We'll Always Have Paris: How Institutional Exposures to Carbon Emissions Have Evolved Since 2015

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SUMMARY:

- We develop a coherent framework to measure decarbonization within portfolios and decompose these changes in carbon exposure into distinct components mapping to company behavior, investor behavior, and relative price effects.
- We apply this framework to a large and high quality proprietary dataset of institutional investor portfolios to understand the evolution of institutional decarbonization in recent years.
- We find there is a noticeable decarbonization trend globally since 2019 from both active holdings (excess positions relative to benchmark) and total holdings perspectives, measured through both carbon emissions and carbon intensity metrics.
- What is the source of the decarbonization in most recent years? Decomposing the changes based on our framework, we find the reduction in investor exposure to carbon on an overall basis (total exposure, using unadjusted portfolio weights) has been primarily driven by the relative repricing of high carbon assets as well as decarbonization by the underlying companies, while the reduction in active carbon exposure (using weights in excess of benchmark allocations) has been driven by portfolio repositioning.
- In terms of regional difference, we find European assets have lead the US, EM and the rest of the world with steady reduction in carbon exposure since 2015, while reduced carbon exposure attributable to US assets has only manifested since 2019.
- At the sector level, we observe price has a substantial impact on exposure as well. The diminishing exposure for Energy sector was mainly driven by a significant

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downward repricing. Conversely, the late 2021 recovery in Energy has partly reversed this.

- While carbon *exposures* have declined substantially since 2019, aggregate *emissions* have not declined at the same pace over this period.

1. Introduction

Climate Change has been described as the biggest threat modern humans have ever faced.[1] According to the IPCC, the increase in the greenhouse gas in our atmosphere and the rise in global temperature since 1750 are unequivocally caused by human activities.[2] The effects of climate change have already manifested in many different ways globally, affecting weather and causing climate extremes in every region, and these impacts are expected to accelerate in the next few decades. In 2015 at COP21, 196 Parties signed the Paris Agreement with the goal of limiting global warming to well below 2, preferably to 1.5 degrees Celsius.[3] This was the first time all nations agreed to work together to tackle climate change and adapt to its effects. Responding to the changing landscape and taxonomy in climate change, investors are increasingly paying attention to the carbon exposure of their portfolios, and are joining forces to decarbonize through active engagement, reallocation and/or divestment as we transition to a low carbon economy. Fast track to 2021, almost six years later, we ask: where are we standing now? Have the institutional investor portfolios achieved lower carbon exposures?

In this analysis, we seek to understand to what degree real-money investors (unlevered institutional portfolios such as mutual funds, pensions, and insurance) as a group have decarbonized their portfolios and to characterize the drivers and nature of any such decarbonization. To this end we utilize our proprietary dataset of aggregated and anonymized portfolio data spanning thousands of funds derived from State Street's custodial information. This enables us to begin with security-level holdings. We then connect these allocations to carbon intensity and emissions data at the company level. This enables us to score portfolios on their carbon intensity and emissions. Each portfolio can then be characterized – assigned a score based on the weighted average carbon intensity or emissions of its holdings. For a given stock, this is the weight of the asset in the portfolio multiplied by the value of the carbon characteristic at hand. From here, we apply a formal decomposition (see Appendix for details) that disentangles the evolution of carbon exposure into three components: price effects, flow or repositioning effects, and company carbon effects. Price effects stem from relative returns

[1] https://www.un.org/press/en/2021/sc14445.doc.htm
[2] https://www.ipcc.ch/report/ar6/wg1/downloads/report/IPCC_AR6_WGI_SPM.pdf
[3] https://unfccc.int/process-and-meetings/the-paris-agreement/the-paris-agreement

impacting portfolio weights. Flow effects stem from investors reallocation of assets by trading. Company carbon effects describe how companies themselves have lowered or increased their carbon footprints or efficiency through time.

In addition to examining overall portfolio allocations, we also study the impact on active positions – holdings above or below benchmark weights. We define active holdings using a proprietary benchmarking methodology as in Cheema-Fox et. al (2021a). A hedonic panel regression estimating log position values while controlling for fund and security attributes such as capitalization weights, fund similarity to market capitalization weighting, equal weights, sector allocations, value tilts, and other features is estimated across all positions observed in the sample each day over the prior three months (on order of millions of datapoints ente r into each estimate). The regression fit is defined as the benchmark for a given fund in a given security, the residual is the active holding. These are then averaged across portfolios to the security and higher levels of aggregation (e.g. sectors and countries). This approach is akin to a "normal portfolio" approach – typically observed behavior is deemed to embody expected or benchmark holdings. Note that since fund holdings do not exactly follow capitalization weights in many cases, the benchmarks implied by this approach will differ from capitalization weights.

Our present contributions include: 1) development of a coherent framework by which to measure decarbonization within portfolios and to decompose these changes in carbon exposure into distinct components mapping to company behavior, investor repositioning, and relative price effects; 2) application of this framework to a large and high quality proprietary dataset of institutional investor portfolios to understand the evolution of institutional decarbonization in recent years.

We have a few notable findings regarding carbon exposure in institutional investor equity holdings. First, we find there is a noticeable decarbonization trend globally since 2019 from both active and overall perspective, measured through both carbon emissions and carbon intensity metrics. Second, decomposing the changes based on our framework, we find the reduction in investor exposure to carbon exposure on an overall basis has been primarily driven by repricing of carbon exposure in the market and carbon reductions by the underlying companies**.** While the reduction in *active* carbon exposure (defined as active weights relative to benchmark, multiplied by a given carbon exposure metric) has been driven by flows repositioning portfolios or active manager bets. Note that, since our benchmark is not a simple capitalization weighted benchmark, that relative returns are not automatically reflected in benchmark weights. Relative returns can also affect active weights in the absence of flow for non-capitalization weighted benchmarks[4].

[4] Consider capitalization versus equally weighted benchmarks. If stock A outperforms stock B, stock A's capitalization weight will reflect this perfectly. Any active position measured against cap-weight would be unaffected by returns alone. Conversely, if the benchmark is taken as equal-weighted, then benchmark weights

Third, in terms of regional difference, we find European assets lead the US, EM and the rest of the world with steady reduction in carbon exposure since 2015, while investors have only begun to reduce carbon exposures with US assets since 2019. Lastly, at the sector level, we observe price effects have exerted substantial impact on exposure as well. The diminishing exposure for Energy sector is mainly driven by the 2019/2020 collapse in Energy sector prices, and the corresponding rise in Tech has resulted in an increase in the carbon exposure contribution of Tech relative to Energy.

2. Data

Company-level emissions and carbon intensity information are obtained from S&P Trucost. Emissions are measured in tonnes of carbon dioxide. Carbon intensity is defined as tonnes of carbon emitted divided by revenue (millions USD). In each case, we utilize Scope 1 and Scope 2 emissions where scope 1 covers the direct GHG emissions from the operation of the business, and scope 2 covers the GHG emissions from purchased utilities of the business such as electricity, steam, or heat. We do not incorporate the more heavily model-derived Scope 3 indirect emissions extending to upstream and downstream of business in our calculations as scope 3 data are not currently reliability and consistently estimated (Cheema-Fox et. al 2021b) . We impute carbon data with the industry mean within each region (for example, US Autos) where there are missing values.[5] One caveat is that this imputation could systematically overestimate emissions (because the distribution of emissions are right-skewed, with some emitters at the far right tail) so the carbon increase or reduction we observe over time might be over or under-estimated and attributed to company effects.

Holdings information are derived from State Street's custodial database and are anonymized and aggregated across portfolios. State Street is among the world's largest global custodians, with assets under custody or administration amounting to over $42 trillion as of Q2 2021.[6] These transaction data comprise complete fiduciary accounts of all equity transactions for the portfolios

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are static (so long as the number of holdings remains fixed) and all relative returns directly manifest as changes to active weights: stock A would automatically increase its active weight relative to stock B. Our benchmark, while as close to cap-weighted as the data imply, differs from cap-weighted, hence relative return effects can on their own affect active weights relative to our hedonic benchmark.

[5] We use the mean value for each group defined by regional market (US, European developed, other developed and emerging markets) and GICS industry code to fill the missing values. Using only the set of security-days where carbon data are available without imputation does not affect our conclusions.

