



April 26, 2022

Global Quantitative Research

Macro, Factor, Crowding, Machine Learning and ESG

Research for Xinhong

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See Appendix A-1 for Analyst Certification, Important Disclosures and Research Analyst Affiliations

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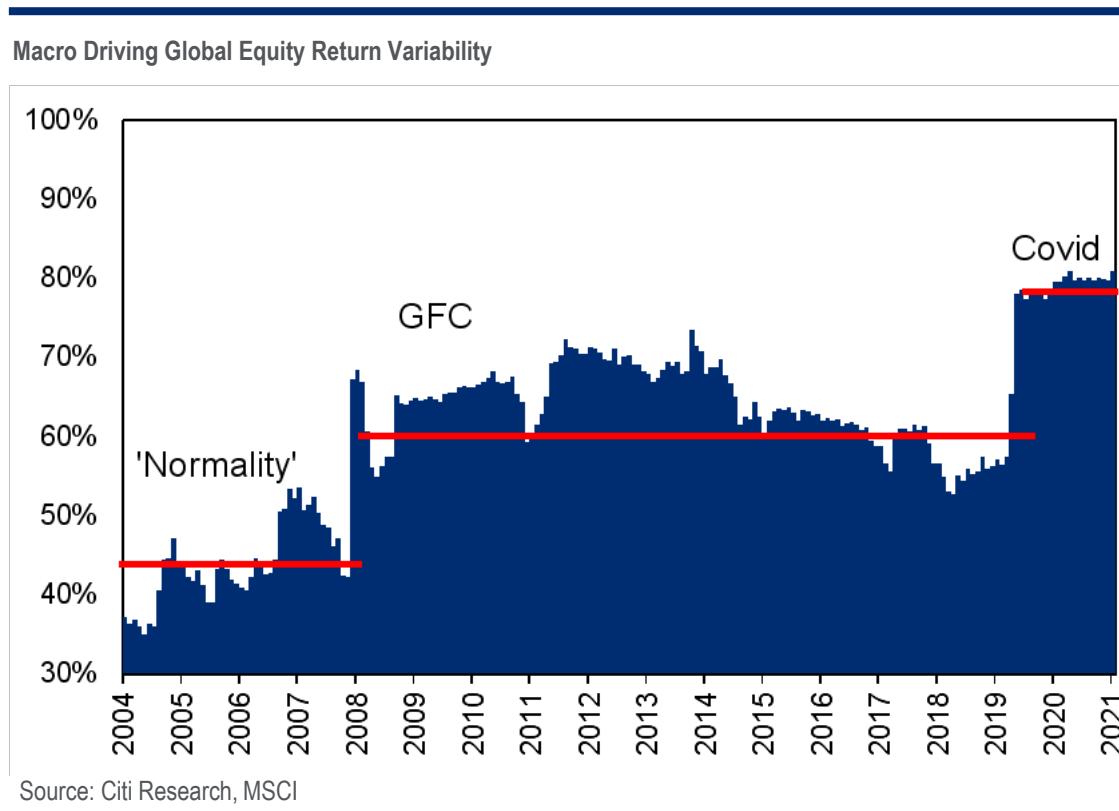
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1. Quantitative Insights

Global Quantitative Insights

Macro Driving Stock Return Variability

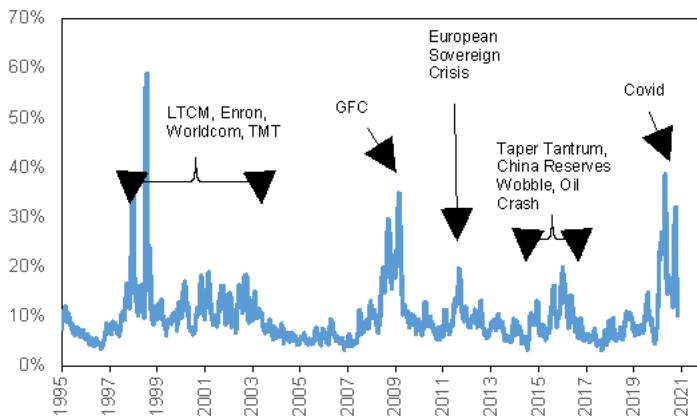
- Macro factors are driving equity market variability to a “record” level. This chart shows the percentage of stock market return variability coming from macro factors.



Global Quantitative Insights

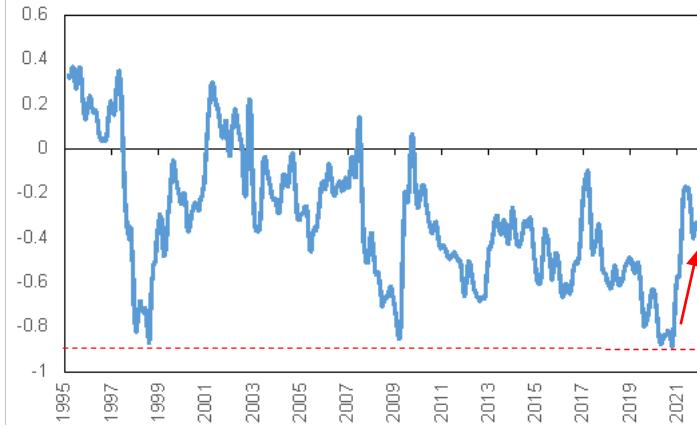
Macro Polarizing Style Performance

Global Style Volatility Is at Historical Highs



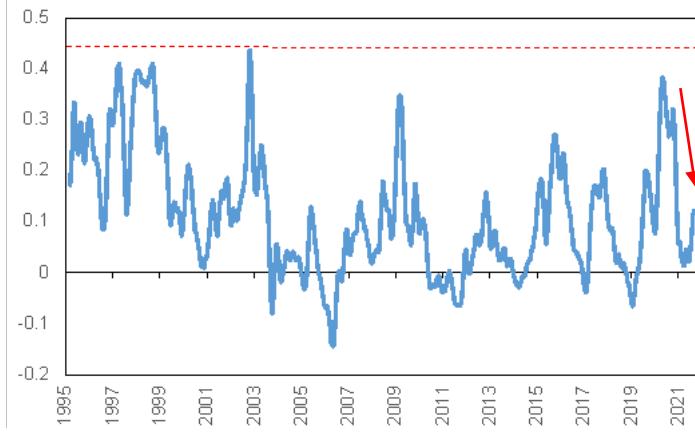
Source: Citi Research, MSCI

Value's Correlation to Other Styles Has Increased



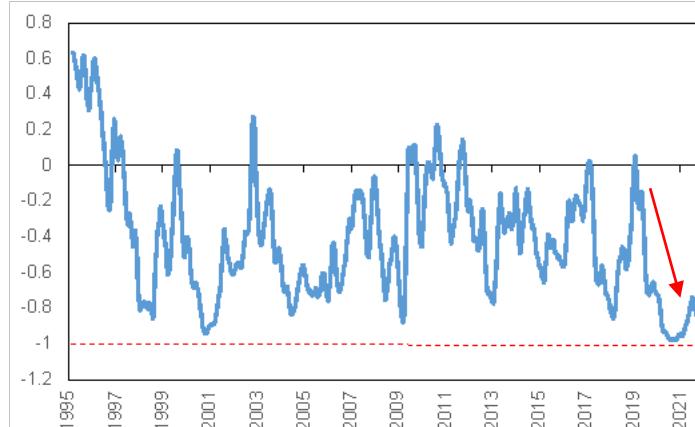
Source: Citi Research, MSCI

Style Return Correlation Has Fallen



Source: Citi Research, MSCI

Correlation of Value and Growth Is at Historical Low

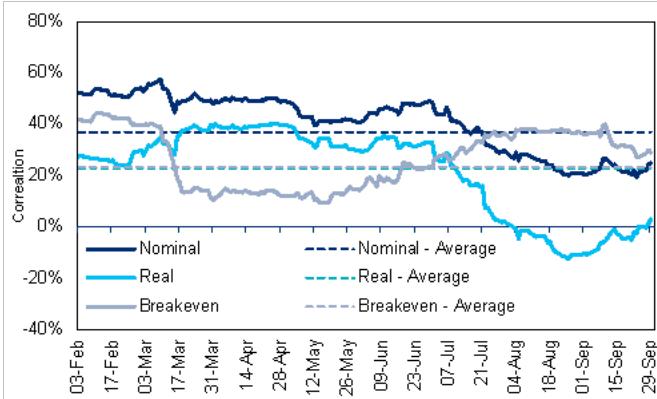


Source: Citi Research, MSCI

Global Quantitative Insights

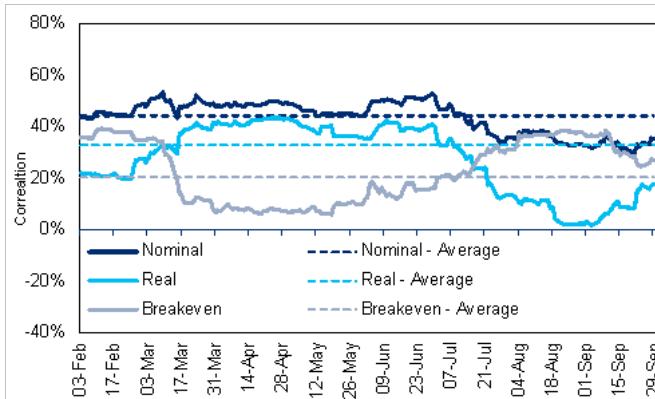
The Relationship of Style Performance to Changes in Interest Rates

90-Day Rolling Correlation – Global Value



Source: Citi Research, MSCI, DataStream

90-Day Rolling Correlation – Global Growth



Source: Citi Research, MSCI, DataStream

U.S. Factor Performance Trend

- Factor rotation has evolved from Value versus Defensive Low Vol (Low Beta) in early 2020 to Value (Cyclicals) versus Growth (Non-Cyclical / Secular Growth) versus Low Vol (Defensive).
- Vaccine news served as the key catalyst for the strong Value rebound started in late 2020. Growth began to recover since the first inflation surprise in May as the 10yr yield started to drop and the yield curve flattened and became more volatile. Value rallied strongly in early 2022 largely due to rising interest rates. Performance of Price Momentum has improved significantly since early 2022.

Factor Performance and Volatility (through 4/22/22)



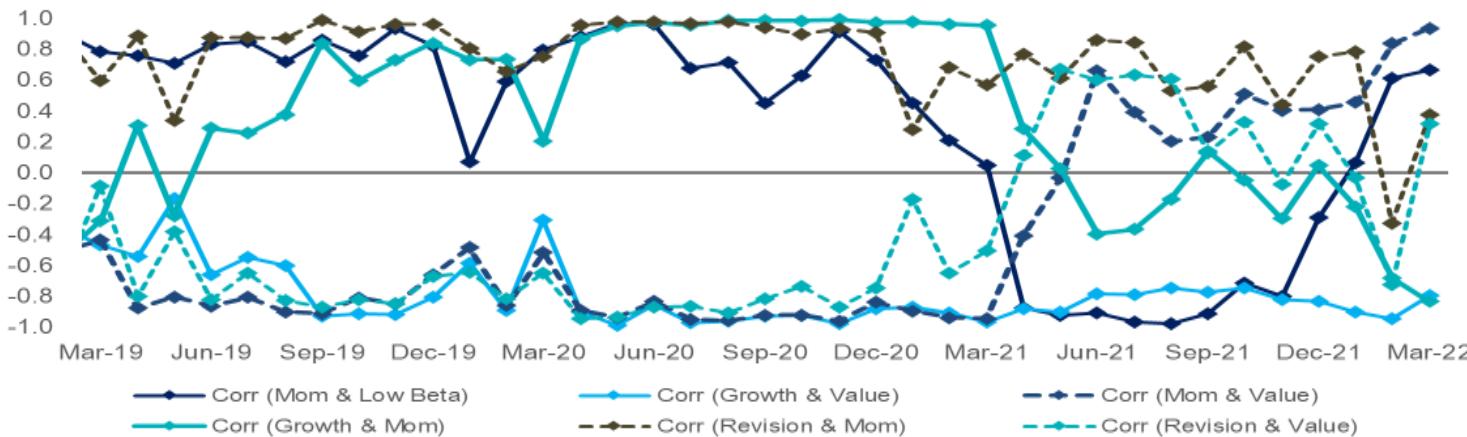
	S&P 500	Value	Quality	Revision	Growth	Momentum	Low Beta
Return (Jan - Mar 2020 - %)	-20.00	-30.03	0.94	14.32	17.11	24.08	23.08
Return (Apr - Jun 2020 - %)	19.95	-5.55	14.40	-14.41	4.23	-14.84	-26.41
Return (Jul - Oct 2020 - %)	5.47	-6.05	-1.99	2.21	4.89	5.47	-3.48
Return (Nov - May 2021 - %)	28.57	31.45	2.44	0.96	-26.15	-25.08	-45.10
Return (Jun - Oct 2021 - %)	9.54	-9.99	5.27	6.05	11.41	1.34	3.19
Return (Nov - Dec 2021 - %)	3.49	13.33	-2.84	6.02	-3.61	1.64	4.49
Return (Jan 2022 - %)	-5.26	15.50	-2.38	-1.04	-10.00	-0.43	-1.28
Return (Feb 2022 - %)	-3.14	2.76	0.43	-0.63	-0.66	3.18	-2.84
Return (Mar 2022 - %)	3.58	-0.16	4.30	0.56	-2.43	3.51	5.13
Return (Apr 2022 - %)	-5.71	8.12	-3.81	1.90	-4.88	6.57	6.33
Vol Jan20 - Mar20 (Daily - Annualized)	55.61	17.74	13.32	9.28	11.95	16.54	29.32
Vol Apr20 - Jun20 (Daily - Annualized)	31.38	50.00	16.98	48.75	43.58	67.02	49.80
Vol Jul20 - Oct20 (Daily - Annualized)	17.75	32.12	10.98	19.02	26.83	34.63	18.25
Vol Nov20 - May21 (Daily - Annualized)	13.80	31.44	11.76	16.39	31.91	41.30	22.75
Vol Jun21 - Oct21 (Daily - Annualized)	10.58	19.78	8.12	8.17	12.55	15.38	18.49
Vol Nov21 - Dec21 (Daily - Annualized)	14.78	24.34	10.95	9.58	14.94	15.48	18.44
Vol Jan22 (Daily - Annualized)	18.27	30.13	13.87	8.42	21.19	15.10	17.39
Vol Feb22 (Daily - Annualized)	21.95	34.15	15.14	9.29	22.41	20.50	21.01
Vol Mar22 (Daily - Annualized)	19.01	22.17	9.67	14.31	18.89	25.29	20.25
Vol Apr (Daily - Annualized)	18.15	26.68	12.00	9.29	18.12	23.06	22.94

Source: Citi Research, S&P, FTSE Russell

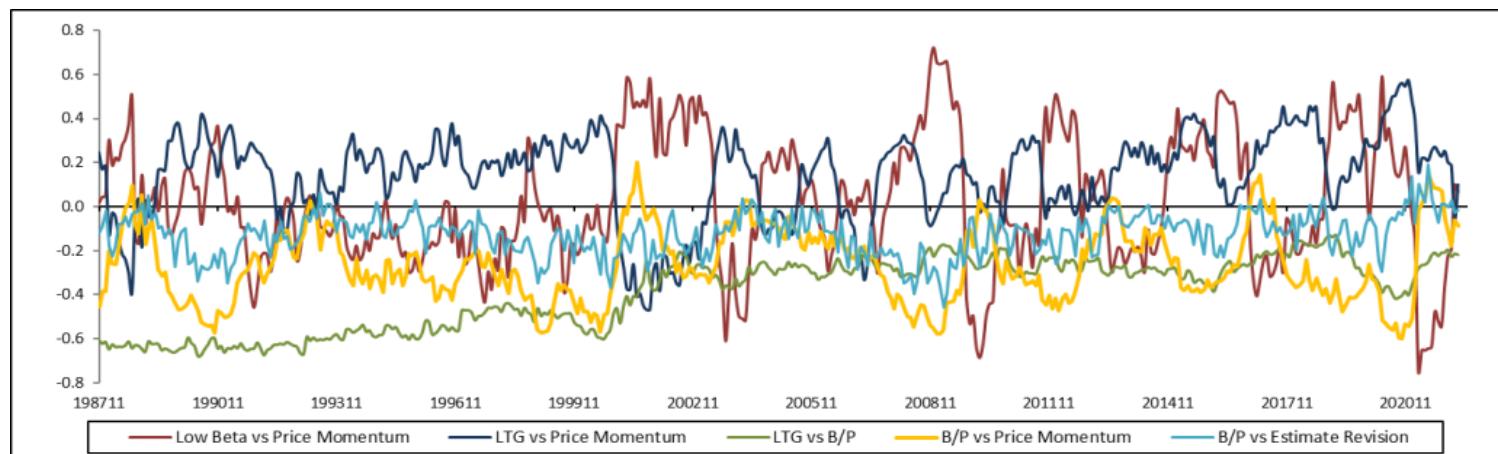
Factor Correlation

- High correlation among Price Momentum, Growth, Earnings Revision and Low Beta has reversed back to normal recently. Price Momentum and Revision remain more positively correlated.
- The key factor rotation has remained mostly Value versus Growth in last few months, largely due to their macro exposures.

Factor Return Correlation



Factor Rank Correlation

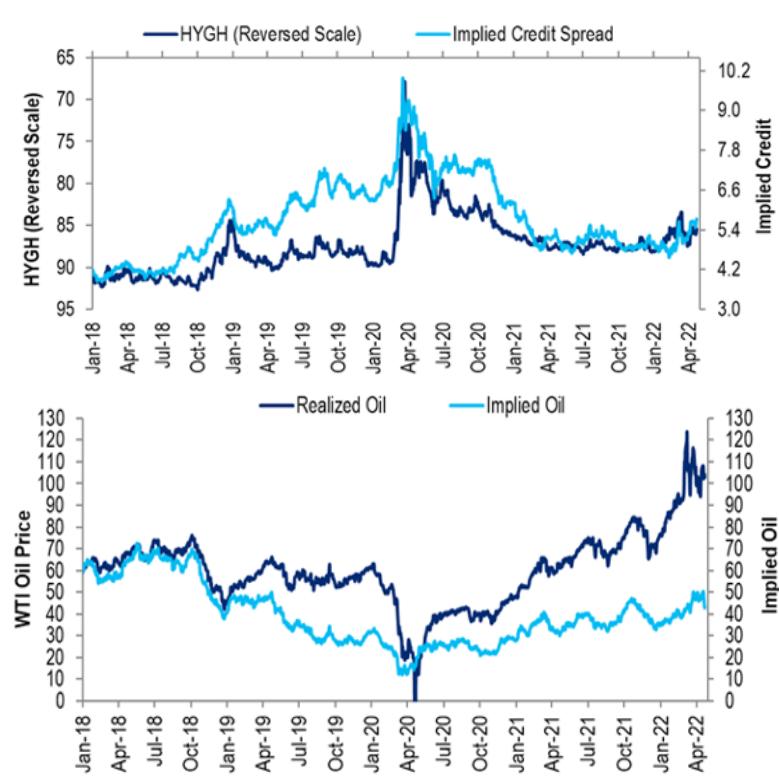
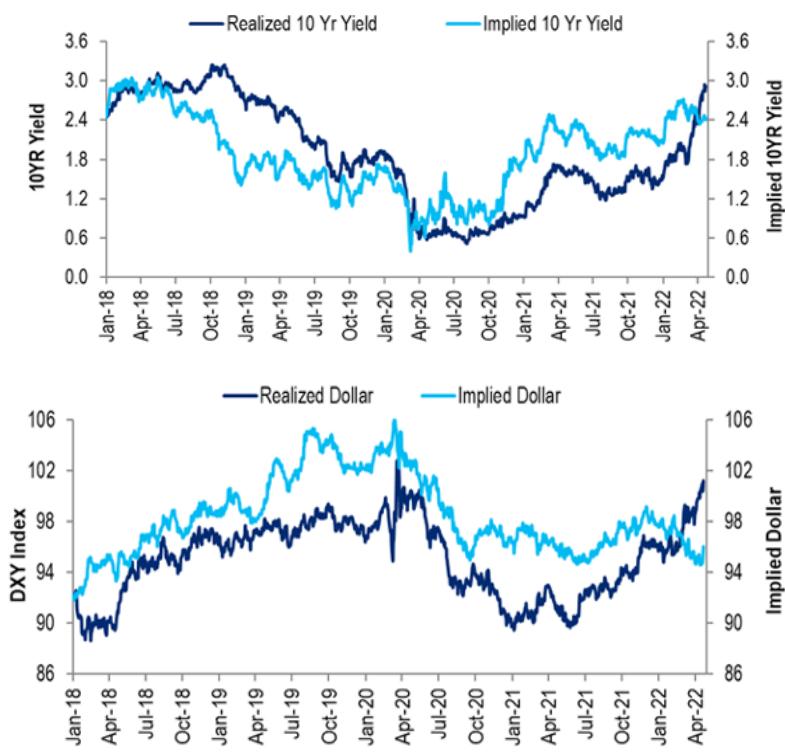


Source: Citi Research, FT Russell, Standard & Poor's

Equity Implied Macro Factors

- Since November 2021, the US equity market has led the bond and currency markets on the reflation trade.
- Recent divergence between implied and realized factors for 10-yr yield, US dollar and Oil suggests that the equity market is not pricing in rising long-term interest rates, high oil prices and a stronger dollar.
- The U.S. equity market tends to price in the oil shocks and current geopolitical risk through inflation and economic growth lens. Lower implied oil prices also reflect concerns over international, particularly EM economic growth.

Implied Macro vs. Underlying Macro Factor

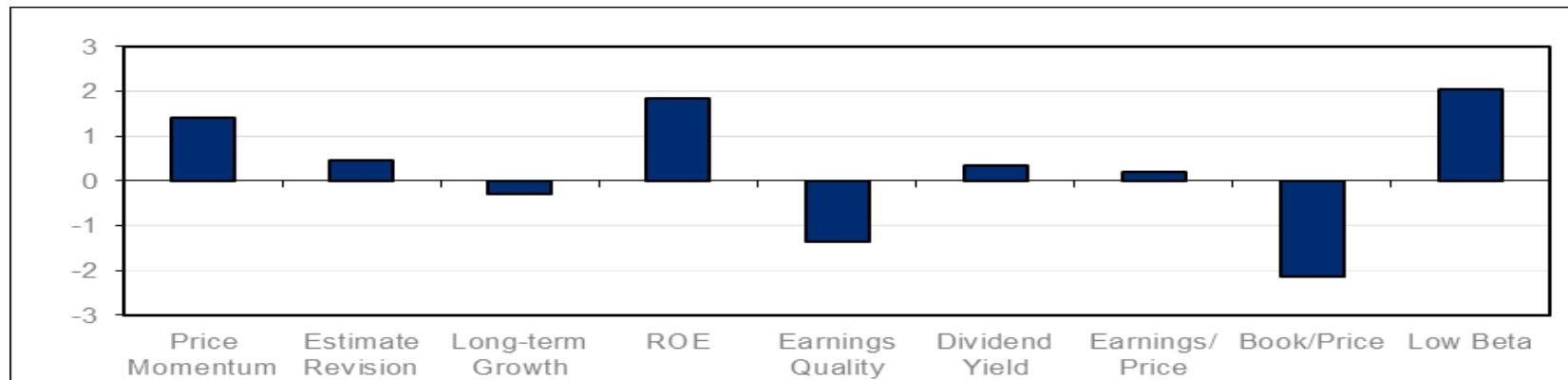


Source: Citi Research

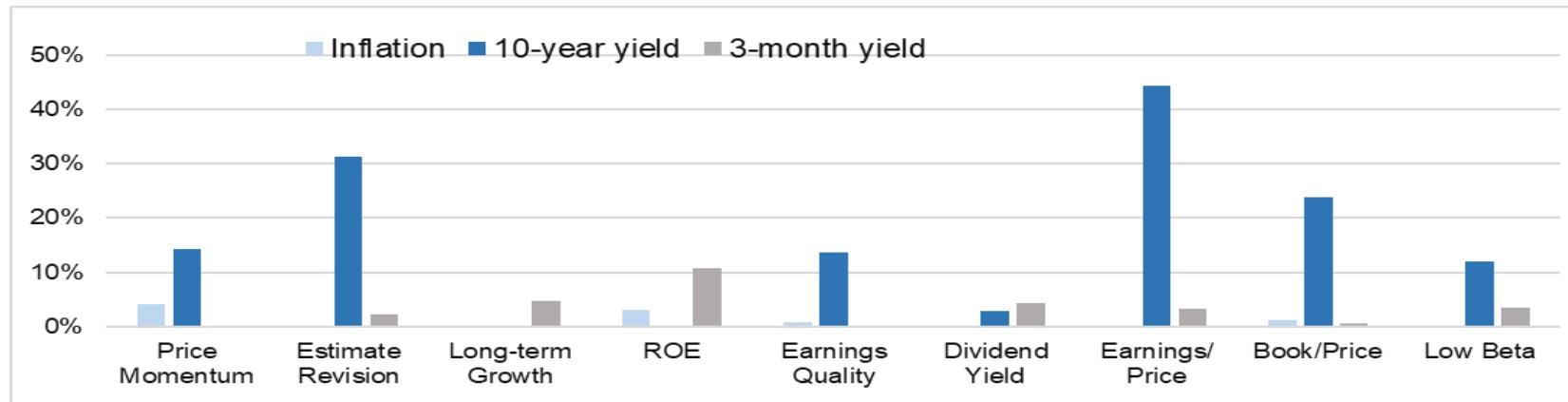
Impact of Rising Inflation on Factors

- Deep value Book / Price and Earnings Quality are likely to suffer the most from rising inflation, while defensive Low Beta and ROE may benefit the most.
- Inflation's contribution to total risk is currently below 10% for major factors, well dwarfed by their exposures to long-term interest rates. We suggest that investors take both into consideration in assessing overall risk of stocks and factors.

Factor Exposure to Rising Inflation



Risk Contribution of Inflation and Interest rates

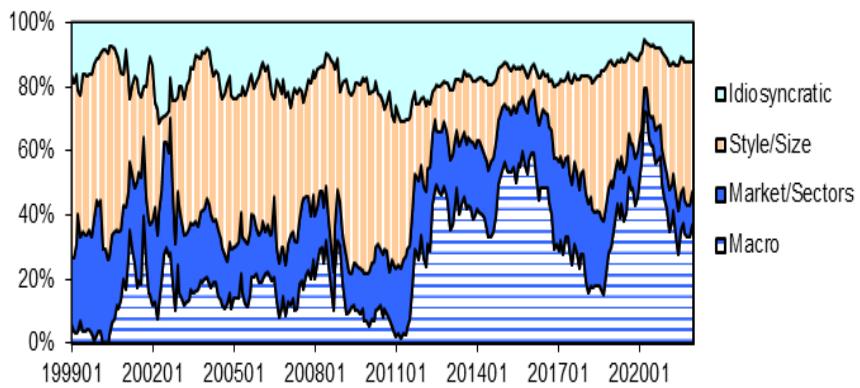


Source: Citi Research

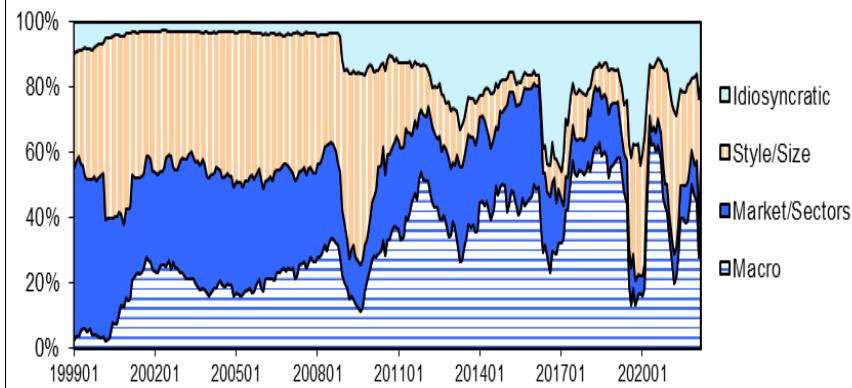
Macro Risk in Major Factors

- Macro risk has dropped significantly in Earnings Revision and Price Momentum, which bodes well for their future performance.
- Long-term interest rates remain the key macro driver for Value.
- Growth has minimal exposure to 10-yr yields, but has a negative exposure to rising short-term interest rates.

