

# Special Topics in Financial Engineering

## Statistical Arbitrage

MGMT237M2

Professor Olivier Ledoit

University of California Los Angeles  
Anderson School of Management  
Master of Financial Engineering  
Fall 2016

# Contact Details

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- Office Hours:
  - Tue 11:30am-12noon
  - Thu 11:30am-12noon

# General Information

- 10 lectures of 1h30 each
- 3-hour in-class final exam
- 3 problem sets in groups
- Grade:
  - 10% participation
  - 40% final exam
  - 50% problem sets (16.67% each)

# Current Positions

- Visiting Professor of Finance, UCLA Anderson School of Management
- Permanent Research Fellow, Department of Economics, University of Zurich, Switzerland
- Founding Partner and Director of Research, AlphaCrest Capital Management, New York
- Managing Partner, Studdridge International Limited, Hong Kong-based consulting firm

# Past Experience

- 1999-2008: Managing Director, Global Statistical Arbitrage Group, Equity Proprietary Trading Division, Credit Suisse, London
- 1995-1998: Assistant Professor of Finance (tenure-track), UCLA Anderson School of Management
- Published over a dozen articles in top-ranked peer-reviewed academic research journals

# Areas of Interest

- Probability theory
- Statistics
- Econometrics
- Finance
- Asset pricing theory

# One of my Latest Papers

Moving on to (A.12), let  $\Delta \equiv \max_{m \in S} |m|$  and note that  $|z_j| \leq 2$ . Therefore, for any  $\tau_1, \tau_2 \in [0, +\infty)$ ,

$$\begin{aligned}
 |h_{m,z_j}(\tau_1) - h_{m,z_j}(\tau_2)| &= |\tau_1 - \tau_2| \left| \frac{1 - d - d z_j m}{(\tau_1 [1 - d - d z_j m] - z_j) (\tau_2 [1 - d - d z_j m] - z_j)} \right| \\
 &= |\tau_1 - \tau_2| \frac{|1 - d - d z_j m|}{|\tau_1 [1 - d - d z_j m] - z_j| |\tau_2 [1 - d - d z_j m] - z_j|} \\
 &= |\tau_1 - \tau_2| \frac{|1 - d - d z_j m|}{|\tau_1 [1 - d - d z_j m] - z_j| |\tau_2 [1 - d - d z_j m] - z_j|} \\
 &\leq |\tau_1 - \tau_2| (1 + d + 2 d \Delta) ,
 \end{aligned}$$

implying that we may choose  $d_1 \equiv (1 + d + 2 d \Delta)$ .

Recall that convergence in distribution of  $\hat{G}_n$  to  $G$  is equivalent to convergence to zero of the bounded-Lipschitz metric between  $\hat{G}_n$  and  $G$ ; for example, see Pollard (1984, Chapter IV, Example 22). Furthermore, since  $\hat{G}_n$  and  $G$  put all their mass on  $[0, \infty)$ , it is sufficient to start all integrals at  $\tau = 0$  rather than at  $\tau = -\infty$ . Therefore,

$$\begin{aligned}
 \int_{-\infty}^{+\infty} \frac{d\hat{G}_n(\tau)}{\tau [1 - d - d z_j m] - z_j} &= \int_0^{+\infty} \frac{1}{\tau [1 - d - d z_j m] - z_j} d\hat{G}_n(\tau) \\
 &= \int_0^{\infty} h_{m,z_j}(\tau) d\hat{G}_n(\tau) \\
 &\rightarrow \int_0^{\infty} h_{m,z_j}(\tau) dG(\tau) \\
 &= \int_0^{+\infty} \frac{1}{\tau [1 - d - d z_j m] - z_j} dG(\tau) \\
 &= \int_{-\infty}^{+\infty} \frac{1}{\tau [1 - d - d z_j m] - z_j} dG(\tau) \quad \text{uniformly in } m \in S ,
 \end{aligned}$$

