

# Regime Modelling using Futures Positioning

## Futures vs. Cash – A Distant but Meaningful Relationship

- **Conclusion(s)** — Futures positioning offers interesting insights to cash equity markets. Revealing from this study is how naturally occurring regime states based on futures positioning information can assist in signaling periods of distinct risk/return characteristics that develop in cash markets.
- **Index Futures Positioning for Timing Cash Equities** — This research explores an application of futures positioning information derived from the EMP framework in timing and identifying regime states and outlines how this information is beneficial in assisting investors manage market exposure.
- **Fixed State Regime Models** — We undertake two different approaches to this analysis, one based upon the economic intuition that regime states naturally exists for different positioning size and P&L on those positions. Based on fixed threshold states, it is possible to identify turning points that help signal a bottoming out on retracements and identify abnormal profitable states that consequently occur. To supplement this analysis, we outline how investors could use information gleaned from historical state transitions to assist in timing entry/exit from these states.
- **Beyond Fixed State Models** — The second part of our study leverages an expanded array of futures positioning metrics within a Machine Learning model to identify abnormal positive return periods.
- **Findings** — The fixed state model is particularly effective in signaling trend reversals during market retracements. Deploying a strategy using this signal provides enhanced risk-adjusted performance. Similar patterns emerge in both European and US futures contracts. These signals have greater efficacy when positioning and profit/losses are at extremes.

Note: Futures trading involves substantial risk of loss.

---

### Europe

**Chris Montagu** <sup>AC</sup>  
+44-20-7986-3958  
chris.montagu@citi.com

**David T Chew**  
+44-20-7986-7698  
david.chew@citi.com

**Josie Gerken**  
+44-20-7986-4060  
josie.gerken@citi.com

**Pier Procacci**  
+44-20-7986-4228  
pier.procacci@citi.com

### North America

**Hong Li**  
+1-212-816-5062  
hong.li@citi.com

### Asia Pacific

**Chris Ma**  
+852-2501-2404  
chris.ma@citi.com

### Multi-Asset

**David Bieber**  
+44-20-7986-4976  
david.bieber@citi.com

**Kim D Jensen, CFA**  
+44-20-7986-3284  
kim.damgaard.jensen@citi.com

---

See Appendix A-1 for Analyst Certification, Important Disclosures and non-US research analyst disclosures.

Citi Research is a division of Citigroup Global Markets Inc. (the "Firm"), which does and seeks to do business with companies covered in its research reports. As a result, investors should be aware that the Firm may have a conflict of interest that could affect the objectivity of this report. Investors should consider this report as only a single factor in making their investment decision. Certain products (not inconsistent with the author's published research) are available only on Citi's portals.

# Regime Modelling using Futures Positioning

## Background

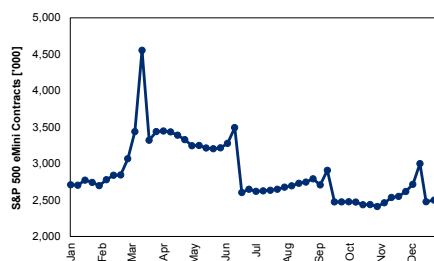
Futures and forward markets began as a way for companies and individuals to hedge against adverse price movements. Historically futures markets were primarily focused on catering for a subset of hedging activity, namely agriculture and commodity type products. Over time, futures contracts have evolved to include the trading of financial-related products.

With the advent of automated trading in the last few decades, a new class of market participants has grown in volume and importance. These include hedge funds/asset managers who often trade in futures contracts as an investment or diversification strategy, and principal trading firms (PTFs) who provide intermediation services over shorter time horizons.

Futures contracts with high correlation to macroeconomic activity, like the S&P 500 E-mini contract and U.S. Treasuries, have higher than average levels of activity from investment firms like hedge funds and asset managers.

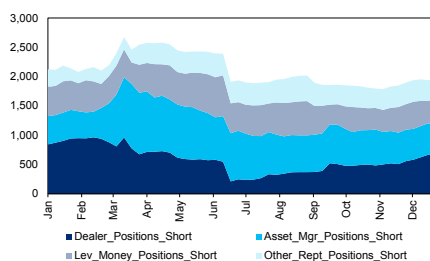
An indication of the level of participation from different classes of investor types is available through CFTC weekly reporting, Figure 2 and Figure 3 below outline recent outstanding contracts and positioning by different participant types.

**Figure 1. Total Open Interest Contracts SPX e-Mini Futures (Jan 2000 – Dec 2000)**



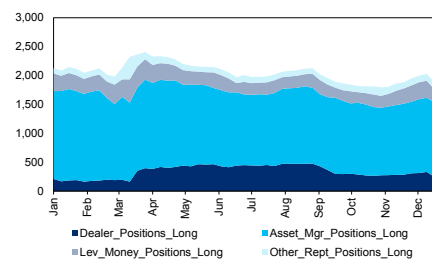
Source: Citi Research, CFTC

**Figure 2. Short Positioning by Participant**



Source: Citi Research, CFTC

**Figure 3. Long Positioning by Participant**



Source: Citi Research, CFTC

Using CFTC's reporting as a guideline; participants are categorized into several classes. Dealers/Intermediaries, these tend to represent the 'sell side' of the market, and are involved in buying/selling futures. The remainder of the market comprises the 'buy-side' which is divided into three separate categories: 'Asset Manager/Institutional', 'Leveraged Funds' and 'Other Reportables'. Leveraged Funds are typically hedge funds and various types of money managers. The strategies involved by this class of participants can vary from taking outright positions or arbitraging within and across markets and some may be engaged in agents trading on behalf of speculative clients. 'Other Reportable' positions cover entities which fall outside the previously defined categories.

As can be seen from both figures, Asset and Leverage Money managers form a significant portion of the overall futures markets, with asset managers having a larger presence in the long side of the market.

As a result, activity on the futures market can potentially offer a different insight from a class of participants that can have a considerable impact on the price action and direction of underlying indices.

This research focuses on S&P500 futures, primarily on the S&P 500 E-mini contract one of the most liquid futures products in the U.S. The analysis has also been

extended to cover some of the other more commonly traded index futures contracts, namely Nasdaq, FTSE and EuroStoxx.

## Data & Methodology

The EMP framework calculates historical market positioning over the last three months and the associated unrealized P&L for equities futures contracts. The wider RPM model, which has the same underlying model structure, covers other asset classes that include G8 rates markets, Eurodollars, and Oil futures contracts.

The estimated outstanding DV01<sup>1</sup> positions (in futures) over the last three months and positioning is captured on a daily basis. In addition, overall normalized positioning and P&L numbers are also calculated. These are estimates of the current outstanding positioning / unrealized P&L over a three month window scaled (from -5 to +5) on a rolling 3 year base (i.e. -5 would be the lowest value that has occurred over a 3 year period). Also published are percentile equivalent ranks (3 years rolling). For more detail information see: [Equity Markets Positioning Model: Introducing the EMP](#)

Regime modelling can potentially assist investors in identifying or determining which strategies to deploy at a given time. As an example within financial markets, regimes could potentially highlight periods where volatility is elevated, promoting the deployment of defensive strategies. Alternatively these can also signal periods when trend following or mean reversion strategies could outperform.

Our aim is to identify and highlight some of the potential advantages of using futures positioning to signal different regime states.

Unlike cash equities, futures markets trade almost 24 hours a day, enabling investors to take a view even when cash equity markets are closed. As a consequence, it provides more timely information on where underlying markets are likely to trade. Large positioning build-up in the futures markets, on the other hand, can potentially offer insight towards investor sentiment.

Various methods exist in developing financial models to identify regime states. In this research we explore two models using features available from futures trading activity as modelled by the EMP framework. The two variant models we explore are:

- Fixed threshold state model
- Predictive state model

## Futures Positioning Feature Variables for a State Model

Using changes to the levels of outstanding open interest and contract prices on the futures market, we are able to estimate how investors are positioned in the futures market. We rely on the premise that the net marginal buyer or seller on any one particular day in the futures market is the determinant of the relative change in net positions on traded futures contracts within the market (Figure 4).

---

<sup>1</sup> Refers to the dollar value for a one basis point change, i.e. the change in the price of the futures contract for a 1 bps change in the underlying market.

Figure 4. Summary of how positioning is calculated for futures markets

		Open Interest	
		Increasing	Decreasing
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. Note: Futures trading involves substantial risk of loss.

With this information, it's possible to define four states from the EMP model. The first instance is partitioning positioning by the model's estimated net positioning levels (Long vs. Short), and secondly splitting by the net profitability levels within each state (Profit vs. Loss).

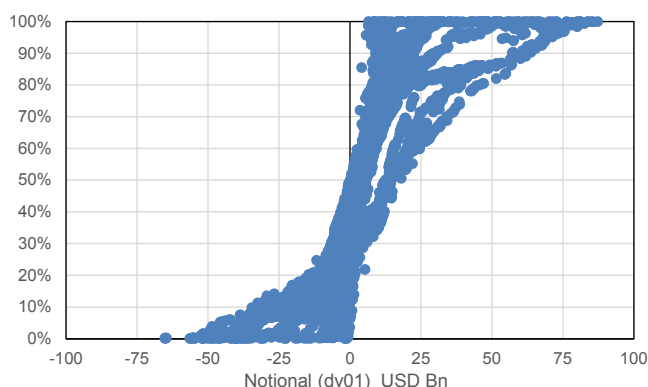
Figure 5. Regime States

		Position P&L	
		Loss	Profit
Net Position	Long	Long/Loss	Long/Profit
	Short	Short/Loss	Short/Profit

Source: Citi Research

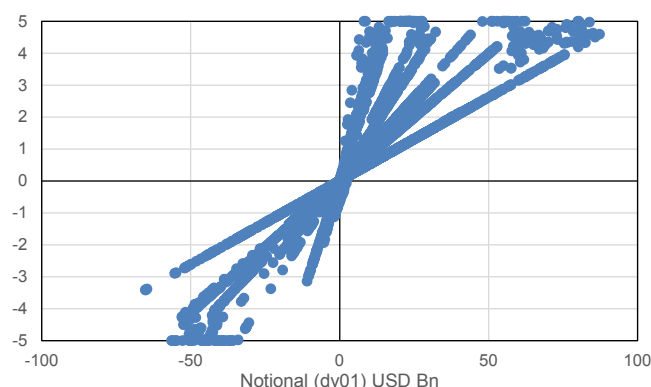
Notional position size and unrealized gains and losses are available as raw values, percentile and standardized score. Both scaling measures utilize a three-year rolling window.

Figure 6. Percentile Positioning vs Net Notional Futures Exposure (SPX)



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

Figure 7. Standardized Positioning vs Net Notional Futures Exposure (SPX)



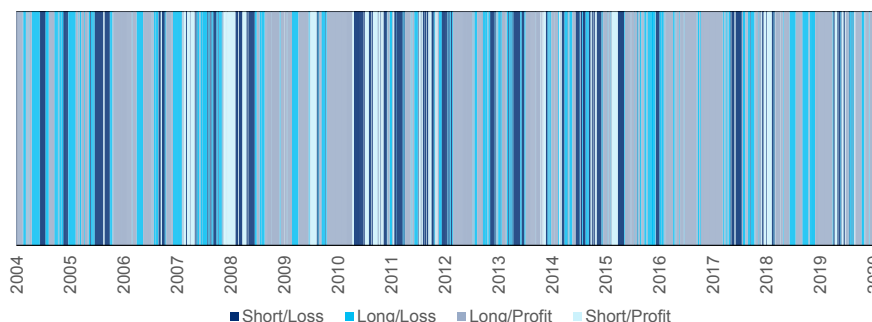
Source: Citi Research. Note: Futures trading involves substantial risk of loss.

Using percentiles or using EMP's internal 'standardized' threshold values both lead to different hypothetical long/short crossings. For example if we use the 50<sup>th</sup> percentile as a demarcation between Long/Short positioning, thresholds can vary from 0 to 20Bn (Figure 7). The same intuition holds for positioning profit/loss.

Our analysis primarily focuses on standardized thresholds as commonly referred within the EMP model, but where relevant we include references to the outcomes of using percentile thresholds as an alternative.

Figure 8 outlines the different states the model has been in for S&P 500 eMini contracts (SPX) since 2004 using scaled positioning metrics. Market positioning has tended to be Long, but switching between Profit/Loss across different periods.

Figure 8. Regime States SPX (Sep 2004 to date)



Source: Citi Research

Figure 9. Futures Positioning Transitions During a Sell-Off



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

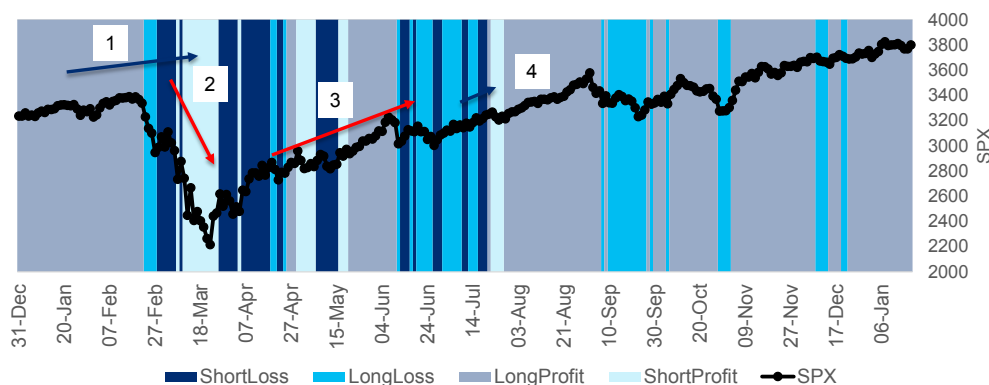
One of the reasons this is likely to be the case, is that for much of the past 16 years (excluding GFC, Covid-19), the S&P 500 has been steadily rising. As a consequence, the EMP model (by construction) has been more frequently in a Long state, i.e. where notional values on futures long exposures are larger than shorts, with unrealized gains/losses on those positions in profit and rising in concert with markets.

Throughout these periods there have been bouts of retracement, represented by 'reversal' periods where short positioning has outpaced longs. Figure 9 outlines how states transition during a protracted sell-off.

## Evolution of futures positioning through an economic shock

To illustrate the transitions lifecycle in greater detail, Figure 10 presents futures positioning for SPX and the S&P 500 cash index levels from the end of 2019 through the Covid-19 pandemic till year end, with each of the four states shaded differently.