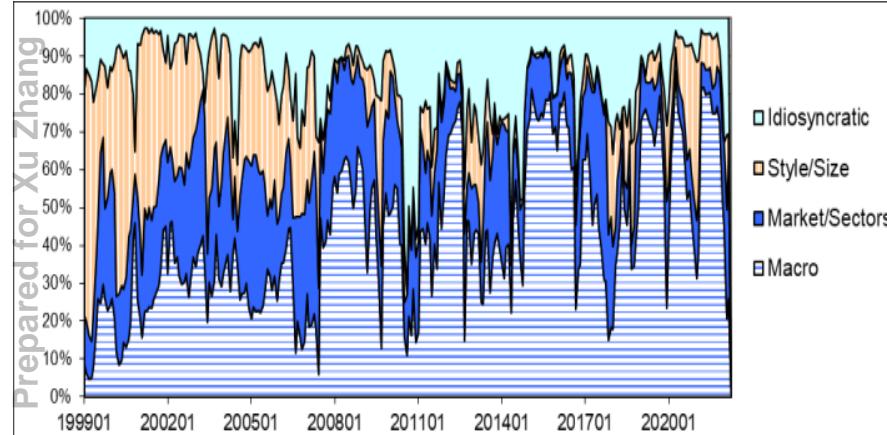
Risk Decomposition of Value (P/B)



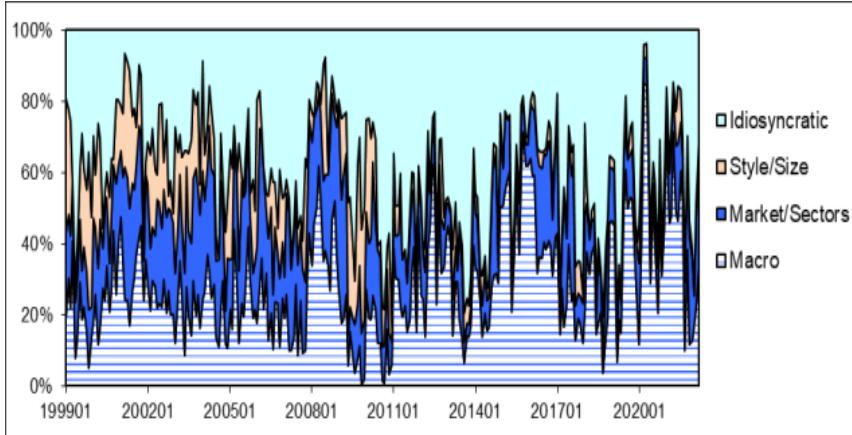
Risk Decomposition of Growth



Risk Decomposition of Price Momentum



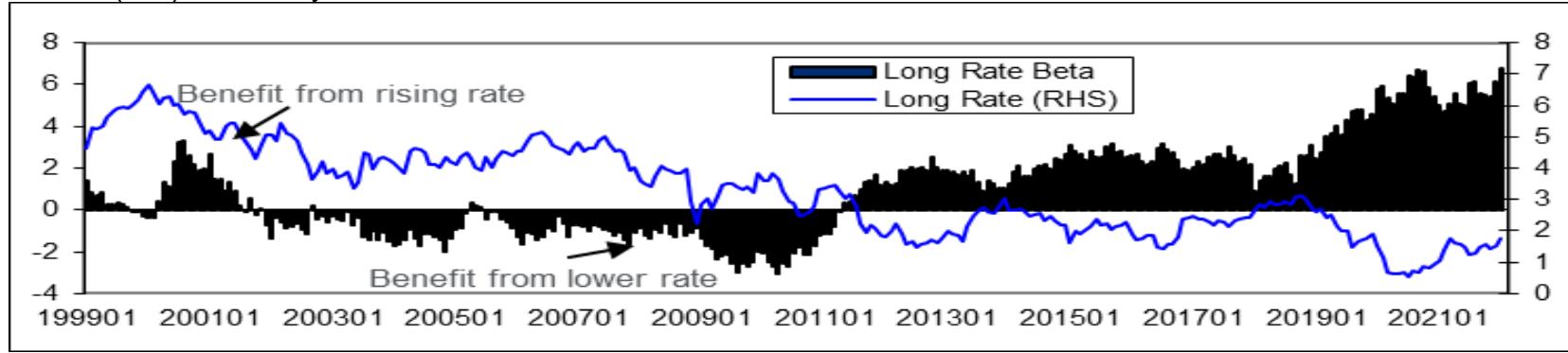
Risk Decomposition of Earnings Revision



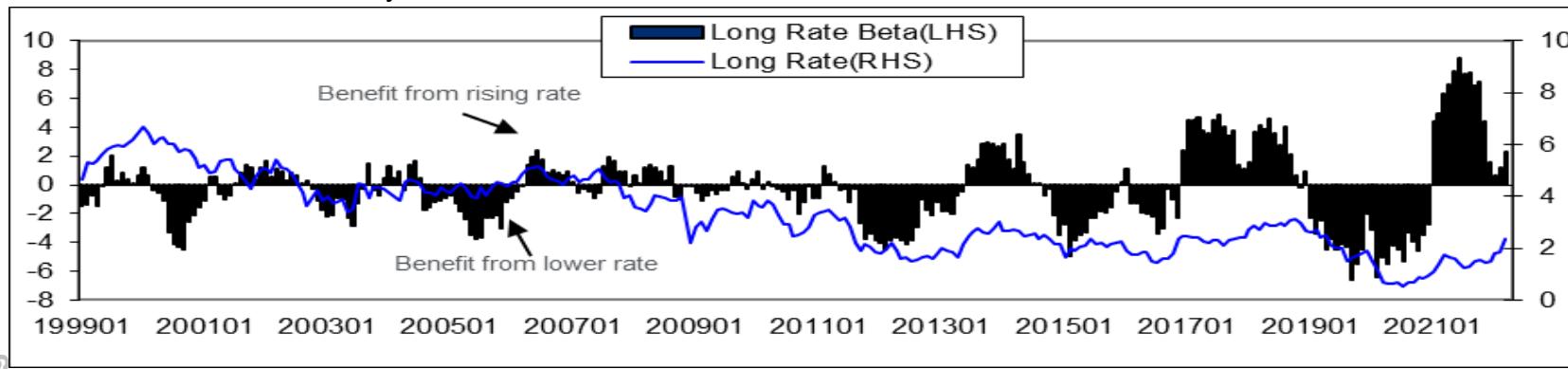
Source: Citi Research

Factor Exposure to 10-Year Yield

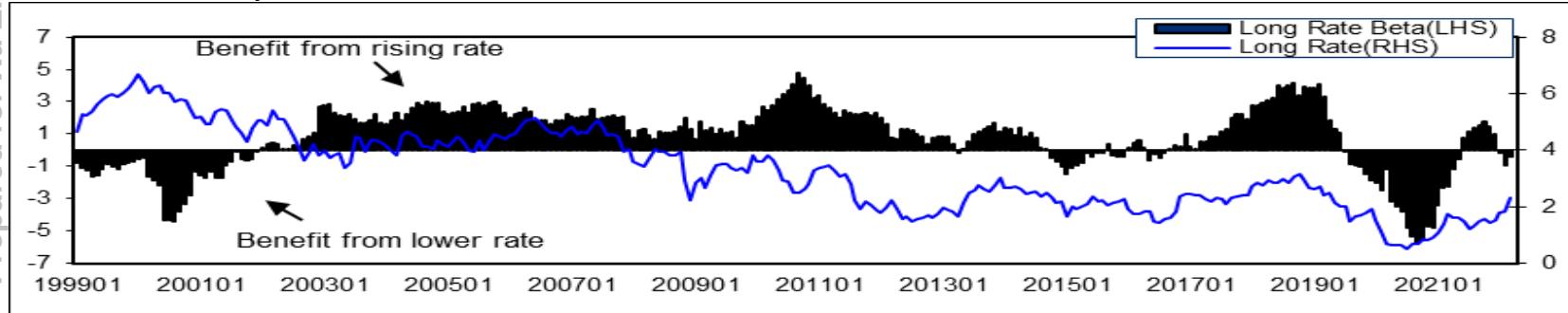
Value (P/B) Sensitivity



Price Momentum Sensitivity

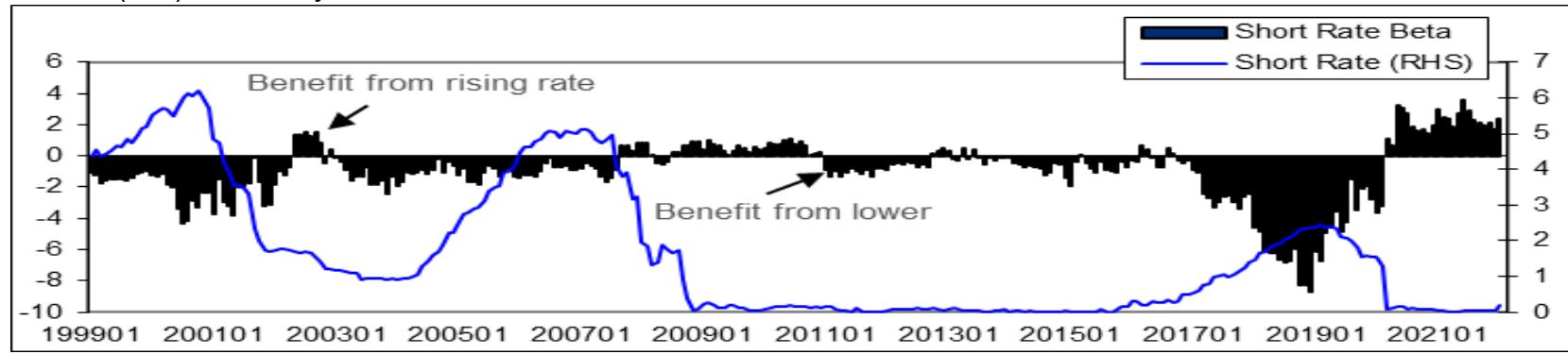


Growth Sensitivity

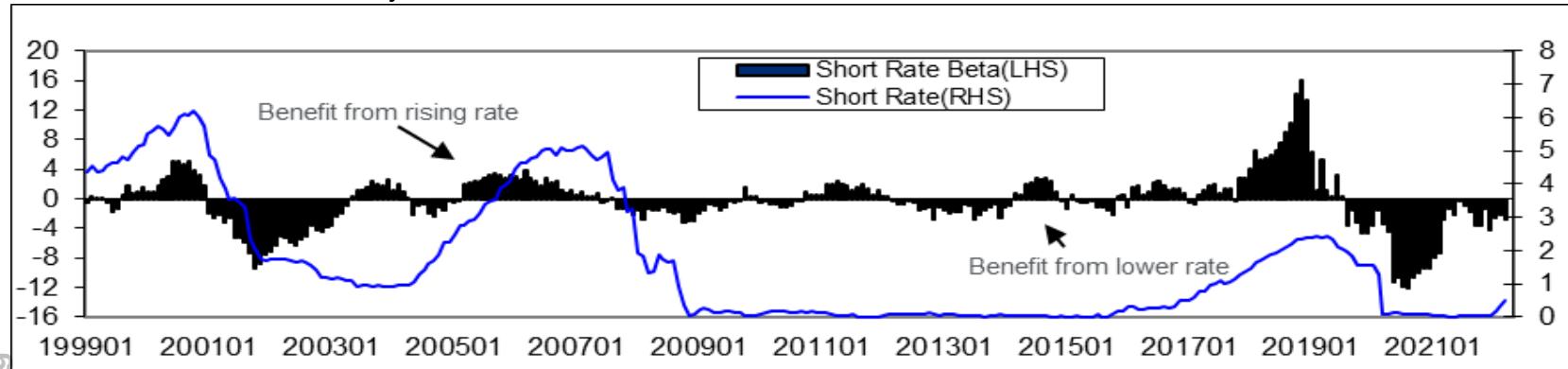


Factor Exposure to 3-Month Yield

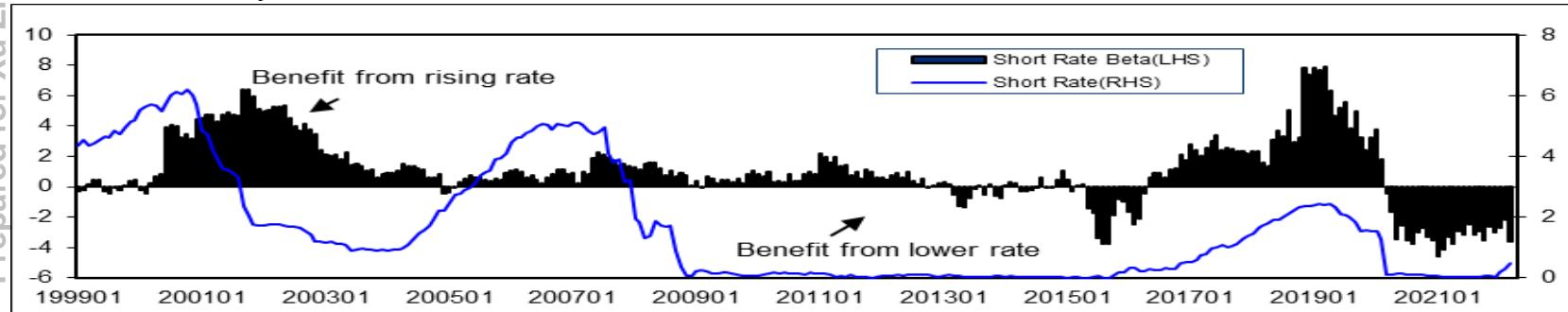
Value (P/B) Sensitivity



Price Momentum Sensitivity



Growth Sensitivity

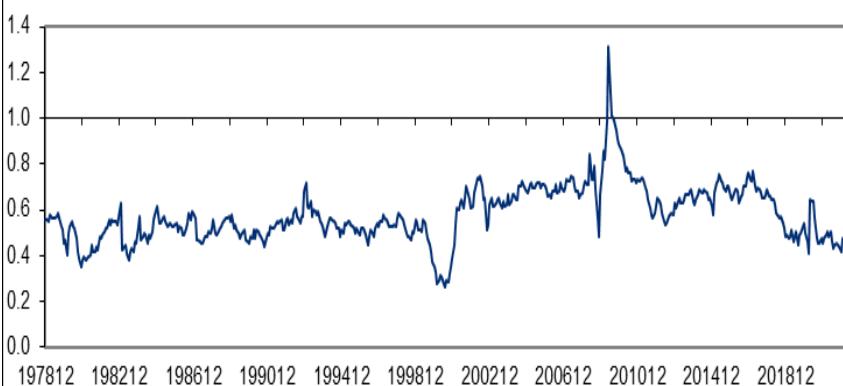


Source: Citi Research

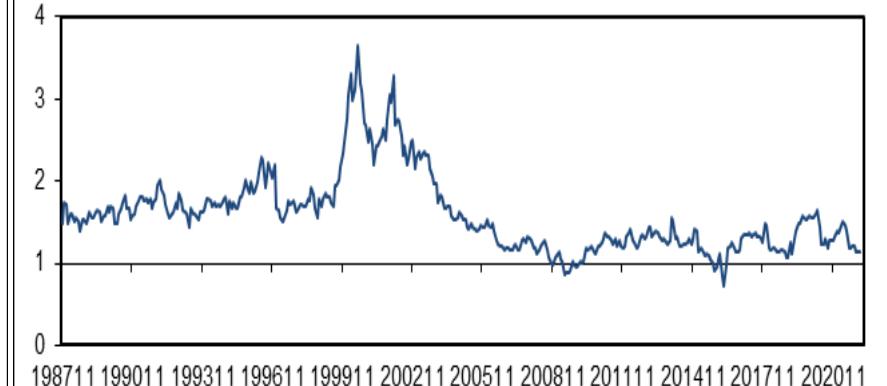
Factor Valuation

- Valuation remains low in Value, Earnings Revision and Price Momentum, suggesting more room to grow.
- Growth has become cheaper in last a few months. Revision is not expensive despite better performance last year.

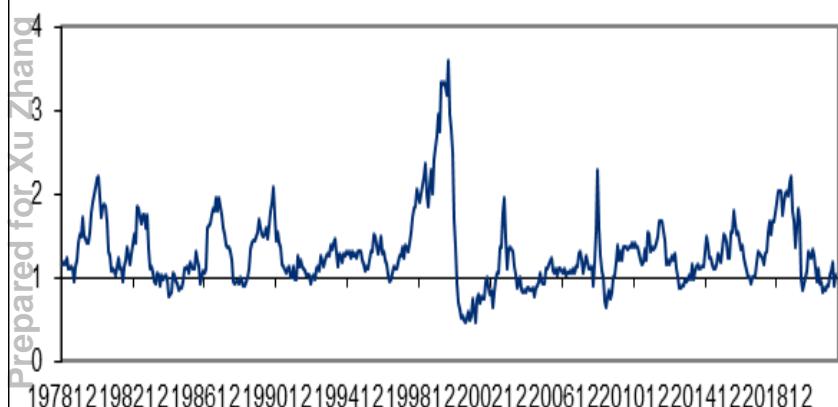
FY1 P/E Ratio of Cheap vs. Expensive Quintile (P/B)



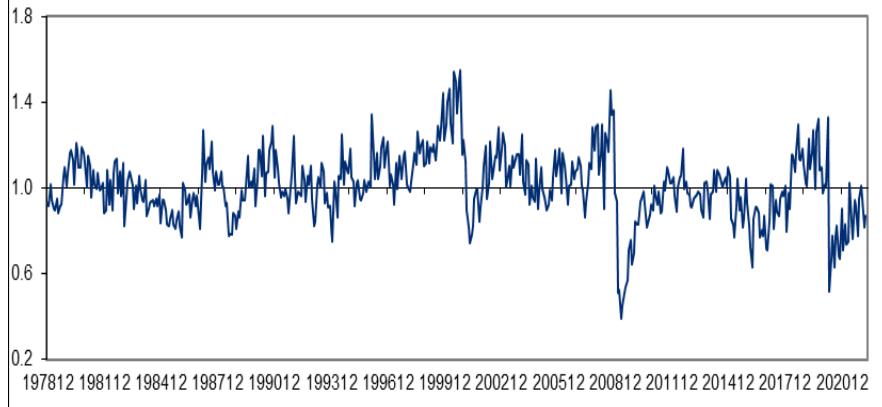
FY1 P/E Ratio of High Growth vs. Low Growth Quintile



FY1 P/E Ratio of High Momentum vs. Low Momentum Quintile



FY1 P/E Ratio of High Revision vs. Low Revision Quintile

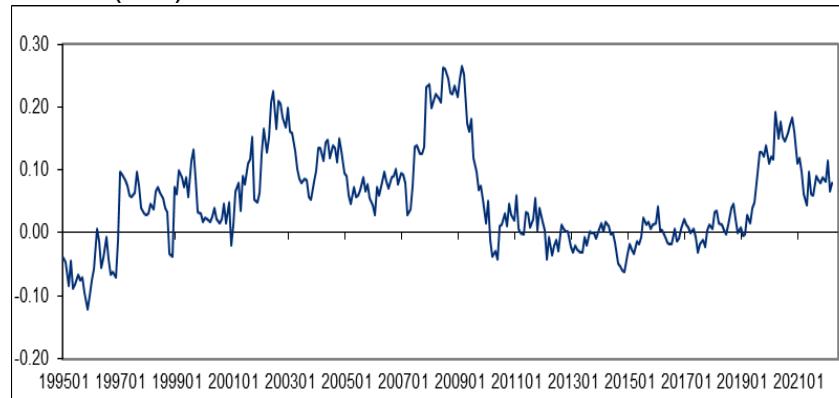


Source: Citi Research

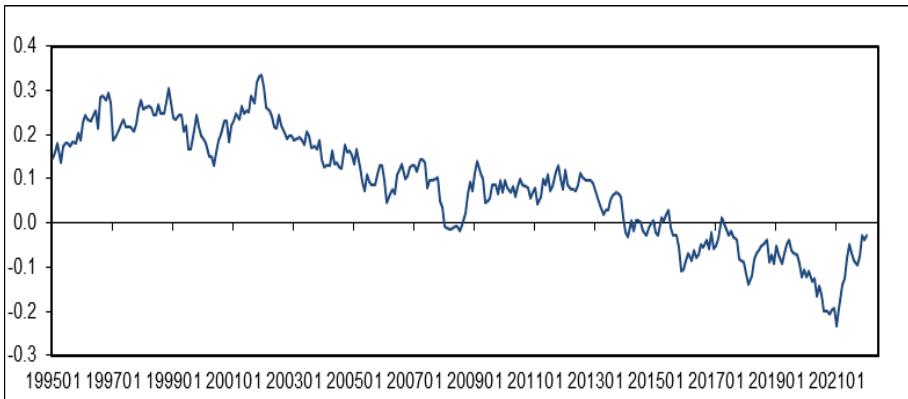
Rank Correlation Between Factor and Short Interest

- Short interest stays around historical average levels for Growth, Price Momentum and Earnings Revision, suggesting that they are not crowded.
- Short interest remains above levels prior to 2019, indicating that shorts have not fully capitulated and investors have not over-owned Value.

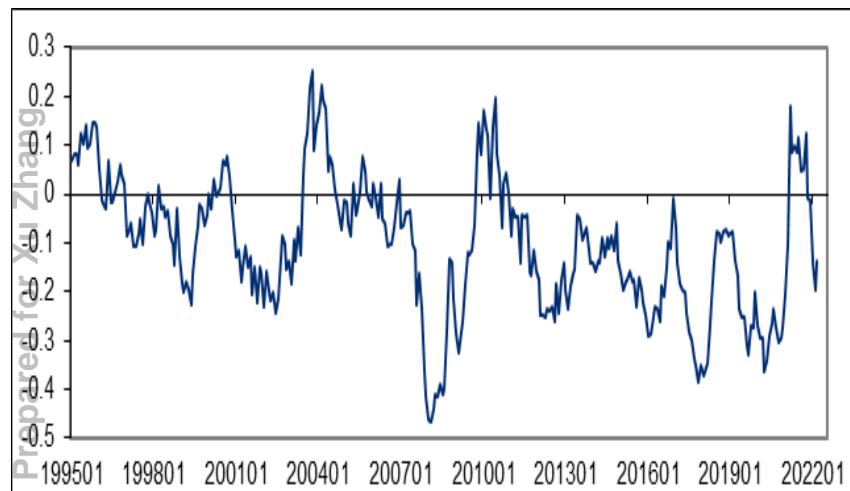
Value (B/P) vs. Short Interest



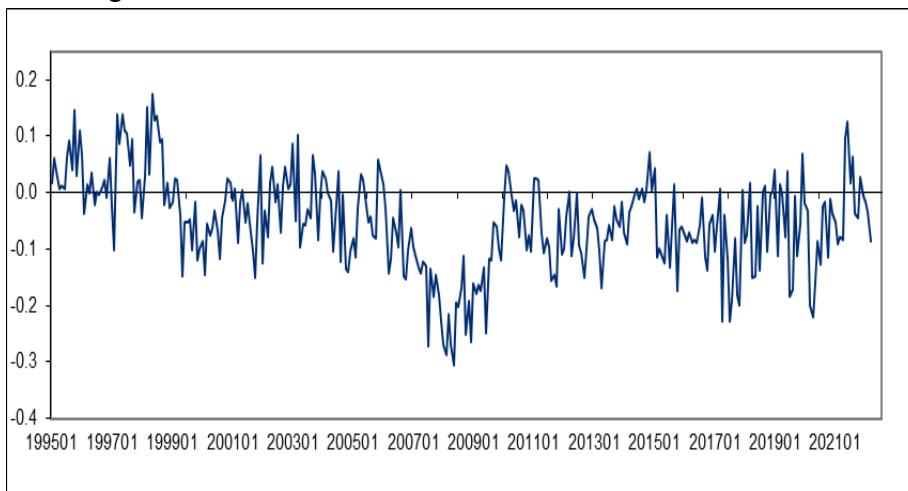
Growth vs. Short Interest



Price Momentum vs. Short Interest



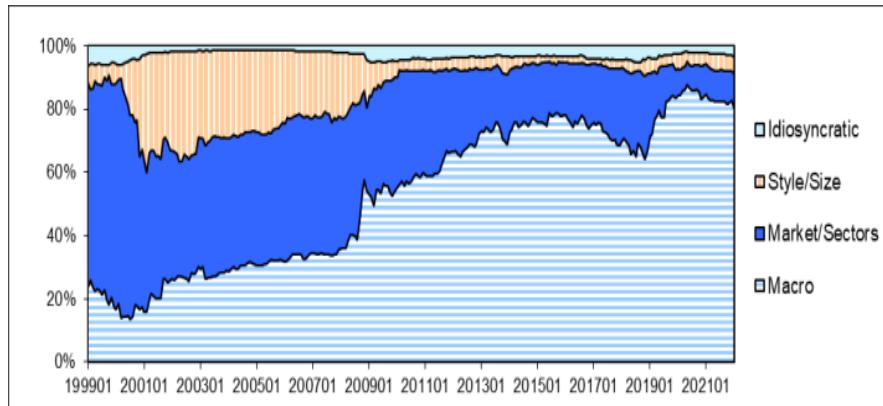
Earnings Revision vs. Short Interest



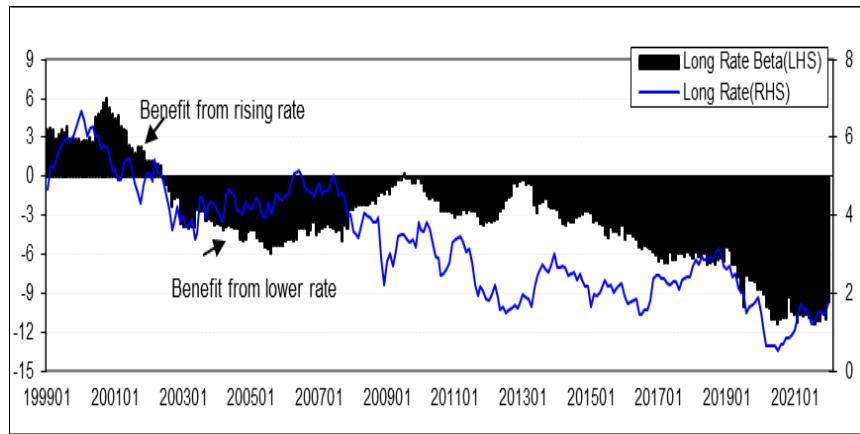
Low Beta is now the most crowded factor

- Macro risk in Low Beta stays near its historical high, with an extremely negative exposure to rising long-term interest rates or a steepening yield curve.
- Valuation for Low Beta is well above its historical average, albeit lower than its peak reached in early 2020.
- Short interest remains high in high beta stocks, suggesting shorts never fully capitulated despite the underperformance in last two years.

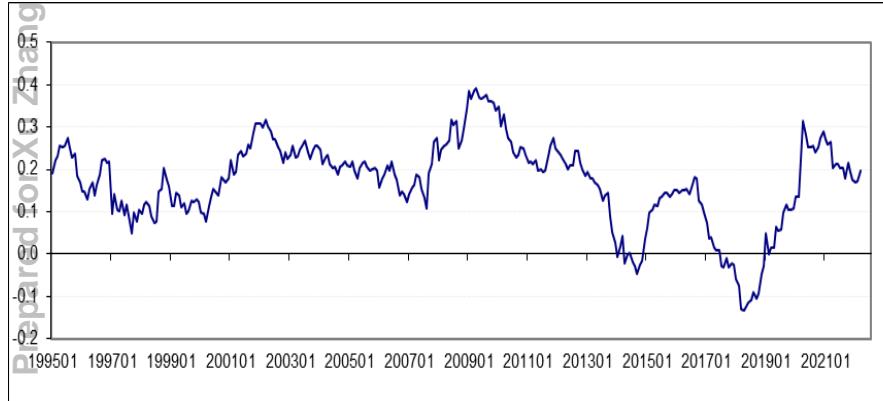
Risk Decomposition of Low Beta



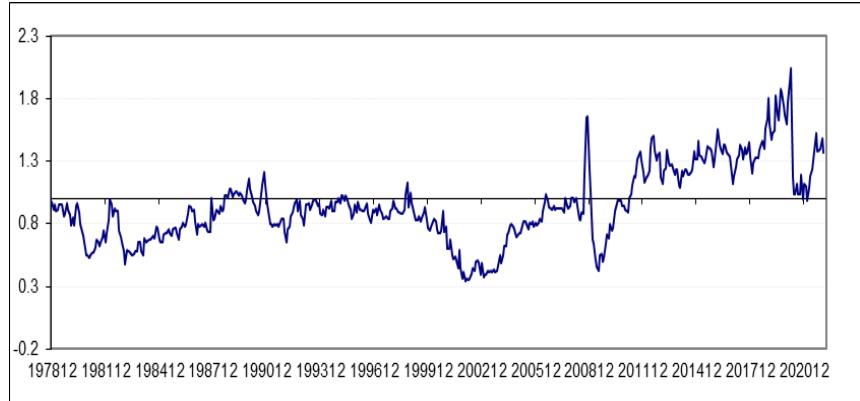
Low Beta Exposure to 10-year Yield



Cross-sectional Correlation between Beta and vs. Short Interest



FY1 P/E Ratio of Low Beta vs. High Beta Quintile



Factor Outlook

- Factor correlation dynamics has reverted back to normal with more diverse returns. Growth versus Value remains the main factor rotation.
- Reduced macro risk and correlation among Earnings Revision and Price Momentum are conducive to their future performance and bode well for the traditional Value and Momentum balanced multi-factor approach.
- Low Beta is more crowded than other factors.
- Despite the headline news on inflation and oil market volatility, empirically the 10-year yield remains the key driver for many factor performance. We advise taking both inflation and interest rates into consideration in assessing investment risk.
- With heightened uncertainties and much less positive surprises expected on company earnings, we recommend investors to diversify across stocks and sectors, overweight Price Momentum and our systematic oversold strategy as they currently carry much less macro exposures.

4. Stock Crowding and Equity Market Positioning Models

Stock Crowding Model

Crowding Factors

- Crowding Composite measure based on the following five metrics:
 - **Ranking of the most crowded factor** – based on our style crowding model
An indicator on quant crowding.
 - **Relative Valuation** – an equal-weighted composite of historical relative Price to Book and Price to FY1 Earnings.
A higher valuation score indicates more crowding.
 - **Short Interest Ratio** – historical relative short interest ratio (the amount of short interest as % of shares outstanding).
A lower short interest ratio indicates a higher consensus trade.
 - **Sell-side Rating Skewness** – based on sell-side analysts' stock rating distribution (IBES).
A higher concentration of buy ratings from sell-side analysts could lead to more crowding.
 - **Macro Exposure** – macro contribution of individual stock risk from our Risk Attribute Model (RAM).
Higher macro exposure in a stock may lead to consensus position.

