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# Accounting for time when estimating financed greenhouse gas emissions from investment and lending portfolios

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ABSTRACT

Because of legislation and rising public pressure, financial institutions have begun to estimate and publish their financed greenhouse gas emissions. Such emissions are indirect from financial institutions' own greenhouse gas emissions and result from those companies' financial institutions invest in or lend capital to. The current convention to allocate indirect carbon emissions of investments and loans does not reflect the duration of such loans or investment holdings, nor the variability of carbon emissions from the underlying investments. Instead, the convention is to use an outstanding loan or investment at year-end against an enterprise value including cash to estimate the portion of emissions from the investment to be allocated to the investor or a financial institution. Using such methods can result in faulty conclusions, as investment portfolios can change dynamically, where some investments may be omitted from a portfolio while others enter a portfolio later in a year. Additionally, company emissions may vary greatly throughout the year, be it because of seasonality or other factors. This pitfall results in moderately skewed financed emissions from financial institutions at best, outright wrong at worst, and opens the possibility for greenwashing. In this paper, we provide a novel way to address this, which we demonstrate through a case study.

## 1. Introduction

The financial sector is important in lowering greenhouse gas emissions in non-financial sectors (Monasterolo, 2020). The sector can play this part by motivating companies and sectors to lower their greenhouse gas emissions through favorable lending terms and increased investments. Previous research has demonstrated the strong link between green energy investments and greenhouse gas emission reductions (Hassan et al., 2022). Banks can do this by providing specific products, such as green car loans and better mortgage rates for environmentally friendly housing. The investment and lending decisions made within financial institutions are often the deciding factors if projects are developed, companies deploy products or initiate operations if they are early stage. A common hurdle for financial institutions is the early nature of climate solutions, which are often in its infancy, with little operating history, unproven business plan and involve high risk. Such ventures often appeal more to venture funds rather than conventional credit institutions which generally have less risk tolerance. This pivotal role has been understood within the financial sector but robust methodologies to monitor the impacts have historically been lacking. The European Union has introduced a regulation (European Union, 2023) within its Sustainable finance package, generally called the EU Taxonomy, which acts as a classification system for sustainable activities. Its intention is to facilitate investments in environmentally friendly activities and help investors to avoid greenwashing. Under the EU Taxonomy regulation, companies of a certain size must declare how much of their turnover, capital expenditures, and operational expenditures are eligible under the Taxonomy regulation and how much is aligned with the regulations technical criteria to be classified as environmentally sustainable or contribute to sustainability. The EU Taxonomy does however not require companies to report on greenhouse gas emissions nor does the regulation help financial institutions to understand the greenhouse gas emissions associated with their investment or lending activities. Upcoming regulation, the Corporate Sustainability Reporting Directive

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(CSRD) will however require companies of a certain size to report on greenhouse gas emissions, which can eventually be used by financial institutions to estimate indirect emissions.

Financial instruments have also been deployed with a specific focus on lower environmental impact. One such instrument is green bonds where the proceeds are used to finance projects which have environmental benefits. As of 2022, green bonds have raised approximately USD 2 trillion which are intended to finance projects such as clean energy and low-carbon transport (Climate Bond Initiative, 2023). There are a variety of types of bonds linked to sustainability, such as social bonds where proceeds are used to improve social factors such as access to education and healthcare, sustainability-linked bonds where interest rates are determined by pre-defined key performance indicators (KPI's), and transition bonds where proceeds are intended to finance a transition from fossil fuels to clean energy within companies operating in high emitting sectors. The issuers of bonds within the sustainability realm are expected by market participants to report on the sustainability benefits of the projects which are financed in a specific impact report. The impact reporting for green bonds has often been focused on avoided greenhouse gas emissions even though other factors are often reported in addition. Issuing a green bond includes extra costs for the issuer as they need to receive a second party opinion, structure a framework which outlines what will be financed and the annual impact report must be published. These costs are however in many instances compensated through a so called "greenium" the issuer may receive upon issuance where the pricing of the bond can be more attractive than comparable plain vanilla bonds (MacAskill et al., 2021). There has however been no coherent methodology provided to issuers of green bonds on how to estimate avoided greenhouse gas emissions which has led to concerns on such reporting and the reliability of the data the reports possess (Mihálovits and Paulik, 2022).

The indirect environmental impact of financial institutions can only be fully understood if the metrics and methodologies to calculate the impact are standardized between institutions and demonstrate the investment decisions made throughout the reported year. Current methodologies to report on financed greenhouse gas emissions (or simply financed emissions) only represent the investment or lending portfolio at the end of the year for the reporting financial institution. This is a major shortfall that can lead to skewness and misrepresentation of financed emissions of these institutions.

