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

> 1,000,000 copies sold

VS

2,931 copies sold

Source: Amazon and Wiley.
Academic articles on value appear to outnumber those on momentum.

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

<table>
<thead>
<tr>
<th>Articles search</th>
<th>Count</th>
</tr>
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<tr>
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<tr>
<td>Momentum</td>
<td>417</td>
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</table>

Source: Journal of Finance website.
The three factor world
… or the absolute building blocks of investing

**Value**
Slow dissemination of fundamentals

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

**Carry**
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
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
1. Carry, Value and Momentum almost Everywhere

2. **Signal constructions**

3. Performance analysis and results

4. Cross-section versus time-series behaviours

5. Conclusion
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
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-FTSEMI, 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

Factor signal construction - **Carry**
What forward positions earn if spot prices don’t change

**FX**

Use 3 month FX-forward to imply the carry

\[ \text{Carry}_t = 4 \times (\text{Spot}_t / \text{Fwd}_{3M,t} - 1) \]

**Equity**

Use first two futures of each index

\[ \text{Carry}_t = 1/(T_2-T_1) \times (\text{Fut}_{t,T_2} - \text{Fut}_{t,T_1}) / \text{Fut}_{t,T_2} \]

**Commodities**

To avoid seasonality, use futures 1 year apart

\[ \text{Carry}_t = (\text{Fut}_{t,T+1} - \text{Fut}_{t,T}) / \text{Fut}_{t,T+1} \]

**Fixed Income**

Carry = "carry + roll down".

\[ \text{Carry}_t = (S_{10Y,t} - \text{Fixing}_t) / \text{Duration}_t + (S_{10Y,t} - S_{7Y,t}) / 3 = \text{Carry} = \text{Roll} \]

Source: «Dissecting investment strategies in the cross section and time series» Baz et al., December 2015.
Factor signal construction - \textbf{Momentum}

Persistence of behaviour in returns

\textbf{CTA standard construction}

- 3 different time-horizons (\(S_k, L_k\)) = Short, Long lookbacks
- Calculate 3 different EWMA differences:
  \[ x_k = \text{ewma}(P, S_k) - \text{ewma}(P, L_k) \]
- Normalise with rolling volatility
- Transform each signal via response function
  \[ R(x) \sim (xe^{-x^2/4}) \]
- Final CTA mom signal = equal sum of 3 speeds

\textbf{a. Moving average signals}

\begin{align*}
\text{Price} & \quad \text{Slow Average} \\
\text{Fast Average} & \\
\end{align*}

\textbf{b. Signal = fast - slow}

\textbf{c. Turning signal into position / risk}

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

---

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
1. Carry, Value and Momentum almost Everywhere
2. Signal constructions
3. **Performance analysis and results**
4. Cross-section versus time-series behaviours
5. Conclusion
Results: Cross section
Unsurprisingly, factors back-test positively

<table>
<thead>
<tr>
<th>Individual</th>
<th>Value</th>
<th>Carry</th>
<th>Mom.</th>
<th>Avg</th>
</tr>
</thead>
<tbody>
<tr>
<td>FX</td>
<td>0.42</td>
<td>0.67</td>
<td>0.74</td>
<td>0.61</td>
</tr>
<tr>
<td>EQ</td>
<td>0.39</td>
<td>0.33</td>
<td>0.01</td>
<td>0.24</td>
</tr>
<tr>
<td>Commo</td>
<td>0.07</td>
<td>0.77</td>
<td>0.45</td>
<td>0.43</td>
</tr>
<tr>
<td>IR</td>
<td>0.56</td>
<td>0.76</td>
<td>-0.31</td>
<td>0.34</td>
</tr>
</tbody>
</table>

| All Asset           | 0.75  | 1.27  | 0.42 |

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

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

Sharpe Ratio = 1.4

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)

<table>
<thead>
<tr>
<th>Individual</th>
<th>Value</th>
<th>Carry</th>
<th>Mom.</th>
<th>Avg</th>
</tr>
</thead>
<tbody>
<tr>
<td>FX</td>
<td>0.27</td>
<td>0.55</td>
<td>0.72</td>
<td>0.51</td>
</tr>
<tr>
<td>EQ</td>
<td>-0.13</td>
<td>0.23</td>
<td>0.41</td>
<td>0.17</td>
</tr>
<tr>
<td>Commo</td>
<td>0.22</td>
<td>0.64</td>
<td>0.45</td>
<td>0.44</td>
</tr>
<tr>
<td>IR</td>
<td>0.48</td>
<td>0.83</td>
<td>0.77</td>
<td>0.69</td>
</tr>
<tr>
<td>Avg</td>
<td>0.21</td>
<td>0.56</td>
<td>0.58</td>
<td></td>
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<tr>
<td>All Asset</td>
<td>0.28</td>
<td>1.25</td>
<td>0.96</td>
<td></td>
</tr>
</tbody>
</table>