# Education

- 1995: Finance PhD, MIT Sloan School of Management, Advisor: Andrew Lo
- 1992: MSc in Statistics & Economics, ENSAE, Paris, France
- 1990: BSc in Applied Mathematics, Ecole Polytechnique, Paris, France



# Journal Officiel de la République

## **Arrêté du 20 août 1987 portant nomination des élèves admis en 1987 à l'Ecole polytechnique**

NOR : DEFA8701646A

Par arrêté du ministre de la défense en date du 20 août 1987 :

1. - Sont nommés élèves français de l'Ecole polytechnique à la suite du concours d'admission organisé conformément au décret n° 71-708 du 25 août 1971 modifié (titre I<sup>er</sup>) et à l'arrêté du 25 juillet 1973 modifié :

### *Option M'*

- 1 Laruelle (Claude).
- 2 de Vigouroux d'Arvieu  
(Alexis).
- 3 Ledoit (Olivier).
- 4 Schmitt (Alain).
- 5 Huve (Pierre).
- 6 Roussel (Jean-François).
- 7 Chassagne (Olivier).

- 45 Blary (Benoît).
- 46 Macchi (Denis).
- 47 Arlès (Olivier).
- 48 Mehadhebi (Karim).
- 49 Kammerer (Clotilde).
- 50 Leroy (Xavier).
- 51 Daulmerie (Christophe).
- 52 Fabiani (Patrick).

# MIT Graduation Day



# Academic Research



Olivier Ledoit

Follow

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[Finance](#), [Economics](#), [Statistics](#), [Probability](#), [Financial Econometrics](#)

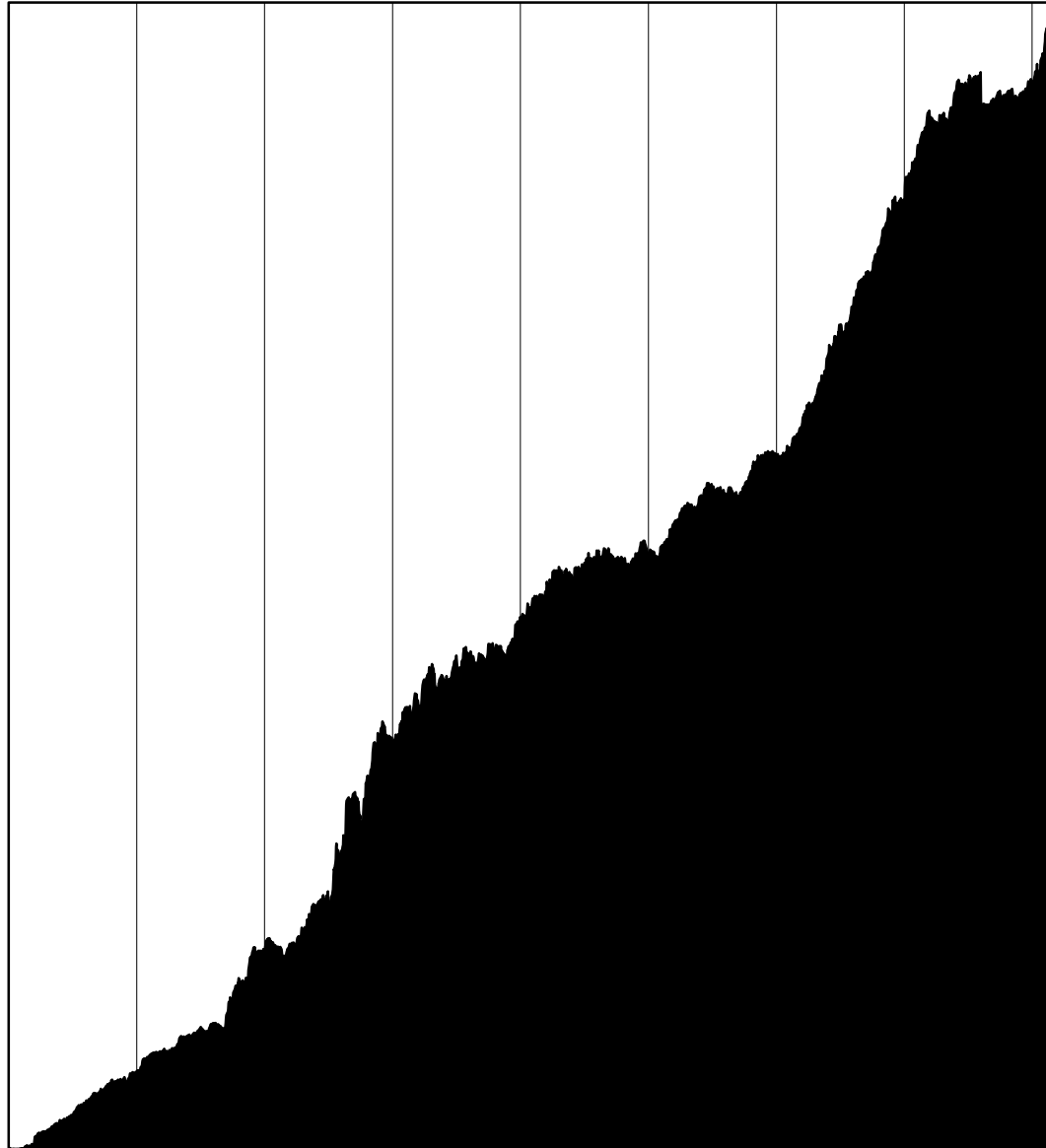
Verified email at econ.uzh.ch - [Homepage](#)