[6] https://investors.statestreet.com/investor-news-events/press-releases/news-details/2021/State-Street-Corporation-Announces-Date-for-Release-of-Third-Quarter-2021-Financial-Results-and-Conference-Call-Webcast/default.aspx#:~:text=With%20%2442.6%20trillion%20in%20assets,and%20employs%20approximately%2039%2C000%20worldwide.

in which these assets are held. The types of institutions comprising this sample consist of mutual fund, pension, insurance, and collective investment vehicle portfolios. Roughly speaking, the counterparties this group as whole may face would consist of retail investors, corporates, brokers/market makers, and leveraged funds. In this study, we focus on equity holdings linked to the MSCI investible universe. We also analyze excess holdings and changes therein. These excess holdings are derived from a proprietary benchmarking function utilized in the State Street Associates Equity Holdings Indicator. This empirical benchmark is computed via ordinary least squares regression models across a panel of position-level holdings (in logs) each day. The regression fit is assigned as the estimated empirical benchmark, and the regression residual for each position constitutes the active holding of a given fund in a given security. We aggregate these residuals across funds to obtain security-level excess and total holdings, and use these in our analysis below.

Pricing, return and market cap data are taken from MSCI, and country and sector classifications follow MSCI definitions. The time period covered by the exposure analysis spans January 2015 through September 2021. Since our carbon metrics at the company level are for the most part annually updated, we consider annual changes, on a 1st of January to 1st of January basis. We include a final, approximate, update from January 2021 through September 2021 as well.

3. Methodology and Framework

3.1. Basic concepts

We concentrate on two quantities and measure these in two ways.

Carbon exposure Measures:

- Intensity: how much carbon does it cost to earn a dollar of revenue?
    - Tonnes of Carbon emitted (Scope 1 + 2 Carbon) / Dollars Revenue (Millions USD)
    - We can think of this as a carbon efficiency measure
- Emissions: how much carbon on the whole did you emit?
    - Tonnes of Carbon emitted (Scope 1 + 2 Carbon)
    - This is a direct measure of carbon footprint for a given company

Portfolio Measures:

We consider exposures of real-money investors in aggregate to these carbon characteristics. Exposures are simply defined as weighted average values of intensity or emissions, taken across securities in a region/country/sector. The weights we use are the total or active holdings of real-money investors in aggregate from our dataset. Think of these exposures as a portfolio attribute like any other. For instance, if we were gauging funds' tilt to value, we might consider the funds' weighted average book to market ratio. Here we substitute carbon intensity or emissions for each security for a more standard fundamental feature.

- Total Exposure: the exposure of aggregate positions to a given carbon characteristic. Note that total weights sum to 100% across all assets for each time period. Total weights combine both benchmark allocations and any active allocations above or below benchmark. Since the sum of all total weights is always the same (100%), if we see changes in total exposure through time, it means investors are shifting allocations towards or away from a given characteristic relative to other periods of time. Total exposure, like total weight, combines decisions taken *across* funds by fund allocators as well as decisions taken *within* funds by portfolio managers.

- Active Exposure: the exposure of excess holdings to a given carbon characteristic. Note that by construction excess weights sum to zero across all securities for each time period, so if we have a positive or negative active exposure, that means investors are making active bets towards or against a given characteristic. Active weights capture the decisions of managers taken *within* portfolios relative to benchmark weights, and active exposures relate these intra-fund decisions to carbon risk.

- Contrasting Active and Total Exposures: Imagine a non-passive mandate fund A whose investible universe is comprised of the S&P500. Fund A would be able to take active bets in various sectors, but since active weights net to zero across all holdings, it cannot take an active view on the US as a whole. However, a cross-fund allocator investing in this S&P500 fund as well as an EAFE fund B and an emerging markets fund C can choose regional exposures by allocating more or less to these various regional portfolios. To understand the allocator's overall risk position and exposures, we must consider total weights. Why, then, do we consider active weights at all? When considering risk exposures such as carbon, we can better disentangle the conceptually distinct portion of exposure attributable to within-fund, benchmark relative manager decisions by examining active weights and active exposures.

3.2. Decomposition of Changes in Carbon Exposure

Suppose we measure aggregate carbon intensity exposure at two points in time. The exposure for a given stock is the product of the weight of the asset in the portfolio and the value of the company's carbon characteristic. Thus, the aggregate carbon exposure for a portfolio at time t is

$$Carbon\ Exposure_t = \sum_{i=1}^{N}(asset\ weight_{i,t} \times\ asset\ carbon\ exposure_{i,t})$$

What moves the above? Corporate behavior could affect company carbon features since the underlying company of the security might take actions to improve carbon efficiency or reduce absolute carbon emissions over time. Portfolio weights, however, are impacted by both prices and flows. If Company A outperforms Company B, its relative price rises, and all else equal so does its weight in a portfolio. Similarly, if we buy shares of A and sell B, all else equal the weight of A rises. In the appendix we derive a way to separate these various effects into three pieces:

- Flow Effect (investors altering their positions by buying or selling)[7]
- Price Effect (relative returns affecting portfolio weights)
- Carbon Effect (companies altering behavior)

We apply this separation in select examples below to understand what has driven the overall changes we observe in institutional investor carbon exposures through time.

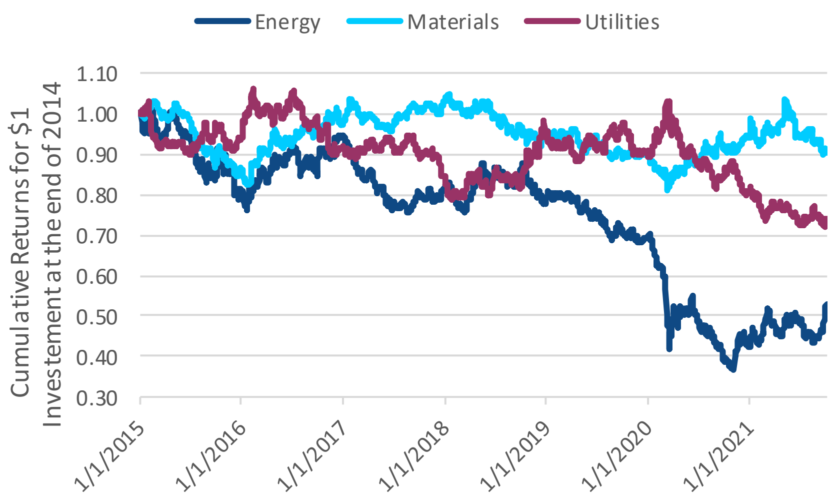
4. Findings for the Global Equity Market

4.1. Market Context

We first want to understand how low carbon assets have performed relative to the broader market. According to Cheema-Fox et. al. (2021a), low carbon value-weighted portfolios in general have exhibited moderately higher stock returns than high carbon value-weighted portfolios. Exhibit 1 shows the three sectors with very high carbon emissions in scope 1 and 2 (Cheema-Fox et al. 2021b). Higher carbon sectors have underperformed the ACWI overall during this period, but by far the most pronounced underperformance has been in the Energy sector. This Energy trough has reversed somewhat in late 2021.

[7] With respect to some companies (e.g. technology firms) it is helpful to note that the set of investors we track here may often be on the opposite side of the trade from corporates buying back stock, among the other potential counterparty types described above. We also perform an adjustment for changes in the overall sample AUM as a proportion of universe market capitalization (the market share of our sample) between any two years before computing share holdings differences to ensure that sample dilation or contraction alone does not mechanically create spurious "flow" effects.

