Commodity Investment Insights

Carbon Tilted Portfolios

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Accounting for climate risk within equity and fixed income portfolios has become well established, with company level metrics used for exclusions or tilting. More recently, attention has widened to commodity markets—with multi-asset investors assessing whether a similar approach can be adopted for futures-based commodity portfolios. Traditional commodity benchmarks are futures-based, with constituents weighted in proportion to economic importance and trading liquidity. An example is the Bloomberg Commodity benchmark (BCOM), which is used to provide returns diversification for equity and fixed income investors and an inflation hedge.

Historically, exclusions based on broad-based attributes have been used to avoid exposure to certain environmental themes. A popular metric to use is GhG emission given its centrality in climate risk discourse. This approach tends to introduce idiosyncratic risk versus the benchmark—which adversely affects tracking error and alters both the commodity portfolio's correlation with equity and fixed income and the inflation hedging properties. Can this coarse approach be replaced by a more nuanced methodology that allows instead for tilting exposures using an emissions-based metric?

Commodities are produced by multiple companies under varying conditions. Together with a derivatives-based portfolio that precludes a direct link to the underlying physical asset requires a fundamental rethinking of the investment proposition, accounting metrics and portfolio construction. Key areas of investigation include appropriate metrics, the potential impact of investing in a derivatives-based portfolio and defining the end goals. Portfolio construction is driven by differences in commodity use-cases, production processes, the need to maintain cross asset class consistency and the role of commodities within a multi-asset portfolio. In this publication, we:

- Introduce an emissions-based measure and provide an overview of the estimation procedure
- Discuss commodity investors' objectives and examine the differences with regard to equity and fixed income portfolios;
- Summarize the results of the emissions per commodity;
- Construct a fully rules-based, modular framework to incorporate the carbon cost of production into the BCOM benchmark while account for asset allocation considerations; and
- Assess the performance impact on sector portfolios and the aggregate benchmark.

Introduction

In recent years, commodity investors have begun investigating how to systematically apply sustainability principles to their portfolios. During this process, it has become increasingly apparent that traditional approaches used in equity and fixed income markets may not be directly applicable—for reasons ranging from the use of derivatives-based instruments to the intrinsic differences arising from the underlying commodity being the outcome of the output of multiple firms. In this paper, we pose some important questions investors need to answer to construct portfolios that best reflect the sustainable objectives and limitations defined by the characteristics of the investment route. In doing so, we outline a fully systematic approach investors can use to incorporate environmental considerations into their existing commodity benchmarks.

The environmental pillar has generated the most interest given the physical nature of commodities. The metric we focus on is greenhouse gas (GhG) emissions, which has been a central topic in climate change discussions. The methodology discussed in this paper can be extended to other themes both within the environmental pillar such as water usage and biodiversity as well as other pillars covering social themes. This publication builds on the paper written to introduce the topic to commodity investors (*Commodity investment insights: Carbon Aware Portfolios*, April 2022).

Over the course of the last four years when we began exploring how to incorporate sustainability concepts into commodity indices, our thoughts have evolved through ongoing research, conferences, conversations with asset owners and managers, and interpreting developments in the equity and fixed income markets. The initial analysis estimated GhG emissions by utilising company data and a US dollar denominated unit of measurement. Since then, there have been significant modifications including the investment rationale and measurement approach, primarily to account for the derivatives-based nature of the investment and climate objectives.

Rethinking terminology

Much of the interest has emanated from multi-asset investors who are looking to expand the sustainability themes from equity and fixed income markets—where the functional units of investment are company-level stocks and bonds. A meta-analysis of academic and practitioner research suggests the need for differentiation between the goals of introducing sustainability metrics into commodity portfolios versus equity and fixed income portfolios. This relates to aspects such as ownership (control), the investment vehicle and the level of estimation uncertainty. Such considerations translate to important differences for commodity portfolios such as the appropriate unit of measure (of GhG emissions), investor objectives and data collection methods.

The reorientation of perspective will likely need to occur both from a regulatory and measurement perspective. For example, the change in the functional unit to the underlying commodity instead of an individual firm potentially results in the ineligibility of metrics such as principle adverse impacts (PAI) considerations. While it is common practice to discuss GHG emissions on a scope 1, 2 & 3 basis since much of the focus has been on firm-level data, the applicability of this classification to commodity markets is questionable. Since each commodity is extracted, grown, or farmed by multiple firms with different geographic conditions and processes, it is likely more meaningful to use a classification system that is based on the physical processes involved with the production each of the commodities. With this in mind, we use the concept of 'system boundaries' to define which physical processes contribute to the production of the underlying commodity as defined by the futures contract.

From a cross-asset perspective

Since the objectives of each asset class portfolio differ, the combination of the carbon tilted commodity benchmark with the equivalent equity and fixed income portfolios provide multiple pathways by which to participate in the wider drive to achieve a more sustainable investment profile. The equity and fixed income portfolios focus on (possible) impact via ownership stakes and project finance while the commodity portfolios use a macroeconomic route—channeling support via funds invested in the derivatives markets.

The estimates for each commodity (in this case GhG emissions) are different from company-based estimates in two important respects: (1) the commodity estimate is an aggregation of data based on global/regional companies and (2) there is, to varying degrees, limited coverage of emission data for every region. Since this translates into estimates with wider confidence intervals than company-level metrics, integration into investors' portfolios suggest a cautious approach with respect to portfolio construction. Key questions include does this suit an optimization-based approach and whether it is possible to construct pathways given the level of accuracy implied.

Carbon or GHG emissions?

Greenhouse gas emissions comprise of different gaseous compounds that contribute to global warming[1]. The GHG emissions associated with the production processes for each commodity are typically listed individually, with a conversion factor used to combine them into a single value called the carbon dioxide equivalent (CO2e). From this viewpoint, since the reference value is in terms of a carbon compound, the GHG emissions metric can be viewed as representative of a carbon factor.

[1] IPCC (2007). IPCC Fourth Assessment Report: Climate Change 2007. Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge.

Characteristics and objectives

What is the unit of measure?

Aggregate economic activity is often represented in monetary terms; in part to allow for a comparison between goods and services. However, when restricting this analysis to the commodity markets, the requirement for monetary representation no longer holds:

- Commodities are referenced in terms of physical units–whether it is barrel of oil extracted, metric tons of zinc produced, or bushels of corn harvested;
- Discussion of relative efficiency gains in physical production processes reference commodity production levels;
- Since commodities included in major benchmarks such as the Bloomberg Commodity Index (BCOM) are primary inputs to consumer and industrial goods, demand for these commodities is relatively inelastic to price changes.