Title	1–20	Cited by	Year
<a href="#">A well-conditioned estimator for large-dimensional covariance matrices</a>	O Ledoit, M Wolf Journal of multivariate analysis 88 (2), 365-411	1064	2004
<a href="#">Improved estimation of the covariance matrix of stock returns with an application to portfolio selection</a>	O Ledoit, M Wolf Journal of empirical finance 10 (5), 603-621	947	2003
<a href="#">Honey, I shrunk the sample covariance matrix</a>	O Ledoit, M Wolf The Journal of Portfolio Management 30 (4), 110-119	586	2004
<a href="#">Some hypothesis tests for the covariance matrix when the dimension is large compared to the sample size</a>	O Ledoit, M Wolf Annals of Statistics, 1081-1102	488 *	2002

# Used Everywhere

- Radar detection
- Speech recognition
- Brain/Computer Interface
- Improving mobile phone reception
- Decoding the human genome
- Finding a cure for cancer
- Saving the planet from Global Warming

# Why I Retired Early



# Holy Grail For Anyone Who Wants A Quant Job At Goldman Sachs

Amazon.com: Heard... Special Topics in Fin... Mail - Ledoit, Olivier... Eingang

https://www.amazon.com/gp/product/0994118252/ref=as heard on the street

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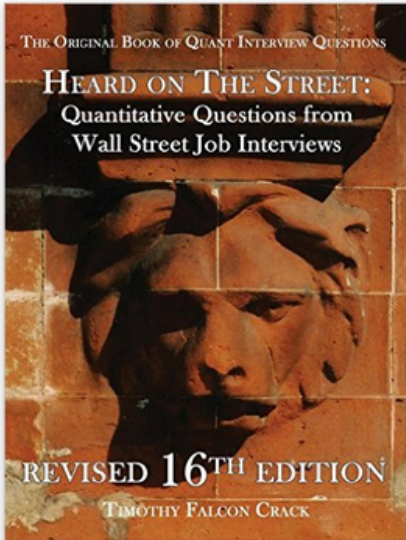
Books Advanced Search New Releases Best Sellers The New York Times Best Sellers Children's Books Textbooks Textbook Rentals

Books > Business & Money > Job Hunting & Careers

## Heard on The Street: Quantitative Questions from Wall Street Job Interviews Revised 16th Edition

by Timothy Falcon Crack (Author)

★★★★☆ 44 customer reviews



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# Wall Street Job Interview Question #1

- A small boat is floating in a swimming pool.
- The boat contains a very small but very heavy rock.
- If the rock is tossed out of the boat into the pool, what happens to the water level in the pool?

