



Pairs Trading – A+H Shares

FRE 7801 Final Presentation

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05/17/2021

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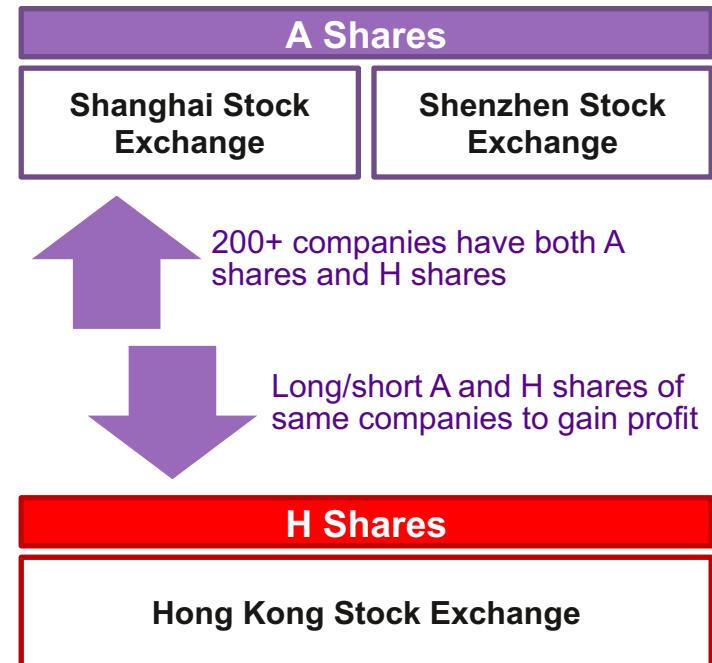
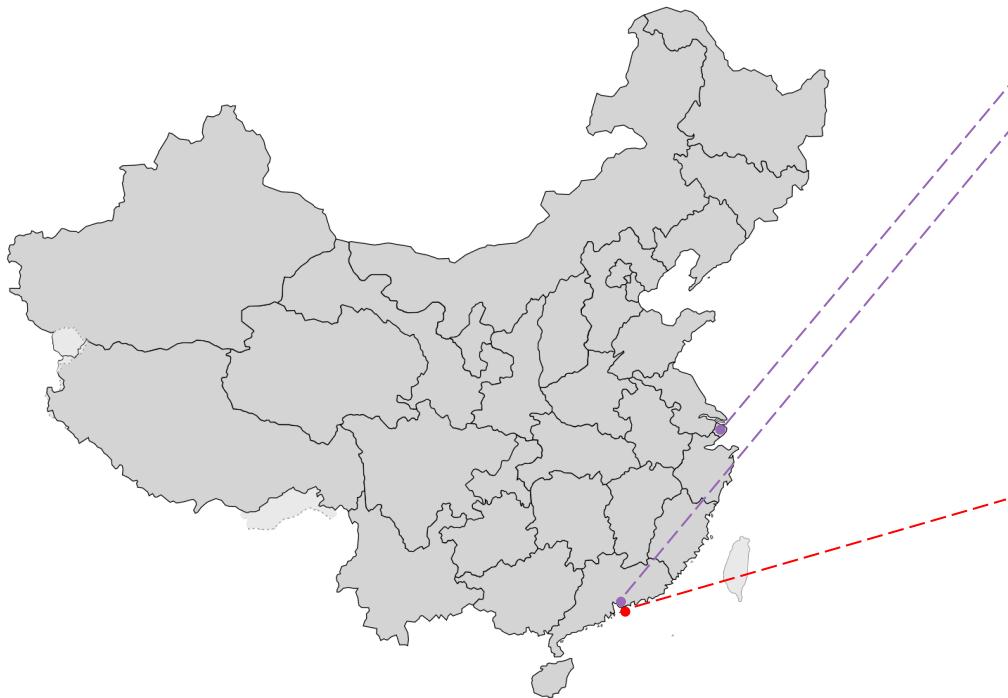
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Project Overview & Motivations

01.

Project Overview



Project Motivations

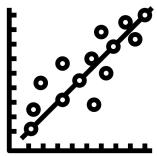
- With same systematic and idiosyncratic risks, A and H shares of the same company should have very **similar pattern**, thus, extremely **high cointegration relationship**
- This high correlation creates a **better opportunity** for pairs trading than traditional pairs trading between stocks of similar companies (more variables are controlled)
- Research has shown there has been existing some levels of **price differentials** in companies' A and H shares
- Both **short-term** and **long-term strategies** can be tested under this context
- Discovery of relationships between **developed** and **emerging markets** can be exciting

Strategy Methodologies Explanation

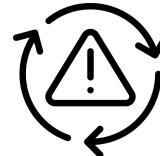
1. Engle-Granger Strategy
2. Kalman Filter Strategy
3. Law of One Price Strategy
4. A Shares Short Restriction