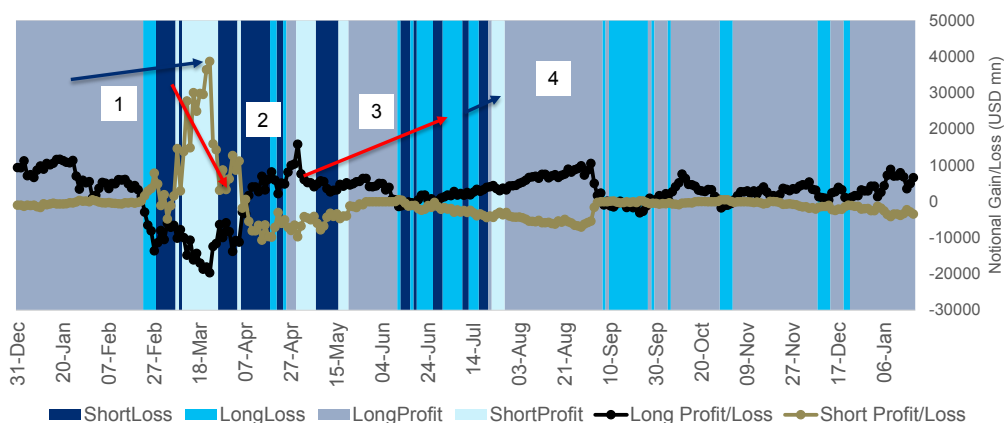
Figure 10. EMP SPX Futures Positioning from (Dec 2019 to Jan 2021) relative to underlying S&P500



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

1. Futures positions were net long and in profit (Long/Profit) in the run-up to March. In late Feb/early March as news of the pandemic spread, markets began to sell off and existing extended long positions began to exhibit losses (Long/Loss). Figure 11 outlines the profit/loss aspects of short and long side positions, Long profits had been in steady decline before March, eventually markets sold off Longs P&L turned negative, and short position profits rapidly increased.

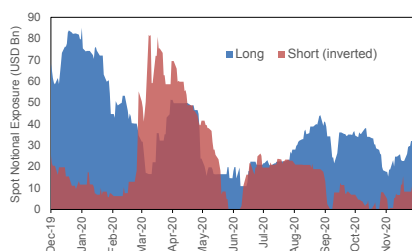
Figure 11. Unrealized Notional Gain/Loss across different regimes (Dec 2019 to Nov 2020)



Source: Citi Research

2. Towards mid-March, short positioning along with reduction of longs within the model led to model positioning turning net short (Figure 12). Losses continued to pile up for legacy long contracts, but with net positioning short, and short profits extending, the model's overall P&L switches positive (Short/Profit).

Figure 12. Daily Long and Short Notional Exposure



Source: Citi Research

3. The market recovers in early April, positioning remains net short, however, established short profits begin to fade. Model futures positioning switches Long and remains in profit from mid-May as the market continues to rally.
4. From August onwards, positioning remains long but volatile, with profit relatively small, the occasional retracement leads to net long positioning exhibiting negative P&L

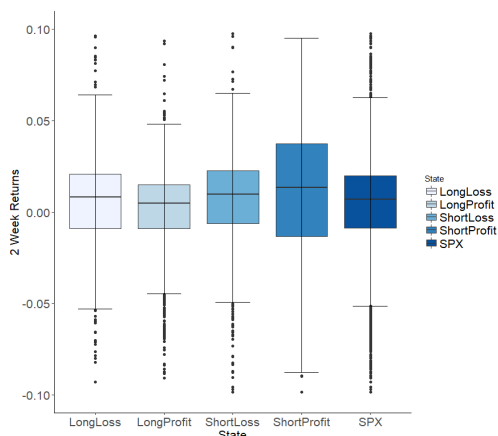
As Figure 10 highlights, despite the extreme volatility seen in 2020, the fixed state model tends to be relatively stable. (We cover stability and transition in Regime Duration and Predicting State Transitions section).

## Regime States and Cash Equities Risk/Return Characteristics

Figure 13 and Figure 14 provide a breakdown of the risk/return characteristics across different regime states. Returns are on average higher when positioning is within the Short/Profit state, and marginally higher in both the Long/Loss and Short/Loss states.

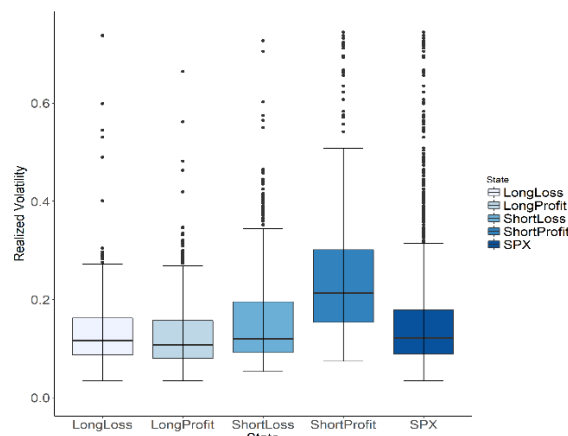
Differences in risk profile are more obvious when comparing volatility, with the Short/Profit state exhibiting considerably different volatility characteristics.

Figure 13. SPX bimonthly returns distributions by regime



Source: Citi Research

Figure 14. SPX monthly volatility by regime



Source: Citi Research

Figure 15. Forward Returns Across Different Regimes

State	1 Week Return			2 Week Return			1 Month Return		
	Average	Median	Pval	Average	Median	Pval	Average	Median	Pval
Short/Loss	0.2%	0.5%	0.95	0.3%	0.9%	0.95	0.9%	1.8%	0.39
Long/Loss	0.2%	0.4%	0.59	0.4%	0.8%	0.38	0.8%	1.6%	0.58
Long/Profit	0.1%	0.2%	0.05	0.1%	0.5%	0.00	0.2%	1.0%	0.00
Short/Profit	0.5%	0.7%	0.11	1.0%	1.3%	0.00	2.3%	2.6%	0.00
SPX	0.2%	0.3%	1.00	0.3%	0.7%	1.00	0.7%	1.4%	1.00

Source: Citi Research

Figure 16. Volatility Across Different Regimes

State	Realised Volatility (1 Month)		
	Average Vol	Median Vol	Pval
ShortLoss	16.7%	12.0%	0.01
LongLoss	14.2%	11.7%	0.00
LongProfit	12.8%	10.8%	0.00
ShortProfit	26.9%	21.6%	0.00
SPX	15.5%	12.2%	1.00

Source: Citi Research

Figure 17. Regime State Risk/Return Characteristics Summary (Forward 1 Month Returns and Volatility)

Net Position		Position P&L	
		Loss	Profit
	Long	Vol-	Vol-, Ret-
	Short	Vol+	Vol+, Ret+

Source: Citi Research

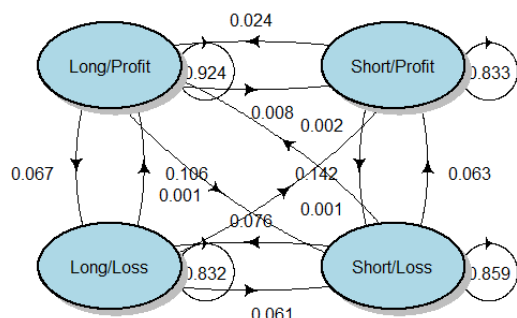
The Short/Profit state offers the greatest performance, across all forward return periods. Across other states, the returns profile is similar to the market. Figure 17 provides a summary of the risk and return characteristics for each regime state based on the statistical significance of average volatility and forward monthly returns.

We explore the risk adjusted return characteristics in more detail further on in the report; the next section however, addresses aspects around the practicalities of the current fixed threshold model by investigating duration/frequency of state transitions, and identifying the likelihood of a state transition.

## Regime Duration and Predicting State Transitions

The fixed state model can be visualized using state transitions with a directed graph. Using historical state transition probabilities, it is possible to illustrate this process in a Markov chain (Figure 18) and to obtain a likelihood measure of being in any of the other states at n-periods in the future. Figure 18 outlines the daily transition probabilities for the SPX state using a Markov chain. For the fixed state threshold model, this serves to assist in timing entry/exit to/from one of the profitable states. Figure 19 demonstrates this in the four state model, computing the probability of transitioning to another state from the current state after 10 days and the long term steady state. For example, if the model is currently Long/Profit, there is a 60% likelihood of it being in that state in the next two weeks, and there is only a 5% probability of it transitioning to the Short/Profit state over the same period. Similarly the diagonals enable us to infer how stable a state is. For example the Short/Profit state indicates the lowest probability of remaining in its state after 2 weeks.

Figure 18. State Transitions Represented within a Recurrent Markov Chain



Source: Citi Research

Figure 19. Forecast probability entering different states and long-term steady state.

Current State	Future State (2 weeks)				Steady State
	Long/Profit	Short/Profit	Long/Loss	Short/Loss	
Long/Profit	60%	5%	26%	10%	41%
Short/Profit	15%	28%	17%	40%	11%
Long/Loss	41%	7%	33%	20%	26%
Short/Loss	17%	18%	24%	41%	22%

Source: Citi Research



Extending this concept further and to better distinguish between independent states, we partition our state variables by adding a separation between large and small positions and profit/losses.

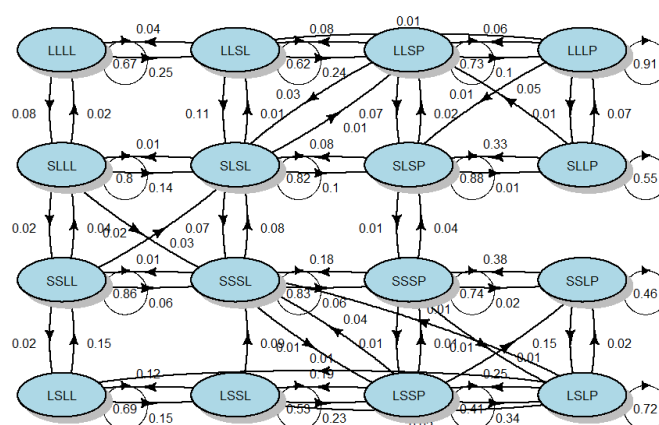
Figure 20. Extended States

Net Position		Position P&L			
		Loss		Profit	
		Long	Short	Long	Short
Net Position	Long	LLLL	LLSL	LLSP	LLLP
		SLLL	SLSL	SLSP	SLLP
	Short	SSLL	SSSL	SSSP	SSLP
		LSLL	LSSL	LSSP	LSLP

For example: 'SSSP' refers to Small Short/Small Profit

Source: Citi Research

Figure 21. Extended State transition probability matrix



Source: Citi Research

The introduction of more granular states enables us to better capture the likelihood of a regime transition at any point in time. For example, although the transition probability statistic on our four state model shows that Long/Loss positions have transitioned to a Long/Profit state about 11% of the time. In practice, when positioning is large (2.5 or more deviations away from average) and losses are large (-2.5 deviations away from average), i.e. the 'LLLL' state in Figure 21, the extended state model has never transitioned across to any of the Long/Profit states, and always passes through one of the intermediate states.

Similarly, Figure 22 and Figure 23 highlight, when positioning is short and small, and net profits are low, there is an increased likelihood in transitioning to a Short Loss state (33%) as opposed to the relatively low probability (7%) assigned using a four state model.

Figure 22. 5 Day Forward State Forecast

Net Position		Position P&L			
		Loss		Profit	
		Long	Short	Long	Short
Net Position	Long	0%	0%	0%	0%
		0%	10%	12%	0%
	Short	1%	37%	29%	1%
		0%	1%	3%	4%

Source: Citi Research

Figure 23. 10 Day Forward State Forecast

Net Position		Position P&L			
		Loss		Profit	
		Long	Short	Long	Short
Net Position	Long	0%	0%	1%	1%
		1%	18%	16%	0%
	Short	3%	34%	15%	1%
		1%	2%	3%	5%

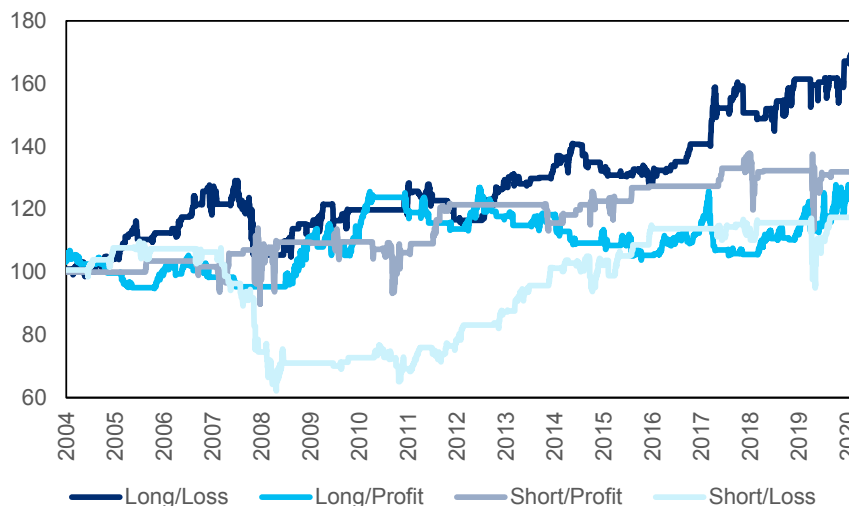
Source: Citi Research

## Fixed Threshold Model Performance.

In addition to comparing average forward returns (Figure 15), to establish if these pre-defined regime states have been more informative over the long term we considered measuring the performance against a buy and hold strategy, which invests daily in the market (t+1) when positioning has been in each of the four states.

When defining a threshold criteria, we explored both percentile and RPM's scaling metrics.

Figure 24. Regime State Performance Wealth Curve



Source: Citi Research

For SPX contracts, over the long term, Long/Loss and Short/Profit appear to show the largest increase in cumulative wealth. However, each state (Figure 26) is only 'active' for a relatively short period (27% Long/Loss, 11% Short Profit) of time. Additionally the Short/Profit state although very profitable comes with periods of high volatility

Figure 25. Performance Summary (SPX) Percentile Thresholds

	Short/Loss	Long/Loss	Long/Profit	Short/Profit	Market
Annualized Return	5.8%	13.6%	0.7%	22.5%	7.3%
Annualized Std Dev	20.3%	14.4%	12.0%	33.4%	19.3%
Annualized Sharpe (Rf=0%)	<b>0.28</b>	<b>0.95</b>	<b>0.06</b>	<b>0.67</b>	<b>0.38</b>
Hit Rate	53%	53%	52%	54%	53%
SortinoRatio	0.03	0.08	0.01	0.07	0.04
Observations	1333	746	1576	585	4240
Skewness	-0.99	-0.47	-0.87	0.20	-0.27
Kurtosis	9.71	3.24	3.70	6.68	14.48
InvestedPeriod	1333	746	1576	585	4240
Total Investible Period	4240	4240	4240	4240	4240
Active Period	31%	18%	37%	14%	100%

Source: Citi Research

Figure 26. Performance Summary (SPX) EMP Scaled Thresholds

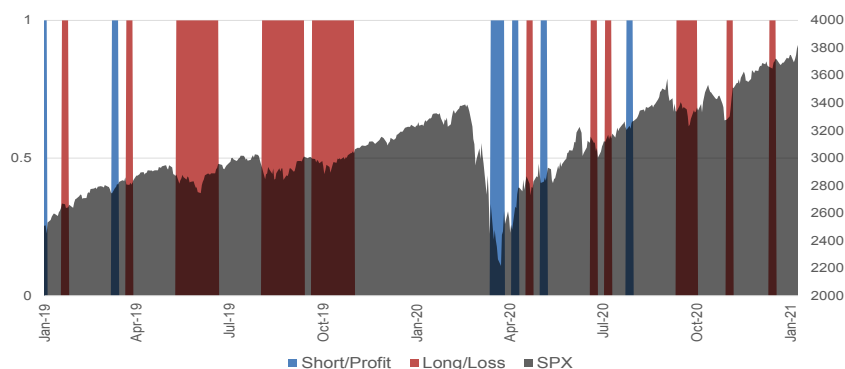
	Short/Loss	Long/Loss	Long/Profit	Short/Profit	Market
Annualized Return	4.3%	12.2%	3.5%	16.8%	7.3%
Annualized Std Dev	20.7%	16.2%	12.4%	37.1%	19.3%
Annualized Sharpe (Rf=0%)	<b>0.21</b>	<b>0.76</b>	<b>0.29</b>	<b>0.45</b>	<b>0.38</b>
Hit Rate	53%	53%	53%	52%	53%
SortinoRatio	0.03	0.07	0.03	0.06	0.04
Observations	955	1124	1711	450	4240
Skewness	-0.98	-0.78	-0.88	0.23	-0.27
Kurtosis	9.53	8.40	5.31	5.16	14.48
InvestedPeriod	955	1124	1711	450	4240
Total Investible Period	4240	4240	4240	4240	4240
Active Period	23%	27%	40%	11%	100%

Source: Citi Research

As Figure 26 outlines, the Long/Loss state exhibits a Sharpe nearing 0.8 which tends to represent periods where there has been a pullback/retracement (Figure 27), and akin to a disciplined buy the dip strategy.

