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Shocking Financed Emissions: The Effect of Economic Volatility on the Portfolio Footprinting of Financial Institutions

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Shocking financed emissions: the effect of economic volatility on the portfolio footprinting of financial institutions

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Abstract

Many financial institutions are now calculating and disclosing their financed emissions, a class of metrics enabling these institutions to calculate the greenhouse gas (GHG) emissions associated with investment and lending activities. These institutions have widely adopted the metric to estimate exposure to climate-related financial risk associated with GHG-emitting activities and to provide shareholders and investors a picture of how their financial activity impacts global climate change. Financed emissions metrics, despite widespread adoption, face two key methodological challenges: lack of comparability of outputs within and between portfolios, and vulnerability of calculations to portfolio volatility. Markets are naturally volatile, but the economic transformation caused by the transition to net-zero GHGs is also likely to create economic volatility, requiring metrics to anticipate this likelihood and take it into account. The paper demonstrates the impact of volatility on the financed emissions of a modeled portfolio comprising five high-emissions industries. The paper concludes that using market value metrics, like enterprise value including cash, to calculate financed emissions exacerbates the effect of volatility on the metric. Using book value metrics to calculate financed emissions across the whole portfolio may potentially reduce – but not eliminate – the impact of volatility while maintaining comparability.

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1. Introduction

Financed emissions reporting is a form of greenhouse gas (GHG) "footprinting," that estimates the emissions associated with the investment and lending activities of financial institutions.[2] The metric draws attention to financing and investment as the most significant financial institution activity resulting in GHG emissions. Financial institutions' financed emissions footprints dwarf other aspects of their GHG footprint: financed emissions are on average 750 times larger than financial institutions' operational emissions.[3] Financial institutions – and other stakeholders such as shareholders, regulators, and civil society – use financed emissions to understand the risk associated with financial exposure to a borrower or investee with GHG-emitting activities, the impact the financial institutions' lending and investment activities have on global climate change, and measure and evaluate actions taken to address those risks and impacts.

Financed emissions are calculated as the product of the GHG emissions of the counterparty the financial institution has financed and an "attribution factor," i.e., a ratio that identifies the proportion of the counterparty's emissions that can be attributed to the financing. The appeal of this metric has been that it allows the overall relationship between financial activities and GHG emissions to be summarized in a single number, improving simplicity and comparability. However, the apparent simplicity of such a calculation belies the range of calculating assumptions embedded within any given methodology. Differing assumptions and methodologies between institutions also limit comparability.

To help address this complexity, the Partnership for Carbon Accounting Financials (PCAF) developed industry-led standards to measure the GHG emissions of various financial portfolios. Early standards were developed and applied by several Dutch financial institutions in 2015, and subsequently adopted by a majority of the financial institutions around the world.[4]

Despite the emergence of PCAF and efforts to standardize and improve the metric, financed emissions still faces several critiques that challenge its practicability as a metric. These various critiques fall into two central themes:

> Comparability: The range of methodology choices adopted by each financial institution – even under a more standardized framework like PCAF – still makes their financed emissions disclosures less comparable.

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[2] The Partnership for Carbon Accounting Financials (PCAF) defines financed emissions as "the absolute emissions that banks and investors finance through their loans and investments." *The Global GHG Accounting and Reporting Standard Part A: Financed Emissions, Second Edition* (PCAF, 2022), https://carbonaccountingfinancials.com/files/downloads/PCAF-Global-GHG-Standard.pdf.

[3] Manveer Gill, *Nature in Green Finance: Bridging the Gap in Environmental Reporting,* (London, CDP, August 2023), https://www.cdp.net/en/research/global-reports/financial-services-disclosure-report-2022.

[4] Stephanie Safdie, "What is the Partnership for Carbon Accounting Financials (PCAF)?" *Greeenly* (blog), April 3, 2023, https://greenly.earth/en-us/blog/ecology-news/what-is-the-partnership-for-carbon-accounting-financials-pcaf.

Volatility: Volatility in a portfolio's financial value (such as share price, revenue, or debt and equity level) can overwhelm the financial institution's adjustment of investment or underwriting strategy to reduce exposure to GHG emissions,[5,6,7] or even imply an increase or decrease in emissions when the opposite is the case.

This paper focuses on the volatility issue, and in particular the effect of the economic cycle on financed emissions metrics. This complements existing critiques on the impact of short-term volatility caused by market sentiments or portfolio company performance.[8]

The transition to net-zero GHGs in coming decades is likely to entail or even precipitate economic and market volatility as the global economy transforms. Metrics seeking to account for and manage this transition will therefore need to anticipate and account for such volatility. Examining financed emissions through economic cycles is therefore critical to ensuring that financial institution tools for managing the transition are fit for purpose.

To investigate the issue, this paper:

1. Reviews the current financed emission methodologies used by five Global Systematically Important Banks (GSIBs) in their sustainability reporting and the primary critiques arising in the literature and bank reporting.

2. Models economic cycle effect on a theoretical portfolio with a mix of large, mid, and small-cap companies across five high-emissions industries.

3. Reviews potential options for reducing – albeit not eliminating – the impact of volatility on portfolios while maintaining the objective of comparability and simplicity.

2. Current Practices and Challenges

2.1 Current Practices

Efforts to develop a footprint of financial portfolios date back to the mid-2000s, when campaigners sought to hold banks accountable for the emissions activities associated with their financing.[9] Various attempts emerged by individual financial institutions and NGOs over the following decade to develop a common footprinting metric.

