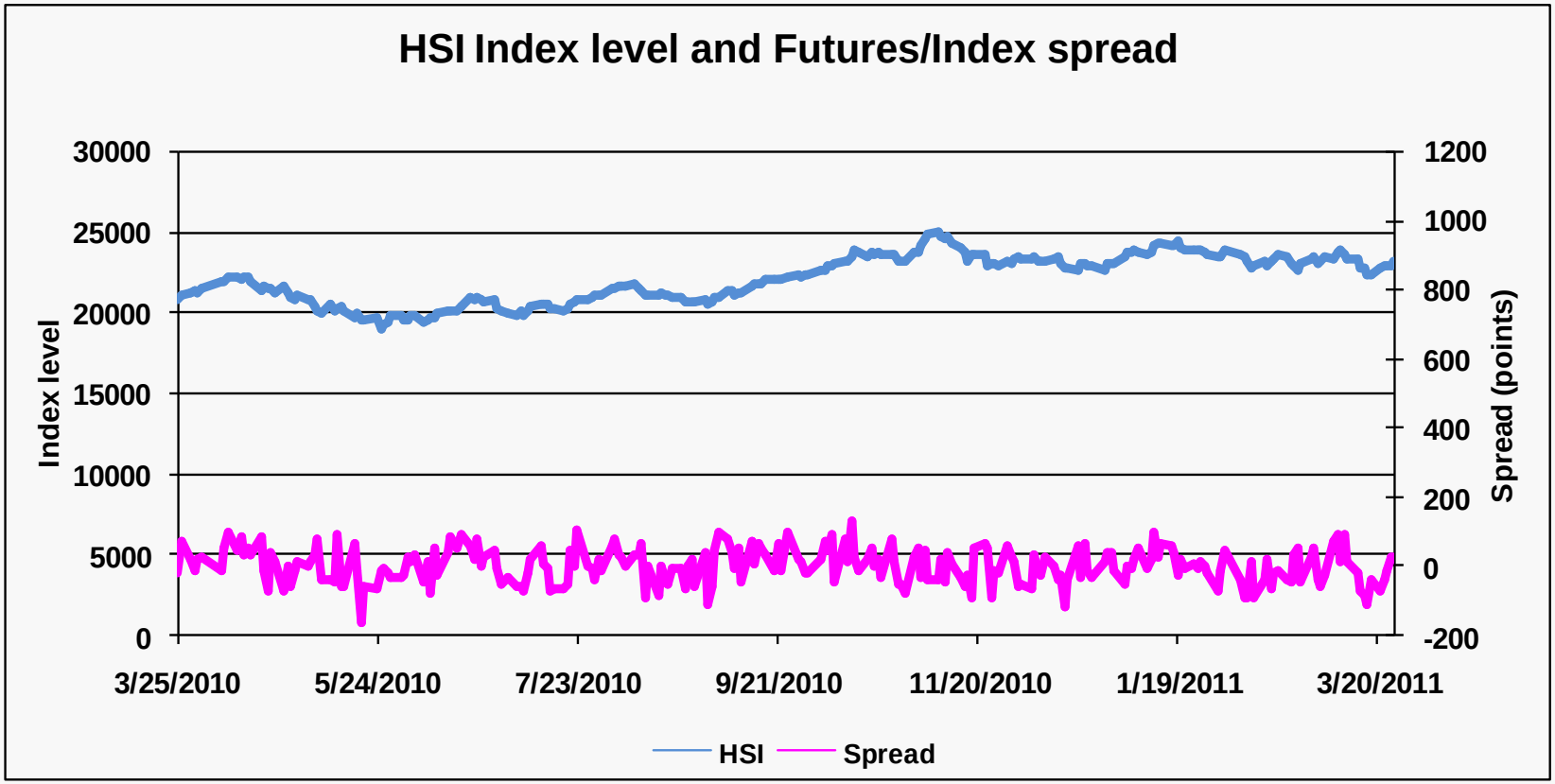
Index arbitrage example

- spot index level = 22500, interest rate = 0.10%, expected dividend = 100 points, time to maturity = 0.0694 yrs, futures trading at 22460 points
- Fair value of futures = (22500 – 100)x(1+rt) = 22401.55
- Strategy is to buy stock basket, sell futures at 22460
- Theoretical expected profit at maturity = 22460 – 22401.55 = 58.45 points per basket (before cost)

