# Systematic Trading of ETFs

## Using ML techniques to create trading rules for ETFs

In this piece, we examine the question, “Can a combination of Inflation (CPI), and 2 proxies for GDP be used to inform future allocation decisions?”. The proxies are ISM PMI and ISM NMI, which correspond to ISM Purchasing Manager’s Index and ISM Non-Manufacturing Index respectively. In addition to the officially published values, we look at forecasts of each of the above series to see if accurate forecasts can assist in forward-looking asset allocation decisions.

Using a combination of intuitive interpretation of these economic metrics, we create a set of features to characterize the trend dynamics of these values and use these features to construct trading rules based on a standard logistic regression’s output. We also examine the performance of two naïve implementations of multi-asset portfolios, a 60/40 stocks/bonds portfolio and a poor man’s risk parity, constructed with a naïve volatility weighting and using only three ETFs to represent major asset classes. Finally, we examine if the individual ETFs can be combined into a mixed portfolio to improve on the risk-adjusted returns of trading the individual ETFs.

## Introduction

### Data

ETFs allow an efficient and easily-accessible vehicle to get exposure to major asset classes. The asset classes in question are US Equities, Bonds (corporate and USTs), and Commodities + Energy. All data used cover a period from 2013 – 2023.

#### CPI, PMI & NMI

Several data sets from Turnleaf Analytics were used to carry out this project. The first is a multi-variate series of data containing US YoY Change in CPI forecasts, non-seasonally adjusted, for forward looking periods ranging from 1 month — 12 months, with a periodicity of 1 month. Additional data sets include 1-month—12-month predictions of ISM PMI (Purchasing Manufacturer’s Index) and ISM NMI (Non-Manufacturing Index). The latter two data series are meant to serve as a proxy for future GDP.

#### ETFs & Total Return Estimation

The ETFs chosen for this study cover Equities, Debt and Commodities markets. Each asset class has a representative ETF which tracks the broader asset class - AGG for fixed income ETFs, SPY for equities ETFs and DBC/GSG for commodities ETFs. A total of 64 ETFs were used for analysis; 19 of these were selected to discuss in greater detail, and are shown in the table below.

#### Total Return Methodology

Adjusted closing prices are used on a rolling monthly basis to construct total return indices. The 60/40 portfolio is constructed using a monthly rebalanced ratio of 60% SPY and 40% AGG. The naïve volatility weighted portfolio is using a weighted portfolio of SPY, AGG and GLD, where each weight is , with a 1-year lookback period.

## CPI, PMI & NMI Interpretation

How does each of CPI, ISM PMI and ISM NMI relate to each asset class? What is the intuition behind this relationship?

### Equities

* CPI: inflation expectations have an impact on equities. Higher CPI can lead to concerns about lowered consumer spending, which can impact earnings. Higher CPI can also impact interest rates, both of which can have an effect on equity prices
* ISM PMI & ISM NMI: these give insight into the health of manufacturing and services sectors. They can be thought of as proxies for GDP. These values are normalized to fall within the [0, 100] range where a value above 50 is considered positive for the respective sector and below 50 is considered negative

### Bonds

* CPI: Changes in inflation have a strong effect on bonds. As inflation rises, the purchasing power of a unit of currency is lowered, which has a very direct impact on how a bond’s cashflows are valued. Higher CPI can lead to expectations of higher interest rates resulting in lowered bond prices
* ISM PMI & ISM NMI: Increases in readings of, and expectations of, GDP can also impact bond prices by influencing expectations about future GDP growth and future inflation.

### Commodities

* CPI: Commodities are often treated as hedges for inflation, so there is an assumed inverse relationship between CPI and commodities prices
* ISM PMI & ISM NMI: These values can provide indications of the demand for commodities themselves, so a positive relationship between commodities prices and PMI/NMI readings is a commonly held belief.

### Energy

* CPI: Energy is a key component of CPI’s measurement basket, so there is a natural reflexive relationship between energy prices and CPI. Higher CPI can lead to expectations of increased energy prices and/or increased demand for energy, further driving up its price
* ISM PMI & ISM NMI: As industrial activity picks up, demand for energy tends to pick up, so there is often a positive relationship between energy prices and PMI/NMI.

We would expect measures such as CPI to have the most noticeable impact when trading debt instruments. If CPI remains high, intuition suggests wanting to be less exposed to risky assets (equities), and increase exposure to inflation-protection assets (commodities). If CPI remains low, we would want to do the contrary.

How, then, can we make use of the intuition behind these values?

*Note that we are not discussing the relationship of the level of interest rates, which is an important consideration when evaluating whether a given CPI trend is good or bad for risky assets.*

## Exploratory Plots

Figure 1 - SPY vs CPI YoY

Looking at a time-series plot of SPY vs CPI YoY (figure 1), it’s clear that CPI lags the broader equities market. CPI alone is not likely to predict future equity returns.

