UN environment programme | finance initiative

PRI Principles for Responsible Investment

UN-convened Net-Zero Asset Owner Alliance

Understanding the Drivers of Investment Portfolio Decarbonisation

A discussion paper on emissions attribution analysis for net-zero investment portfolios

December 2023

Antitrust and regulatory disclaimer

The Net-Zero Asset Owner Alliance (the Alliance) and its members are committed to comply with all laws and regulations that apply to them. This includes, amongst others, antitrust and other regulatory laws and regulations and the restrictions on information exchange and other collaborative engagement they impose.

For the avoidance of doubt, the content set out within this paper do not constitute advice to members of the Alliance. This paper is not prescriptive as to actions or decisions to be taken by members—the Alliance's members set individual targets and make their own unilateral decisions. As such, the Alliance takes no liability for actions or decisions taken by members when applying the principles of this paper.

Contents

Introduction

Members of the UN-convened Net-Zero Asset Owner Alliance (the Alliance), managing more than USD 9.5 trillion, have committed to individually transition their respective investment portfolios to net zero greenhouse gas emissions by 2050. The members' individual commitments include setting intermediate targets every five years, in line with Article 4.9 of the Paris Agreement schedule and reporting regularly on progress.[1] Alliance members were the first in the finance industry to set intermediate sub-portfolio decarbonisation targets with the reduction ranges consistent with a maximum temperature rise of 1.5°C above pre-industrial levels (22%–32% by 2025 and 40%–60% by 2030). These ranges were defined in the Alliance's Target-Setting Protocol;[2] they are based on the best available scientific knowledge and in particular the pathways put forth by the Intergovernmental Panel on Climate Change (IPCC).[3] According to the Alliance's protocol, these targets can be set on absolute or intensity-based KPIs.

As pension funds and insurance companies, asset owners represent long-term global investors that have a unique role to play in capital allocation towards a low-carbon transition. Alliance members are individually committed to decarbonising their investment portfolios and financing the transition through: capital allocation strategies; engagement with relevant stakeholders; and field building,[4] which refers to contributing to public discourse and pushing for high quality reporting standards. The Alliance believes a combination of these strategies is most effective.

However, measuring the impact of these strategies on real-economy decarbonisation is not always straightforward; in fact, it is particularly challenging to measure the decarbonisation impact of engagement and field building activities. Still, the impact of capital allocation strategies on investment portfolio decarbonisation can be measured and disaggregated.

1 UN-convened Net-Zero Asset Owner Alliance [NZAOA] (2022). *Commitment Document for Participating Asset Owners*. unepfi.org/wordpress/wp-content/uploads/2022/07/AOA-COMMITMENT-DOC-2022.pdf.

2 NZAOA (2023). *Target-Setting Protocol Third Edition*. unepfi.org/industries/target-setting-protocol-third-edition/.

3 Intergovernmental Panel on Climate Change [IPCC] (2022). *Sixth Assessment Report*. ipcc.ch/report/sixth-assessment-report-cycle.

4 Marti, M., Fuchs, M., DesJardine, M. R., Slager, R., Gond, J-P. (2023). The Impact of Sustainable Investing: A Multidisciplinary Review. *Journal of Management Studies*. warwick.ac.uk/fac/soc/wbs/research/ikon/research/climate-finance/blog/j_management_studies_-_2023_-_marti_-_the_impact_of_sustainable_investing_a_multidisciplinary_review.pdf.

Within capital allocation strategies for the purpose of decarbonisation, the following sub-strategies can be defined:

1. **Strategic asset class re-allocation:** for example, shifting towards renewables while concurrently reducing unsustainable exposure in another asset class.
2. **Sector re-allocation within one asset class:** some sectors are more carbon intensive than others; thus, an asset owner could optimise long-term capital allocation by considering transition financing or by increasing holdings in low-carbon sectors, while simultaneously decreasing exposure to high-emitting sectors.
3. **Best in class strategy:** includes, for example, overweighting industry leaders in high-emitting sectors (such as steel or cement) that demonstrate superior climate performance (both current and forward-looking) while underweighting climate laggards.

Investments in climate solutions is not a separate, but rather an overarching strategy that connects the aforementioned ones with a focus on "green" and enabling investments—deploying capital in low-carbon solutions (e.g., renewables, grid infrastructure, and battery manufacturing facilities) or increasing climate related revenue shares (e.g., EU Taxonomy aligned revenue shares).

The focus of this paper is an analysis of investment portfolio emissions in the context of sector re-allocation and best in class strategies. In the future, once carbon footprint reporting is available for all asset classes, strategic asset class re-allocation could also be covered with the methodology outlined in this paper.

The question, purpose, and approach

A question that arose amidst the Alliance members' internal and external progress reporting (which showed a reduction in members' total financed emissions) was the following: **what are the factors that drive the (absolute or relative) decarbonisation of an investment portfolio?**

Possible factors are:

- **Real world emissions reduction:** derived from the decarbonisation of investees, this is the most favourable driver of decarbonisation, since it marks an actual reduction of greenhouse gases emitted into the atmosphere.
- **Investment portfolio reallocation:** this driver can lead to decarbonisation if asset managers tilt their portfolios towards companies that are reducing their carbon emissions. Asset managers can do so by investing in or overweighting companies that have set and are implementing ambitious net-zero targets. Asset managers can also divest from or underweight companies that are not taking action against climate change.
- **Changes in coverage:** this driver relates to the increase or decrease in data coverage between the initial and final period.
- **Other external forces:** for example, decarbonisation derived from changes in enterprise value or revenues of investee companies.

The emissions attribution analysis looks at past emissions and investment decisions. Nevertheless, as this tool informs portfolio steering, it can also incentivise investment managers to allocate capital to companies with most ambitious transition plans and thus reduce emissions in the investment portfolio in the future.

Therefore, emissions attribution analysis can be used for various purposes, including the ones listed below.

- **Enhanced understanding:** it helps a financial institution's management as well as investment managers better understand what leads to a lower portfolio carbon footprint and opens a possibility to act based on this information.
- **Assessment and dialogue:** it informs dialogue with asset managers to assess and, where appropriate, challenge their decarbonisation performance.
- **Engagement insights:** it provides input for engagement dialogues with corporates by comparing decarbonisation efforts of peers within a given sector.
- **Transparency for public reporting:** it informs the wider public on progress and drivers of decarbonisation on a total level or, more granularly, on a sector or country level.

- **Increased data quality:** it helps to detect data quality issues as it provides a deep dive into the constituent parts of the calculation.

