ARC
Asset Risk Company

Risk Factor Decomposition of Commodity Indices

Introduction

Risk factor models are popular in the equity space and used on a daily basis by investment professionals. It is common to look at equity portfolios exposures to both sectors plus styles and measure their risk and performance attribution. Factor models are also used by quantitative managers to tilt and build portfolios with a specific risk/reward profile. In this paper we look at the risk of a set of leading commodities indices through the prism of the ARC Commodity Risk Factor Model. We will show that the model provides an innovative way to look at the risk of commodity portfolios, and unlocks a view of risk that is deeper than sector or product allocation. Finally we will present a simple case of a tilted portfolio.

Commodity Indices

The two most popular commodity indices are the S&P GSCI index and the Bloomberg Commodity index (BB COM). Both indices were created decades ago, with focus on production and liquidity. As a result the S&P GSCI has an overweight exposure to energy. Both indices tend to have positions in the front month or second month futures in their composition. Unlike the equity space where Large Cap indices will provide similar risk/return profiles (much like the S&P 500 and Russell 1000), commodity indices will behave very differently. Table 1 below summarizes realized risk of both indices and their respective sectors target weights for 2020.

Sector	S&P GSCI	BB COM
Energy	61.7%	29.9%
Agriculture	23.1%	35.2%
Metals	15.2%	34.9%
1 yr Vol	36%	17%
YTD Return	-32.1%	-12.1%

Table 1: Target Sector allocation for 2020, and risk return profiles

The risk is calculated using daily returns over a year as of 7/31/2020. Not surprisingly the S&P GSCI Index is more volatile as energy suffered the most during the crisis, while its YTD performance was affected as well. The Bloomberg Commodity Index is allocated more uniformly across sectors. However most of the indices' constituents are front month contracts or next deferred creating a bias towards the front of the curve.

To correct this bias a slew of providers have created commodity indices that provide both liquidity and diversity in the term structure. To this effect we looked in more detail at the Invesco DB Commodity Index (Invesco DB). The index constituents' maturities span from the front contract up to a year into the term structure.

The 3 indices were run through the prism of the ARC risk factor model. The Asset Risk Company (ARC) Commodity model is a cross-sectional commodity factor model. Factors include sectors, sub-sectors, and styles. The factor exposures as well as factor returns are estimated daily. The model is presented in a nesting format-allowing the decision maker to view the market from a macro lense of broad classes (metals, energy, agricultural) to finer product classifications, while preserving the attribution of risk between the style and non-style factors. The model contains more than 1200 commodity futures with full term structure. The style factors are composed of Basis, Momentum, Short Term Momentum, Open Interest, Trading Activity, Volatility and Short Term Volatility. The definition of each factor is provided in Appendix 1.

Exposures & Risk Attribution with the ARC Model

The exposures to sectors are simply 1 or 0. ARC sector returns come from the regression model and not from a manual weighings of commodities in each sector. For the styles factors, exposures are standardized (z-scores). We compute exposures daily for more than 1,200 commodity futures. So an exposure of 0 corresponds to the mean. A negative exposure means the asset is less exposed to the factor than the average of the assets in the model. Conversely, a positive exposure reflects the fact that the asset has more exposure than the average. Table 2 shows the factors exposures for each index as of 7/31/2020.

Exposures	Invesco DB Index	BB COM Index	S&P GSCI Index
Agriculture	23%	34%	26%
Energy	43%	23%	53%
Metals	34%	43%	21%
Basis	-0.29	-0.43	-0.45
OpenInterest	1.12	2.54	2.53
Momentum	0.17	0.31	-0.33
ST Momentum	0.15	0.50	0.05
Trading Activity	0.03	1.36	1.35
Volatility	0.45	0.34	1.38
ST Volatility	0.05	0.24	0.44

Table 2: ARC Commodity Risk Factor Exposures as of 7/31/2020

A quick look at the indices shows that each is taking a very different sector bet. S&P GSCI is still overweight in energy as is the Invesco DB index, while the BB COM index is currently overweight in Metals. The mismatch does not end with just sectors.

