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Momentum, Carry and Value: Time Series Versus Cross Section

Matthew Sargaison, CIO AHL (with thanks to Jamil Baz, Nick Granger & Cam Harvey)

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1. **Carry, Value and Momentum *almost* Everywhere**
2. Signal constructions
3. Performance analysis and results
4. Cross-section versus time-series behaviours
5. Conclusion

Value and Momentum Everywhere. And Carry everywhere else…

A short history

Momentum, Carry and Value

- Heavily written about market phenomena.
- Papers usually focus on explaining the *cross-section* of returns, **or** *time-series* (univariate/directional) returns.
- Approach often appears ideological…

- We focus on *simple* formulations
- Simulate multi-asset trading via futures, forwards and swaps
- Examine the differences and similarities between cross-section ***and*** time-series

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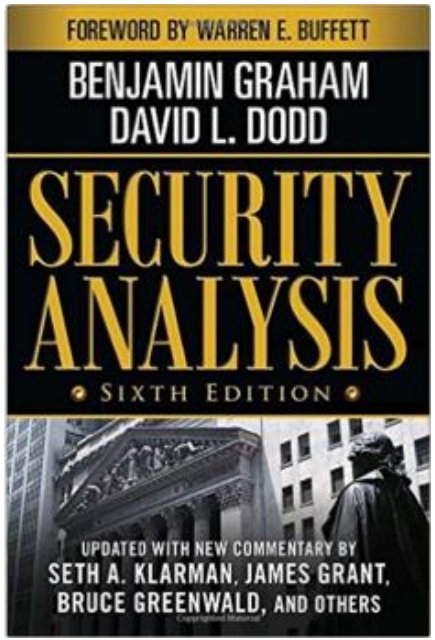
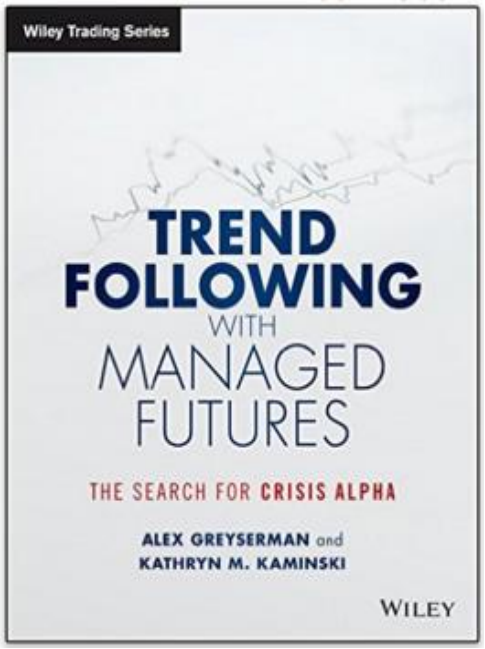
Aside - It seems books on value sell more than books on momentum



> 1,000,000 copies sold

VS



2,931 copies sold

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Source: Amazon and Wiley.

Academic articles on value appear to outnumber those on momentum

The Journal of FINANCE

Vol. 69 CONTENTS for FEBRUARY 2014 No. 1

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(Contents continued on back cover)

The Journal of THE AMERICAN FINANCE ASSOCIATION

Articles search	Count
Value	**5,982**
Momentum	**417**

Using an online search of all Journal of Finance articles since 1946

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Source: Journal of Finance website.

The three factor world

… or the absolute building blocks of investing

Value	Momentum	Carry
Slow dissemination of fundamentals	**Behavioural bias** or **over/under-reaction to new information**	**Systematic forward mispricing** or **reward for term-risk**
Makes money when prices revert or move back	*Makes money when prices keep moving in same direction*	*What is earned when prices don't move*

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How factors are traded is a stylistic choice

Value

Slow dissemination of fundamentals
or **dumb momentum traders**

Momentum

Behavioural bias
or **over/under-reaction to new information**

Carry

Systematic forward mispricing
or **reward for term-risk**

Some traditional quant equity strategies will trade:

Cross-section

Equally Long-Short to hedge any common factor in each asset class.
High leverage. Low vol
Profit from **relative** movements

4 Asset Classes

While others (CTAs) will prefer:

Time-series

Fully directional, actively exposed to underlying market and factor.
Lower leverage. Higher vol
Profit from **market** movements

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1. Carry, Value and Momentum almost Everywhere
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Our approach

- We focus on *simple* formulations
- Simulate multi-asset trading via futures, forwards and swaps
- Examine the differences and similarities between cross-section ***and*** time-series

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Factor signal construction - Markets

The usual four asset classes

all data January 1990-April 2015

Currencies

32 crosses
all versus US$

Commodity

16 Futures

Equities

26 Index Futures

Interest Rates

15 10Yr Swaps

e.g. Equities

- **US**: S&P, DowJones, Nasdaq, MidCap, Russell2000
- **EUROPE**: Eurostoxx50, Germany-DAX, Germany-Tech, Germany-MidCap, France-CAC40, Spain-IBEX, Italy-FTSEMIB, Sweden-OMX, Norway-OBX, Greece-FTASE, Finland-HEX25, Belgium-BEL20, Austria-ATX, Netherlands-AEX
- **Japan**: NIKKEI, TOPIX
- **UK**: FTSE100
- **SWITZERLAND**: SMI
- **EM Latam**: Brazil-IBOV, Mexico-MEXBOL
- **EM Asia**: Hong Kong-HIS, Korea-KOSPI2, Taiwan-TWSE, India-NIFTY, India-SENSEX
- **CEEMEA**: Russia-RTSI$, South Africa-TOP40
- **EMEA**: Poland-WIG20, Hungary-BUX
- **AUSTRALIA**: AS51

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Source: Bloomberg, Global Financial Data & AHL proprietary database January 1990 – April 2015.