Recognising these various purposes, the Alliance established a working group in 2023 with the goal of exchanging technical knowledge and practitioners' experience on emissions attribution analysis. Alliance members shared and discussed their respective methodologies, outputs, and challenges. The working group created a simple model portfolio, which helped to better understand and assess the various methodologies. In addition, MSCI[5] and LSEG[6] provided valuable insights, proposals, and tangible applications by submitting presentations, papers, and Excel spreadsheets with concrete examples of emissions attribution analysis. Comparing the results of the different methodologies enabled a better understanding of various options and discussions on rationale.

The work of this endeavour is presented in this paper to discuss the different methodologies and their rationales; and explain the boundaries of the currently available emissions attribution analysis.

As such, this paper is directed toward investors who manage investment portfolios with a net-zero commitment. The foremost purpose of this paper is to guide and encourage investors to establish their own emissions attribution analyses and to share knowledge on how to do so among financial institutions. This exploration constitutes one approach; however, other attribution approaches may work just as well.

In addition, the Alliance notes that the SBTi proposes emissions attribution analysis as a key element for emissions reporting in its latest consultation draft, the SBTi Financial Institutions Net-Zero Standard.[7]

5 MSCI (2023). *A Framework for Attributing Changes in Portfolio Carbon Footprint*. msci.com/www/research-report/a-framework-for-attributing/03802978549.

6 FTSE Russell (2022). *Decarbonisation in equity benchmarks: Smoke still rising.* ftserussell.com/research/decarbonization-equity-benchmarks-smoke-still-rising.

7 SBTi (2023). The SBTi Financial Institutions Net-Zero Standard. Consultation Draft, p.65. sciencebasedtargets.org/resources/files/The-SBTi-Financial-Institutions-Net-Zero-Standard-Consultation-Draft.pdf

Methodologies and an output example

Alliance members, and all investors, can set decarbonisation targets based on absolute financed emissions or financed emissions intensity targets by EVIC or by revenues. The Alliance recommends reporting both absolute and intensity-based emissions but requires absolute (for Alliance-level aggregation purposes). The advantages and disadvantages of the different methodologies are discussed in the Alliance's Inaugural Target-Setting Protocol;[8] Table 1 below also provides an overview. Different target setting and respective KPIs require different methodologies of emissions attribution analysis. (see Appendix I). In the Appendix I, the NZAOA Emissions Attribution Working Group presents two mathematical frameworks for emissions attribution analysis: the "consensus approach" and the "simplified approach".

Table 1: Comparison of advantages and disadvantages of financed absolute and intensity emissions

Absolute financed emissions	Carbon intensity
Pros: ▪ Easily understandable and well-known across the investment industry; ▪ The metric can be used on a number of asset classes, including real estate, by using the asset value as the denominator; ▪ Linked to the total absolute global carbon emission budget available in a 1.5°C scenario.	**Pros:** ▪ As emissions data coverage improves and new asset classes are added, an intensity metric becomes more stable and better accommodates baseline adjustments. ▪ The metric can be used on a number of asset classes, including real estate assets. If a member selects a combined target, this metric can still be created by using the asset value or revenues as the denominator. ▪ This metric can be used to compare the emission intensity level of different asset classes, portfolios or even members. It is also a useful metric to select the best performers within the same sector to rebalance a portfolio towards a low-carbon tilt. ▪ A quantitative analysis on variation factors can be performed on this metric.

8 NZAOA (2021). *Inaugural 2025 Target-Setting Protocol*. 35. unepfi.org/publications/inaugural-2025-target-setting-protocol/.

Cons:	Cons:
▪ Portfolio growth can outpace the reduction in carbon emissions. ▪ Adjustments for M&A under unusual portfolio growth rates are necessary. ▪ Make it difficult to compare portfolios to each other or to a benchmark.	▪ Allows for the reduction/increase in emissions to be driven by volatility in the economic metric selected as the denominator. ▪ Total emissions can still increase even if the used carbon intensity measure decreases. ▪ Revenues in high-emitting sectors are often directly linked to volatile commodity prices (e.g., oil, gas, and coal) making this metric unstable.

The calculation of emissions attribution is similar to the calculation of performance attribution. For both, one breaks down the overall change in a metric (emissions or performance) into its constituents, explaining allocation and selection effects. For a performance analysis, a market benchmark is usually used. For emissions attribution, it is the initial portfolio that takes the role of a benchmark in most cases. The emissions attribution analysis then usually includes at least one more level of analysis—breaking down the constituents' emissions intensity or attribution factor into its components of the numerator and denominator (see Figure 1).

Table 2: Driving factors of emissions changes in investment portfolios

Factors driving investment portfolio emissions changes	
Absolute Financed Emissions	**Financed Carbon Intensity**
Changes in exposure	Changes in weights
Changes in carbon emissions	Changes in carbon emissions
Changes in EVIC	Changes in EVIC/revenue
Changes in coverage	Changes in coverage
New investments (which may be a subset of allocation)	New investments (which may be a subset of allocation)
Divested investments (which may be a subset of allocation)	Divested investment (which may be a subset of allocation)
Interaction attribution factors (in instances where it is directly calculated)	Interaction attribution factors (in instances where it is directly calculated)

Factors that are driving changes of investment portfolios emissions are introduced in Table 2.

Analysing the main factors two approaches have been discussed:

1. **Partial equilibrium approach:** this approach considers the impact of a single variable on the overall carbon metric while holding all other variables constant. This approach is intuitive and relatively simple to implement, but it does not account for interaction terms (see Appendix III). In addition, since it is a "one-layer" calculation and does not report investees' carbon intensity nor the attribution factor, the results cannot easily be used to inform neither engagement dialogues nor dialogues with investment managers and asset managers.

2. **Three-layer approach:** this approach splits the calculation into layers and therefore supports a better understanding of decarbonisation drivers. It takes into account the interaction terms by explicitly computing them or by incorporating them with other variables. This approach is more complex than the partial equilibrium approach, but it provides a more accurate depiction of the impact of changes in exposure, emissions, and EVIC. Therefore, it is the more appropriate approach for informing stakeholder dialogues. Two possible sequences for this approach are graphically represented in Figure 1.