Exhibit 1: Relative Performance of High Carbon Sectors to ACWI



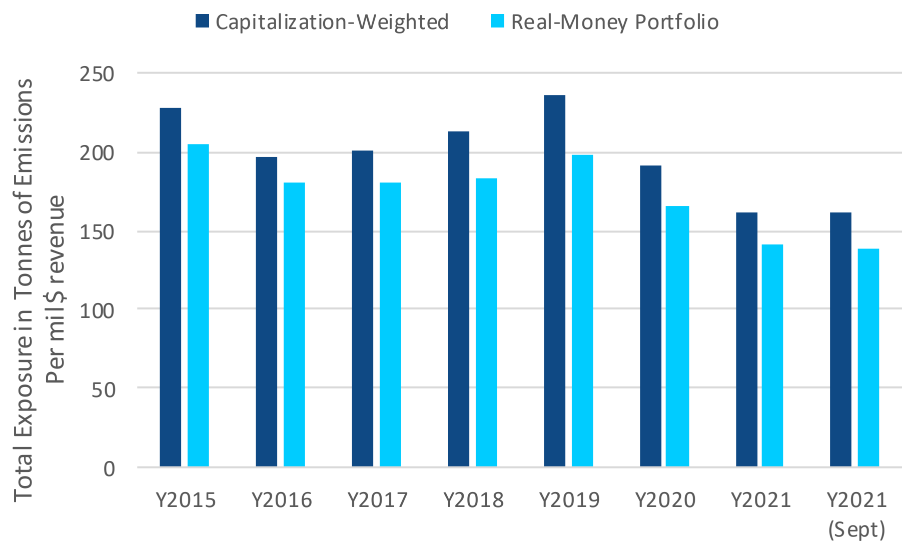
Source: Bloomberg, MSCI

These provide important context that high carbon assets have generally performed less well during this time period, which implies that they could have decreased in portfolio weights even without active decisions from the institutional investors. Therefore, our decomposition into the flow, price, and carbon components will help isolate the price impact and have a better understanding the decarbonization process and attributions.

4.2. Total Carbon Exposures

a.) Carbon Intensity

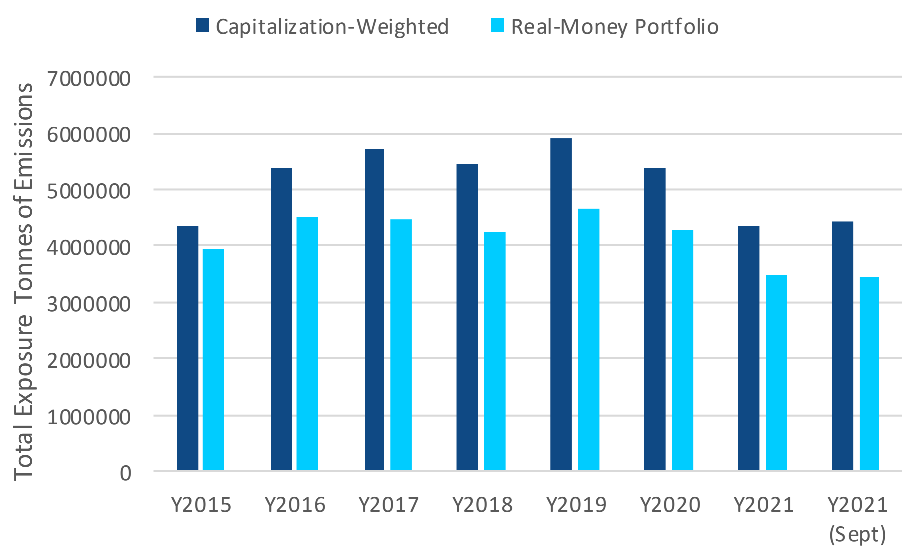
Exhibit 2a: Global Total Exposure Based on Carbon Intensity



Source: State Street Associates, S&P Trucost, MSCI

b.) Carbon Emissions

Exhibit 2b: Global Total Exposure Based on Carbon Emissions



Source: State Street Associates, S&P Trucost, MSCI

Exhibits 2a and 2b summarize the real-money aggregate exposure to carbon intensity and carbon emissions from January 2015 to 2021 on an annual basis. These are contrasted with capitalization-weighted aggregate exposures computed across all firms in our sample. The Y2015 bar indicates the exposure on the first trading day in 2015. To view the progress in 2021, snapshot at the end of September of 2021 is presented as well.

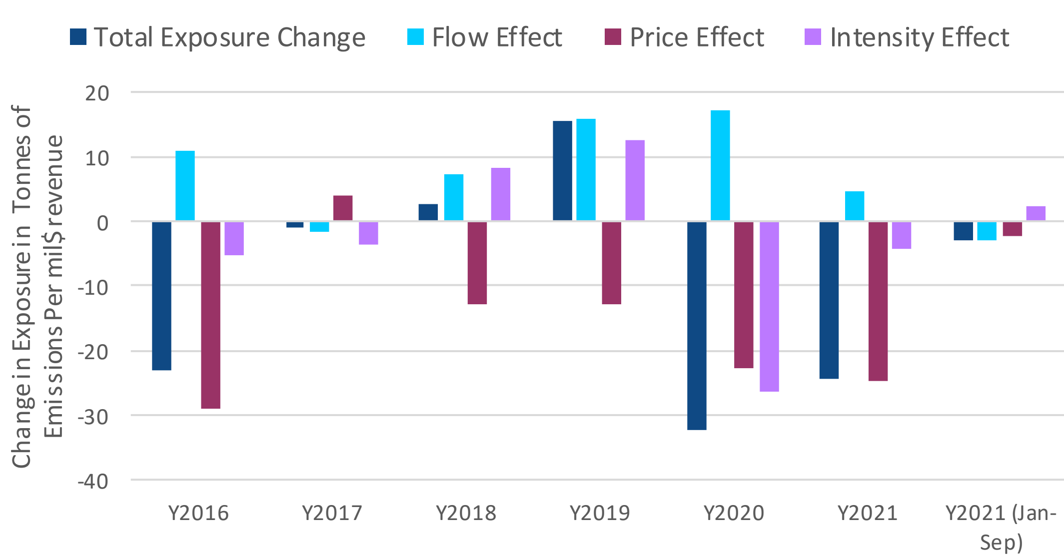
We find while there is less of a pattern in carbon exposures prior to 2019 globally, we see a clear decarbonization trend measured through both carbon intensity and emissions since 2019. The carbon reduction from January 2019 to September 2021 is about 30% in terms of intensity, and about a quarter by emissions. The aggregate real-money investor portfolio is moving towards lower carbon assets in the past two to three years.

Also notable is a gap between exposures computed using market-capitalization weights versus exposures computed using the weights in our sample of real-money portfolios. This implies that other participants are, on a relative basis, absorbing positions in higher carbon exposure assets that are held relatively less by institutions. This is especially pronounced in absolute carbon emissions.

4.3. Decomposed Changes: Total Exposure

a.) Carbon Intensity

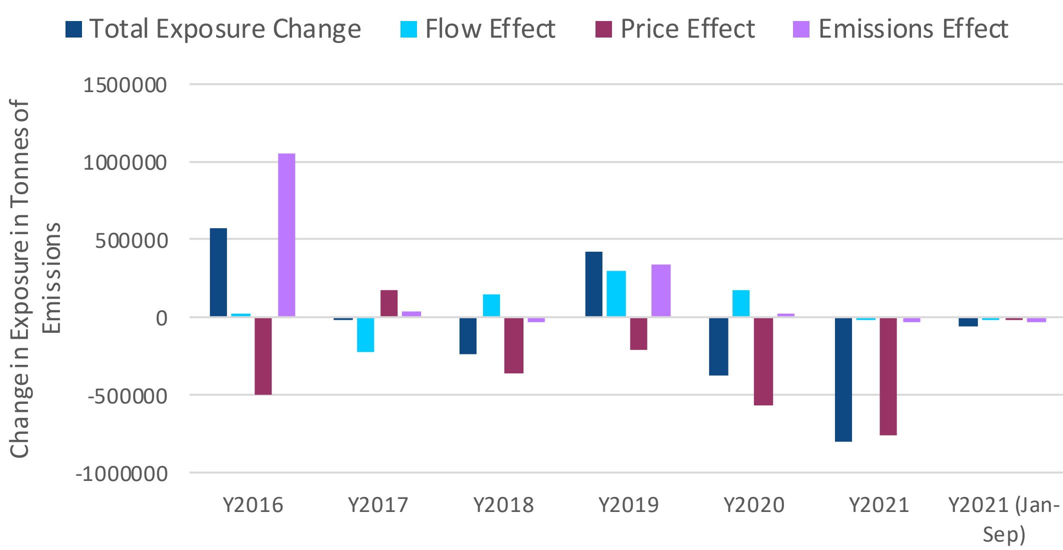
Exhibit 3a: Total Exposure Decomposition Based on Carbon Intensity



Source: State Street Associates, S&P Trucost, MSCI

b.) Carbon Emissions

Exhibit 3b: Total Exposure Decomposition Based on Carbon Emissions



Source: State Street Associates, S&P Trucost, MSCI

What drove this carbon reduction in recent years? Decarbonization of a portfolio can be effected intentionally or can occur passively from the perspective of any individual portfolio manager. Based on our decomposition framework, changes from underlying companies becoming more carbon efficient as well as from investors titling towards low carbon assets constitute more active and intentional decarbonization (in the one case driven by corporate behavior, in the other by investor repositioning), while the changes from variation in relative market values are indirect. These exposure changes happen to a portfolio due to price movements, they are not effected by trading behavior or by changes in company behavior.