Stock Crowding Model

Factor Crowding has been mostly consistent through time

Global Factor Crowding Summary

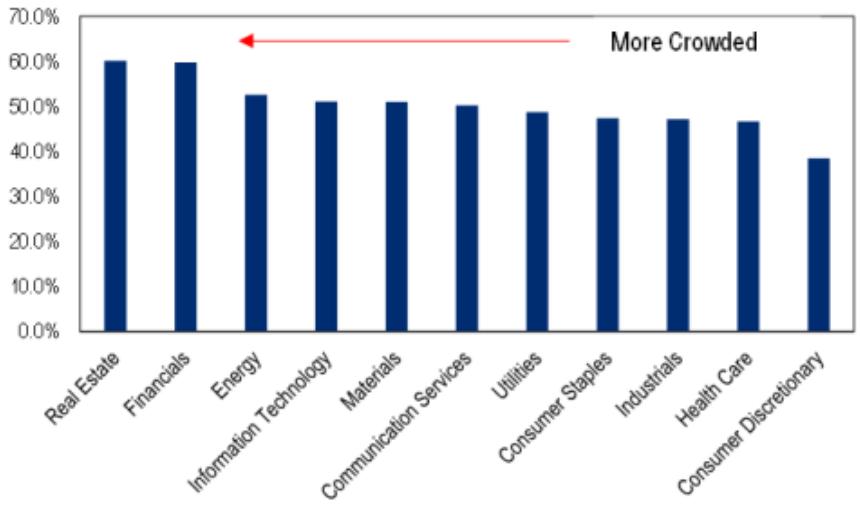
Region	<u>Most Crowded Style</u>	
	March	April
Asia ex Japan	Quality	Quality
Australia	Price Momentum	Low Risk
Europe	Earnings Momentum	Earnings Momentum
Japan	Earnings Momentum	Earnings Momentum
US	Low Beta	Low Beta

Source: Citi Research,

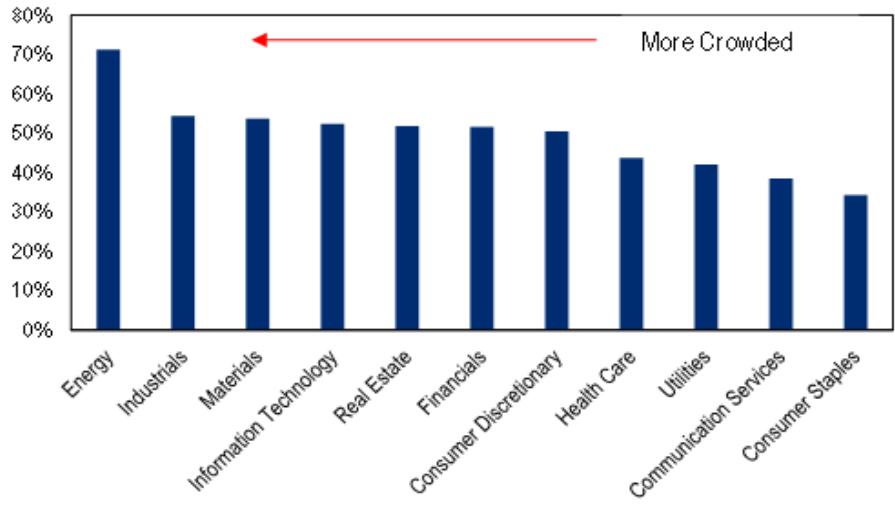
Stock Crowding Model

Sector Crowding

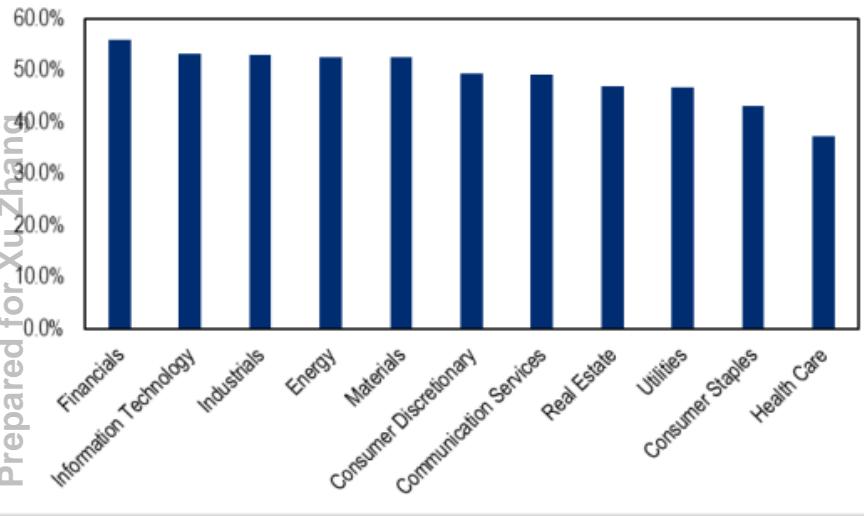
US



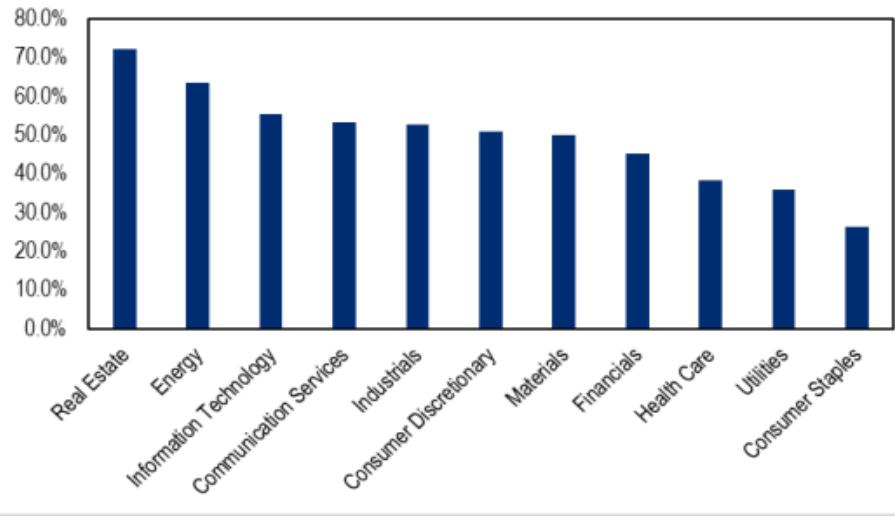
Europe



Asia ex. Japan



Japan

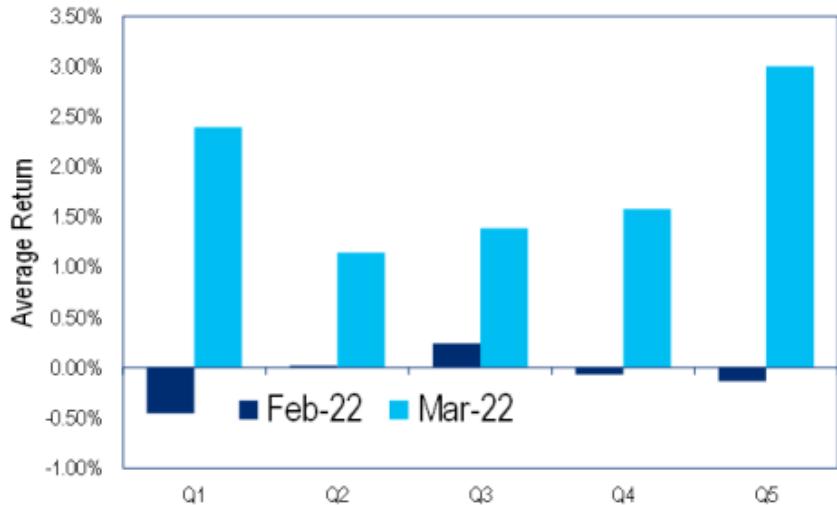


Source: Citi Research

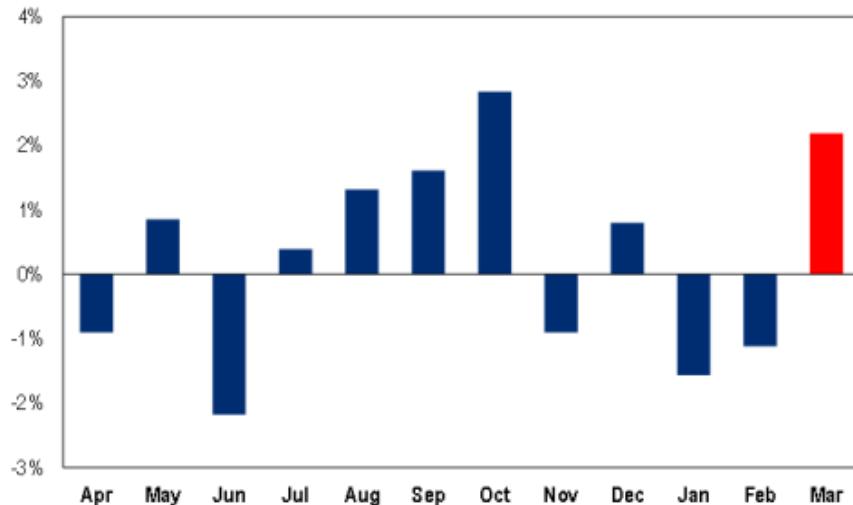
Stock Crowding Model

Crowding Premium

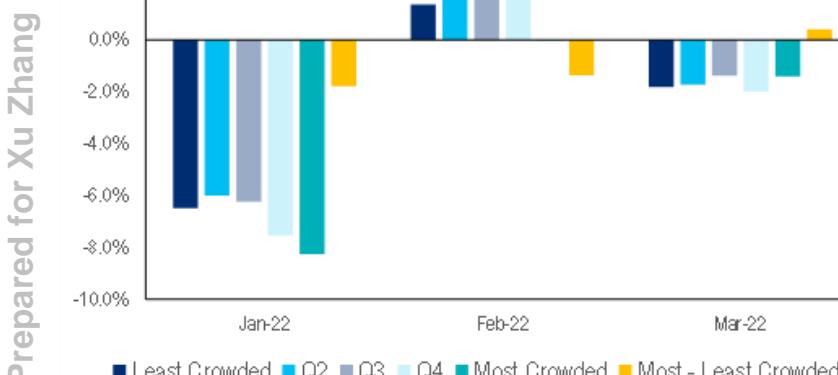
US – Average Return by Crowding Quintile



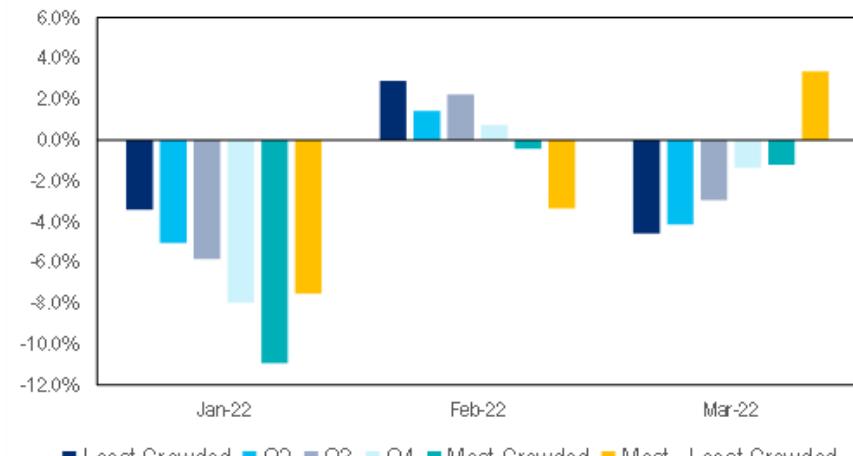
Europe – Average Return Spread



Asia ex. Japan – Average Return by Crowding Quintile



Japan – Average Return by Crowding Quintile

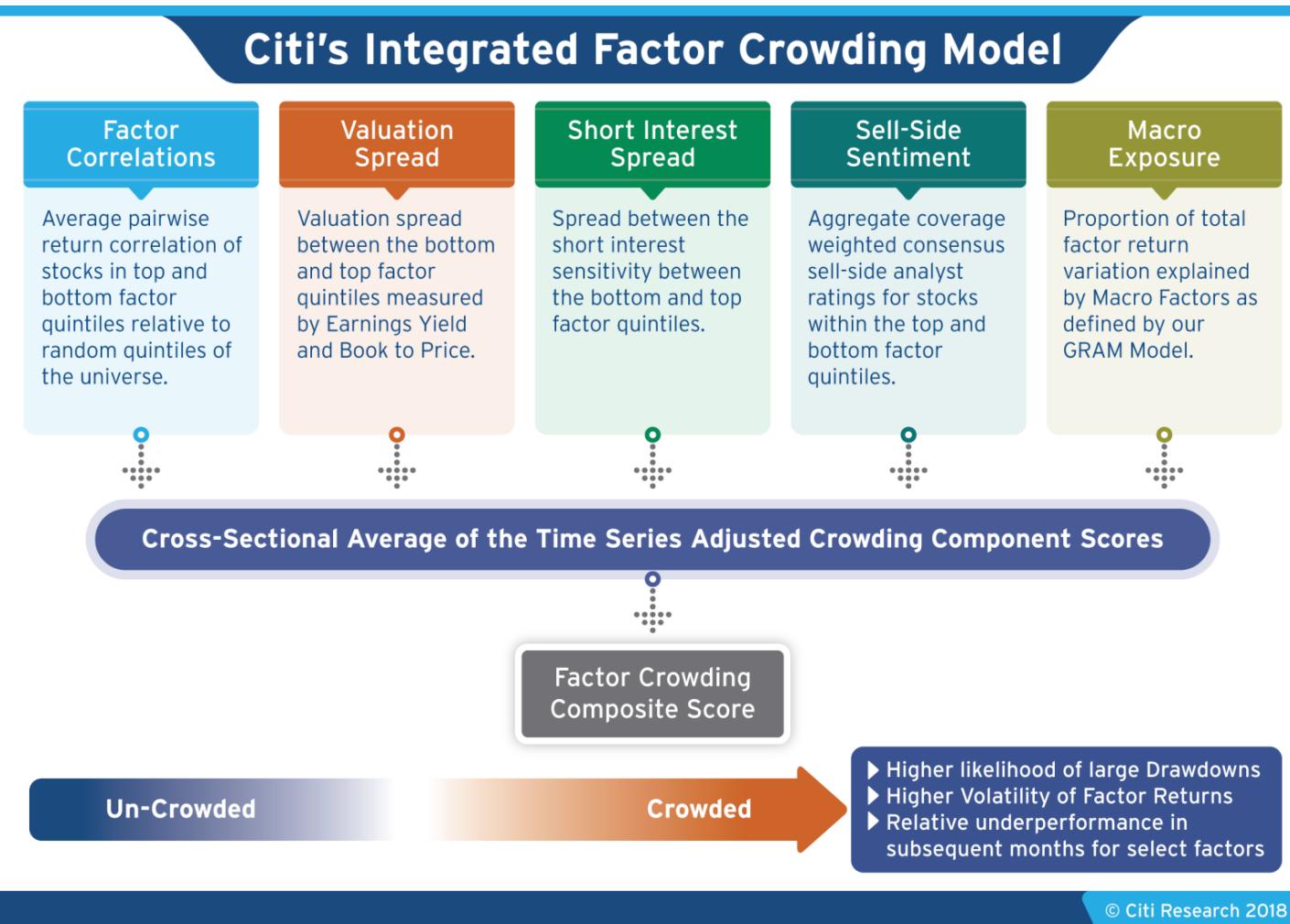


Prepared for Xu Zhang

Factor Crowding Model

Input – Style Crowding Model

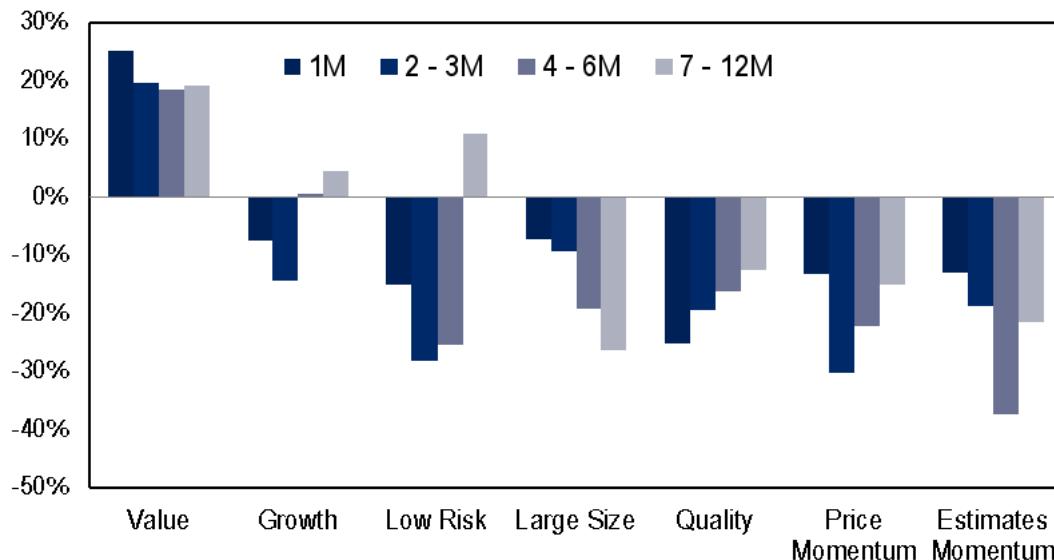
- Systematic approach to measure the crowdedness level of investment styles



Performance of Crowded Factor

- The individual components of our integrated factor crowding model show complex characteristics and appear less effective on a stand-alone basis. However, the individual components complement each other and result in a highly effective score when combined in a multi-factor approach
- The Crowding Composite is largely negatively correlated with subsequent-month returns across factors over varying holding periods
 - A notable exception is the Value factor, which could be attributed to the capacity of the factor and valuation being one of the components of the crowding score

Information Coefficient Decay Profile



Source: Citi Research

Equity Markets Positioning Model

How Does it Work?

- The Equity Markets Positioning Model (EMP) is a carve-out of the very successful cross-asset Citi RPM model.
- The aim of the model is to provide information on current equity market positioning and how this might influence subsequent price action. It allows readers to “visualize” the investor exposures in equity futures/ETFs across multiple markets in order to
 - Quantify the current market positioning and profitability;
 - Identify extreme market positions;
 - Categorize periods in which price action will be dominated by positioning.
- Price action is dominated by the size, level and speed at which investors choose to execute trades with other financial intermediaries. Buy/sell orders can clearly drive prices higher or lower, and the EMP attempts to quantify these flows in order to understand the market direction and motivation of the marginal investor.
- Given that there is no one market participant who holds a complete view of all market flows, we are only analyzing and aggregating futures trading to extrapolate the positioning across the whole market (i.e., including all cash trading).

Equity Markets Positioning Model

How Does It Work?

- Overall, we estimate the following:
 - **Market positioning:** What is the marginal market positioning (i.e., has there been net buying or selling in recent history)? At what price and size were these trades executed?
 - **Market P&L:** What is the unrealized profit or loss of these marginal investors (given the current outstanding market positioning)? When is this a motivation for investors to risk manage their positions?
- The EMP model calculates the historical equity market positioning (over the last three months) and the associated unrealized P&L for the main markets around the world (and others).

Equity Markets covered by EMP Model

	US	Germany	UK	Europe (€)	US Tech	Japan	Developed World	Emerging Markets
Index Code	S&P 500 ES	DAX GX	FTSE 100 Z	EStoxx50 VG	Nasdaq NQ	Nikkei NI	MSCI World ex US MFS	MSCI EM MES

Source: Citi Research

Equity Markets Positioning Model

Position Calculations

- The model identifies an objective subset of positions entered into (or closed) on a given day and classifies these as being the relevant marginal long or short positions that determined (being the “aggressor”) the price move that day. These are considered as the aggregate position of the ‘marginal’ investor.
- By tracking the daily changes in overall open interest (the number of contracts after the exchange creates or cancels contracts) and combining that measure with the change in price, we can make a classification for the marginal positioning change on that day.
- The change in open interest is taken to be the relevant marginal subset of positions that day, and together with the change in price, we determine whether to consider it a change in long or short positions.

Positioning Matrix for Futures Markets

		Open Interest			
		Increasing		Decreasing	
		New Longs	Rising prices and increasing open interest implies the 'aggressor' is the buyer pushing the market higher	Cover Shorts	Rising prices and decreasing open interest implies the 'aggressor' is covering shorts (i.e. buying into the rally)
Daily Prices	Increasing	New Longs	Rising prices and increasing open interest implies the 'aggressor' is the buyer pushing the market higher	Cover Shorts	Rising prices and decreasing open interest implies the 'aggressor' is covering shorts (i.e. buying into the rally)
	Decreasing	New Shorts	Falling prices and increasing open interest implies the 'aggressor' is the seller pushing the market lower	Cover Longs	Falling prices and decreasing open interest implies the 'aggressor' is covering longs (i.e. selling into the sell-off)

Source: Citi Research

Equity Markets Positioning Model

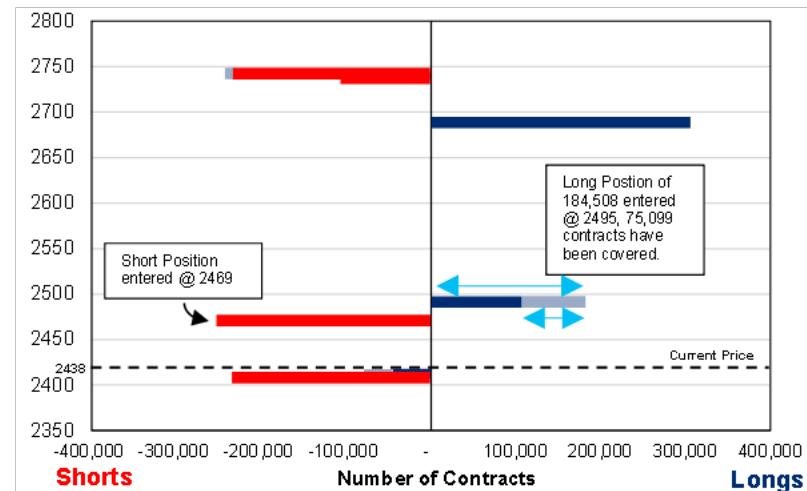
Position Calculations

- Performing this analysis on a day-by-day basis creates a “trade activity” history over a three-month period, which can be converted into a snapshot of cumulative positioning and unrealized P&L.

Example of positioning for S&P500 during March 2020.

Date	Trade Price	Open Interest	Delta Price	Delta Interest	Trade Activity	Contract Buy/Sell	Cum. Pos.	P&L Snapshot (\$, mil)
06-Mar	2964.0	3,213,000						
09-Mar	2747.8	3,442,251	-7.3%	229,251	New Short	-229,251	-229,251	3,551
10-Mar	2865.8	3,438,501	4.3%	-3,750	Cover Short	3,750	-225,501	-58
11-Mar	2740.3	3,549,717	-4.4%	111,216	New Short	-111,216	-336,717	1,681
12-Mar	2469.0	3,808,784	-9.9%	259,067	New Short	-259,067	-595,784	402
13-Mar	2696.0	4,124,586	9.2%	315,802	New Long	315,802	-279,982	-4,074
16-Mar	2416.3	4,369,586	-10.4%	245,000	New Short	-245,000	-524,982	-266
17-Mar	2495.5	4,554,094	3.3%	184,508	New Long	184,508	-340,474	-531
18-Mar	2414.0	4,628,421	-3.3%	74,327	New Short	-74,327	-414,801	-89
19-Mar	2403.3	4,553,322	-0.4%	-75,099	Cover Long	-75,099	-489,900	216
20-Mar	2438.0	4,522,463	1.4%	-30,859	Cover Short	30,859	-459,041	37
Total							-459,041	868

Example visualization of positioning.



Source: Citi Research. Futures trading involves substantial risk of loss.

Source: Citi Research. Futures trading involves substantial risk of loss.

- VWAP is used in the calculations, and the EMP model chooses to cover trades that have the maximum economic impact (i.e., trades with the largest gains or losses are closed out first).
- The reported numbers in the EMP model are normalized into a range from -5 to +5 (representing large shorts / losses to large longs / profits) in order to compare across markets/time.

Equity Markets Positioning Model

Output Generated by Model

Example of Equity Market Positioning and PnL

		Investors currently net long S&P 500 Emini futures				Investors currently neutral to net short EuroStoxx 50			
(\$bn)	03/09/2020	S&P 500	DAX	FTSE 100	EStoxx50	Nasdaq	Nikkei	MSCI World x-US	MSCI EM
All metrics in table are normalised between +5 and -5									
Positioning	Future	1.7	-0.1	1.0	-0.0	4.8	1.1	-0.7	2.0
	ETF	3.0	1.4	-0.6	0.9	3.6	1.0		1.1
	3m Net Pos	2.3	0.7	0.2	0.4	4.2	1.1	-0.7	1.6
	1w Change	0.4	0.2	0.3	0.3	-0.3	0.3	-0.4	-0.3
P&L	Future	1.2	-0.1	-0.7	-0.0	4.8	0.5	0.1	1.8
	ETF	3.7	1.9	-0.5	1.1	3.9	1.3		1.4
	3m Net PnL	2.5	0.9	-0.6	0.5	4.4	0.9	0.1	1.6
	1w Change	0.3	0.3	-0.0	0.3	-0.4	0.3	0.0	-1.1

Investors are sitting on profitable positions in MSCI EM.

Source: Citi Research. Note: Futures trading involves substantial risk of loss.

Equity Markets Positioning Model

Output Generated by Model

Example of Breakdown of Market Positioning – Not Current

Net Notional = Longs minus Shorts (in \$blns)

Percentile refers to positioning relative to past 3 years

% Offside refers to what percentage of shorts are below Ref price – indicates risk of short squeeze if market rallies. Opposite for Longs

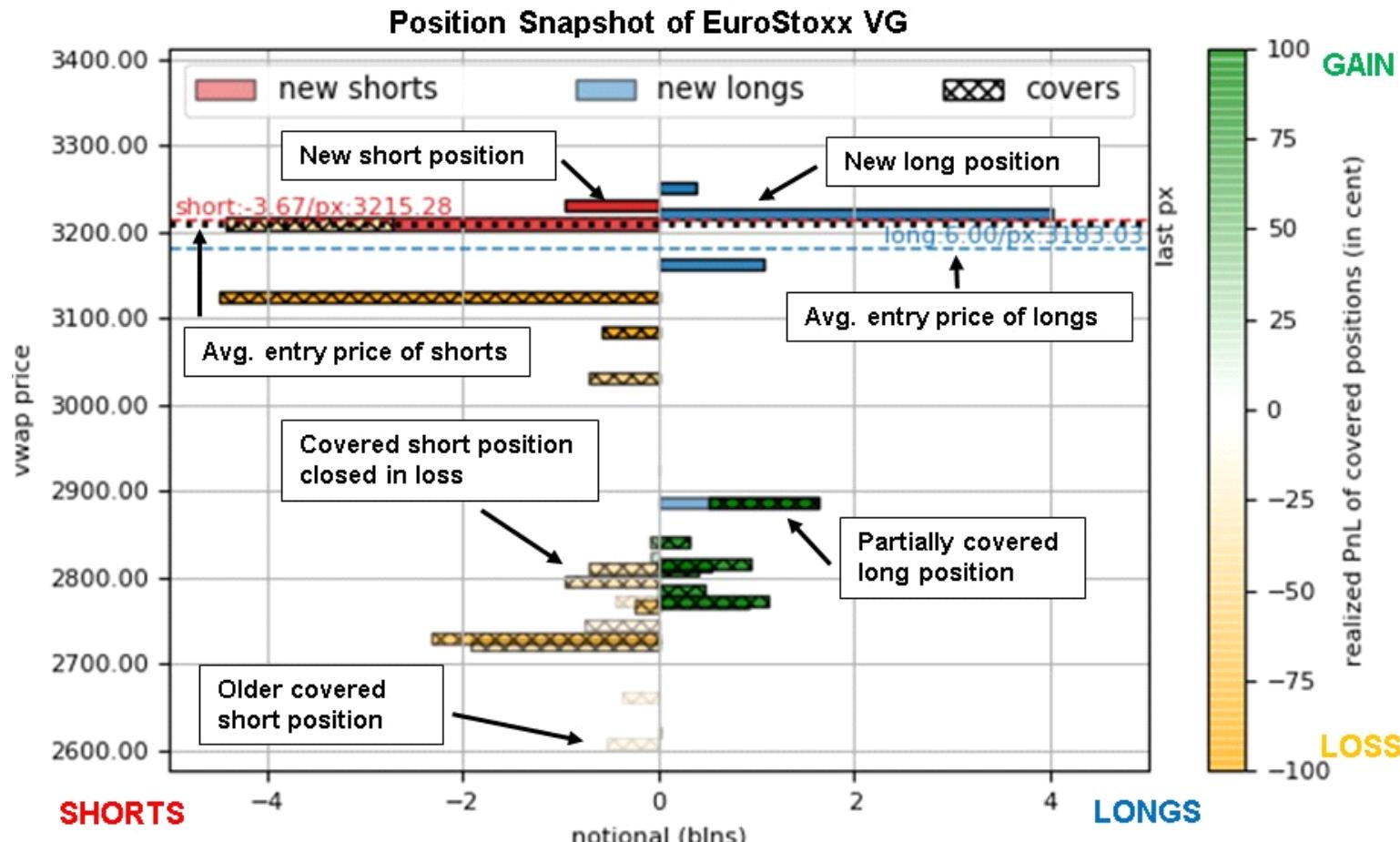
	S&P 500	DAX	FTSE 100	EStoxx50	Nasdaq	Nikkei	MSCI World x-US	MSCI EM
Futures	03/09/2020	ES	GX	Z	VG	NQ	NI	MFS
Notional	31.7	-0.1	2.4	-0.4	10.8	1.2	-1.1	6.4
Percentile	67%	36%	53%	33%	99%	64%	11%	75%
Shorts	Notional	-7.5	-1.3	-3.9	-1.4	-1.6	-1.1	-2.7
	Notional	-7.5	-1.3	-3.9	-1.4	-1.6	-1.1	-2.7
	Percentile	24%	37%	81%	24%	28%	20%	80%
	Avg. Entry	3,246	12,994	6,116	3,316	10,993	22,959	1,890
	% offside	100%	100%	3%	100%	100%	100%	32%
Longs	Notional	39.2	1.2	6.3	0.9	12.4	2.3	1.6
	Notional	39.2	1.2	6.3	0.9	12.4	2.3	1.6
	Percentile	57%	18%	72%	10%	99%	25%	18%
	Avg. Entry	3,337	13,068	6,096	3,311	11,166	22,889	1,893
	% offside	13%	0%	100%	0%	18%	0%	60%
	Ref Price	3,463	13,304	5,909	3,366	11,803	23,490	1,878
Activity	1-day	-2.6	-0.2	0.0	-0.1	-0.9	0.3	0.0
	1-day	-2.6	-0.2	0.0	-0.1	-0.9	0.3	0.0
	Type	longs	shorts	longs	shorts	longs	longs	shorts
1-week	4.2	0.1	0.1	-0.5	-0.4	0.1	-0.7	0.5
Average entry price over past 3 months	1 day trading activity in \$blns. Negative (positive) means risks is being cut (added)				Defines what side the risk is being traded		1 week cumulative trading flow	

Source: Citi Research. Note: Futures trading involves substantial risk of loss.

Equity Markets Positioning Model

Output Generated by Model

Example Snapshot of Position in EuroStoxx Futures – Not Current



Source: Citi Research. Note: Futures trading involves substantial risk of loss.