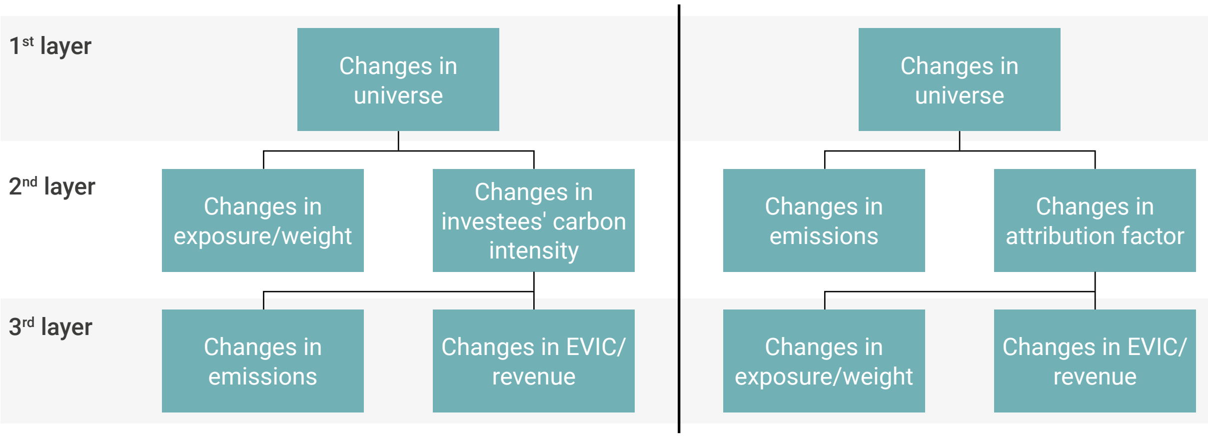

Figure 1: How two possible three-layer approaches consider allocation effects and emissions changes/real world impact

Both three-layer approaches are valid and are selected based on the desired focus, which can be placed on allocation effects or on emissions changes and real-world impact. The model and calculation sequence will align with organisational structures and decision-making processes, akin to a performance attribution analysis. While the sequencing of layers may lead to slight variations in results, the core messages will remain consistent.

An example output

The Examples 1 and 2 presented in Figure 2 demonstrate that the same carbon intensity reduction may have been achieved through different combinations of the impacts of underlying drivers.

In the illustrative Example 1, changes in weight/allocation, divestments and carbon emissions have significant negative impacts on the change in carbon intensity, counterbalancing the opposing effects of the changes in data coverage, new investments, and the changes in EVIC.

In contrast, the illustrative Example 2 exhibits a lower negative contribution from changes in weight/allocation, divestments and carbon emissions, a lower positive contribution from new investments, and a shift from a positive to a negative impact of the changes in EVIC.

Thus, the first example demonstrates higher impacts from single portfolio activities; it also shows in total a slightly lower contribution from the investees to the carbon intensity reduction. The investees' carbon emissions reduction of 6%-p is partially compensated by a positive EVIC change of 3%-p, thus the investee's contribution to the carbon intensity reduction results in -3%-p. In Example 2 the contribution of investees is slightly higher, as the sum of investees' contribution is -4%-p (-3%-p from emissions change and -1% from EVIC change).

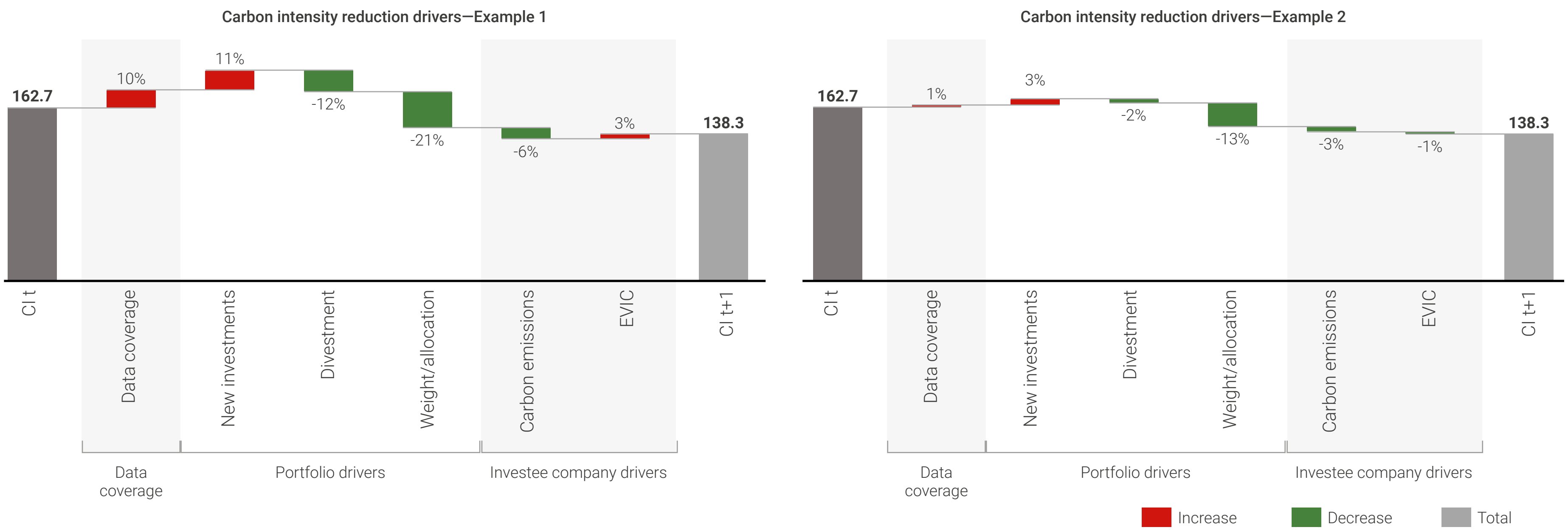

Figure 2: Carbon intensity reduction drivers—illustrative examples

Discussion

Impacts of divestment/new investment programs on carbon footprint are important to report. However, carbon footprints can be calculated at different levels (single mandate, entity, or group) within the same institution. Therefore, the interpretation of the calculation may change from one level to the other. For example, divestments and new investments at a mandate level may occur in form of a reallocation of assets within a higher portfolio hierarchy (e.g., on asset class or entity level). Additionally, maturing bonds could be interpreted as a change in allocation rather than active divestment. Therefore, in terms of allocation effects, an explicit split between divestments and new investments may not always be accurate or meaningful.

Introducing various levels of analysis clearly separates the factors and enables a sequenced analysis.

The **impact of the change in data coverage** is relevant for interpreting financed emissions changes. The working group extensively discussed two approaches dealing with data quality issues and missing data (see Appendix II). The Alliance recommends separating these technical issues from the factors of main interest, not to dilute the main factors based on reported data. The first approach involves estimating missing data, typically based on sector averages. The second approach entails excluding companies with missing data from the calculation, leading to a reduction in coverage. Both approaches have their merits, but the Alliance observed significant differences in the computation of financed emissions when comparing the two methodologies applied to the model portfolio. Specifically, the exclusion of companies with incomplete data coverage could result in the underrepresentation of the actual amount of financed emissions. Consequently, the Alliance emphasises the need for improved data quality and encourages collaboration among all stakeholders—including companies in the real economy, investors, and data providers—to address this issue.

It is recommended to **actively calculate interaction effects** (see Appendix III). A calculation based on residuals may hide potential computational mistakes that should be further analysed.

The dynamic base year analysis can support conversations with asset managers or other stakeholders, depending on circumstances (e.g., change of market benchmark, change of asset manager or change of strategy).