Factor signal construction - **Carry**

What forward positions earn if spot prices don't change

FX

Use 3 month FX-forward to imply the carry

$$Carry_t = 4 \times (Spot_t / Fwd_{3M,t} - 1)$$

Equity

Use first two futures of each index

$$Carry_t = 1/(T_2-T_1) \times (Fut_{t,T2} - Fut_{t,T1})/Fut_{t,T2}$$

Commodities

To avoid seasonality, use futures 1 year apart

$$Carry_t = (Fut_{t,T+1} - Fut_{t,T})/Fut_{t,T+1}$$

Fixed Income

Carry = "carry + roll down".

$$Carry_t = (S_{10Y,t}\text{-}Fixing_t)/Duration_t \quad = Carry$$
$$+ (S_{10Y,t} - S_{7Y,t}) / 3 \quad = Roll$$

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Source: «Dissecting investment strategies in the cross section and time series» Baz et al., December 2015.

Factor signal construction - **Momentum**

Persistence of behaviour in returns

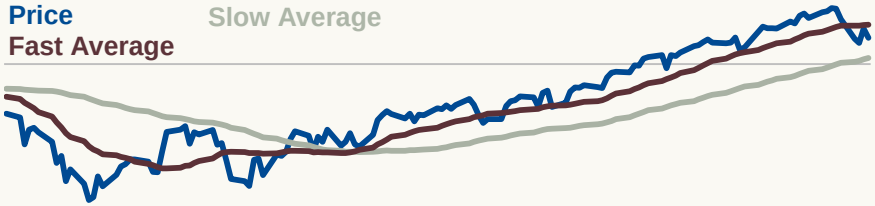
CTA standard construction

- 3 different time-horizons (S_k, L_k) = Short, Long lookbacks
- Calculate 3 different EWMA differences:
  x_k= ewma(P, S_k) – ewma(P,L_k)

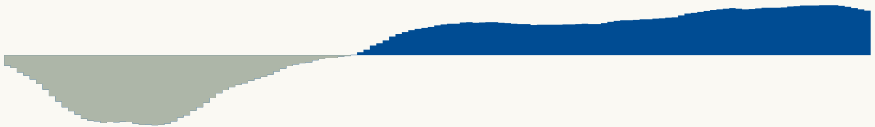
- Normalise with rolling volatility
- Transform each signal via response function
  R(x) ~ $(xe^{-x^2/4})$

- Final CTA mom signal = equal sum of 3 speeds

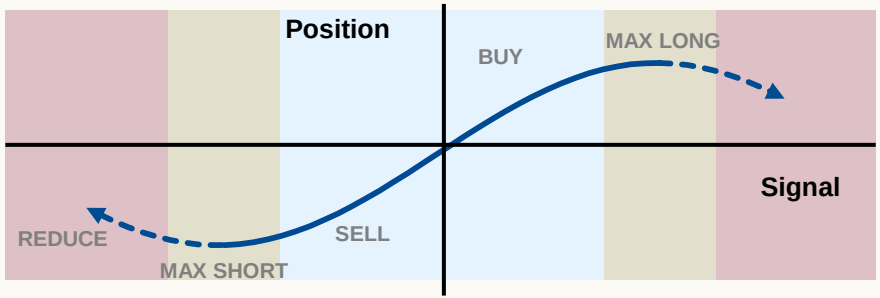
a. Moving average signals



b. Signal = fast - slow



c. Turning signal into position / risk



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Source: «Dissecting investment strategies in the cross section and time series» Baz et al., December 2015.

Factor signal construction - **Value**

The difference between the 'fundamental' price of an asset and current market price

FX

Purchasing Power Parity : CPI ratios

Equity

$Value_t = DividendYield_t$

Commodities

Reversion to the mean: today's price divided by (deflated) historical average

Fixed Income

$Value = S_{10Y,t} - GDP_t$

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Source: "Dissecting investment strategies in the cross section and time series", Baz et al., working paper 2015.