### 1.1. *Legislative environment around financed emissions*

Legislation for sustainability disclosures has become more stringent (Wang et al., 2022; Van Caenegem, 2021). Current regulations from the European Union require financial institutions to calculate and report their financed greenhouse gas emissions in more than one avenue (Brühl, 2022; European Parliament, 2019). This requirement can be seen in the Sustainable Finance Disclosure Regulation (SFDR) and reporting requirements from the European Banking Authority (EBA) where financial institutions need to report on their financed emissions through a reporting template provided by the EBA (Aevoae et al., 2022; European banking authority, 2020).

Before the year 2020 financial institutions (FIs) rarely reported on the carbon emissions of their investment or loan portfolio. The carbon emissions of an investment or loan portfolio are generally referred to as Scope 3 Category 15 emission category as defined by the Greenhouse Gas Protocol (W. R. I. – World Resources Institute, 2004). This lack of carbon accounting was mainly due to the absence of a coherent and mutually agreed upon methodology widely adopted by FI's. This changed when the Partnership for Carbon Accounting Financials (PCAF), a partnership of FI's with the objective of developing such methodology, published the first version of their guidelines in 2020. The guidelines provided by PCAF have now become the industry standard when FI's measure and report on financed emissions globally (Teubler and Kühlert, 2020). The guidelines provided by PCAF are intended to be practical for its users but the simplification of the guidelines has come at a cost.

It is our intention in this paper to demonstrate the possible pitfalls of using the methodology proposed by PCAF and demonstrate how incorporating time into carbon accounting addresses the PCAF pitfalls.

## 2. Background to PCAF

The goal of the PCAF standard is to provide a coherent method for FI's to attribute the carbon emissions of their individual investments (Scope 1, 2 and 3) to their Scope 3 emissions. PCAF has greatly improved disclosure from FI's whereas of the year 2022 more than 300 FI's are a part of PCAF, including some the world largest banks, asset management and investment firms. The first version of PCAF provided a way to estimate the attribution factor for six asset classes, a) listed equity and corporate bonds, b) business loans and unlisted equity, c) project finance, d) commercial real estate, e) mortgages and f) car loans. Subsequent additions to the PCAF standard include government bonds, carbon removal and facilitated emissions through capital markets. The focus of this paper will be on the first two, listed equity and corporate bonds and business loans and unlisted equity (Teubler and Kühlert, 2020). This focus area is chosen as the PCAF method has been adopted by the EU in the SFDR disclosure for Principle Adverse Impacts (PAI), where a few indicators are aimed at reporting on financed emissions (European Parliament, 2019).

One reason for the widespread use of the PCAF standard, including by the EU, is its simplicity (Teubler and Kühlert, 2020). The standard is built around the so-called attribution factor. The attribution factor is a central concept which demonstrates the portion of a company's carbon emission to be attributed to a FI's scope 3 (PCAF, 2020). The attribution factor for listed equity is shown in eq. 1:

$$attribution\ factor_c = \frac{Outstanding\ amount_c}{EVIC_c} \tag{1}$$

where *EVIC* is the enterprise value including cash at year end and the outstanding amount is the market value of outstanding listed equity at year end for company *c* owned by the FI (PCAF, 2020). A similar approach is taken for bonds where the attribution factor is defined as is shown in eq. 2:

$$attribution\ factor_c = \frac{Outstanding\ amount_c}{Total\ equity + debt_c} \tag{2}$$

For bonds, the outstanding amount refers to the total debt held by the FI or investor (PCAF, 2020).

However, the attribution factor is calculated at year end and the carbon emissions from each investee or borrowing company is taken at year end. In this paper we demonstrate how this approach can result in skewed results if a company is devested from a portfolio before year end or has been included in the portfolio for only a portion of the year, excluding the year end. This can seem undesirable if an investor gains a majority share of a company with the aim of reducing carbon emissions. In such a scenario, the investor, according to the PCAF methodology, needs to account for the total carbon emission for the year of the invested company in her Scope 3 in relation to her attribution factor. In addition, the outstanding amount of the investor can also change throughout the year, whereby the end of the year holding amount is not representative of the holding throughout the year.

Fig. 1 demonstrates such a scenario whereas the value of the underlying investment (EVIC) changes throughout the year (here shown at the end of each quarter but may as well be days or other more granular timeframe). The figure also shows how the greenhouse gas emissions from the company varies, whereas in the first quarters the company emitted relatively much compared to the second two quarters where greenhouse gas emissions dropped significantly. In the fictional example shown in Fig. 1, an investor takes a position in a company in the third