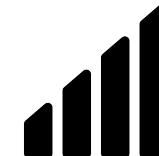
Engle-Granger Strategy



Build rolling regression models of two stock prices

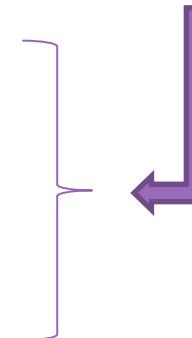


Calculate price residues on each day

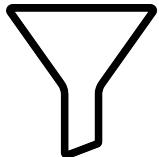


Generate trading signals based on residues

- When current residue falls within the bands from above, we **short A shares and long H shares**
- When current residue rises within the bands from below, we **long A shares and short H shares**
- Current positions are closed **only if** the opposite trading signal appears



Kalman Filter Strategy



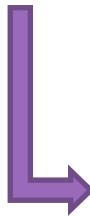
Update price relationships via
Kalman Filter



Calculate price residues on
each day



Generate trading signals
based on residues



State equation: $\beta_t = \beta_{t-1} + \omega_t$

Measurement equation: $S_{t,A} = \beta_t \times S_{t,H} + v_t$

$$\begin{aligned}\omega_t &\sim N(0, \sigma_w) \\ v_t &\sim N(0, \sigma_v)\end{aligned}$$



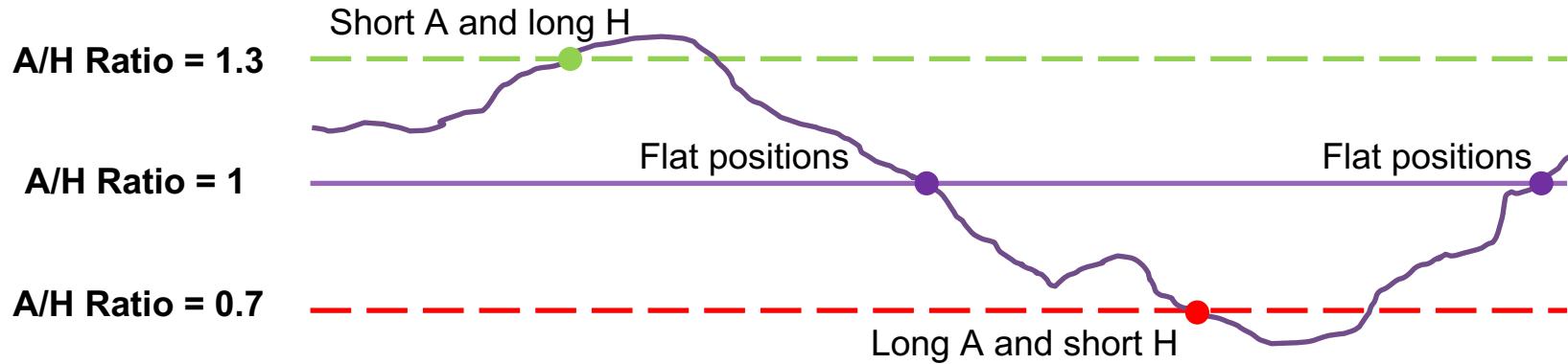
Minimize posteriori estimate error

$$\beta_{t|t} = \beta_{t|t-1} + \frac{s_{t,H}}{s_{t,H}^2 + \gamma^{-1}} \times (S_{t,A} - \beta_{t|t-1} \times S_{t,H})$$

$$\gamma = \frac{E[(\beta_t - \beta_{t|t-1})^2]}{\sigma_v^2}$$

Law of One Price Strategy

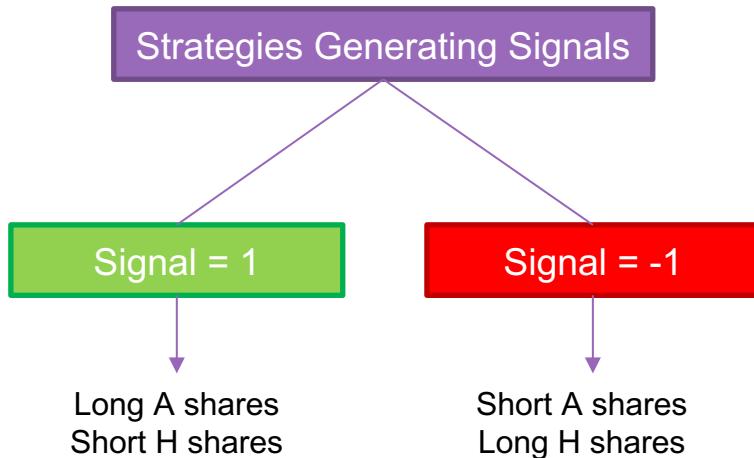
Law of One Price: the price of an identical asset or commodity will have the same price globally, which means A shares and H shares should have the same price after foreign exchange conversion