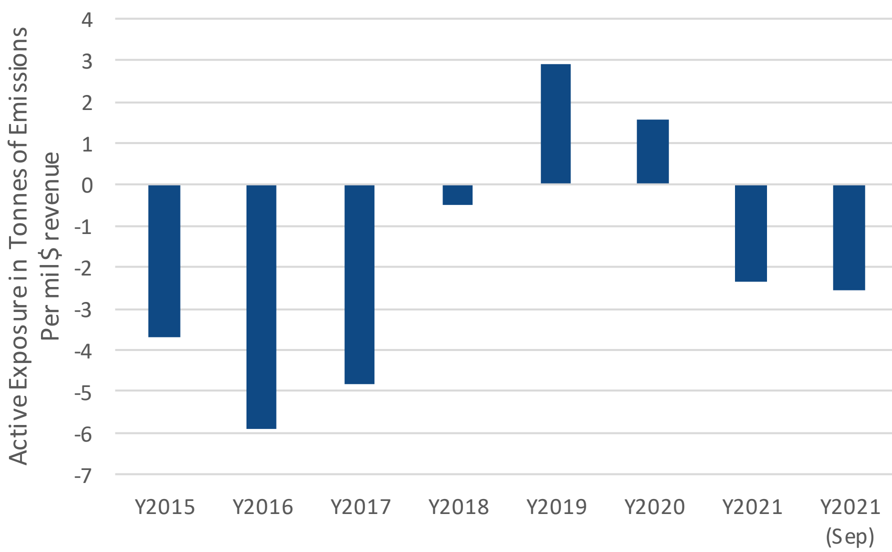
Exhibit 3a and 3b present the decomposition results for the carbon exposures based on total holdings. We find the reduction of carbon exposure has been driven more by price movements (relative returns) than by either company changes or investor reallocations since 2019 in Exhibit 3b. Viewed from the lens of intensity in Exhibit 3a, which captures carbon efficiency rather than simply carbon amounts, we see a similar pattern, but with more of the reduction in exposure ascribable to a reduction in underlying company intensity as well between 2019 and 2020. Nonetheless, whether measured by carbon intensity or by emissions, flow effects are positive and relatively small in magnitude compared to the other two effects, suggesting that investor reallocation is not the key driver for the decarbonization trend we have observed in the aggregate portfolio.

This does not, however, imply the irrelevance of institutional investors views to this process. Repricing of assets can occur with relatively little flow if there is consensus. Inasmuch as prices have moved and institutions have not traded substantially against these movements, this may imply agreement with the repricing trend that has on the whole favored lower carbon versus higher carbon assets in recent years.

4.4. Active Exposure

a.) Carbon Intensity

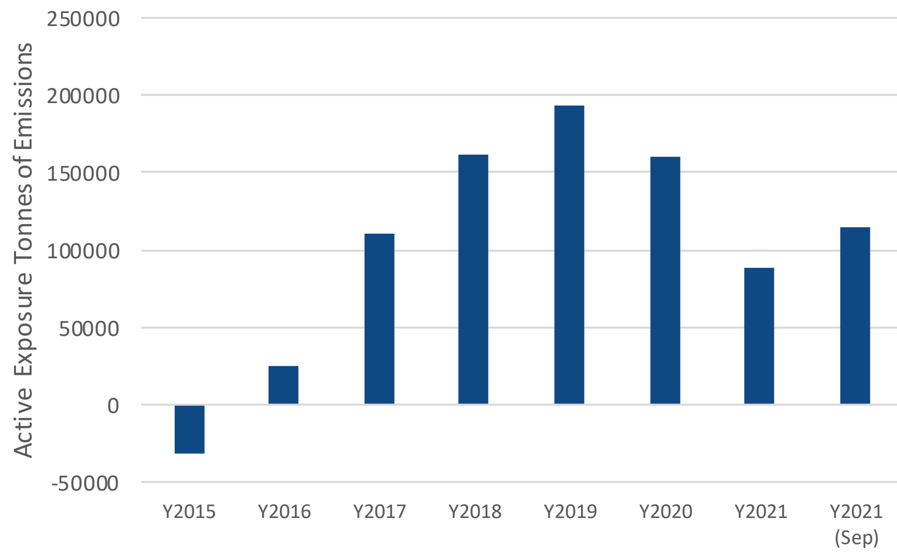
Exhibit 4a: Global Active Exposure Based on Carbon Intensity



Source: State Street Associates, S&P Trucost, MSCI

b.) Carbon Emissions

Exhibit 4b: Global Active Exposure Based on Carbon Emissions



Source: State Street Associates, S&P Trucost, MSCI

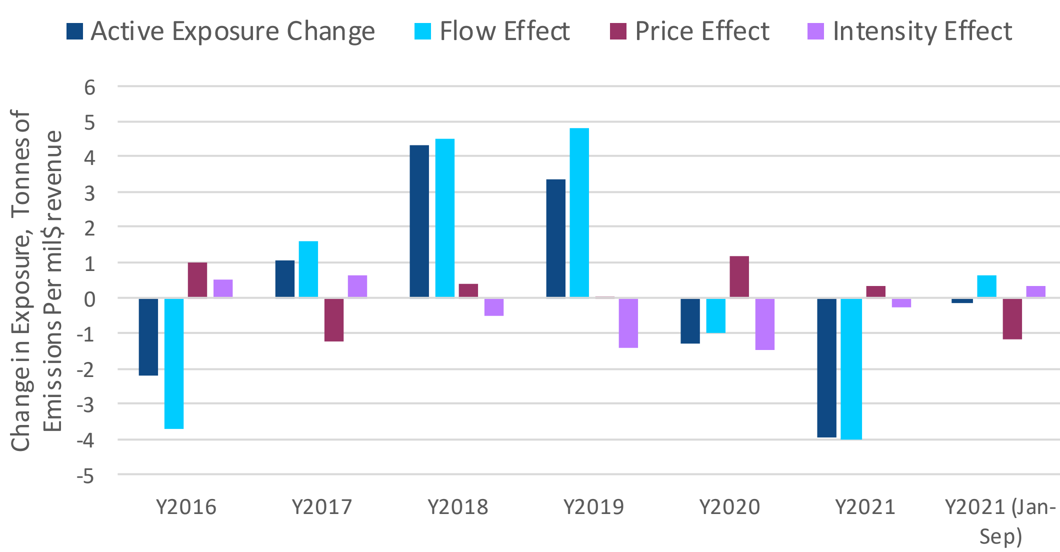
Now turning to the active carbon exposure results based on excess (relative to benchmark) portfolio holdings/weights. As mentioned in the Data section, active weights are calculated by subtracting benchmark weights from total weights. Active weights can be thought of as capturing manager decisions *within* portfolios. The benchmark weights are what we anticipate the position to be based on a set of fund level and security level characteristics. For example, a value fund has more of value tilt reflected in its holdings, and so would be expected to take larger positions in a value stocks than a balanced fund. Here we are more interested in the idiosyncratic positioning or unanticipated holdings above and beyond expected positions, reflected by active holdings. A positive or negative active weight indicates that investors are making an active bet towards or against a given characteristic. Therefore, the active carbon exposure calculated in this section tells us how investors' active bets lead to higher or lower carbon exposure for the group.