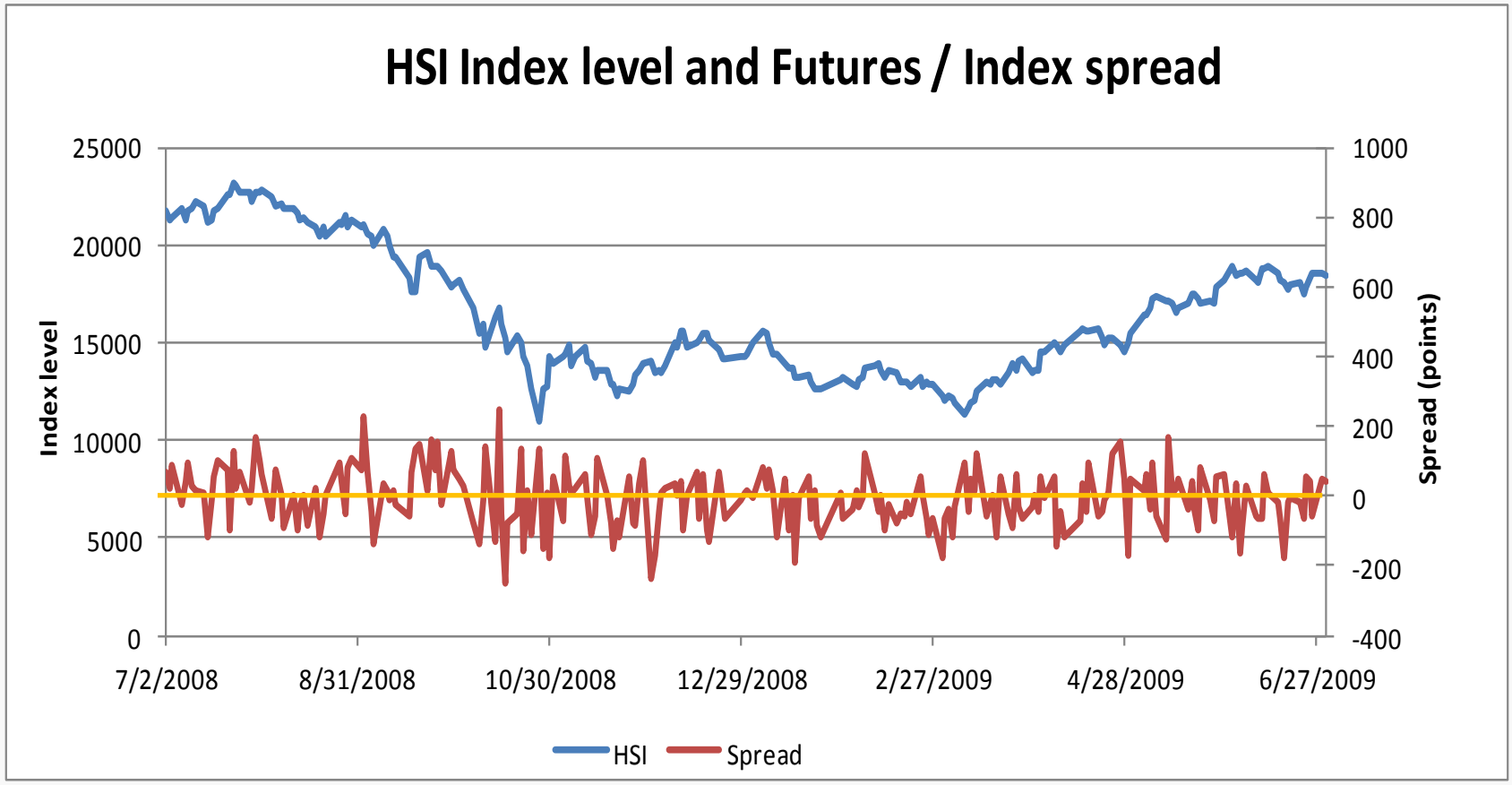
Why would arbitrage opportunity exist?