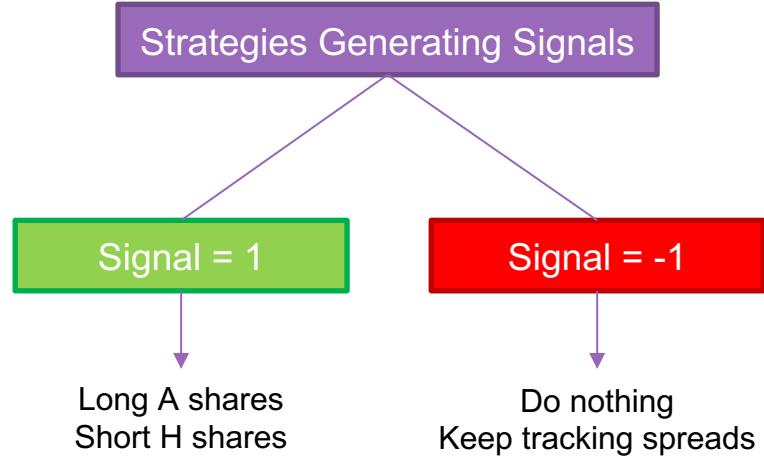
A Shares Short Restriction

Short-selling Restriction: by Chinese securities regulations, short-selling in Chinese A shares is strictly prohibited, so the practicability of our pairs trading strategies may be challenged

Model Without Restriction



Model With Restriction



Data Used & Backtesting Result

1. Data Explanation
2. Best Strategies of Each Company
3. Strategies Comparison
4. Visualization

03.

Data Used



CNYHKD

Foreign Exchange

CSI300 Index

A Share Index

Hang Seng Index

H Share Index

BYD Company

Consumer
Discretionary

2011/06/30 – 2021/05/07

COSCO Shipping

Industrials

2007/06/26 – 2021/05/07

Data Used

FOSUN PHARMA
复星医药



Fosun Pharma

Healthcare

2012/10/30 – 2021/05/07

ICBC The logo for Industrial and Commercial Bank of China (ICBC) features the letters 'ICBC' in a bold, black, sans-serif font next to a red circular emblem containing the Chinese characters '工商银行'.

ICBC

Utilities

2004/12/31 – 2021/05/07

The logo for PetroChina features a stylized sunburst design composed of yellow and orange segments above a red base, with the text 'PetroChina' in a serif font below it.

PetroChina

Financials

2006/10/27 – 2021/05/07

The logo for China Shenhua Energy features a stylized mountain range graphic with a red peak at the top, accompanied by the Chinese characters '中国神华' and the English text 'CHINA SHENHUA' below it.

**China Shenhua
Energy**

Energy

2007/11/05 – 2021/05/07

Materials

2007/10/09 – 2021/05/07

The NYU logo consists of a purple square containing a white torch icon followed by the letters 'NYU' in a bold, purple, sans-serif font.

Data Used



Tsingtao Brewery

Consumer Staples

2004/12/31 – 2021/05/07

Vanke 万科 Vanke

Real Estate

2014/06/25 – 2021/05/07

ZTE ZTE

Materials

2004/12/31 – 2021/05/07

Best Strategies w/o Restriction

	BYD	Cosco	Fosun	Huaneng	ICBC	PetroChina	Shenhua	Tsingtao	Vanke	ZTE
Annualized Return	0.206994	0.15774	0.262617	0.100682	0.0419926	-0.00169585	0.108622	-0.0272417	0.0157585	0.0423513
Annualized Volatility	0.273767	0.280256	0.271036	0.315835	0.104804	0.193615	0.200743	0.351639	0.205016	0.376532
Sharpe Ratio	0.756096	0.562842	0.968936	0.31878	0.400677	-0.0087589	0.541101	-0.0774707	0.0768648	0.112477
Max Drawdown	-0.146261	-0.201136	-0.233926	-0.366046	-0.0860142	-0.293318	-0.121113	-0.472443	-0.246918	-0.321487
95% CVaR	-0.0611815	-0.0676101	-0.0637245	-0.0883621	-0.0280484	-0.0419752	-0.057669	-0.0840028	-0.0360653	-0.214008
Strategy	Kalman Filter	Kalman Filter	Engle-Granger	Engle-Granger	Law of One Price	Law of One Price	Engle-Granger	Engle-Granger	Kalman Filter	Engle-Granger
Beat or Miss	Beat	Beat	Beat	Only Miss CSI300	Beat	Only Miss CSI300 and HSI	Beat	Miss	Miss	Only Beat H Shares