The Alliance discussed conducting an analysis that, in addition to a comparison to the initial portfolio, compares to a **market benchmark**. While it would indeed be interesting to explore whether an asset owner's investment portfolio is decarbonising faster than a market benchmark (and what the drivers are compared to the market), this analysis would not explain the decarbonisation success in line with the Alliance's approach to target setting. This is because the Alliance's target setting asks for decarbonisation of an actual investment portfolio and not relative to a market benchmark (which may not decarbonise in line with expectations or at all).

Institutional investors usually set **multi-year decarbonisation targets.** Depending on turnover of an investment portfolio, the allocation driver will increase when running the models over multiple years. Therefore, we recommend that asset owners conduct both a multi-year analysis as well as an analysis where the data is split into annual tranches and then aggregated into a multi-year result.

The analysis could be enhanced through a **ranking approach**, whereby drivers (e.g., aforementioned factors, sectors, and single constituents) are ranked for the final reporting.

Different calculations were applied to a simple model portfolio. An encouraging finding was that, **independent of the methodology used, the impact of the main drivers remained consistent overall—deviations of various methodologies were within acceptable ranges and were not relevant in the context of decision making or general interpretation of the results.** The difference in results is most likely a product of difference in data handling, data quality, and coverage.

The “consensus approach” and boundaries

The Alliance’s working group has analysed and discussed various calculations and decided on a “consensus approach” as a reference model (see formulae and details in Appendix I). This approach is not an explicit recommendation (as other calculations may be equally valid) but is rather seen as one possible favourable approach.

The emissions attribution models proposed in the Appendix I for financed absolute emissions and for financed carbon intensity follow the left approach described in Figure 1.

A simplification of the model could be achieved by aggregating new investments, divested investments, and changes in exposure or weight into one single factor.

Boundaries

The object of analysis in this paper are the following asset classes: (listed) corporates, bonds and equity. For other asset classes and non-listed corporates, data availability and data quality are even a higher challenge. Moreover, the carbon footprint methodology for other asset classes—especially for sovereign debt and real estate—apply different attribution factors and, therefore, cannot easily be combined with an emissions reduction analysis of a corporate portfolio.

The attribution analysis can be extended to sector or country level attributions, similar to a performance attribution analysis.

Asset owners invested in fund structures without look-through will not be able to run an emissions attribution analysis as they do not have access to the data on constituent level. In this case, asset owners should request the respective analysis from their asset managers, so as to be able to discuss it in the review meetings.

Allocations can be affected by foreign exchange rates and other price fluctuations, typically addressed within conventional financial performance attribution analysis. Yet, within the domain of carbon performance attribution, the most pivotal factors pertain to the tangible reduction of greenhouse gas emissions, the reallocation of the investment portfolio, and external influences like shifts in investee companies’ EVIC or revenues, as well as fluctuations in data coverage. While considerations such as prices and exchange rates may have an impact on allocation, they are not the central focus. The primary objective is to highlight the key drivers of emissions attribution analysis.

Conclusion

Emissions attribution analysis is a useful tool in understanding investment portfolio decarbonisation targets and in interpreting the progress towards those targets. This added transparency can help managers discern the factors affecting portfolio carbon changes, thereby leading to a better comprehension of decarbonisation developments. Knowing the impact of these factors helps to ascertain the magnitude of real-world emissions reduction as well as the effects of portfolio allocations. Ultimately, identifying the main decarbonisation drivers supports conversations with the responsible asset and investment managers, who support achievement of decarbonisation targets.

The Alliance concludes that it is not of the highest relevance which model is ultimately applied since the observed differences in the final results are in a range that would not affect general interpretation or decision making. **However, it is of the highest relevance that net-zero investment teams start to incorporate emissions attribution analysis since it can support achievement of the ultimate climate goals and provide needed transparency**. Thus, the Alliance encourages every asset owner and asset manager with a net-zero commitment to endeavour to run its own emissions attribution analysis.

Appendix I: Formulae for the consensus approach and the simplified approach

In this appendix, the NZAOA Emissions Attribution Working Group presents two mathematical frameworks for emissions attribution analysis: the "consensus approach" and the "simplified approach".

The consensus approach, as described in the main body of the paper, aligns with the commonly employed practices that emerged during the comparison and discussion of models created by the participants in the Alliance's working group.

The simplified approach maintains the same overall structure of the consensus approach but offers a streamlined version by avoiding the use of averages in metric computations. This could make it a more efficient approach in cases where data are not available and sector averages are used instead.

It is important to note that neither the consensus approach nor the simplified approach should be seen as recommendations. The Alliance maintains that other mathematical frameworks may be equally valid.

Definitions of the variables

Notation	Term
I_i^t	Current value of investment in issuer i at time t
w_i^t	Portfolio weight of the investment in issuer i at time t referring to the overall portfolio of the entities included in the computation of the carbon metric. $w_i^t = \frac{I_i^t}{\sum_i I_i^t}$
C_i^t	Carbon emissions Scope 1 and 2 of issuer i at time t
$EVIC_i^t$	Enterprise Value Including Cash of issuer i at time t
R_i^t	Annual revenues of issuer i at time t
$Held_i$	Dummy variable that takes the value of 1 if the issuer i is present in the portfolio with available data at both time t and the subsequent period t+1. Otherwise, it takes the value of 0.

Div_i	Dummy variable that takes the value of 1 when both of the following conditions are met: 1) at time t, the issuer i is present in the portfolio and data is available; and 2) the issuer is divested in the subsequent period t+1. If any of these conditions are not met, Div_i is assigned a value of 0.
$NewI_i$	Dummy variable that takes the value of 1 when both of the following conditions are met: 1) at time t+1, the issuer i is present in the portfolio and data is available; and 2) the issuer was not present in the portfolio at time t. If any of these conditions are not met, $NewI_i$ is assigned a value of 0.
Cov_i	Dummy variable that takes the value of 1 when there is a change in data availability between period t and period t+1. This occurs when the issuer i is present in the portfolio at both time t and the subsequent period t+1 and one of the following conditions is verified: 1) data is available at time t but unavailable at time t+1, or 2) data is unavailable at time t but available at time t+1. Otherwise, it takes the value of 0.
FE^t	$Financed\ emissions^t = \sum_{i=1}^{n} \left(I_i^i * \frac{C_i^t}{EVIC_i^t} \right)$
EI^t	$Carbon\ intensity\ by\ EVIC^t = \frac{\sum_{i=1}^{n} \left(I_i^t * \frac{C_i^t}{EVIC_i^t} \right)}{\sum_{i=1}^{n} I_i^t}$
REI^t	$Carbon\ intensity\ by\ revenues^t = \frac{\sum_{i=1}^{n} \left(I_i^t * \frac{C_i^t}{R_i^t} \right)}{\sum_{i=1}^{n} I_i^t}$

Formulae for the consensus approach

Financed emissions: formulae for the attribution of the change in financed emissions of an issuer

$$\text{Change in financed emissions for issuer i} = \mathrm{I}_{\mathrm{i}}^{\mathrm{t+1}} * \frac{C_i^{t+1}}{EVIC_i^{t+1}} - I_i^t * \frac{C_i^t}{EVIC_i^t}$$

The model decomposes the overall change in financed emissions for issuer i into six (or five) drivers:

1. Changes in data coverage: This includes changes in the availability of data on emissions and EVIC. **This driver can be eliminated if sector averages are used to fill in missing data, as described in Appendix II.**
2. New investments: This includes investments in companies that were not previously in the portfolio (it may be modelled as a subset of changes in exposure).
3. Divested investments: This includes investments that were sold or otherwise disposed of (it may be modelled as a subset of changes in exposure).
4. Changes in exposure: This includes changes in the number of companies in the portfolio, as well as changes in the amount of money invested in each company.