# Statistical Arbitrage

- Equity Long-Short Market Neutral
- Systematic: No Human Overlay
- Medium Frequency: Turn portfolio around in 1 week to 1 month



# High Frequency

- Orders must travel to the Stock Exchange in less than 10 milliseconds
- Flat position overnight
- Make money every day
- Technological horse race
- Low capacity

# Low Frequency

- Quantitative Asset Management (Jason Hsu)
- Sharpe Ratio  $< 0.7$
- More emphasis on asset gathering, distribution, marketing
- Lower fees

# Medium Frequency

- Golden outlet: work in a hedge fund
- Other possibilities:
  - Work for Investment Bank outside the US (Volcker rule)
  - Work inside traditional asset management company
  - Work from home

"This is a whole new ball game. Highly recommended."  
—DR. STEWART D. FRIEDMAN,  
Director of the Work/Life Integration Project, The Wharton School

# The 4-Hour Workweek



THE #1 NEW  
YORK TIMES  
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AND JOIN THE NEW RICH

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The  
4-Hour  
Work-  
week

ESCAPE 9–5,  
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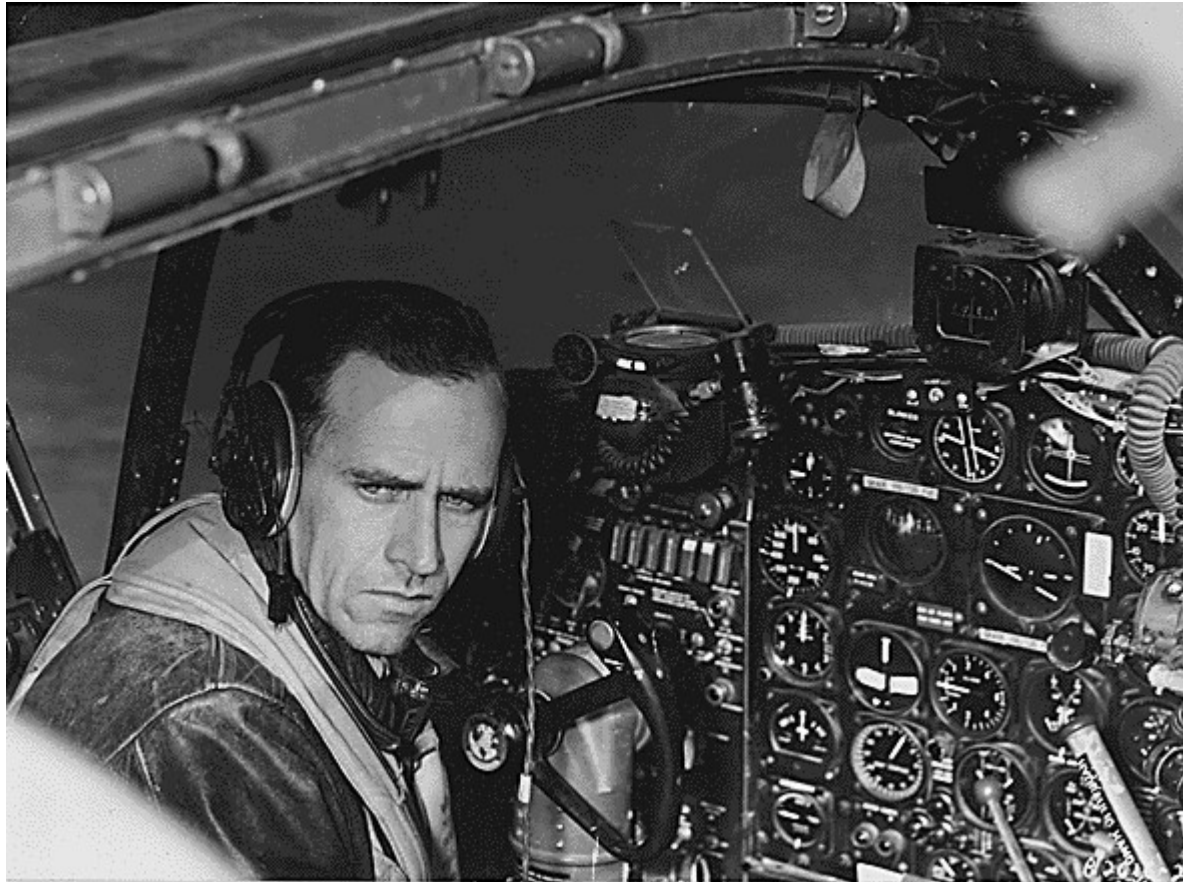
# Stat Arb