- Without A shares short-selling restriction, **Fosun (Engle-Granger)** has the highest Sharpe Ratio, but **BYD (Kalman Filter)** seems to have a better risk profile; **both outperform** their individual stocks and indices
- Tsingtao (Engle-Granger)** has the lowest and negative Sharpe Ratio, and it has the worst risk profile; it **underperforms** its individual shares and indices

Best Strategies with Restriction

	BYD	Cosco	Fosun	Huaneng	ICBC	PetroChina	Shenhua	Tsingtao	Vanke	ZTE
Annualized Return	0.0813541	0.0727055	0.157042	0.0624999	0.0175669	-0.180326	0.0456565	0.0296151	0.0521621	0.0251403
Annualized Volatility	0.182534	0.226875	0.139873	0.235314	0.142953	0.222182	0.148704	0.219259	0.152856	0.24784
Sharpe Ratio	0.445694	0.320464	1.12275	0.265602	0.122886	-0.811615	0.307029	0.135069	0.341251	0.101438
Max Drawdown	-0.110233	-0.16463	-0.0608316	-0.221997	-0.211983	-0.415315	-0.150738	-0.293577	-0.157812	-0.205407
95% CVaR	-0.054488	-0.0622384	-0.038776	-0.0744106	-0.0450343	-0.106316	-0.0629076	-0.075405	-0.0347403	-0.115385
Strategy	Kalman Filter	Kalman Filter	Kalman Filter	Engle-Granger	Engle-Granger	Kalman Filter	Kalman Filter	Engle-Granger	Kalman Filter	Engle-Granger
Beat or Miss	Beat	Beat	Beat	Only Miss CSI300	Only Beat CSI300	Miss	Beat	Miss	Only Beat CSI300 and HSI	Only Beat H Shares

- Without short-selling restriction, **Fosun (Kalman Filter)** remains to be the top choice for pairs trading, and it **beats** its individual shares and indices
- PetroChina (Kalman Filter)** has the lowest and negative Sharpe Ratio, and it **underperforms** its individual shares and indices
- The existence of the restriction generally **lowers both the potential profitability and risk**

Strategies Comparison

Summary of Which Strategies Become the Best Choice for each Company

	Engle-Granger	Kalman Filter	Law of One Price
Without Restriction	5/10	3/10	2/10
With Restriction	4/10	6/10	N/A
Total	9/20	9/20	2/20

- **Engle-Granger** and **Kalman Filter** strategies do not have significant better performance over the other
- **Law of One Price** strategy is generally not practical

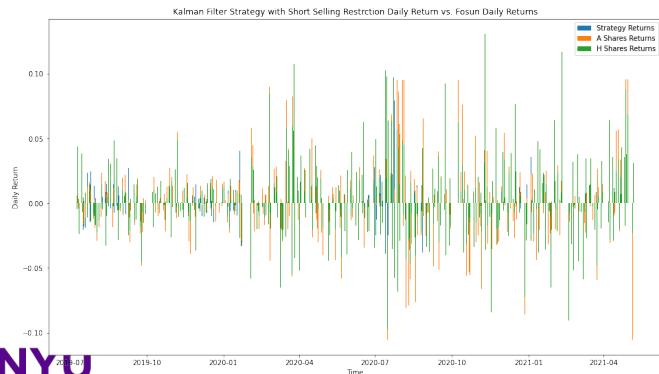
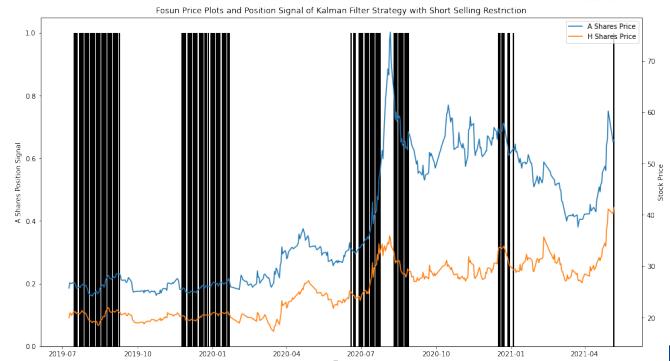
Benchmarks Comparison

	Without Restriction	With Restriction
Outperform A Shares	7/10	5/10
Outperform H Shares	8/10	6/10
Outperform CSI 300	5/10	6/10
Outperform HIS Index	6/10	6/10

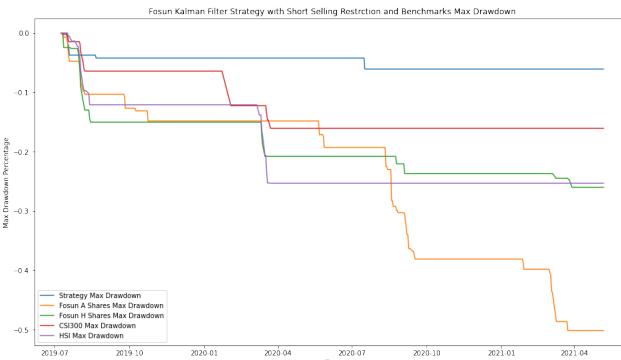
- All pairs trading strategies have **no less than 50%** probability of beating benchmarks
- The existence of short-selling restriction **negatively** ¹⁷ affects strategies' abilities to outperform benchmarks