Figure 2 – Naïve Vol & 60/40 vs CPI YoY

Examining the plot of a poor man’s risk parity (naïve vol) and a 60/40 portfolio vs CPI, again, we find that CPI appears to lag changes in these strategy returns.

## **Methodology**

The instrument set used is comprised primarily of US-listed ETFs with the majority of their risk exposure being domiciled in the US.

Total return indices are created for each ETF used in the study, along with two representative portfolios of traditional asset allocation strategies. One is a 60/40 Stocks/Bonds portfolio, and another is a naïve volatility-weighted multi-asset portfolio, which includes debt, equity and commodities exposure.

These total return indices are then used along with Turnleaf Analytics’ CPI & ISM forecasts to construct trading rules using a model-driven trading rule.

The trading strategies examined include a long/short trading method and a long-only trading method. The long-short strategy allows entering short positions and assumes 0 financing cost; the long-only trading method does not allow entering short positions, and the decisions possible are to be long an asset, or to be flat.

### Trading Rules

#### Intuition Behind PMI / NMI

Generally speaking, the interpretation of PMI and NMI values is straight forward. PMI and NMI both range from 0-100. If PMI is above 50, it can be viewed as an indication that the manufacturing sector is expanding. If PMI == 50, there is no change, and if PMI is below 50, the manufacturing sector is contracting.

Similarly for NMI – values above 50 indicate the non-manufacturing sector (services) is expanding; NMI == 50 indicates no change, and values below 50 indicate a contraction in the non-manufacturing sectors.

If PMI and NMI are persistently above 50, our intuition suggests that an economic expansion is underway and this should be reflected in equity (risky) markets. On the contrary, if PMI and NMI are persistently below 50, we would expect that less risky assets would be outperforming.

#### Feature Design

What if we can partition the next-period returns using either CPI or PMI/NMI? We construct a trailing sample median of CPI, PMI and NMI using a 36-month rolling window. Next, we look at various forecasts and create binary variables of each measure based on whether the forecast is above the trailing median or below. Intuitively, this gives some insight into the direction the measure is headed up to 12 months forward.

Next, we examine scatter plots of Equities (SPY) and Debt (AGG), with monthly returns on the y-axis and trailing CPI median on the x-axis.

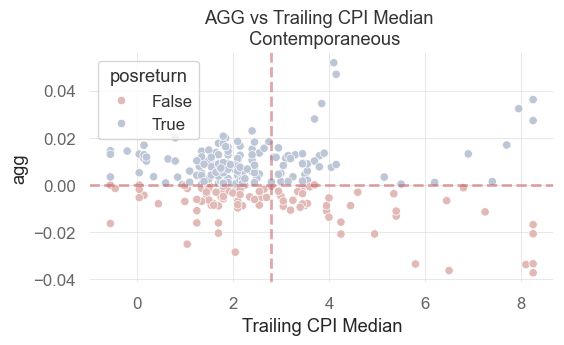
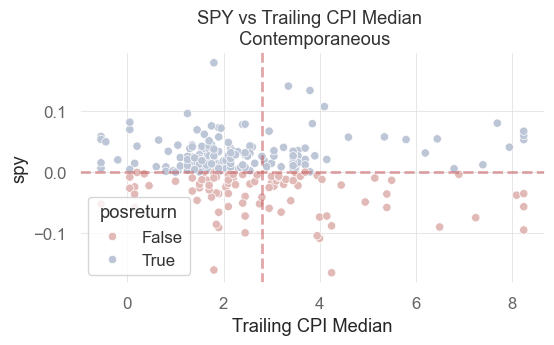


Figure 3 - SPY Returns vs 12-month trailing median CPI Figure 4 - AGG returns vs 12-month trailing median CPI

Examining the scatter plots in Figures 3 and 4, we find what looks to be a partitioning scheme emerging. looks more promising. While far from a crystal ball, the expected return of an asset *may* have a conditional relationship on CPI’s recent relative level.

Using this approach with PMI and NMI, along with CPI, we construct a series of factors that aim to capture the intuition described earlier. Using the forecasts of CPI, NMI, PMI for the 1-month, 3-month, 6-month, 9-month and 12-month periods, a series of factors are created as follows:

1. Above/below a threshold (trailing 3-year median) for all periodicities
2. Differential between consensus estimates and CPI/PMI/NMI forecasts

## Logistic Regression & Trading Strategy Returns

Only a subset of the instruments used in the study are represented below to reduce chart clutter. Further, the key points, both good and bad, are able to be observed in this subset. For each asset class, some winners and some losers were chosen for visualization. As with many model-driven strategies, the same model does not work unilaterally across all related products, and this model is no different in that regard.

#### Definitions

***Baseline strategy*** refers to holding the underlying asset passively throughout the entire sample period.

***Model-driven long-only*** refers to entering either long positions in the asset or being flat (uninvested) in the asset. The decision to be long or flat depends on the output of the logistic regression model.