5. Changes in carbon intensity which can be further split into:

5.1 Changes in carbon emissions: This includes changes in the total amount of emissions generated by the companies.

5.2 Changes in EVIC: This is a measure of the change of the enterprise value including cash of the companies in the portfolio.

$$Changes\ in\ data\ coverage = \sum_{i=1}^{n} Cov_i * \left(I_i^{t+1} * \frac{C_i^{t+1}}{EVIC_i^{t+1}} - I_t^i * \frac{C_i^t}{EVIC_i^t} \right)$$

Readers should note that when the ratio between emissions and EVIC cannot be computed due to data limitations, it is assumed to be zero.

$$New\ investments = \sum_{i=1}^{n} NewI_i * I_i^{t+1} * \frac{C_i^{t+1}}{EVIC_i^{t+1}}$$

$$Divested\ investments = \sum_{i=1}^{n} -Div_i * I_i^t * \frac{C_i^t}{EVIC_i^t}$$

$$Changes\ in\ exposure = \sum_{i=1}^{n} Held_i * \frac{C_i^t}{EVIC_i^t} * \left(I_i^{t+1} - I_i^t\right)$$

$$Changes\ in\ carbon\ intensity = \sum_{i=1}^{n} Held_i * I_i^{t+1} * \left(\frac{C_i^{t+1}}{EVIC_i^{t+1}} - \frac{C_i^t}{EVIC_i^t} \right)$$

$$Changes\ in\ carbon\ emissions = \sum_{i=1}^{n} Held_i * I_i^{t+1} * \frac{\frac{1}{EVIC_i^t} + \frac{1}{EVIC_i^{t+1}}}{2} * \left(C_i^{t+1} - C_i^t\right)$$

$$Changes\ in\ EVIC = \sum_{i=1}^{n} Held_i * I_i^{t+1} * \frac{C_i^t + C_i^{t+1}}{2} * \left(\frac{1}{EVIC_i^{t+1}} - \frac{1}{EVIC_i^t} \right)$$

The formula used to assess the impact of changes in exposure on the metric multiplies the change in the amount invested in issuer i is based on the initial value of the carbon intensity. This is because it is assumed that the portfolio manager is aware of the carbon intensity of the issuer at the beginning of the period and manages accordingly. Carbon intensity is a metric that supports comparison across and within sectors or countries. The Alliance's working group decided to start the attribution with the impact of exposure change as this is what is actively managed. Cross comparisons of carbon intensities can be easily analysed.

Appendix III contains a step-by-step explanation of the recursive approach followed to segment the change in financed emissions into changes in exposure, changes in carbon emissions, and changes in EVIC.

To assess the impact of changes in carbon emissions on the metric, the change in carbon emissions for issuer i is multiplied by the average value of its EVIC between the initial and final period.

This approach distributes equally the interaction terms between changes in emissions and changes in EVIC between the two factors. This balancing prevents the assessment of changes in carbon emissions from being disproportionately affected by a significant change in EVIC between the initial and final periods.

The formula used to evaluate changes in EVIC reflects these same considerations symmetrically.

Carbon intensity by EVIC: formulae for the attribution of the change in carbon intensity by EVIC of an issuer

$$Change\ in\ carbon\ intensity\ by\ EVIC\ for\ issuer\ i = w_i^{t+1} * \frac{C_i^{t+1}}{EVIC_i^{t+1}} - w_i^t * \frac{C_i^t}{EVIC_i^t}$$

The model decomposes the overall change in carbon intensity by EVIC for issuer i into six (or five) drivers:

1. Changes in data coverage: This includes changes in the availability of data on emissions and EVIC. **This driver can be eliminated if sector averages are used to fill in missing data, as described in Appendix II.**
2. New investments: This includes investments in companies that were not previously in the portfolio (it may be modelled as a subset of changes in weight/allocation).
3. Divested investments: This includes investments that were sold or otherwise disposed of (it may be modelled as a subset of changes in weight/allocation).
4. Changes in weight/allocation: This includes changes in the amount of money invested in each company expressed as a percentage of the overall portfolio of the entities included in the computation of the carbon metric.
5. Changes in carbon intensity which can be further split into:
   - **5.1** Changes in carbon emissions: This includes changes in the total amount of emissions generated by the companies.
   - **5.2** Changes in EVIC: This is a measure of the change of the enterprise value including cash of the companies in the portfolio.

$$Changes\ in\ data\ coverage = \sum_{i=1}^{n} Cov_i * \left(w_i^{t+1} * \left(\frac{C_i^{t+1}}{EVIC_i^{t+1}} - EI^t \right) - w_i^t * \left(\frac{C_i^t}{EVIC_i^t} - EI^t \right) \right)$$

Readers should note that when the ratio between emissions and EVIC cannot be computed due to data limitations, it is assumed to be zero.

$$New\ investments = \sum_{i=1}^{n} NewI_i * w_i^{t+1} * \left(\frac{C_i^{t+1}}{EVIC_i^{t+1}} - EI^t \right)$$

$$Divested\ investments = \sum_{i=1}^{n} -Div_i * w_i^t * \left(\frac{C_i^t}{EVIC_i^t} - EI^t \right)$$

$$Changes\ in\ weight - allocation = \sum_{i=1}^{n} Held_i * \left(\frac{C_i^t}{EVIC_i^t} - EI^t \right) * \left(w_i^{t+1} - w_i^t \right)$$

The rationale behind subtracting the average initial intensity—EI^t—of the portfolio from the intensity of individual companies is to enhance the interpretability and economic relevance of the drivers.

This ensures that the contribution of a new investment is positive only if it adds a position with above-average intensity. Similarly, a divestment has a positive contribution only if it removes a position with below-average intensity, and vice versa.