The speed of technological development, advancements in extracting and growing techniques and the mix of energy sources result in a relatively slow-moving change in GHG emissions estimates per unit of production. In contrast, the annualized volatility of individual commodity futures ranges between approximately 20-40% while also displaying trend-following properties. Accordingly, a consequence of adopting a US dollar-based measure instead of a per unit measure likely results in a metric which is volatile and potentially uncorrelated to the changes in the environmental impact of the underlying physical processes.

What is the objective?

Financial investors gain exposure to the commodity markets via the derivatives markets; with open positions rolled into a deferred contract as the future nears expiry. For each commodity, the volume of futures traded tends to be a multiple of the volume associated with the physical underlying that is referenced by the futures contract. The implications of this are two-fold:

- There is no direct linkage between futures positioning and physical demand/supply and,
- It is not meaningful to discuss the 'portfolio's emissions' since investors do not take delivery of the physical underlying.

The 24 commodities represented within the BCOM benchmark can be viewed as primary inputs in industrial production processes, the food industry and consumer manufacturing. In-line with this, academic studies looking at commodities indicate that, at a commodity level, the elasticity of supply is larger than the elasticity of demand[2]; in other words, commodity producers tend to be

[2] For example see *Identifying supply and demand elasticities of agricultural commodities: implications for the us ethanol mandate*, Roberts & Schlenker

more price sensitive than consumers—which are limited in their ability to defray purchases. Conventional economics theory states that capital expenditure by firms tends to be negatively correlated to pricing uncertainty.[3]

The asymmetry in price elasticity together with the impact of price stability on firm-level investment decisions suggests long-only investors can potentially facilitate increasing supply by supporting prices for hedgers. Considering the above, we believe that an appropriate goal may be to measure the deviation from benchmark weights by over (under) weighting contracts associated with commodities with lower (higher) GHG emissions on a per unit of output basis.

Data and methodology

During this publication, references to commodity sectors and subsectors can be equated to groups and subgroups in the BCOM benchmark methodology documents. The analysis covers 24 commodities spanning five sectors; with the reference (investment) entity in each case being a US dollar denominated future listed on US and European exchanges. The commodity universe is:

- Energy: Brent, Gasoil and RBOB/Gasoline, Heating Oil, Natural Gas, WTI;
- Precious metals: Gold and Silver;
- Industrial metals: Aluminum, Copper, Lead, Nickel and Zinc;
- Livestock: Lean Hogs and Live Cattle; and
- Agriculture: Coffee, Corn, Cotton, Kansas Wheat, Soybeans, Soybean Meal, Soybean Oil, Sugar and Wheat.

For each commodity future, GHG emissions during the production of the physical underlying commodity (as defined by the contract on exchange) are estimated. This includes emissions that result directly from the extraction and cultivation processes as well as emissions from energy use. While not an exact equivalent, this is comparable to the scope 1 & 2 emissions reporting for companies.

Emissions estimation

Emissions are estimated using the Life Cycle Assessment (LCA) approach, which calculates the environmental impacts arising from the different stages of a production process or service. A model is constructed to capture the physical processes at each stage of the value chain, the results of which are estimates for considerations such as carbon emissions and water usage. As part of the process, group-specific considerations include the reduced emissions from recycled metals production (compared to primary production/mining), the treatment of carbon sequestration in agriculture and geographical variations (e.g., coffee production and crude oil extraction).

[3] Dixit R. and Pindyck R, Investment Under Uncertainty, Princeton Press (1994)

In LCA parlance, the 'cradle-to-gate' calculation for each commodity defines the boundaries of the system, which correspond to the underlying commodity (as specified by the futures contract). For example, in the case of corn, the system boundary (referred to as 'farm-to-gate') spans the processes that begin with preparing the land for tilling and the use of fertilizer, to the bagging process that culminates in a bushel of corn. In the industrial metals group, aluminium has the highest GhG emissions per unit of production; with the system boundaries span the extraction process at the mine to the refining of the bauxite to alumina to the production of aluminium ingots with a minimum purity level of 99.70%. Given the increasingly common use of LCA models, documentation and curated datasets are increasingly widely available.

Complexity in aggregation

If the holder of a futures contract decided to take deliver[4], the ex-ante provenance of the physical asset is unknown with respect to the extraction techniques, energy mixes and soil composition related to that asset. One approach to account for this uncertainty is to construct a weighted average by regional output. However, since it is not possible to comprehensively account for all global production or identify the exact input variables for each unit of production, there is variability that is not accounted for by the traditionally computed confidence intervals. For example, our dataset is not complete nor is it a random sample and we cannot be sure what part of the population we have included in the sample.

This has important implications for portfolio construction since a traditional optimization approach can be problematic because boundary conditions are difficult to compute. The same difficulty arises when trying to replicate the pathways approach used in equity portfolios to follow a glideslope. In the sections below, we discuss a transparent and rules-based approach that accounts for this estimation uncertainty. While more modest in its claims, the portfolio construction methodology allows for added complexity as data gathering and GHG estimation techniques improve.

GhG emissions data

The 24 commodities in the BCOM benchmark are divided into 7 sectors & subsectors. Among other reasons is the need to avoid double-counting of emissions and model consistency (please see the next section for a more detailed exposition). The heatmap indicates the relative size of the per unit emissions for each commodity within a sector/subsector; with the scale of 0-100 representing the extremes.

Estimates are updated annually to account for both new datasets available along with updates in the LCA models. While estimate updates are produced at the same time, there are three aspects to note: (1) LCA model updates occur at different frequencies, (2) new data sets are available for use at different times during the year and (3) the collection interval of data sets varies.

[4] For the purposes of illustration, we do not distinguish between physical delivery and cash settled.

Figure 2: GhG emissions: relative scores

Source: Bloomberg

Returns data

We use the BCOM single commodity excess return indices to assess the performance impact of tilting a traditional commodity benchmark based on emissions estimates. Deferred indices can be substituted for the nearby indices to incorporate the curve (carry) premium. The full list of available BCOM indices can be found on the Bloomberg Terminal via IN <GO> using the commodity tab. While performance statistics are shown starting January 2014, it should be noted that emissions estimates are not point in-time for the purposes of this analysis.

All performance discussed in the paper is in excess return terms to avoid conflating funding returns which have contributed varying amounts since 2011.