Visualization of Best Strategy

Kalman Filter Strategy on Fosun with Short-selling Restriction

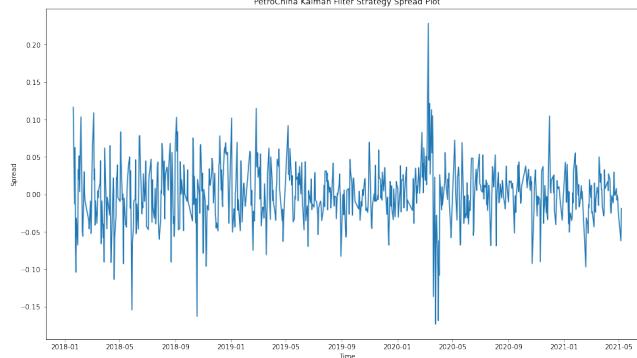
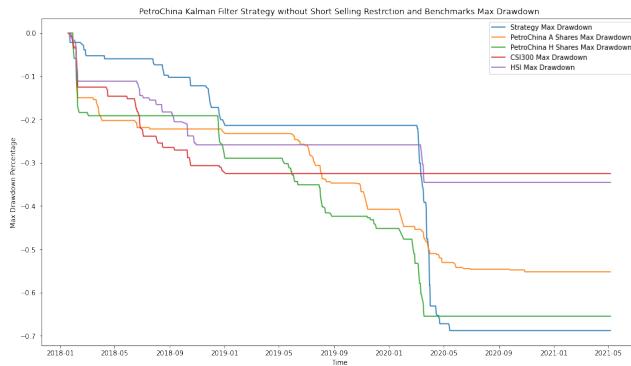
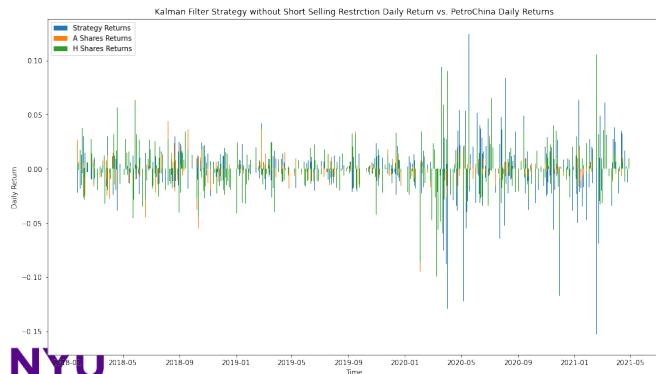
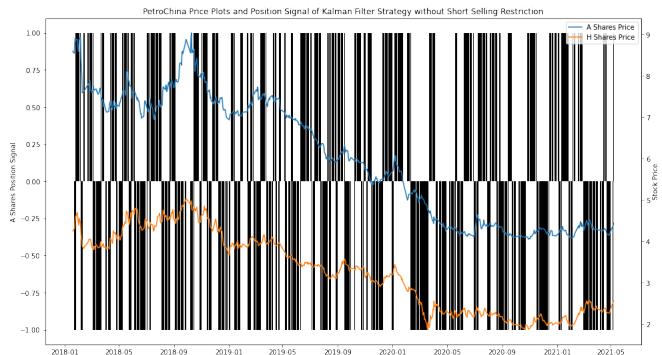


FOSUN PHARMA
复星医药



Visualization of Worst Strategy

Kalman Filter Strategy on PetroChina without Short-selling Restriction



NYU

Discussion of Result & Main Takeaways

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1. Engle-Granger vs. Kalman Filter
 2. Law of One Price Strategies Failure
 3. Limitations
 4. Main Takeaways