While Open Interest exposure is similar for BB COM and S&P GSCI, it is much smaller for the Invesco DB. Having longer maturity assets in the portfolio will have several impacts on its characteristics. First, there is the basis effect. Basis will capture backwardation/contango of a commodity future. Our exposures are standardized and the front month contract (basis of zero) has a Basis negative exposure of -0.49 for the July model. As expected BB COM and SP& GSCI have Basis exposures reflecting the short maturity contract. Noticeably DB Invesco has a Basis exposure of -0.29 (so bigger than the front month basis exposure) and indicates that the index is weighted towards contango contracts. Second, as more longer date futures are held, the trading activity and Open Interest exposure will, in most cases, fall since it is typically the front month contracts which will have higher open interest and trading activity.

Using the model, we now estimate the risk contribution of each factor to the total volatility of the index (Table 3, below).

Risk	Invesco DB Index	BB COM Index	S&P GSCI Index
Total Volatility	17.4%	18.0%	25.5%
Agriculture	2.0%	2.1%	2.2%
Energy	6.7%	3.2%	7.7%
Metals	4.5%	4.6%	1.8%
Basis	0.3%	0.2%	0.4%
OpenInterest	2.7%	7.4%	6.8%
Momentum	-0.3%	-0.4%	0.7%
ST Momentum	-0.4%	-0.8%	-0.1%
Trading Activity	0.0%	-0.6%	-0.5%
Volatility	1.3%	0.6%	6.2%
ST Volatility	0.0%	0.8%	0.5%
Specific Risk	4.6%	5.3%	5.3%

Table 3: Risk decomposition & contribution using ARC Commodity Risk Factor Model as of 07/31/2020

As a reminder $Total\ volatility^2 = Systematic\ risk^2 + Specific\ risk^2$, with $Systematic\ risk$ as the sum of sectors and styles volatility contributions. Not surprisingly the model confirms that the S&P GSCI is the most volatile with a 25.5% ex-ante annualized volatility. We use the ARC short term model (252 days with a half life of 60 days).

Table 3 provides a unique way to look at the risk of commodities. For instance the risk contribution of the 3 sectors represent respectively 76%, 65% and 55% of the total risk for the invesco DB index, BB COM Index and S&P GSCI index. This is rather surprising in particular for the S&P GSCI Index since it is so overweight on a very volatile sector, energy. The energy sector's weight in the portfolio is 53% while its risk contribution is 30% of the total risk. The Agriculture sector allocation is significant in all indices, we can see that the risk contribution is relatively small with less than 11% for all indices.

The total risk contribution of the style factors represents 20% of the total risk for the Invesco DB index and around 40% and 55% for the BB COM and S&P GSCI. The largest contributor for BB COM and second largest for S&P GSCI is the Open Interest factor, with contributions to the total risk of 40% and 26% respectively. The factor captures quite well and quantifies the term structure risk bias (front of the curve bias) as most liquid and volatile instruments are typically in the front months.The weighted average maturity of both indices is below 60 days while 200 for the Invesco DB index. Rolling contracts is an essential part of managing a commodity portfolio. The Open Interest factor on the ARC Model can help managers quantify and compare the risk associated with it.

As discussed above our model is constructed in a nesting format approach, meaning you can decide to use a risk decomposition at the sector or sub-sector level while preserving the styles' contributions.

Finally while the index risk is mostly systematic, there is still a significant portion being specific. That would be very important for active risk management. Moreover, the specific risk as a percentage of the total risk varies dramatically across the indices.

Active Risk Management

Now that we can look at commodities beyond sector analysis, it is possible to apply all the quantitative analysis and portfolio construction techniques that equity portfolio managers have enjoyed for decades.

Let us say, for instance, that a manager believes that Momentum is on an upward trend. ARC does not take a position on the viability of a Momentum investment strategy, but note that this capricious factor is one of the most popular ones. One can now easily construct portfolios that are Momentum tilted using our exposures analysis. As an example we take the Invesco DB index as of 6/30/2020 and re-weight it to favor higher momentum exposures futures, while preserving the sectors allocation and liquidity. We then compare the exposures for the 2 portfolios and the active risk decomposition (portfolio vs index) as of 6/30/2020 (Table 4 & 5).