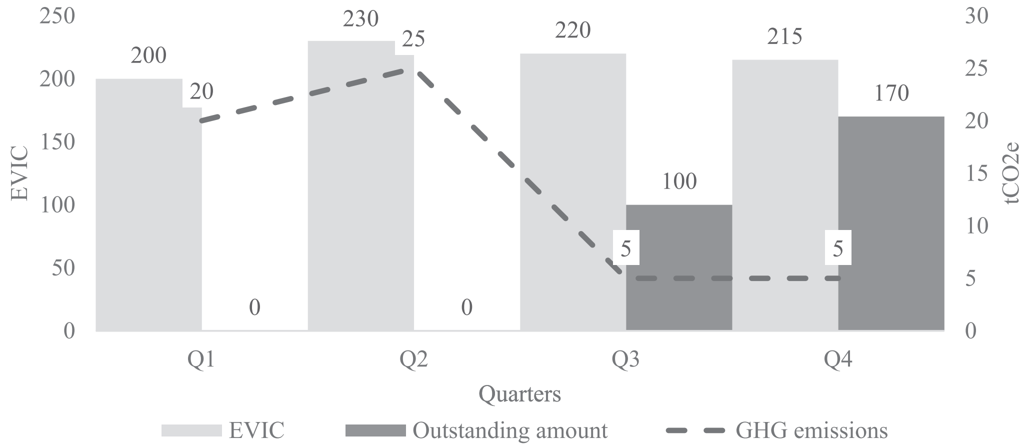


**Fig. 1.** Development of a fictional company value (EVIC), emissions and ownership over a year.

quarter, a position which grows from 100 to 170 in the fourth quarter. (See Tables 1–4.)

This limitation to the current practice of accounting for carbon emissions in investment portfolios is at the core of this paper, which we demonstrate how can be navigated at a more granular level even with present day data. This pitfall also opens the possibility for greenwashing among funds where performance is also demonstrated by their carbon footprint, where an incentive is currently being provided to restructure portfolios at year end with low carbon emitting companies.

## 3. Methods

For calculated financed emissions to be representative of the investment holdings or outstanding loans over a given period, we suggest a method that incorporates time as a variable into the currently used method as proposed by PCAF. We complement current practices suggested by PCAF by using the attribution factor as the way of attributing carbon emissions from a company scope 1 & 2 emissions to the investor or creditor scope 3 category 15. We then introduce time into the method, requiring FIs to calculate the attribution factor for a given period for the underlying investments in the portfolio in which the FI has invested or has an outstanding loan. We also require knowledge about the investee company greenhouse gas emissions with the same granularity as is used when calculating the attribution factor. The fluctuation in greenhouse gas emissions from company operations is however generally not reported by companies in the same frequency as financial metrics and therefore not attainable by investors or creditors. This may however be bypassed in practice if the information is not available by assuming that the greenhouse gas emissions occur evenly throughout the period. For clarity, we introduce eq. 3:

$$\sum_{c=p}^{P} \sum_{d=1}^{n} GHG^{*} attribution\ factor_{cd} \tag{3}$$

where:

- o $c$ are companies in the investment portfolio.
- o $d$ are appropriate periods within the holding period, i.e. days or quarters.
- o *GHG* is the amount of greenhouse gases, measured in $CO_2$-equivalents emitted by the company during each period.

To demonstrate the effect of accounting only for greenhouse gas emissions using data from the end of the year, compared to the method proposed in eq. 3 we look at the indexed exchange-traded fund (ETF) with the ticker LEQ managed by the Icelandic asset and fund management firm Landsbréf (Landsbref, 2022). This ETF is listed on the Icelandic stock exchange (Nasdaq CSD) and tracks the OMXI10CAP index (Nasdaq Index Methodology OMXI10CAP, 2022). This fund is suitable to demonstrate the possible differences in accounting for greenhouse gas emissions at the end of the year (as proposed by current PCAF methodology) compared to using more granular, time sensitive data as proposed in this paper. LEQ is also suitable for examining this effect as it only invests in publicly listed companies which generally disclose better sustainability information than non-listed companies.

LEQ publishes its holdings at the end of each month, but the underlying companies only publish their financial statements needed to calculate the EVIC quarterly. It is therefore possible to calculate the attribution factor monthly. The portfolio companies also only report on their greenhouse gas emissions annually. To deal with the lack of granularity with greenhouse gas emissions data, we are forced to assume that the greenhouse gas emissions occur evenly throughout the year and that debt and equity maintain at a constant as reported quarterly for each of the months the attribution factor is calculated. It should however be noted that it is preferred to use emissions data in the same granularity as the financial data and that the data would be provided in more detail. One way to address this might be through estimation of greenhouse gas emissions based on financial indicators as reported quarterly.

## 4. Results

In 2021 LEQ held 15 companies at some point in time, but only 10 at each point in time. We calculated the EVIC for each company at each quarter end. This data was then complimented with data about LEQ holdings in each company at each month's end.