Simulated portfolio construction

Cross-Section

```
For each asset class {
    For each signal {
        rank signal across assets
         >long $1m top 3 assets
         >short $1m bottom 3
}}
Rebalance Daily

(and assume no costs)
```

Time-Series

```
For each asset class {
    For each signal {
        for all n markets
        position = sign(signal)/n
}}
Rebalance Daily

(and assume no costs)
```

In each case, regroup asset classes together scaling each asset class to target 10% volatility

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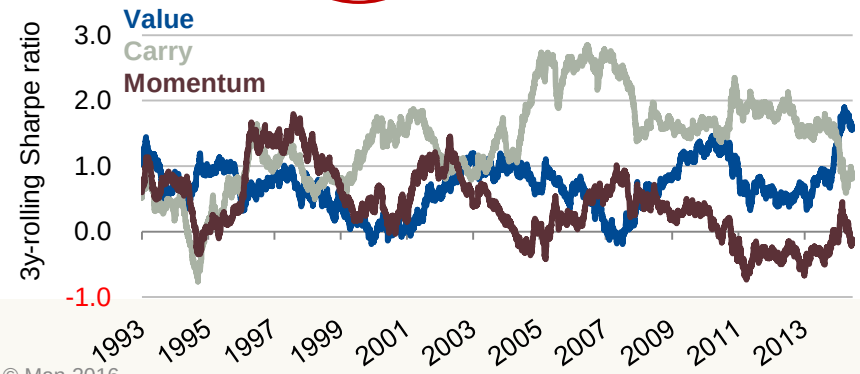
Results: Cross section
Unsurprisingly, factors back-test positively

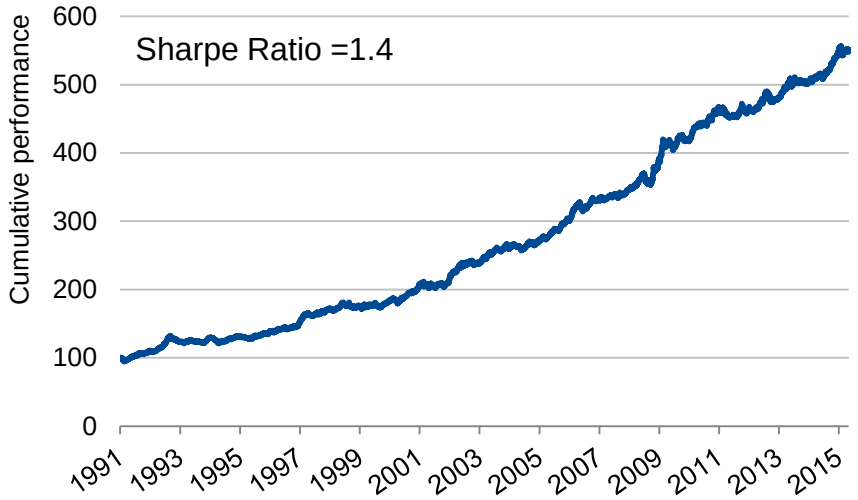
Simulated Sharpe Ratio Jan 1991 – Apr 2015 (no costs)

Individual

	Value	Carry	Mom.	Avg
FX	0.42	0.67	0.74	0.61
EQ	0.39	0.33	0.01	0.24
Commo	0.07	0.77	0.45	0.43
IR	0.56	0.76	-0.31	0.34
Avg	0.36	0.63	0.22	
All Asset	**0.75**	**1.27**	**0.42**	



Combined



- Value seems better than momentum
- But carry seems best!

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Past performance is not indicative of future results.
Sharpe ratio is a measure of risk-adjusted performance that indicates the level of excess return per unit of risk. It is calculated using the risk-free rate in the appropriate currency over the period analysed.

Source: «Dissecting investment strategies in the cross section and time series» Baz et al., December 2015.

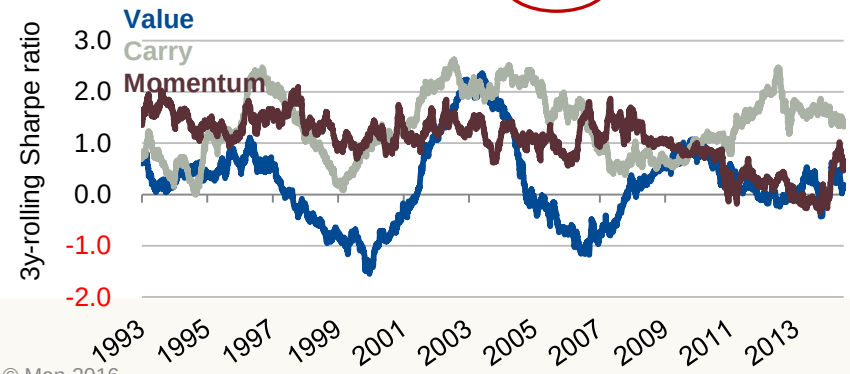
Results: Time series

Again... described factors back test positively. Momentum and Carry > Value

Simulated Sharpe Ratio Jan 1991 – Apr 2015 (no costs)

Individual

	Value	Carry	Mom.	Avg
FX	0.27	0.55	0.72	0.51
EQ	-0.13	0.23	0.41	0.17
Commo	0.22	0.64	0.45	0.44
IR	0.48	0.83	0.77	0.69
Avg	0.21	0.56	0.58	
All Asset	**0.28**	**1.25**	**0.96**	