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[5] Jakob Thomä, Stan Dupré, Michael Hayne, "A Taxonomy of Climate Accounting Principles for Financial Portfolios," *Sustainability* 10, no.22 (2018): 328, https://doi.org/10.3390/su10020328.
[6] Nick Gaskell, "Why the Choice of Carbon Metric Matters," *Abrdn*, 2022, https://www.abrdn.com/en/investor/insights-thinking-aloud/article-page/why-the-choice-of-carbon-metric-matters".
[7] Frederic Yves Ducoulombier, and Victor Liu, "Carbon Intensity Bumps on the Way to Net Zero," *The Journal of Impact and ESG Investing* 1, no. 3 (2021): 59-73, https://doi.org/10.3905/jesg.2021.1.013.
[8] Ibid.
[9] Stanislas Dupre, Hugues Chenet, Jakob Thomä, and Guylaine Déniel *From Financed Emissions to Long Term Investing Metrics: State of the Art Review of GHG Missions Accounting for the Financial Sector*, (Paris: 2° Investing Initiative, July 2013), https://2degrees-investing.org/resource/from-

Prior to the formation of PCAF and its release of Global GHG Accounting and Reporting Standard for the Financial Industry in 2020,[10] there was no widely adopted standard approaches or accounting methodologies to measure financed emissions.[11] Today, PCAF has become one of the most adopted approaches to measure and report financed emissions among financial institutions. Based on the CDP Financial Serviced Disclosure Report,[2] of the 219 Financial Institutions that disclosed financed emissions on CDP, 79% referenced PCAF as their methodology for calculating financed emissions.

We reviewed the 2022 climate disclosures of five GSIBs: J.P. Morgan,[12,13] Bank of America (BoA),[14,15] Citi,[16,17] HSBC,[18] and ING.[19] Only J.P. Morgan did not expressly adopt the PCAF standard.[20] However, even among PCAF member financial institutions, the adoption of guidance was uneven. Table 1A provides a summary of the financed

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financed-emissions-to-long-term-investing-metrics/.

[10] *The Global GHG Accounting and Reporting Standard Part A: Financed Emissions, First Edition* (PCAF, November 2020), https://carbonaccountingfinancials.com/files/downloads/PCAF-Global-GHG-Standard-2020.pdf.

[11] Chidera Nelson, *Financed Emissions–Methodologies and Implication for Global Financial Institutions* (Durham, Duke University, 2022), https://dukespace.lib.duke.edu/server/api/core/bitstreams/baf298bf-9b8a-439f-aa97-5b9bf7d511db/content.

[12] *Carbon Compass[SM]: Paris-Aligned Financing Commitment Methodology* (New York: J.P. Morgan Chase & Co, May 2021), https://www.jpmorganchase.com/content/dam/jpm/cib/complex/content/investment-banking/carbon-compass/Carbon_Compass_Final.pdf.

[13] *Carbon Compass[SM]: Iron & Steel, Cement and Aviation* (New York: J.P. Morgan Chase & Co, 2022), https://www.jpmorganchase.com/content/dam/jpm/cib/complex/content/investment-banking/carbon_compass_2022/JPMC_Carbon_Compass_2022.pdf.

[14] Bank of America, "Bank of America Announces Actions to Achieve Net Zero Greenhouse Gas Emissions before 2050," press release, February 11, 2021, https://newsroom.bankofamerica.com/content/newsroom/press-releases/2021/02/bank-of-america-announces-actions-to-achieve-net-zero-greenhouse.html.

[15] *Task Force on Climate-related Financial Disclosures (TCFD) Report*: *Managing our Future* (New York: Bank of America, 2022), https://about.bankofamerica.com/content/dam/about/report-center/esg/2022/BOA_TCFD_2022%209-22-2022-VOX220929%20split%20paragraph%20Secured.pdf.

[16] *Taskforce on Climate-Related Financial Disclosures Report 2021: Citi's Approach to Climate Change and Net Zero* (New York: Citibank, 2021), https://www.citigroup.com/rcs/citigpa/akpublic/storage/public/taskforce-on-climate-related-financial-disclosures-report-2021.pdf.

[17] *Taskforce on Climate-Related Financial Disclosures Report 2022: Citi's Approach to Climate Change and Net Zero* (New York: Citibank, 2022), https://www.citigroup.com/rcs/citigpa/storage/public/taskforce-on-climate-related-financial-disclosures-report-2022.pdf.

[18] *Financed Emissions Methodology Update* (London: HSBC, February 2023), https://www.hsbc.com/-/files/hsbc/investors/hsbc-results/2022/annual/pdfs/hsbc-holdings-plc/230221-financed-emissions-methodology-update-published-february-2023.pdf?download=1.

[19] *2022 Climate Report* (Amsterdam: ING, September 222), https://www.ing.com/Newsroom/News/2022-Climate-Report-1.htm.

[20] In J.P. Morgan's 2023 disclosures they have included an appendix with PCAF-aligned calculations. *Climate Report 2023* (New York: J.P. Morgan Chase & Co, 2023), p.34, https://www.jpmorganchase.com/content/dam/jpmc/jpmorgan-chase-and-co/documents/Climate-Report-2023.pdf.

emissions disclosures of the four banks applying PCAF standards, and how their disclosures vary. Table 1B provides a summary of the methodological choices these five GSIBs make for reporting their financed emissions and their sector targets for the oil and gas sector.

Despite Bank of America (BoA), Citi, HSBC, and ING adopting the same framework, they do not calculate or report financed emissions in the same way. Banks have choices as to which emissions to attribute to a company or sector and how to estimate the value of those emissions. In attributing those emissions to a measure of financial value, they have choices as to whether to include committed or outstanding financing activity, and then have a choice as to the attribution factor. Variation exists among banks on each of these choices, and even within banks across different parts of the portfolio. Further, although these banks disclosed financed emissions data, they each use entirely separate methodologies to establish and disclose emission reduction *targets* in each sector and their progress against those targets. These reporting deviations reduce the comparability of financed emissions data and thus their utility as a benchmark among financial institutions.

In the 2022 bank disclosures analyzed for this paper, we observed relatively little discussion of volatility, with Citi being the only bank among those analyzed to address it. Subsequent to this paper's preparation, banks released 2023 disclosures with several beginning to discuss the issue, including BoA,[21] J.P. Morgan,[22] and Wells Fargo.[23] In some cases, they attempted to reduce volatility with changes to either their financed emissions methodology or, separately, target-setting methodologies (discussed further below).