Equity Markets Positioning Model

Current Market Positioning (Close 9 January 2022)

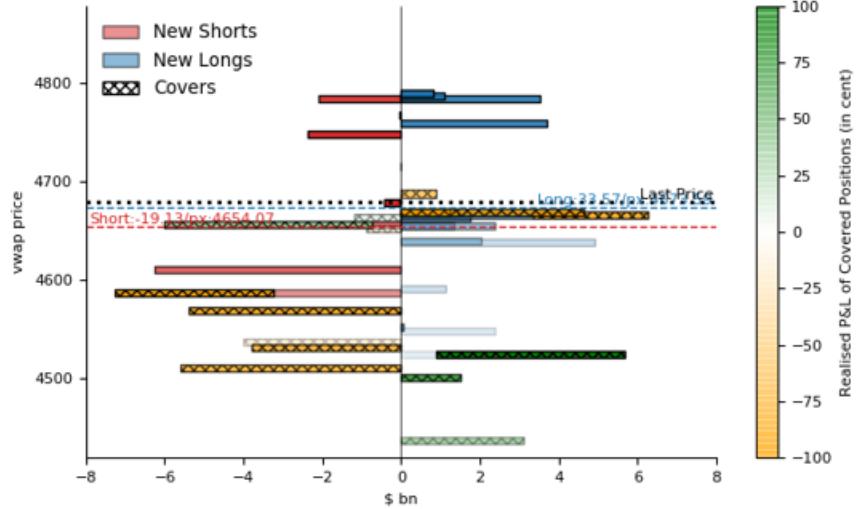
	Code	ES	NQ	VG	Z	GX	NI	MFS	XP	CA	XU
		S&P 500	Nasdaq	Euro Stoxx 50	FTSE 100	DAX	Nikkel	MSCI World ex-US	S&P/ASX 200	Eur. Banks	China A50
(\$bn)	07/01/2022	ES	NQ	VG	Z	GX	NI	MFS	XP	CA	XU
Futures	Net Notional	14.4	3.2	-14.9	-2.1	2.3	1.5	-2.0	2.4	-0.3	-1.2
	Percentile	32%	50%	12%	19%	61%	58%	9%	39%	32%	10%
Shorts	Notional	-19.1	-7.1	-26.6	-5.0	-2.2	-1.1	-4.9	0.0	-1.5	-2.7
	Percentile	53%	87%	91%	88%	52%	25%	87%	10%	89%	99%
	Avg. Entry	4,654	16,159	4,172	7,246	15,573	28,694	2,283	-	100.6	15,683
	% offside	76%	0%	99%	100%	96%	45%	89%	-	100%	34%
Longs	Notional	33.6	10.3	11.7	2.9	4.5	2.6	2.9	2.4	1.2	1.5
	Percentile	33%	78%	46%	42%	63%	28%	34%	31%	67%	50%
	Avg. Entry	4,674	15,932	4,219	7,263	15,972	28,646	2,313	7,359	103.2	15,706
	% offside	27%	93%	8%	12%	52%	64%	36%	60%	0%	100%
	Ref Price	4,678	15,667	4,296	7,405	15,954	28,576	2,320	7,353	108.9	15,420
Activity	1-day	0.4	-0.9	2.1	0.2	-0.7	0.3	0.0	-0.9	-0.2	-0.0
	Type	shorts	longs	shorts	longs	longs	shorts	longs	shorts	shorts	longs
	1-week	↘ -1.0	↘ -3.1	↘ -0.9	↗ -0.1	↗ 0.8	↘ -0.0	↗ 0.4	↗ 1.6	↗ 0.8	↘ -0.3
Normalised Scores (-5 / +5)											
Positioning	Futures	0.8	0.8	-1.4	-0.8	1.3	1.7	-1.0	0.8	-0.7	-1.9
	ETF	3.9	2.5	-0.3	-0.2	-1.8	-1.2				-0.1
	3m Net Pos	2.3	1.6	-0.8	-0.5	-0.3	0.3	-1.0	0.8	-0.4	-1.9
	1w Change	-0.6	-0.6	0.1	-0.0	0.5	0.3	-0.0	0.3	0.9	-0.7
P&L	Futures	-0.1	0.1	-0.6	-0.3	-0.3	-0.0	-1.7	-0.0	-1.0	0.5
	ETF	1.6	-1.4	0.1	-0.1	-0.2	1.3			-2.0	
	3m Net PnL	0.8	-0.6	-0.3	-0.2	-0.2	0.6	-1.7	-0.0	-1.5	0.5
	1w Change	-1.8	-1.5	0.1	-0.1	-0.1	0.0	-0.2	-0.1	-0.4	0.7

Source: Citi Research. Note: Futures trading involves substantial risk of loss

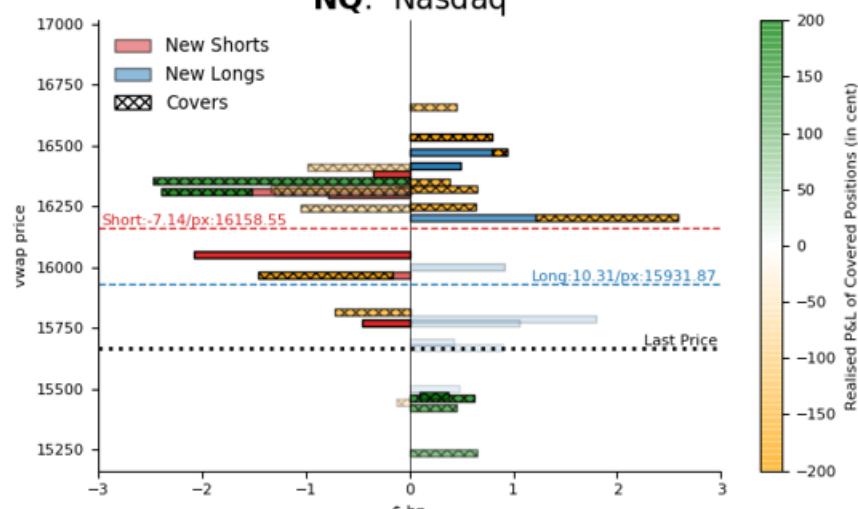
Equity Markets Positioning Model

Current Market Positioning (Close 9 January 2022)

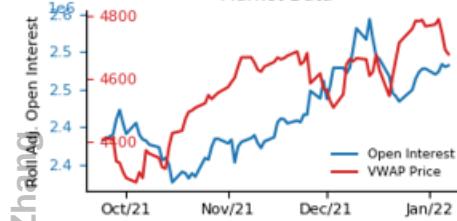
ES: S&P mini



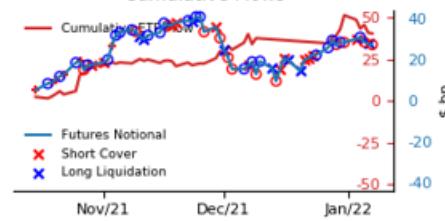
NQ: Nasdaq



Market Data



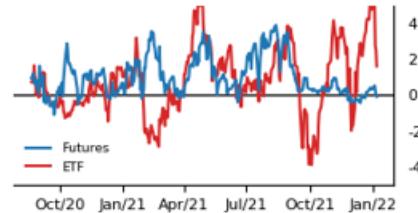
Cumulative Flows



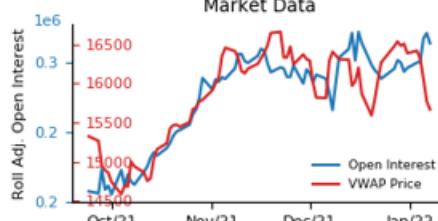
Normalised Positioning



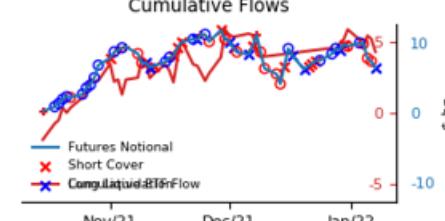
Normalised P&L



Market Data



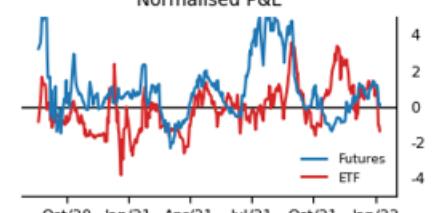
Cumulative Flows



Normalised Positioning



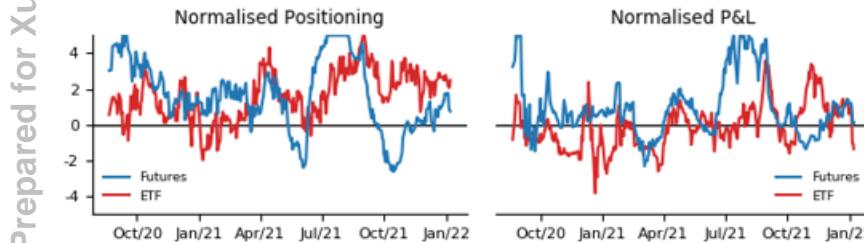
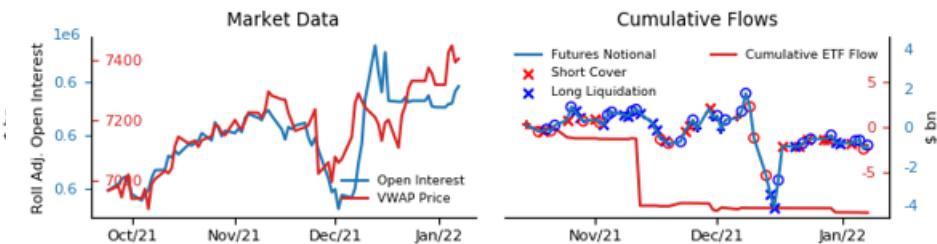
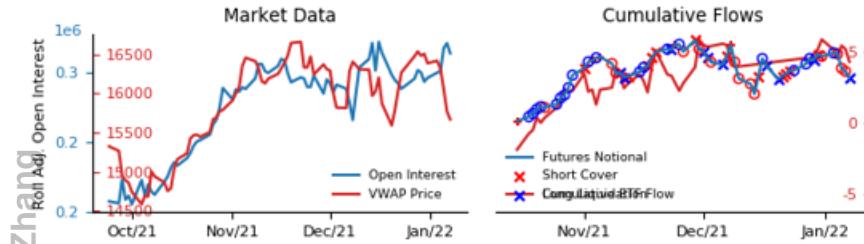
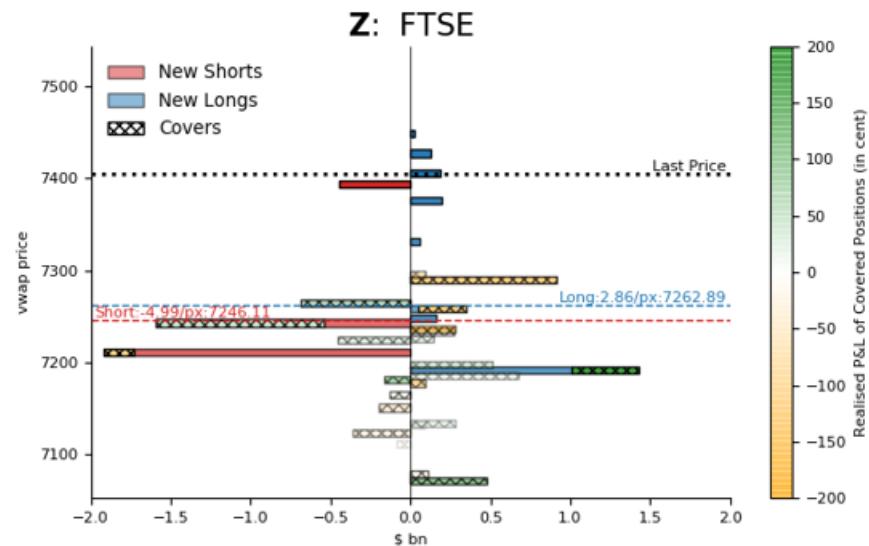
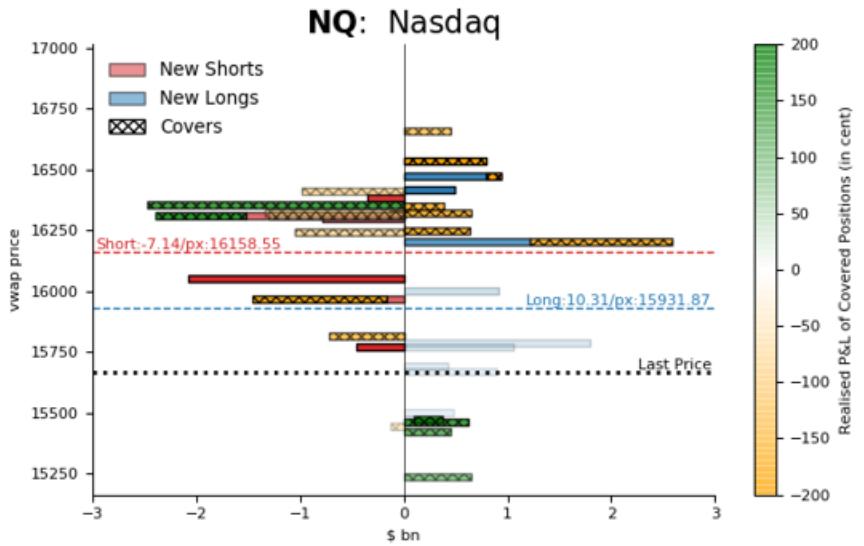
Normalised P&L



Prepared for Xu Zhang
Source: Citi Research. Note: Futures trading involves substantial risk of loss.

Equity Markets Positioning Model

Current Market Positioning (Close 9 January 2022)



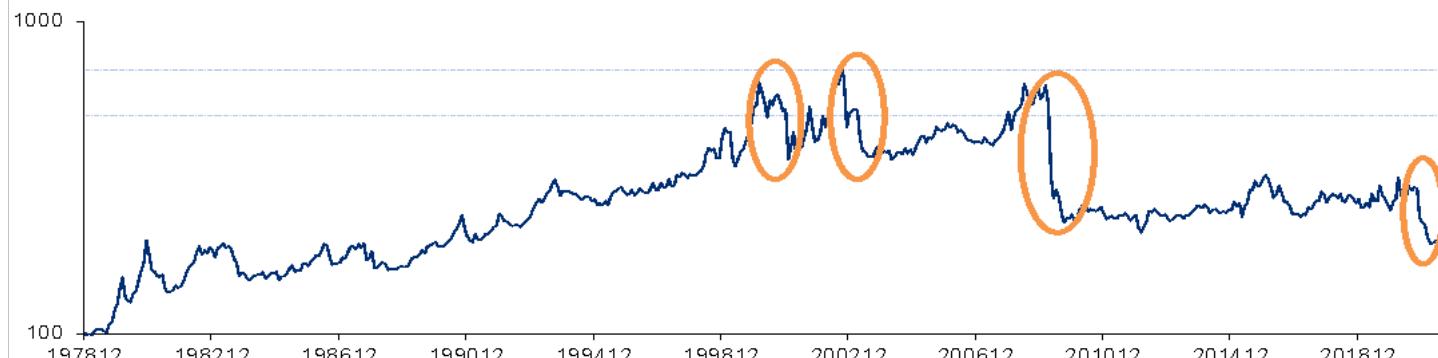
Source: Citi Research. Note: Futures trading involves substantial risk of loss.

5. A Systematic Oversold Strategy: Overlaying Price Momentum and Short Interest to Avoid Drawdown and Improve Return

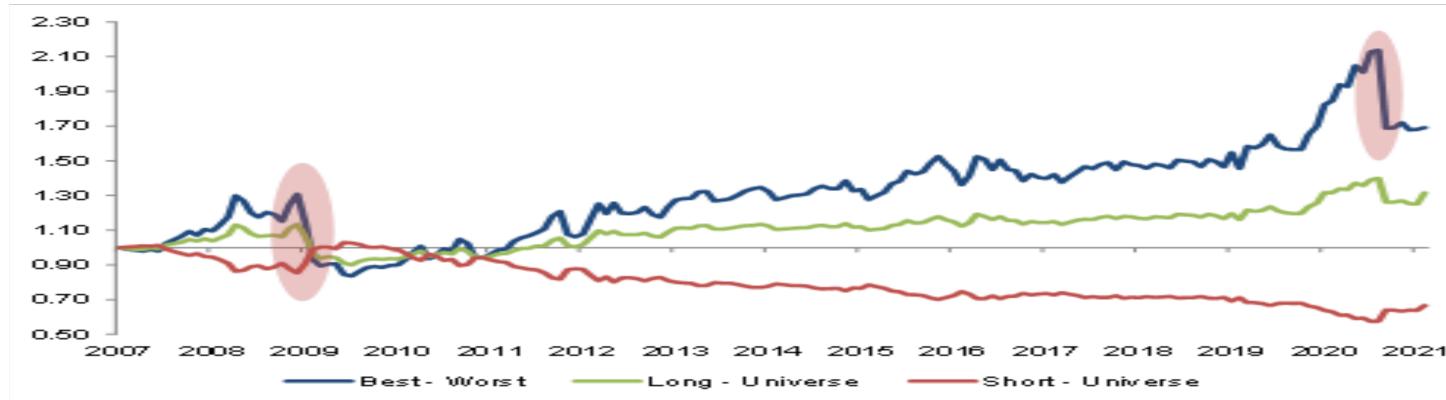
Price Momentum Factor Performance

- Price Momentum (first 11 of last 12 months) in the US has suffered the worst performance drawdown since the GFC and the fourth worst in the last 43 years.
- Momentum has a behavioral element that inherently leads to crashes from time to time.
- There is a continuing debate about whether Price Momentum is a long-term risk premium or more of a tactical factor with a dynamic nature.

US Long/Short Price Momentum Factor Performance



European Price Momentum Factor Performance (Excess Return)

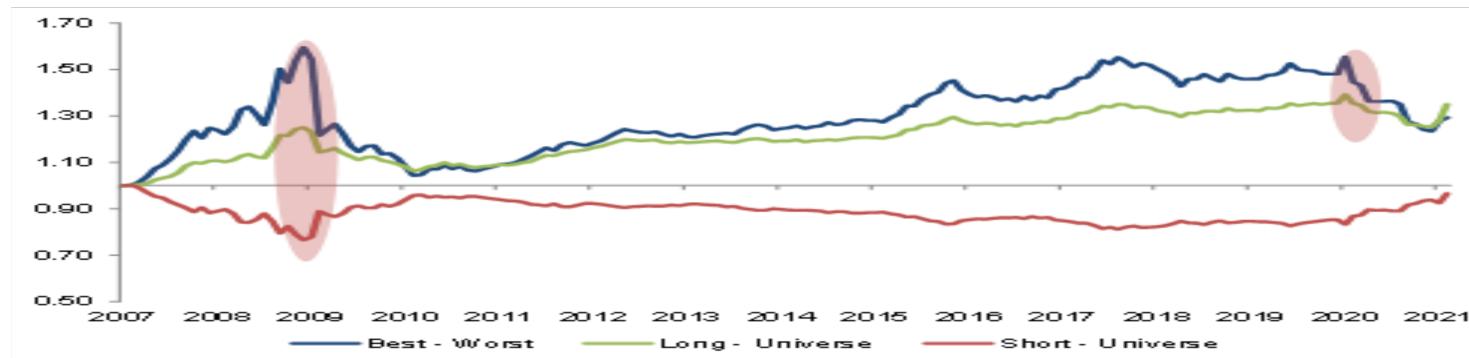


Source: Citi Research, MSCI, Standard & Poor's

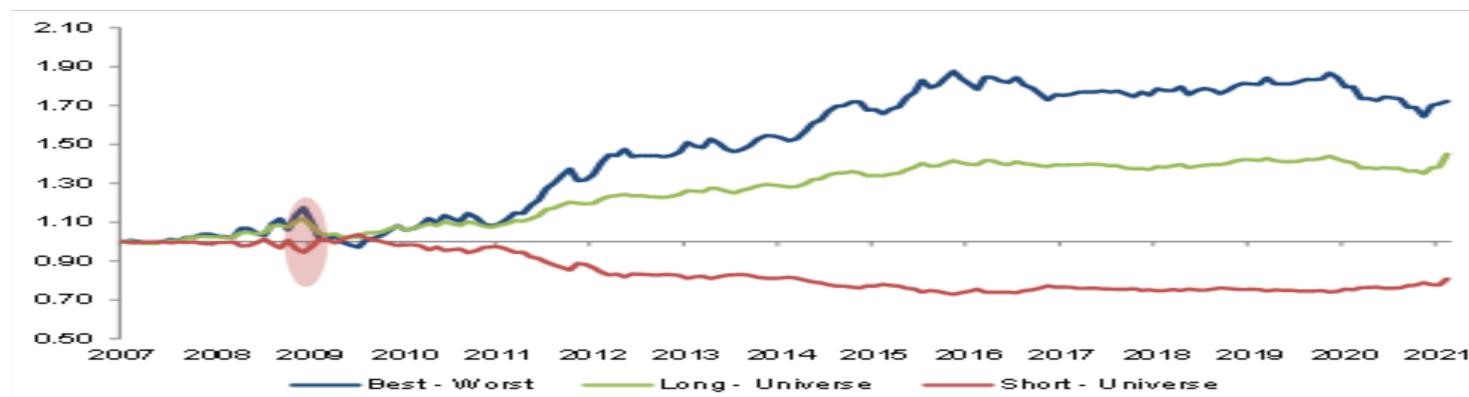
Short Interest Factor Performance

- Short Interest has experienced frequent bouts of underperformance in last 15 years, due to market regime shift and short squeeze.
- Both Price Momentum and Short Interest are often considered indicators of crowded positioning. Short Interest is a key input into our crowding scores for stocks and factors (see [VIEWPOINT | Measuring the Crowded Trade in Global Equities: Crowding performance consistent with styles in the US and Japan](#)).

US Short Interest Factor Performance (Excess Return, Long: Low Short Interest, Short: High Short Interest)



European Short Interest Factor Performance (Excess Return)



Source: Citi Research, Markit, MSCI

Intersection of Short Interest and Price Momentum

- A double screening process provides flexibility to study the interaction between Short Interest and Price Momentum.
- Low Price Momentum and Low Short Interest stocks (Oversold) have outperformed other cohorts since 1995.
- High Price Momentum and Low Short Interest stocks (Overbought) have delivered the best risk-adjusted return, mostly due to returns before 2008.
- Low Price Momentum and High Short Interest stocks (Crowded Shorts) have had the worst performance.

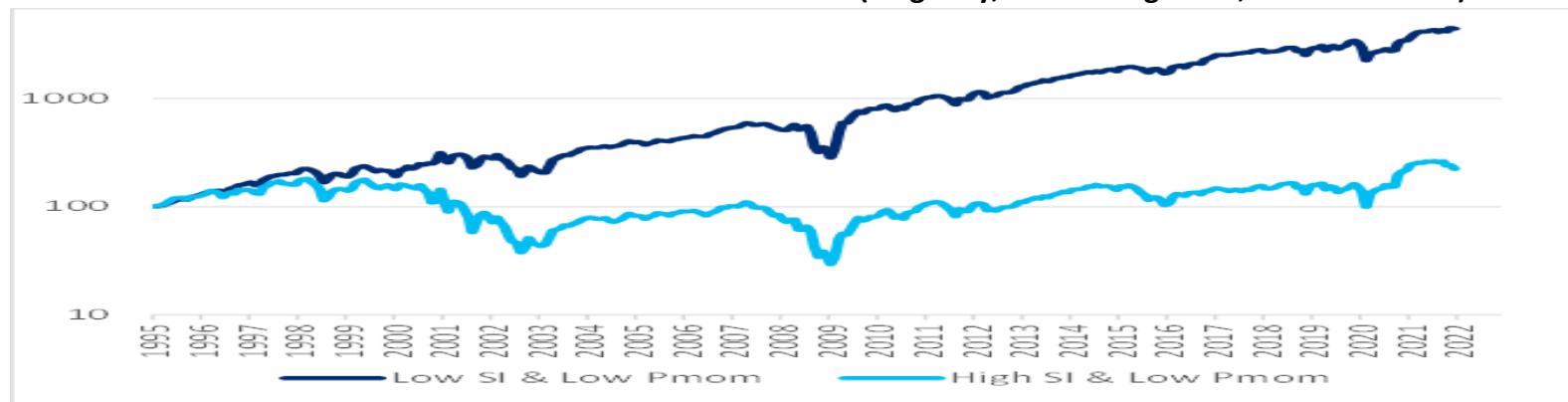
Average Return of SI vs. Price Momentum (Long-only)

		Short Interest (SI)			
		Low	Mid	High	ALL
Price Mom (PMom)	Low	16.6%	12.9%	7.4%	11.6%
	Mid	13.9%	13.2%	10.1%	12.7%
	High	15.1%	13.9%	13.5%	14.2%
	ALL	14.7%	13.5%	10.3%	

I.R. of SI vs. Price Momentum (US, since 1995)

		Short Interest (SI)			
		Low	Mid	High	ALL
Price Mom (PMom)	Low	0.75	0.53	0.25	0.45
	Mid	0.96	0.81	0.53	0.79
	High	1.04	0.81	0.65	0.83
	ALL	0.98	0.76	0.44	

Performance of Price Momentum & Short Interest Intersections (long-only, US exchange data, Mar'95 - Jan'22)



Source: Citi Research, FTSE Russell



Intersection of Short Interest and Price Momentum

Summary statistics of SI & Momentum Intersections (US exchange data, since 1995)

Annualized Turnover of SI vs. Price Momentum (Long-only)

		Short Interest (SI)			
Price Mom (PMom)	Low	Mid	High		
	Low	416%	456%	373%	
	Mid	439%	577%	444%	
High	275%	574%	340%		

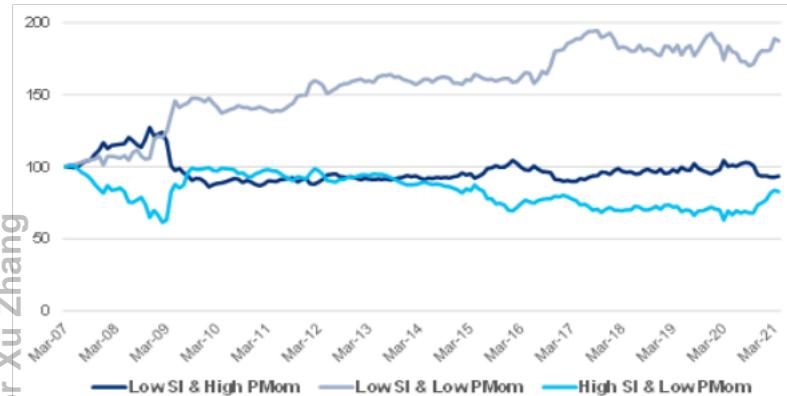
Avg. # of stocks of SI vs. Price Momentum

		Short Interest (SI)			
Price Mom (PMom)	Low	Mid	High		
	Low	84	104	136	
	Mid	129	110	85	
High	110	109	104		

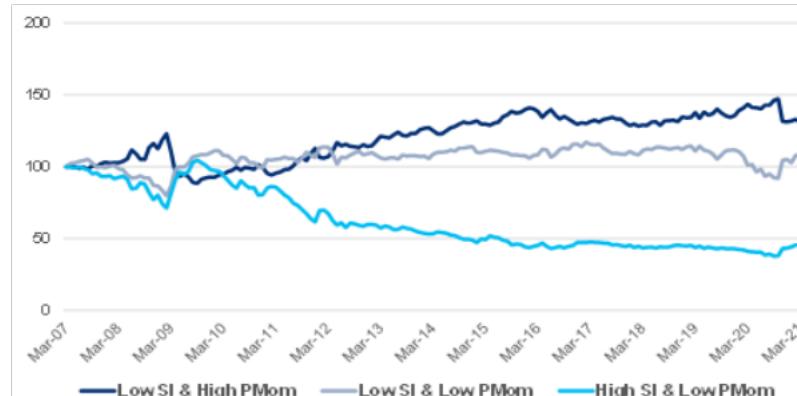
Source: Citi Research, FTSE Russell

Performance of SI & Momentum Intersections (Markit data, since 2007)

US performance (Excess return)



Europe performance (Excess return)



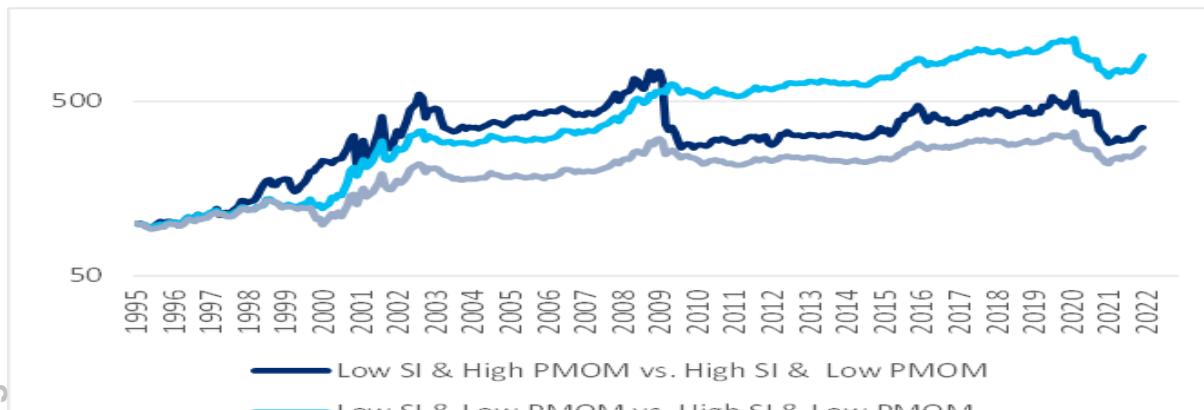
Source: Citi Research, MSCI, Markit

- More synchronized performance during the crisis periods suggests that Low Short Interest and Low Price Momentum (Oversold) and High Short Interest and Low Price Momentum (Crowded Shorts) stocks may work together in a combined long / short strategy.

Long/Short Oversold Strategy Performance (US Exchange Data)

- The long “Low SI and Low PMom”(Oversold) and short “High SI and Low PMom”(Crowded Shorts) strategy has outperformed other long/short combinations of SI and PMom intersections, helped by better performance during major crises.
- The result implies that the “Low SI and Low PMom versus High SI and Low PMom” strategy is an oversold strategy and is effectively similar to a long-term momentum reversal strategy.
- The result also suggests that the conventional “following shorts” strategy can be more effectively implemented among low Price Momentum stocks.

Performance Summary of Long/Short Price Momentum & Short Interest Intersections



US			
	Low SI & High PMOM vs High SI & Low PMOM	Low SI & Low PMOM vs High SI & Low PMOM	Low SI vs High SI
Annualised Return	7.7%	9.2%	4.5%
Annualised Volatility	23.3%	13.6%	12.3%
Information Ratio	0.33	0.67	0.36

Source: Citi Research, FTSE Russell



Long/Short Oversold Strategy Performance (Markit Data)

- We have similar conclusions for MSCI US and European stocks based on the Markit Short Interest data.