It is important to note that since both weight vectors w^t and w^{t+1} sum to 100%, the term EI^t cancels out when summing the first four drivers. This occurs because the term EI^t is multiplied by the sum of the weight differences for each company, resulting in a total of zero. Thus, from a computational standpoint, the formulae would hold even without considering the term EI^t. However, including it allows for a more meaningful interpretation. Specifically, without the term EI^t, the contribution from new investments would always be positive or zero, and the contribution from divested investments would always be negative or zero.

For financed emissions, the drivers are computed in absolute terms rather than relative to the initial value. This approach aligns with the economic assumption that a new investment will invariably lead to an increase in financed emissions, and a divestment will result in a decrease.

$$Changes\ in\ carbon\ intensity = \sum_{i=1}^{n} Held_i * w_i^{t+1} * \left(\frac{C_i^{t+1}}{EVIC_i^{t+1}} - \frac{C_i^t}{EVIC_i^t}\right)$$

$$Changes\ in\ carbon\ emissions = \sum_{i=1}^{n} Held_i * w_i^{t+1} * \frac{\frac{1}{EVIC_i^t} + \frac{1}{EVIC_i^{t+1}}}{2} * \left(C_i^{t+1} - C_i^t\right)$$

$$Changes\ in\ EVIC = \sum_{i=1}^{n} Held_i * w_i^{t+1} * \frac{C_i^t + C_i^{t+1}}{2} * \left(\frac{1}{EVIC_i^{t+1}} - \frac{1}{EVIC_i^t}\right)$$

In a manner similar to the financed emissions model, the formula employed to assess the impact of the changes in weight/allocation on the metric involves multiplying the change in issuer i's portfolio weight by the initial carbon intensity. This is because it is assumed that the portfolio manager is aware of the carbon footprint of the issuer at the beginning of the period and manages accordingly.

To assess the impact of the changes in carbon emissions on the metric, the change in carbon emissions for issuer i is multiplied by the average value of its EVIC between the initial and final period.

As outlined in Appendix III, this approach distributes equally the interaction terms between changes in emissions and changes in EVIC between the two factors. This balancing prevents the assessment of changes in carbon emissions from being disproportionately affected by a significant change in EVIC between the initial and final periods.

The formula used to evaluate the changes in EVIC reflects these same considerations symmetrically.

Carbon intensity by revenues: formulae for the attribution of the change in carbon intensity by revenues of an issuer

$$Change\ in\ carbon\ intensity\ by\ revenues\ for\ issuer\ i = w_i^{t+1} * \frac{C_i^{t+1}}{R_i^{t+1}} - w_i^t * \frac{C_i^t}{R_i^t}$$

The model decomposes the overall change in carbon intensity by revenues for issuer i into six (or five) drivers:

1. Changes in data coverage: This includes changes in the availability of data on emissions and revenues. **This driver can be eliminated if sector averages are used to fill in missing data, as described in Appendix II.**
2. New investments: This includes investments in companies that were not previously in the portfolio (it may be modelled as a subset of changes in weight/allocation)
3. Divested investments: This includes investments that were sold or otherwise disposed of (it may be modelled as a subset of changes in weight/allocation).
4. Changes in weight/allocation: This includes changes in the amount of money invested in each company expressed as a percentage of the overall portfolio of the entities included in the computation of the carbon metric.
5. Changes in carbon intensity by revenues which can be further split into:
   5.1 Changes in carbon emissions: This includes changes in the total amount of emissions generated by the companies.
   5.2 Changes in revenues: This is a measure of the change of the revenues of the companies in the portfolio.

$$Changes\ in\ data\ coverage = \sum_{i=1}^{n} Cov_i * \left(w_i^{t+1} * \left(\frac{C_i^{t+1}}{R_i^{t+1}} - REI^t \right) - w_i^t * \left(\frac{C_i^t}{R_i^t} - REI^t \right) \right)$$

Readers should note that when the ratio between emissions and revenues cannot be computed due to data limitations, it is assumed to be zero.

$$New\ investments = \sum_{i=1}^{n} NewI_i * w_i^{t+1} * \left(\frac{C_i^{t+1}}{R_i^{t+1}} - REI^t \right)$$

$$Divested\ investments = \sum_{i=1}^{n} -Div_i * w_i^t * \left(\frac{C_i^t}{R_i^t} - REI^t \right)$$

$$Changes\ in\ weight - allocation = \sum_{i=1}^{n} Held_i * \left(\frac{C_i^t}{R_i^t} - REI^t \right) * \left(w_i^{t+1} - w_i^t \right)$$

$$Changes\ in\ carbon\ intensity\ by\ revenues = \sum_{i=1}^{n} Held_i * w_i^{t+1} * \left(\frac{C_i^{t+1}}{R_i^{t+1}} - \frac{C_i^t}{R_i^t} \right)$$

$$Changes\ in\ carbon\ emissions = \sum_{i=1}^{n} Held_i * w_i^{t+1} * \frac{\frac{1}{R_i^t} + \frac{1}{R_i^{t+1}}}{2} * \left(C_i^{t+1} - C_i^t \right)$$

$$Changes\ in\ revenues = \sum_{i=1}^{n} Held_i * w_i^{t+1} * \frac{C_i^t + C_i^{t+1}}{2} * \left(\frac{1}{R_i^{t+1}} - \frac{1}{R_i^t} \right)$$

Formulae for the simplified approach

Financed emission: formulae for the attribution of the change in financed emissions of an issuer

$$Change\ in\ financed\ emissions\ for\ issuer\ i = I_i^{t+1} * \frac{C_i^{t+1}}{EVIC_i^{t+1}} - I_i^t * \frac{C_i^t}{EVIC_i^t}$$

The model decomposes the overall change in financed emissions for issuer I into the following drivers:

$$Changes\ in\ data\ coverage = \sum_{i=1}^{n} Cov_i * \left(I_i^{t+1} * \frac{C_i^{t+1}}{EVIC_i^{t+1}} - I_t^i * \frac{C_i^t}{EVIC_i^t} \right)$$

Readers should note that the ratio between emissions and EVIC cannot be computed due to data limitations, it is assumed to be zero.

$$New\ investments = \sum_{i=1}^{n} NewI_i * I_i^{t+1} * \frac{C_i^{t+1}}{EVIC_i^{t+1}}$$

$$Divested\ investments = \sum_{i=1}^{n} -Div_i * I_i^t * \frac{C_i^t}{EVIC_i^t}$$

$$Changes\ in\ exposure = \sum_{i=1}^{n} Held_i * \frac{C_i^t}{EVIC_i^t} * (I_i^{t+1} - I_i^t)$$

$$Changes\ in\ carbon\ intensity = \sum_{i=1}^{n} Held_i * I_i^{t+1} * \left(\frac{C_i^{t+1}}{EVIC_i^{t+1}} - \frac{C_i^t}{EVIC_i^t} \right)$$

$$Changes\ in\ carbon\ emissions = \sum_{i=1}^{n} Held_i * \frac{I_i^{t+1}}{EVIC_i^t} * (C_i^{t+1} - C_i^t)$$

$$Changes\ in\ EVIC = \sum_{i=1}^{n} Held_i * I_t^{t+1} * C_i^{t+1} * \left(\frac{1}{EVIC_i^{t+1}} - \frac{1}{EVIC_i^t} \right)$$

The simplified approach avoids using averages of EVIC and carbon emissions to determine the effects of changes in carbon emissions and EVIC. Instead, it uses a sequential process, which is described in the final section of Appendix III. This could make the "simplified approach" more efficient, especially in cases where data are not available and sector averages must be used instead.