By using the method as proposed by PCAF the scope 3, category 15 emissions for LEQ is calculated to be 473 tons of $CO_2$-equivalents ($tCO_2e$). By using the proposed method as demonstrated in Eq. 3, LEQ's scope 3 (category 15) emissions amounts to 52 $tCO_2e$. By taking only the end of year EVIC and ownership in each equity the impact of owning 5 equities is eliminated and financed emissions are overstated by 421 $tCO_2e$.

Fig. 2 demonstrates how the attribution factor varies throughout the reporting year for each equity and how the structure of the portfolio changes throughout the period. Using current PCAF methodology, only attribution factors as shown in month 12 would be used. This would lead to results assuming that the investor or credit institution held the investments or loans in the company shown in that month throughout the year. This is a pitfall of the PCAF methodology as the results from financed emissions can appear to reflect ownerships or loans as they evolve over a year, but merely reflect the portfolio at the year end. By looking at month 1 for instance, one can see that the company TM is within the fund holdings. TM is an insurance company with relatively low Scope 1 & 2 emissions. The low greenhouse gas emission of this

**Table 1**
Financial data for companies held at some point in 2021 by LEQ.

| | TM* | MAREL | SIMINN | REITIR | KVIKA | FESTI | HAGA | EIK | VIS | ARION | ICEAIR | ICESEA | SVN | EIM | ISB |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| tCO2e year end (Scope 1 + 2) | 47,2 | 14.891 | 523 | 35 | 52 | 932 | 1.556 | 93 | 34 | 113 | 486.277 | 5.136 | 54.372 | 297.786 | 111 |
| Q1 | | | | | | | | | | | | | | | |
| Market capitalization | 50.173.023 | 4.393 | 84.956 | 46.291 | 97.557.242 | 59.933.381 | 67.394 | 32.186 | 27.688.530 | 206.616 | 292.744 | 40.393 | – | 49.161.552 | – |
| Debt | 24.452.037 | 288,7 | 26.534 | 104.732 | 189.808.666 | 54.683.228 | 36.461 | 74.358 | 41.996.844 | 992 | 762.536 | 183.308 | 255.387.281 | 122.053 | 1.199.764 |
| Cash | 2.045.857 | 101,6 | 697 | 2.084 | 37.816.597 | 2.462.919 | 388 | 2.904 | 1.685.258 | 76.592 | 53.466 | 21.389 | 54.198.356 | 17.212 | 88.748 |
| EVIC | 76.670.917 | 4.784 | 112.187 | 153.107 | 325.182.505 | 117.079.528 | 104.243 | 109.448 | 71.370.632 | 284.199 | 1.108.746 | 245.090 | 309.585.637 | 49.300.817 | 1.288.512 |
| Q2 | | | | | | | | | | | | | | | |
| Market capitalization | | 4.411 | 81.529 | 56.016 | 110.771.886 | 64.539.291 | 72.933 | 36.131 | 32.204.250 | 246.582 | 273.591 | 47.080 | 24.117.926.266 | 66.125.543 | – |
| Debt | | 267,9 | 38.477 | 106.152 | 170.242.497 | 55.131.581 | 36.961 | 76.018 | 41.773.334 | 1.024.315 | 1.021.799 | 170.274 | 213.053.593 | 342.261 | 1.256.505 |
| Cash | | 85,6 | 6.964 | 1.990 | 18.503.021 | 3.134.061 | 1.331 | 3.141 | 1.720.264 | 95.093 | 155.500 | 13.304 | 63.141.256 | 15.385 | 130.968 |
| EVIC | – | 4.765 | 126.970 | 164.158 | 299.517.404 | 122.804.933 | 111.225 | 115.290 | 75.697.848 | 1.365.990 | 1.450.890 | 230.658 | 24.394.121.115 | 66.483.189 | 1.387.473 |
| Q3 | | | | | | | | | | | | | | | |
| Market capitalization | | 4.444 | 81.996 | 58.739 | 117.607.692 | 68.306.446 | 75.587 | 38.590 | 33.480.000 | 278.421 | 396.181 | 46.409 | 31.041.490.168 | 80.226.944 | 240.000 |
| Debt | | 186,6 | 38.184 | 109.430 | 158.547.088 | 55.016.507 | 38.189 | 76.711 | 40.232.240 | 1.151.512 | 967.043 | 133.954 | 208.585.657 | 351.102 | 1.258.991 |
| Cash | | 66,2 | 6.952 | 4.609 | 15.265.917 | 4.245.037 | 951 | 3.028 | 1.324.706 | 86.190 | 216.978 | 18.876 | 64.847.224 | 25.081 | 110.233 |
| EVIC | – | 4.697 | 127.132 | 172.778 | 291.420.697 | 127.567.990 | 114.727 | 118.329 | 75.036.946 | 1.516.123 | 1.580.202 | 199.239 | 31.314.923.049 | 80.603.127 | 1.609.224 |
| Q4 | | | | | | | | | | | | | | | |
| Market capitalization | | 4.476 | 87.768 | 66.130 | 128.375.725 | 71.442.668 | 77.355 | 42.005 | 35.700.000 | 303.467 | 404.739 | 40.167 | 42.674.644.331 | 88.459.840 | 252.400 |
| Debt | | 199,2 | 38.648 | 112.405 | 167.872.201 | 52.061.362 | 39.274 | 3.297 | 38.610.036 | 1.119.266 | 949.175 | 187.619 | 211.634.296 | 372.859 | 1.225.111 |
| Cash | | 77,1 | 3.509 | 957 | 38.645.894 | 4.002.716 | 2.056 | 77.444 | 1.552.903 | 90.678 | 204.767 | 27.766 | 79.856.239 | 36.986 | 113.667 |
| EVIC | – | 4.753 | 129.925 | 179.492 | 334.893.820 | 127.506.746 | 118.685 | 122.746 | 75.862.939 | 1.513.411 | 1.558.681 | 255.552 | 42.966.134.866 | 88.869.685 | 1.591.178 |
| Denoted in | 1.000 ISK | 1.000.000 EUR | 1.000.000 ISK | 1.000.000 ISK | 1.000 ISK | 1.000 ISK | 1.000.000 ISK | 1.000.000 ISK | 1.000 ISK | 1.000.000 ISK | 1.000 USD | 1.000 EUR | 1 USD | 1.000 EUR | 1.000.000 ISK |