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

Sharpe Ratio = 1.37

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

<table>
<thead>
<tr>
<th>V-FX</th>
<th>V-EQ</th>
<th>V-Com</th>
<th>V-IR</th>
<th>C-FX</th>
<th>C-EQ</th>
<th>C-Com</th>
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<th>M-FX</th>
<th>M-EQ</th>
<th>M-Com</th>
<th>M-IR</th>
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<td>1</td>
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<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

- 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.
1. Carry, Value and Momentum almost Everywhere
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Okay, so what drives the differences?
A stylised explanation

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

**Factor loadings - Original portfolio**

- With first factor fully hedged
- … with only first factor
- … or with partial hedging

---

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**

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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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 \( X, \varepsilon, \vartheta \) all iid \((0,1)\)

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

We can make simplifying assumptions to analyse behaviour.
- equal correlation \( \rho \) across markets
- equal correlation \( \omega \) across signals
- equal correlation \( \theta \) across information

Then cross-sectional portfolio \( SR > \text{time-series} \) iff

\[
\frac{(1-\theta)^2}{(1-\rho)(1-\omega)} \left[ \rho \omega (n-1) + 1 \right] > \frac{n}{n-1}
\]
Modelling the behaviours of markets and signals

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

<table>
<thead>
<tr>
<th># mkts --&gt;</th>
<th>omega = theta</th>
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<tr>
<td>0</td>
<td>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</td>
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<tr>
<td>0.15</td>
<td>1.03 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</td>
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<tr>
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<td>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</td>
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<tr>
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<td>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</td>
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</tr>
<tr>
<td>0.55</td>
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</tr>
<tr>
<td>0.6</td>
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</tr>
<tr>
<td>0.65</td>
<td>1.60 1.78 1.92 2.03 2.11 2.18 2.23 2.26 2.27 2.26 2.25 2.21 2.15 2.10 1.98 1.86 1.71 1.52 1.27</td>
</tr>
<tr>
<td>0.7</td>
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</tr>
<tr>
<td>0.95</td>
<td>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</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
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<th>Number of assets</th>
<th>Correlation</th>
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</tr>
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</tr>
<tr>
<td>3</td>
<td>1.2</td>
</tr>
<tr>
<td>4</td>
<td>1.2</td>
</tr>
<tr>
<td>5</td>
<td>1.1</td>
</tr>
<tr>
<td>7</td>
<td>1.1</td>
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<tr>
<td>10</td>
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<tr>
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<td>1.0</td>
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<tr>
<td>50</td>
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<tr>
<td>100</td>
<td>1.0</td>
</tr>
</tbody>
</table>

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

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?

<table>
<thead>
<tr>
<th>EMPIRICAL RESULTS</th>
<th>Carry</th>
<th>Mom</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time Series Sharpe</td>
<td>0.56</td>
<td>0.80</td>
<td>0.28</td>
</tr>
<tr>
<td>Cross Sectional Sharpe</td>
<td>0.67</td>
<td>0.38</td>
<td>0.45</td>
</tr>
<tr>
<td>XS / TS Sharpe</td>
<td>1.20</td>
<td>0.48</td>
<td>1.60</td>
</tr>
<tr>
<td>Avg. Asset Sharpe</td>
<td>0.21</td>
<td>0.30</td>
<td>0.07</td>
</tr>
<tr>
<td>Avg. Sharpe using wrong signal</td>
<td>0.09</td>
<td>0.22</td>
<td>-0.01</td>
</tr>
<tr>
<td>Ratio (Theta)</td>
<td>0.41</td>
<td>0.74</td>
<td>-0.18</td>
</tr>
<tr>
<td>Rho (asset correlation)</td>
<td>0.25</td>
<td>0.25</td>
<td>0.25</td>
</tr>
<tr>
<td>Omega (signal correlation)</td>
<td>0.20</td>
<td>0.44</td>
<td>0.39</td>
</tr>
<tr>
<td>Number of assets (per asset class)</td>
<td>21.50</td>
<td>21.50</td>
<td>21.50</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>MODEL IMPLIED RESULTS</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Implied Theta</td>
<td>0.33</td>
<td>0.83</td>
<td>0.37</td>
</tr>
<tr>
<td>Implied Ratio (XS / TS)</td>
<td>1.06</td>
<td>0.72</td>
<td>2.99</td>
</tr>
</tbody>
</table>

- 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.

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
- 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