[21] *Managing our Transition to a Sustainable Future: 2023 Task Force on Climate-related Financial Disclosures (TCFD) Report* (New York, Bank of America, 2023), p.34, https://about.bankofamerica.com/en/making-an-impact/task-force-on-climate-related-financial-disclosures-report.

[22] *Climate Report 2023*, p. 29.

[23] *Task Force on Climate-related Financial Disclosures (TCFD) Report*, (San Francisco: Wells Fargo, July 2023), p. 54, https://www08.wellsfargomedia.com/assets/pdf/about/corporate-responsibility/climate-disclosure.pdf.

Table 1A. PCAF reporting requirement summary by banks

PCAF Reporting Category	PCAF Requirement	Banks			
		BoA	Citi	HSBC	ING
1. Attribution Factor calculation (using loan outstanding)	Outstanding amount (numerator): This is the actual outstanding amount in listed equity or corporate bonds. It should be defined in line with the denominator. Therefore, the value of outstanding listed equity is defined based on its market value (i.e., market price times number of shares), and the value of outstanding corporate bonds is defined based on the book value of the debt that the borrower owes to the lender. Financial institutions should either use the calendar or financial year-end outstanding amount, provided the approach is communicated clearly and used consistently.	Yes (Note: Outstanding is used for financed emission but not for target)	Yes (Note: Outstanding is used for financed emission but not for target)	Yes	Yes
2. Covered facility (asset) type	1) Business loans include all on-balance sheet loans and lines of credit to businesses, nonprofits, and any other structure of organization that are not traded on a market and are for general corporate purposes, i.e., with unknown use of proceeds as defined by the GHG Protocol. 2) Revolving credit facilities, overdraft facilities, and business loans secured by real estate such as CRE-secured lines of credit are also included.	Yes	Yes	**No- HSBC excludes facilities origination shorter than 12 months and facilities with weak link to production activities**	Yes
3. GHG boundary	1)Institutions **shall** disclose the absolute emissions (scope 1 and 2 combined) of their loans and investments 2) Financial institutions **shall** start reporting scope 3 emissions for the oil, gas, and mining sectors from 2021 onward	**No- for power generation only covers scope 1**	**Partial- it covers scope 1 and 2 for its power segment's absolute financed emissions. However, for power segment's physical intensity metrics, it only covers scope 1.**	**No- for aviation only covers scope 1 and scope 3**	**Partial- it covers scope 1 and scope 2 GHG emissions. However, it is unclear if scope 3 is covered for its energy sector financed emissions based on current disclosure**
4. Gases and units:	1) Financial institutions **shall** account for the seven gases under the Kyoto Protocol that are also mandated under the UNFCCC to be included in national inventories if they are emitted in the value chain. These are carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), sulfur hexafluoride (SF_6), and nitrogen trifluoride (NF_3). 2) These seven gases **shall** be converted to carbon dioxide equivalents (CO_2e) using the 100-year time horizon global warming potentials published by the IPCC	Yes- all financed emissions are calculated as carbon dioxide equivalents (CO_2e).	Yes- all financed emissions are calculated as carbon dioxide equivalents (CO_2e).	**No- only oil&gas sector's emissions are calculated as carbon dioxide equivalents (CO_2e); other sectors covers CO_2 only**	Yes- all financed emissions are calculated as carbon dioxide equivalents (CO_2e).
5. Emissions removal/ carbon credits	1. Absolute emissions **shall** be reported without taking into account carbon credits retired by clients to offset these emissions. Carbon credits retired by clients may be reported, and if so, shall be reported separately. 2. If financial institutions choose to disclose emission removals or avoided emissions, they **shall** disclose absolute emission removals or avoided emissions separately from the financial institution's scope 1, scope 2, and scope 3 inventories	**No- no separate disclosure noticed for emissions removal**	Yes	Yes	Yes

Source: Authors' analysis of PCAF 2022;[2] J.P. Morgan;[11,12] BoA;[13,14] Citi;[15,16] HSBC;[17] and ING.[18]

Table 1B. Financed emissions and target for oil& gas sector reporting by 5 selected GSIBs (based on 2022 reporting)