- Convenience of futures trading as a speculative tool
- Some stocks within the index may be very illiquid, affecting index calculation
- Regulatory issues – not possible to short sell in certain Asian markets, therefore reverse arbitrage could not occur, and futures could trade well below its fair value
- Technical issues – limits in stock price movements exist in some markets, therefore futures could move more than the cash market

Index arbitrage in practice



Levels seen in 2008/2009



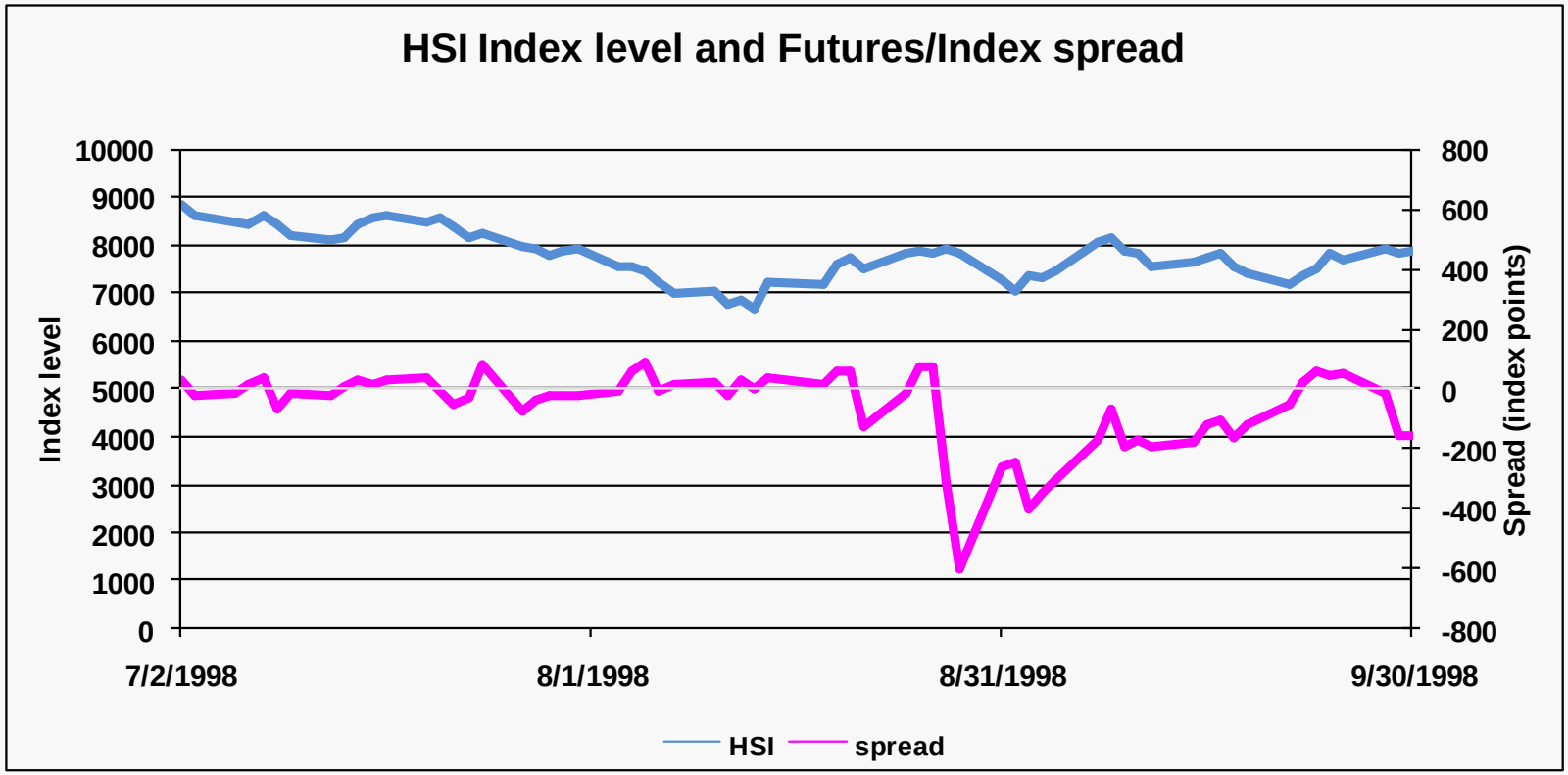
Practical issues

- Real-time index calculation
  - HSI is published every 2 seconds using the last traded prices of each stock (c.f. Shanghai updates their indices every 5 seconds)
  - we need to have real time prices
- Stock bid/ask spread
  - Using all bid prices if we are selling stocks, all ask prices if we are buying stocks
- Borrow/deposit rate spread
- Dividend estimation
- Check the liquidity of stocks
  - e.g. could you complete the buy/sell orders when we need to trade stock baskets worth 50 futures contracts?