04

Engle-Granger vs. Kalman Filter

Engle-Granger Method

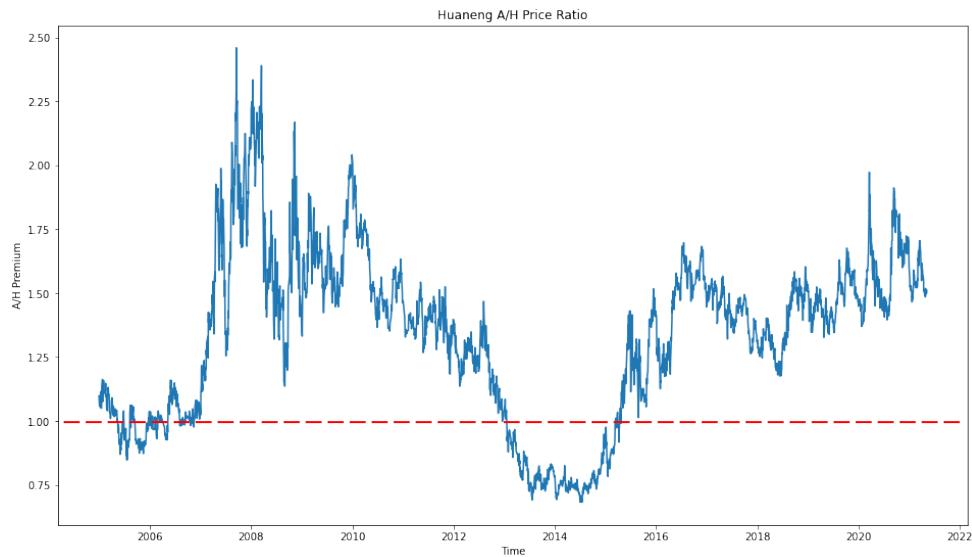
- Find relationships by averaging past observations for a period of time
- Easier to understand and implement and good enough when there is no significant intrinsic relationship change
- Slow adjustment to intrinsic relationship changes

Kalman Filter Method

- Find relationships by giving more weights on the most recent observation
- More dynamic adjustment method which thrives when there is intrinsic change in the relationship
- May take more noises into modeling which can cause “overfitting” problem

A and H shares of same companies are **not subject to intrinsic relationship changes**, so Kalman Filter strategy **cannot outperform** Engle-Granger strategy (9:9 in 20 cases); the potential **overfitting problem** of Kalman Filter sometime may lead to **disastrous results**

Law of One Price Strategies Failure



Facts

- Hong Kong market has been consistently **undervalued** than Mainland China markets
- The ratio **does not converge to 1**, so the strategy rationale fails

Potential Reasons

- **No short-selling** in A shares
- Information **asymmetry**
- Lots of **irrational retail investors** trade A shares while H shares are more traded by **domestic and foreign institutions**

Limitations

- Some strategies have very frequent position rebalances, so the **ignorance of transaction cost** may make huge differences
- Positions are always **indivisible** in reality, making it almost impossible to build a perfectly dollar-neutral strategy
- Cost model that incorporates **impact cost is not considered** in the backtesting
- Even in H shares, short-selling in every stock is **not always available**, and the short-selling sometimes may have **high borrowing fees** that could potentially affect trading performance

Main Takeaways

- In an ideal world where short-selling is permitted in A shares, pairs trading between A and H shares of same companies have **high probability beating benchmarks**
- Short-selling restriction in A shares **limits strategies' capabilities of beating benchmarks**, but the winning probability is still **not less than 50%**
- The choice of companies used for A/H pairs trading is important, and the pairs trading strategy is **not generally profitable for every A+H stocks**
- There is **no significant preference** between Engle-Granger and Kalman Filter strategies because Kalman Filter's advantages cannot be exploited under this context
- Law of One Price **fails to describe A shares' premiums over H shares**, so the strategy associated to it **fails to make good profit**