	JP Morgan	BoA	Citi	HSBC	ING
Financed Emissions					
Reporting Standard	JP Morgan Carbon Compass	PCAF	PCAF	PCAF	PCAF
Reporting Format	Physical emissions intensities (g CO2e / MJ and gCO2 / MJ)	Absolute and economic emission intensities (tCO2 e/outstanding in million)	Absolute, physical emissions intensities (g CO2e/MJ) and economic emission intensities (mt CO2e/ $MM Committed)	Absolute and physical emissions intensities (Mt CO2e/Ej)	Absolute and economic emissions intensities (t CO2e/€MM)
Financed Emissions Calculation	**Operational carbon intensity** (Scope 1 + 2 Emissions - Credits (g CO_2e)) (Embedded Energy in Oil + Gas + Bioenergy (MJ)) **End Use carbon intensity** (Scope 3 Emissions - Credits (g CO_2)) (Embedded Energy in Oil + Gas + Bioenergy + Other Renewables (MJ))	Absolute: **Listed Companies:** $\sum_C \frac{\text{Outstanding amount}_c}{\text{Enterprise Value Including Cash (EVIC}^{14})_c} \times \text{Client Emissions}_c$ **Private Companies:** $\sum_C \frac{\text{Outstanding amount}_c}{\text{Total Equity + Debt}_c} \times \text{Client Emissions}_c$	Absolute: **Listed Companies:** $\sum_C \frac{\text{Outstanding amount}_c}{\text{Enterprise Value Including Cash (EVIC}^{14})_c} \times \text{Client Emissions}_c$ **Private Companies:** $\sum_C \frac{\text{Outstanding amount}_c}{\text{Total Equity + Debt}_c} \times \text{Client Emissions}_c$ [Note: There are different approaches when client's financial or emissions are not available]	Absolute: $\text{On-balance sheet financed emissions} = \sum \text{attribution factor} \times \text{counterparty emissions}$ $\text{Attribution factor} = \sum \frac{\text{outstanding amount}}{\text{economic value}}$ Economic value has waterfall approach: EVIC/ Total debt and equity/ Total assets	No specific formula disclosed in 2022 climate report; but based on disclosure, financed emissions are reported with PCAF standard
Reporting basis	Includes direct exposure (ie. RCF, in total limit, not just outstanding) and share of facilitated financing (underwriting in debt and equity capital market) The methodology currently allows all types of company implemented carbon removals — including carbon capture, use and storage (CCS/CCUS), direct air capture and nature-based solutions	Advising and underwriting transactions in the debt and equity capital markets, as well as tax equity investment are currently not included (inline with PCAF) Reporting on outstanding level (inline with PCAF)	Capital markets activity, structured products (such as derivatives, hedging or trading) and tax equity-financed projects are excluded (inline with PCAF) Reporting on both outstanding level (inline with PCAF) and committed exposure level	Only include products for which the typical original term is 12 months or longer Product types that were excluded include limited recourse receivables finance and trade finance products (import, export, bills) and corporate activities which are not lending products	Do not use any offsetting in measuring its portfolio.
Target					
Reporting Format	Same as financed emissions reporting	Physical emissions intensity Sector Intensity: $\text{Company Scope 1 and 2 Intensity} = \frac{\text{Energy Company Scope 1 and 2 } CO_2e \text{ emissions (g)}}{\text{MJ of energy produced}}$ $\text{Company Scope 3 Intensity} = \frac{\text{Energy Company Scope 3 } CO_2 \text{ emissions (g)}}{\text{MJ of energy produced}}$ Portfolio Intensity: $\text{Weighted Average Physical Unit Intensity} = \sum \left(\frac{\text{Client Emissions}}{\text{Client Production}} \times \frac{\text{Client Financing}}{\text{Total Sector Financing}} \right)$	Absolute emissions (M mt CO2e) [Note: for other industries, targets are set at physical emissions format]	Absolute emissions (M mt CO2e) [Note: for other industries, targets are set at physical emissions format]	OS amount (EUR Million) (M mt CO2e) [Note: for other industries, targets are set at physical emissions format]
Reporting basis	Appear to be the same base as financed emissions reporting	Targets are set using committed commercial credit exposure (instead of outstanding) Targets appear to be reported on net basis (allow for client use of carbon offset)	Targets are set using committed commercial credit exposure (instead of outstanding)	Appear to be the same base as financed emissions reporting	Different basis and methodologies adopted for target. For example, for oil& gas segment, it used PACTA Credit Application Paper to set up target. For the rest of the industries, each also applied different standard

Source: Author analysis of PCAF;[2] J.P. Morgan;[11,12] BOA;[13,14] Citi;[15,16] HSBC;[17]and ING.[18]

2.2 Challenges

We reviewed the academic literature and sustainability reporting of major banks to understand common critiques of the methodology and how they have been addressed. The relevant literature on commonly adopted financed emissions approaches is limited since common standards created by PCAF were only published in 2020. Our findings are summarized below, grouped under the two themes of (1) lack of comparability and (2) volatility.

Challenge #1: Lack of Comparability

PCAF reporting standards provide financial institutions flexibility in how they calculate both emissions and financial value for different activities and parts of their value chain. This means that financed emissions calculations for different parts of a financial institution's business may use different methodologies, and different financial institutions will use different methodologies overall. We summarize some of the commonly arising critiques about lack of comparability below:

i. Emissions disclosed in differing formats

PCAF allows financed emissions metrics to be presented in the following forms:[24]

1. Absolute emissions;
2. Economic emissions intensity (absolute emissions divided by the loan or investment);
3. Physical emissions intensity (absolute emissions divided by a value of physical activity or output);
4. Weighted average carbon intensity (portfolio's exposure to emission-intensive companies, expressed as tCO_2e/USD or MM USD company revenue).

We also observed similar guidance from NZBA (Net Zero Banking Alliance) to its members,[25] where the financed emissions profile of the bank's portfolio shall be calculated and disclosed annually in either of the following form: absolute emissions, portfolio-wide emissions intensity (CO_2e/USD lent or invested), or sector-specific emissions intensity (CO_2e/metric). The various metrics reporting formats contributed to one of the PCAF methodology challenges for low comparability across the Financial Institutions.[26]

One recent case study of four US banks in the energy sector by Rajgopal[27] indicated

[24] *The Global GHG Accounting and Reporting Standard Part A*.

[25] *Guidelines for Climate Target Setting for Banks* (Geneva: UN Environment Finance Initiative, April 2021), https://www.unepfi.org/wordpress/wp-content/uploads/2021/04/UNEP-FI-Guidelines-for-Climate-Change-Target-Setting.pdf.

[26] Lisa Sachs, Nora Mardirossian, and Perrine Toledano, *Finance for Zero: Redefining Financial-Sector Action to Achieve Global Climate Goals* (New York: Columbia Center on Sustainable Investment, June 2023), https://ccsi.columbia.edu/finance-for-zero.

[27] Shiva Rajgopal, "The Hotchpotch World Of Financed Emissions: A Case Study Of Top Four US Banks In The Energy Sector," *Forbes*, April 19, 2023, https://www.forbes.com/sites/shivaramrajgopal/2023/04/19/the-hotchpotch-world-of-financed-

that only one of four banks in the case study reported financed emissions in multiple formats (absolute, economic emissions, physical emissions) which allows some degree of comparability; the other three only reported in one format. A similar study from Ceres looking at six US banks in the energy sector[28] also showed that only two out of six of the US banks it studied met the "best practice" to disclose financed emissions in both absolute amount and physical emissions intensity.

ii. Financial value is calculated using different methodologies within and between portfolios

To calculate financed emissions, financial institutions use an "attribution factor" to calculate the relevant financial value exposed to emissions. Financial institutions use different attribution factors for different portions of their financial portfolio, and among financial institutions.

Under the PCAF guidance, financed emissions are calculated as follows:

$$Financed\ Emissions = \Sigma_i\ Attribution\ factor_i * Emissions_i$$

PCAF recommends calculating the attribution factor using enterprise value including cash (EVIC) for listed companies, using debt plus equity (D+E) for unlisted companies, or using total assets if D+E is not available.