When examining exposures based on active weights in Exhibit 4a and 4b rather than total allocations, we see some differences. Active emissions exposures increased until 2019, and have since declined indicating that investors' excess positions on the whole tilted towards higher emission companies. While the trends were more similar when comparing the active and total exposure based on intensity, the net exposures have been more negative – investors have more systematically underweighted high intensity companies relative to low intensity companies than they have along the emissions dimension. Similar as to what we have observed based on the total exposure, we have seen noticeable decarbonization trend from 2019 to 2020 in active exposures whether measured through intensity or emissions. This has however reversed somewhat in late 2021, as rising oil prices have fueled a recovery in the energy sector.

4.5. Decomposed Changes: Active Exposures

a.) Carbon Intensity

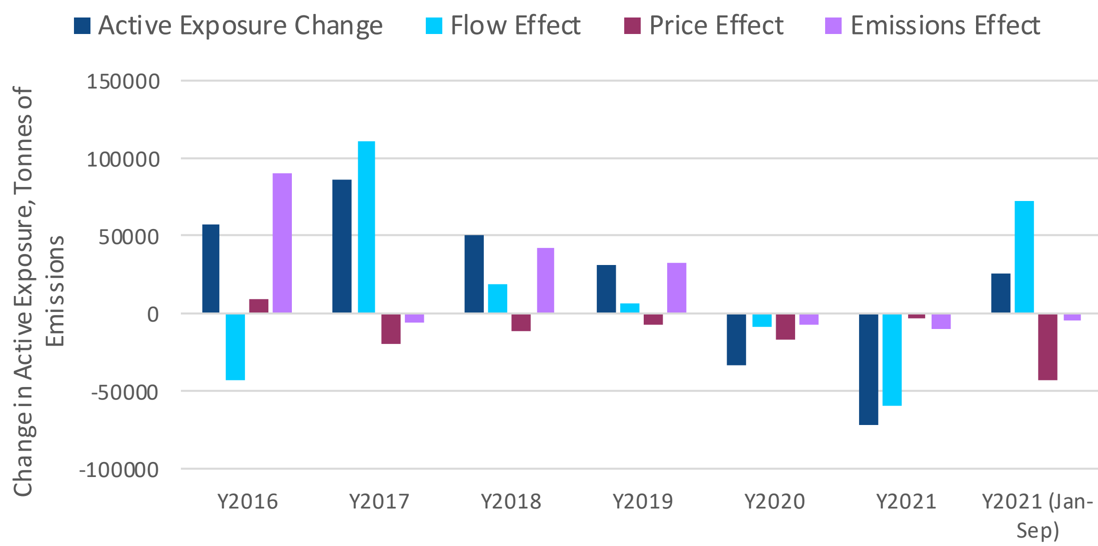
Exhibit 5a: Global Active Exposure Decomposition Based on Intensity



Source: State Street Associates, S&P Trucost, MSCI

b.) Carbon Emissions

Exhibit 5b: Global Active Exposure Decomposition Based on Emissions



Source: State Street Associates, S&P Trucost,, MSCI

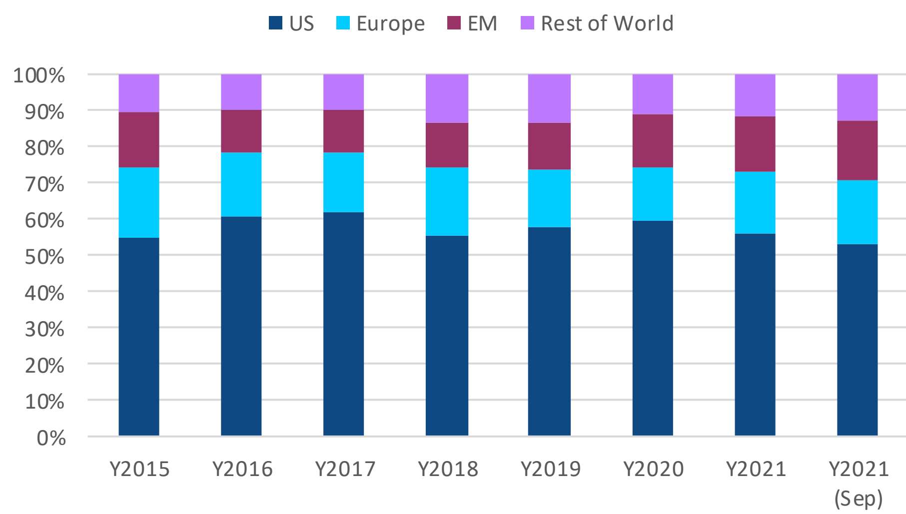
When we examine how active exposures change, while the broad trends are similar to the evolution of total exposures, we see that far more of the variation is driven by flows – manager portfolio rebalances – than in the case of total allocations. Price effects in particular shrink, though in several cases, for instance 2015-2016 emissions, company effects are at the forefront. Aggregate portfolio manager repositioning decisions have, in recent years, seemingly begun to tilt towards favoring decarbonization. Once more, however, 2021, with the rebound in Energy valuations, has bucked this tendency.

5. Regional Contrasts

5.1. Total Exposure Breakdown By Region

a.) Intensity Exposure By Region

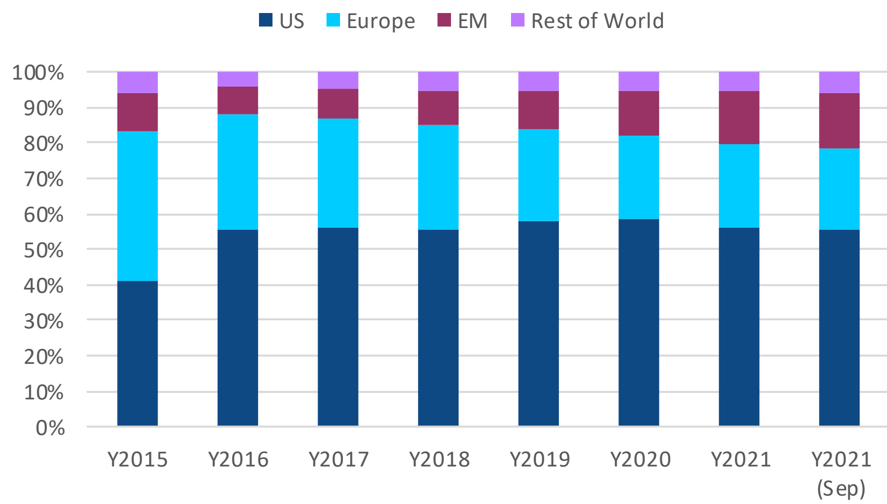
Exhibit 6a: Regional Exposure Based on Intensity (as % of global exposure)



Source: State Street Associates, S&P Trucost, MSCI

b.) Emissions Exposure by Region

Exhibit 6b: Regional Exposure Based on Emissions (as % of global exposure)

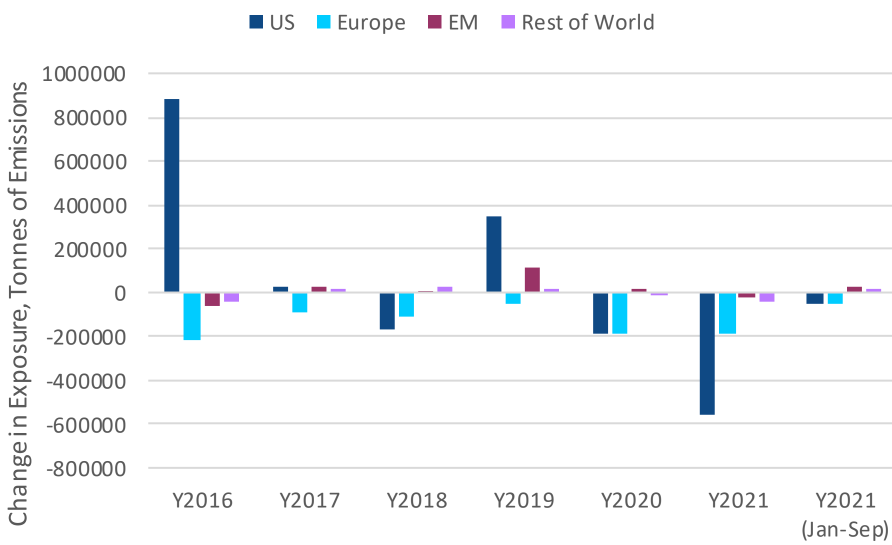


Source: State Street Associates, S&P Trucost, MSCI

Exhibit 6 shows the breakdown of exposures by region based on State Street's custodial holdings in the global equity market. Post Paris 2015, we see an increase in the US proportion of emissions and intensity exposure. This remains elevated until after the 2020 election, when we see a new decline in US proportions of both intensity and emissions exposure. Europe notably decreases its weights throughout the period, EM generally rises after 2016.