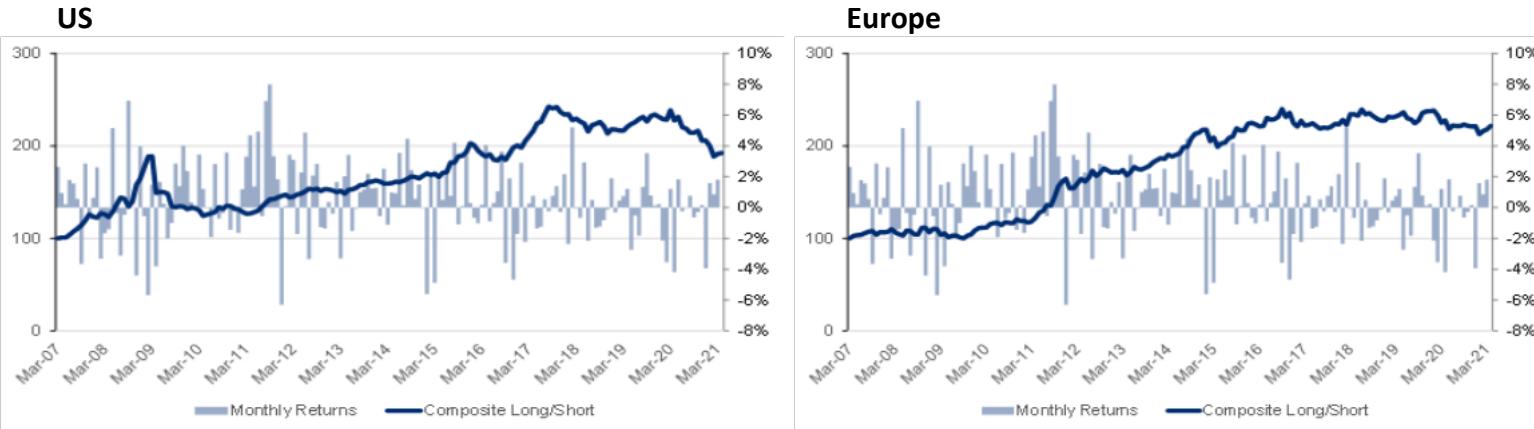
Performance Summary of Long/Short Price Momentum & Short Interest Intersections (2007 - 2021)

	US		Europe	
	Low SI & High PMom vs High SI & Low PMom	Low SI & Low PMom vs High SI & Low PMom	Low SI & High PMom vs High SI & Low PMom	Low SI & Low PMom vs High SI & Low PMom
Annualised Return	-2.1%	4.8%	5.2%	5.8%
Annualised Volatility	21.0%	10.9%	19.8%	8.5%
Information Ratio	-0.11	0.44	0.26	0.68
Hit Rate	55%	57%	60%	60%
Max Drawdown	64%	34%	55%	11%
Turnover (Long)	384%	456%	372%	432%
Turnover (Short)	283%	283%	312%	312%

Source: Citi Research, Markit, MSCI

Performance of Long/Short “Low SI & Low PMom vs. High SI & Low PMom” Strategy

Prepared for Xu Zhang



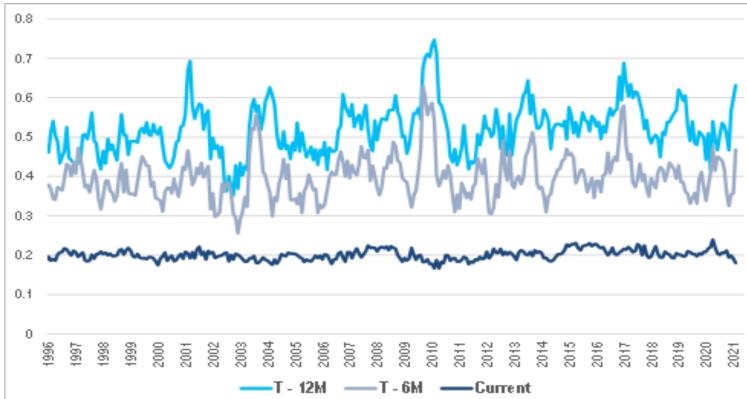
Source: Citi Research, Markit, MSCI



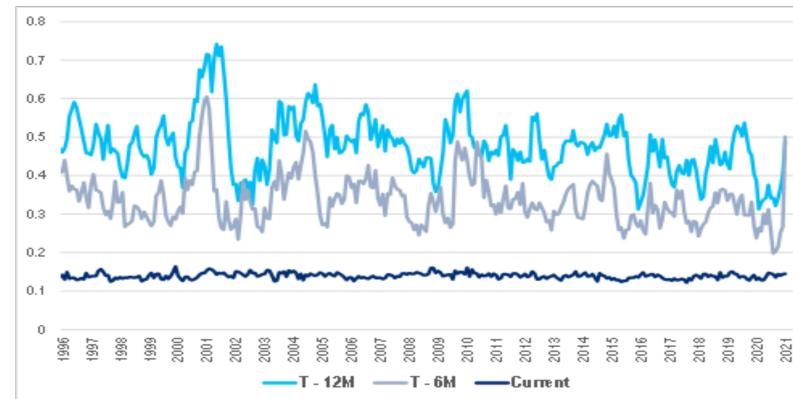
Momentum Characteristics of the Oversold Strategy

- Stocks on both long and short sides are the ones that used to have much higher momentum, but deteriorated over time.
- The momentum ranking tends to be higher for the long side than the short side.
- This suggests that the long side stocks may have bottomed out as the shorts have cashed out, and they may be ripe for a rebound.
- The short side continues to have lower momentum as their short interest stays high.

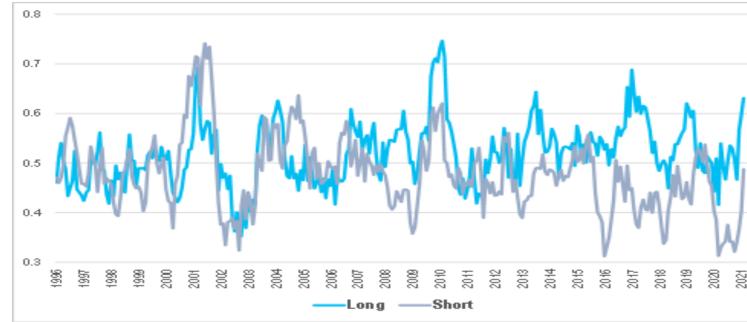
12M Momentum Characteristics of Long side



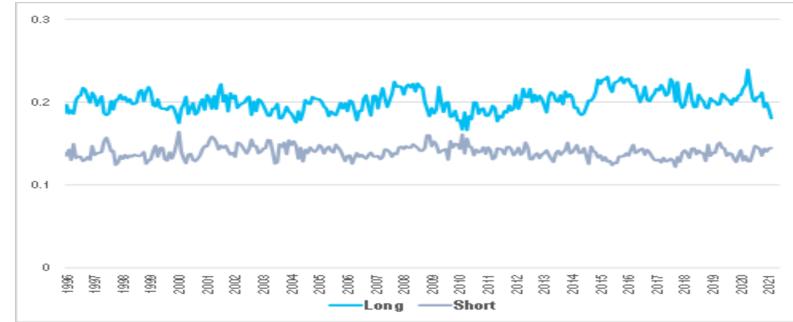
12M Momentum Characteristics of Short Side



12M Lagged Momentum Characteristics of Long vs Short



Concurrent Momentum Characteristics of Long vs Short

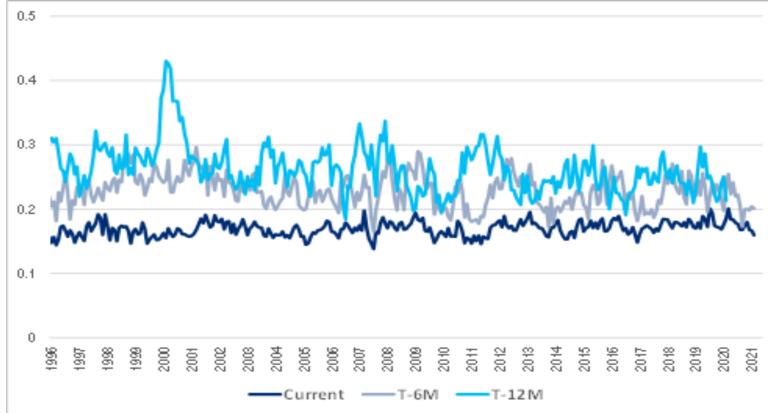


Source: Citi Research, FTSE Russell

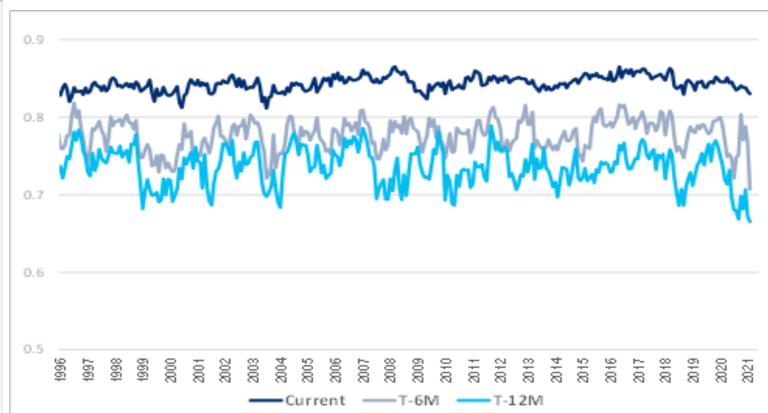
Short Interest and Valuation Characteristics of the Oversold Strategy

- Long side stocks used to have higher short interest 12 months ago, but have gradually decreased over time. Short side stocks used to have higher than average short interest to start with 12 months ago, and their short interests actually increased over time.
- This is consistent with the conventional wisdom of the “following shorts” strategy.
- Valuations for both sides are not significantly different most of time, suggesting this strategy may be different from the traditional value strategies.

Short Interest Characteristics of Long side



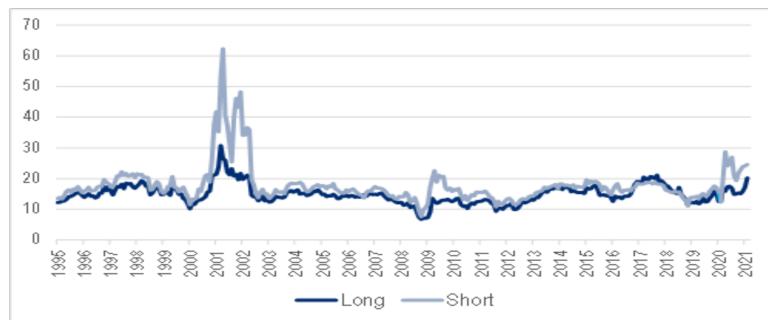
Short Interest Characteristics of Short Side



P/B Ratio of Long and Short Sides



FY1 P/E Ratio of Long and Short Sides



Source: Citi Research, FTSE Russell



Sector and Performance Attribution of the Oversold Strategy

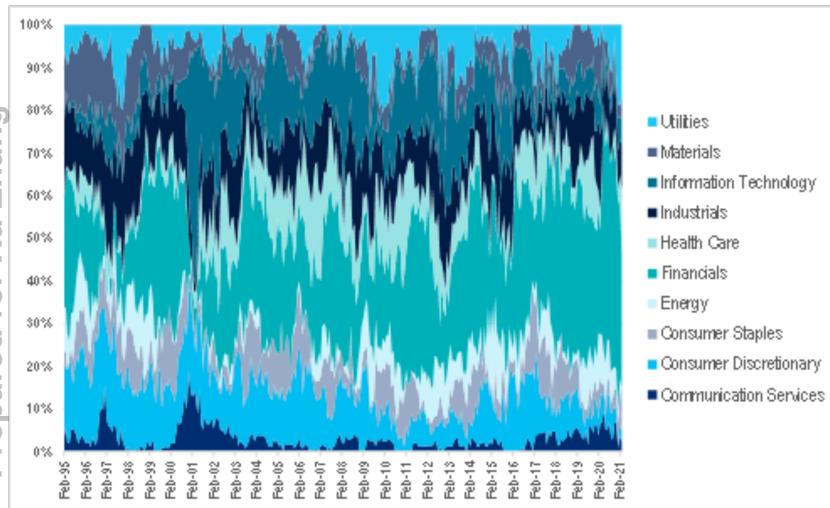
- Fama-French factor performance attribution analysis shows that the long/short strategies have the most consistent and significant exposures to Value and Quality. It has virtually no Price Momentum exposure in the US.
- The alphas are all statistically significant (60+ bps return per month).
- The strategy tends to overweight Financials on the long side and Consumer Discretionary on the short side.

Factor Attribution of the Long/Short Strategies

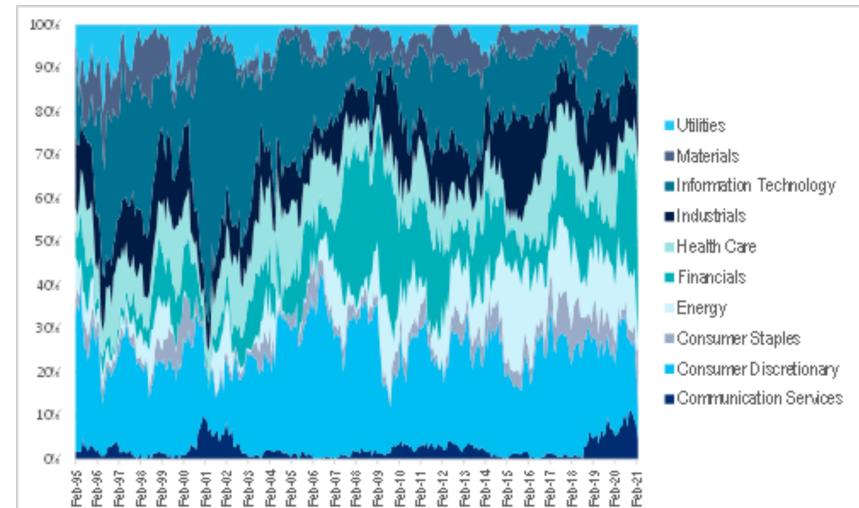
	Alpha	Beta / Risk Exposures						
		Market	Value	Size	Growth	Quality	Low Risk	Price Mom
Exchange US (since 1995)	0.65% ***	-0.11 **	0.22 ***	0.16 **	-0.08	0.43 ***	0.03	0.05
Markit US (Since 2007)	0.67% ***	-0.06	0.31 ***	0.46 ***	0.34 ***	0.21 *	-0.18 *	0.02
Markit Europe (Since 2007)	0.62% ***	-0.04	0.37 ***	0.00	-0.03	0.22 ***	0.05	0.22 ***

Superscripts ***, **, and * refer to the 1%, 5%, and 10% levels of statistical significance, respectively.

Sector Distribution of Long Side



Sector Distribution of Short Side



Source: Citi Research, FTSE Russell, MSCI, Markit

Conclusions

- Both Price Momentum and Short Interest strategies have experienced frequent bouts of underperformance, often associated with crowded positioning, due to market regime shift and short squeeze.
- With an intersection approach, we have found that stocks with High Short Interest and Low Momentum have consistently underperformed the market in both the US and Europe. A strategy of long Low Short Interest and Low Momentum stocks and short High Short Interest and Low Momentum stocks has produced the best risk-adjusted return in both US and Europe.
- The long/short oversold strategy has outperformed both stand-alone Price Momentum and Short Interest strategies. This suggests that the so-called “following shorts” strategy should be implemented among Low Momentum stocks to mitigate short squeeze risk.
- The oversold strategy is not predicated on oversold conditions of the broad market. However, it has worked better during volatile periods and delivered positive returns in the last six consecutive months.
- Attribution analysis shows that the long/short oversold strategy has a statistically significant 60+ bps monthly alpha, in addition to positive biases toward Value and Quality. It is effectively an oversold strategy that captures the benefit of momentum reversal with less downside risk.

6. Practical Considerations in Building Neural Networks for Stock Selection

Searching for Alpha: Deep Learning

Investing Framework

- Stock selection via one-month-ahead return forecasting (i.e., cross sectional)
- MSCI World universe, long/short portfolio with monthly rebalance
- 48 Fundamental, Risk and Macro factors used as Predictors. Data from 1995 to 2021.
- Stock-specific factors are percentile ranked within [0,1], Sector and Region Neutral.

Macro, Risk and Fundamental Factors

Macro / Technical Factors	Fundamental Factors	
Size Squared Returns	Earnings Yield (12 month Forward)	Earnings Yield (12 month Historical)
Price Mo Squared Returns	Cash Flow to Price	Dividend Yield
1M Returns	Book to Price	Sales to Price
RSI (14 days)	EBITDA to EV	Sales to EV
Volumes	Earnings Growth (12 month Forward)	S&P Growth-Value Score
Oil	1-Year Sales Growth	Long Term Earnings Growth
DXY	1-Year EPS Growth	1-Year DPS Growth
GSCI	3 Month Volatility Adj Price Trend	12 Month Volatility Adj Price Trend
JPY	First 11 Month Volatility Adj Price Trend	FCFY
VIX Index	1 Month Change in Earnings Forecasts	Earnings Revision
Credit Spread	Sales Revision	Cash Revision
Correlation	Equity to Debt	Earnings Stability
Dispersion	Beta against MSCI AC World	Beta against MSCI Country Index
	Earnings Certainty	ROE
	Net Profit Margin on Sales	Margin Growth
	Earnings Quality (Accruals)	Balance Sheet Quality (NOA)
	Market Capitalization (log)	Liquidity Ratio
	6M Price Volatility	

Source: Citi Research

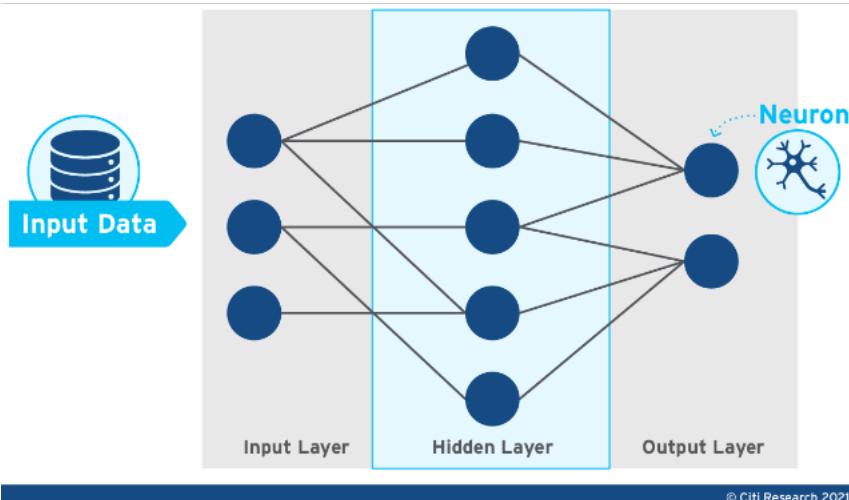
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How Does it Work

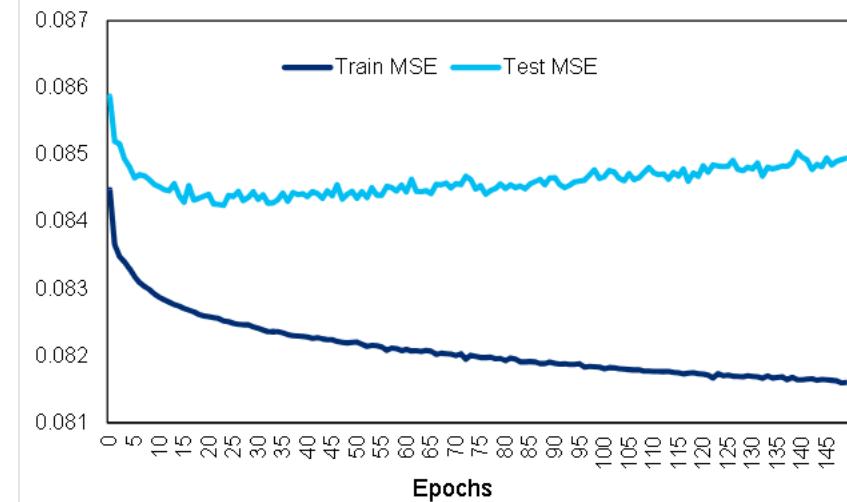
- Modern Neural Networks consists of neurons arranged into layers in a sequential fashion
- Each neuron consists of a set of weights (plus a constant) that are multiplied to the inputs (i.e., logistic regression)
- The input data enter the first layer of neurons, the weights are applied, and their outputs enter the second set of neurons.
- The output of the last layer is used to compute a loss function (i.e., to measure how good the predictions are). Based on this, the weights are adjusted accordingly, and a new iteration (epoch) is carried out.

Prepared for Xu Zhang

Shallow Network



Model Errors vs. Epochs



Source: Citi Research

Source: Citi Research

Searching for Alpha: Deep Learning

Model Set-Up and Hyperparameter

- While computation is made easy by readily available libraries, many decisions (including choices of techniques) need to be addressed, typically referred to as hyperparameters, when setting up a neural network.
- Three groups of key hyperparameters:
 - **Architecture and Learning Capacity (to reduce bias)**
 - Output form: discrete or continuous. We choose continuous output as the objective here is to forecast relative return ranking of stocks. However, CS literature suggests considering discrete output first whenever possible.
 - Number of hidden layers;
 - Number of neurons in each layer;
 - Choice of activation function (e.g., Rectified Linear Unit (ReLU) is a common choice);
 - Training set size.
 - **Optimization (to fit the data)**
 - Loss function (MSE or R2 are most commonly used, but we also explore alternatives such as IC);
 - Optimization algorithm (we choose ADAM, a popular choice in CS literature);
 - Learning rate (often considered the single most important hyperparameter by CS experts)
 - Learning rate decay;
 - Weight initialization (key source for instability/repeatability issue);
 - Mini-batch size and Batch normalization.
 - **Regularization (to reduce variance and control overfitting)**
 - Dropout;
 - L1/L2 regularization;
 - Early stopping (patience/upbound of epochs, the number of iterations used in the gradient descent).

Searching for Alpha: Deep Learning

Challenges in Tuning Hyperparameters

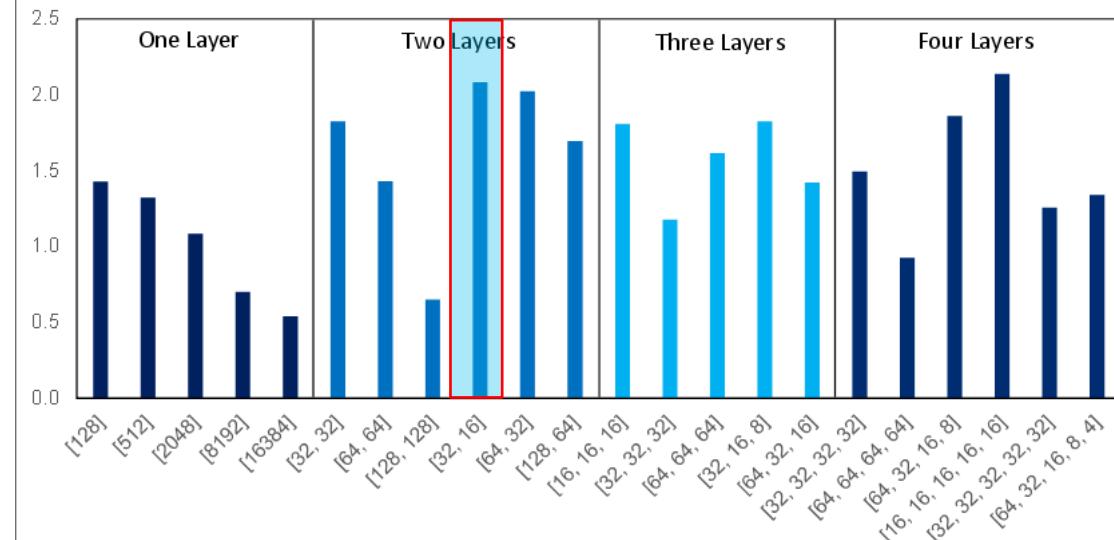
- There are a large number of hyperparameters to tune, and many of them are often interconnected (i.e., changing one might impact the others), making it difficult and computationally expensive to tune Neural Networks.
- Little theoretical or empirical guidance exists regarding what algos/techniques may be better suited for different datasets. Most algos are designed to handle cross-sectional data, with no consideration of the time dimension, which is critical in investment decisions.
- Some have suggested applying a grid search to find an optimal set of hyperparameters, which can be computationally very expensive. Random search algos have been proposed to improve the search process.
- Ideally, the data set should be split into three subsets: Training, Validation/In-sample Testing and Out-of-sample Testing
- We adopt the “orthogonalization” approach, focusing only on one hyperparameter at a time while holding everything else constant to identify and explore sensitivities of key hyperparameters. This may lead to an iterative process of tuning.
- In order to identify more sensitive hyperparameters and to keep the testing environment plain while maintaining feasible computational time, we tested hyperparameters using a static framework with ten years of data in training and ten years in testing/validation.

Searching for Alpha: Deep Learning

Architecture

- With “architecture,” we refer to the number of Layers and Neurons within each layer.
- We tested multiple architectures, looking for a “even or pyramid pattern.”
- Instead of MSE, we use standardized monthly IC as the validation metric to choose the two hyperparameters.
- The empirical result favors less complex architectures, and we selected two layers with 32 and 16 neurons, respectively (consistent with some similar academic studies).

Figure 1. Model Performance with Different Layers



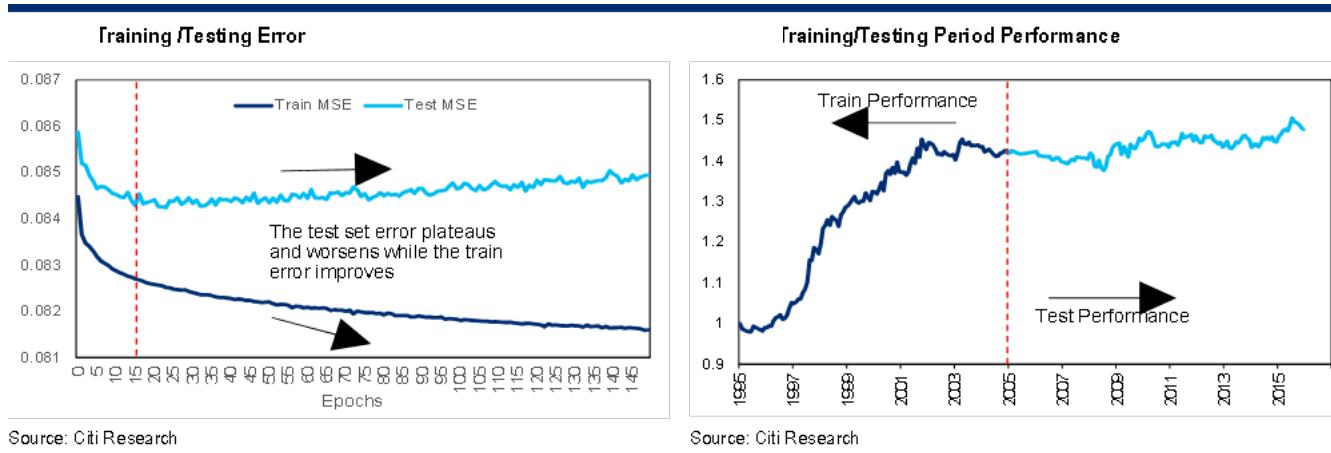
Source: Citi Research

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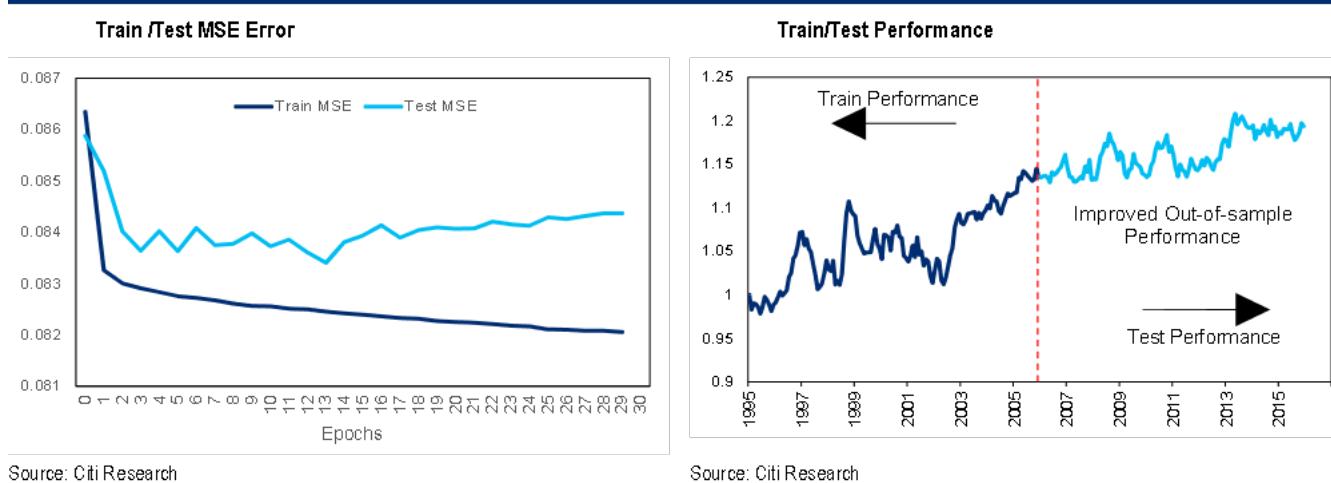
Learning Rate and Epochs

Small learning rate may be needed in this case, indicating sensitivity of the hyperparameter.

- LR = 3e-4, often set as the default for ADAM optimizer



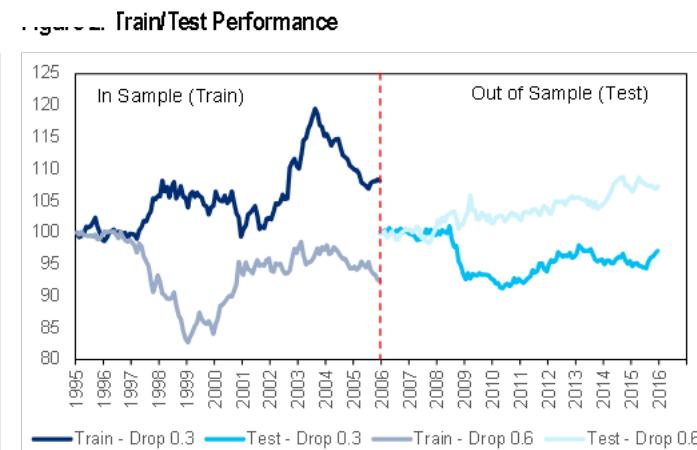
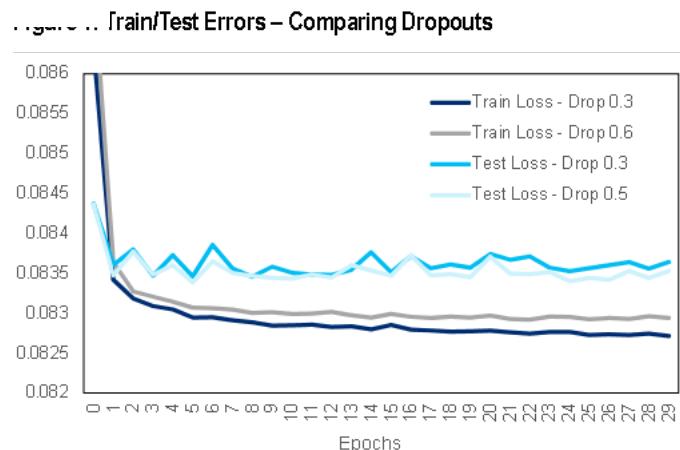
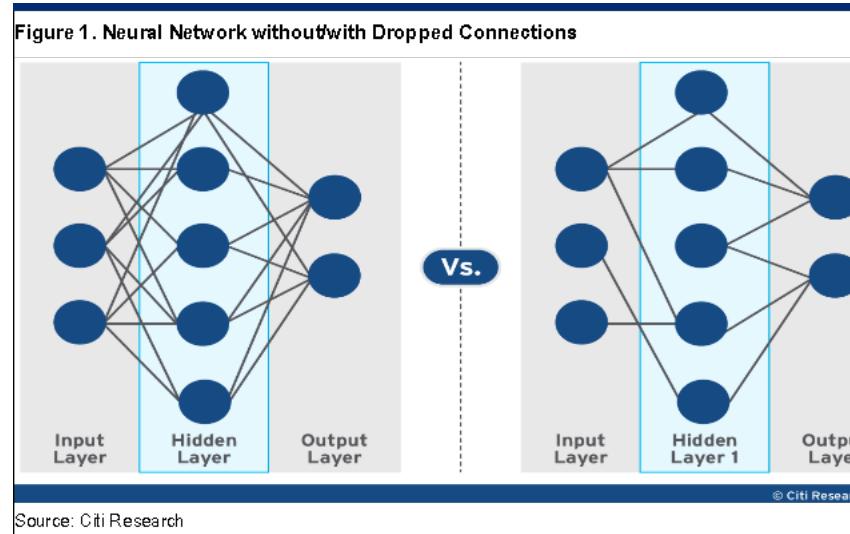
- LR = 3e-7



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Dropout

Higher dropout leads to better testing result, suggesting noisy data/unstable system and ease of overfit.