Portfolio construction

Portfolio construction is driven by three considerations: (1) low correlations displayed by sector returns, (2) differences in inflation betas by sector and (3) primary versus derived commodities. Since the objective is to reflect global economic activity while acknowledging an environmental cost, a key assumption of the reweighting process is the partial substitutability between commodities in direct comparison. The aim is to re-allocate weights across commodities with comparable use-cases to continue to support existing economic goals. In that case, a natural grouping is by the defined sectors as per the BCOM methodology. Though not perfect substitutes, commodities within each sector broadly correspond to similar types of economic activity. Other important benefits of sector neutrality are:

1. Maintaining consistency in relative weights when sectors are excluded from consideration; for example, if the reference benchmark excludes agriculture and livestock;
2. Better like-for-like comparisons on which to base the tilting of benchmark weights. Since the estimation models within each sector tend to be common, advancements in techniques and parameterization along with updates in model selection will likely flow through all estimates in the same sector.
3. Integrating other sustainability metrics into the weighting scheme given certain metrics may not be applicable for all sectors;
4. Energy is upstream for all other sectors—i.e., allocation away from energy has potentially unintended demand/supply consequences in other sectors.

The distinction between primary and derived commodities is required to reduce the double-counting when measuring emissions during the production cycle.

Sector portfolios

The five portfolios represent energy, industrial metals, precious metals, agriculture and livestock; with energy and agriculture each having subsectors to account for derived commodities. In energy, the subsectors are defined as (1) WTI, Brent and natural gas and (2) gasoil, RBOB/gasoline and heating oil. In agriculture, the subsectors are (1) soybean meal and soybean oil and (2) all other agricultural commodities. The subsector weights are restricted to the sum of the BCOM benchmark weights for those commodities.

Emissions weights

The emission-based weights (ω_{GHG}) are calculated by normalizing the inverse of the emissions values and are constructed such that it can offer an additional instrument for tilting (see below). The emissions per unit of production associated with commodity i is given by GHG_i and the emissions-based weight is defined below, where $0 \leq \alpha$.

Step 1:

$$GHG\_inverse_i = \frac{1}{GHG_i^{\alpha}}$$

Step 2:

$$\omega_{i,GHG} = \frac{GHG\_inverse_i}{\sum_i GHG\_inverse_i}$$

The value of α (which can be interpreted as a dispersion factor) determines the distribution of GhG emissions estimates—which in turn affects the sensitivity of the tilt factor β (see below). The base case is $\alpha = 1$. A larger α applies a bigger penalty to commodities with relatively higher associated emissions per unit of production.

Tilted weights

For industrial metals, precious metals and livestock sectors, the tilted weight for commodity i ($\omega_{i,tilt}$) is given by:

$$\omega_{i,tilt} = f\left(\omega_{i,BCOM}, \omega_{i,GHG}, \beta\right) = \frac{\left(1 + \omega_{i,BCOM}\right) * \left(1 + \omega_{i,GHG}\right)^{\beta} - 1}{\sum_{i=1}^{N}\left[\left(1 + \omega_{i,BCOM}\right) * \left(1 + \omega_{i,GHG}\right)^{\beta} - 1\right]}$$

Where $\omega_{i,BCOM}$ is the BCOM weight, $\omega_{i,GHG}$ is the emissions-based weight and β is a scaling parameter (tilt factor) that determines the sensitivity to emissions. The assigned value of β will depend on the trade-off between maintaining the return profile and hedging characteristics of the BCOM benchmark and the potential emissions-based price support for commodities. If β is set to zero, the portfolio weights are identical to the weights of the BCOM benchmark.

Adjustments for subsectors

In the case of the energy and agriculture sectors, we apply the weighting scheme above to each of the relevant subsectors; which are then combined as per BCOM benchmark weights to form the sector portfolio. All sector and subsector portfolios are rebalanced annually to maintain consistency with the

BCOM benchmark methodology.

Assigning sector tilts

Each sector displays a unique trade-off between a reduction in the associated GHG emissions and tracking error volatility (versus its respective BCOM sector benchmark). The trade-off is a function of (1) the distribution of GHG emissions levels, (2) the number of constituents per sector and (3) the return correlation among the constituents of each sector. This suggests the use of a universal tilt factor across the five sectors is potentially problematic due both to differences in tracking error volatility (TEV) by sector and the percentage contribution to the associated emissions reduction of the overall portfolio. Instead, we allow for sector-specific values for the tilt factor which accounts for differences in sector dynamics. For the avoidance of doubt, the tilted sector weight for a commodity i in sector j is re-defined as:

$$\omega_{i,tilt} = f\left(\omega_{i,BCOM}, \omega_{i,GHG}, \beta_j\right) = \frac{\left(1+\omega_{i,BCOM}\right) * \left(1+\omega_{i,GHG}\right)^{\beta_j} - 1}{\sum_{i=1}^{N}\left[\left(1+\omega_{i,BCOM}\right) * \left(1+\omega_{i,GHG}\right)^{\beta_j} - 1\right]}$$

As a final step, to ensure sufficient liquidity, we cap commodity weights at 3x the weight assigned in the BCOM sector portfolio. The residual weight is redistributed to the remaining commodities in the sector/subsector portfolio in proportion to their uncapped weights. If the reweighting leads to other commodities requiring capping, we recursively apply the capping methodology.

Selecting the tilt factor

The two dimensions which determine the sector tilt factor (β_j) are tracking error volatility and the relative reduction in GHG emissions. One possible route– commonly used for equity and fixed income portfolios– is to use a standard optimization-based approach which targets a certain reduction in GHG emissions subject to given TEV. However, three features of the commodity portfolios make this potentially problematic:

- A limited number of instruments compared to equity and fixed income;
- A high return volatility, the magnitude of return shocks and the frequency of idiosyncratic shocks due to demand and supply disruptions; and
- Average estimates for the GHG emissions per commodity instead of point estimates for companies.

Under these conditions, an optimization-based approach is difficult to adopt. Instead, we use a heuristics-based approach with coarse bucketing to assign tilt factors that translate to realized (historical) TEV bands. Figure 3 provides the tilt factors that correspond to the each of the TEV bands per sector.