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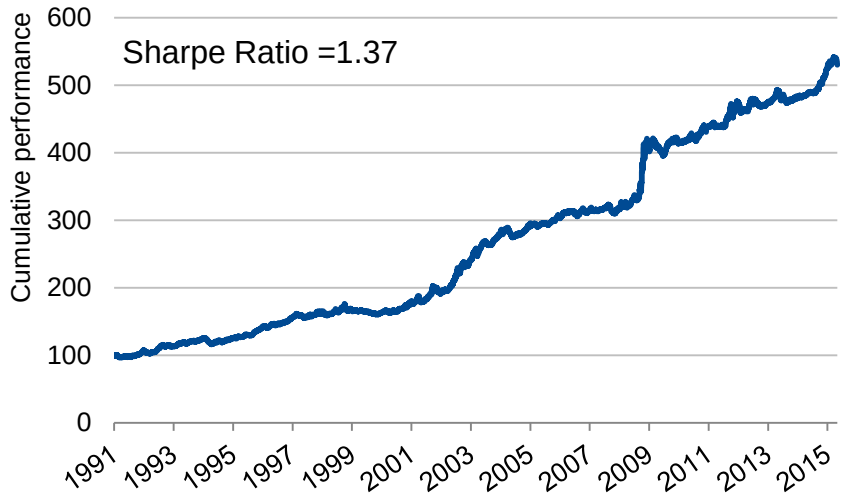

- Momentum now better than value
- Again carry seems best!

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Past performance is not indicative of future results.
Sharpe ratio is a measure of risk-adjusted performance that indicates the level of excess return per unit of risk. It is calculated using the risk-free rate in the appropriate currency over the period analysed.

Source: «Dissecting investment strategies in the cross section and time series» Baz et al., December 2015.

Asset class/factor returns mostly low correlation in cross-section and time-series

Monthly return correlations (cross-section in grey, time-series blue) Jan 1990 – Apr 2015

	V-FX	V-EQ	V-Com	V-IR	C-FX	C-EQ	C-Com	C-IR	M-FX	M-EQ	M-Com	M-IR	V-FX	V-EQ	V-Com	V-IR	C-FX	C-EQ	C-Com	C-IR	M-FX	M-EQ	M-Com	M-IR
V-FX	1																							
V-EQ	(1%)	1																						
V-Com	2%	0%	1																					
V-IR	(3%)	(3%)	(3%)	1																				
C-FX	(10%)	(0%)	(1%)	7%	1																			
C-EQ	0%	(3%)	(0%)	(3%)	(11%)	1																		
C-Com	(1%)	0%	(48%)	1%	(0%)	2%	1																	
C-IR	2%	(1%)	0%	8%	(12%)	2%	(1%)	1																
M-FX	3%	(2%)	(4%)	(1%)	2%	2%	4%	0%	1															
M-EQ	2%	(7%)	1%	(0%)	1%	(3%)	0%	(0%)	3%	1														
M-Com	(1%)	(1%)	(32%)	1%	(1%)	3%	51%	(1%)	4%	(0%)	1													
M-IR	1%	(6%)	0%	15%	(5%)	1%	(0%)	1%	6%	1%	3%	1												
V-FX	62%	(2%)	4%	(7%)	(37%)	4%	(1%)	4%	14%	2%	(0%)	8%	1											
V-EQ	(6%)	9%	1%	(6%)	(9%)	(5%)	(3%)	(2%)	(3%)	9%	(2%)	(6%)	(8%)	1										
V-Com	(1%)	2%	49%	(2%)	3%	(4%)	(29%)	(1%)	(4%)	(1%)	(18%)	(1%)	1%	9%	1									
V-IR	(1%)	1%	0%	56%	8%	(3%)	(0%)	(3%)	(2%)	(0%)	(2%)	3%	(5%)	(7%)	(1%)	1								
C-FX	(30%)	2%	(4%)	9%	69%	(8%)	1%	(8%)	(2%)	(1%)	(0%)	(8%)	(67%)	3%	4%	9%	1							
C-EQ	(8%)	7%	(3%)	(0%)	(13%)	36%	1%	(0%)	3%	11%	3%	1%	(7%)	51%	(4%)	(5%)	1%	1						
C-Com	13%	(5%)	(17%)	(2%)	(19%)	6%	47%	3%	7%	3%	30%	6%	32%	(8%)	(30%)	(1%)	(32%)	0%	1					
C-IR	3%	3%	(1%)	(6%)	(6%)	(2%)	1%	47%	5%	1%	1%	7%	5%	(4%)	(3%)	8%	(3%)	(9%)	4%	1				
M-FX	11%	(0%)	(4%)	(1%)	(7%)	5%	3%	2%	55%	6%	5%	12%	19%	(16%)	(11%)	(1%)	(4%)	6%	9%	3%	1			
M-EQ	2%	0%	(6%)	(1%)	(14%)	0%	6%	4%	19%	21%	6%	16%	17%	(13%)	(9%)	1%	(16%)	19%	14%	11%	30%	1		
M-Com	4%	(3%)	(19%)	2%	(10%)	5%	37%	(1%)	13%	4%	51%	10%	12%	(18%)	(31%)	0%	(12%)	3%	46%	1%	31%	24%	1	
M-IR	1%	(4%)	(1%)	(2%)	(3%)	(1%)	2%	5%	9%	3%	4%	39%	6%	3%	(2%)	(20%)	(3%)	2%	5%	20%	9%	16%	8%	1

- Correlations generally very low
- Exception is between cross-section and time-series formulation for same signals in **FX and Commodities**
- The most heterogeneous asset classes?