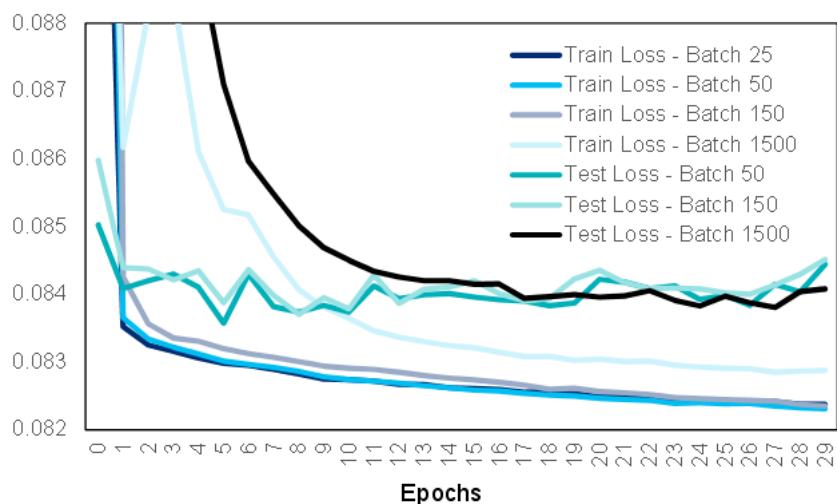


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Batch Size

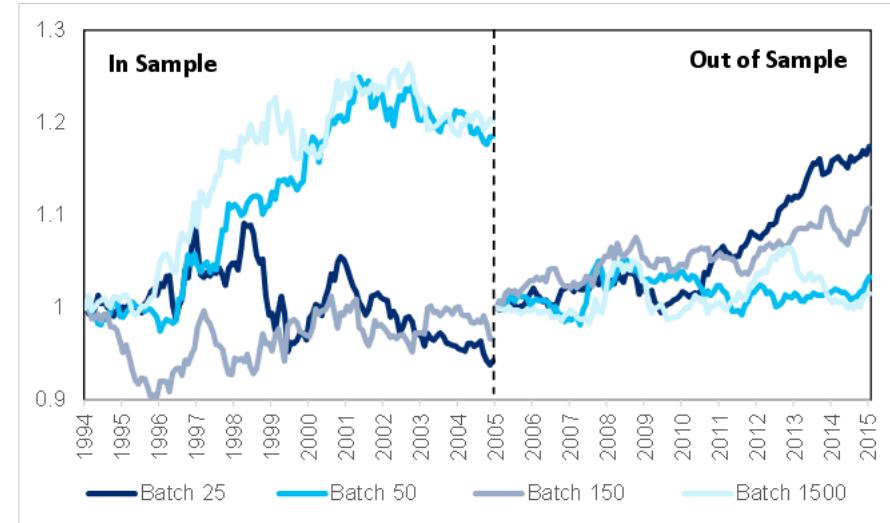
- A bigger batch size may not help, as our dataset is relatively small.
- It is difficult to take the time dimension into consideration in creating batches.
- There is no need for higher epoch upbound (patience).

Train/Test Errors - Comparing Batch Sizes



Source: Citi Research

Train/Test Performances vs. Batch Size



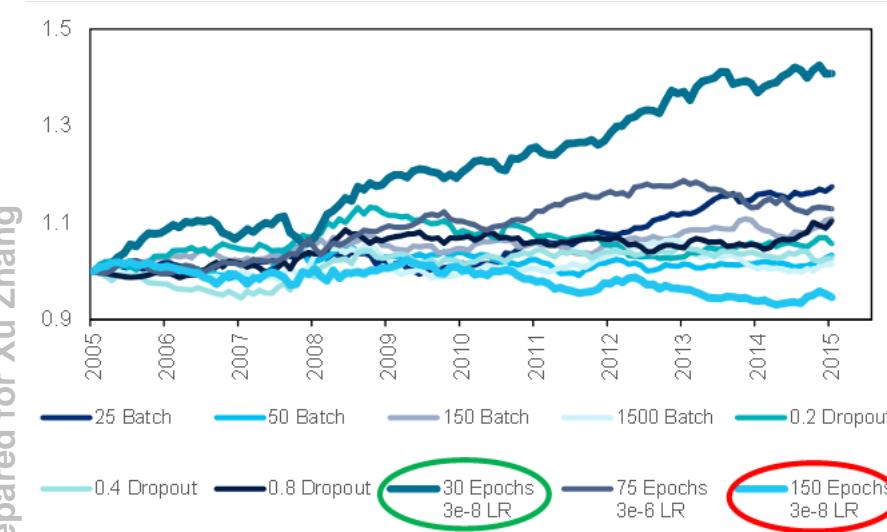
Source: Citi Research

Searching for Alpha: Deep Learning

Comparison with Various Settings of Hyperparameters

- We focus on Learning Rate and Epochs#, Dropout and Batch Size
- We tested different values while holding other parameters constant.
- A less complicated architecture (i.e., less overfitting) tends to deliver better results.
- Backtests are very unstable.

Wealth Curves for Various Hyperparameters



Source: Citi Research

Performance of Hyperparameter Settings

	Ann. Avg Return	Ann. Volatility	IR	Hit Rate	Min	Max
25 Batch	1.6%	2.1%	0.79	60%	-1.8%	1.9%
50 Batch	0.4%	2.2%	0.16	52%	-1.9%	2.5%
150 Batch	1.0%	2.1%	0.50	54%	-1.4%	1.6%
1500 Batch	0.2%	2.3%	0.08	54%	-2.5%	2.6%
0.2 Dropout	0.6%	2.5%	0.24	51%	-1.8%	2.5%
0.4 Dropout	0.3%	2.4%	0.12	45%	-1.6%	2.4%
0.8 Dropout	1.0%	2.3%	0.45	57%	-1.3%	2.1%
30 Epochs, 3e-8 LR	5.4%	3.8%	1.42	65%	-3.1%	4.2%
75 Epochs, 3e-6 LR	1.2%	2.3%	0.55	53%	-1.9%	1.8%
150 Epochs, 3e-8 LR	-0.5%	2.5%	-0.21	44%	-1.6%	2.5%

Source: Citi Research

Searching for Alpha: Deep Learning

Main Takeaways on Hyperparameter Tuning

- Results are very sensitive to many hyperparameter settings, and it is often difficult to find stable patterns.
- Neural Networks are keen to overfit our dataset: this could be due to not having enough data (compared to typical NN applications) and / or to the nonstationary nature of financial time series.
- Different parameter values often perform very differently across different out-of-sample periods, particularly after the GFC. (This finding is somewhat understandable given our experiences with significantly increased macro influences on factors and the broad market).
- We may need to tune hyperparameters frequently in order to improve results. In the end, we adopt the approach of using a rolling ten-year training period and one-year validation, and we re-tune hyperparameters annually to generate the final out-of-sample backtests.

Searching for Alpha: Deep Learning

Stability / Repeatability Issue: A Potential Business Risk

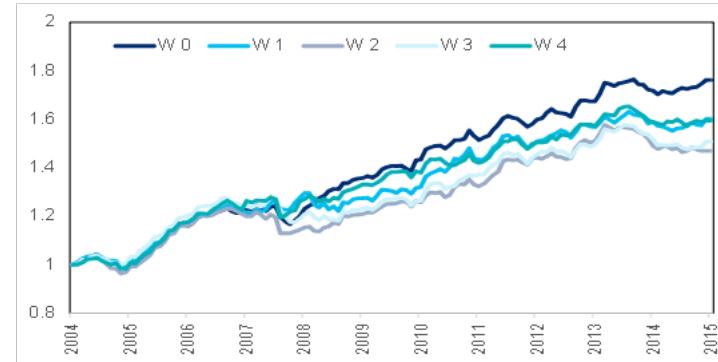
- Initial weight setting, in theory, should not be a big concern in a stable system with high signal-to-noise ratio. However, in many real world applications, the optimization can often lead to local minima quickly, resulting in very different predictions with different random seeds.
- In our dataset, the average cross-sectional correlation between forecasts from different initial weights is quite low (between 0.5 and 0.6), and the resulting out-of-sample performances are marked differently after the GFC.

Cross-sectional Correlation of return forecasts from five weight initializations

	W 0	W 1	W 2	W 3	W 4
W 0	1.00	0.56	0.58	0.57	0.58
W 1		1.00	0.58	0.55	0.56
W 2			1.00	0.59	0.60
W 3				1.00	0.57
W 4					1.00

Source: Citi Research

Backtest performance of the NN model with five weight initializations



Source: Citi Research

Searching for Alpha: Deep Learning

Ensembling

- We aim to gain stability via ensembling.
- We average the predictions from several model runs with the same hyperparameters but different weight initializations.
- With our dataset, averaging over ten initializations can lead to high cross-sectional correlations with much more stable forecasts.

Cross-sectional Rank Correlation – Ensemble of 5 runs

	W0	W1	W2	W3	W4
W0	1.00	0.89	0.90	0.90	0.91
W1		1.00	0.91	0.90	0.90
W2			1.00	0.90	0.90
W3				1.00	0.91
W4					1.00

Source: Citi Research

Cross-sectional Rank Correlation - Ensemble of 10 runs

	W0	W1	W2	W3	W4
W0	1.00	0.95	0.95	0.95	0.94
W1		1.00	0.95	0.95	0.96
W2			1.00	0.95	0.95
W3				1.00	0.95
W4					1.00

Source: Citi Research

Searching for Alpha: Deep Learning

Deep Learning Ensemble – Backtesting and Performance

- Rolling window, ensemble model of ten neural networks.
- Ten years of training and one year validation
- Hyperparameters re-tuned every year (in January)
- Long/short quintile portfolio
- Monthly rebalance

Searching for Alpha: Deep Learning

Deep Learning Ensemble – Backtesting and Performance

- Sharpe ratio is 0.94, and annualized average return on a Long Short basis is 5%.
- Drawdowns are significantly mitigated.
- Performance has a slight low beta bias.

Final Ensemble Model Backtest Performance



Performance Metrics of Final Ensemble Model

	MSCI World	Deep Learning Long Short	Deep Learning Long Only
Annualised Avg Return	5.7%	5.0%	9.3%
Annualised Volatility	14.4%	5.3%	18.5%
IR	0.40	0.94	0.51
Hit Rate	64%	68%	61%
Min	-16.5%	-4.9%	-24.8%
Max	11.8%	5.5%	16.4%

Source: Citi Research

Final Ensemble Model: Two Year Rolling Correlation vs MSCI World



Searching for Alpha: Deep Learning

Conclusions

- A large set of hyperparameters poses a major challenge for building a neural network for stock selection. Neural Network (NN) models are prone to overfit financial data in-sample and may result in poor out-of-sample predictions.
- Learning rate, dropout and batch size are among the most sensitive hyperparameters. Frequent hyperparameter tuning may be needed to build an effective NN stock selection model.
- “Deep” models are not necessarily required for this type of application. A shallow network of two or three hidden layers works reasonably well.
- Instability and unrepeatability of NN models is another major concern. We propose an ensemble approach to mitigate the risk and instill confidence in the model output.
- The out-of-sample performance of our NN model is somewhat comparable to the results from our Random Forest models (see [Searching for Alpha: Machine Learning: Beyond Random Forest for Stock Selection](#) and [Searching for Alpha: Machine Learning: SHAP Value as Factor Selection Criterion](#)).
- The NN model can be fine-tuned further, and more sophisticated algorithms can be explored to take the time series property of our dataset into consideration.

7. Applying Machine Learning to Pairs Trading

Key Considerations in Pairs Trading

Introduction

Pairs trading models come down to two stages:

1. Identifying the pairs universe – i.e., the stocks that “move together.”
2. Defining a trading rule that triggers the buy/sell signals when pairs diverge / reverse

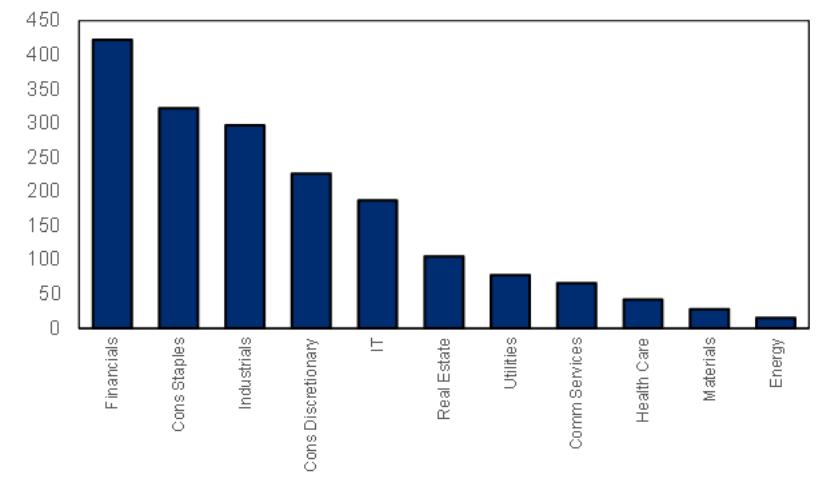
In this research, we review two standard approaches to pairs identification (Distance Method versus Correlation/Co-integration) and a ML-based trading rule that incorporates stock fundamentals, risk characteristics and macro environment indicators.

Construction of Pairs

Testing Environment

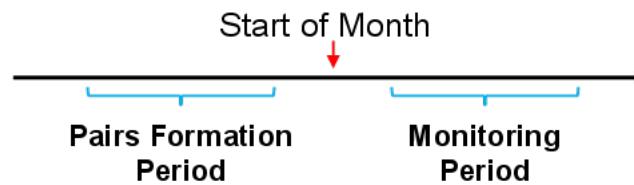
- MSCI US and MSCI Europe
- Screen for pairs within each GICS Industry Group
- Six months “monitoring period” to trade selected pairs

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Source: Citi Research, MSCI

Formation and Execution Time Frames



Source: Citi Research, MSCI

Previous Pairs Models

Common Approaches

Pair Identification Measures:

- Correlation
- Co-integration (using ADF test)

Trading Rules:

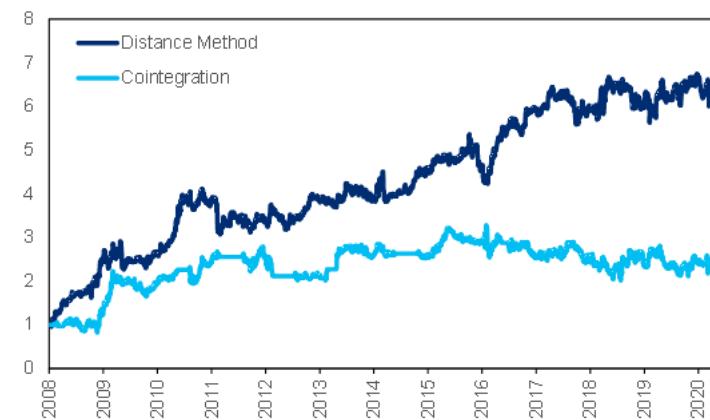
- Open trade based on wide spread (spread $> 2.5\sigma$ from its historical equilibrium)
- Set stop loss (at 25%) and maximum holding period (three months)
- Close trade when the spread reverts to equilibrium

Performance Comparison

New Pair Identification Process: Distance Method

- Distance Method:
 - Cumulative squares of return spreads of pairs
 - Positive correlation between the pair
- Distance method has delivered higher return and risk-adjusted performance.
- Co-integration provides less volatility.
- Performances has declined in recent times.

Distance Method and Cointegration – Historical Performance



Performance Summary Statistics

	Distance Method	Cointegration
Annualised Return	15.7%	6.5%
Annualised Volatility	19.2%	16.7%
IR	0.82	0.39
Min	-7.0%	-8.6%
Max	9.9%	8.7%

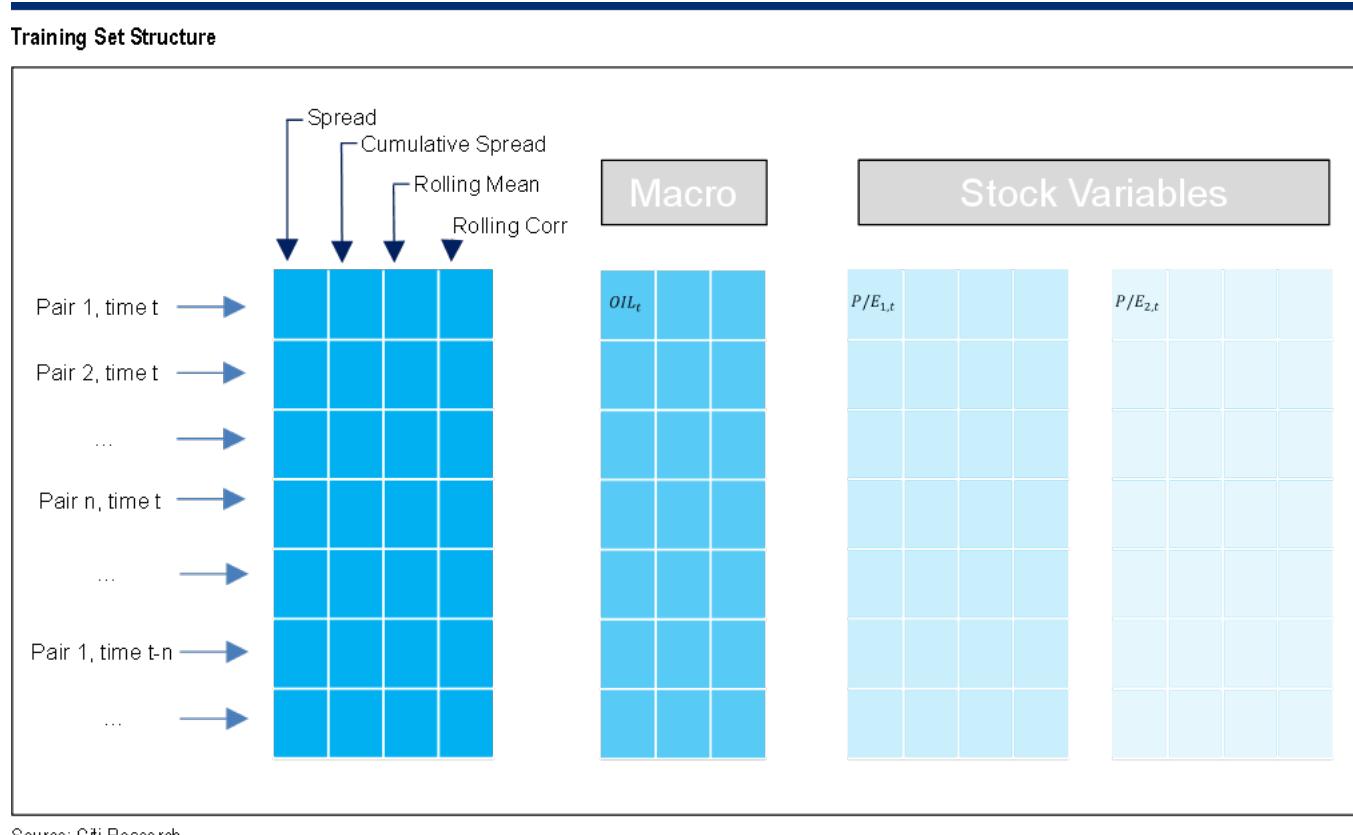
Source: Citi Research

New Entry/Exit Approach

Introducing Random Forest Modelling

Goals:

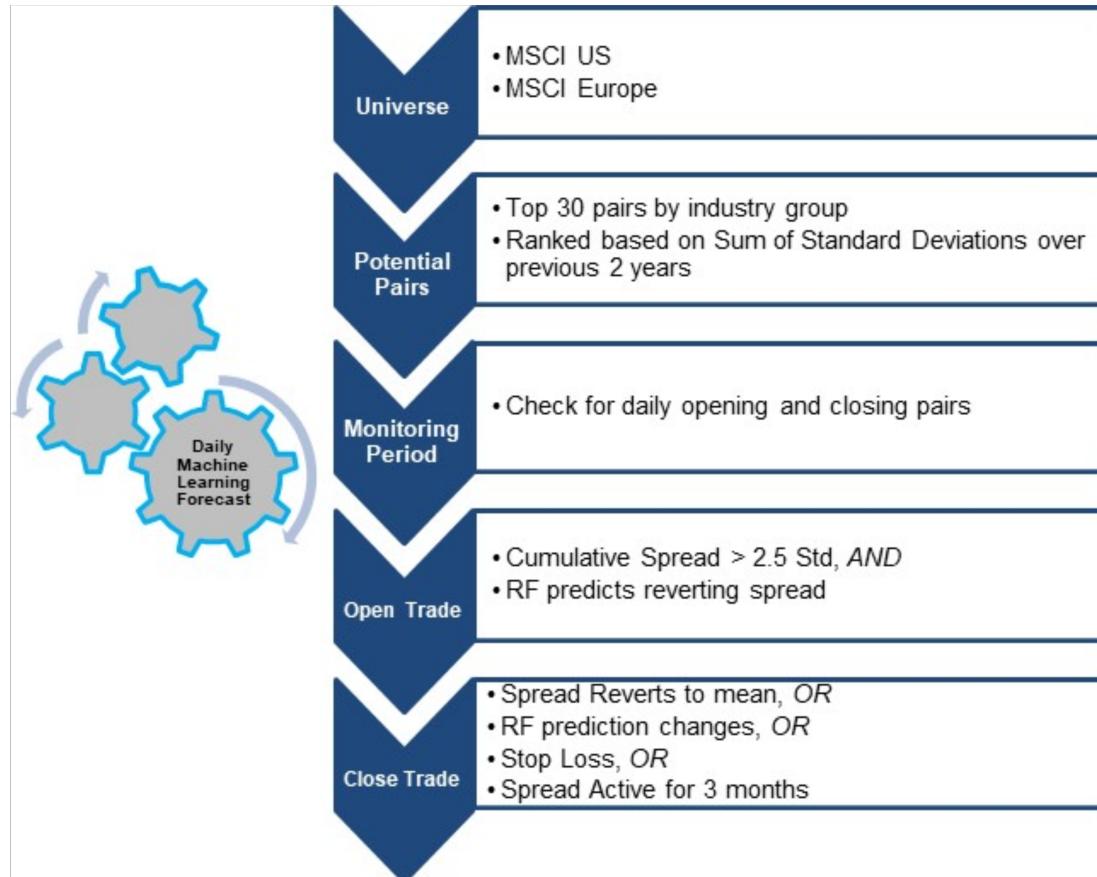
1. Model the mean reversion pattern of the pairs spread.
2. Incorporate stock fundamentals, risk characteristics and macro indicators.



New Pairs Construction Process

Including RF Triggers

Pairs Strategy Flow Chart

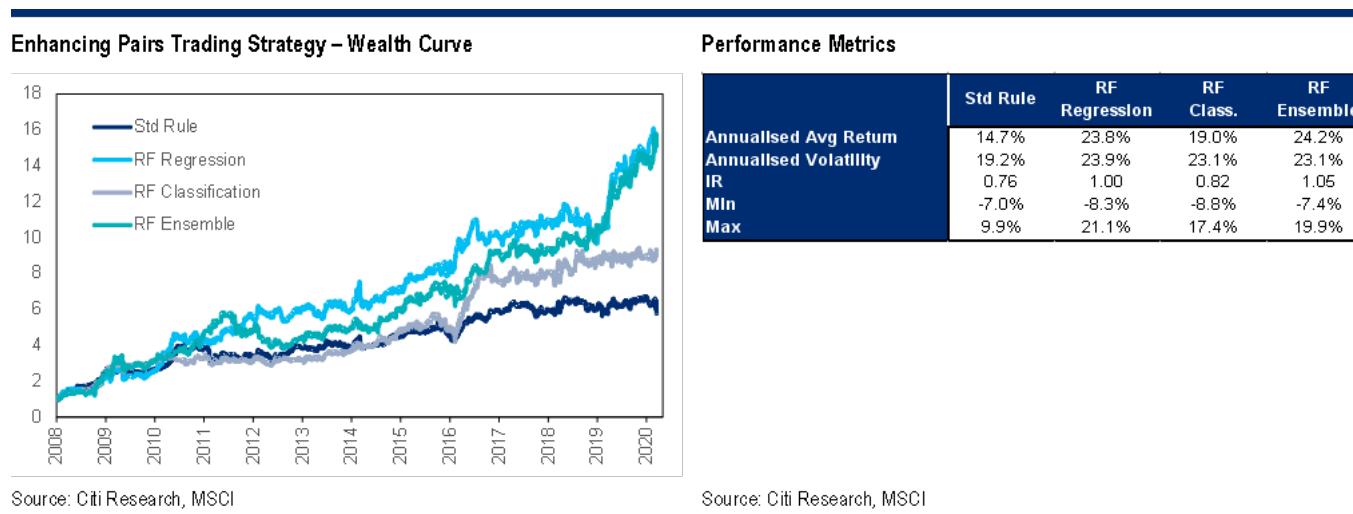


Source: Citi Research

Entry/Exit Triggers

Performance Comparison

- Both regression and classification approaches outperformed the “standard” rules.
- Strong performance has occurred in recent times.
- We tested for an ensemble of regression/classification, but the added complexity is probably not worth it.



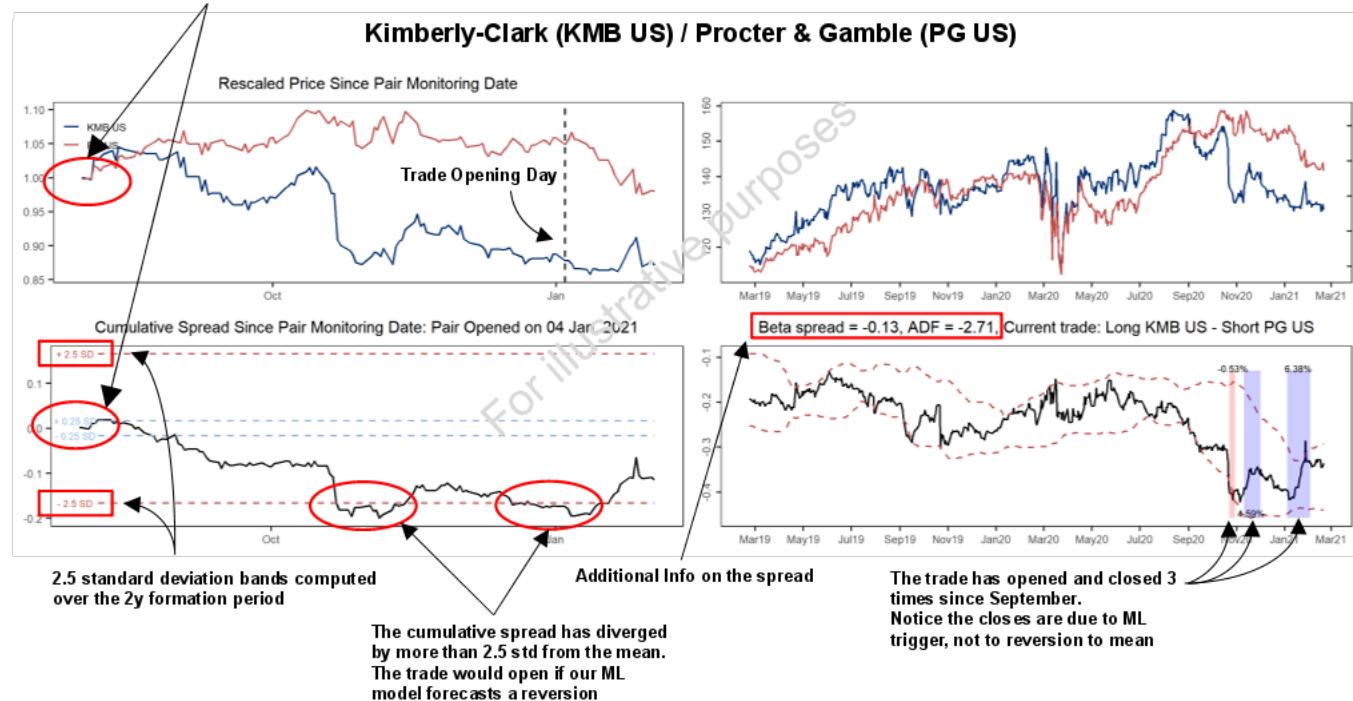
Daily Report Details

Pair Monitor

- Spread evolution
- Two-year summary price action
- Trades and profits/losses on the same pair over the last two years

Example of Specific Pair Monitoring charts

The price series and the spread are re-scaled at the beginning of the monitoring period



Source: Citi Research. Note: this is provided as guide on how to read the report and should not be considered as a current investment view.

8. Inferred ESG Ratings Data

Quantitative ESG Investing

Exploiting AI-Driven ESG Data

- ESG research using an AI-driven ESG dataset provided by TruValue Labs (TVL).
- Acceleration in the ESG investment landscape has led to growth in the number and variety of data providers.
- There are several pros and cons related to ESG data providers; the common conundrum is which one (or ones) to use.

We examine the characteristics of TVL data and its return-generating efficacy:

- For long-short strategies
- For long-only portfolios
- Versus strategies based on standard ESG ratings

Fundamentally, what is the value-add from utilizing a machine learning-driven approach to assess firms from an ESG perspective?

A Broader Choice of Data Providers

- The market is inundated with third-party ESG data providers that now offer better coverage and improved breadth, some of which offer data on very specific topics.
- We classify ESG data providers into three types:
 1. Subjective Ratings providers
 2. Inferred Ratings providers
 3. Reported Data providers
- Common criticisms of traditional ESG datasets include subjectivity, non-independence and a lack of robustness.
- In previous analysis, we focused on one specific data provider that falls into the Subjective Ratings providers category, and in this discussion, we focus on data from an Inferred Ratings provider called TruValue Labs (TVL).

What do we require from ESG data?

- We require a contemporaneous and historical perspective on individual firms' ESG credentials and their respective standing among their peers.
- We look for a forward-looking view or forecast of where a firm is heading from an ESG perspective.
- TVL data, in theory, is better placed to represent the first point; the second point is still to be formalized.