Figure 3: Tilt factor by sector: 2023 estimates

Sector	TEV band (bps)								
	200	250	300	350	400	450	500	550	600
Energy	0.48	0.73	1.03	1.41	1.87	2.40	2.99	3.63	4.29
Precious	0.13	0.17	0.22	0.27	0.33	0.39	0.44	0.51	0.58
Industrial	0.66	1.05	1.59	2.33	3.29	4.48	5.91	7.64	9.84
Agric	0.46	0.71	1.04	1.49	2.11	2.93	4.01	5.32	6.86
Livestock	0.21	0.31	0.40	0.51	0.63	0.76	0.91	1.08	1.27

Source: Bloomberg

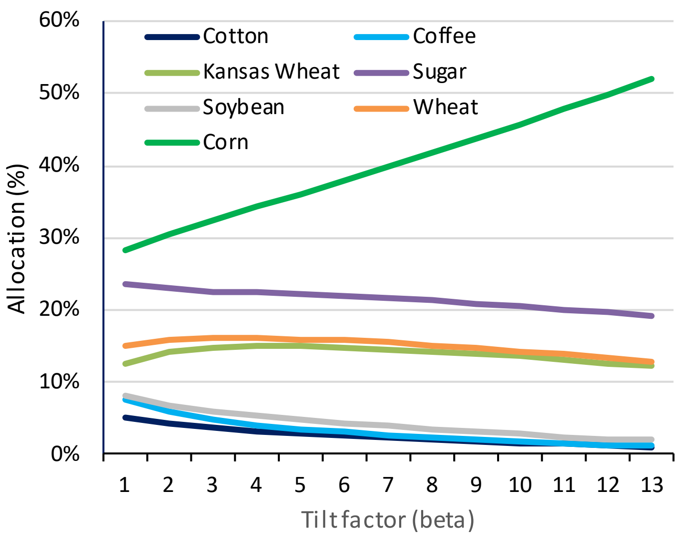
To better manage contribution to overall portfolio tracking error (see next section for methodology to combine sectors) and potentially balance reduction contributions, sector tilt factors are selected by column. Given the relatively slow evolution of the energy mix, technology and production processes and the 5-year rolling window for TEV measurement, the table used to assign the tilt factor can be updated on a multi-year frequency.

The impact of β

Since the assigned weights are a multiplicative function of the BCOM benchmark weight and the inverse GhG emissions weight (see page 11), the increase in β has a non-linear impact on the size and ordering of the constituent weights. Depending on the rank ordering of the BCOM benchmark weights and the inverse GhG weights, the ordering of the final weights may change with the value of β. For the rank ordering of commodity weights within a sector/subsector to remain the same for all values of β, the ranking by BCOM weight must be the same as that by the GhG emissions weight. Regardless, the reduction in associated emissions of the sector/subsector portfolio is monotonically increasingly with the value of β.

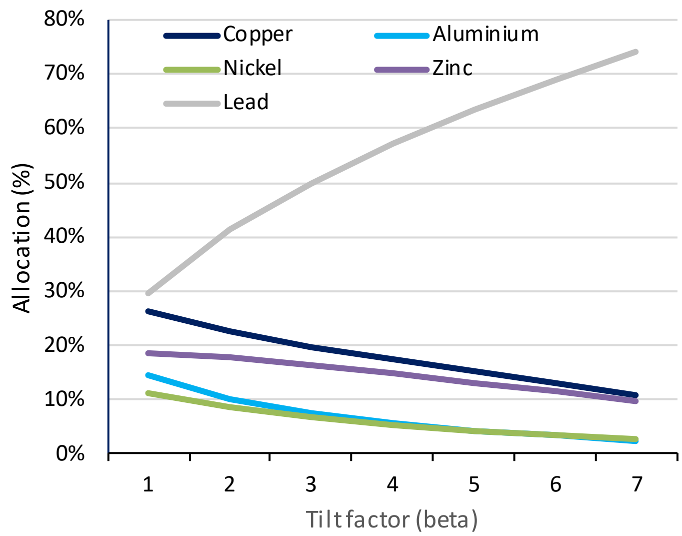
As we can see from the examples of the agriculture ex-derived subsector and the industrial metals sector (figures 4 and 5) the relative weights within the portfolio can vary significantly with the tilt factor.

Figure 4: Tilt factor impact on portfolio weights (2023): Agriculture ex-derived



Source: Bloomberg

Figure 5: Tilt factor impact on portfolio weights (2023): Industrial metals



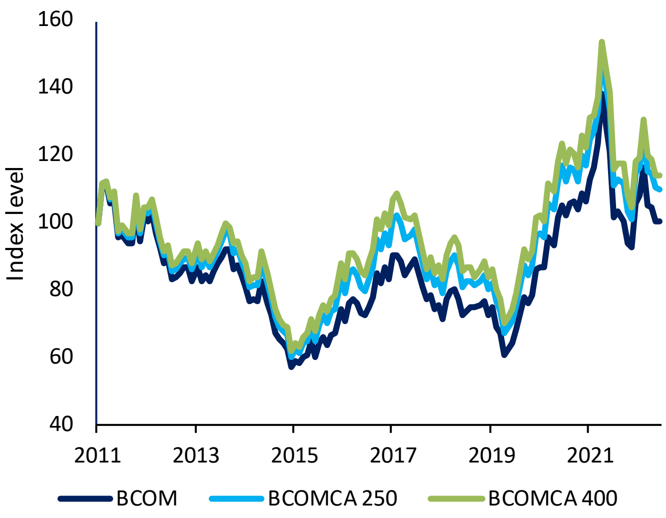
Source: Bloomberg

Assessing performance: sector portfolios

The final step in constructing the sector portfolios is to ensure sufficient liquidity. This is done by applying a cap that is 3x the weight assigned in the BCOM sector portfolio. The residual weight is redistributed to the remaining commodities in the portfolio in proportion to their uncapped weights. If the reweighting leads to other commodities requiring capping, we recursively apply the capping methodology

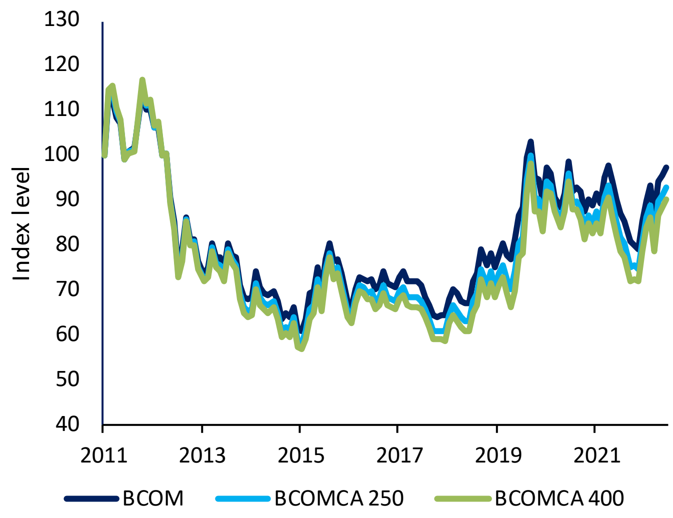
The performance of each sector portfolios varies relative to the BCOM sector benchmark based on the TEV band (see figure 3). We illustrate the performance for the bands corresponding to 250bps and 400bps respectively for the industrial metals and precious metals sectors (figures 6 and 7). The relative under/outperformance of the tilted portfolios is a byproduct of the weighting scheme since there is no explicit return objective, i.e. if the sector of commodities that deliver relatively higher returns are also those which emit relatively less GhG emissions, the tilted portfolio will outperformance the corresponding BCOM (sub)sector benchmark.