5.2. Regional Changes

Exhibit 7: Change in Regional Emissions Exposure



Source: State Street Associates, S&P Trucost, MSCI

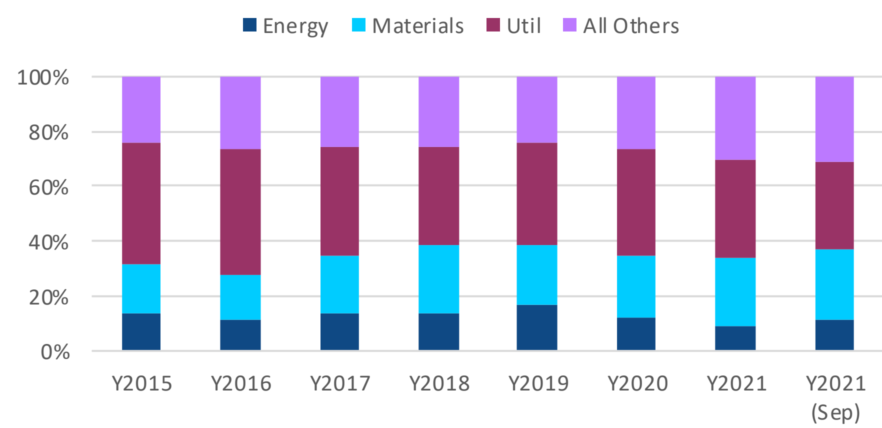
Exhibit 7 speaks to the breakdown of emissions exposure by region – here we examine the actual changes and see a consistent story. 2015-2016 saw a sharp rise in US emissions exposure and a drop European exposure. Each subsequent year since the Paris Agreement has seen falling exposures in European emissions. The US story has been mixed, but we have seen steady drops since 2019, accelerating during 2020.

6. Sector Exposures and Drivers

6.1. Sectoral Drivers of Total Exposure

a.) Carbon Intensity

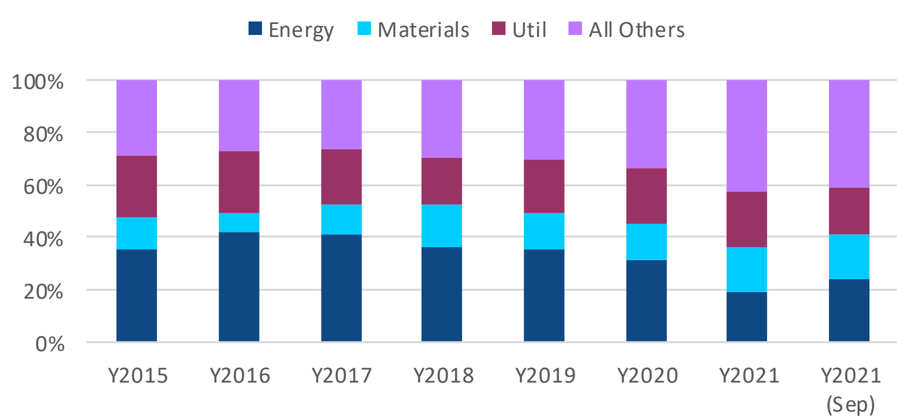
Exhibit 9a: Sectoral Exposure Based on Intensity



Source: State Street Associates, S&P Trucost, MSCI

b.) Carbon Emissions

Exhibit 9b: Sectoral Exposure Based on Emissions



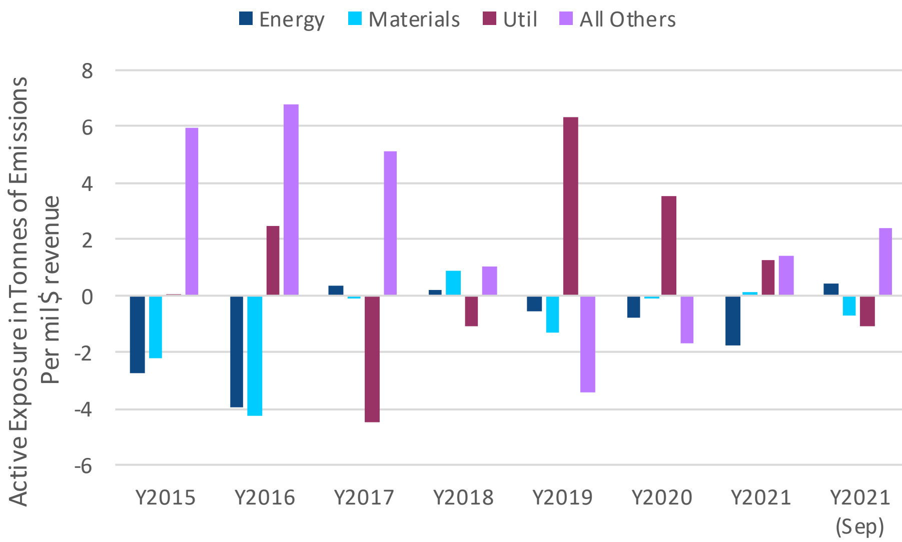
Source: State Street Associates, S&P Trucost, MSCI

The bulk of carbon exposure, whether measured as intensity or emissions, are driven by Energy, Materials, and Utilities. The sharp decline in Energy valuations, however, has greatly reduced the contribution of the sector to overall exposures. The Energy recovery in late 2021 has in turn attenuated this reduction.

6.2. Active Sector Exposures

a.) Carbon Intensity

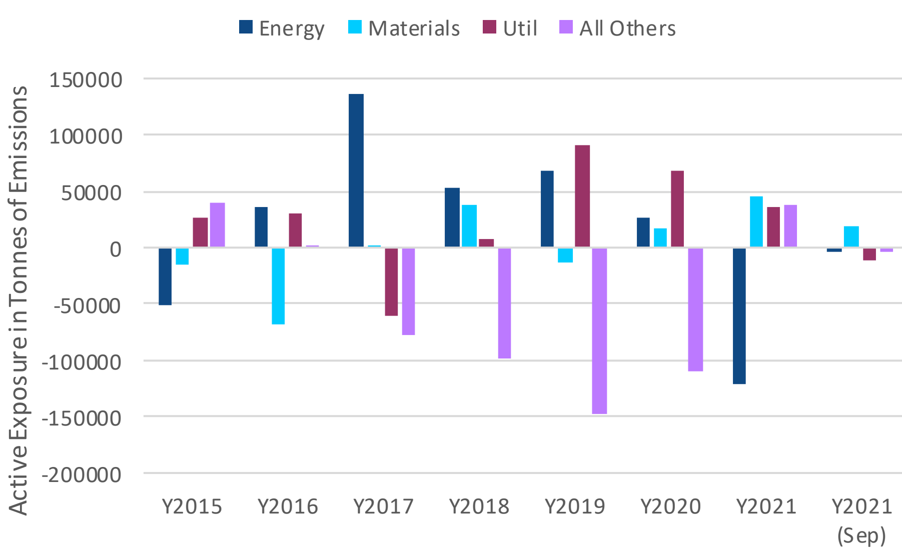
Exhibit 10a: Active Sectoral Exposure Based on Intensity