- Time-series momentum higher Sharpe than cross-section. Opposite for value signals. **Question: why and how predictably?**

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Source: «Dissecting investment strategies in the cross section and time series» Baz et al., December 2015.

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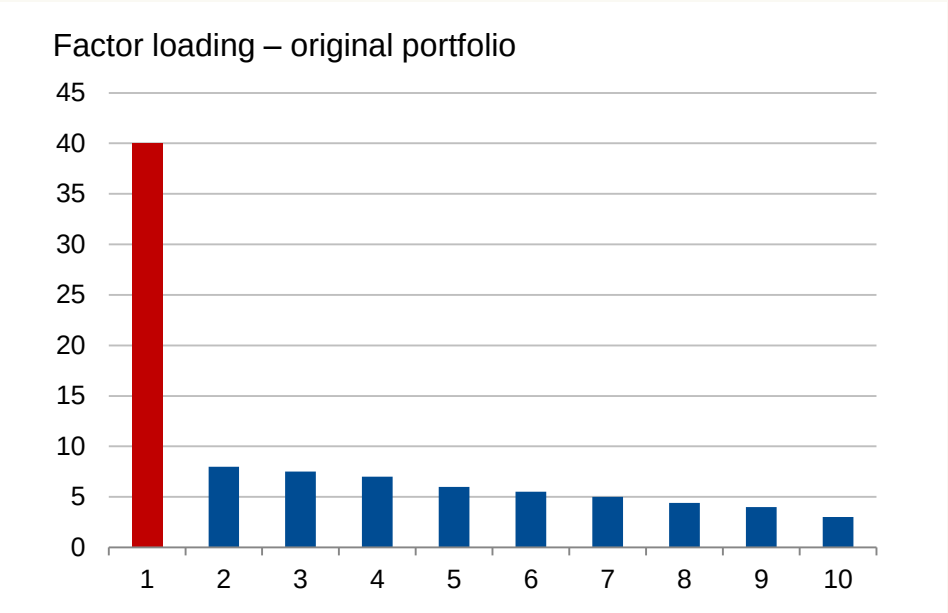
Okay, so what drives the differences?
A stylised explanation



- Consider the portfolio as a series of factors of decreasing importance

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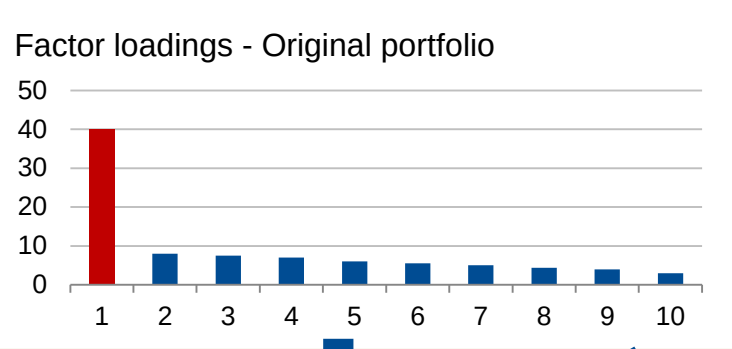
Source: Man Group database.

Okay then, so what drives the differences?



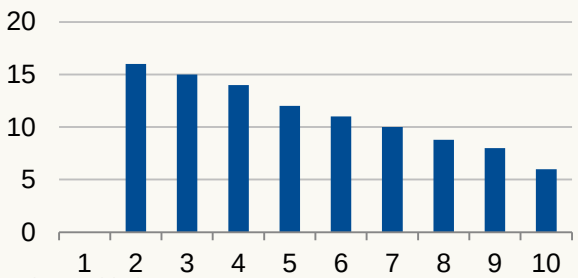
Intuition

If first factor dominates, we can:

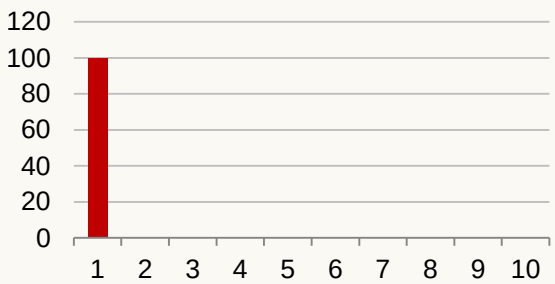
- Hedge out the factor to lever exposure to more factors (cross-section)
- Concentrate loading on first factor only (time-series)
- Mix both approaches