The Short/Profit state on the other hand, is more representative of larger drawdowns; which have persisted over a longer period of time, and it potentially offers an early indication of a market bottom. Less clear in the model are states which exhibit continued/persistent underperformance.

Figure 27. Long/Loss & Short/Profit Active Periods (Jan-2019 to Jan-2021)

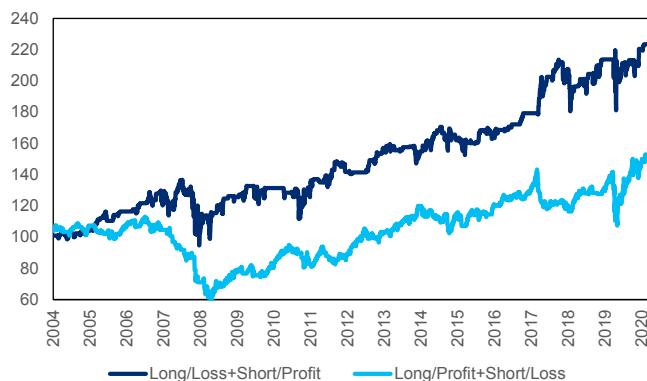


Source: Citi Research

## Combining Threshold Based Signals

Building on the previous analysis we considered alternative strategies to increase the overall 'activity' period. One solution, is to combine the most profitable states (Long/Loss and Short/Profit) together. Figure 29 outlines the results comparing the combined state, market, and a simulated (1000) random sampled selection average performance.

Figure 28. Combined State Strategy



Source: Citi Research

Figure 29. Performance Summary (SPX Combined States)

	Long/Loss+Short/Profit		Market	Random Sampling
	All Periods	Active Periods		
Annualized Return	4.9%	13.7%	7.5%	7.6%
Annualized Std Dev	14.6%	24.0%	19.3%	19.2%
Annualized Sharpe (Rf=0%)	<b>0.33</b>	<b>0.57</b>	<b>0.39</b>	<b>0.40</b>
Hit Rate	20%	53%	53%	52%
SortinoRatio	0.04	0.06	0.04	
Observations	4275	1580	4273	1600
Skewness	0.29	0.10	-0.27	
Kurtosis	37.09	11.83	14.57	
InvestedPeriod	4275	1580	4275	1600
Total Investible Period	4275	4275	4275	4240
Active Period	100%	37%	100%	38%

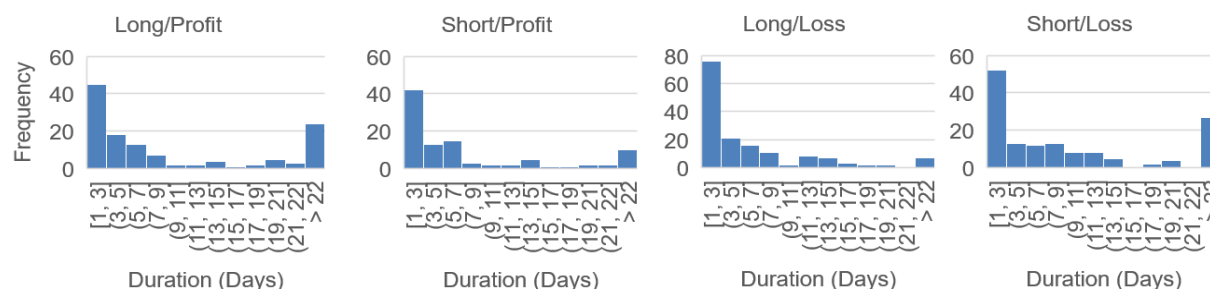
Source: Citi Research

Combining the most profitable states (Long/Loss and Short/Profit) increases the investible duration. However, performance is now averaged across pairs limiting the strategy's efficacy. With combination strategies trending in the same direction, creating a long/short portfolio is unlikely to yield any significant improvements. The analysis so far has only considered regime states on the basis of fixed thresholds on normalized scores, a rather naïve and basic representation, however both the individual and combined state form a baseline benchmark for comparing performance against other state model implementations.

## Reducing strategy turnover

One of the immediate challenges with a fixed threshold model is the existence of intermediate less stable periods which lead to excessive turnover and churn. Figure 30 highlights the prevalence of this by bucketing the time spent within each state when the strategy is implemented.

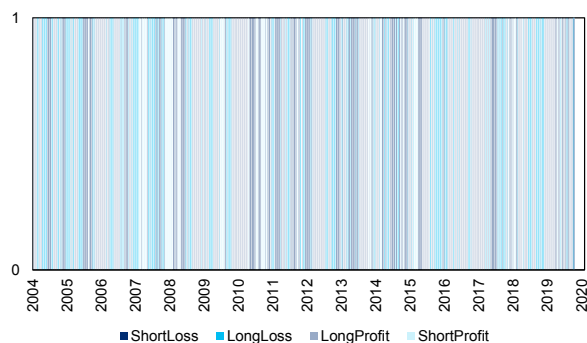
Figure 30. SPX Historical Time Spent Within Each State



Source: Citi Research

Slowing the rebalance frequency, by only evaluating regime states on a weekly basis helps reduce some of this churn. As Figure 32 highlights, performance against, the Long/Loss strategy deteriorates, marginally. Interestingly, Short/Profit regime returns improve. Results for the other two states are broadly similar to daily rebalanced strategies. Figure 32 provides a summary of weekly performance in each state relative to the S&P 500 benchmark.

Figure 31. Regime States (Weekly Rebalanced)



Source: Citi Research

Figure 32. Weekly Rebalanced Strategy Performance (Sep 2004-Jan 2021)

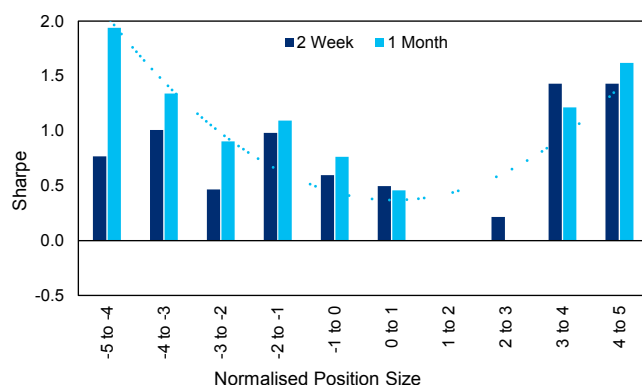
	Short/Loss	Long/Loss	Long/Profit	Short/Profit	Market
Annualized Return	4.3%	9.9%	2.4%	31.0%	7.8%
Annualized Std Dev	18.8%	15.6%	12.0%	35.9%	18.6%
Annualized Sharpe (Rf=0%)	0.23	0.63	0.20	0.86	0.42
Hit Rate	61%	57%	55%	59%	57%
SortinoRatio	0.05	0.14	0.05	0.21	0.10
Observations	183	229	343	98	853
Skewness	-1.87	-0.11	-0.65	0.24	-0.11
Kurtosis	6.54	1.26	2.08	1.48	7.26
InvestedPeriod	183	229	343	98	853
Total Investible Period	853	853	853	853	853
Active Period	21%	27%	40%	11%	100%

Source: Citi Research

## Regime State Alpha – A case of Non-linearity

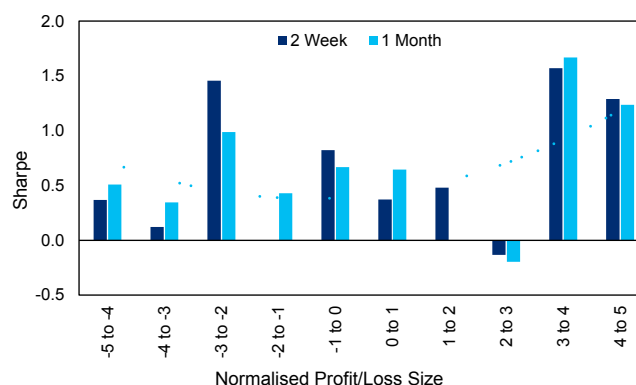
The dynamics of a fixed state model, although useful, fail to address the more complex relationship that exists between futures positioning and profit/losses in these positions. Figure 33 and Figure 34 show the Sharpe ratios from two week and one month forward returns across the range of position and profit/loss sizes. Forecast return dispersion rises and tends to peak when positioning is extended, specifically when profits are large.

Figure 33. SPX – Sharpe based on Relative Position Size



Source: Citi Research

Figure 34. SPX – Sharpe based on Profit/Loss Size



Source: Citi Research

As such, futures positioning appears more informative towards financial asset price performance when volumes are large and profit/losses are sizeable (Figure 33). Therefore we should observe an increasing relation between large positioning with losses/profits against future returns relative to the small positioning and small losses/gains.

This is a term often referenced within our EMP reports as ‘extended’ positioning or profit/loss; opposing this are states where futures positioning is less prevalent, and at those levels forward returns become less predictable.

## A Non-parametric State Predictive Model

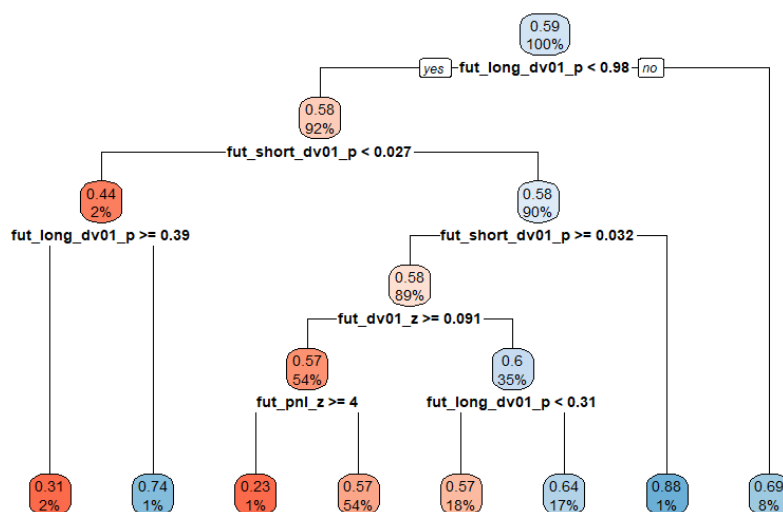
As highlighted earlier, the regime state cut-off/thresholds at each cross section can vary depending on the methodology chosen when standardizing positions and profit/loss metrics. Additionally the interaction between both positioning and positioning profit/loss on future returns are likely to be more dynamic than that which could be modeled through a fixed level or within a linear framework.

In order to explore this further, we expand on our analysis by considering a non-linear dynamic model and increase the feature variables used. As opposed to using pre-defined states to then observe forward returns, we attempt to use forward returns to define states.

The models utilize our baseline parameters (scaled positioning and P&L), but we also include the percentile relative to long term averages and spot levels and allow the decision tree to determine the best variables and cut-offs for estimations.

The model is trained using the past five years of weekly positioning metrics while our target prediction variable is the following 1 week return. Predictions are computed weekly and the model is re-estimated once a month.

Figure 35. Decision Tree Node Splits (All Observations)



Source: Citi Research

Figure 35 outlines the decision tree model created using all weekly observations. In this example the decision tree model has selected the primary split variable to be the percentile size of long positions. The decision cut selected is at the 98<sup>th</sup> percentile, if long positioning exceeds this level, there is a 69% probability of a positive return in the next week, 8% of samples fall within this category. Again its indicative that large positioning is influential in determining forward returns. When long positioning isn't as extended, the next decision node to be evaluated is the short percentile and so on.

For this analysis, we included a reduced grid search (Figure 37), to better understand which hyper-parameters are influencing model performance.

Figure 36. Model Parameterization

Model ID	Rolling Window	Min Bucket	Max Tree Depth	Min Tree Splits	Complexity	Decision Threshold
1	FALSE	25	5	2	0.001	0.5
2	FALSE	35	5	2	0.001	0.5
3	FALSE	45	5	2	0.001	0.5
4	FALSE	25	5	25	0.001	0.5
5	FALSE	25	5	55	0.001	0.5
6	TRUE	25	5	2	0.001	0.5
7	TRUE	25	5	2	0.001	0.5
8	TRUE	25	10	2	0.001	0.5
9	TRUE	25	15	2	0.001	0.5

Source: Citi Research

Figure 37. Classifier Performance

	1	2	3	4	5	6	7	8	9
Accuracy	53%	53%	56%	53%	53%	54%	54%	54%	54%
Precision	60%	60%	60%	60%	60%	61%	61%	61%	61%
Recall	0.62	0.61	0.72	0.62	0.62	0.61	0.61	0.62	0.62
F1	61%	60%	66%	61%	61%	61%	61%	61%	61%
False Positive Rate	0.24	0.24	0.28	0.24	0.25	0.23	0.23	0.24	0.24
False Negative Rate	0.22	0.23	0.16	0.22	0.22	0.23	0.23	0.22	0.22

Source: Citi Research

Our cut down grid search reveals that narrowing buckets leads to deteriorating Sharpe's, it marginally increases model accuracy, however increased false positives lead to falling returns on the strategy. There is less to differentiate in terms of the choice between an expanding or rolling window for the training set, with the latter offering marginal improvements. (Figure 38)

Figure 38. Decision Tree Model Performance (2004-Jan 2021)

	1	2	3	4	5	6	7	8	9	Market
Annualized Return	19.6%	18.9%	15.8%	19.6%	19.2%	18.2%	18.2%	18.3%	18.3%	12.4%
Annualized Std Dev	17.9%	18.8%	17.6%	17.9%	17.9%	16.5%	16.5%	16.4%	16.4%	17.2%
Annualized Sharpe (Rf=0%)	<b>1.09</b>	<b>1.00</b>	<b>0.90</b>	<b>1.09</b>	<b>1.07</b>	<b>1.10</b>	<b>1.10</b>	<b>1.12</b>	<b>1.12</b>	<b>0.72</b>
Hit Rate	60%	60%	60%	60%	60%	61%	61%	61%	61%	59%
SortinoRatio	0.23	0.21	0.19	0.23	0.22	0.22	0.22	0.22	0.22	0.15
Skewness	-0.07	-0.04	-0.02	-0.07	-0.06	-1.05	-1.05	-1.04	-1.04	-0.32
Kurtosis	9.77	8.49	9.78	9.77	9.83	6.94	6.94	7.06	7.06	8.90
InvestedPeriod	365	358	424	365	368	353	353	363	363	598
Total Investible Period	598	598	598	598	598	598	598	598	598	598
Active Period	61%	60%	71%	61%	62%	59%	59%	61%	61%	100%

Source: Citi Research

In all configurations, the decision tree was able to outperform the benchmark index, and activity periods rose to about 60% a step up from the fixed threshold model.