Figure 6: Comparing performance: Industrial metals



Source: Bloomberg

Figure 7: Comparing performance: Precious metals



Source: Bloomberg

Portfolio weights

For the remainder of this section, we focus on the tilted sector portfolios that result from weights corresponding to the 400 bps TEV band. The under and overweighting relative to the BCOM weights is given by sector in Figures 8–11.

Figure 8: Difference in energy sector weights (BCOM tilted – BCOM)

Year	Nat gas	WTI	Brent	Heating oil	Gasoline	Gasoil
2012	-3.38%	-1.92%	5.30%	0.52%	-0.52%	0.00%
2013	-3.22%	-1.70%	4.92%	0.52%	-0.52%	0.00%
2014	-2.76%	-1.45%	4.21%	0.54%	-0.54%	0.00%
2015	-2.43%	-1.18%	3.62%	0.56%	-0.56%	0.00%
2016	-2.30%	-1.01%	3.31%	0.56%	-0.56%	0.00%
2017	-2.07%	-0.92%	2.99%	0.57%	-0.57%	0.00%
2018	-2.08%	-1.00%	3.08%	0.60%	-0.60%	0.00%
2019	-2.20%	-1.16%	3.35%	0.14%	-0.50%	0.36%
2020	-2.03%	-1.41%	3.44%	0.14%	-0.49%	0.35%
2021	-2.08%	-1.48%	3.57%	0.15%	-0.45%	0.30%
2022	-2.03%	-1.44%	3.47%	0.16%	-0.45%	0.29%
2023	-2.03%	-1.28%	3.31%	0.16%	-0.45%	0.29%

Source: Bloomberg

In primary energy, there is an underweight in natural gas and WTI with the excess weight allocated to Brent. While the differences in weights between the distillates is smaller, there is an overweight to heating oil and gasoil at the expense of gasoline.

Figure 9: Difference in precious metals and livestock sector weights (BCOM tilted – BCOM)

Year	Gold	Silver	Live cattle	Lean hogs
2012	-2.65%	2.65%	-0.74%	0.74%
2013	-3.00%	3.00%	-0.67%	0.67%
2014	-3.20%	3.20%	-0.67%	0.67%
2015	-3.30%	3.30%	-0.68%	0.68%
2016	-3.17%	3.17%	-0.73%	0.73%
2017	-3.11%	3.11%	-0.83%	0.83%
2018	-3.26%	3.26%	-0.91%	0.91%
2019	-3.35%	3.35%	-0.87%	0.87%
2020	-3.68%	3.68%	-0.86%	0.86%
2021	-3.98%	3.98%	-0.82%	0.82%
2022	-4.10%	4.10%	-0.75%	0.75%
2023	-4.05%	4.05%	-0.69%	0.69%

Source: Bloomberg

In the precious metals sector, there is an over and underweight to silver and gold respectively given the significant differences in mining and refining intensities. The underweight to live cattle relative to lean hogs stems from fertilizer and land usage along with the elevated levels of methane release by cattle.

Figure 10: Difference in industrial metals sector weights (BCOM tilted – BCOM)

Year	Copper	Aluminium	Zinc	Nickel	Lead
2012	1.20%	-4.21%	4.03%	-1.02%	0.00%
2013	0.51%	-3.47%	3.81%	-0.85%	0.00%
2014	0.24%	-3.32%	3.80%	-0.72%	0.00%
2015	0.22%	-3.21%	3.76%	-0.77%	0.00%
2016	0.31%	-3.19%	3.83%	-0.94%	0.00%
2017	0.41%	-3.16%	3.82%	-1.08%	0.00%
2018	0.73%	-3.10%	3.63%	-1.26%	0.00%
2019	0.64%	-3.01%	3.58%	-1.21%	0.00%
2020	0.81%	-2.95%	3.39%	-1.26%	0.00%
2021	1.28%	-2.92%	2.97%	-1.33%	0.00%
2022	1.26%	-2.95%	3.02%	-1.33%	0.00%
2023	0.11%	-2.47%	1.71%	-1.23%	1.87%

Source: Bloomberg

Prior to 2023 when the industrial metals sector comprised of four commodities, zinc and copper received an overweight at the expense of aluminum and nickel. However, since the introduction of lead in 2023, change in the ranking—with lead being the lowest emitter per unit of production (see Figure 2)—has seen the overweight in copper and zinc decline, with the former's weight now only slightly above that in the BCOM benchmark.

Figure 11: Difference in agriculture sector weights (BCOM tilted – BCOM)

Year	Corn	Soybean	Wheat	Kansas Wheat	Sugar	Coffee	Cotton	Soybean oil	Soybean meal
2012	3.63%	-0.05%	0.57%	0.00%	-1.85%	-1.39%	-0.91%	0.00%	0.00%
2013	1.51%	-0.08%	0.74%	2.19%	-2.13%	-1.39%	-0.84%	-1.07%	1.07%
2014	1.39%	-0.23%	0.78%	2.24%	-2.19%	-1.30%	-0.69%	-1.10%	1.10%
2015	1.32%	-0.25%	0.77%	2.25%	-2.23%	-1.21%	-0.65%	-1.08%	1.08%
2016	1.20%	-0.30%	0.74%	2.23%	-1.95%	-1.29%	-0.64%	-1.08%	1.08%
2017	1.17%	-0.40%	0.75%	2.21%	-1.77%	-1.35%	-0.60%	-1.06%	1.06%
2018	1.81%	-0.55%	0.72%	2.06%	-1.90%	-1.54%	-0.61%	-1.01%	1.01%
2019	1.75%	-0.72%	0.70%	1.96%	-1.63%	-1.46%	-0.61%	-1.14%	1.14%
2020	1.75%	-0.48%	0.75%	1.81%	-1.52%	-1.64%	-0.67%	-1.06%	1.06%
2021	1.88%	-0.61%	0.84%	1.74%	-1.51%	-1.67%	-0.68%	-1.17%	1.17%
2022	1.83%	-0.62%	0.85%	1.66%	-1.37%	-1.67%	-0.68%	-1.17%	1.17%
2023	1.86%	-0.63%	0.87%	1.58%	-1.19%	-1.77%	-0.73%	-1.21%	1.21%

Source: Bloomberg

Of note in the agriculture sector is the size of the underweight to coffee and overweight to Kansas wheat, given their weight in the BCOM benchmark (approximately 3.6% and 1.8% respectively).