Exposures	Invesco DB Index	Momentum Invesco DB
Agriculture	23.9%	23.9%
Energy	43.4%	43.4%
Metals	32.7%	32.7%
Basis	-0.69	-0.11
OpenInterest	0.95	1.26
Momentum	0.31	0.95
STMomentum	0.25	-0.10
TradingActivity	0.05	-0.03
Volatility	-0.27	0.33
STVolatility	-0.39	0.17

Table 4: Exposures as of 6/30/2020 for the Invesco DB index and Momentum tilted Index.

Risk	Momentun Invesco DB
Tracking Error	6.2%
Agriculture	0.0%
Energy	0.0%
Metals	0.0%
Basis	0.5%
OpenInterest	0.2%
Momentum	2.6%
ST Momentum	1.6%
Trading Activity	0.0%
Volatility	0.0%
ST Volatility	0.1%
Specific Risk	3.5%

Table 5: Active Risk Contribution for a tilted momentum portfolio as of 6/30/2020

The active risk (Tracking Error) is estimated at 6.2% per annum. As expected most of the risk comes from Momentum, while the other systematic exposures were mostly reduced or eliminated. In other words we easily created a portfolio that tracked the index, but also expressed our given style view. The return for the following month (July) was respectively 5.2% for the index vs 8.6% for the tilted portfolio[1].

[1] Practitioners will note that precious metals overperformed in July. We did a similar exercise with a sub-sector constraint on precious metals and obtained similar results. Correlations between the precious metal sub-sector and the ARC momentum factor are close to zero.

ARC Style Tilted Model Portfolios

ARC has created style tilted portfolios for Low Volatility, Momentum and Value. Each has very different performance and risk characteristics. These style titled portfolios are highly liquid and could form the basis of thematic funds and target portfolios. For the construction methodology we refer to the Commodity Factor Investing note available on our website. We post performance and risk every month.

We looked at the daily correlations YTD between the ARC Momentum and the 3 indices. The BB COM index seems to have the highest correlations with the ARC Momentum factor portfolio, 0.84 vs 0.77 and 0.65 for the Invesco DB and S&P GSCI.

In practice, commodity managers, like their peers in equity, could select to tilt their portfolios while controlling for sectors and factors exposures. Furthermore, either the pure factor returns or the returns of the style tilted portfolios could be used as a diagnostic tool to root out hidden factor exposure when the investigator has no access to position level data.

Conclusion

In this paper we have presented a risk analysis of commodity indices through the prism of a risk factor model. We demonstrated that the risk drivers of commodity portfolios go beyond sectors and sub-sectors analysis. For instance, the act of rolling contracts is a key part of managing risk and building portfolios in the commodity space. It is possible to quantify the risk associated with futures maturity through style factors like Open Interest, Trading Activity and Basis.

Active managers can then better understand their exposures and active risk. We presented a simple case of tilting well known indices in the direction of our views on a particular factor. In general, a factor model and, specifically, a commodity factor model allows the portfolio manager the ability to express a view while at the same time stay within his/her investment guidelines.

Appendix 1

- Basis: log difference of prices between a contract (at a maturity older than front month) and front month contract.

  $P_{t,i}$ - Price of i[th] expiring (with i increasing in expiry date) future for a commodity

  $basis = ln(P_{t,i}) - ln(P_{t,0})$

- Momentum: difference of return for full year minus the last 30 days for a contract

  $M_{t,i} = ln(P_{t-30,i}) - ln(P_{t-252,i})$

  Standardized and winsorized to deal with extreme values.

- Short term Momentum: Last 30 days of return of the contract

  $M_{t,i} = ln(P_{t,i}) - ln(P_{t-30,i})$

  Standardized and winsorized to deal with extreme values.

- Open Interest: Open Interest for each contract standardized and winsorized to deal with extreme values

- Trading Activity: One day change in Open Interest for each contract, standardized and winsorized

- Volatility: one year historical daily standard deviation of return of a contract

  $r_{it} = ln(P_{it}) - ln(P_{it-1})$ *where* P_{it} = *the ith expiry's price at time t*

  $$std(r_{it}) = \sqrt{\sum_{l=1}^{252} \frac{(r_{it-l} - r_i)^2}{N-1}}$$

  Standardized and winsorized to deal with extreme values.