## Regime Performance of Other Equity Futures Indices

We repeat our analysis against the other futures indices which are tracked by the EMP model, namely Nasdaq, and in Europe, SX5E and FTSE 100.

We find stronger evidence of outperformance in some of the regime states in Nasdaq, in particular the futures Short/Loss state on a weekly rebalance frequency, exhibits a Sharpe nearing 1.5 (Figure 46), generating excess returns with volatility levels remaining in line with the benchmark.

The decision tree state model, with optimization offers improving risk/return relative to the benchmark and increased participation in comparison to regime states which are only present for a much shorter period of time.

In Europe, state performance varies considerably. With a much longer period of underperformance across European markets; the Short/Loss periods seem to capture recovery states. This divergence in state performance may be a consequence of a slower recovery rate exhibited in European markets.

Nevertheless, unlike US indices, both FTSE and EuroStoxx highlight opportunities of both identifying potential out/under-performing states. Regime states here are stronger from a contrarian perspective, with Long futures positioning leading to relative underperformance relative to Short futures positioning. Performance in Short/Loss and Short/Profit states for FTSE and EuroStoxx have overshadowed their benchmark. The Short/Loss state on FTSE and EuroStoxx, has led to Sharpe's (1.6, 0.8) respectively.

Long/Short strategies created using the best and worst performing states (Figure 55 and Figure 64), offer an option for a market neutral strategy and are more attractive for the FTSE where relative returns are near four times the average. The decision tree model; in near all cases, offers a performance somewhere between the benchmark and optimal states. The increased activity periods, offers an alternative solution, against individual regime states, which are far more infrequent. Upon closer scrutiny, the decision tree splits highlight the very marginal percentiles involved when trying to forecast weekly returns, the cuts uniquely highlight how estimation is strongest at the tails for futures positioning and profit/loss.

## Conclusion

Futures positioning offers interesting insights to cash equity markets, in particular we demonstrate that regime states using futures positions can potentially highlight periods with considerably different risk/return characteristics.

This research explores one such application of futures positioning signals to identify different regime states and how this information could potentially be used as an overlay to other signals for macro based strategies.

We undertook two different approaches to this problem, one based upon the economic intuition of regime states, based on positioning size and unrealized profit/losses on those positions can forecast the risk/return profile of their underlying cash markets. Based on fixed states, Long/Loss and Short/Profit, appear to represent bouts of retracements (SPX); offer improved performance across underlying cash indices, reflecting a disciplined 'buy-the-dip' like strategy.

Across the other futures contracts; NASDAQ, EuroStoxx and FTSE risk/return characteristics arguably differ, however they share a number of common features, namely, Figure 39 provides a concise summary of each of the 4 states and their corresponding risk/returns characteristics relative to their benchmarks as evidenced from the performance of weekly rebalanced strategies.

Figure 39. Futures Positioning – Cash Equities State Risk/Returns Characteristics Summary

Net Position		S&P 500		Nasdaq		EuroStoxx		FTSE	
		Position P&L		Position P&L		Position P&L		Position P&L	
		Loss	Profit	Loss	Profit	Loss	Profit	Loss	Profit
Long	Rets	↗	↘	↗	↗	↘	↘	↘	↘
		↗	↗	↗	↗	↗	↗	↗	↗
	Vol	↗	↗	↗	↗	↗	↗	↗	↗
		↗	↗	↗	↗	↗	↗	↗	↗
Short	Rets	↗	↗	↗	↗	↗	↗	↗	↗
		↗	↗	↗	↗	↗	↗	↗	↗
	Vol	↗	↗	↗	↗	↗	↗	↗	↗
		↗	↗	↗	↗	↗	↗	↗	↗

Source: Citi Research. Note: Performance is measured relative to each benchmark. Up/Down icons represent Returns/Volatilities that are 50% above long term average. Diagonal Up/Down arrows represent average between 10%-50% of benchmark averages. Note: Futures trading involves substantial risk of loss.

To supplement this analysis, we outlined how users could also use the information gained from historical positioning and previous states transitions in combination to estimate the likelihood of transitioning to the next state.

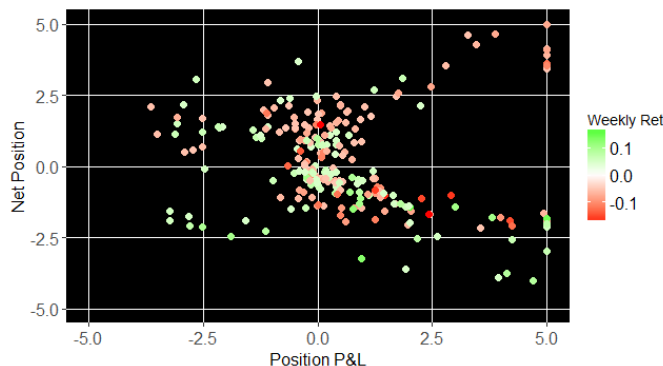
The second more alpha oriented analysis aimed to leverage futures positioning to forecast positive/negative return periods in conjunction with an expanded array of positioning metrics; additionally the decision tree model was selected to provide a more flexible approach to fixed state thresholds and attempt to address the limited duration of a number of states. This particular model aimed to overcome the limited active investment period (duration) for the state based model, and rather than using states to determine returns, utilizes returns to define states.

Both models are able to time states that offer increased outperformance relative to long term benchmark. However less consistent is the ability of these models to identify retracement periods.



## Performance Summary – Nasdaq (NDX)

Figure 40. Historical Weekly Returns By Position/P&L



Source: Citi Research

Figure 41. Benchmark Relative Summary State Risk/Returns Characteristics

		Position P&L	
		Loss	Profit
Net Position	Long	Rets 🏠 Vol 🏠	Rets 🏠 Vol 🏠
	Short	Rets 📈 Vol 📈	Rets 📈 Vol 📈

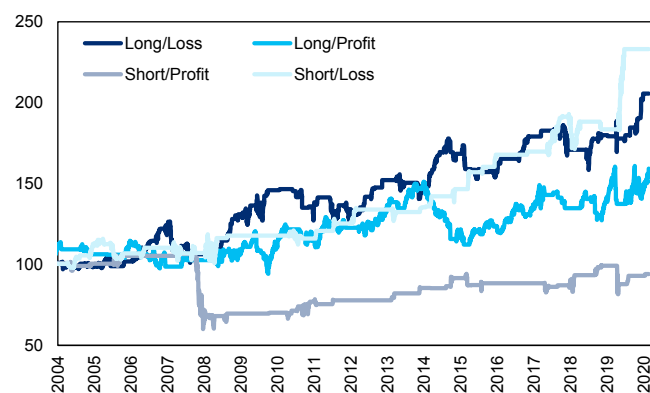
Source: Citi Research

Figure 42. Forecast and Steady States Probabilities

		Future State (2 weeks)				Steady State
		Long/Profit	Short/Profit	Long/Loss	Short/Loss	
Current State	Long/Profit	62%	6%	24%	8%	50%
	Short/Profit	28%	24%	20%	28%	10%
	Long/Loss	47%	7%	30%	15%	26%
	Short/Loss	28%	15%	27%	30%	15%

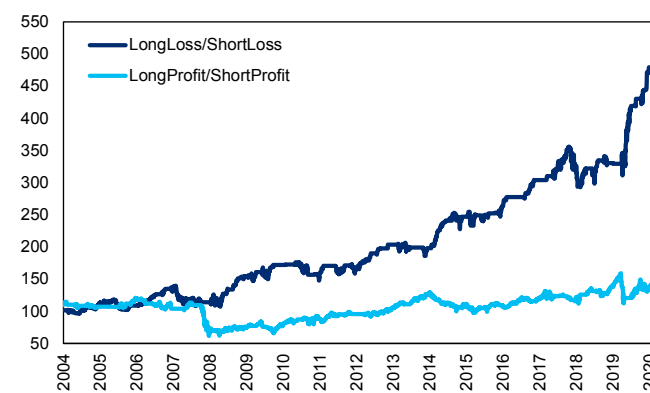
Source: Citi Research

Figure 43. Regime State Performance Wealth Curve



Source: Citi Research

Figure 44. Combining Regime Signals



Source: Citi Research

Figure 45. Summary Regime State Performance (Daily)

	Short/Loss	Long/Loss	Long/Profit	Short/Profit	Long/Loss + Short/Loss	Long/Profit + Short/Profit	Market
Annualized Return	38.8%	-3.7%	18.0%	6.2%	25.3%	4.6%	12.6%
Annualized Std Dev	21.9%	41.1%	18.5%	15.2%	19.8%	21.6%	20.9%
Annualized Sharpe (Rf=0%)	1.77	-0.09	0.97	0.41	1.28	0.21	0.60
Hit Rate	56%	53%	53%	54%	54%	54%	54%
SortinoRatio	0.15	0.01	0.09	0.04	0.12	0.03	0.06
Observations	651	410	1099	2131	1750	2541	4291
Skewness	0.01	0.03	0.01	0.01	-0.01	-0.40	0.01
Kurtosis	0.25	-0.16	-0.29	-0.72	3.71	12.51	-0.27
InvestedPeriod	651	410	1099	2133	1750	2543	4293
Total Investible Period	4293	4293	4293	4293	4293	4293	4293
Active Period	15%	10%	26%	50%	41%	59%	100%

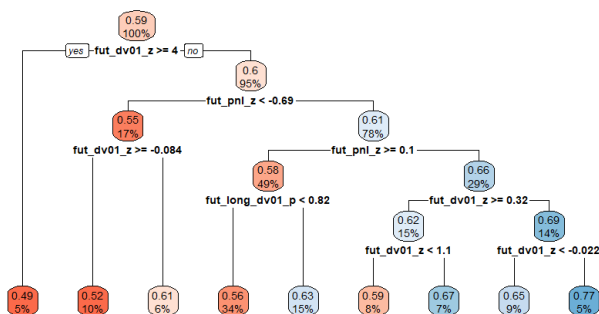
Source: Citi Research

Figure 46. Summary Regime State Performance (Weekly)

	Short/Loss	Long/Loss	Long/Profit	Short/Profit	Market
Annualized Return	29.1%	15.5%	7.1%	16.2%	13.1%
Annualized Std Dev	19.8%	17.2%	15.7%	35.3%	19.3%
Annualized Sharpe (Rf=0%)	1.47	0.90	0.45	0.46	0.68
Hit Rate	59%	59%	56%	59%	58%
SortinoRatio	0.32	0.19	0.10	0.12	0.15
Observations	125	224	427	82	858
Skewness	0.15	-0.36	-0.78	-0.54	-0.50
Kurtosis	1.61	1.58	2.03	1.09	3.78
InvestedPeriod	125	224	427	82	858
Total Investible Period	858	858	858	858	858
Active Period	15%	26%	50%	10%	100%

Source: Citi Research

Figure 47. Decision Tree Threshold Current Splits (All Observations)



Source: Citi Research

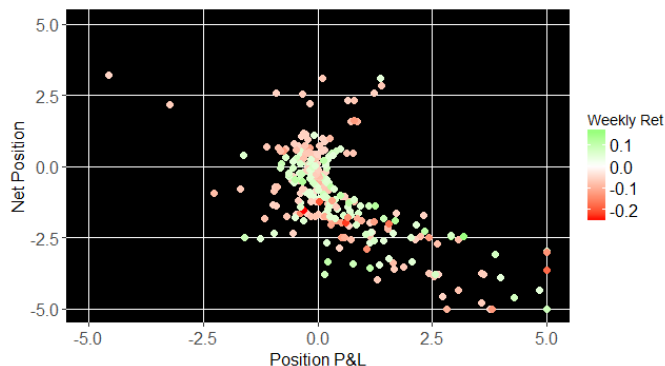
Figure 48. Decision Tree Model Performance Summary

	1	2	3	4	5	Benchmark
Annualized Return	15.4%	18.7%	28.0%	15.4%	16.0%	18.3%
Annualized Std Dev	19.8%	19.5%	19.0%	19.8%	19.8%	19.0%
Annualized Sharpe (Rf=0%)	0.78	0.96	1.47	0.78	0.81	0.96
Hit Rate	62%	64%	65%	62%	62%	60%
SortinoRatio	0.15	0.19	0.29	0.15	0.16	0.20
Skewness	-1.32	-1.19	-0.49	-1.32	-1.34	-0.70
Kurtosis	4.32	3.66	3.21	4.32	4.48	4.87
InvestedPeriod	381	354	386	381	377	598
Total Investible Period	598	598	598	598	598	598
Active Period	64%	59%	65%	64%	63%	100%

Source: Citi Research

## Performance Summary – EuroStoxx (SX5E)

Figure 49. Historical Weekly Returns By Position/P&L



Source: Citi Research

Figure 50. Benchmark Relative Summary State Risk/Returns Characteristics

		Position P&L	
		Loss	Profit
Net Position	Long	Rets ↓ Vol ↗	Rets ↓ Vol ↗
	Short	Rets ↑ Vol ↘	Rets ↓ Vol ↑

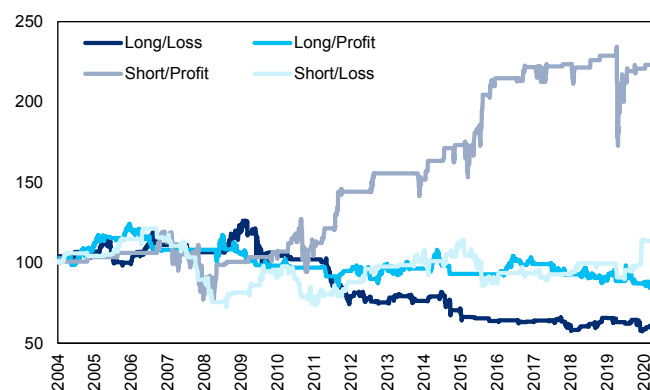
Source: Citi Research

Figure 51. Forecast and Steady States Probabilities

Current State		Future State (2 weeks)				Steady State
		Long/Profit	Short/Profit	Long/Loss	Short/Loss	
Current State	Long/Profit	55%	8%	26%	12%	35%
	Short/Profit	15%	38%	13%	35%	19%
	Long/Loss	40%	11%	30%	19%	23%
	Short/Loss	18%	27%	19%	37%	23%

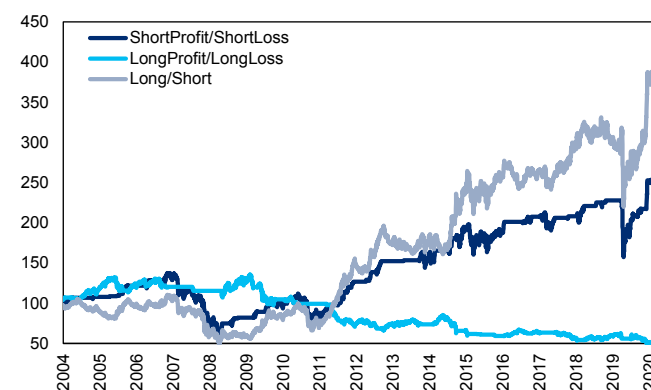
Source: Citi Research

Figure 52. Regime State Performance Wealth Curve



Source: Citi Research

Figure 53. Combined Regime Signals



Source: Citi Research

Figure 54. Summary Regime State Performance (Daily)