Key is how effective signal is on 1st vs other factors

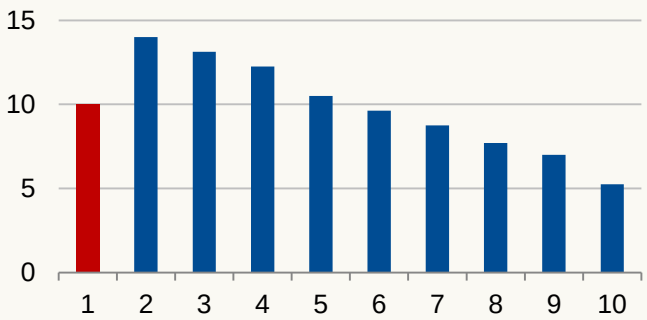
with first factor fully hedged



… with **only** first factor



… or with **partial** hedging



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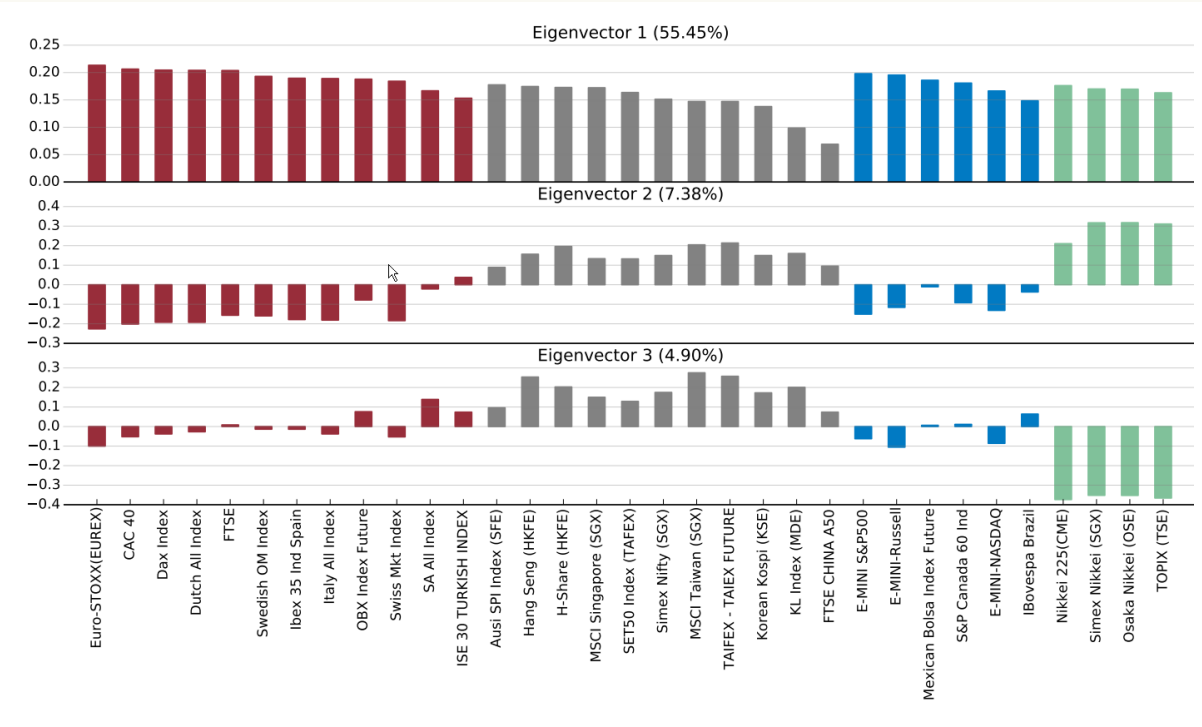
Source: Man Group database.

Evidence in markets - Cross-sections in Equities



- Market factor dominates regional differences. First factor explains ~**56**% of variance
- Secondary and third factors show regional variations, but explain **~5-7**% of market variance

Region Key:
Europe
Asia
Americas
Japan

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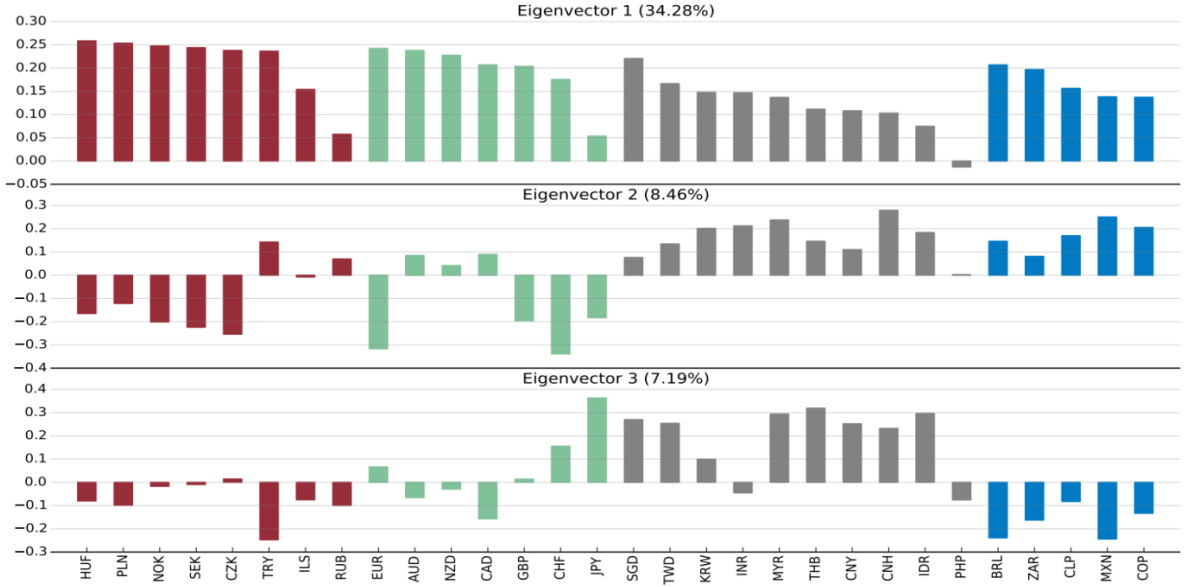
PCA analysis on 5 day overlapping returns 1995-2015.
Source: Man Group database.