**Table 2**
Share price and outstanding shares of companies held by LEQ at some point in 2021.

| | TM | Marel hf (XAMS: MAREL) | Iceland Telecom. (XICE: SIMINN) | Reitir fasteignafelag hf (XICE: REITIR) | Kvika banki hf (XICE: KVIKA) | Festi hf (XICE: FESTI) | Hagar hf (XICE: HAGA) | Eik fasteignafelag hf (XICE:EIK) | VIS Insurance Ltd. (XICE: VIS) | Arion banki hf (XICE: ARION) | Icelandair Group hf (XICE: ICEAIR) | Iceland Seafood Internation hf (XICE: ICESEA) | Sildarvinnslan hf (XICE:SVN) | Eimskipafelag Islands hf (XICE:EIM) | Islandsbanki hf (XICE:ISB) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 31.3.2021 | 65,0 ISK | 5,84 EUR | 10,1 ISK | 59,5 ISK | 20,8 ISK | 185,5 ISK | 58,4 ISK | 9,4 ISK | 14,7 ISK | 123,5 ISK | 1,4 ISK | 15,1 ISK | | 272,0 ISK | |
| 30.6.2021 | | 5,86 EUR | 10,9 ISK | 72,0 ISK | 23,4 ISK | 201,0 ISK | 63,2 ISK | 10,6 ISK | 17,6 ISK | 154,5 ISK | 1,7 ISK | 17,6 ISK | 61,7 ISK | 377,5 ISK | 103,5 ISK |
| 30.9.2021 | | 5,90 EUR | 11,1 ISK | 75,5 ISK | 24,7 ISK | 214,0 ISK | 65,5 ISK | 11,3 ISK | 18,6 ISK | 177,0 ISK | 1,5 ISK | 17,1 ISK | 76,6 ISK | 458,0 ISK | 120,0 ISK |
| 30.12.2021 | | 5,94 EUR | 12,0 ISK | 85,0 ISK | 26,8 ISK | 226,0 ISK | 67,5 ISK | 12,3 ISK | 20,4 ISK | 190,5 ISK | 1,8 ISK | 14,8 ISK | 101,0 ISK | 505,0 ISK | 126,2 ISK |
| Shares | | | | | | | | | | | | | | | |
| 31.3.2021 | 771.893 | 752 | 8.399 | 778 | 4.690.252 | 323.091 | 1.154 | 3.415 | 1.878.462 | 1.673 | 209.103 | 2.675 | 356.052.282 | 180,741 | |
| 30.6.2021 | | 753 | 7.466 | 778 | 4.743.978 | 321.091 | 1.154 | 3.415 | 1.835.000 | 1.596 | 163.827 | 2.675 | 390.890.215 | 175,167 | |
| 30.9.2021 | | 753 | 7.387 | 778 | 4.761.445 | 319.189 | 1.154 | 3.415 | 1.800.000 | 1.573 | 259.791 | 2.714 | 405.241.386 | 175,168 | 2000 |
| 30.12.2021 | | 754 | 7.314 | 778 | 4.790.139 | 316.118 | 1.146 | 3.415 | 1.750.000 | 1.593 | 222.384 | 2.714 | 422.521.231 | 175,168 | 2000 |