Source: State Street Associates, S&P Trucost, MSCI

b.) Carbon Emissions

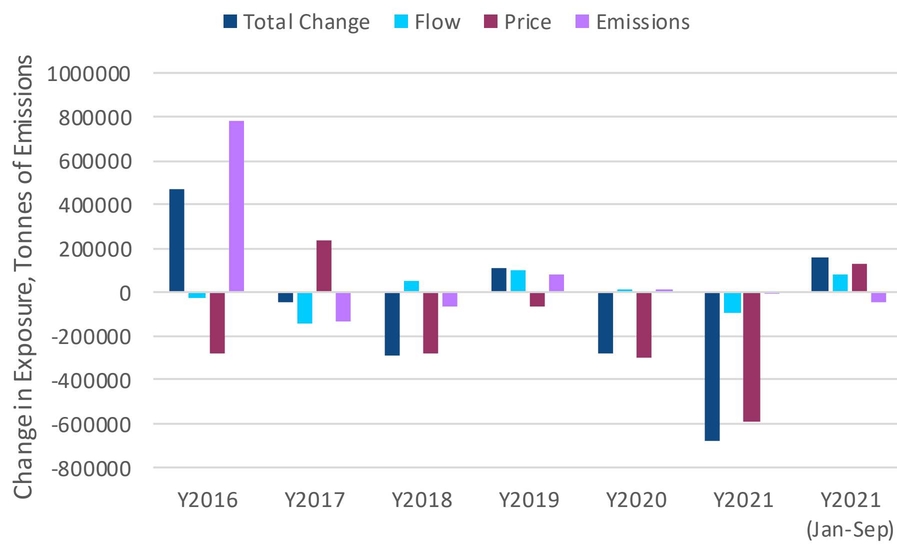
Exhibit 10b: Active Sectoral Exposure Based on Emissions



Source: State Street Associates, S&P Trucost, MSCI

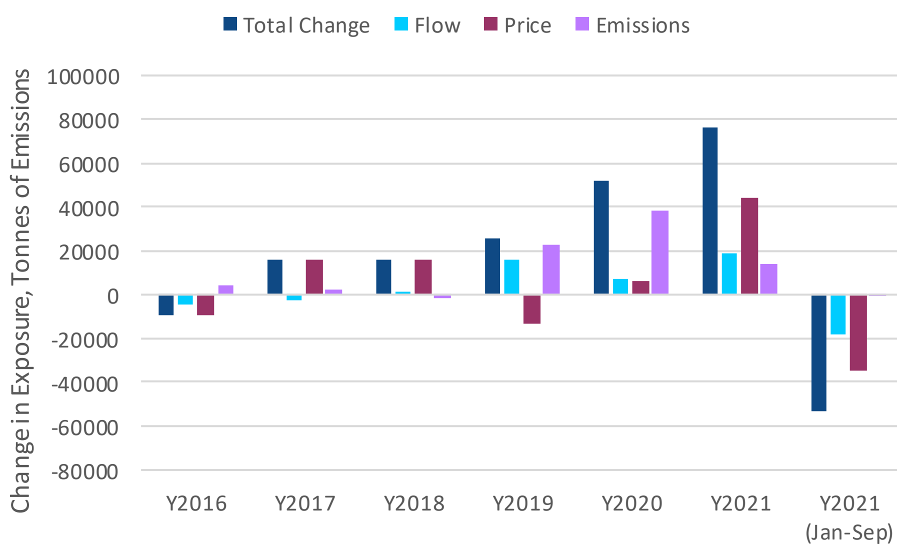
c.) Decomposition of Exposure Changes: Energy vs. Tech Sectors

Exhibit 11a: Decomposing Total Exposure Change Based on Emissions for Energy Sector



Source: State Street Associates, S&P Trucost, MSCI

Exhibit 11b: Decomposing Total Exposure Change Based on Emissions for IT Sector



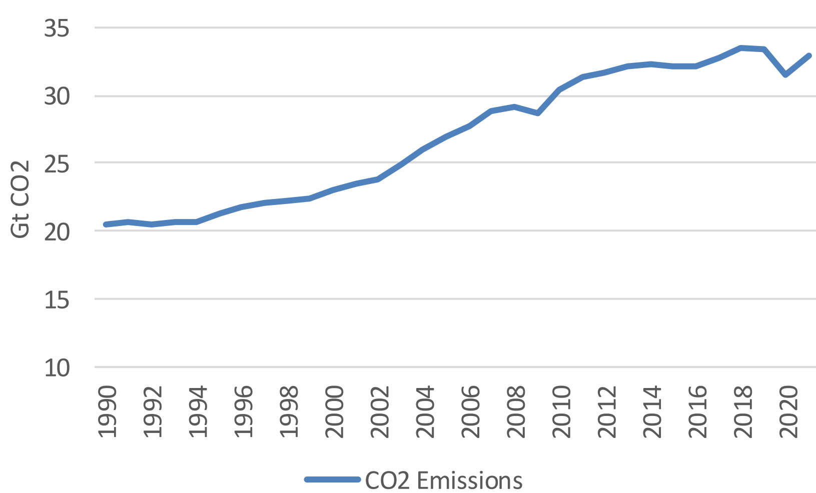
Source: State Street Associates, S&P Trucost, MSCI

Consistent with the sharply negative relative returns we observed for Energy, the price-driven component of exposure changes has been the main driver of reductions in emissions exposure attributable to Energy holdings. Mirroring this has been an increase in the amount of emission exposure attributable to the Technology sector, driven by strong relative returns as well as increasing carbon emissions from the underlying companies (which could be due to the growth of the business). These shifts have been nearly symmetric and opposing since 2019. The rise in oil prices and the Energy sector in late 2021 has somewhat reversed this pattern, again demonstrating the importance of price effects.

7. Total Emissions

A distinction should be made, however, between what we have thus far discussed – investor exposures to carbon – and the actual quantities of carbon emitted. Globally, total CO2 emissions have been rising steadily from 1990 to 2018 according to IEA's 2021 report as shown in Exhibit 12. Total emissions have experienced the largest decline, by about 6% from 2018 to 2020; while 2021 has seen a rebound as demand for oil, gas and coal recovers with the economy.[8] However this is not within the scope of this paper.

Exhibit 12: Global energy-related CO2 emissions, 1990-2021



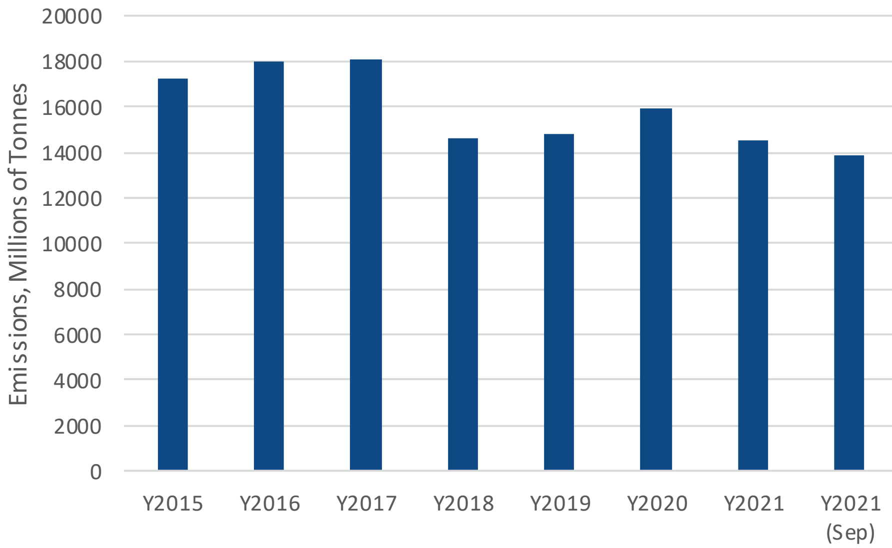
Source: IEA, Global energy-related CO2 emissions, 1990-2021

Instead we focus on investors' exposure to carbon emissions through their portfolio holdings. Simply because investors have reduced their exposure to carbon does not tell us with

[8] IEA, Global energy-related CO2 emissions, 1990-2021, IEA, Paris https://www.iea.org/data-and-statistics/charts/global-energy-related-co2-emissions-1990-2021