***Model-driven long/short*** refers to a strategy which allows taking long and short positions. The same logistic regression model that is used for the model-driven long-only strategy. This assumes 0 financing costs (what a wonderful world that would be).

#### Variable Selection

If we consider all possible variations of the features described earlier, we end up with nearly as many features as the number of sample data points, so some feature removal is necessary. To remove unnecessary variables, we train a logistic regression on all ETFs using variations totaling 33 features and examine their coefficients by asset class. There are some features, in particular those extending out beyond the 9month horizon, whose coefficients are consistently near 0, so these are removed from the feature matrix. Next, we look for frequent changes in sign of a coefficient.

For example, consider the coefficients for 1-month CPI above threshold, 2-month CPI above threshold, 3-month CPI above threshold, termed and their corresponding coefficients, . If the respective signs for each of these coefficients are , combined with a low likelihood that the coefficients are significantly different than 0, then these variables are likely not informative and are also removed from the feature set.

#### Model Training

A logistic regression model was trained using the same features for all ETFs. The models were setup to predict whether the next-month return would be positive or negative. In other words, should we buy or sell an asset given the information contained in the feature variables. The models are fit using the prior 36 months of historical data, and are used to predict the next month return direction; they are re-fit every sample period with a rolling 36-month window.

### Model Results

[summarize model results]

### ETF Reference Table

|  |  |  |
| --- | --- | --- |
| **Class** | **Ticker** | **Name** |
| **Debt** | **AGG** | iShares Core U.S. Aggregate Bond ETF |
| **Debt** | **VCIT** | Vanguard Intermediate-Term Corporate Bond ETF |
| **Debt** | **SPIB** | SPDR Portfolio Intermediate Term Corporate Bond ETF |
| **Debt** | **BSV** | Vanguard Short-Term Bond ETF |
| **Debt** | **JNK** | SPDR Bloomberg High Yield Bond ETF |
| **Debt** | **TBT** | ProShares UltraShort 20+ Year Treasury *(Levered)* |
| **Debt** | **TMV** | Direxion Daily 20 Year Plus Treasury Bear 3x Levered |
| **Debt** | **VCLT** | Vanguard Long-Term Corporate Bond ETF |
| **Debt** | **LQD** | iShares iBoxx $ Investment Grade Corporate Bond ETF |
| **Debt** | **TMF** | Direxion Daily 20 Year Plus Treasury Bull 3x Levered |
| **Equity** | **SPY** | SPDR S&P 500 ETF Trust |
| **Equity** | **SPYG** | SPDR Portfolio S&P 500 Growth ETF |
| **Equity** | **SPLG** | SPDR Portfolio S&P 500 ETF |
| **Equity** | **KBE** | SPDR S&P Bank ETF |
| **Equity** | **XRT** | SPDR S&P Retail ETF |
| **Commodities** | **DBC** | Invesco DB Commodity Index Tracking Fund |
| **Commodities** | **GSG** | iShares S&P GSCI Commodity-Indexed Trust |
| **Commodities** | **UNG** | United States Natural Gas Fund LP |
| **Commodities** | **XOP** | SPDR S&P Oil & Gas Exploration & Production ETF |

#### Fixed Income ETFs

What is apparent from the results when comparing Sharpe ratios in particular is the outperformance of debt instruments in the long-only and long/short models when compared to a long-only baseline. For the instruments shown below, most show a significant improvement above the baseline approach using only CPI, ISM PMI and ISM NMI forecasts. For equities and commodities products, the trading rule was not as successful.

#### Levered Fixed Income ETFs

However, the outperformance was not present for all fixed income ETFs. Longer-dated and levered ETF products performed considerably worse than their short-medium maturity counterparts. Note VCLT and LQD in the charts below, both of which hold longer-dated corporate bonds. Not surprisingly, when trading levered products, the effects were magnified well beyond the leverage factor (note TBT, TMV and TMF). TBT is a Short 20yr+ Treasury ETF, TMV is a 3x levered short 20yr+ Treasury ETF and TBT is a 3x levered long 20yr+ Treasury ETF.

#### Equity ETFs

Equity strategies did not fare as well as fixed income with the logistic regression trading rule.

#### Commodity ETFs

## Conclusion

In this piece, we covered several classes of ETFs and examined whether inflation forecasts as well as proxies for GDP could inform asset class selection for future periods. Inflation was forecast directly via Turnleaf Analytics’ CPI forecasts, and GDP forecasts were proxied using Turnleaf Analytics’ forecasts for ISM PMI and ISM NMI. In order to combine multiple forecast periods into a singular trading rule, we used a logistic regression which was trained on the same feature set for all ETFs presented.

The inflation and ISM PMI & ISM NMI forecasts appear most informative with fixed income ETFs. This is not to say they are not informative in other asset classes, though on their own, they do not appear to be informative enough to create a trading strategy based exclusively on these forecasts.

## Future Work