Thank You

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05/17/2021

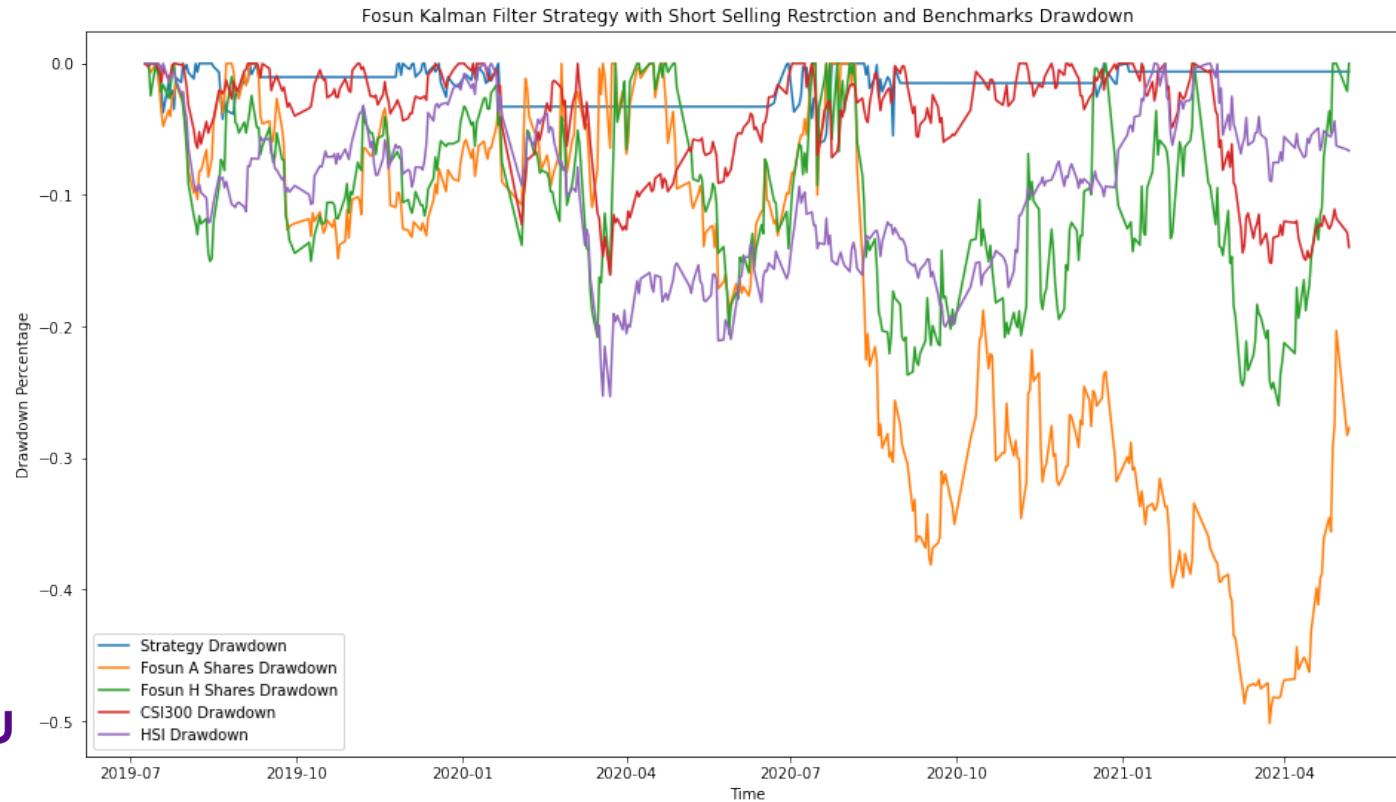
Appendix

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- 1. Best Strategy Plots
 - 2. Worst Strategy Plots

05.