Portfolio performance

The largest impact on annualized returns was in the energy and industrial metals sectors, while the difference was smallest in agriculture (Figure 12). Industrial and precious metals displayed the largest difference in the 1st half, while the divergence in returns was largest in the 2nd half for energy and livestock. More recently, since 2022, the tilted energy portfolio has returned 5% (annualized) more than the BCOM portfolio.

The impact on tail risk characteristics (skewness and the drawdown-to-volatility ratio) is mixed. There is little change for energy and livestock, while precious and industrial metals and agriculture display lower drawdown-to-volatility ratios. There is also an improvement in the skew for precious metals—increasing from 0.30 to 0.46.

The sensitivity to inflation is an important measure to assess whether the tilted sector portfolios are likely to provide empirical hedges for fixed income investors during periods of high/rising inflation. The two forms of inflation—which display a low-to-moderate correlation—are realized inflation (percentage change in CPI) and inflation expectations (change in the 10-year breakeven rate). Since realized inflation and inflation expectations tend to be weakly correlated over extended periods and asset prices are impacted by both forms of inflation (see *A Toolkit for Hedging Inflation*, December 2020), we run univariate regressions using data spanning 2012 – April 2023. Percentage changes in US CPI and changes in the US 10-year breakeven interest rate are regressed on quarterly commodity portfolio returns. In the case of realized inflation, the betas are approximately unchanged; with the slight decline in sensitivity for industrial metals offset by the increased sensitivity for energy (due to the persistent underweight applied to natural gas). Of note is the marked increase in sensitivity to inflation expectations for the precious metals and energy portfolios. Subject to how the sector portfolios are combined, this suggests investors can potentially expect similar inflation hedging characteristics from a carbon-tilted portfolio as a traditional benchmark.

Figure 12: Performance statistics: A closer look at sector returns

	Industrial		Precious		Livestock		Agriculture		Energy	
	BCOM	Tilted	BCOM	Tilted	BCOM	Tilted	BCOM	Tilted	BCOM	Tilted
Full sample (2012 – Apr 2023)										
Ann return	0.0%	1.2%	-0.4%	-1.1%	-4.2%	-5.2%	-1.4%	-1.7%	-9.2%	-7.5%
Volatility	18.6%	19.1%	16.7%	19.3%	15.2%	17.3%	16.6%	18.6%	28.4%	28.5%
Sharpe ratio	0.00	0.06	NA	NA	NA	NA	NA	NA	NA	NA
Drawdown/Vol	2.63	2.34	2.81	2.67	3.74	3.72	3.80	3.45	2.94	2.92
Skewness	0.11	0.13	0.31	0.46	-0.34	-0.29	0.54	0.62	-0.58	-0.68
1st half (2012 – 2017)										
Ann return	-1.7%	1.1%	-5.2%	-6.3%	-3.0%	-3.8%	-7.9%	-8.0%	-14.6%	-13.7%
Volatility	17.7%	18.2%	17.8%	19.8%	15.2%	16.8%	17.6%	20.0%	22.2%	22.8%
Sharpe ratio	NA	0.06	NA	NA	NA	NA	NA	NA	NA	NA
2nd half (2018 – Apr 2023)										
Ann return	2.0%	1.2%	5.3%	5.1%	-5.5%	-6.8%	6.6%	5.9%	-2.7%	-0.1%
Volatility	19.7%	20.3%	15.5%	18.7%	15.2%	18.0%	15.2%	16.8%	34.1%	33.7%
Sharpe ratio	0.10	0.06	0.34	0.27	NA	NA	0.43	0.35	NA	NA
Since 2022										
Ann return	-8.4%	-10.0%	3.3%	3.1%	0.7%	-1.5%	7.2%	5.3%	4.7%	9.7%
Volatility	27.6%	26.7%	17.1%	20.0%	11.9%	14.9%	15.1%	17.5%	40.2%	35.9%
Sharpe ratio	NA	NA	0.19	0.16	0.06	NA	0.48	0.30	0.12	0.27
Inflation beta										
Realized	1.64	1.35	1.58	1.63	0.20	0.58	3.53	3.38	9.70	9.98
Expectations	25.50	25.50	11.19	15.43	10.62	11.03	10.68	9.50	33.41	36.62

Source: Bloomberg

Combining sectors

The three main requirements most asset allocators have for their commodity portfolio are:

- Reflective of production levels and economic importance
- High level of liquidity/capacity
- Ability to provide diversification benefits and inflation hedges in-line with traditional benchmarks such as the BCOM index

From above we see sector-based returns characteristics differ significantly, including the size of the inflation betas. Furthermore, while sector correlations tend to be low and relatively stable, intra-sector correlations tend to be moderate-to-high. Liquidity, as measured by average daily volume (ADV) traded in US dollars, also varies—for example the ratio of the ADV of the most liquid and least liquid commodities exceeds 3x. From a tradability perspective, since the capacity of a portfolio is determined by the least liquid constituent, the relative ADV is an important consideration.

Figure 13: Implications for asset allocation: Sector correlations with US assets (2012 – April 2023)

	Industrial	Precious	Livestock	Agriculture	Energy
US Equity	0.48	0.21	0.13	0.08	0.41
US Fixed income	0.12	0.36	-0.12	-0.14	-0.18
Equity volatility	-0.36	-0.15	-0.12	-0.02	-0.27
US dollar	-0.52	-0.54	-0.03	-0.27	-0.29

Source: Bloomberg

The sector correlations with US equity and fixed income markets along with two gauges of market sentiment indicate significant variations by sector (Figure 13). These results highlight why the decision about how to combine sectors is important for asset allocators and reiterates the importance of sector-neutrality when tilting. The weighting scheme used to combine sectors drives the size of the TEV versus a traditional benchmark. The variability of the TEV (proxy for forecast) is driven by whether sector neutrality is maintained. Tilting commodities across sectors introduces idiosyncratic risk that potentially amplifies the variability of the TEV and makes it a function of market conditions.