**Table 3**
LEQ attribution factors for each month and GHG emissions per month.

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Attribution factor M1 | 0,20% | 0,0008% | 0,13% | 0,11% | 0,05% | 0,22% | 0,21% | 0,10% | 0,13% | 0,13% | | | | | |
| Attribution factor M2 | 0,24% | 0,0010% | 0,17% | 0,11% | 0,06% | 0,24% | 0,23% | 0,11% | 0,16% | 0,18% | | | | | |
| Attribution factor M3 | 0,26% | 0,0009% | 0,17% | 0,10% | 0,06% | 0,25% | 0,23% | 0,10% | 0,15% | 0,18% | | | | | |
| Attribution factor M4 | | 0,0010% | 0,14% | 0,10% | 0,15% | 0,22% | 0,19% | 0,09% | 0,14% | 0,04% | 0,0001% | | | | |
| Attribution factor M5 | | 0,0010% | 0,15% | 0,10% | 0,16% | 0,23% | 0,20% | 0,09% | 0,14% | 0,04% | 0,0001% | | | | |
| Attribution factor M6 | | 0,0011% | 0,12% | 0,12% | 0,17% | 0,19% | 0,25% | | 0,13% | 0,04% | 0,0001% | 0,18% | | | |
| Attribution factor M7 | | 0,0012% | 0,13% | 0,11% | 0,19% | 0,19% | 0,24% | | 0,14% | 0,04% | 0,0001% | 0,20% | | | |
| Attribution factor M8 | | 0,0014% | 0,15% | 0,14% | 0,22% | 0,24% | 0,30% | | 0,17% | 0,05% | 0,0002% | 0,23% | | | |
| Attribution factor M9 | | 0,0013% | 0,15% | 0,14% | 0,23% | 0,24% | 0,30% | | 0,17% | 0,05% | 0,0002% | 0,23% | | | |
| Attribution factor M10 | | 0,0014% | 0,16% | 0,15% | 0,23% | 0,25% | 0,29% | | 0,20% | 0,06% | 0,0002% | 0,22% | | | |
| Attribution factor M11 | | 0,0013% | 0,15% | 0,15% | 0,22% | 0,25% | 0,30% | | 0,18% | 0,05% | 0,0002% | 0,20% | | | |
| Attribution factor M12 | | 0,0015% | 0,15% | | 0,18% | 0,19% | 0,17% | | | 0,05% | 0,0002% | | 0,35% | 0,09% | 0,04% |
| tCO2e emissions per month | 3,9 | 1240,9 | 43,6 | 2,9 | 4,4 | 77,6 | 129,7 | 7,8 | 2,8 | 9,4 | 40,523,1 | 428,0 | 4531,0 | 24,815,5 | 9,3 |

**Table 4**
Monthly financed emissions shown using the proposed methodology compared with current PCAF method.

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Financed emissions M1 | 0,01 | 0,01 | 0,06 | 0,00 | 0,00 | 0,17 | 0,27 | 0,01 | 0,00 | 0,01 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 |
| Financed emissions M2 | 0,01 | 0,01 | 0,07 | 0,00 | 0,00 | 0,18 | 0,30 | 0,01 | 0,00 | 0,02 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 |
| Financed emissions M3 | 0,01 | 0,01 | 0,07 | 0,00 | 0,00 | 0,19 | 0,30 | 0,01 | 0,00 | 0,02 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 |
| Financed emissions M4 | 0,00 | 0,01 | 0,06 | 0,00 | 0,01 | 0,17 | 0,25 | 0,01 | 0,00 | 0,00 | 0,05 | 0,00 | 0,00 | 0,00 | 0,00 |
| Financed emissions M5 | 0,00 | 0,01 | 0,06 | 0,00 | 0,01 | 0,18 | 0,26 | 0,01 | 0,00 | 0,00 | 0,04 | 0,00 | 0,00 | 0,00 | 0,00 |
| Financed emissions M6 | 0,00 | 0,01 | 0,05 | 0,00 | 0,01 | 0,15 | 0,32 | 0,00 | 0,00 | 0,00 | 0,06 | 0,78 | 0,00 | 0,00 | 0,00 |
| Financed emissions M7 | 0,00 | 0,01 | 0,06 | 0,00 | 0,01 | 0,15 | 0,31 | 0,00 | 0,00 | 0,00 | 0,06 | 0,84 | 0,00 | 0,00 | 0,00 |
| Financed emissions M8 | 0,00 | 0,02 | 0,07 | 0,00 | 0,01 | 0,18 | 0,38 | 0,00 | 0,00 | 0,00 | 0,06 | 0,97 | 0,00 | 0,00 | 0,00 |
| Financed emissions M9 | 0,00 | 0,02 | 0,06 | 0,00 | 0,01 | 0,19 | 0,39 | 0,00 | 0,00 | 0,00 | 0,07 | 1,00 | 0,00 | 0,00 | 0,00 |
| Financed emissions M10 | 0,00 | 0,02 | 0,07 | 0,00 | 0,01 | 0,20 | 0,38 | 0,00 | 0,01 | 0,01 | 0,08 | 0,95 | 0,00 | 0,00 | 0,00 |
| Financed emissions M11 | 0,00 | 0,02 | 0,07 | 0,00 | 0,01 | 0,20 | 0,39 | 0,00 | 0,01 | 0,00 | 0,07 | 0,85 | 0,00 | 0,00 | 0,00 |
| Financed emissions M12 | 0,00 | 0,02 | 0,07 | 0,00 | 0,01 | 0,14 | 0,23 | 0,00 | 0,00 | 0,00 | 0,07 | 0,00 | 15,66 | 23,28 | 0,00 |
| Total tCO2e proposed method | 0,03 | 0,17 | 0,77 | 0,04 | 0,08 | 2,11 | 3,78 | 0,04 | 0,05 | 0,09 | 0,55 | 5,39 | 15,66 | 23,28 | 0,00 |
| Total tCO2e PCAF EOY method | 0,00 | 0,22 | 0,78 | 0,00 | 0,09 | 1,73 | 2,72 | 0,00 | 0,00 | 0,05 | 0,81 | 0,00 | 187,90 | 279,34 | 0,04 |