Evidence in markets - Cross-sections in Currencies



- Dollar dominates currency market movements. But first factor only explains ~**34**% of fx market variance
- Secondary and third factors show strong regional variations, explaining ~**7-8**% of market variance

Region Key:
EMEA
G10
Asia
LATAM

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PCA analysis on 5 day overlapping returns 1995-2010.
Source: Man Group database.

Modelling the behaviours of markets and signals

Given a simple model for market returns, and signals:

returns: $r_{i,t+1} = \alpha_i X_{i,t} + \beta_i \varepsilon_{i,t+1}$
signals: $\varphi_{i,t} = \gamma_i X_{i,t} + \delta_i \vartheta_{i,t+1}$ - with X, ε, ϑ all iid (0,1)

with $Cov(X_i, X_j) = \theta_{i,j}$
describing the (unobserved) information driving markets and signals.

We can make simplifying assumptions to analyse behaviour.
- equal correlation ρ across markets
- equal correlation ω across signals
- equal correlation θ across information

Then cross-sectional portfolio SR > time-series **iff**

$$\frac{(1-\theta)^2}{(1-\rho)(1-\omega)}[\rho\omega(n-1)+1] > \frac{n}{n-1}$$

And, generalising

	Directional Portfolio	Hedged Portfolio
Mean	$\gamma \sum_{i=1}^{n} \alpha_i$	$\gamma \sum_{i=1}^{n} \alpha_i \left(\frac{(n-1)(1-\theta)}{n}\right)$
Variance	$n[\rho\omega(n-1)+1]$	$(n-1)(1-\rho)(1-\omega)$
Sharpe	$\frac{\gamma \sum_{i=1}^{n} \alpha_i}{\sqrt{n[\rho\omega(n-1)+1]}}$	$\frac{\gamma \sum_{i=1}^{n} \alpha_i \left(\frac{(n-1)(1-\theta}{n}\right)}{\sqrt{(n-1)(1-\rho)(1-\omega)}}$

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Source: Man Group internal research.

Modelling the behaviours of markets and signals

Ratio of SR's of cross-sectional to directional for 10 markets, omega = theta

		omega = theta																			
# mkts -->	10	0	0.05	0.1	0.15	0.2	0.25	0.3	0.35	0.4	0.45	0.5	0.55	0.6	0.65	0.7	0.75	0.8	0.85	0.9	0.95
	0	0.95	0.92	0.90	0.87	0.85	0.82	0.79	0.76	0.73	0.70	0.67	0.64	0.60	0.56	0.52	0.47	0.42	0.37	0.30	0.21
	0.05	0.97	0.96	0.94	0.93	0.91	0.89	0.87	0.84	0.82	0.79	0.76	0.73	0.69	0.65	0.61	0.56	0.51	0.44	0.36	0.26
rho	0.1	1.00	1.00	0.99	0.98	0.97	0.96	0.94	0.92	0.90	0.88	0.85	0.82	0.78	0.74	0.70	0.65	0.59	0.51	0.43	0.30
	0.15	1.03	1.04	1.04	1.04	1.04	1.03	1.02	1.01	0.99	0.97	0.94	0.91	0.88	0.83	0.79	0.73	0.66	0.58	0.48	0.35
	0.2	1.06	1.08	1.09	1.10	1.11	1.11	1.10	1.09	1.08	1.06	1.03	1.00	0.97	0.92	0.87	0.81	0.74	0.65	0.54	0.39
	0.25	1.10	1.13	1.15	1.17	1.18	1.19	1.19	1.18	1.17	1.15	1.13	1.10	1.06	1.02	0.96	0.90	0.82	0.72	0.60	0.43
	0.3	1.13	1.18	1.21	1.24	1.26	1.27	1.28	1.27	1.27	1.25	1.23	1.20	1.16	1.11	1.06	0.99	0.90	0.80	0.66	0.48
	0.35	1.18	1.23	1.28	1.32	1.34	1.36	1.37	1.38	1.37	1.36	1.34	1.30	1.27	1.22	1.15	1.08	0.99	0.87	0.73	0.53
	0.4	1.22	1.30	1.35	1.40	1.44	1.46	1.48	1.48	1.48	1.47	1.45	1.42	1.38	1.32	1.26	1.18	1.08	0.96	0.80	0.58
	0.45	1.28	1.37	1.44	1.50	1.54	1.57	1.59	1.60	1.60	1.59	1.57	1.54	1.50	1.44	1.37	1.29	1.18	1.04	0.87	0.63
	0.5	1.34	1.45	1.53	1.60	1.65	1.69	1.72	1.74	1.74	1.73	1.71	1.68	1.63	1.57	1.50	1.40	1.29	1.14	0.95	0.69
	0.55	1.41	1.54	1.64	1.72	1.78	1.83	1.87	1.88	1.89	1.88	1.86	1.83	1.78	1.72	1.64	1.54	1.41	1.25	1.04	0.76
	0.6	1.50	1.65	1.77	1.86	1.93	1.99	2.03	2.06	2.07	2.06	2.04	2.00	1.95	1.88	1.80	1.69	1.55	1.37	1.15	0.83
	0.65	1.60	1.78	1.92	2.03	2.11	2.18	2.23	2.26	2.27	2.27	2.25	2.21	2.15	2.08	1.98	1.86	1.71	1.52	1.27	0.92
	0.7	1.73	1.94	2.10	2.23	2.33	2.41	2.46	2.50	2.52	2.52	2.49	2.46	2.39	2.31	2.21	2.07	1.90	1.69	1.41	1.02
	0.75	1.90	2.14	2.33	2.48	2.60	2.69	2.76	2.81	2.83	2.83	2.81	2.76	2.70	2.61	2.49	2.34	2.15	1.91	1.60	1.16
	0.8	2.12	2.41	2.64	2.82	2.96	3.07	3.15	3.21	3.24	3.24	3.22	3.17	3.09	2.99	2.86	2.68	2.47	2.19	1.83	1.33
	0.85	2.45	2.81	3.09	3.31	3.48	3.62	3.72	3.79	3.82	3.83	3.80	3.75	3.66	3.54	3.38	3.18	2.92	2.60	2.18	1.57
	0.9	3.00	3.47	3.83	4.12	4.34	4.52	4.65	4.74	4.78	4.80	4.77	4.70	4.59	4.44	4.24	3.99	3.67	3.26	2.73	1.98
	0.95	4.24	4.94	5.48	5.91	6.25	6.51	6.70	6.83	6.91	6.93	6.89	6.80	6.64	6.43	6.14	5.78	5.31	4.72	3.96	2.87