Carbon intensity by EVIC: formulae for the attribution of the change in carbon intensity by EVIC of an issuer

The model decomposes the overall change in carbon intensity by EVIC for issuer i:

$$Change\ in\ carbon\ intensity\ by\ EVIC\ for\ issuer\ i = w_i^{t+1} * \frac{C_i^{t+1}}{EVIC_i^{t+1}} - w_i^t * \frac{C_i^t}{EVIC_i^t}$$

into the following drivers:

$$Changes\ in\ data\ coverage = \sum_{i=1}^{n} Cov_i * \left(w_i^{t+1} * \left(\frac{C_i^{t+1}}{EVIC_i^{t+1}} - EI^t \right) - w_i^t * \left(\frac{C_i^t}{EVIC_i^t} - EI^t \right) \right)$$

Note: When the ratio between emissions and EVIC cannot be computed due to data limitations, it is assumed to be zero.

$$New\ investments = \sum_{i=1}^{n} NewI_i * w_i^{t+1} * \left(\frac{C_i^{t+1}}{EVIC_i^{t+1}} - EI^t \right)$$

$$Divested\ investments = \sum_{i=1}^{n} -Div_i * w_i^t * \left(\frac{C_i^t}{EVIC_i^t} - EI^t \right)$$

$$Changes\ in\ weight - allocation = \sum_{i=1}^{n} Held_i * \left(\frac{C_i^t}{EVIC_i^t} - EI^t \right) * \left(w_i^{t+1} - w_i^t \right)$$

$$Changes\ in\ carbon\ intensity = \sum_{i=1}^{n} Held_i * w_i^{t+1} * \left(\frac{C_i^{t+1}}{EVIC_i^{t+1}} - \frac{C_i^t}{EVIC_i^t} \right)$$

$$Changes\ in\ carbon\ emissions = \sum_{i=1}^{n} Held_i * \frac{w_i^{t+1}}{EVIC_i^t} * \left(C_i^{t+1} - C_i^t \right)$$

$$Changes\ in\ EVIC = \sum_{i=1}^{n} Held_i * w_t^{t+1} * C_i^{t+1} * \left(\frac{1}{EVIC_i^{t+1}} - \frac{1}{EVIC_i^t} \right)$$

Carbon intensity by revenues: formulae for the attribution of the change in carbon intensity by revenues of an issuer

$$Change\ in\ carbon\ intensity\ by\ revenues\ for\ issuer\ i = w_i^{t+1} * \frac{C_i^{t+1}}{R_i^{t+1}} - w_i^t * \frac{C_i^t}{R_i^t}$$

The model decomposes the overall change in carbon intensity by revenues for issuer i into the following drivers:

$$Changes\ in\ data\ coverage = \sum_{i=1}^{n} Cov_i * \left(w_i^{t+1} * \left(\frac{C_i^{t+1}}{R_i^{t+1}} - REI^t \right) - w_i^t * \left(\frac{C_i^t}{R_i^t} - REI^t \right) \right)$$

Readers should note that when the ratio between emissions and revenues cannot be computed due to data limitations, it is assumed to be zero.

$$New\ investments = \sum_{i=1}^{n} NewI_i * w_i^{t+1} * \left(\frac{C_i^{t+1}}{R_i^{t+1}} - REI^t\right)$$

$$Divested\ investments = \sum_{i=1}^{n} -Div_i * w_i^t * \left(\frac{C_i^t}{R_i^t} - REI^t\right)$$

$$Changes\ in\ weight - allocation = \sum_{i=1}^{n} Held_i * \left(\frac{C_i^t}{R_i^t} - REI^t\right) * \left(w_i^{t+1} - w_i^t\right)$$

$$Changes\ in\ carbon\ intensity\ by\ revenues = \sum_{i=1}^{n} Held_i * w_i^{t+1} * \left(\frac{C_i^{t+1}}{R_i^{t+1}} - \frac{C_i^t}{R_i^t}\right)$$

$$Changes\ in\ carbon\ emissions = \sum_{i=1}^{n} Held_i * \frac{w_i^{t+1}}{EVIC_i^t} * \left(C_i^{t+1} - C_i^t\right)$$

$$Changes\ in\ revenues = \sum_{i=1}^{n} Held_i * w_t^{t+1} * C_i^{t+1} * \left(\frac{1}{EVIC_i^{t+1}} - \frac{1}{EVIC_i^t}\right)$$

Appendix II: How to deal with data quality issues

The lack of coverage resulting from incomplete, missing, or inaccurate emissions or EVIC data from issuers is a challenge encountered by every investor when conducting an investment portfolio carbon footprint analysis. This can lead to either reduced coverage of the portfolio or the use of estimations when all data sources have been exhausted. When emissions data is unavailable, a sector average calculation can be applied. The steps outlined below can be taken.[9]

1. **Choose the sector classification system:** the Appendix of the Alliance's Target-Setting Protocol considers three sector classification systems: NACE (Statistical Classification of Economic Activities in the European Community), GICS (Global Industry Classification System), and BICS (Bloomberg Industry Classification System). Each system comprises a hierarchy of at least four levels of increasing granularity. For NACE, the levels are: Level 1: Sections, Level 2: Divisions, Level 3: Groups, Level 4: Classes. For GICS: Sector, Industry Group, Industry, Sub-Industry. For BICS: Level 1: Sector, Level 2: Industry Group, Level 3: Industry, Level 4: Sub-Industry.

2. **Assign levels:** allocate the four levels of the selected classification system to the company with missing data. If sector mapping is not available, use judgmental assignment.

3. **Determine the sector average universe:** select all issuers with available reported emissions and EVIC values, along with their relevant sector classifications within a broader universe. This broader universe could be represented by companies already present in the owned portfolio or companies included in a benchmark, or all companies with relevant data provided by a given information provider.