equity holding is not reflected at month 12 as the company is no longer a part of the portfolio. At month 12 the company Síldarvinnslan (ticker SVN) enters the portfolio. Síldarvinnslan has relatively high Scope 1 emissions, which would lead the funds financed emissions to increase substantially using the conventional PCAF method. However, LEQ only holds Síldarvinnslan for 1 month of the full year which is not reflected using current PCAF method. The introduction of time into the PCAF method as shown in Eq. 3 solves the dilemma demonstrated in the examples of TM and Síldarvinnslan as they are proportionally included in the financed emissions based on their duration in the portfolio and fluctuation in the attribution factor.

## 5. Discussions

By using the method we propose in this paper we reveal the skewness which can become apparent but not obvious using the current PCAF methodology. The reason for this skewness can be a result of four factors.

1) growth or decline in the funds' holdings size over the period reported
2) a significant change in the attribution factor in companies with high Scope 1 & 2 emissions
3) a change within the funds' holdings throughout the year which is not reflected in the annual report at the end of the year
4) a change in the stock market valuation of the underlying stock holdings.

If the PCAF method had been used, the shipping company Eimskip and Síldarvinnslan a fishing company (both in sectors with a high carbon intensity) would have been assumed to have remained in the portfolio for the full year, whereas in reality it only entered the portfolio in M12.

The case study demonstrated in this paper is focused on listed equity investments. However, this method may also be valid for loans or unlisted equity investments. In the case of loans, the skewing effect would mostly be seen when a bank might issue a loan at the end of a year or get a loan repaid late in the year. In such case, the arithmetic to calculate the financed emissions as currently conducted would assume the portion of the company emissions over the whole year, or none at all, to be allocated to the lender according to the attribution factor as calculated at the end of the year.