Practical issues

- Ease of simultaneous execution – electronic trading
  - Could we execute all the stocks in the index basket?
  - Could we use a smaller "tracking" basket to represent the index? (c.f. S&P 500 has 500 constituent stocks)
- Stock borrowing condition (for reverse arbitrage trades)
  - August 1998 – futures trading at 3% discount, but stocks could not be borrowed
- Execution rounding errors due to board lots
- Transaction costs: as of January 2017, the stamp duty + transaction fee = 0.1077% of transaction amount (roughly equal to 25 index points when HSI is at 23000)

What happened in 1998



- c.f. Paul Draper and Joseph K.W. Fung, Discretionary Government Intervention and the Mis-pricing of Index Futures, Journal of Futures Markets, Special Issue 23(12):1159-89, 2003.

Example: Index arbitrage using HSI (c.f. lecture 5, p.8)

stock code	name	shares outstandin (millions)	3-Jan close	board lot	shares required for 25 futures	rounded
5	HSBC	12,250	63	400	46,904	46,800
700	Tencent	3,844	189.4	100	14,718	14,700
939	China Construction Bank	108,188	5.86	1,000	414,244	414,000
1299	AIA	12,056	43.75	200	46,163	46,200
941	China Mobile	6,143	82	500	23,520	23,500
1398	ICBC	73,775	4.68	1,000	282,479	282,000
3988	Bank of China	79,441	3.48	1,000	304,175	304,000
1	CK Hutchison	2,702	90.8	500	10,345	10,500
388	Hong Kong Exchanges	1,163	184.3	100	4,453	4,500
2318	Ping An Insurance	5,213	39.35	500	19,961	20,000
883	CNOOC	17,859	9.79	1,000	68,381	68,000
2628	China Life Insurance	7,441	20.8	1,000	28,492	28,000
386	Sinopec	25,513	5.57	2,000	97,689	98,000
2	CLP Holdings	1,895	72.55	500	7,255	7,500
16	Sun Hung Kai Prop	1,303	100.7	1,000	4,989	5,000
1113	Cheung Kong Prop	2,692	48.25	500	10,307	10,500
857	PetroChina	21,099	5.8	2,000	80,786	80,000
823	Link REIT	2,231	50.9	500	8,544	8,500
11	Hang Seng Bank	765	146.8	100	2,928	2,900
3	Hong Kong & China Gas	7,630	13.76	1,000	29,216	29,000

- The above shows a partial list of stocks required for 25 HSI futures as of Jan 3, 2017

Profit realization

- Once an arbitrage trade has been carried out, the theoretical arbitrage profit is "locked in"
- **However, unless the position is closed successfully, the profit could not be realized**
  - The arbitrage condition is only satisfied at maturity; hence the profit can be realized if the stocks are unwound at exactly at the price level of the futures final settlement price

Profit realization

- To realize the profit, one could
  - Unwind the portfolio at maturity
    - Transaction cost
    - Need to know how futures settlement price is determined, e.g. Expected Average Settlement Price (EAS) in Hong Kong, using the opening print in Tokyo etc.
    - There may be difficulties in execution due to market conditions
  - Look for market opportunity to reverse the trade (potentially most profitable)
- If there is no opportunity to unwind, one could roll over to the next futures contract (maybe at a gain or loss)

Some selected references

- Euan Sinclair, *Volatility Trading*, 2nd edition, Wiley (2013), chapter 8.
- FTSE Russell, *Arbitraging the Chinese A-shares and H-shares Anomaly* (2016).
- Ruey Tsay, *Analysis of Financial Time Series*, 3rd edition, Wiley (2010).
- Ganapathy Vidyamurthy, *Pairs Trading: Quantitative Methods and Analysis*, Wiley Finance (2004).
- Paul Wilmott, *Paul Wilmott Introduces Quantitative Finance*, 2nd Edition, Wiley (2007), 1:306-309.