Considering the investors' requirements and the characteristics displayed by the commodity futures, a relatively straightforward and transparent solution is to assign BCOM sector target weights to each of the corresponding sector tilted portfolios.

BCOM Carbon Tilted portfolios

The aggregate tilted portfolio ('BCOM Carbon Tilted') comprises of the five sector tilted portfolios weighted as per the BCOM sector target weights determined annually. To maintain consistency with the BCOM benchmark and to take advantage of the trend-following characteristics generally displayed by commodity futures, rebalancing occurs annually. Each of the selected constituent sector portfolios correspond to the same TEV band. i.e., the tilt factors applied to the sector portfolios correspond to a single column from Figure 3. For summary purposes, we examine results for sector TEV bands ranging from 250bps to 450bps (Figure 14).

Figure 14: Assessing aggregate portfolio returns (2012 – April 2023)

	BCOM	BCOM tilted (TEV bands)				
		250	300	350	400	450
Full sample (2012 - Apr 2023)						
Ann return	-2.7%	-2.4%	-2.3%	-2.2%	-2.1%	-2.1%
Volatility	14.0%	14.2%	14.2%	14.3%	14.3%	14.4%
Sharpe ratio	NA	NA	NA	NA	NA	NA
Drawdown/Vol	4.21	4.16	4.15	4.14	4.13	4.11
Skewness	-0.35	-0.34	-0.33	-0.33	-0.32	-0.32
1st half (2012 - 2017)						
Ann return	-7.5%	-7.1%	-7.1%	-7.0%	-6.9%	-6.8%
Volatility	12.5%	12.8%	12.9%	13.0%	13.1%	13.2%
Sharpe ratio	NA	NA	NA	NA	NA	NA
2nd half (2018 - Apr 2023)						
Ann return	2.9%	3.3%	3.4%	3.4%	3.5%	3.5%
Volatility	15.5%	15.5%	15.5%	15.6%	15.6%	15.6%
Sharpe ratio	0.19	0.21	0.22	0.22	0.22	0.23
Since 2022						
Ann return	2.8%	3.2%	3.3%	3.4%	3.5%	3.6%
Volatility	18.5%	17.9%	17.7%	17.6%	17.4%	17.3%
Sharpe ratio	0.15	0.18	0.19	0.19	0.20	0.21
TEV (BCOM)	NA	1.3%	1.5%	1.8%	2.0%	2.3%
Inflation beta						
Realized	4.94	4.98	4.98	4.98	4.98	4.98
Expectations	0.33	0.35	0.35	0.35	0.36	0.36

Source: Bloomberg

The performance statistics indicate minor improvements in returns over the sample period as measured by the annualized return (Figure 14). Downside risk characteristics along with the inflation betas remain approximately unchanged relative to the BCOM benchmark. The full-sample TEV of the portfolios are approximately half that of the associated sector TEV bands. Repeating the US asset correlation analysis (Figure 15) confirms the BCOM tilted portfolios provide similar diversification benefits as a traditional benchmark.

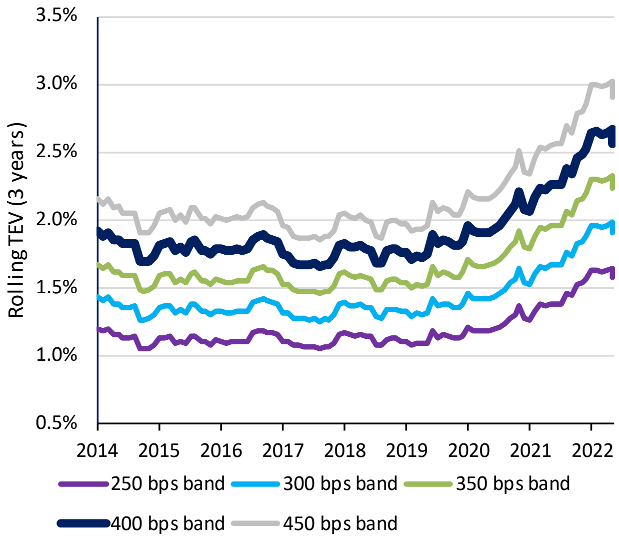
Figure 15: Implications for asset allocation: Portfolio correlations with US assets (2012 – April 2023)

	BCOM	BCOM tilted (TEV bands)				
		250	300	350	400	450
US Equity	0.43	0.44	0.44	0.44	0.44	0.44
US Fixed income	-0.04	-0.06	-0.06	-0.06	-0.07	-0.07
Equity volatility	-0.27	-0.28	-0.29	-0.29	-0.29	-0.29
US dollar	-0.49	-0.50	-0.50	-0.51	-0.51	-0.51

Source: Bloomberg

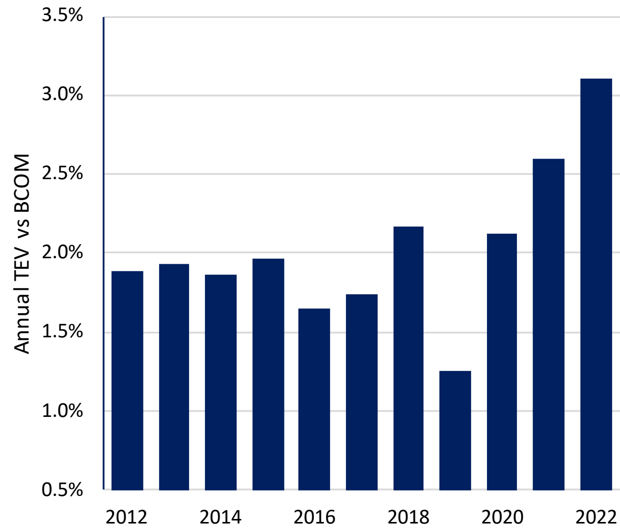
The need to target a TEV at the aggregate portfolio level is lessened by the sector-neutral approach to tilting and the use of BCOM sector target weights to combine the sector tilted portfolios.

Figure 16: Rolling TEV: Aggregate portfolio



Source: Bloomberg

Figure 17: A look at annual deviations



Source: Bloomberg

As we can see from Figure 16, using monthly returns to measure TEV on a rolling 3-year basis highlights the steady increase with the tilt factor. The recent rise in TEV since 2020 is attributable among other things to the dislocation in the Nickel market and the sharp increase and then decrease in natural gas prices following the Russia-Ukraine conflict. This can be confirmed by looking at annual TEV (Figure 17). In general, we expect a higher realized TEV when commodities with a relatively large under/overweight experience higher volatility of returns.