	Short/Loss	Long/Loss	Long/Profit	Short/Profit	Long/Loss + Short/Loss	Long/Profit + Short/Profit	Market
Annualized Return	3.3%	-11.7%	-2.4%	28.3%	13.8%	-6.2%	1.8%
Annualized Std Dev	20.1%	19.7%	14.3%	33.5%	26.9%	16.6%	21.6%
Annualized Sharpe (Rf=0%)	0.16	-0.59	-0.17	0.84	0.51	-0.37	0.09
Hit Rate	51%	50%	49%	53%	52%	49%	51%
SortinoRatio	0.02	-0.05	-0.01	0.08	0.06	-0.03	0.02
Observations	1007	966	1497	813	1820	2463	4283
Skewness	-0.34	0.15	-0.28	-0.17	-0.18	-0.03	-0.11
Kurtosis	3.83	6.03	3.40	4.73	6.44	6.08	8.47
InvestedPeriod	1007	966	1499	813	1820	2465	4285
Total Investible Period	4285	4285	4285	4285	4285	4285	4285
Active Period	24%	23%	35%	19%	42%	58%	100%

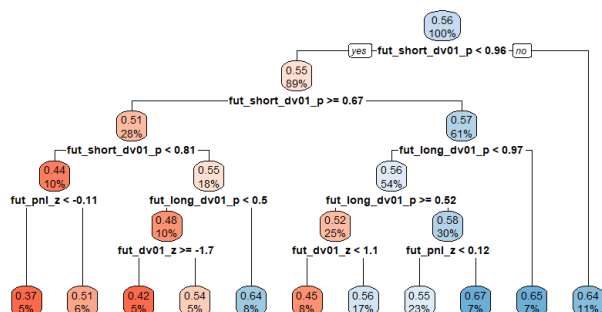
Source: Citi Research

Figure 55. Summary Regime State Performance (Weekly)

	Short/Loss	Long/Loss	Long/Profit	Short/Profit	Market
Annualized Return	15.5%	-2.5%	-2.2%	-1.9%	1.7%
Annualized Std Dev	20.0%	19.2%	14.9%	33.1%	21.5%
Annualized Sharpe (Rf=0%)	0.78	-0.13	-0.15	-0.06	0.08
Hit Rate	55%	56%	56%	57%	56%
SortinoRatio	0.18	-0.01	-0.01	0.02	0.03
Observations	202	192	300	164	858
Skewness	-0.06	-0.59	-0.59	-1.17	-0.97
Kurtosis	0.61	0.78	6.17	4.79	7.22
InvestedPeriod	202	192	300	164	858
Total Investible Period	858	858	858	858	858
Active Period	24%	22%	35%	19%	100%

Source: Citi Research

Figure 56. Decision Tree Threshold Current Splits (All Observations)



Source: Citi Research

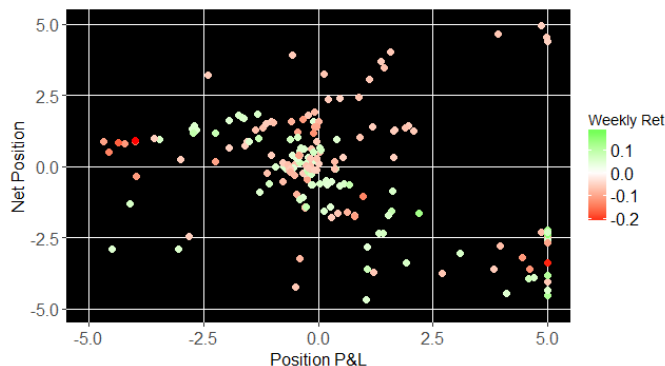
Figure 57. Decision Tree Model Performance Summary

	1	2	3	4	5	Benchmark
Annualized Return	8.5%	3.7%	-0.1%	8.5%	7.9%	2.4%
Annualized Std Dev	21.4%	21.8%	21.6%	21.4%	21.4%	20.8%
Annualized Sharpe (Rf=0%)	0.39	0.17	0.00	0.39	0.37	0.12
Hit Rate	58%	58%	56%	58%	58%	55%
SortinoRatio	0.09	0.05	0.02	0.09	0.09	0.04
Skewness	-0.76	-0.74	-0.72	-0.76	-0.75	-0.57
Kurtosis	4.96	4.97	5.11	4.96	4.95	4.18
InvestedPeriod	456	414	402	456	454	598
Total Investible Period	596	596	596	596	596	598
Active Period	77%	69%	67%	77%	76%	100%

Source: Citi Research

## Performance Summary – FTSE (Z)

Figure 58. Historical Weekly Returns By Position/P&L



Source: Citi Research

Figure 59. Benchmark Relative Summary State Risk/Returns Characteristics

		Position P&L	
		Loss	Profit
Net Position	Long	Rets ↓ Vol ↗	Rets ↓ Vol ↗
	Short	Rets ↑ Vol ↘	Rets ↑ Vol ↘

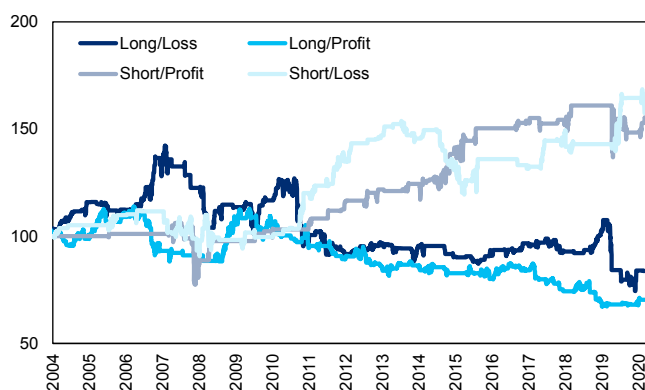
Source: Citi Research

Figure 60. Forecast and Steady States Probabilities

Current State		Future State (2 weeks)				Steady State
		Long/Profit	Short/Profit	Long/Loss	Short/Loss	
	Long/Profit	54%	8%	28%	11%	42%
	Short/Profit	27%	25%	21%	26%	12%
	Long/Loss	41%	9%	33%	17%	28%
	Short/Loss	24%	17%	27%	31%	18%

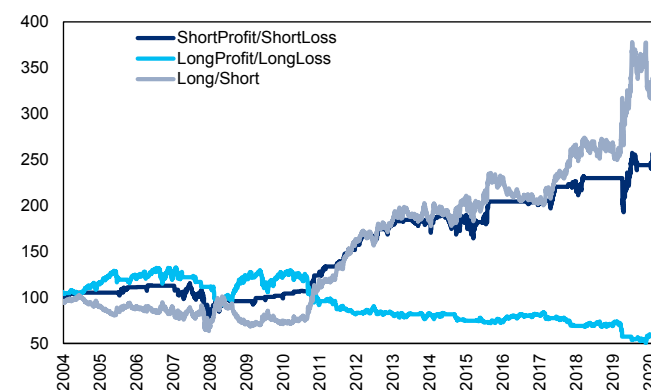
Source: Citi Research

Figure 61. Regime State Performance Wealth Curve



Source: Citi Research

Figure 62. Combined Regime Signals



Source: Citi Research

Figure 63. Summary Regime State Performance (Daily)

	Short/Loss	Long/Loss	Long/Profit	Short/Profit	Long/Loss + Short/Loss	Long/Profit + Short/Profit	Market
Annualized Return	15.9%	-3.6%	-4.8%	25.4%	19.5%	-4.3%	2.3%
Annualized Std Dev	19.9%	17.3%	12.3%	30.6%	24.7%	14.5%	18.2%
Annualized Sharpe (Rf=0%)	0.80	-0.21	-0.39	0.83	0.79	-0.30	0.12
Hit Rate	52%	51%	49%	54%	53%	50%	51%
SortinoRatio	0.08	-0.01	-0.03	0.08	0.08	-0.02	0.02
Observations	776	1205	1795	504	1280	3000	4280
Skewness	-0.09	-0.57	-0.34	-0.10	-0.09	-0.51	-0.18
Kurtosis	2.85	4.43	1.99	7.30	8.12	4.54	10.48
InvestedPeriod	776	1205	1795	506	1282	3000	4282
Total Investible Period	4282	4282	4282	4282	4282	4282	4282
Active Period	18%	28%	42%	12%	30%	70%	100%

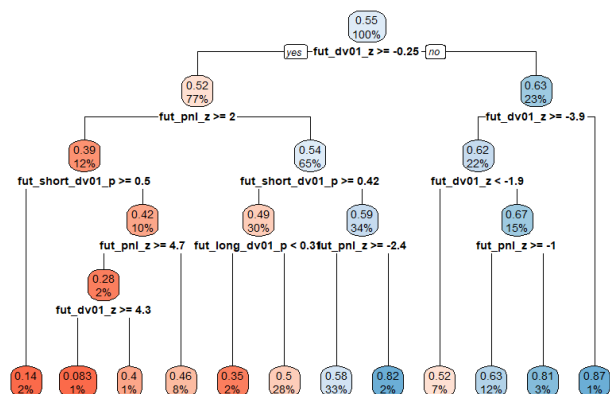
Source: Citi Research

Figure 64. Summary Regime State Performance (Weekly)

	Short/Loss	Long/Loss	Long/Profit	Short/Profit	Market
Annualized Return	26.3%	-5.5%	-5.1%	13.4%	2.0%
Annualized Std Dev	16.5%	20.0%	11.5%	28.7%	17.7%
Annualized Sharpe (Rf=0%)	1.60	-0.27	-0.45	0.47	0.11
Hit Rate	63%	52%	51%	58%	55%
SortinoRatio	0.33	-0.03	-0.07	0.11	0.04
Observations	158	237	362	101	858
Skewness	-0.41	-1.37	-0.33	-1.03	-1.06
Kurtosis	1.44	6.87	0.60	8.71	11.53
InvestedPeriod	158	237	362	101	858
Total Investible Period	858	858	858	858	858
Active Period	18%	28%	42%	12%	100%

Source: Citi Research

Figure 65. Decision Tree Threshold Current Splits (All Observations)



Source: Citi Research

Figure 66. Decision Tree Model Performance Summary

	1	2	3	4	5	Benchmark
Annualized Return	4.9%	-2.5%	-2.8%	4.9%	4.9%	2.4%
Annualized Std Dev	16.1%	17.1%	17.1%	16.1%	16.1%	16.7%
Annualized Sharpe (Rf=0%)	0.30	-0.15	-0.16	0.30	0.30	0.14
Hit Rate	53%	51%	51%	53%	53%	53%
SortinoRatio	0.08	-0.01	-0.01	0.08	0.08	0.04
Skewness	0.18	-0.81	-0.80	0.18	0.18	-0.55
Kurtosis	3.71	5.81	5.71	3.71	3.71	5.75
InvestedPeriod	430	440	442	430	430	596
Total Investible Period	596	596	596	596	596	596
Active Period	72%	74%	74%	72%	72%	100%

Source: Citi Research

Note: Futures trading involves substantial risk of loss.

## Previously Published Research

Figure 67. Research Reports (since 2009)

Report	Date Published
ESG Insights: The ESG 'Premium' – How does ESG compare to other Factors?	18-Feb-2021
Searching for Alpha: Asia Earnings Surprise – Predicting Asia Earnings Surprises	01-Feb-2021
ESG Insights: Where Machines do it Better – Inferred ESG Ratings Data	14-Jan-2021
Searching for Alpha: China A Alpha – Smoothing Price Momentum	30-Oct-2020
Under the Microscope: Overlapping Momentum	16-Oct-2020
Equity Markets Positioning Model – Introducing the EMP	14-Sep-2020
Searching for Alpha: Combining ESG and Risk Premia – A Double Screen Approach	11-Sep-2020
Searching for Alpha: Factoring Short Interest – Measuring and Profiting from Information in Shorts	8-Sep-2020
Searching for Alpha: Machine Learning – Attributing Higher-Order Interactions: SHAP Value as Factor Selection Criterion	28-May-2020
Searching for Alpha: Machine Learning – Leveraging Return Forecasts	28-Feb-2020
Searching for Alpha: China A Alpha - Sector-relative Value Is Powerful, Choose Sector Mappings Wisely	21-Feb-2020
Searching for Alpha: Machine Learning – Beyond Random Forests for Stock Selection	03-Oct-2019
Searching for Alpha: Earnings Surprise: Managing Expectations	23-Sep-2019
Searching for Alpha: Machine Learning – Interpreting Machine Learning Predictions	5-Mar-2019
Searching for Alpha: GAAP vs. Non-GAAP - Which Earnings does the Market Price?	7-Feb-2019
Searching for Alpha: Style Crowding in Asia - Getting Ahead of the Crowd	21-Nov-2018
Searching for Alpha: Earnings Surprise – Using Machine Learning to Forecast Earnings Surprises & Returns	17-Sep-2018
Searching for Alpha: The ESG Edge – A Step Forward	13-Sep-2018
Searching for Alpha: Machine Learning – Interacting Machine Learning and Factors	3-Sep-2018
Measuring the Crowded Trade: Introduction to our Crowding Composite for Individual Stocks	3-May-2018
Searching for Alpha: Profiting from Capex – Look to Capex Announcements	14-Mar-2018
Searching for Alpha: Tactical Style Rotation – Using Risk and Return to Manage Style Exposure	7-Sep-2017
Searching for Alpha: Big Data – Navigating New Alternative Datasets	10-Mar-2017
Searching for Alpha: Betting Against Accurate Beta	13-Feb-2017
Searching for Alpha: Competitive Advantage – Survival of the Fittest	19-Sep-2016
Searching for Alpha: Financial Strength Redux	9-Sep-2016
Searching for Alpha: Dynamic Style Weighting – Risk-Based Equity Style Allocation	14-Apr-2016
No Shorts Please: Long-Only Pure Style Portfolios	4-Mar-2016
Industry Alpha insights: Banks – One Size Does Not Fit All	18-Feb-2016
Under the Microscope: Stock Momentum Conflation	21-Sep-2015
Searching for Alpha: Macro Moves Markets	15-Sep-2015
Searching for Alpha: Style Performance, Trading Volumes and Investor Agreement	23-Mar-2015
World Radar Screen: Refining Our Global Search for Alpha	13-Mar-2015
Searching for Alpha: Networking with Analysts: Modelling Analyst Forecast Dependence	18-Feb-2015
The Rise of Low Risk Investing: Is it Getting Crowded Out There	01-Oct-2014
Under the Microscope: Five Innovations in Momentum Investing	27-Mar-2014
Searching for Alpha: Timing Price Momentum	07-Mar-2014
Equity Risk Premia Investing: A New Methodology For Monitoring Style Performance	27-Nov-2013
Stock Market Country Selection: Changes to a Well Established Model	23-Jul-2013
Searching for Alpha: Digging for Dividends – QUARI Quality with A Reliable Income	02-Jul-2013
Global Theme Machine: An Objective Way of Identifying Attractive Investment Themes	24-Jun-2013
Searching for Alpha: Purifying Analyst Recommendations – Removing Beta to get to the Alpha	25-Mar-2013
Searching for Alpha: Tangible Benefits of Intangibles – Brand, Respect & Intellectual Capital	06-Nov-2012
Low-Risk Portfolio Strategies: Sharpe Ratio Maximisation and Multi-Asset Applications	09-Mar-2012
Macro Risk and Style Rotation: A Guide Rather than a Prescription	28-Feb-2012
Searching for Alpha: Accruals Volatility – A New Approach to Quality Investing	14-Sep-2011
Industry Alpha Insights: Four Approaches to Tactical Industry Selection	24-Aug-2011
Industry Alpha Insights: Quantifying Industry Specific Fundamentals	17-Mar-2011
Low-Risk Equity Portfolios: More than just Minimum Variance	18-Nov-2010
Under the Microscope: Measuring Systemic Risk – The Absorption Ratio	15-Nov-2010
Under the Microscope: Optionality in Valuation	14-Jun-2010
Searching for Alpha: Earnings Surprise – Still Profiting from Surprises	31-Mar-2010
Searching for Alpha: Optimising Style Rotation Strategies	15-Oct-2009