For listed companies:

$$Attribution\ factor_c = \frac{Outstanding\ amount_c}{Enterprise\ Value\ Including\ Cash_c}$$

For bonds to private companies:

$$Attribution\ factor_c = \frac{Outstanding\ amount_c}{Total\ equity + Equity_c}$$

(with c = borrower or investee company)

For business loans and equity investments to/in private companies:

$$Attribution\ factor_c = \frac{Outstanding\ amount_c}{Total\ equity + Debt_c}$$

PCAF defines EVIC as follows:

> *The sum of the market capitalization of ordinary shares at fiscal year-end, the market capitalization of preferred shares at fiscal year-end, and the book values of total debt and minorities' interests. No deductions of cash or cash equivalents*

emissions-a-case-study-of-top-four-us-banks-in-the-energy-sector/?sh=378da9f4538b.

[28] Blair Bateson, Simon Dietz, and Tess Sokol, *U.S. Banks and the Road to Net Zero: Analyzing the 2030 Oil and Gas Targets of the Six Largest U.S. Banks* (Boston: Ceres, April 2023), https://www.ceres.org/resources/reports/us-banks-and-road-net-zero.

are made to avoid the possibility of negative enterprise values.[29]

Under existing standards, although PCAF has preferred attribution factor by asset class, financial institutions still have some discretion to apply different factors for different portions of the portfolio (especially with respect to non-public companies). Portfolio construction will also differ from one institution to another. Together, this means that variation in financed emissions calculations will be driven largely by methodological choices regarding attribution factor and portfolio structure, rather than any underlying connection between the portfolio and emissions in the material economy.

iii. Incomplete scope in terms of activities

Until December 2023, PCAF's financed emissions covered listed equity and corporate bonds, business loans and unlisted equity, project finance, commercial real estate, mortgages, motor vehicle loans, and sovereign debt, but not banks' facilitation activities, such as underwriting. In December 2023, PCAF issued guidance on facilitated emissions accounting standards,[30] but these standards do not yet appear to be widely adopted: most banks did not report them as part of the financed emissions disclosures, and based on the report from ShareAction, only 16% of the reviewed banks report capital market facilitation in their sectoral targets.[31]

Capital market facilitation can be material, especially for the fossil fuel industry,[32] with 51% of the financing activities being underwriting. Even if some banks report certain business activities that are not covered by PCAF (such as underwriting), the level of transparency still varies among banks.[33] Financed emissions disclosures thus reflect a partial view of a financial institution's exposure to GHG emissions, and one that varies from institution to institution, further reducing comparability.

iv. Different approaches to account for financed emissions in each industry sector's value chain

PCAF provides the financed emission calculation guidance based on financial asset type instead of industrial sector type. As a result, the decisions that financial institutions make as to which part of the industry sector value chain to include in financed emissions calculations – and, separately, for climate targets – can also limit the comparability among peers.

This challenge is commonly observed in the oil and gas sector. For example, Wells

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[29] *The Global GHG Accounting and Reporting Standard Part A*.

[30] *The Global GHG Accounting and Reporting Standard Part B: Facilitated Emissions, First Version* (PCAF, December 2023), https://carbonaccountingfinancials.com/files/PCAF-PartB-Facilitated-Emissions-Standard-Dec2023.pdf.

[31] *NZBA Round 1: An Assessment of Banks' Decarbonisation Targets* (London: ShareAction, October 2022), https://shareaction.org/reports/nzba-round-1-an-assessment-of-banks-decarbonisation-targets.

[32] Kirsch Alison, Marr Grant, Opeña Disterhoft Jason, Butijn Henrieke, Frijns Johan, Beenes Maaike, Saldamando Alberto, Johnson Mea, Rees Collin, Tong David, Gracey Kyle, Stockman Lorne, Faul Clément, Lentilhac Maude, Cooper Ryan, Louvel Yann, Shraiman Adele, Cushing Ben, Dubslaff Julia, and Katrin Ganswindt, *Banking on Climate Chaos: Fossil Fuel Finance Report 2022* (Rainforest Action Network (RAN), BankTrack, Indigenous Environmental Network (IEN), Oil Change International (OCI), Reclaim Finance, Sierra Club, and Urgewald, March 2022), https://www.ran.org/wp-content/uploads/2022/03/BOCC_2022_vSPREAD-1.pdf.

[33] Bateson, Dietz, and Sokol, *U.S. Banks and the Road to Net Zero*.

Fargo excluded emissions associated with the financing of downstream operations of integrated oil companies to avoid double counting, but the five other largest US banks include them.[34] In addition, most of the US banks cover exploration and production activities, but excluded midstream services (such as storage and transportation), reducing the resulting footprint estimate.[35] In other cases, some banks include renewable energy or low-carbon fuel in the same sector as oil and gas for their target setting, which may create a misleading impression of the decarbonization path of that target.[28]

Challenge #2 Market Volatility

There has been increasing attention to how changes affecting portfolio value unrelated to emissions introduce volatility in financed emissions calculations.[36, 37, 38]

The volatility caused by attribution factors, such as changes to stock price or inflation, may create confusing or misleading financed emission reporting and adversely affect the reliability of climate-related financial disclosures – and the decarbonization strategy – of financial institutions.

To illustrate the effect of market volatility on the calculation of financed emissions metrics, we begin by demonstrating the effect of the economic contraction from the COVID-19 pandemic when using EVIC for the attribution factor for a single listed company: Chevron Corporation (CVX). Table 2 below shows the EVIC and GHG emissions of CVX as well as the calculated financed emission during 2019–2022. Assume a financial institution lends CVX USD 0.1 billion for this period, the financial institution's financed emissions intuitively should directionally align with CVX's emissions during 2019–2022 given the outstanding amount is fixed. However, this is not the case as demonstrated in Table 2 below.