- Realized (*not backtested*) Sharpe Ratio  $> 2$
- Make profit over any 6-months period
- Leverage: for \$1M capital, go \$2M long and \$2M short
- Scalable up to \$250M capacity
- Globally (developed equity markets only)
- Long-term sustainable through research

# What does it take to succeed?

- Managing complexity
- 10,000+ lines of code, 100's of databases
- Must retain intellectual control at all times
- Need to “feel” the model and the markets
- Box is black to others, transparent to you
- Like piloting an airplane

# Managing Complexity



# Qualities

- High IQ
- Work > 60 hours/week
- **Passionate** about beating the market

**DISCIPLINED**

**EMPIRICAL**

**PARANOID**



# Market Efficiency

- Need to reinvent 30% of your business every year just to stand still
- One new market anomaly published every day on Financial Economics Network
- In 10 years @ CS, I released one new version every 2 weeks
- Like fixing an airplane as you're flying it
- I won't give you a fish, I'll teach you how to fish

# What this Class Is About

- Teaching you simple Stat Arb model
- Building Blocks
- Design Principles
- Homework:
  - You'll walk away with code you can improve
  - Europe (hardest but juiciest)
  - Jan 1998 – Dec2002 (save recent past as out-of-sample period)

# Basic Structure

- One program to load data into memory
  - Create the alphas
  - Rebalance the portfolio
  - Run historical backtest simulation
  - Generate current trade
- 
- Processes to update databases
  - Auditing programs