4. **Determine the appropriate level:** establish the minimum number of companies required within the sector average universe to attain statistical significance for the chosen level. Start with the highest level of granularity, such as Level 4 (Classes) in the case of NACE. If the number of identified companies at this level is equal to or exceeds the established minimum, this level will be utilised for calculating the sector average. If the minimum number of companies is not met, proceed to the next higher level of granularity, such as Level 3 (Groups) for NACE, and repeat the process. Continue this progression until a statistically significant sample size is achieved. In the event that even at the broadest level, such as Level 1 (Sections)

9 PCAF (2022). Part A. *The Global GHG Accounting and Reporting Standard for the Financial Industry*. carbonaccountingfinancials.com/standard.

for NACE, the minimum number of companies cannot be met, utilise the average emission intensity of all identified companies in the owned portfolio.

5. **Calculate the sector average carbon intensity:** divide for the pertinent level the sum of emissions by the sum of EVICs of all companies within the sector average universe belonging to that level. Alternative weighting schemes, including equal weights for all companies' carbon intensities, can also be applied.

6. **Compute owned emissions:** determine owned emissions by multiplying the sector average carbon intensity by the company's exposure in the investment portfolio.

The EVIC (market capitalization, preferred stock, non-redeemable, total debt, minority interest) is sourced from the data provider. If not available, a practitioner is advised to check other data providers. If still no EVIC data is available and it is needed for a calculation, the company's market cap or total assets from the balance sheet can be used instead.

These methods address data gaps, but other methods may also be effective. Whichever estimation method is used should be reported transparently.

Appendix III: A note on the interaction terms in the carbon performance metrics

Interaction terms arise when two factors contribute to performance through a non-additive function such as multiplication. For instance, considering two variables A and B, where:

$$A_2 = A_1 + \Delta A$$

$$B_2 = B_1 + \Delta B$$

The change in the product A * B can be decomposed as follows:

$$\Delta(A * B) = A_2 * B_2 - A_1 * B_1 = (A_1 + \Delta A) * (B_1 + \Delta B) - A_1 * B_1 =$$

$$= A_1 * \Delta B + B_1 * \Delta A + \Delta A * \Delta B$$

In this case, the last term $\Delta A * \Delta B$ represents the interaction.

Interaction terms are undesirable because the goal of performance attribution is to identify each factor's independent contribution.

Therefore, in the consensus approach described in Appendix I, the Alliance's working group has aimed to consolidate interaction terms with other performance components that can be attributed to a single factor.

There are three ways in which the consolidation of the interaction term can be implemented; all three are valid methods and the best approach will depend on the specific situation.

Incorporate the interaction with the first term $(A_1 * \Delta B)$

$$\Delta(A * B) = (A_1 * \Delta B + \Delta A * \Delta B) + B_1 * \Delta A = A_2 * \Delta B + B_1 * \Delta A$$

Incorporate the interaction with the second term $(B_1 * \Delta A)$

$$\Delta(A * B) = A_1 * \Delta B + (B_1 * \Delta A + \Delta A * \Delta B) = A_1 * \Delta B + B_2 * \Delta A$$

Split and incorporate the interaction into both the first $(A_1 * \Delta B)$ *and second* $(B_1 * \Delta A)$ *term*

$$\Delta(A * B) = \left(A_1 * \Delta B + \frac{\Delta A * \Delta B}{2}\right) + \left(B_1 * \Delta A + \frac{\Delta A + \Delta B}{2}\right) = \left(A_1 + \frac{\Delta A}{2}\right) * \Delta B + \left(B_1 + \frac{\Delta B}{2}\right) * \Delta A$$

$$= \frac{A_1 + A_2}{2} * \Delta B + \frac{B_1 + B_2}{2} * \Delta A$$

When encountering three factors that should be multiplied, the previously described formulae need to be applied recursively, first to $\Delta(A * B)$ and then to $\Delta(C * D)$ (assuming that: $B = C * D$).

For instance, to derive the formulae employed for the attribution of the change in carbon intensity by EVIC of an issuer, the consensus approach starts from assigning the variables as follows:

$A = w_i^t$; $B = \frac{C_i^t}{EVIC_i^t}$; $C = C_i^t$ and $D = \frac{1}{EVIC_i^t}$.

To isolate the contribution of changes in weight, the consensus approach refers to the relationship:

$$\Delta(A * B) = A_2 * \Delta B + B_1 * \Delta A$$

This results in the following expression:

$$w_i^{t+1} * \left(\frac{C_i^{t+1}}{EVIC_i^{t+1}} - \frac{C_i^t}{EVIC_i^t}\right) + \frac{C_i^t}{EVIC_i^t} * \left(w_i^{t+1} - w_i^t\right)$$

In this equation, the second addendum represents the contribution of changes in weight while the first is the contribution of the change in carbon intensity by EVIC.

The consensus approach further splits the contribution of the change in carbon intensity by EVIC:

$$w_i^{t+1} * \left(\frac{C_i^{t+1}}{EVIC_i^{t+1}} - \frac{C_i^t}{EVIC_i^t}\right)$$

into changes in EVIC and changes in carbon emissions by employing the relationship:

$\Delta(C * D) = \frac{C_1 + C_2}{2} * \Delta D + \frac{D_1 + D_2}{2} * \Delta C$, resulting in:

$$w_i^{t+1} * \left(\frac{C_i^{t+1}}{EVIC_i^{t+1}} - \frac{C_i^t}{EVIC_i^t}\right) =$$

$$= w_i^{t+1} * \frac{C_i^t + C_i^{t+1}}{2} * \left(\frac{1}{EVIC_i^{t+1}} - \frac{1}{EVIC_i^t}\right) + w_i^{t+1} * \frac{\frac{1}{EVIC_i^t} + \frac{1}{EVIC_i^{t+1}}}{2} * \left(C_i^{t+1} - C_i^t\right)$$

In the equation above, the first addendum represents the contribution of the changes in EVIC while the second addendum represents the contribution of the changes in emissions.

To avoid using averages of EVIC and carbon emissions, the simplified approach further splits the contribution of the change in carbon intensity by EVIC:

$$w_i^{t+1} * \left(\frac{C_i^{t+1}}{EVIC_i^{t+1}} - \frac{C_i^t}{EVIC_i^t}\right)$$

into changes in EVIC and changes in carbon emissions by employing instead the relationship:

$\Delta(C * D) = C_2 * \Delta D + D_1 * \Delta C$, resulting in:

$$w_i^{t+1} * C_i^{t+1}\left(\frac{1}{EVIC_i^{t+1}} - \frac{1}{EVIC_i^t}\right) + w_i^{t+1} * \frac{1}{EVIC_i^t} * \left(C_i^{t+1} - C_i^t\right)$$

In the equation above, the first addendum represents the contribution of the changes in EVIC while the second addendum represents the contribution of the changes in emissions.

UN environment programme | finance initiative

PRI Principles for Responsible Investment

UN-convened Net-Zero
Asset Owner Alliance

unepfi.org/net-zero-alliance/