Source: Citi Research

## Citi Quant Research Team

Figure 68. Citi Quantitative Research Teams

### Global Quantitative Research

#### Europe

Chris Montagu <sup>1</sup>	+44-20-7986-3958	chris.montagu@citi.com
David Chew <sup>1</sup>	+44-20-7986-7698	david.chew@citi.com
Josie Gerken <sup>1</sup>	+44-20-7986-4060	josie.gerken@citi.com
Pier Procacci <sup>1</sup>	+44-20-7986-4228	pier.procacci@citi.com

#### North America

Hong Li <sup>4</sup>	+1-212-816-5062	hong.li@citi.com
Jason Li <sup>4</sup>	+1-212-816-6692	jason.li@citi.com
Tiffany Zhou <sup>4</sup>	+1-212-816-9476	tiffany.zhou@citi.com
Richard Schlatter <sup>4</sup>	+1-212-816 0591	richard.w.schlatter@citi.com

#### Asia

Chris Ma <sup>2</sup>	+852-2501-2404	chris.ma@citi.com
Simon Jin <sup>2</sup>	+852-2501-2444	simon.jin@citi.com
Yue Hin Pong <sup>2</sup>	+852-2501-2449	yue.hin.pong@citi.com
Liz Dinh <sup>3</sup>	+61-2-8225-4896	liz.dinh@citi.com
Rory Anderson <sup>3</sup>	+61-2-8225-4808	rory.anderson@citi.com
Bhavik Bochar <sup>4</sup>	+91-22-4277-5019	bhavik.k.bochar@citi.com

#### Multi-Asset

David Bieber <sup>1</sup>	+44-20-7986-4976	david.bieber@citi.com
Kim Jensen <sup>1</sup>	+44-20-7986-3284	kim.jensen@citi.com

1 Citigroup Global Markets Ltd; 2 Citigroup Global Markets Asia Limited; 3 Citigroup Pty Limited, 4 Citigroup Global Markets Inc., 5 Citigroup Global Markets India Private Limited

**NON-US RESEARCH ANALYST DISCLOSURES:** The non-US research analysts listed above (i.e., the research analysts listed above other than those identified as employed by Citigroup Global Markets Inc.) are not registered/qualified as research analysts with FINRA. Such research analysts may not be associated persons of the member organization and therefore may not be subject to the NYSE Rule 472 and NASD Rule 2711 restrictions on communications with a subject company, public appearances and trading securities held by a research analyst account. Unless indicated in Appendix A-1 of this document or any of the referenced documents, the analysts listed above have not contributed to this document or any of the referenced documents.



## Appendix A-1

### Analyst Certification

The research analysts primarily responsible for the preparation and content of this research report are either (i) designated by "AC" in the author block or (ii) listed in bold alongside content which is attributable to that analyst. If multiple AC analysts are designated in the author block, each analyst is certifying with respect to the entire research report other than (a) content attributable to another AC certifying analyst listed in bold alongside the content and (b) views expressed solely with respect to a specific issuer which are attributable to another AC certifying analyst identified in the price charts or rating history tables for that issuer shown below. Each of these analysts certify, with respect to the sections of the report for which they are responsible: (1) that the views expressed therein accurately reflect their personal views about each issuer and security referenced and were prepared in an independent manner, including with respect to Citigroup Global Markets Inc. and its affiliates; and (2) no part of the research analyst's compensation was, is, or will be, directly or indirectly, related to the specific recommendations or views expressed by that research analyst in this report.

### IMPORTANT DISCLOSURES

**Disclosure for investors in the Republic of Turkey:** Under Capital Markets Law of Turkey (Law No: 6362), the investment information, comments and recommendations stated here, are not within the scope of investment advisory activity. Investment advisory service is provided in accordance with a contract of engagement on investment advisory concluded between brokerage houses, portfolio management companies, non-deposit banks and clients. Comments and recommendations stated here rely on the individual opinions of the ones providing these comments and recommendations. These opinions may not fit to your financial status, risk and return preferences. For this reason, to make an investment decision by relying solely to this information stated here may not bring about outcomes that fit your expectations. Furthermore, Citi Research is a division of Citigroup Global Markets Inc. (the "Firm"), which does and seeks to do business with companies and/or trades on securities covered in this research reports. As a result, investors should be aware that the Firm may have a conflict of interest that could affect the objectivity of this report, however investors should also note that the Firm has in place organisational and administrative arrangements to manage potential conflicts of interest of this nature.

Analysts' compensation is determined by Citi Research management and Citigroup's senior management and is based upon activities and services intended to benefit the investor clients of Citigroup Global Markets Inc. and its affiliates (the "Firm"). Compensation is not linked to specific transactions or recommendations. Like all Firm employees, analysts receive compensation that is impacted by overall Firm profitability which includes investment banking, sales and trading, and principal trading revenues. One factor in equity research analyst compensation is arranging corporate access events between institutional clients and the management teams of covered companies. Typically, company management is more likely to participate when the analyst has a positive view of the company.

For securities recommended in the Product in which the Firm is not a market maker, the Firm is a liquidity provider in the issuers' financial instruments and may act as principal in connection with such transactions. The Firm is a regular issuer of traded financial instruments linked to securities that may have been recommended in the Product. The Firm regularly trades in the securities of the issuer(s) discussed in the Product. The Firm may engage in securities transactions in a manner inconsistent with the Product and, with respect to securities covered by the Product, will buy or sell from customers on a principal basis.

Unless stated otherwise neither the Research Analyst nor any member of their team has viewed the material operations of the Companies for which an investment view has been provided within the past 12 months.

For important disclosures (including copies of historical disclosures) regarding the companies that are the subject of this Citi Research product ("the Product"), please contact Citi Research, 388 Greenwich Street, 30th Floor, New York, NY, 10013, Attention: Legal/Compliance [E6WYB6412478]. In addition, the same important disclosures, with the exception of the Valuation and Risk assessments and historical disclosures, are contained on the Firm's disclosure website at [https://www.citivelocity.com/cvr/eppublic/citi\\_research\\_disclosures](https://www.citivelocity.com/cvr/eppublic/citi_research_disclosures). Valuation and Risk assessments can be found in the text of the most recent research note/report regarding the subject company. Pursuant to the Market Abuse Regulation a history of all Citi Research recommendations published during the preceding 12-month period can be accessed via Citi Veloccity (<https://www.citivelocity.com/cv2>) or your standard distribution portal. Historical disclosures (for up to the past three years) will be provided upon request.

#### Citi Research Equity Ratings Distribution

<b>Data current as of 31 Dec 2020</b>	<b>12 Month Rating</b>			<b>Catalyst Watch</b>		
	<b>Buy</b>	<b>Hold</b>	<b>Sell</b>	<b>Buy</b>	<b>Hold</b>	<b>Sell</b>
Citi Research Global Fundamental Coverage	56%	34%	10%	24%	67%	9%
% of companies in each rating category that are investment banking clients	64%	64%	57%	68%	62%	67%
Citi Research Quantitative World Radar Screen Model Coverage	30%	40%	30%			
% of companies in each rating category that are investment banking clients	39%	34%	31%			
Citi Research Quantitative Latam Radar Screen Model Coverage	20%	60%	20%			
% of companies in each rating category that are investment banking clients	75%	72%	38%			
Citi Research Quantitative Asia Radar Screen Model Coverage	20%	60%	20%			
% of companies in each rating category that are investment banking clients	33%	29%	24%			
Citi Research Quantitative Australia Radar Screen Model Coverage	49%	0%	51%			
% of companies in each rating category that are investment banking clients	51%	0%	35%			

#### Guide to Citi Research Fundamental Research Investment Ratings:

Citi Research stock recommendations include an investment rating and an optional risk rating to highlight high risk stocks.

**Risk rating** takes into account both price volatility and fundamental criteria. Stocks will either have no risk rating or a High risk rating assigned.

**Investment Ratings:** Citi Research investment ratings are Buy, Neutral and Sell. Our ratings are a function of analyst expectations of expected total return

("ETR") and risk. ETR is the sum of the forecast price appreciation (or depreciation) plus the dividend yield for a stock within the next 12 months. The target price is based on a 12 month time horizon. The Investment rating definitions are: Buy (1) ETR of 15% or more or 25% or more for High risk stocks; and Sell (3) for negative ETR. Any covered stock not assigned a Buy or a Sell is a Neutral (2). For stocks rated Neutral (2), if an analyst believes that there are insufficient valuation drivers and/or investment catalysts to derive a positive or negative investment view, they may elect with the approval of Citi Research management not to assign a target price and, thus, not derive an ETR. Additionally, in certain circumstances Citi Research may suspend its rating and target price and place the stock "Under Review". "Under Review" status may be imposed when the rating has been suspended for (a) regulatory and/or internal policy reasons or (b) other exceptional circumstances (e.g. lack of information critical to the analyst's thesis) affecting the company and / or trading in the company's securities (e.g. trading suspension). In such situations, the rating and target price will show as "-" and "-" respectively in the rating history price chart. As soon as practically possible, the analyst will publish a note re-establishing a rating and investment thesis. Investment ratings are determined by the ranges described above at the time of initiation of coverage, a change in investment and/or risk rating, or a change in target price (subject to limited management discretion). At times, the expected total returns may fall outside of these ranges because of market price movements and/or other short-term volatility or trading patterns. Such interim deviations will be permitted but will become subject to review by Research Management. Your decision to buy or sell a security should be based upon your personal investment objectives and should be made only after evaluating the stock's expected performance and risk.

#### Catalyst Watch Upside/Downside calls:

Citi Research may also include a Catalyst Watch Upside or Downside call to highlight specific near-term catalysts or events impacting the company or the market that are expected to influence the share price over a specified period of 30 or 90 days. A Catalyst Watch Upside (Downside) call indicates that the analyst expects the share price to rise (fall) in absolute terms over the specified period. A Catalyst Watch Upside/Downside call will automatically expire at the end of the specified 30/90 day period; the analyst may also close a Catalyst Watch call prior to the end of the specified period in a published research note. A Catalyst Watch Upside or Downside call may be different from and does not affect a stock's fundamental equity rating, which reflects a longer-term total absolute return expectation. For purposes of FINRA ratings-distribution-disclosure rules, a Catalyst Watch Upside call corresponds to a buy recommendation and a Catalyst Watch Downside call corresponds to a sell recommendation. Any stock not assigned to a Catalyst Watch Upside or Catalyst Watch Downside call is considered Catalyst Watch Non-Rated (CWNR). For purposes of FINRA ratings-distribution-disclosure rules, we correspond CWNR to Hold in our ratings distribution table for our Catalyst Watch Upside/Downside rating system. However, we reiterate that we do not consider CWNR to be a recommendation. For all Catalyst Watch Upside/Downside calls, risk exists that the catalyst(s) and associated share-price movement will not materialize as expected.

#### Guide to Citi Research Quantitative Research Investment Ratings:

Citi Research Quantitative Research World Radar Screen recommendations are based on a globally consistent framework to measure relative value and momentum for a large number of stocks across global developed and emerging markets. Relative value and momentum rankings are equally weighted to produce a global attractiveness score for each stock. The scores are then ranked and put into deciles. A stock with a decile rating of 1 denotes an attractiveness score in the top 10% of the universe (most attractive). A stock with a decile rating of 10 denotes an attractiveness score in the bottom 10% of the universe (least attractive).

Citi Research Asia Quantitative Radar Screen model recommendations are based on a regionally consistent framework to measure relative value and momentum for a large number of stocks across regional developed and emerging markets. Relative value and momentum rankings are equally weighted to produce a global attractiveness score for each stock. The scores are then ranked and put into quintiles. A stock with a quintile rating of 1 denotes an attractiveness score in the top 20% of the universe (most attractive). A stock with a quintile rating of 5 denotes an attractiveness score in the bottom 20% of the universe (least attractive).

Citi Research Quantitative Research Latam Radar Screen recommendations are based on a globally consistent framework to measure relative value and momentum for a large number of stocks across markets in Latin America. Relative value and momentum rankings are equally weighted to produce a global attractiveness score for each stock. The scores are then ranked and put into quintiles. A stock with a quintile rating of 1 denotes an attractiveness score in the top 20% of the universe (most attractive). A stock with a quintile rating of 5 denotes an attractiveness score in the bottom 20% of the universe (least attractive).

Citi Research Australia Quantitative Radar Screen model recommendations are based on a robust framework to measure relative value and momentum for a large number of stocks across the Australian market. Stocks with a ranking of 1 denotes a stock that is above average in terms of both value and momentum relative to the stocks in the Australian market. A ranking of 10 denotes a stock that is below average in terms of both value and momentum relative to the stocks in the Australian market.

For purposes of FINRA ratings-distribution-disclosure rules, a Citi Research Quantitative World Radar Screen recommendation of (1), (2) or (3) most closely corresponds to a buy recommendation; a recommendation from this product group of (4), (5), (6) or (7) most closely corresponds to a hold recommendation; and a recommendation of (8), (9) or (10) most closely corresponds to a sell recommendation. An (NR) recommendation indicates that the stock is no longer in the screen.

For purposes of FINRA ratings-distribution-disclosure rules, a Citi Research Latam Radar Screen recommendation of (1) most closely corresponds to a buy recommendation; a recommendation of (2),(3) or (4) most closely corresponds to a hold recommendation; and a recommendation of (5) most closely corresponds to a sell recommendation. An (NR) recommendation indicates that the stock is no longer in the screen.

For purposes of FINRA ratings distribution disclosure rules, a Citi Research Asia Quantitative Radar Screen recommendation of (1) most closely corresponds to a buy recommendation; a Citi Research Asia Quantitative Radar Screen recommendation of (2), (3), (4) most closely corresponds to a hold recommendation; and a recommendation of (5) most closely corresponds to a sell recommendation. An (NR) recommendation indicates that the stock is no longer in the screen.

For purposes of FINRA ratings-distribution-disclosure rules, a Citi Research Quantitative Research Australia Radar Screen recommendation of "attractive" (1) most closely corresponds to a buy recommendation. All other stocks in the sector are considered to be "unattractive" (10) which most closely corresponds to a sell recommendation. An (NR)/(0) recommendation indicates that the stock is no longer in the screen.