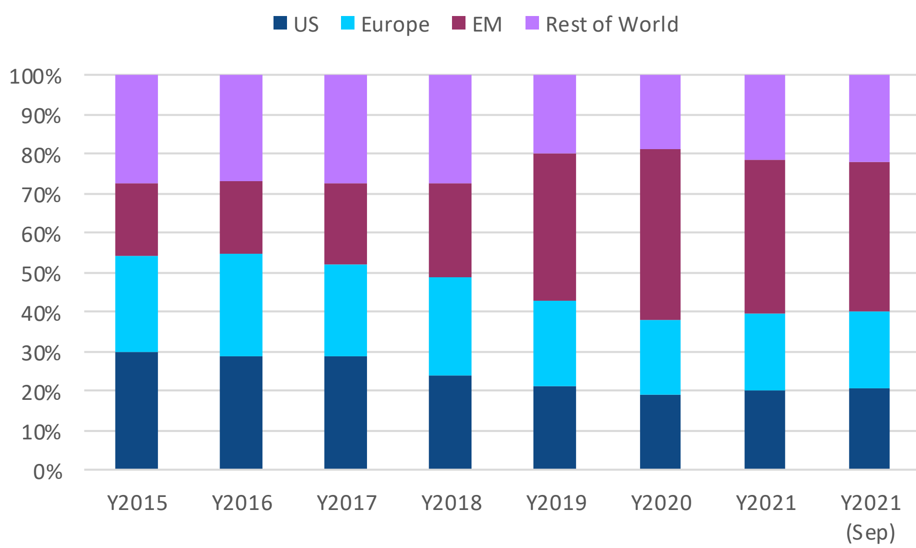
certainty that emissions have themselves fallen. Below we examine, for the companies in our sample, how emissions have evolved.

Exhibit 13a: Aggregate Emissions From Companies



Source: State Street Associates, S&P Trucost, MSCI

Exhibit 13b: Attribution of Aggregate Emissions



Source: State Street Associates, S&P Trucost, MSCI

Exhibit 13a delineates an overall reduction in emissions since 2015, but the trend in emissions reduction is less pronounced since 2019 than the corresponding evolution of investor carbon exposures. In Exhibit 13b we see a sharp increase in the proportion of aggregate emissions attributable to emerging market economies, far outpacing the analogous proportion of carbon exposure. While it is possible that the in large part price-driven reductions in carbon exposure we have seen in institutional portfolios will eventually impact the sheer quantity of emissions produced in equal measure, this does not yet appear to have been fully actualized. The decreased valuations of higher carbon companies may be anticipatory, and the emissions reductions may be to come in the future.

8. Conclusions

Despite the prominence of the Paris agreement, we see ambiguous patterns in institutional investors' tilts towards carbon emissions from 2015 to 2018. However, since 2019 there has been a pronounced decarbonization trend reflected in the aggregate institutional investor carbon exposures, from both active and overall perspective, measured through carbon emissions and carbon intensity metrics. This has coincided with an acceleration in the relative returns of a low-carbon equity securities and indexes and more recently in a run-up in the price of carbon futures.

To understand the source of the change in aggregate real-money carbon exposure, we develop a methodology to decompose the change in carbon exposure into three components – price impact, flow impact and the impact from the change in underlying company's carbon characteristics. Using this framework, we find the reduction in investor exposure to carbon exposure on an overall basis (total exposures, using total portfolio weights) has been driven by repricing of carbon assets in the market as well as decarbonization in the underlying companies, while the carbon reduction based on investors' active bets (active exposures, using holdings in excess of benchmark weights) has been driven by flows repositioning portfolios.

In terms of regional difference, we find while European assets have generally contributed to lowering of carbon exposure steadily since 2015, investors' US assets have only begun to do so in since 2019.

At the sector level, we observe price has a big impact as well. The rout in Energy and the corresponding rise in Tech have resulted in an increase in the carbon exposure contribution of Tech relative to Energy. The recent (Q3 2021) recovery in Energy has partly reversed this effect.

However, when we directly examine carbon emissions generated by the companies tracked in this study, we see less of a decline since 2019 than institutional exposures – in large part driven by potentially anticipatory repricing of assets – have evidenced.

References:

Cheema-Fox, A., B.R. LaPerla, G. Serafeim, D. Turkington, and H. Wang. 2021(a). "Decarbonization Factors." *Journal of Impact & ESG Investing* 2 (1): 47-73; DOI: https://doi.org/10.3905/jesg.2021.1.026

Cheema-Fox, A., B.R. LaPerla, G. Serafeim, D. Turkington and H. Wang. 2021(b). "Decarbonizing Everything." *Financial Analyst Journal* 77 (3): 93-108; DOI: 10.1080/0015198X.2021.1909943

APPENDIX:

DEFINITIONS

Indices:

s – stock   t – time

Measurements:

I(s, t): Carbon intensity of stock s at time t. Units : Scope 1+2 emissions / $ Revenue,

C(s,t) : Carbon emissions (Scope 1+2) of stock s at time, tonnes.

AUM(t): total equity AUM at time t.

sh(s,t) : portfolio shares in stock s at time t.

p(s,t) : asset price in stock s at time t.

v(s,t) : USD holdings in a given stock at time t. Units: USD

v(s,t) = p(s,t) * sh(s,t)

w(s,t) : portfolio weight in stock s at time t.

w(s,t) = v(s,t)/ AUM(t)

E(s,t) : Carbon exposure of stock s at time t. Units: as carbon intensity or emissions, depending on which feature we chose to measure. For example, if we chose intensity exposure this would be in units of intensity and computed as

E(s,t) = w(s,t)* I(s, t)

Exposure Dynamics (for any given stock, security notation suppressed)

Change in exposure (this could be carbon, intensity, or any arbitrary characteristic; for illustration we take the case of carbon intensity below):

$$dE_t = w_t * I_t - w_{t-1} * I_{t-1}$$

We can rewrite by adding and subtracting a “cross-term”

$$w_{t-1} * (I_t)$$

as

$$= w_{t-1} * (I_t - I_{t-1}) - w_{t-1} * I_t + w_t * I_t$$

$$= w_{t-1} * (I_t - I_{t-1}) + I_t * (w_t - w_{t-1})$$

$$= I_{t-1} * (w_t - w_{t-1}) + w_t * (I_t - I_{t-1})$$

This allows us to further decompose the change in weight. We can read as

*Constant intensity * change in weight + current weight*change in intensity*

Change in weight:

$$dw_t = \frac{p_t * sh_t}{AUM_t} - \frac{p_{t-1} * sh_{t-1}}{AUM_{t-1}} = sh_t * \frac{p_t}{AUM_t} - sh_{t-1} * \frac{p_{t-1}}{AUM_{t-1}}$$

Change in shares is driven by flow. Prices/shares assumed adjusted for splits etc. above. Relative prices enter indirectly, through the change in price of the asset vs AUM of all holdings

So we can further expand to anchor on change in position vs price by adding/subtracting a “cross-term”.

$sh_{t-1} * (\frac{p_t}{AUM_t})$

as

$$sh_t * \frac{p_t}{AUM_t} - sh_{t-1} * \frac{p_{t-1}}{AUM_{t-1}} =$$

$$\frac{p_t}{AUM_t} * (sh_t - sh_{t-1}) + sh_{t-1} * (\frac{p_t}{AUM_t} - \frac{p_{t-1}}{AUM_{t-1}})$$

Current value of the change in position + effect of change in price on initial position

We can then swap back into

$$dE_t = I_{t-1} * (w_t - w_{t-1}) + w_t * (I_t - I_{t-1})$$

As

$$dE_t = I_{t-1} * \left(\frac{p_t}{AUM_t} * (sh_t - sh_{t-1}) + sh_{t-1} * \left(\frac{p_t}{AUM_t} - \frac{p_{t-1}}{AUM_{t-1}} \right) \right) + w_t * (I_t - I_{t-1})$$

=

$$\left(I_{t-1} * \frac{p_t}{AUM_t} * (sh_t - sh_{t-1}) \; + I_{t-1} * sh_{t-1} * \left(\frac{p_t}{AUM_t} - \frac{p_{t-1}}{AUM_{t-1}} \right) \right) + w_t * (I_t - I_{t-1})$$

Which we can read the components of as:

Flow impact, constant intensity, current prices +

Return impact, constant intensity, constant position +

Intensity change impact, current allocation