TruValue Labs' ESG Scores

Score Types and Categories

- The TVL dataset contains performance, trend and volume scores relating to 26 ESG categories.
- The categories are directly linked to those that SASB deems to be material to different industries.
- TVL provides four datasets:
 1. Pulse scores
 2. Insight scores
 3. Momentum scores
 4. Volume scores

The 26 SASB Categories Companies are Scored Against

ESG Dimension	General Issue Category
Environment	GHG Emissions Air Quality Energy Management Water & Wastewater Management Waste & Hazardous Materials Management Ecological Impacts
Social Capital	Human Rights & Community Relations Customer Privacy Data Security Access & Affordability Product Quality & Safety Customer Welfare Selling Practices & Product Labeling
Human Capital	Labor Practices Employee Health & Safety Employee Engagement, Diversity & Inclusion
Business Model & Innovation	Product Design & Lifecycle Management Business Model Resilience Supply Chain Management Materials Sourcing & Efficiency Physical Impacts of Climate Change
Leadership & Governance	Business Ethics Competitive Behavior Management of the Legal & Regulatory Environment Critical Incident Risk Management Systemic Risk Management

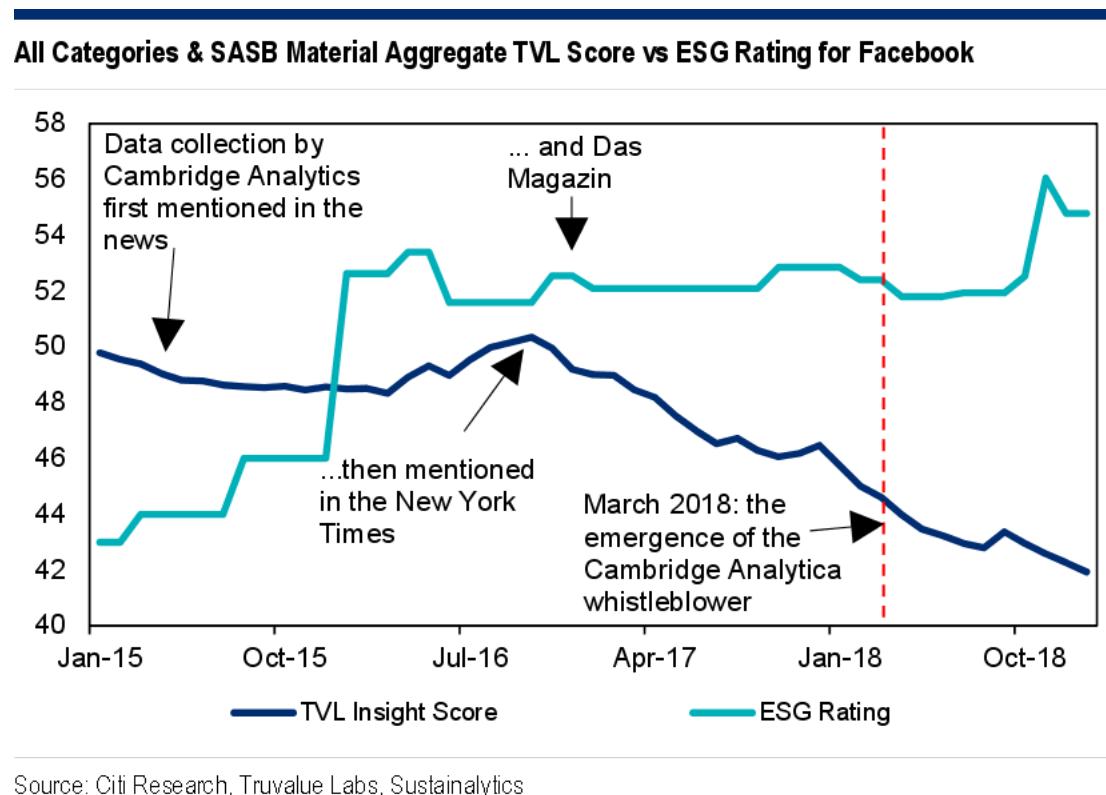
Source: Citi Research, SASB, Truvalue Labs

- For each set of scores, numbers are provided for individual categories as well as for two aggregate scores.
- The aggregate scores are volume-weighted category scores that either incorporate every single category (in the table above, All Category Insight, for example) or account only for those categories that SASB deems to be material to the industry in which the company resides.

A Company-Specific Example

Where TVL Scores Differ from Subjective Ratings Data

- We show below the aggregate TVL Insight score as well as a standard ESG rating for Facebook (now Meta) over the period from January 2015 to November 2018.



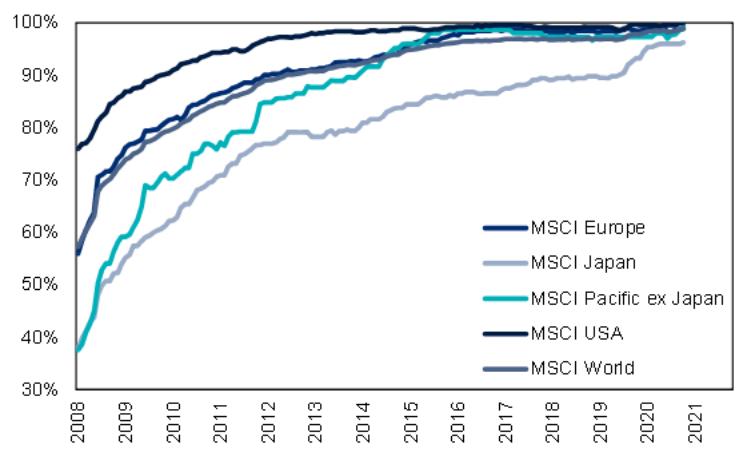
- This sequence of events is clearly being picked up by the TVL data but is not having a significant impact on its subjective ESG rating from another data provider.

TruValue Labs ESG Scores

Coverage

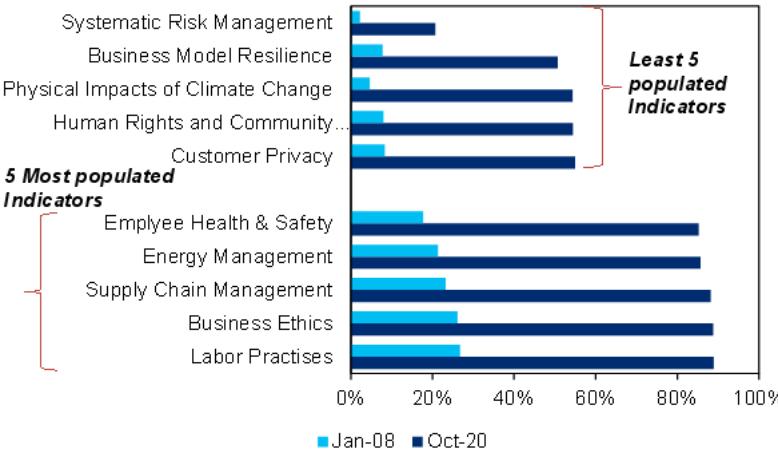
- Similar to the history provided by standard ratings data providers, TVL ESG data goes as far back as January 2008.
- For global developed indices, coverage of TVL Insight scores is approximately 37% at the earlier end of the data history but improves following 2010 and is almost 100% for all global regions as of 2020.

Global coverage of TVL's Weighted Insight Score Data



Source: Citi Research, Truvalue Labs

TVL Insight Category Coverage for MSCI World Stocks



Source: Citi Research, Truvalue Labs

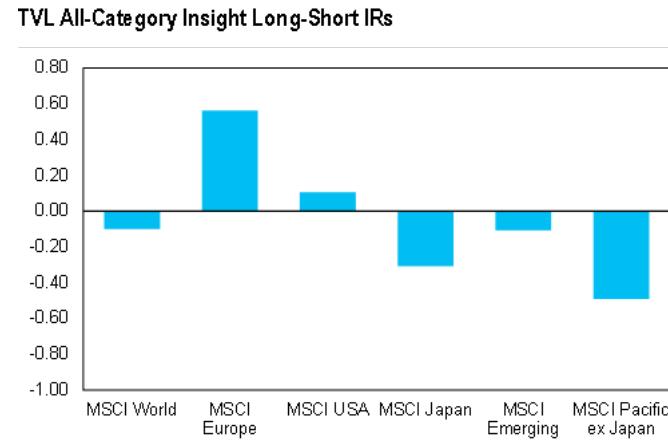
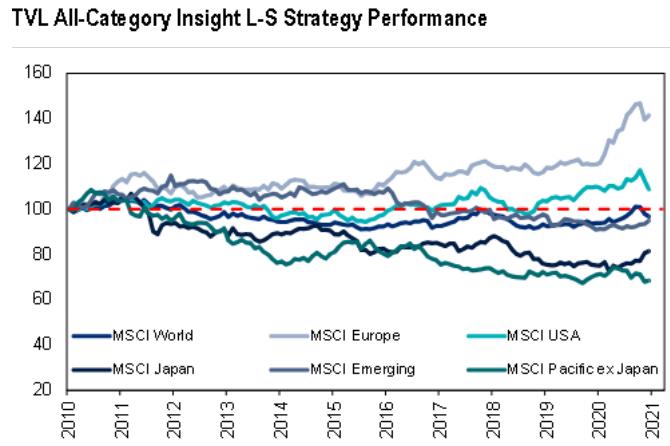
Prepared for Xu Zhang

- At the granular level, coverage is lower given that not all categories will be relevant for every stock on each day. Again, however, we see a significant improvement in the proportion of the universe that the data covers when we compare the earliest and latest datasets.

ESG Strategies Based on TVL Data

High-Level TVL Insight ESG Leaders

- We empirically test the efficacy of TVL Insight scores based on developed global benchmarks to confirm or refute whether high-ESG-sentiment firms outperform low-ESG-sentiment firms.
- Our testing framework covers the period from January 2010 to December 2020. We use a set of global regional indices as our benchmarks, which include MSCI Developed World, MSCI Europe, MSCI USA, MSCI Japan, MSCI Pacific ex Japan and MSCI Emerging Index
- We first look at the performance of long-short TVL strategies on TVL's dynamic weighted All-Category Insight Score and SASB's Material All-Category Score.



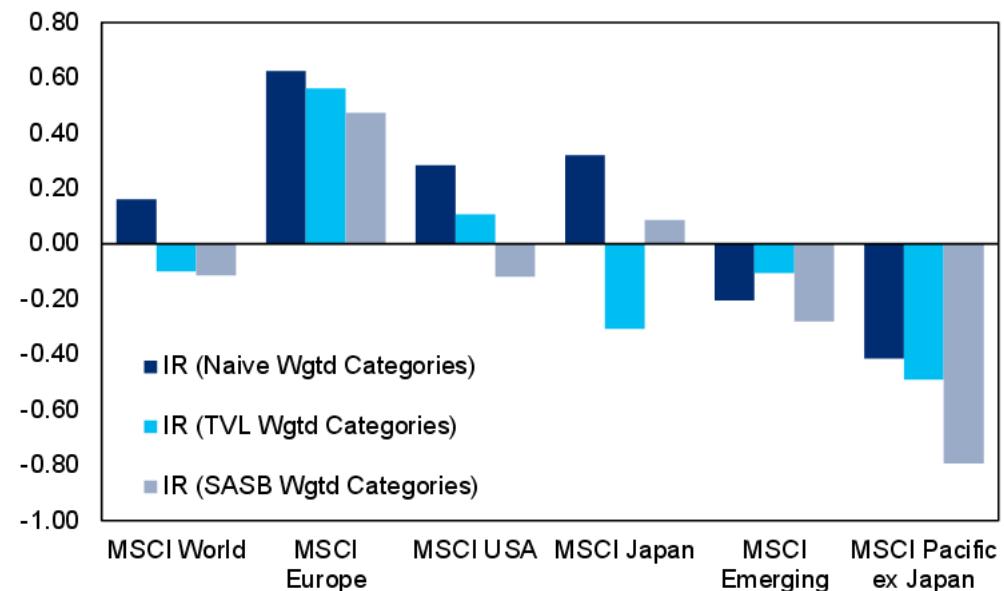
- The long-short strategy outperforms in Europe and the US; the degree of outperformance is greatest in Europe.

ESG Strategies Based on TVL Data

A Case for Naïve Weighted TVL Strategies

- The benefit of having both TVL's weighted scores and the equivalent scores based on the SASB materiality framework means that we can distinguish between static materiality and dynamic materiality.
- So far, we have shown that dynamic materiality outperforms static materiality. We also find that an equal-weighted materiality framework serves as an effective trading signal and turns out to perform better than the dynamic TVL Insight score, as the IRs in the chart demonstrate.

Comparison of IRs: Naïve vs. Dynamic and Static Materiality

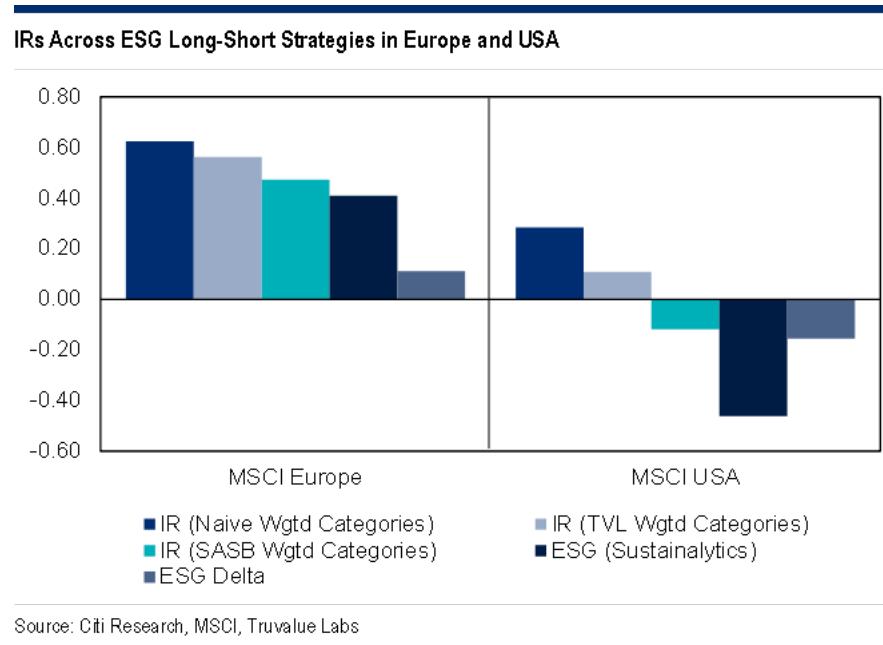


Source: Citi Research, MSCI, Truvalue Labs

ESG Strategies Based on TVL Data

Comparisons with Subjective ESG Ratings

- How do TVL's ESG sentiment signals compare to the “standard” ESG ratings from a portfolio construction and performance perspective?

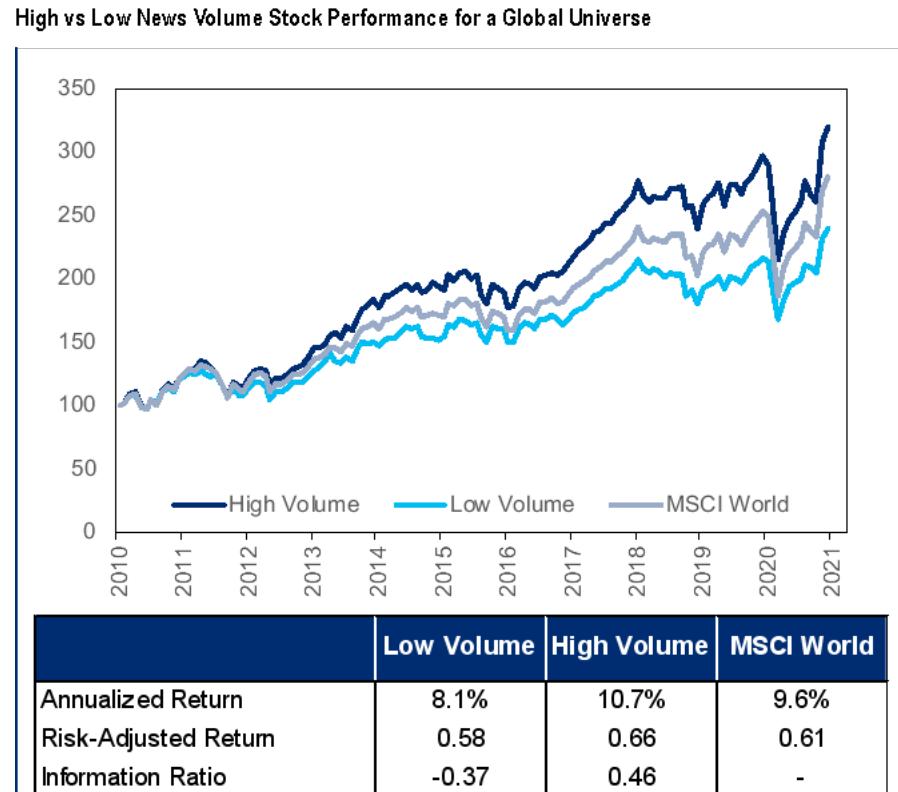


- TVL ESG scores generate higher long-short returns for the US and Europe compared with Sustainalytics' ESG ratings.

ESG New Flow Volume

Does the Volume of News Flow Drive Returns?

- As part of the methodology in which TVL constructs its ESG scores, news flow is a key component. As part of its data, TVL provides a volume metric at the stock level for the aggregate scores plus the SASB factors.
- An obvious question is this: do companies that have higher ESG news flow do better than companies with lower ESG news (regardless of whether its positive or negative)?
- There is a clear positive performance spread between companies with high and low ESG news volume, even before classifying the news flow as positive or negative.



Source: Citi Research, MSCI, Truvalue Labs

9. How Does ESG Compare to Other Factors?

ESG as a Factor

How Does ESG Compare to Other Factors?

- A common question – and one that many ESG experts would say is naïve – that we get is this: what has been the historical performance of ESG over time? A variation on this question is also this: how does ESG as a factor compare to other investment factors?
- Our objective is to compare ESG strategy returns with the returns of the style. The aim is to identify any established style relationships, if they exist, and then evaluate the returns to an ESG investment strategy in the US and Europe.
- Our base universe for this analysis includes the constituents of MSCI US and MSCI Europe indices where we have TruValue Labs' ESG scores. The analysis spans the period of January 2010 to January 2021. While the adage that “more data is better” generally holds true, in the case of ESG, we think that going back further than 10 years may be of limited value given how investors’ focus on ESG has changed dramatically over the past 20 years.
- We performance benchmark the ESG factor against the 7 composite factors and their underlying components so that, overall, we use 39 factors.

ESG as a Factor

Long-Short (High vs. Low) – 2010-2021

Cumulative Performance – MSCI US

Style	Factor	Annualised		
		Returns	Vol	IR
QUALITY	Balance Sheet Quality(NOA) (Inverted)	8.6%	6.8%	1.25
GROWTH	SB Growth-Value Score	3.7%	7.2%	0.51
ESTIMATES MOMENTUM	1 Month Change in Earnings Forecast	3.2%	7.3%	0.43
QUALITY	Earnings Quality (Accruals) (Inverted)	1.8%	6.3%	0.28
GROWTH	Earnings Growth (12 month forward)	2.1%	9.0%	0.24
ESTIMATES MOMENTUM	ESTIMATES MOMENTUM Composite	1.7%	7.5%	0.23
ESTIMATES MOMENTUM	Earnings Revision	1.6%	7.2%	0.22
LOWRISK	Earnings Stability	1.7%	8.3%	0.21
ESTIMATES MOMENTUM	Sales Revisions	1.7%	8.2%	0.21
GROWTH	One Year DPS Growth	1.4%	7.0%	0.19
QUALITY	QUALITY Composite	1.4%	9.4%	0.15
ESG	ESG	0.6%	4.6%	0.14
PRICE MOMENTUM	Price Momentum 12 months	1.3%	14.6%	0.09
PRICE MOMENTUM	Price Momentum First 11 months	1.2%	14.2%	0.08
ESTIMATES MOMENTUM	Cash Revisions	0.4%	6.6%	0.07
GROWTH	Long Term Earnings Growth	0.5%	8.9%	0.06
PRICE MOMENTUM	Price Momentum 3 months	0.4%	11.6%	0.03
QUALITY	Earnings Certainty	0.3%	13.2%	0.02
LOW RISK	LOW RISK Composite	0.2%	16.2%	0.01
GROWTH	GROWTH Composite	-0.3%	9.6%	-0.03
SIZE (LARGE)	Size (Market Cap)	-0.3%	10.1%	-0.03
QUALITY	Return on Equity	-0.2%	7.9%	-0.03
PRICE MOMENTUM	PRICE MOMENTUM Composite	-0.8%	15.0%	-0.05
LOWRISK	Debt to Equity(Inverted)	-0.5%	5.2%	-0.09
QUALITY	Margin Growth	-0.7%	6.1%	-0.11
LOWRISK	Beta against MSCI CountryIndex (Low-High)	-2.7%	18.5%	-0.15
LOWRISK	Beta against MSCI AC World (Low-High)	-3.1%	18.4%	-0.17
QUALITY	Net Profit Margin on Sales	-1.6%	9.2%	-0.18
VALUE	Dividend Yield	-2.8%	10.6%	-0.26
VALUE	Earnings Yield - 12 month forward	-3.5%	11.2%	-0.32
GROWTH	One Year EPS Growth	-2.3%	7.3%	-0.32
VALUE	Sales /EV	-3.4%	10.4%	-0.33
VALUE	Sales to Price Ratio	-3.9%	11.4%	-0.35
GROWTH	One Year Sales Growth	-3.6%	9.2%	-0.39
VALUE	Earnings Yield-12 month historical	-4.2%	10.5%	-0.40
VALUE	VALUE Composite	-5.2%	12.2%	-0.43
VALUE	Book to Price Ratio	-6.3%	11.4%	-0.55
VALUE	Operating Cash Flow/Yield	-7.6%	12.6%	-0.60
VALUE	EBITDA/EV	-7.4%	11.3%	-0.66

Source: Citi Research, Truvalue Labs, MSCI

Cumulative Performance – MSCI Europe

Style	Factor	Annualised		
		Returns	Vol	IR
ESTIMATES MOMENTUM	Cash Revisions	6.3%	6.7%	0.94
ESTIMATES MOMENTUM	1 Month Change in Earnings Forecast	7.0%	7.7%	0.91
ESTIMATES MOMENTUM	Earnings Revision	7.2%	8.8%	0.82
ESTIMATES MOMENTUM	ESTIMATES MOMENTUM Composite	6.7%	8.4%	0.80
ESTIMATES MOMENTUM	Sales Revisions	4.9%	7.4%	0.67
QUALITY	Balance Sheet Quality(NOA) (Inverted)	2.9%	4.9%	0.60
ESG	ESG	3.1%	5.3%	0.58
PRICE MOMENTUM	PRICE MOMENTUM Composite	8.1%	16.0%	0.51
PRICE MOMENTUM	Price Momentum 12 months	8.0%	16.2%	0.50
QUALITY	QUALITY Composite	5.4%	11.4%	0.47
PRICE MOMENTUM	Price Momentum First 11 months	7.3%	15.8%	0.46
QUALITY	Return on Equity	5.4%	11.9%	0.46
PRICE MOMENTUM	Price Momentum 3 months	4.7%	12.9%	0.36
GROWTH	One Year DPS Growth	2.8%	8.3%	0.34
LOWRISK	Earnings Stability	2.7%	8.5%	0.32
QUALITY	Earnings Quality (Accruals) (Inverted)	1.6%	5.3%	0.31
QUALITY	Net Profit Margin on Sales	3.2%	10.7%	0.30
LOWRISK	Debt to Equity(Inverted)	1.9%	7.0%	0.27
QUALITY	Earnings Certainty	3.5%	14.4%	0.24
GROWTH	SB Growth-Value Score	2.0%	8.6%	0.23
GROWTH	Long Term Earnings Growth	2.2%	10.5%	0.21
LOW RISK	LOW RISK Composite	2.5%	15.5%	0.16
QUALITY	Margin Growth	0.9%	8.4%	0.11
GROWTH	GROWTH Composite	1.1%	10.6%	0.11
GROWTH	Earnings Growth (12 month forward)	0.8%	8.1%	0.10
LOWRISK	Beta against MSCI AC World (Low-High)	1.2%	16.4%	0.07
GROWTH	One Year EPS Growth	0.4%	8.5%	0.05
LOWRISK	Beta against MSCI CountryIndex (Low-High)	0.5%	16.0%	0.03
SIZE (LARGE)	Size (Market Cap)	-0.5%	8.0%	-0.06
VALUE	Dividend Yield	-1.9%	9.2%	-0.21
VALUE	Earnings Yield - 12 month forward	-4.2%	16.0%	-0.26
VALUE	Sales /EV	-3.2%	12.0%	-0.27
VALUE	Sales to Price Ratio	-3.8%	13.3%	-0.29
VALUE	Earnings Yield-12 month historical	-4.2%	13.5%	-0.31
VALUE	Operating Cash Flow/Yield	-5.1%	13.5%	-0.38
VALUE	VALUE Composite	-7.6%	17.2%	-0.44
VALUE	EBITDA/EV	-5.4%	11.8%	-0.45
VALUE	Book to Price Ratio	-8.8%	17.8%	-0.50
GROWTH	One Year Sales Growth	-4.5%	9.1%	-0.50

Source: Citi Research, Truvalue Labs, MSCI

ESG as a Factor

Long-Short (High vs. Low) – 2016-2021

Cumulative Performance – MSCI US

Style	Factor	Annualised		
		Returns	Vol	IR
QUALITY	Balance Sheet Quality(NOA) (Inverted)	9.3%	7.6%	1.22
GROWTH	SB Growth-Value Score	6.4%	8.8%	0.72
ESTIMATES MOMENTUM	1 Month Change in Earnings Forecast	3.9%	8.5%	0.46
GROWTH	Earnings Growth (12 month forward)	3.3%	8.4%	0.39
LOWRISK	Earnings Stability	3.4%	9.0%	0.37
ESG	ESG	1.6%	5.3%	0.29
GROWTH	GROWTH Composite	1.8%	10.3%	0.17
LOWRISK	Debt to Equity(Inverted)	0.6%	4.8%	0.13
GROWTH	Long Term Earnings Growth	1.3%	10.0%	0.13
PRICE MOMENTUM	Price Momentum 3 months	0.8%	12.8%	0.06
ESTIMATES MOMENTUM	ESTIMATES MOMENTUM Composite	-0.1%	8.9%	-0.01
ESTIMATES MOMENTUM	Sales Revisions	-0.2%	10.1%	-0.02
SIZE (LARGE)	Size (Market Cap)	-0.5%	13.5%	-0.04
GROWTH	One Year DPS Growth	-0.4%	7.2%	-0.06
QUALITY	Net Profit Margin on Sales	-1.0%	11.9%	-0.08
GROWTH	One Year Sales Growth	-0.8%	10.1%	-0.08
PRICE MOMENTUM	Price Momentum First 11 months	-1.8%	17.6%	-0.10
ESTIMATES MOMENTUM	Earnings Revision	-0.8%	7.8%	-0.11
QUALITY	QUALITY Composite	-1.6%	11.3%	-0.14
PRICE MOMENTUM	Price Momentum 12 months	-2.5%	17.6%	-0.14
PRICE MOMENTUM	PRICE MOMENTUM Composite	-3.8%	17.8%	-0.21
QUALITY	Return on Equity	-2.0%	9.3%	-0.22
GROWTH	One Year EPS Growth	-2.5%	8.5%	-0.29
LOW RISK	LOW RISK Composite	-6.1%	18.4%	-0.33
QUALITY	Margin Growth	-2.6%	7.4%	-0.35
QUALITY	Earnings Certainty	-5.4%	14.7%	-0.37
QUALITY	Earnings Quality(Accruals) (Inverted)	-2.8%	6.7%	-0.42
ESTIMATES MOMENTUM	Cash Revisions	-3.3%	7.5%	-0.44
LOWRISK	Beta against MSCI CountryIndex (LowHigh)	-10.7%	20.1%	-0.53
VALUE	Book to Price Ratio	-7.7%	14.5%	-0.54
VALUE	Earnings Yield - 12 month forward	-7.5%	13.7%	-0.55
VALUE	Sales to Price Ratio	-8.5%	14.9%	-0.57
LOWRISK	Beta against MSCI AC World (Low-High)	-11.5%	20.0%	-0.57
VALUE	VALUE Composite	-9.5%	16.1%	-0.59
VALUE	Earnings Yield- 12 month historical	-7.8%	13.1%	-0.60
VALUE	Dividend Yield	-6.7%	10.9%	-0.62
VALUE	Sales /EV	-8.7%	13.2%	-0.66
VALUE	Operating Cash FlowYield	-10.5%	15.8%	-0.67
VALUE	EBITDA/EV	-12.0%	14.1%	-0.85

Source: Citi Research, Truvalue Labs, MSCI

Cumulative Performance – MSCI Europe

Style	Factor	Annualised		
		Returns	Vol	IR
ESG	ESG	5.0%	5.8%	0.86
LOWRISK	Debt to Equity(Inverted)	4.5%	7.3%	0.62
ESTIMATES MOMENTUM	1 Month Change in Earnings Forecast	4.5%	7.4%	0.60
ESTIMATES MOMENTUM	ESTIMATES MOMENTUM Composite	3.5%	8.1%	0.43
PRICE MOMENTUM	Price Momentum 3 months	4.5%	13.5%	0.33
GROWTH	Earnings Growth (12 month forward)	2.2%	8.1%	0.28
ESTIMATES MOMENTUM	Cash Revisions	1.6%	6.9%	0.23
GROWTH	SB Growth-Value Score	2.0%	9.4%	0.21
ESTIMATES MOMENTUM	Earnings Revision	1.7%	8.5%	0.20
QUALITY	Return on Equity	2.3%	11.6%	0.20
QUALITY	Net Profit Margin on Sales	1.8%	10.2%	0.17
QUALITY	Balance Sheet Quality(NOA) (Inverted)	0.7%	5.0%	0.15
PRICE MOMENTUM	PRICE MOMENTUM Composite	1.9%	17.0%	0.11
ESTIMATES MOMENTUM	Sales Revisions	0.3%	7.2%	0.03
PRICE MOMENTUM	Price Momentum 12 months	-0.1%	17.9%	-0.01
PRICE MOMENTUM	Price Momentum First 11 months	-0.1%	17.5%	-0.01
QUALITY	QUALITY Composite	-0.2%	10.9%	-0.02
GROWTH	One Year EPS Growth	-0.4%	7.3%	-0.05
GROWTH	GROWTH Composite	-1.1%	11.1%	-0.10
LOWRISK	Earnings Stability	-1.0%	7.1%	-0.14
VALUE	Operating Cash FlowYield	-2.2%	15.5%	-0.14
VALUE	EBITDA / EV	-2.3%	14.8%	-0.16
QUALITY	Margin Growth	-1.5%	9.4%	-0.16
LOWRISK	LOW RISK Composite	-2.6%	15.8%	-0.17
VALUE	Sales to Price Ratio	-3.0%	15.4%	-0.20
GROWTH	Long Term Earnings Growth	-2.4%	11.1%	-0.22
LOWRISK	Beta against MSCI AC World (Low-High)	-4.0%	17.4%	-0.23
VALUE	Sales / EV	-3.3%	14.2%	-0.23
VALUE	Book to Price Ratio	-5.2%	19.3%	-0.27
LOWRISK	Beta against MSCI CountryIndex(Low-High)	-4.8%	16.7%	-0.29
GROWTH	One Year DPS Growth	-2.7%	8.2%	-0.33
VALUE	Earnings Yield - 12 month forward	-6.4%	18.9%	-0.34
QUALITY	Earnings Quality(Accruals) (Inverted)	-1.9%	5.3%	-0.36
SIZE (LARGE)	Size (Market Cap)	-3.4%	8.9%	-0.38
VALUE	Earnings Yield- 12 month historical	-6.4%	16.3%	-0.39
VALUE	VALUE Composite	-7.9%	20.2%	-0.39
QUALITY	Earnings Certainty	-6.1%	12.6%	-0.49
GROWTH	One Year Sales Growth	-5.1%	8.9%	-0.57
VALUE	Dividend Yield	-6.7%	10.6%	-0.63

Source: Citi Research, Truvalue Labs, MSCI

ESG as a Factor

Do Sectors Play a Part in the Strong Returns?