High market breadth (low correlation) and correlated signals => time-series best

Low market breadth (high correlation) => cross-section best

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Sharpe ratio is a measure of risk-adjusted performance that indicates the level of excess return per unit of risk.
Source: Man Group internal research.

Potential cost of high correlation in cross-sectional trading

Leverage requirements increase quickly with assets

		Correlation									
		0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
Number of assets	2	1.4	1.6	1.8	2.1	2.5	3.2	4.1	5.8	9.1	19.0
	3	1.2	1.4	1.6	1.9	2.3	3.0	4.0	5.7	9.2	19.8
	4	1.2	1.3	1.5	1.9	2.3	3.1	4.2	6.0	9.9	21.4
	5	1.1	1.3	1.5	1.9	2.4	3.2	4.4	6.4	10.5	23.0
	7	1.1	1.2	1.5	1.9	2.5	3.4	4.8	7.1	11.9	26.1
	10	1.1	1.2	1.5	2.0	2.7	3.8	5.4	8.2	13.7	30.3
	15	1.0	1.2	1.6	2.2	3.1	4.4	6.4	9.7	16.3	36.4
	20	1.0	1.2	1.7	2.4	3.4	4.9	7.2	11.0	18.6	41.5
	30	1.0	1.3	1.9	2.8	4.0	5.8	8.6	13.2	22.5	50.3
	50	1.0	1.4	2.2	3.4	5.0	7.4	10.9	16.8	28.7	64.4
	100	1.0	1.6	2.8	4.5	6.9	10.2	15.2	23.6	40.3	90.6

Cross-sectional trading across highly correlated assets can require growing leverage to achieve target volatility

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Sharpe ratio is a measure of risk-adjusted performance that indicates the level of excess return per unit of risk.
Source: Man Group internal research.

Modelling the behaviours of markets and signals

And the empirical evidence?

EMPIRICAL RESULTS	Carry	Mom	Value
Time Series Sharpe	0.56	0.80	0.28
Cross Sectional Sharpe	0.67	0.38	0.45
XS / TS Sharpe	1.20	0.48	1.60
Avg. Asset Sharpe	0.21	0.30	0.07
Avg. Sharpe using wrong signal	0.09	0.22	-0.01
Ratio (Theta)	0.41	0.74	-0.18
Rho (asset correlation)	**0.25**	**0.25**	**0.25**
Omega (signal correlation)	**0.20**	**0.44**	**0.39**
Number of assets (per asset class)	**21.50**	**21.50**	**21.50**
MODEL IMPLIED RESULTS			
Implied Theta	0.33	0.83	0.37
Implied Ratio (XS / TS)	**1.06**	**0.72**	**2.99**

- We can estimate values for rho and omega from markets and signals.
- Applying prior assumptions, the model implies a value of theta (information correlation)
- Based on observed data, model correctly suggests momentum better traded in time-series, value in cross-section.
- Possible to infer also an ‘optimal’ weight to both portfolio styles.

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Source: Man Group internal research.

1. Carry, Value and Momentum almost Everywhere
2. Signal constructions
3. Performance analysis and results
4. Cross-section versus time-series behaviours
5. **Conclusion**

Conclusion

- Carry, Value and Momentum have been written about and traded for many years
- Time-series (CTAs) and cross-sectional (traditional quant equity strategies) choices often seem **ideological**
- Modelling the relationships between the signals themselves and the assets they trade on yields insights into which *ought* to fare better

- Historical preferences appear somewhat justified, but ideological indifference is better

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