Table 2. Chevron's EVIC, GHG emissions and financed emissions movement

Chevron Corporation	2019	2020	2021	2022
EVIC (billion)	259	212	262	372
Outstanding (billion)	0.1	0.1	0.1	0.1
GHG Emissions (million metric tons)	1,162	1,115	1,221	1,094
GHG change %	-	*-4%*	*10%*	*-10%*
Financed Emissions				
Financed Emissions- EVIC (million metric tons)	0.45	0.53	0.47	0.29
Financed Emissions- EVIC change %	-	*17%*	*-12%*	*-37%*

Source: Factset, Chevron's website

From Table 2, we noticed:

1. During economic contraction from COVID-19, CVX-associated financed emissions increased even when the company's emissions decreased. From 2019 to 2020, CVX emissions decreased by 4% in 2020 compared to 2019

[34] Bateson, Dietz, and Sokol, *U.S. Banks and the Road to Net Zero*.

[35] Sierra Club "Leaders or Laggards? Report Analyzes Net-zero Pledges of US Banks," press release, November 2, 2022, https://www.sierraclub.org/press-releases/2023/09/leaders-or-laggards-report-analyzes-net-zero-pledges-us-banks.

[36] Thomä, Dupré, Hayne, "A Taxonomy of Climate Accounting Principles for Financial Portfolios."

[37] Gaskell, "Why the Choice of Carbon Metric Matters."

[38] Ducoulombier, and Liu, "Carbon Intensity Bumps on the Way to Net Zero."

driven by the COVID-19 pandemic. During that same period, financed emissions increased by 17% during the same period because EVIC decreased by 18%; that is, the enterprise value of CVX decreased more rapidly than emissions.

2. During economic recovery following the COVID-19 pandemic, CVX-associated financed emissions decreased while CVX GHG emissions increased. CVX's 2021 GHG emissions increased by 10% compared to 2020. CVX financed emissions, on the other hand, decreased by 12% during the same period because CVX's EVIC grew by 24% – CVX enterprise value grew faster than its actual emissions.

The example above illustrates the volatility of the denominator (i.e. EVIC in this example) will impact the direction of the financial institution's financed emissions, despite actual emissions changing in the opposite direction and despite the fact that there is no change on the outstanding amount of debt to the company during the same period. As a result, during market downturn, the financial institution's financed emissions may trend upward merely due to the market volatility, even if the GHG emission of the company decreases, and vice versa during a market rally.

PCAF recognizes that market value fluctuations reduce the utility of EVIC in financed emissions calculations, proposing the concept of "adjusted EVIC." However, the standards leave the mechanism of adjustment open to each financial institution, provided that there is sufficient disclosure.[39] This approach diminishes comparability between institutions and introduces opportunities for gaming. More recently, Banks have begun to acknowledge the issue and attempted to address it. For example, WFC addressed volatility in its target-setting methodology (CO_2e Mission) by fixing client value at the end of the quarter that the financing activity occurred. J.P. Morgan uses a 3-year rolling average for client value.

Thomä et al.[40] suggest that accounting choices are equally important to the data quality where more awareness and standards are required. Currently, there have been several articles discussing the WACI (weighted revenue) and PCAF (EVIC) approaches:

Gaskell[41] reviews how the EVIC movement can impact investors' financed emission calculations and assesses the pros and cons among three attribution factors: financed emissions, economic emissions intensity, and WACI. Gaskell concludes that each metric provides different perspectives and that investors should disclose all of them and disaggregate them if possible.

Ducoulombier and Liu[42] prefer the revenue approach as the EVIC approach introduces the market volatility into the equation which incapacitates the connection between carbon intensity (CI) and the real decarbonization progress. In addition, not all companies are publicly listed. While PCAF suggested to use book value (balance sheet approach) for private companies, this also creates the comparability problem among the

[39] *The Global GHG Accounting and Reporting Standard Part A.*

[40] Thomä, Dupré, Hayne, "A Taxonomy of Climate Accounting Principles for Financial Portfolios."

[41] Gaskell, "Why the Choice of Carbon Metric Matters."

[42] Ducoulombier, and Liu, "Carbon Intensity Bumps on the Way to Net Zero."

portfolio. Another analysis done by Brightman et al.[43] concluded that both approaches are largely similar with material growth bias (with EVIC approach's bias slightly stronger) and both approaches are suitable for investment purposes.

Howell and Shreck[44] analyze the wide variation in financed emissions outputs and the implications for bank performance that arise from different methodological choices as to emissions factor, financial attribution factor, and scope, by comparing disclosures of Citi and J.P. Morgan. They conclude that banks should rely on and disclose multiple metrics when communicating their climate risks and impacts, that care should be taken to sync the timing of emissions and financial data, and that, ultimately, regulation should help standardize relevant reporting.

Prior to PCAF methodology, the Taskforce on Climate-Related Financial Disclosure (TCFD) recommended the Weighted Average Carbon Intensity (WACI) metrics for asset owners or asset managers- which is easy to use and is not sensitive to share price movements.[45] Reporting only in emissions intensity may, however, be misleading if not accompanied with absolute emissions, since emissions intensity reductions can be achieved while absolute emissions continue to grow. In October 2022, ShareAction published a report that examined 43 large banks that are NZBA's members and with exposures to the fossil fuel industry.[46] It observed that the majority of the reviewed banks only report or set targets on emissions intensity.[47] A separate report published by Sierra Club in November 2022 also reached a similar conclusion for fossil fuel industry metrics after reviewing six financial institutions in the US.[48]

3. Modeling the effect of volatility on a hypothetical financial portfolio

To demonstrate the effect of volatility on a financial portfolio, we model this effect using a hypothetical portfolio weathering the two most recent financial crises. We focus on examining the volatilities among three methodologies introduced by PCAF: EVIC, D+E and total assets, and specifically focusing on periods of economic contraction and recovery rather than short-term volatility. When examining the market volatilities, the current literature primarily focuses narrowly on comparing the application of financed emissions methods (like PCAF) with portfolio-weighted methods (like WACI). This paper seeks to understand the basis for volatility across various attribution factors and what factors may reduce this effect.