Measuring the outcome

Since the main role of a commodity financial investor is to provide hedging support, any measure referencing 'portfolio emissions' is non-sequitur. Instead, we can construct a measure referencing the associated funding support (FS) per US dollar invested. This is defined as follows:

$$FS = \sum_{i=1}^{N} \omega_i \epsilon_i$$

Where ω_i and ϵ_i refer to the weight and emissions level of commodity i. The difference in funding support measures the change in per unit emissions of the tilted portfolio versus the BCOM benchmark:

$$\Delta FS_{Tilt} = \sum_{i=1}^{N} (\omega_{BCOM,i} - \omega_{Tilt,i})\epsilon_i$$

The extent to which the portfolio is tilted is determined by the trade-off between tracking error volatility and the reduction in the GhG emissions associated with funding support.

The trade-off between reduction in associated GhG emissions and the realized (ex-post) tracking error volatility is illustrated in Figure 18. For each tracking error band (estimated using a 5-year window) the associated reduction in emissions vary according to the emissions dispersion within the sector.

Figure 18: Trade-offs differ by sector: Reduction estimates for 2023

Sector	TEV bands				
	250	300	350	400	450
Energy	3.5%	4.2%	5.0%	5.8%	6.6%
Precious	17.0%	20.4%	23.8%	27.2%	30.5%
Industrial	24.1%	27.5%	30.8%	33.9%	36.9%
Agriculture	16.7%	20.1%	23.6%	27.2%	30.8%
Livestock	5.3%	6.3%	7.3%	8.3%	9.3%

Source: Bloomberg

The reduction in the aggregate portfolio is simply a weighted sum of the sector weights in the BCOM benchmark. The aggregate associated reduction in GhG emissions is given in Figure 19.

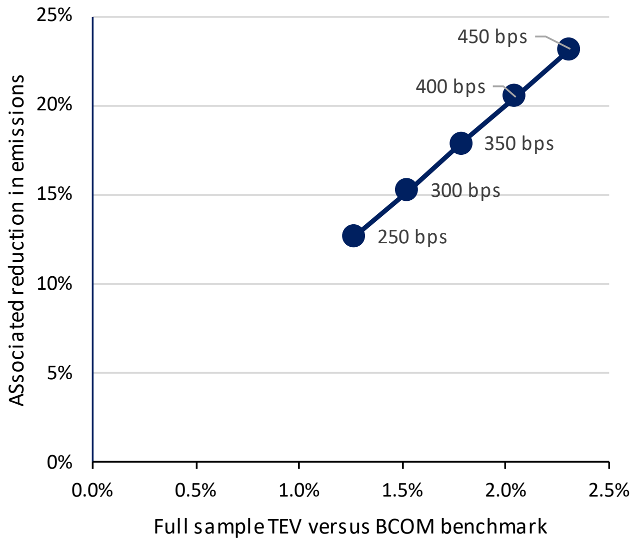
Figure 19: Mapping the aggregate trade-off

	Sector TEV bands (bps)				
	250	300	350	400	450
2012	13.0%	15.7%	18.4%	21.2%	24.0%
2013	13.1%	15.7%	18.4%	21.1%	23.8%
2014	12.7%	15.3%	17.9%	20.5%	23.2%
2015	12.4%	14.9%	17.5%	20.2%	22.8%
2016	12.2%	14.7%	17.3%	19.9%	22.6%
2017	12.1%	14.6%	17.1%	19.7%	22.3%
2018	12.4%	15.0%	17.6%	20.2%	22.9%
2019	12.3%	14.9%	17.5%	20.1%	22.7%
2020	12.6%	15.2%	17.8%	20.5%	23.2%
2021	12.9%	15.5%	18.2%	20.9%	23.5%
2022	12.9%	15.5%	18.2%	20.9%	23.6%
2023	13.3%	15.8%	18.3%	20.8%	23.3%

Source: Bloomberg

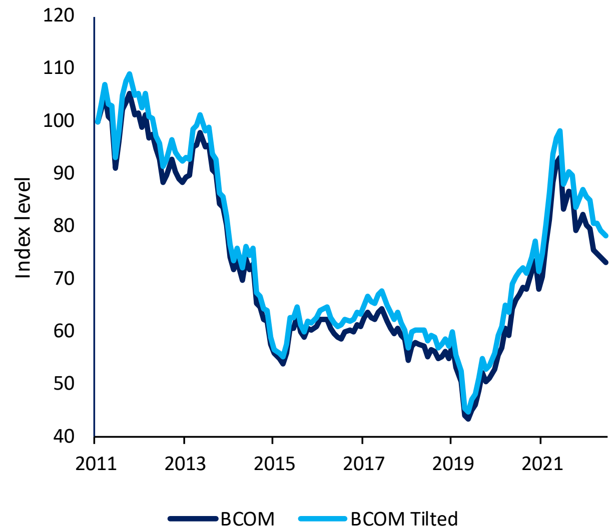
The selected tilt factor is likely based on achieving a certain percentage reduction in emissions versus the BCOM benchmark. For the purposes of our analysis, we look at a threshold of 20%. From Figure 19, this translates to using the BCOM Carbon Tilted portfolio that correspond to a TEV band of 400 bps.

Figure 20: Trade-off: TEV versus reduction in associated emissions



Source: Bloomberg

Figure 21: Tracking the BCOM benchmark



Source: Bloomberg

Based on the analysis in Figure 19, if we measure the full sample TEV versus the BCOM benchmark using monthly returns along with the average annual reduction in associated emissions, we get a trade-off for the aggregate portfolio (Figure 20). Visual confirmation of the tracking properties to the BCOM benchmark is provided in Figure 21.

Conclusion

Controlling carbon emissions is one of the central themes in climate risk discussions. The traditional focus has been on companies – whereby behaviour and activity is scrutinized, following which stocks or bonds are reweighted relative to a benchmark based on certain carbon metrics. Multi-asset investors can extend this framework to the commodity markets by accounting for fundamental differences in the nature of the asset, the derivatives-based exposure and portfolio characteristics.

We tilt the weights of the Bloomberg Commodity benchmark based on the carbon cost associated with the production of each commodity, using life cycle assessment models. Accounting for commodity characteristics, we developed a fully rules-based framework to incorporate the emissions metric into the benchmark while accounting for asset allocation considerations typically faced by multi-asset investors. The modular portfolio construction process provides the flexibility to incorporate additional sustainability metrics—including those that might not be applicable across all sectors—while achieving similar objectives.

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