Recommendations are based on the relative attractiveness of a stock, thus can not be directly equated to buy, hold and sell categories. Accordingly, your decision to buy or sell a security should be based on your personal investment objectives and only after evaluating the stock's expected relative performance.

## NON-US RESEARCH ANALYST DISCLOSURES

Non-US research analysts who have prepared this report (i.e., all research analysts listed below other than those identified as employed by Citigroup Global Markets Inc.) are not registered/qualified as research analysts with FINRA. Such research analysts may not be associated persons of the member organization and therefore may not be subject to the FINRA Rule 2241 restrictions on communications with a subject company, public appearances and trading securities held by a research analyst account. The legal entities employing the authors of this report are listed below (and their regulators are listed further herein):

Citigroup Global Markets Limited	Chris Montagu; David T Chew; Josie Gerken; Pier Procacci; David Bieber; Kim D Jensen, CFA
Citigroup Global Markets Inc.	Hong Li
Citigroup Global Markets Asia Limited	Chris Ma

## OTHER DISCLOSURES

Any price(s) of instruments mentioned in recommendations are as of the prior day's market close on the primary market for the instrument, unless otherwise stated.

The completion and first dissemination of any recommendations made within this research report are as of the Eastern date-time displayed at the top of the Product. If the Product references views of other analysts then please refer to the price chart or rating history table for the date/time of completion and first dissemination with respect to that view.

Regulations in various jurisdictions require that where a recommendation differs from any of the author's previous recommendations concerning the same financial instrument or issuer that has been published during the preceding 12-month period that the change(s) and the date of that previous recommendation are indicated. For fundamental coverage please refer to the price chart or rating change history within this disclosure appendix or the issuer disclosure summary at [https://www.citivelocity.com/cvr/eppublic/citi\\_research\\_disclosures](https://www.citivelocity.com/cvr/eppublic/citi_research_disclosures).

Citi Research has implemented policies for identifying, considering and managing potential conflicts of interest arising as a result of publication or distribution of investment research. A description of these policies can be found at [https://www.citivelocity.com/cvr/eppublic/citi\\_research\\_disclosures](https://www.citivelocity.com/cvr/eppublic/citi_research_disclosures).

The proportion of all Citi Research research recommendations that were the equivalent to "Buy", "Hold", "Sell" at the end of each quarter over the prior 12 months (with the % of these that had received investment firm services from Citi in the prior 12 months shown in brackets) is as follows: Q4 2020 Buy 33% (69%), Hold 43% (60%), Sell 23% (54%), RV 0.6% (79%); Q3 2020 Buy 33% (69%), Hold 43% (63%), Sell 23% (58%), RV 0.7% (87%); Q2 2020 Buy 33% (68%), Hold 43% (62%), Sell 24% (60%), RV 0.7% (88%); Q1 2020 Buy 33% (68%), Hold 43% (60%), Sell 24% (57%), RV 0.6% (85%). For the purposes of disclosing recommendations other than for equity (whose definitions can be found in the corresponding disclosure sections), "Buy" means a positive directional trade idea; "Sell" means a negative directional trade idea; and "Relative Value" means any trade idea which does not have a clear direction to the investment strategy.

European regulations require a 5 year price history when past performance of a security is referenced. CitiVelocity's Charting Tool ([https://www.citivelocity.com/cv2/#go/CHARTING\\_3\\_Equities](https://www.citivelocity.com/cv2/#go/CHARTING_3_Equities)) provides the facility to create customisable price charts including a five year option. This tool can be found in the Data & Analytics section under any of the asset class menus in CitiVelocity (<https://www.citivelocity.com/>). For further information contact CitiVelocity support ([https://www.citivelocity.com/cv2/go/CLIENT\\_SUPPORT](https://www.citivelocity.com/cv2/go/CLIENT_SUPPORT)). The source for all referenced prices, unless otherwise stated, is DataCentral, which sources price information from Thomson Reuters. Past performance is not a guarantee or reliable indicator of future results. Forecasts are not a guarantee or reliable indicator of future performance.

Investors should always consider the investment objectives, risks, and charges and expenses of an ETF carefully before investing. The applicable prospectus and key investor information document (as applicable) for an ETF should contain this and other information about such ETF. It is important to read carefully any such prospectus before investing. Clients may obtain prospectuses and key investor information documents for ETFs from the applicable distributor or authorized participant, the exchange upon which an ETF is listed and/or from the applicable website of the applicable ETF issuer. The value of the investments and any accruing income may fall or rise. Any past performance, prediction or forecast is not indicative of future or likely performance. Any information on ETFs contained herein is provided strictly for illustrative purposes and should not be deemed an offer to sell or a solicitation of an offer to purchase units of any ETF either explicitly or implicitly. The opinions expressed are those of the authors and do not necessarily reflect the views of ETF issuers, any of their agents or their affiliates.

Citigroup Global Markets India Private Limited and/or its affiliates may have, from time to time, actual or beneficial ownership of 1% or more in the debt securities of the subject issuer.

Please be advised that pursuant to Executive Order 13959 of November 12, 2020 (the "Order"), U.S. persons are prohibited from investing in securities of any company determined by the United States Government to be a Communist Chinese military company as defined in the Order. This research is not intended to be used or relied upon in any way that could result in a violation of the Order. Investors are encouraged to rely upon their own legal counsel for advice on compliance with the Order and other economic sanctions programs administered and enforced by the Office of Foreign Assets Control of the U.S. Treasury Department.

This communication is directed at persons who are "Eligible Clients" as such term is defined in the Israeli Regulation of Investment Advice, Investment Marketing and Investment Portfolio Management law, 1995 (the "Advisory Law"). Within Israel, this communication is not intended for retail clients and Citi will not make such products or transactions available to retail clients. The presenter is not licensed as investment advisor or marketer by the Israeli Securities Authority ("ISA") and this communication does not constitute investment or marketing advice. The information contained herein may relate to matters that are not regulated by the ISA. Any securities which are the subject of this communication may not be offered or sold to any Israeli person except pursuant to an exemption from the Israeli public offering rules, including according to the Israeli Securities Law.

Citi Research generally disseminates its research to the Firm's global institutional and retail clients via both proprietary (e.g., Citi Velocity and Citi Personal Wealth Management) and non-proprietary electronic distribution platforms. Certain research may be disseminated only via the Firm's proprietary distribution platforms; however such research will not contain changes to earnings forecasts, target price, investment or risk rating or investment thesis or be otherwise

inconsistent with the author's previously published research. Certain research is made available only to institutional investors to satisfy regulatory requirements. Individual Citi Research analysts may also opt to circulate published research to one or more clients by email; such email distribution is discretionary and is done only after the research has been disseminated. The level and types of services provided by Citi Research analysts to clients may vary depending on various factors such as the client's individual preferences as to the frequency and manner of receiving communications from analysts, the client's risk profile and investment focus and perspective (e.g. market-wide, sector specific, long term, short-term etc.), the size and scope of the overall client relationship with the Firm and legal and regulatory constraints.

Pursuant to Comissão de Valores Mobiliários Rule 598 and ASIC Regulatory Guide 264, Citi is required to disclose whether a Citi related company or business has a commercial relationship with the subject company. Considering that Citi operates multiple businesses in more than 100 countries around the world, it is likely that Citi has a commercial relationship with the subject company.

Securities recommended, offered, or sold by the Firm: (i) are not insured by the Federal Deposit Insurance Corporation; (ii) are not deposits or other obligations of any insured depository institution (including Citibank); and (iii) are subject to investment risks, including the possible loss of the principal amount invested. The Product is for informational purposes only and is not intended as an offer or solicitation for the purchase or sale of a security. Any decision to purchase securities mentioned in the Product must take into account existing public information on such security or any registered prospectus. Although information has been obtained from and is based upon sources that the Firm believes to be reliable, we do not guarantee its accuracy and it may be incomplete and condensed. Note, however, that the Firm has taken all reasonable steps to determine the accuracy and completeness of the disclosures made in the Important Disclosures section of the Product. The Firm's research department has received assistance from the subject company(ies) referred to in this Product including, but not limited to, discussions with management of the subject company(ies). Firm policy prohibits research analysts from sending draft research to subject companies. However, it should be presumed that the author of the Product has had discussions with the subject company to ensure factual accuracy prior to publication. All opinions, projections and estimates constitute the judgment of the author as of the date of the Product and these, plus any other information contained in the Product, are subject to change without notice. Prices and availability of financial instruments also are subject to change without notice. Notwithstanding other departments within the Firm advising the companies discussed in this Product, information obtained in such role is not used in the preparation of the Product. Although Citi Research does not set a predetermined frequency for publication, if the Product is a fundamental equity or credit research report, it is the intention of Citi Research to provide research coverage of the covered issuers, including in response to news affecting the issuer. For non-fundamental research reports, Citi Research may not provide regular updates to the views, recommendations and facts included in the reports. Notwithstanding that Citi Research maintains coverage on, makes recommendations concerning or discusses issuers, Citi Research may be periodically restricted from referencing certain issuers due to legal or policy reasons. Where a component of a published trade idea is subject to a restriction, the trade idea will be removed from any list of open trade ideas included in the Product. Upon the lifting of the restriction, the trade idea will either be re-instated in the open trade ideas list if the analyst continues to support it or it will be officially closed. Citi Research may provide different research products and services to different classes of customers (for example, based upon long-term or short-term investment horizons) that may lead to differing conclusions or recommendations that could impact the price of a security contrary to the recommendations in the alternative research product, provided that each is consistent with the rating system for each respective product.

Investing in non-U.S. securities, including ADRs, may entail certain risks. The securities of non-U.S. issuers may not be registered with, nor be subject to the reporting requirements of the U.S. Securities and Exchange Commission. There may be limited information available on foreign securities. Foreign companies are generally not subject to uniform audit and reporting standards, practices and requirements comparable to those in the U.S. Securities of some foreign companies may be less liquid and their prices more volatile than securities of comparable U.S. companies. In addition, exchange rate movements may have an adverse effect on the value of an investment in a foreign stock and its corresponding dividend payment for U.S. investors. Net dividends to ADR investors are estimated, using withholding tax rates conventions, deemed accurate, but investors are urged to consult their tax advisor for exact dividend computations. Investors who have received the Product from the Firm may be prohibited in certain states or other jurisdictions from purchasing securities mentioned in the Product from the Firm. Please ask your Financial Consultant for additional details. Citigroup Global Markets Inc. takes responsibility for the Product in the United States. Any orders by US investors resulting from the information contained in the Product may be placed only through Citigroup Global Markets Inc.

**Important Disclosures for Bell Potter Customers:** Bell Potter is making this Product available to its clients pursuant to an agreement with Citigroup Global Markets Australia Pty Limited. Neither Citigroup Global Markets Australia Pty Limited nor any of its affiliates has made any determination as to the suitability of the information provided herein and clients should consult with their Bell Potter financial advisor before making any investment decision.

**The Citigroup legal entity that takes responsibility for the production of the Product is the legal entity which the first named author is employed by.**

The Product is made available in **Australia** through Citigroup Global Markets Australia Pty Limited. (ABN 64 003 114 832 and AFSL No. 240992), participant of the ASX Group and regulated by the Australian Securities & Investments Commission. Citigroup Centre, 2 Park Street, Sydney, NSW 2000. Citigroup Global Markets Australia Pty Limited is not an Authorised Deposit-Taking Institution under the Banking Act 1959, nor is it regulated by the Australian Prudential Regulation Authority. The Product is made available in Australia to Private Banking wholesale clients through Citigroup Pty Limited (ABN 88 004 325 080 and AFSL 238098). Citigroup Pty Limited provides all financial product advice to Australian Private Banking wholesale clients through bankers and relationship managers. If there is any doubt about the suitability of investments held in Citigroup Private Bank accounts, investors should contact the Citigroup Private Bank in Australia. Citigroup companies may compensate affiliates and their representatives for providing products and services to clients.

The Product is made available in **Brazil** by Citigroup Global Markets Brasil - CCTVM SA, which is regulated by CVM - Comissão de Valores Mobiliários ("CVM"), BACEN - Brazilian Central Bank, APIMEC - Associação dos Analistas e Profissionais de Investimento do Mercado de Capitais and ANBIMA - Associação Brasileira das Entidades dos Mercados Financeiro e de Capitais. Av. Paulista, 1111 - 14º andar(parte) - CEP: 01311920 - São Paulo - SP.

If the Product is being made available in certain provinces of **Canada** by Citigroup Global Markets (Canada) Inc. ("CGM Canada"), CGM Canada has approved the Product. Citigroup Place, 123 Front Street West, Suite 1100, Toronto, Ontario M5J 2M3.

This product is available in **Chile** through Banchile Corredores de Bolsa S.A., an indirect subsidiary of Citigroup Inc., which is regulated by the Superintendencia de Valores y Seguros. Agustinas 975, piso 2, Santiago, Chile.



The Product is made available in **Germany** by Citigroup Global Markets Europe AG ("CGME"), which is regulated by the German Federal Financial Supervisory Authority (Bundesanstalt für Finanzdienstleistungsaufsicht BaFin). CGME, Reuterweg 16, 60323 Frankfurt am Main.

Research which relates to "securities" (as defined in the Securities and Futures Ordinance (Cap. 571 of the Laws of Hong Kong)) is issued in **Hong Kong** by, or on behalf of, Citigroup Global Markets Asia Limited which takes full responsibility for its content. Citigroup Global Markets Asia Ltd. is regulated by Hong Kong Securities and Futures Commission. If the Research is made available through Citibank, N.A., Hong Kong Branch, for its clients in Citi Private Bank, it is made available by Citibank N.A. (organized under the laws of U.S. A. with limited liability), Champion Tower, 3 Garden Road, Hong Kong. Citibank N.A. is regulated by the Hong Kong Monetary Authority. Please contact your Private Banker in Citibank N.A., Hong Kong, Branch if you have any queries on or any matters arising from or in connection with this document.

The Product is made available in **India** by Citigroup Global Markets India Private Limited (CGM), which is regulated by the Securities and Exchange Board of India (SEBI), as a Research Analyst (SEBI Registration No. INH000000438). CGM is also actively involved in the business of merchant banking and stock brokerage in India, and is registered with SEBI in this regard. CGM's registered office is at 1202, 12th Floor, FIFC, G Block, Bandra Kurla Complex, Bandra East, Mumbai – 400098. CGM's Corporate Identity Number is U99999MH2000PTC126657, and its contact details are: Tel: +9102261759999 Fax: +9102261759961.

The Product is made available in **Indonesia** through PT Citigroup Securities Indonesia. 5/F, Citibank Tower, Bapindo Plaza, Jl. Jend. Sudirman Kav. 54-55, Jakarta 12190. Neither this Product nor any copy hereof may be distributed in Indonesia or to any Indonesian citizens wherever they are domiciled or to Indonesian residents except in compliance with applicable capital market laws and regulations. This Product is not an offer of securities in Indonesia. The securities referred to in this Product have not been registered with the Capital Market and Financial Institutions Supervisory Agency (BAPEPAM-LK) pursuant to relevant capital market laws and regulations, and may not be offered or sold within the territory of the Republic of Indonesia or to Indonesian citizens through a public offering or in circumstances which constitute an offer within the meaning of the Indonesian capital market laws and regulations.