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[43] Chris Brightman, Vitali Kalesnik, Ari Polychronopoulos, and Joseph Shim, "Carbon Intensity for Climate Mitigation: Clearing Up "Scaling" Confusion," *Research Affiliates,* July 2022, https://www.researchaffiliates.com/publications/articles/924-carbon-intensity-for-climate-mitigation.

[44] Andrew Howell and Maxamilian Shreck, *Carbon Conundrum: The Curious Case of Financed Emissions* (New York: Environmental Defense Fund, September 2023), https://www.edf.org/sites/default/files/2023-09/ESG-EDF_Financed_Emissions.pdf.

[45] TCFD, 2017, Recommendations of the Task Force on Climate-related Financial Disclosures, https://assets.bbhub.io/company/sites/60/2021/10/FINAL-2017-TCFD-Report.pdf

[46] *NZBA Round 1: An Assessment of Banks' Decarbonisation Targets*.

[47] Ibid.

[48] *Banking on Climate Chaos: Fossil Fuel Finance Report 2022*.

3.1 Methodology

To understand the impact of the economic cycle on the reliability of financed emissions calculations, we model the effects on a hypothetical investment portfolio during the two most recent major economic downturns.

To model a portfolio, we first identify companies from three US S&P indices – S&P 500, Midcap 400, SmallCap 600 – and global top-10 players not captured in these indices for five high-emissions industries: automobile manufacturers, energy, passenger airlines, steel, and utilities. Based on the criteria, 90 companies were selected for the portfolio, with industry distributions as below:

- Auto manufacturers (11)
- Energy (25)
- Passenger airlines (14)
- Steel (9)
- Utilities (31)

We include both large-, mid-, and small-cap companies in the model portfolio with the expectations that volatility will affect companies of different sizes differently. We would expect larger companies to tend to have more access to capital and more diversified in business operations. As a result, large companies may have less volatile stock prices or balance sheet movement compared to that of smaller companies. We therefore also modeled a portfolio with only mid- and small-cap companies to analyze how company size may affect financed emissions results.

We then collect the market and financial data of these companies for two economic cycles (2008 financial crisis and 2020 COVID-19 pandemic). We then calculate the financed emissions using three approaches, EVIC, D+E, and total assets, assuming the outstanding amount are the same for all companies during the period (USD 0.1 billion).

For company emissions, we use each company's 2021 emission data (scopes 1, 2 and 3), holding emissions levels constant across 2007–2009 and 2019–2021. We hold this data constant for three reasons. First, there is significantly less company level emissions data available prior to 2021, and especially for the 2007–2009 period. Second, it allows us to focus on the impact of financial valuation on the financed emissions calculations, holding emissions constant. Third, we would expect that holding emissions constant reduces any adverse impacts of volatility on a financed emissions calculation reliability. We chose 2021 emissions data as it represents the most recent emissions data for the majority of the selected companies when we construct the portfolio.

Finally, we use Coefficient of Variation (COV) to measure volatility. COV is the ratio of the standard deviation of data over the mean.

$$COV = \frac{Standard\ deviation\ (\sigma)}{mean\ (\mu)}$$

The higher the COV, the greater the level of dispersion around the mean, hence more

volatile.[49] Since we are using 2021 emissions for all companies in the portfolio across 2007–2009 and 2019–2021, the hypothesis financed emissions at portfolio level are not affected by the movement of emissions but impacted by the change of each company's enterprise value or book value of debt, equity or asset level over time. We first show the results for all companies, then we separately calculate the results for mid- and small-cap companies to see if we get similar results.

3.2 Results

Results for a portfolio of all companies

Table 3 provides the COV of financed emissions, using three financial metrics, for a model portfolio of all company sizes: large-, mid-, and small-cap. The book value approach (using D+E or total assets) has lower COV than EVIC approach in four out of five industries during the last two economic downturns (i.e. 2007–2009 or 2019–2021).[50] These four industries are automobile manufacturers, energy, airlines, and steel. Take automobile manufacturers for example, during 2007–2009, financed emissions calculated using D+E has the lowest volatility among the three methods (0.07 of COV) while financed emissions calculated using EVIC has the highest volatility (0.17 of COV).

Table 3. Coefficient of variations under different methodology by industry

Automobile Manufacturers		
Coefficient Variations	2007-2009	2019-2021
Financed Emissions- EVIC	0.17	0.19
Financed Emissions - D+E	**0.07**	0.20
Financed Emissions - Total Assets	0.12	**0.12**
Energy		
Coefficient Variations	2007-2009	2019-2021
Financed Emissions- EVIC	0.20	0.20
Financed Emissions - D+E	0.12	**0.10**
Financed Emissions - Total Assets	**0.06**	0.12
Airlines		
Coefficient Variations	2007-2009	2019-2021
Financed Emissions- EVIC	0.12	**0.07**
Financed Emissions - D+E	**0.05**	0.10
Financed Emissions - Total Assets	0.08	0.09
Steel		
Coefficient Variations	2007-2009	2019-2021
Financed Emissions- EVIC	0.24	0.17
Financed Emissions - D+E	0.07	**0.12**
Financed Emissions - Total Assets	**0.06**	**0.12**
Utilities		
Coefficient Variations	2007-2009	2019-2021
Financed Emissions- EVIC	**0.05**	**0.02**
Financed Emissions - D+E	0.07	0.06
Financed Emissions - Total Assets	0.07	0.05

Source: Authors' analysis of US S&P indices – S&P 500, Midcap 400, and SmallCap 600.

The only sector that has lower COV using EVIC is the utility industry for both 2007–

[49] So, for example, a company whose financed emissions calculator has a high COV (say, steel), it is because the value is rarely the mean value, whereas for one with a low COV (say, utilities), the financed emissions values are closer to the mean value.

[50] Further analysis could compare the effects on volatility of prioritizing the two book value approaches different among portfolios, but would require analysis of unlisted company data.