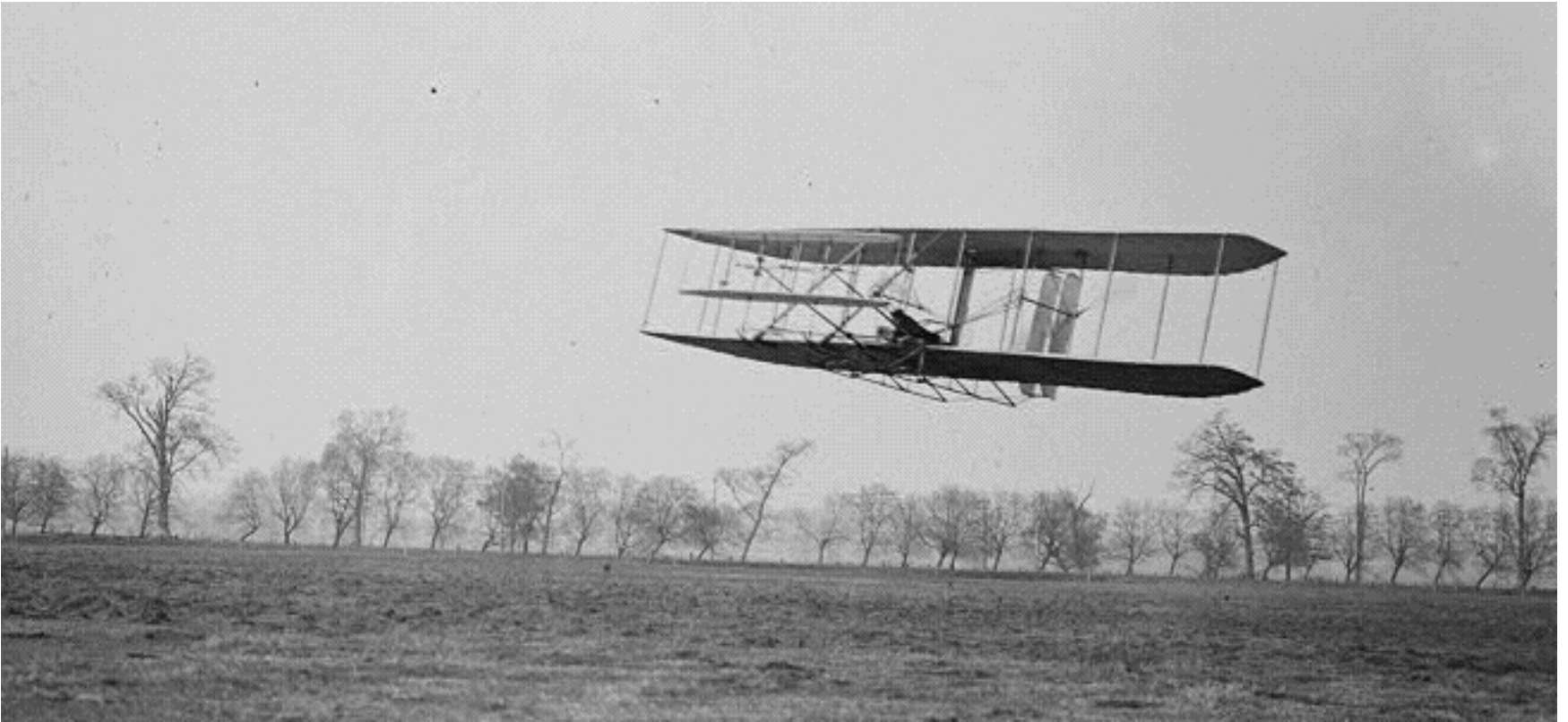
# Categories of Alpha

- Short-term momentum
- Short-term reversion
- Long-term momentum
- Long-term reversion

# Main Components

- Alphas
- Risk model (covariance matrix)
- T-cost model
- Optimizer

# Wright Brothers



# Boeing 747



# HSBC Hedge Fund Report



## Hedge Weekly N°28

Investment Funds Performance Review

HSBC Alternative Investment Group

Week of Monday 04 Jul to Friday 08 Jul 2016



Alternative Investment Products are:

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# Equity Market Neutral Funds

TWO SIGMA ABSOLUTE RETURN CAYMAN FUND LTD <i>Two Sigma Advisers, LP</i>	31 Oct 11	M	\$1'066M Apr 16	1,472.64	30 Jun 16	(4.45%)	(0.70%)	14.99%	10.09%	11.25%	4.03%	1.23%	8.64%	5.43%	(4.45%) May 16 - Jun 16
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## Multi-Strategy

Ytd Avg. 2016 0.60%

### Multi-Strategy/Asia

Ytd Avg. 2016  
(0.10%)

LIM ASIA MULTI-STRATEGY FUND CLASS A <i>George W. Long</i>	31 Dec 95	Q	\$975M May 16	39.53	24 Jun 16	(1.10%)	(0.10%)	1.77%	4.12%	5.63%	3.57%	-0.23%	6.94%	5.59%	(15.79%) Feb 08 - Nov 08
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### Multi-Strategy/Global