The Product is made available in **Israel** through Citibank NA, regulated by the Bank of Israel and the Israeli Securities Authority. Citibank, N.A., Platinum Building, 21 Ha'arba'ah St, Tel Aviv, Israel.

The Product is made available in **Japan** by Citigroup Global Markets Japan Inc. ("CGMJ"), which is regulated by Financial Services Agency, Securities and Exchange Surveillance Commission, Japan Securities Dealers Association, Tokyo Stock Exchange and Osaka Securities Exchange. Otemachi Park Building, 1-1-1 Otemachi, Chiyoda-ku, Tokyo 100-8132 Japan. If the Product was distributed by SMBC Nikko Securities Inc. it is being so distributed under license. In the event that an error is found in an CGMJ research report, a revised version will be posted on the Firm's Citi Velocity website. If you have questions regarding Citi Velocity, please call (81 3) 6270-3019 for help.

The product is made available in the **Kingdom of Saudi Arabia** in accordance with Saudi laws through Citigroup Saudi Arabia, which is regulated by the Capital Market Authority (CMA) under CMA license (17184-31). 2239 Al Urubah Rd – Al Olaya Dist. Unit No. 18, Riyadh 12214 – 9597, Kingdom Of Saudi Arabia.

The Product is made available in **Korea** by Citigroup Global Markets Korea Securities Ltd., which is regulated by the Financial Services Commission, the Financial Supervisory Service and the Korea Financial Investment Association (KOFIA). Citibank Building, 39 Da-dong, Jung-gu, Seoul 100-180, Korea. KOFIA makes available registration information of research analysts on its website. Please visit the following website if you wish to find KOFIA registration information on research analysts of Citigroup Global Markets Korea Securities Ltd. <http://dis.kofia.or.kr/webssquare/index.jsp?w2xPath=/wq/fundMgr/DISFundMgrAnalystList.xml&divisionId=MDIS03002002000000&serviceId=SDIS03002002000>. The Product is made available in Korea by Citibank Korea Inc., which is regulated by the Financial Services Commission and the Financial Supervisory Service. Address is Citibank Building, 39 Da-dong, Jung-gu, Seoul 100-180, Korea. This research report is intended to be provided only to Professional Investors as defined in the Financial Investment Services and Capital Market Act and its Enforcement Decree in Korea.

The Product is made available in **Malaysia** by Citigroup Global Markets Malaysia Sdn Bhd (Company No. 460819-D) ("CGMM") to its clients and CGMM takes responsibility for its contents. CGMM is regulated by the Securities Commission of Malaysia. Please contact CGMM at Level 43 Menara Citibank, 165 Jalan Ampang, 50450 Kuala Lumpur, Malaysia in respect of any matters arising from, or in connection with, the Product.

The Product is made available in **Mexico** by Citibanamex Casa de Bolsa, S.A. de C. V., Casa de Bolsa, Integrante del Grupo Financiero Citibanamex which is a wholly owned subsidiary of Citigroup Inc. and is regulated by Comisión Nacional Bancaria y de Valores. Reforma 398, Col. Juárez, 06600 Mexico, D.F.

In **New Zealand** the Product is made available to 'wholesale clients' only as defined by s5C(1) of the Financial Advisers Act 2008 ('FAA') through Citigroup Global Markets Australia Pty Ltd (ABN 64 003 114 832 and AFSL No. 240992), an overseas financial adviser as defined by the FAA, participant of the ASX Group and regulated by the Australian Securities & Investments Commission. Citigroup Centre, 2 Park Street, Sydney, NSW 2000.

The Product is made available in **Pakistan** by Citibank N.A. Pakistan branch, which is regulated by the State Bank of Pakistan and Securities Exchange Commission, Pakistan. AWT Plaza, 1.1. Chundrigar Road, P.O. Box 4889, Karachi-74200.

The Product is made available in the **Philippines** through Citicorp Financial Services and Insurance Brokerage Philippines, Inc., which is regulated by the Philippines Securities and Exchange Commission. 20th Floor Citibank Square Bldg. The Product is made available in the Philippines through Citibank NA Philippines branch, Citibank Tower, 8741 Paseo De Roxas, Makati City, Manila. Citibank NA Philippines NA is regulated by The Bangko Sentral ng Pilipinas.

The Product is made available in **Poland** by Dom Maklerski Banku Handlowego SA an indirect subsidiary of Citigroup Inc., which is regulated by Komisja Nadzoru Finansowego. Dom Maklerski Banku Handlowego S.A. ul. Senatorska 16, 00-923 Warszawa.

The Product is made available in the **Russian Federation** through AO Citibank, which is licensed to carry out banking activities in the Russian Federation in accordance with the general banking license issued by the Central Bank of the Russian Federation and brokerage activities in accordance with the license issued by the Federal Service for Financial Markets. Neither the Product nor any information contained in the Product shall be considered as advertising the securities mentioned in this report within the territory of the Russian Federation or outside the Russian Federation. The Product does not constitute an appraisal within the meaning of the Federal Law of the Russian Federation of 29 July 1998 No. 135-FZ (as amended) On Appraisal Activities in the Russian Federation. 8-10 Gasheka Street, 125047 Moscow.

The Product is made available in **Singapore** through Citigroup Global Markets Singapore Pte. Ltd. ("CGMSPL"), a capital markets services license holder, and regulated by Monetary Authority of Singapore. Please contact CGMSPL at 8 Marina View, 21st Floor Asia Square Tower 1, Singapore 018960, in respect of any matters arising from, or in connection with, the analysis of this document. This report is intended for recipients who are accredited, expert and institutional investors as defined under the Securities and Futures Act (Cap. 289). The Product is made available by The Citigroup Private Bank in Singapore through Citibank, N.A., Singapore Branch, a licensed bank in Singapore that is regulated by Monetary Authority of Singapore. Please contact your Private Banker in Citibank N.A., Singapore Branch if you have any queries on or any matters arising from or in connection with this document. This report is intended for recipients who are accredited, expert and institutional investors as defined under the Securities and Futures Act (Cap. 289). This report is distributed in Singapore by Citibank Singapore Ltd ("CSL") to selected Citigold/Citigold Private Clients. CSL provides no independent research or analysis of the substance or in preparation of this report. Please contact your Citigold/Citigold Private Client Relationship Manager in CSL if you have any queries on or any matters arising from or in connection with this report. This report is intended for recipients who are accredited investors as defined under the Securities and Futures Act (Cap. 289).

Citigroup Global Markets (Pty) Ltd. is incorporated in the **Republic of South Africa** (company registration number 2000/025866/07) and its registered office is at 145 West Street, Sandton, 2196, Saxonwold. Citigroup Global Markets (Pty) Ltd. is regulated by JSE Securities Exchange South Africa, South African Reserve Bank and the Financial Services Board. The investments and services contained herein are not available to private customers in South Africa.

The Product is made available in the **Republic of China** through Citigroup Global Markets Taiwan Securities Company Ltd. ("CGMTS"), 14 and 15F, No. 1, Songzhi Road, Taipei 110, Taiwan, subject to the license scope and the applicable laws and regulations in the Republic of China. CGMTS is regulated by the Securities and Futures Bureau of the Financial Supervisory Commission of Taiwan, the Republic of China. No portion of the Product may be reproduced or quoted in the Republic of China by the press or any third parties [without the written authorization of CGMTS]. Pursuant to the applicable laws and regulations in the Republic of China, the recipient of the Product shall not take advantage of such Product to involve in any matters in which the recipient may have conflicts of interest. If the Product covers securities which are not allowed to be offered or traded in the Republic of China, neither the Product nor any information contained in the Product shall be considered as advertising the securities or making recommendation of the securities in the Republic of China. The Product is for informational purposes only and is not intended as an offer or solicitation for the purchase or sale of a security or financial products. Any decision to purchase securities or financial products mentioned in the Product must take into account existing public information on such security or the financial products or any registered prospectus.

The Product is made available in **Thailand** through Citicorp Securities (Thailand) Ltd., which is regulated by the Securities and Exchange Commission of Thailand. 399 Interchange 21 Building, 18th Floor, Sukhumvit Road, Klongtoey Nua, Wattana, Bangkok 10110, Thailand.

The Product is made available in **Turkey** through Citibank AS which is regulated by Capital Markets Board. Tekfen Tower, Eski Buyukdere Caddesi # 209 Kat 2B, 23294 Levent, Istanbul, Turkey.

In the **U.A.E**, these materials (the "Materials") are communicated by Citigroup Global Markets Limited, DIFC branch ("CGML"), an entity registered in the Dubai International Financial Center ("DIFC") and licensed and regulated by the Dubai Financial Services Authority ("DFSA") to Professional Clients and Market Counterparties only and should not be relied upon or distributed to Retail Clients. A distribution of the different Citi Research ratings distribution, in percentage terms for Investments in each sector covered is made available on request. Financial products and/or services to which the Materials relate will only be made available to Professional Clients and Market Counterparties.

The Product is made available in **United Kingdom** by Citigroup Global Markets Limited, which is authorised by the Prudential Regulation Authority ("PRA") and regulated by the Financial Conduct Authority ("FCA") and the PRA. This material may relate to investments or services of a person outside of the UK or to other matters which are not authorised by the PRA nor regulated by the FCA and the PRA and further details as to where this may be the case are available upon request in respect of this material. Citigroup Centre, Canada Square, Canary Wharf, London, E14 5LB.

The Product is made available in **United States** by Citigroup Global Markets Inc, which is a member of FINRA and registered with the US Securities and Exchange Commission. 388 Greenwich Street, New York, NY 10013.

Unless specified to the contrary, within EU Member States, the Product is made available by Citigroup Global Markets Europe AG ("CGME"), which is regulated by the German Federal Financial Supervisory Authority (Bundesanstalt für Finanzdienstleistungsaufsicht-BaFin).

The Product is not to be construed as providing investment services in any jurisdiction where the provision of such services would not be permitted. Subject to the nature and contents of the Product, the investments described therein are subject to fluctuations in price and/or value and investors may get back less than originally invested. Certain high-volatility investments can be subject to sudden and large falls in value that could equal or exceed the amount invested. Certain investments contained in the Product may have tax implications for private customers whereby levels and basis of taxation may be subject to change. If in doubt, investors should seek advice from a tax adviser. The Product does not purport to identify the nature of the specific market or other risks associated with a particular transaction. Advice in the Product is general and should not be construed as personal advice given it has been prepared without taking account of the objectives, financial situation or needs of any particular investor. Accordingly, investors should, before acting on the advice, consider the appropriateness of the advice, having regard to their objectives, financial situation and needs. Prior to acquiring any financial product, it is the client's responsibility to obtain the relevant offer document for the product and consider it before making a decision as to whether to purchase the product. Citi Research product may source data from dataCentral. dataCentral is a Citi Research proprietary database, which includes the Firm's estimates, data from company reports and feeds from Thomson Reuters. The source for all referenced prices, unless otherwise stated, is DataCentral. Past performance is not a guarantee or reliable indicator of future results. Forecasts are not a guarantee or reliable indicator of future performance. The printed and printable version of the research report may not include all the information (e.g., certain financial summary information and comparable company data) that is linked to the online version available on the Firm's proprietary electronic distribution platforms.

**Card Insights.** Where this report references Card Insights data, Card Insights consists of selected data from a subset of Citi's proprietary credit card transactions. Such data has undergone rigorous security protocols to keep all customer information confidential and secure; the data is highly aggregated and anonymized so that all unique customer identifiable information is removed from the data prior to receipt by the report's author or distribution to external parties. This data should be considered in the context of other economic indicators and publicly available information. Further, the selected data represents

only a subset of Citi's proprietary credit card transactions due to the selection methodology or other limitations and should not be considered as indicative or predictive of the past or future financial performance of Citi or its credit card business.

Where included in this report, MSCI sourced information is the exclusive property of Morgan Stanley Capital International Inc. (MSCI). Without prior written permission of MSCI, this information and any other MSCI intellectual property may not be reproduced, disseminated or used to create any financial products, including any indices. This information is provided on an "as is" basis. The user assumes the entire risk of any use made of this information. MSCI, its affiliates and any third party involved in, or related to, computing or compiling the information hereby expressly disclaim all warranties of originality, accuracy, completeness, merchantability or fitness for a particular purpose with respect to any of this information. Without limiting any of the foregoing, in no event shall MSCI, any of its affiliates or any third party involved in, or related to, computing or compiling the information have any liability for any damages of any kind. MSCI, Morgan Stanley Capital International and the MSCI indexes are services marks of MSCI and its affiliates. Part of this product may contain Sustainalytics proprietary information that may not be reproduced, used, disseminated, modified nor published in any manner without the express written consent of Sustainalytics. Sustainalytics, its affiliates and any third party involved in, or related to, computing or compiling the information hereby expressly disclaim all warranties of originality, accuracy, completeness, merchantability or fitness for a particular purpose with respect to any of this information. Any information attributed to Sustainalytics is provided solely for informational purposes and on its own should not be considered an offer to buy or sell a security. Neither Sustainalytics nor all its third-party suppliers provide investment advice (as defined in the applicable jurisdiction) or any other form of (financial) advice. The information is provided "as is" and, therefore Sustainalytics assumes no responsibility for errors or omissions. Sustainalytics cannot be held liable for damage arising from the use of this product or information contained herein in any manner whatsoever. Where data is attributed to Morningstar that data is © 2020 Morningstar, Inc. All Rights Reserved. That information: (1) is proprietary to Morningstar and/or its content providers; (2) may not be copied or distributed; and (3) is not warranted to be accurate, complete or timely. Neither Morningstar nor its content providers are responsible for any damages or losses arising from any use of this information.

The Firm accepts no liability whatsoever for the actions of third parties. The Product may provide the addresses of, or contain hyperlinks to, websites. Except to the extent to which the Product refers to website material of the Firm, the Firm has not reviewed the linked site. Equally, except to the extent to which the Product refers to website material of the Firm, the Firm takes no responsibility for, and makes no representations or warranties whatsoever as to, the data and information contained therein. Such address or hyperlink (including addresses or hyperlinks to website material of the Firm) is provided solely for your convenience and information and the content of the linked site does not in any way form part of this document. Accessing such website or following such link through the Product or the website of the Firm shall be at your own risk and the Firm shall have no liability arising out of, or in connection with, any such referenced website.

© 2021 Citigroup Global Markets Inc. Citi Research is a division of Citigroup Global Markets Inc. Citi and Citi with Arc Design are trademarks and service marks of Citigroup Inc. and its affiliates and are used and registered throughout the world. All rights reserved. The research data in this report are not intended to be used for the purpose of (a) determining the price of or amounts due in respect of (or to value) one or more financial products or instruments and/or (b) measuring or comparing the performance of, or defining the asset allocation of a financial product, a portfolio of financial instruments, or a collective investment undertaking, and any such use is strictly prohibited without the prior written consent of Citi Research. Any unauthorized use, duplication, redistribution or disclosure of this report (the "Product"), including, but not limited to, redistribution of the Product by electronic mail, posting of the Product on a website or page, and/or providing to a third party a link to the Product, is prohibited by law and will result in prosecution. The information contained in the Product is intended solely for the recipient and may not be further distributed by the recipient to any third party.

ADDITIONAL INFORMATION IS AVAILABLE UPON REQUEST