The current method used by many financial institutions to calculate

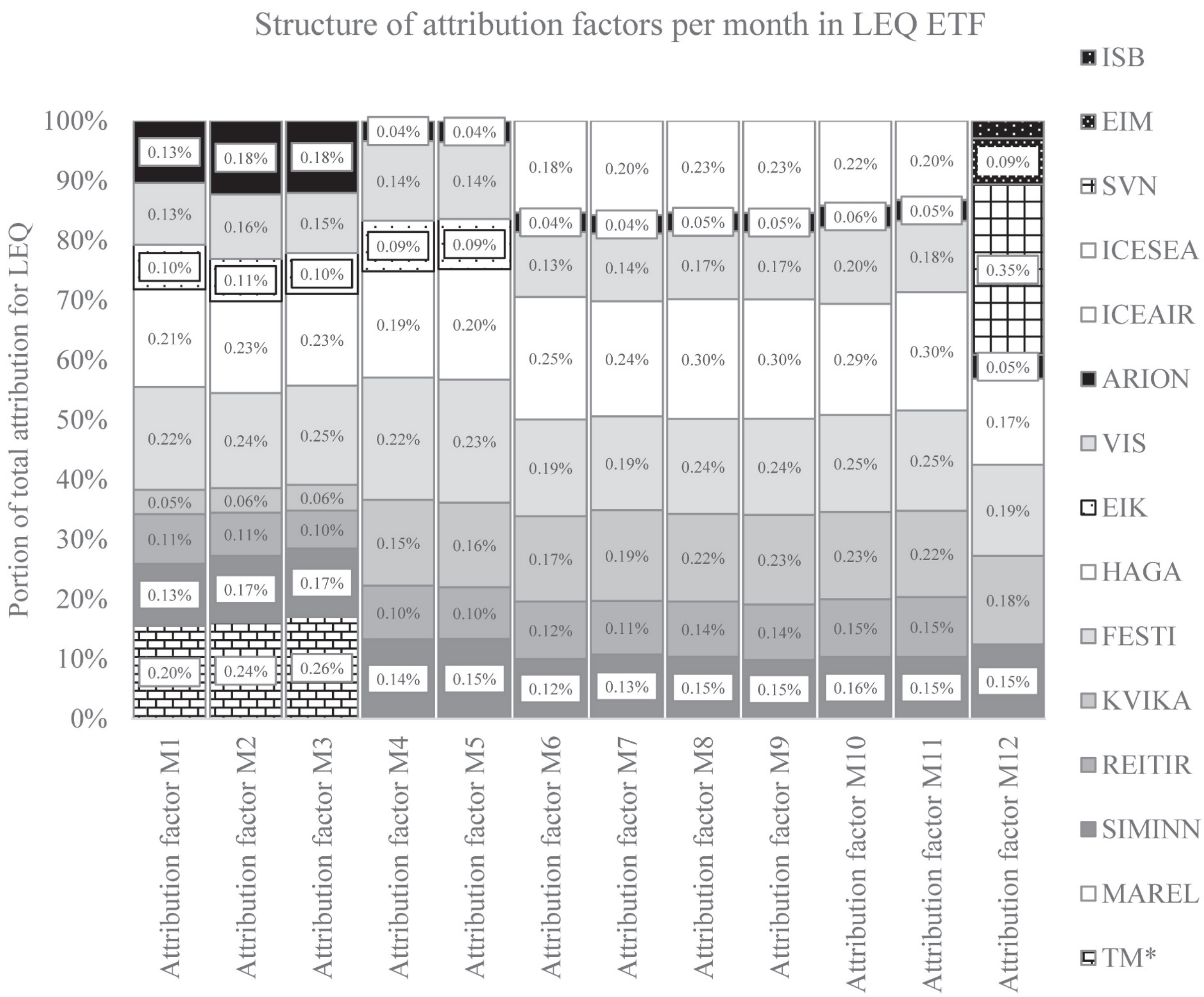


**Fig. 2.** The attribution factor used to calculate the scope 3 emissions of investments changes throughout the year. The percentages next to each ticker demonstrates the attribution factor for that equity at that point in time.

their financed greenhouse gas emissions may therefore in some instances be substantially skewed.

### *5.1. Recommendations for policy and regulation*

The EBA and the EU through the SFDR regulation (Deschryver et al., 2020) require many financial institutions to report on financed emissions. Using current methodologies as proposed within the SFDR regulation and originally provided by the PCAF standard may result in skewed reporting to authorities, investors and the public in general, as the reporting does not consider the time element of investments or loans in or to the underlying companies. We propose that further research is conducted to estimate the scale of the effect of only accounting for holding at the end of year. Current methodologies are also prone to non-intentional greenwashing as FI's may report on financed emissions not representative of their investments or loan holdings throughout the reporting year. This is counterintuitive to the intention of the SFDR regulation which is precisely designed to minimize greenwashing. The method proposed in this paper, even if more data intensive, would solve this issue to a large extent. We understand the practical hurdle FI's may face when calculating financed emissions as proposed in this paper but using that method would reduce the risk of greenwashing by FI's (Deschryver et al., 2020). This risk is reduced by including financed emissions from equity ownership or loans, even if those investments or loans are not included in the FI's annual accounts at the end of the year.

We suggest that regulators and policymakers investigate the cumulative effect of current reporting methodologies and further refine calculation methods for financed greenhouse gas emissions and amend and align the EBA guidelines or SFDR regulations. We also propose that data availability is improved by the regulators to allow FI's to access emission factors for companies that do not report their greenhouse gas emissions.

The main limitation of this study is its small sample size. The sample size of only one ETF is chosen to put emphasis on the methodological deficiencies of PCAF and the possible distorted outcomes as a result. To demonstrate the possible grand scale effect of time being excluded from calculations of financed emissions of investment or loan portfolios a sample size of much greater size should be used. Future researchers could perform such a study for ETFs using published holding data. Future research and awareness inside FI's, especially credit institutions are also encouraged where loan portfolios can be studied in better detail where public information is not as available as for ETFs. We also encourage FI's to publish financed emissions incorporating time along with conventional PCAF results.

### **Declaration of Competing Interest**

This manuscript has not been published or presented elsewhere in part or in entirety and is not under consideration by another journal. All study participants provided informed consent, and the study design was approved by the appropriate ethics review board. We have read and understood your journal's policies, and we believe that neither the manuscript nor the study violates any of these. There are no conflicts of interest to declare.

## Data availability

Data will be made available on request.

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