Ytd Avg. 2016  
1.30%

HUDSON BAY INTERNATIONAL FUND LTD <i>Hudson Bay Capital Management LP</i>	31 May 06	Q	\$2'222M May 16	230.12	31 May 16	0.50%	1.30%	-1.91%	-2.08%	7.9%	11.37%	4.31%	8.68%	4.92%	(6.11%) Feb 14 - Nov 15
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## Statistical Arbitrage

Ytd Avg. 2016 (2.74%)

### Statistical Arbitrage/Global

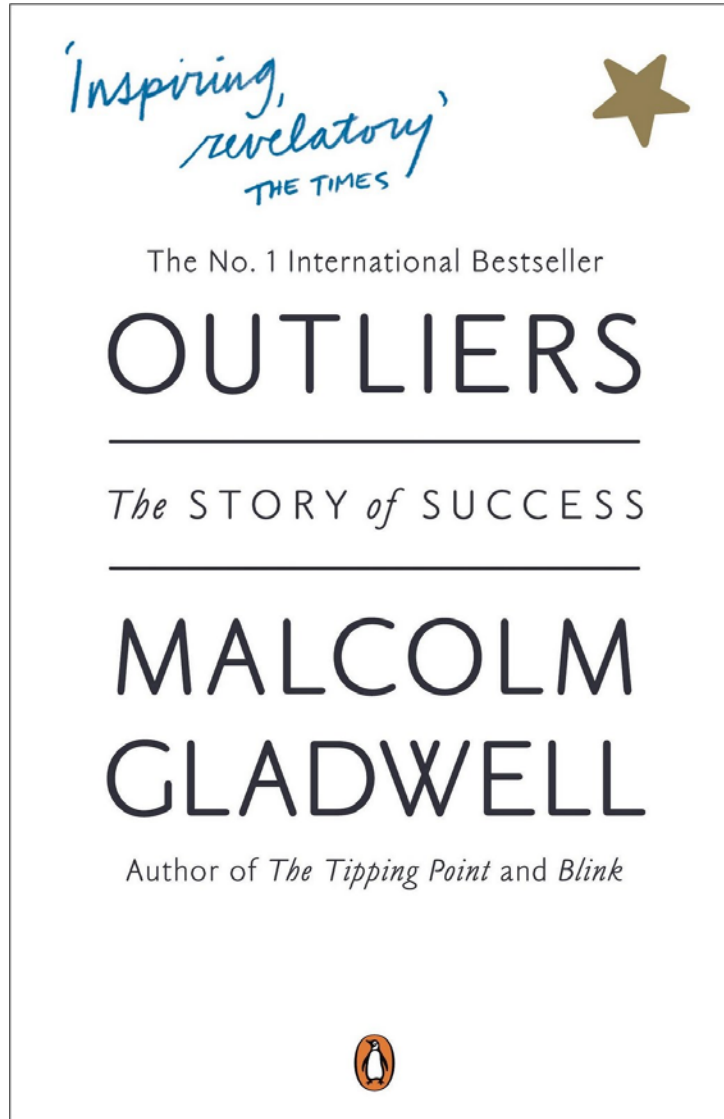
Ytd Avg. 2016  
(2.74%)

A.R.T. INTERNATIONAL INVESTOR (BVI) Ltd <i>Aaron Sosnick</i>	28 Feb 07	Q	\$849M May 16	242.31	30 Jun 16	(2.29%)	(1.27%)	3.11%	9.83%	4.91%	5.67%	7.88%	9.94%	7.19%	(10.48%) Jul 07 - Aug 07
GSA INTERNATIONAL FUND - CLASS A <i>David Khabie-Zeitoune</i>	28 Feb 05	Q	\$803M May 16	282.21	30 Jun 16	(0.97%)	(4.22%)	11.41%	12.14%	13.28%	3.64%	15.2%	9.58%	4.41%	(11.91%) Jun 08 - Sep 08