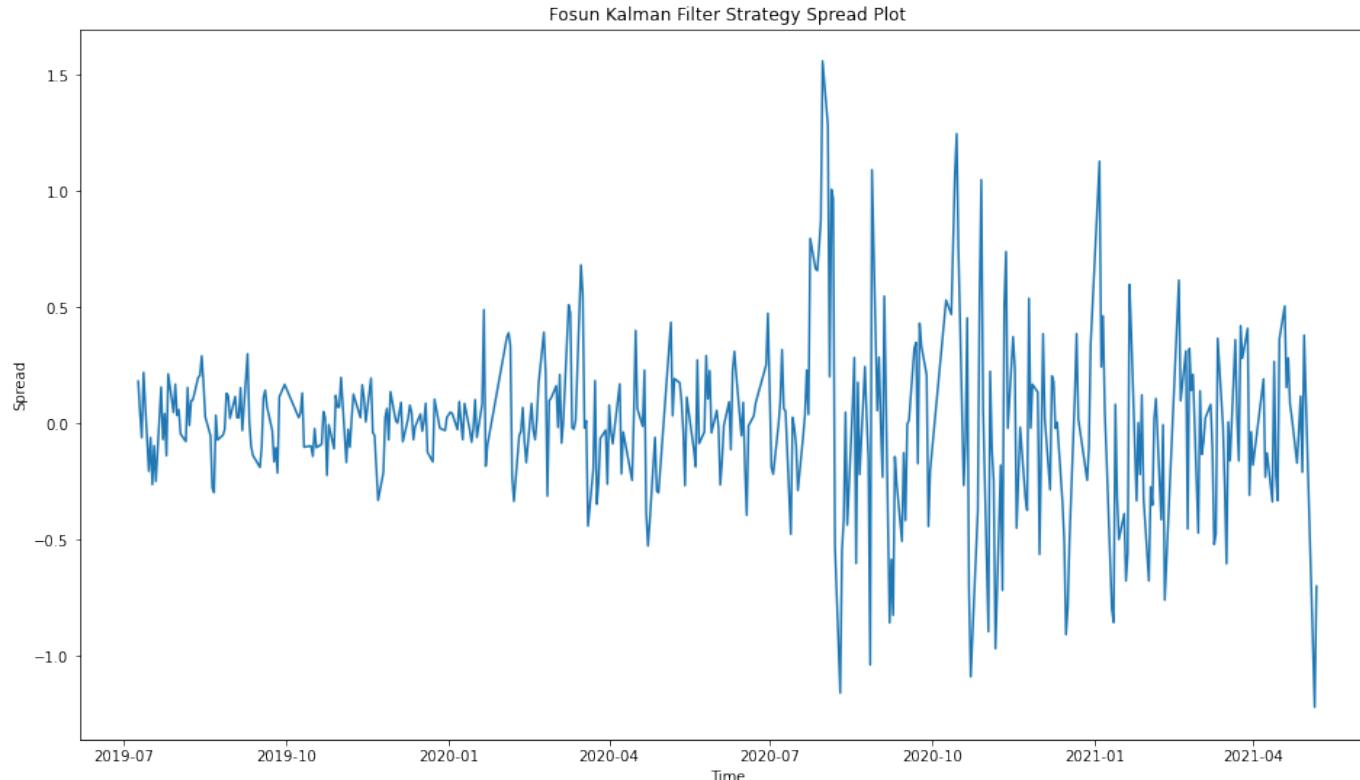
Best Strategy Drawdown Plot

Kalman Filter Strategy on Fosun with Short-selling Restriction



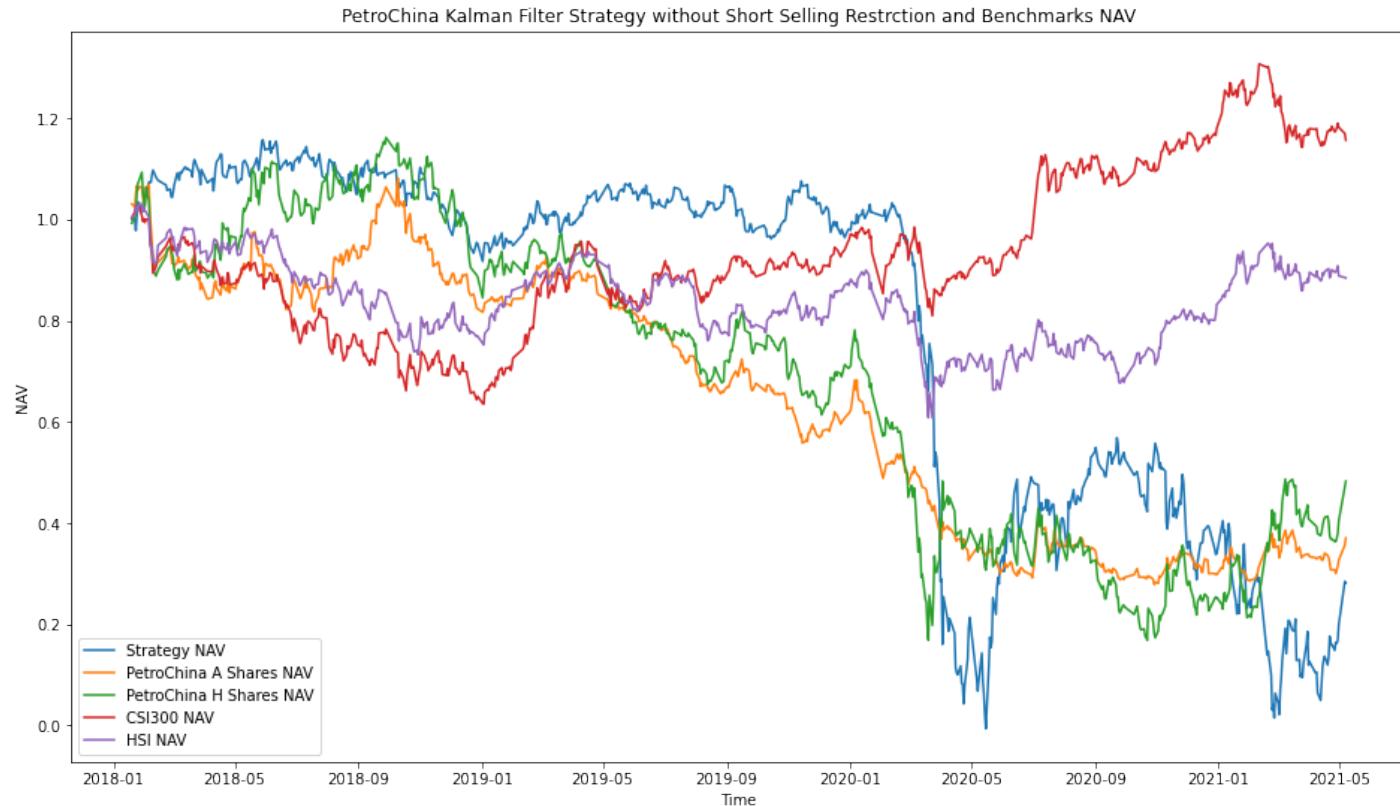
Best Strategy Spreads Plot

Kalman Filter Strategy on Fosun with Short-selling Restriction



Worst Strategy NAV Plot

Kalman Filter Strategy on PetroChina without Short-selling Restriction



Worst Strategy Drawdown Plot

Kalman Filter Strategy on PetroChina without Short-selling Restriction