ESG Factor Performance: Before and After Sector Neutrality

Time Period	Region	Portfolio Type	Annualised		
			Returns	Vol	IR
2010-2021	US	No Constraint	0.6%	4.6%	0.14
	US	Sector Neutral	0.3%	3.5%	0.08
	Europe	No Constraint	3.1%	5.3%	0.58
	Europe	Sector Neutral	2.9%	4.3%	0.67
2016-2021	US	No Constraint	1.6%	5.3%	0.29
	US	Sector Neutral	1.6%	3.4%	0.47
	Europe	No Constraint	5.0%	5.8%	0.86
	Europe	Sector Neutral	2.8%	4.8%	0.58

Source: Citi Research, Truvalue Labs, MSCI

- Regardless of the universe or the time period, we see a general decrease in performance as sector risk is eliminated, but in some cases, the risk falls at a faster rate, resulting in better risk-adjusted performance.

- Rank performance of ESG does not fall significantly, if at all, especially in Europe.

Cumulative Performance – MSCI US: 2010-2021

Style	Factor	Annualised		
		Returns	Vol	IR
ESTIMATES MOMENTUM	ESTIMATES MOMENTUM Composite	3.3%	5.1%	0.64
LOW RISK	LOW RISK Composite	1.7%	11.3%	0.15
PRICE MOMENTUM	PRICE MOMENTUM Composite	1.1%	8.0%	0.14
ESG	ESG	0.4%	3.5%	0.12
QUALITY	QUALITY Composite	1.2%	11.3%	0.11
GROWTH	Growth Composite	-0.1%	6.5%	-0.02
SIZE (LARGE)	SIZE (Market Cap)	-0.3%	6.3%	-0.04
VALUE	VALUE Composite	4.5%	9.9%	0.46

Source: Citi Research, Truvalue Labs, MSCI

Cumulative Performance – MSCI Europe: 2010-2021

Style	Factor	Annualised		
		Returns	Vol	IR
ESTIMATES MOMENTUM	ESTIMATES MOMENTUM Composite	6.2%	6.7%	0.92
ESG	ESG	2.9%	4.3%	0.67
PRICE MOMENTUM	PRICE MOMENTUM Composite	6.2%	12.9%	0.48
QUALITY	QUALITY Composite	3.8%	8.2%	0.43
GROWTH	Growth Composite	1.8%	7.8%	0.23
LOW RISK	LOW RISK Composite	2.2%	11.1%	0.19
SIZE (LARGE)	SIZE (Market Cap)	1.2%	6.7%	0.19
VALUE	VALUE Composite	3.5%	13.1%	0.26

Source: Citi Research, Truvalue Labs, MSCI

Cumulative Performance – MSCI US: 2016-2021

Style	Factor	Annualised		
		Returns	Vol	IR
ESTIMATES MOMENTUM	ESTIMATES MOMENTUM Composite	2.8%	5.6%	0.50
ESG	ESG	1.6%	3.4%	0.47
GROWTH	Growth Composite	2.4%	7.3%	0.33
SIZE (LARGE)	SIZE (Market Cap)	0.6%	10.4%	0.06
PRICE MOMENTUM	PRICE MOMENTUM Composite	-2.0%	13.2%	-0.15
LOW RISK	LOW RISK Composite	-3.9%	13.1%	-0.30
QUALITY	QUALITY Composite	-3.9%	8.2%	-0.48
VALUE	VALUE Composite	-6.6%	13.0%	-0.51

Source: Citi Research, Truvalue Labs, MSCI

Cumulative Performance – MSCI Europe: 2016-2021

Style	Factor	Annualised		
		Returns	Vol	IR
ESG	ESG	2.8%	4.8%	0.58
ESTIMATES MOMENTUM	ESTIMATES MOMENTUM Composite	2.9%	7.1%	0.41
PRICE MOMENTUM	PRICE MOMENTUM Composite	1.2%	13.6%	0.09
LOW RISK	LOW RISK Composite	-0.3%	11.8%	-0.02
GROWTH	Growth Composite	-0.2%	8.2%	-0.03
QUALITY	QUALITY Composite	-0.7%	8.1%	-0.09
SIZE (LARGE)	SIZE (Market Cap)	-0.8%	7.3%	-0.11
VALUE	VALUE Composite	-5.4%	16.0%	-0.34

Source: Citi Research, Truvalue Labs, MSCI

ESG as a Factor

How Correlated Is ESG to Other Style Factors?

- We regress the time series of long-short ESG returns on the long-short returns of seven risk premia. The coefficients of this regression indicate the exposure that ESG returns have to the risk premia, and we bold the factors that are statistically significant.

- While the longer-term ESG factor loadings appear inconsistent, running the same analysis over a more recent period does not provide additional clarification.

- For both the US and Europe, none of the factors are statistically significant. What this suggests is that ESG is still maturing as an investment consideration or style and that the exposures are time varying.

ESG Factor Loadings - 2010 to 2020

		Alpha	Value	Growth	Low Risk	Quality	Size	Emom	Pmom
US	Coeff.	0	-0.12	-0.07	-0.04	0.32	-0.22	-0.08	0.05
	Tstat.	-0.1	-2.3	-1.3	-0.8	3.9	-3.0	-1.1	0.9
Europe	Coeff.	0	-0.25	0.04	-0.13	-0.05	-0.15	-0.35	0.14
	Tstat.	2.3	-4.2	0.7	-2.1	-0.6	-1.8	-4.4	2.0

Source: Citi Research, Truvalue Labs, MSCI

ESG Factor Loadings – Jan 2019 to August 2021

		Alpha	Value	Growth	Low Risk	Quality	Size	Emom	Pmom
US	Coeff.	0	-0.10	-0.20	0.10	0.40	-0.28	-0.01	-0.07
	Tstat.	1.3	-0.6	-1.0	0.6	1.7	-1.6	0.0	-0.3
Europe	Coeff.	0	-0.12	0.05	-0.31	0.14	0.14	-0.20	0.24
	Tstat.	1.7	-0.8	0.3	-1.7	0.7	0.6	-1.1	1.9

Source: Citi Research, Truvalue Labs, MSCI

ESG as a Factor

Purifying ESG Returns

- We apply our style “purification” methodology on ESG whereby we build an optimised portfolio with the objective is of having a beta 1 exposure to ESG but zero exposure to other style factors and neutral to country and sector. We find that once we strip out other style/risk exposure, the return to ESG falls dramatically, suggesting that a large proportion of ESG returns are driven by exposure to other factors.

Performance Summary for Pure ESG Factor

	US		Europe	
	Pure ESG	Quantile ESG	Pure ESG	Quantile ESG
Annualised Return	-0.04%	0.64%	0.55%	3.10%
Annualised Volatility	1.2%	4.6%	1.3%	5.3%
Information Ratio	-0.0	0.1	0.4	0.6

Source: Citi Research, Truvalue Labs, MSCI

ESG Wealth Curves – MSCI US



Source: Citi Research, Truvalue Labs, MSCI

ESG Wealth Curves – MSCI Europe



Source: Citi Research, Truvalue Labs, MSCI

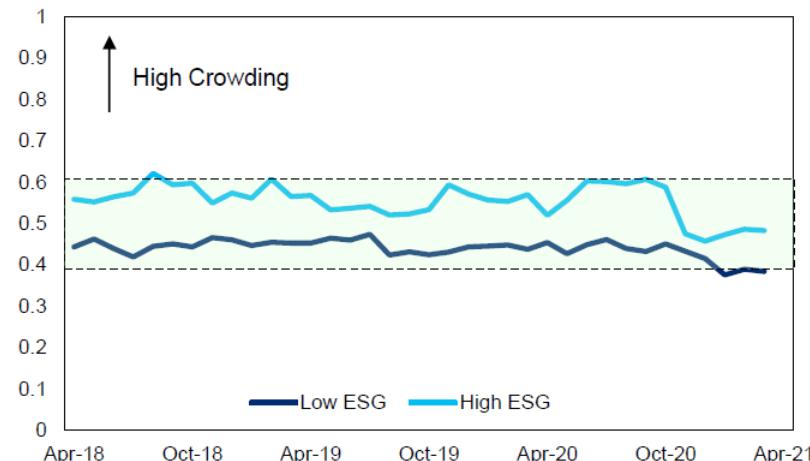
10. Has ESG Become a Crowded Trade?

Crowding in ESG

Is ESG Crowded?

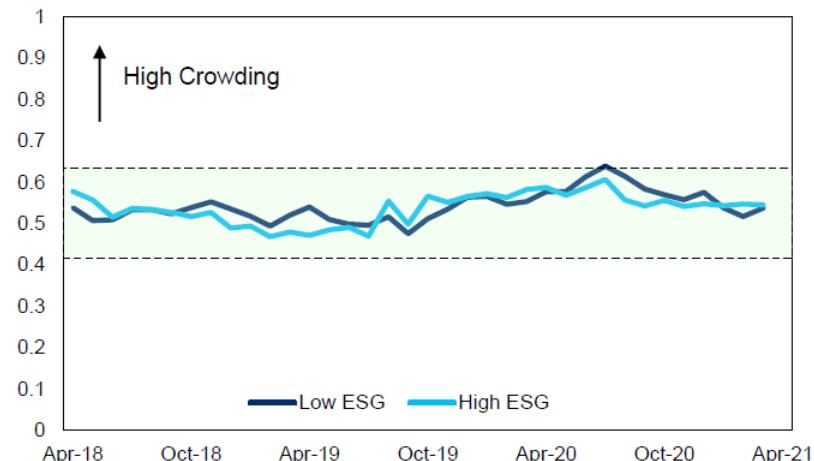
- Based on the crowding framework, high-ESG firms are, on average, neither in the upper or lower quintile in either region, and this has been consistent since April 2018. In addition, the spread in crowdedness between top- and bottom-quintile ESG stocks is narrow. There is a subtle difference between the two regions: in the US, there is no evidence to suggest that investors have primarily crowded into high-ESG firms versus low-ESG firms, whereas in Europe, high-ESG firms are consistently slightly more crowded.

Average Crowding Score for High ESG Firms in Europe



Source: Citi Research, Truvalue Labs, MSCI

Average Crowding Score for High ESG Firms in US

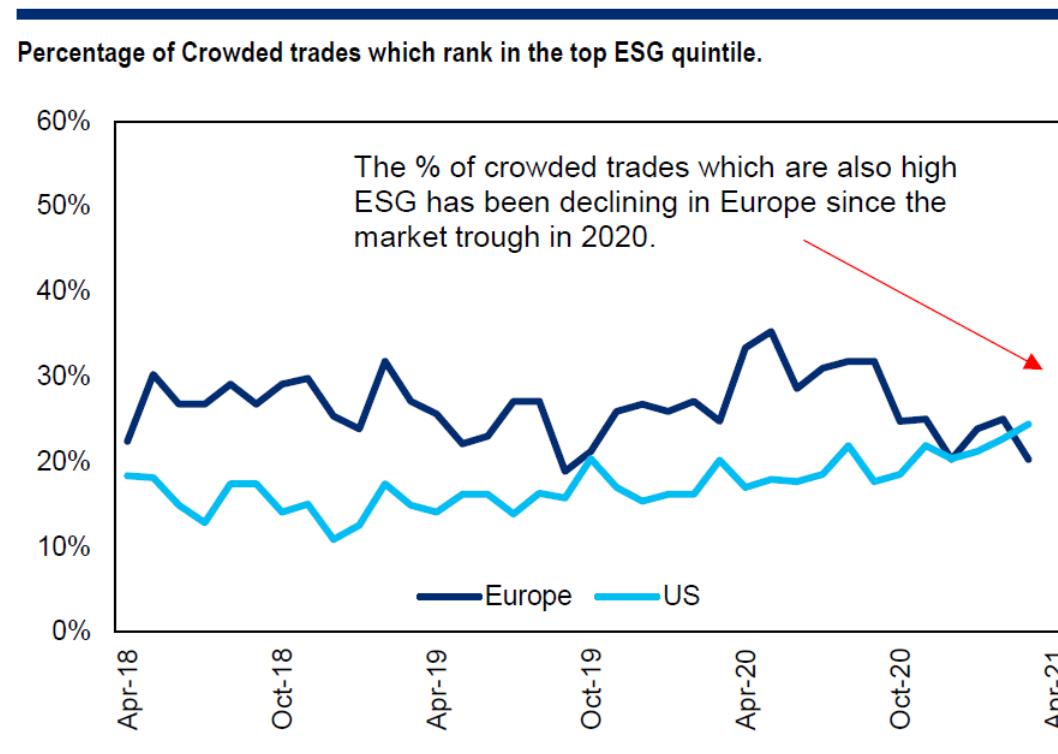


Source: Citi Research, Truvalue Labs, MSCI

Crowding in ESG

Is ESG Crowded?

- Another way of thinking about the crowdedness of ESG investing is whether the percentage of crowded stocks at the regional level that are also high ESG has been increasing or decreasing over time.
- European ESG stocks are more crowded (but declining) than their US equivalents, and the proportion is increasing in the US in 2021.



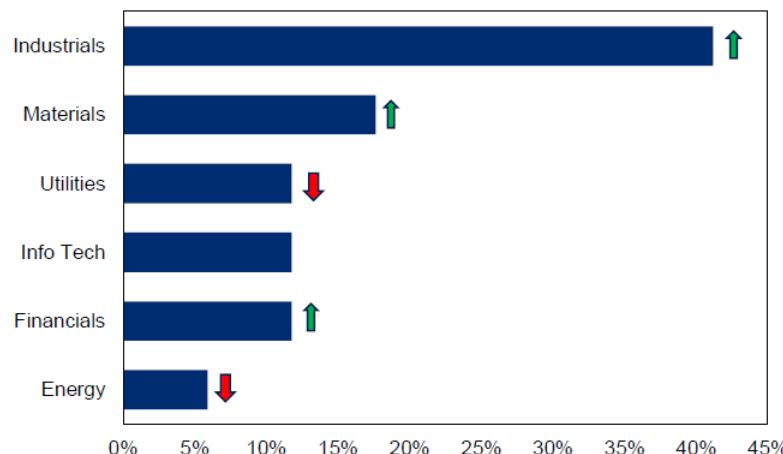
Crowding in ESG

Sector ESG Crowding

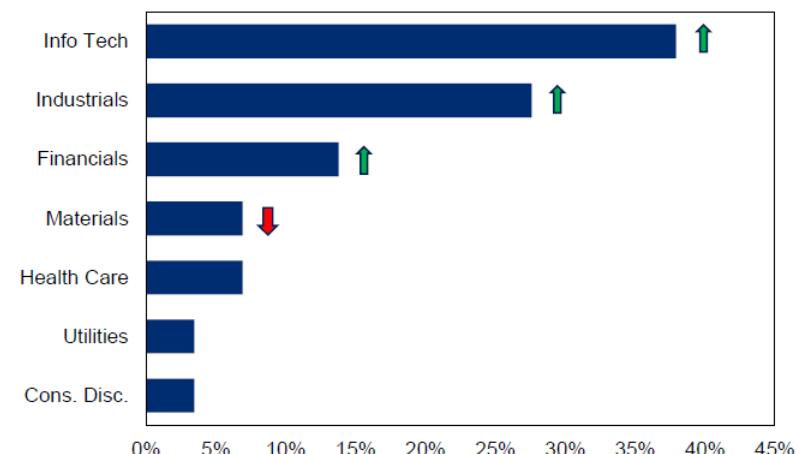
Regarding sectors screened for stocks that are in the top quintile for crowdedness and the top quintile on ESG,

- In Europe, 71% of the firms belong to Industrials, Utilities and Materials.
- In the US, the concentration in the top three sectors is higher (79%) and includes Information Technology, Industrials and Financials.

Latest Sector % of Crowded and High ESG Baskets (EU)



Latest Sector % of Crowded and High ESG Baskets (US)



Source: Citi Research, Truvalue Labs, MSCI

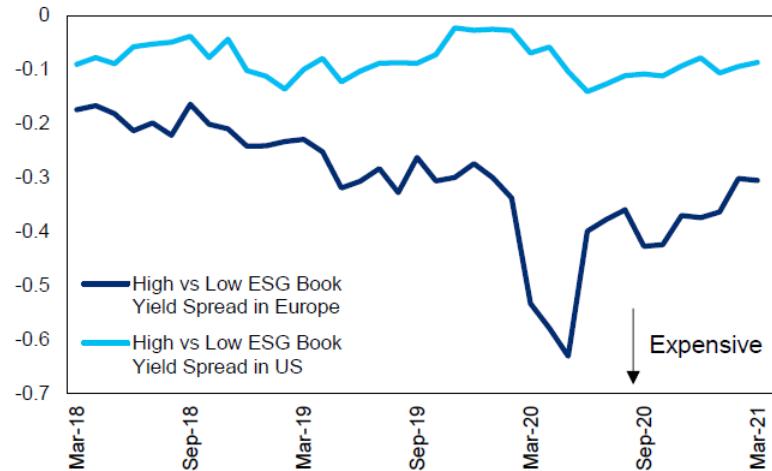
Source: Citi Research, Truvalue Labs, MSCI

Crowding in ESG

Valuations in ESG

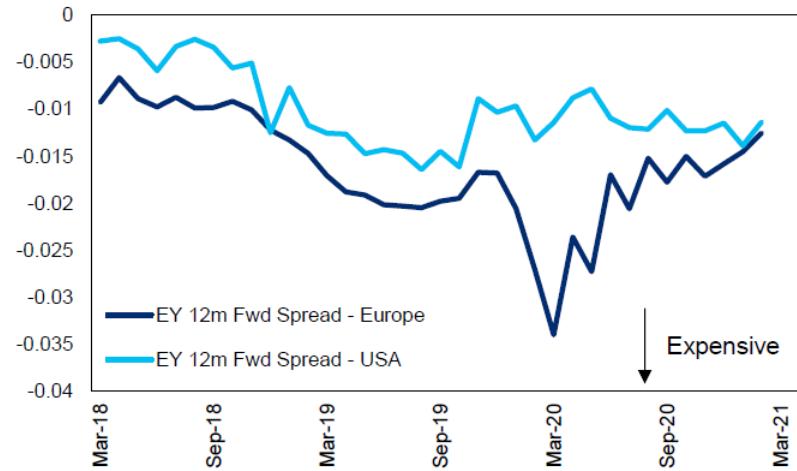
- Crowding in ESG should be reflected in valuations.
- High-ESG firms have consistently been more expensive than low-ESG firms over the entire period since early 2018. Spreads widened significantly in Q2 2020 but were already widening prior to the market trough in February of that same year.
- High-ESG firms in Europe have been bid up to a much greater extent than in the US, although we saw convergence in 2021.

Book Yield Spread between High and Low ESG Firms



Source: Citi Research, Truvalue Labs, MSCI

Earnings Yield Spreads between High and Low ESG Firms

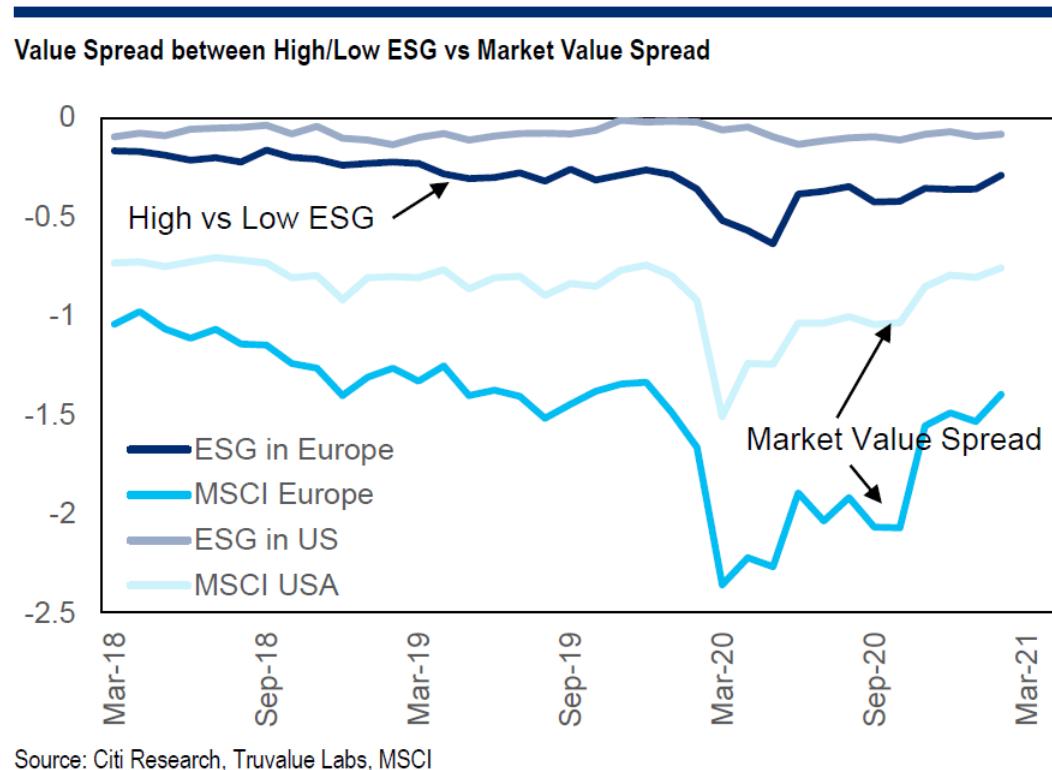


Source: Citi Research, Truvalue Labs, MSCI

Crowding in ESG

Valuations in ESG

- Although we have seen periods when valuations have become stretched when comparing high- and low-ESG names, the degree to which they are stretched is lower in magnitude than that of the market when we compare the average valuations between high- and low-Value stocks.

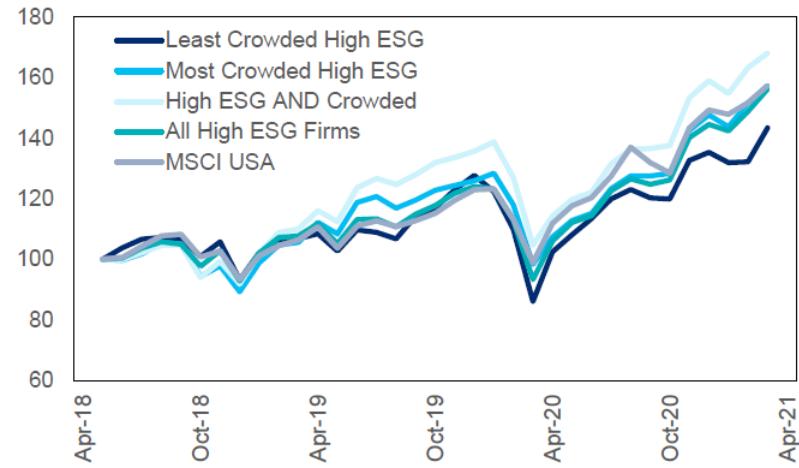


Crowding in ESG

Performance of ESG and Crowding

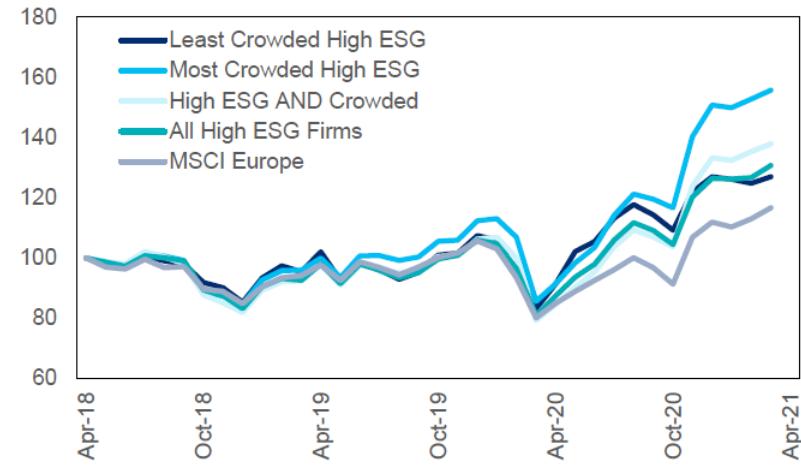
- Crowding in ESG stocks was a clear driver of ESG performance for Europe, whereas for the US, crowding within ESG has been less influential in driving ESG returns.

Most Crowded vs. Least Crowded ESG Portfolios Annualized Returns in US



Source: Citi Research, Truvalue Labs, MSCI

Most Crowded vs. Least Crowded ESG Portfolios Cumulative Returns in Europe



Source: Citi Research, Truvalue Labs, MSCI

11. ESG Fundamental Characteristics

ESG Fundamental Characteristics

How Do High/Low ESG Stocks Stack Up?

Fundamental Metrics as at 31-May-2021

	US			Europe		
	Top ESG	Bottom ESG	Market	Top ESG	Bottom ESG	Market
Profitability						
Gross Margin	41.8%	40.6%	44.9%	34.1%	49.8%	37.2%
Net Margin	8.1%	6.2%	5.9%	3.4%	6.0%	2.9%
ROA	2.5%	2.4%	2.0%	1.5%	0.6%	0.5%
ROE	9.8%	10.6%	10.2%	5.7%	5.9%	4.6%
ROIC	5.7%	6.4%	5.9%	3.0%	4.7%	2.7%
Efficiency						
Revenue per Employee (USD)	375,502	581,387	427,911	458,076	374,243	358,533
Assets per Employee (USD)	850,911	914,175	688,941	980,800	759,238	669,720
Asset Quality						
Asset Turnover	0.4	0.6	0.6	0.5	0.5	0.5
Fixed Asset Turnover	1.1	2.4	2.0	1.1	2.3	1.7
Liquidity						
Current Ratio	1.5	1.5	1.4	1.2	1.1	1.2
Coverage						
Net Debt/EBITDA	2.5	1.4	2.1	2.7	2.5	2.7
EBIT/Interest Expense	4.3	5.5	4.7	4.2	4.5	4.1
Cash Div Coverage Ratio	3.6	4.8	4.2	3.9	3.2	3.7
Leverage						
Net Debt to Total Equity	65.4%	45.0%	64.0%	70.0%	72.8%	70.0%
Valuation						
Price to Earnings	34.7	29.7	29.5	31.7	16.0	24.8
Price to Sales	4.6	5.8	4.7	2.8	1.6	2.1
Price to Book Value	4.0	3.6	3.3	1.8	1.8	1.8
Dividend Yield	1.5%	1.1%	1.4%	2.5%	3.0%	2.5%
Payout Ratio	52%	33%	40%	79%	48%	61%
Cashflow Yield	4.7%	4.6%	4.8%	6.8%	9.3%	7.5%
Free Cashflow Yield	1.9%	3.0%	3.0%	2.8%	5.6%	4.2%
Growth						
Earnings	5.4%	-2.6%	-2.2%	7.8%	-0.6%	-10.5%
Sales	4.7%	6.4%	5.6%	1.4%	3.5%	2.6%
Dividends	4.2%	5.6%	3.7%	3.8%	-0.9%	-0.7%
Cashflow	5.0%	7.8%	6.6%	4.3%	6.0%	5.1%
Free Cashflow	4.8%	9.9%	9.3%	4.4%	7.9%	10.6%

Source: Citi Research, Truvalue Labs, MSCI, Worldscope

ESG Fundamental Characteristics

Sector Composition Drives Fundamental Characteristics

Sectoral Composition (# of stocks %)			
US			
Sector	High ESG	Low ESG	Market
Industrials	24%	9%	14%
Information Technology	22%	18%	18%
Financials	21%	23%	19%
Utilities	10%	2%	5%
Health Care	9%	14%	13%
Materials	6%	2%	5%
Consumer Discretionary	5%	14%	11%
Consumer Staples	2%	2%	6%
Energy	1%	1%	3%
Communication Services		17%	7%

Europe			
Sector	High ESG	Low ESG	Market
Industrials	27%	9%	17%
Utilities	19%		6%
Materials	14%	4%	9%
Financials	8%	35%	21%
Information Technology	8%	4%	6%
Consumer Staples	7%	7%	9%
Communication Services	5%	12%	8%
Energy	5%		3%
Consumer Discretionary	4%	8%	12%
Health Care	4%	21%	9%

Source: Citi Research, TruValue Labs, MSCI

- Currently, results are mixed across metrics but also across regions. This should be no surprise given that the sector composition of low- and high-ESG cohorts can vary over time and across regions.
- For the US, the sectors that are dominant and fairly equally represented in the high-ESG score category through time are Industrials, IT, Financials and Utilities. On the low-ESG side, Financials are more dominant, together with IT, Health Care and Communication Services.
- For Europe, the composition is much clearer and is dominated by Industrials on the high-ESG side and Financials on the low side. Overall, these varying sector tilts can have a meaningful impact on the fundamental characteristics of each of the ESG cohorts.

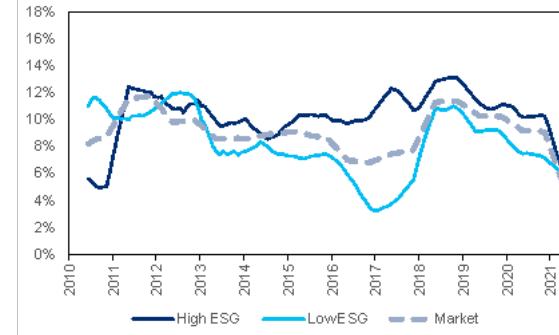
ESG Fundamental Characteristics

Fundamental Metrics Through Time – Examples

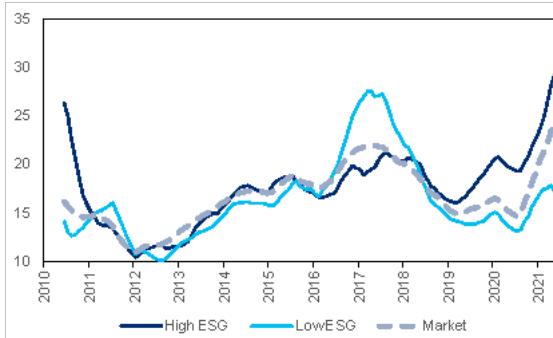
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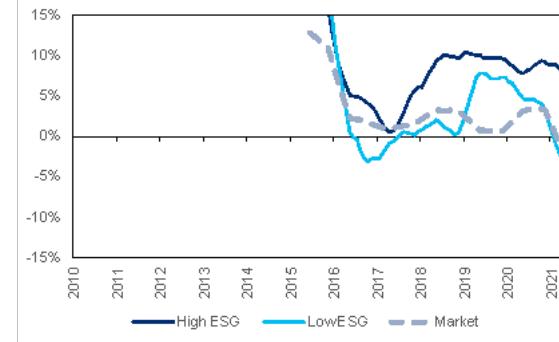
Europe



PE - Europe



Earnings Growth - US





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Appendix A-1

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Data current as of 31 Mar 2022	12 Month Rating			Catalyst Watch		
	Buy	Hold	Sell	Buy	Hold	Sell
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% of companies in each rating category that are investment banking clients	62%	66%	54%	69%	60%	68%
Citi Research Quantitative World Radar Screen Model Coverage	30%	40%	30%			
% of companies in each rating category that are investment banking clients	43%	31%	26%			
Citi Research Quantitative Latam Radar Screen Model Coverage	21%	59%	21%			
% of companies in each rating category that are investment banking clients	77%	71%	57%			
Citi Research Quantitative Asia Radar Screen Model Coverage	20%	60%	20%			
% of companies in each rating category that are investment banking clients	42%	24%	18%			
Citi Research Quantitative Australia Radar Screen Model Coverage	54%	0%	46%			
% of companies in each rating category that are investment banking clients	48%	0%	35%			

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