# GSA Capital International Fund

- Manager: Jonathan Hiscock
- Inception Date: February 28, 2005
- Assets under Management: \$803M
- Return in 2015: +11.41%; 2013: +12.14%
- Annual Return since Inception: +9.58%
- Annual Volatility: +4.41%
- Max Drawdown: -11.91% (Jun-Sep 2008)

# 10,000-Hour Rule



# Toolkit

- Linear Algebra
- Statistics
- Economics
- Finance
- Optimization
- Programming

# Required Readings for Next Week

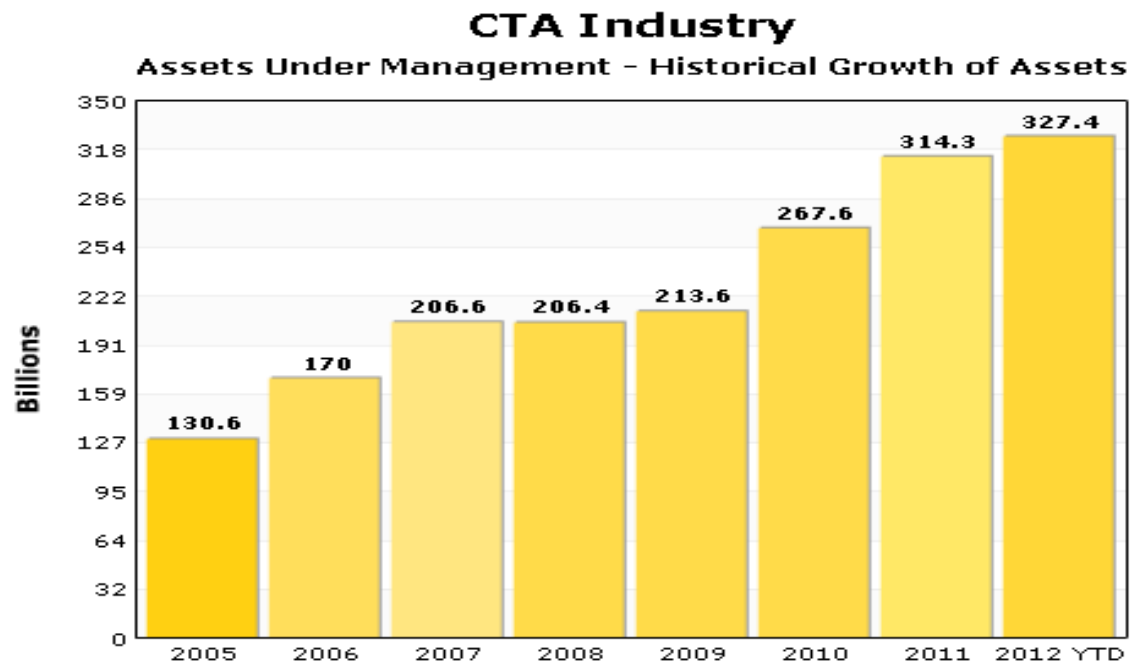
- Quantitative Trading (2009), by Ernest P. Chan:
  - How Will Transaction Costs Affect the Strategy?  
pp.22-23
  - Minimizing Transaction Costs, pp.87-88
- VWAP Strategies (2002), by Ananth Madhavan  
Only 7 pages!
- Execution Costs (2008), by Robert Almgren in  
the Encyclopedia of Quantitative Finance  
Only 5 pages!

# Additional Readings

- Transactions costs and investment style, Keim and Madhavan (1997)
- Direct Estimation of Equity Market Impact, Almgren et al. (2005)
- Quantitative Trading, Ernest P. Chan (2009)  
“Transaction Costs”, pp. 60-65

# Other Applications

- Volatility Harvesting
- Systematic Merger Arbitrage
- Index Rebalancing
- CTA:



# Let's Have Fun!