2009 and 2019–2021 as shown in Table 3. This may be attributable to the industry's nature, as the utility sector has been viewed as non-cyclical industry.[51] To confirm this hypothesis, we compared the 2023 betas[52] of the five sectors analyzed.[53] Based on the US sector beta published by NYU,[54] utilities (general utility and power) have the lowest industry beta among the five reviewed sectors and is the only reviewed sector with industry beta below 1.0 as illustrated in Table 4.

Table 4. US Sector betas[55]

Industry	beta (Jan 2023)
Auto & Truck	1.54
Oil/Gas (Production and Exploration)	1.26
Air Transport	1.42
Steel	1.34
Utility (General)	0.64
Power	0.73

Source: NYU[47]

Results for a portfolio of mid- and small-cap companies

We expected mid- and small-cap companies securities to be more volatile, and thus have more volatile financed emissions results. We therefore calculate COV of mid- and small-cap companies' financed emissions separately. This allows us to discover whether the EVIC approach is more volatile for mid- and small-cap companies and whether the book value approach also has lower volatility for mid-and small- companies.

Note that there are no mid- or small-cap auto manufacturers in our hypothesis portfolio. The results for the rest of the four industries can be found in Table 5. From the results, we confirmed that mid- and small-cap companies experienced more volatility than that of large-cap companies for the studied period, especially for energy, airlines and utilities sectors in the 2007–2009 cycle. Taking the energy sector as an example, the financed emissions' COV using EVIC was 0.2 for all companies during 2007–2009, while COV using EVIC was 0.32 for mid- and small-cap companies for the same period.

In terms of volatility across the three valuation methodologies, we observe a similar pattern for mid- and small-cap companies: the book value approach (using D+E or total assets) have lower COV than EVIC approach in three out of four industries during the

[51] De Heer, M., Koller, T., Schauten, M. B., & Steenbeek, O. W. (2000). The valuation of cyclical companies. The McKinsey Quarterly, 62-96.

[52] Beta measures the volatility of a security relatively to the broader market. A beta of over 1.0 implies a more cyclical security, and a beta below 1.0 implies less cyclical one.

[53] The sector betas appeared generally consistent with 2023 in the other years analyzed in this study.

[54] Aswath Damodaran, "Betas by Sector (US)," New York University, January 2024, https://pages.stern.nyu.edu/~adamodar/New_Home_Page/datafile/Betas.html.

[55] Data are updated annually in January. Aswath uses a simple average of each firm's beta across firms, taken as a weighted average of 2-year and 5-year weekly return regression betas, with 2-year betas weighted 2/3rds. If the company has only a 2-year beta, it is used.

last two economic fluctuation period (i.e. 2007–2009 or 2019–2021). For the utilities sector, while the financed emission COVs are in general more volatile for mid- and small-cap companies; financed emissions calculated using EVIC still demonstrated the lowest volatility among the three approaches for both 2007–2009 and 2019–2021 period.

Table 5. Coefficient of variations under different methodology by industry for mid- and small-cap companies only

Energy (Small/Medium cap)

Coefficient Variations	2007-2009	2019-2021
Financed Emissions- EVIC	0.32	0.14
Financed Emissions - D+E	0.31	0.10
Financed Emissions - Total Assets	**0.28**	**0.08**

Airlines (Small/Medium cap)

Coefficient Variations	2007-2009	2019-2021
Financed Emissions- EVIC	0.10	**0.02**
Financed Emissions - D+E	0.10	0.07
Financed Emissions - Total Assets	**0.09**	0.09

Steel (Small/Medium cap)

Coefficient Variations	2007-2009	2019-2021
Financed Emissions- EVIC	0.29	0.28
Financed Emissions - D+E	**0.00**	0.18
Financed Emissions - Total Assets	0.05	**0.17**

Utilities (Small/Medium cap)

Coefficient Variations	2007-2009	2019-2021
Financed Emissions- EVIC	**0.08**	**0.06**
Financed Emissions - D+E	0.09	0.08
Financed Emissions - Total Assets	0.25	0.07

4. Conclusion

The findings of the present research provide some useful insights as to how to improve the financed emissions metrics and their limitations.

First, our analysis suggests that using a book value approach for the attribution factor may potentially reduce the volatility in financed emission calculations of high-emissions sectors and at the portfolio level. We did not reach a conclusion regarding the cost and benefits between the two book value approaches or, indeed, using another accounting metric for the attribution factor. It would do so by reducing the effect on financed emissions values of market volatility that does not correspond to any underlying change in emissions of portfolio companies. It will not eliminate the effect on financed emissions calculations of changes in economic conditions that affect book value (or other accounting metrics that do not reflect market sentiment) across a portfolio. Though the book value approach is unable to completely remove the perverse effects of volatility on financed emissions attribution factors – accounting numbers may change during an economic shock in ways not corresponding with commensurate emissions changes – it may at least reduce those impacts relative to using EVIC as an attribution factor.

Second, using the book value approach to calculate financed emissions across both listed and unlisted companies can help to enhance comparability across financial institutions to some degree. Currently, PCAF suggests deriving the attribution factor using EVIC for publicly listed companies and debt + equity (or total assets) for private companies. PCAF's approach of encouraging an elective mix of attribution factors causes inconsistency and reduces the comparability depending on the portfolio composition of each financial institution. In principle, other accounting numbers disclosed by portfolio companies not subject to the volatility induced by market sentiment would reduce volatility, and consistent, standardized application of them should improve comparability. Unifying the approach to book value methodology would be a way to reduce volatility across the portfolio while eliminating one source of non-comparability.

Limitations

While the conclusions drawn from this paper may help to address the two key challenges when reporting financed emissions as discussed earlier, we should also bear in mind that these findings were tested within a limited scope and data availability.

The first limitation of our current methodology is the lack of comprehensive historical company emissions. As there are no sufficient comprehensive historical company emissions data for us to calculate the financed emissions, we assume the company emissions to hold constant for all years (i.e. at 2021 level). By doing so, the changes in financed emissions throughout years are purely driven by the change of company's EVIC, D+E or total assets in each year. In reality, the volatility of the financed emissions will likely be *more than* what we showed in the hypothesis portfolio if we were able to incorporate a company's GHG emissions for each year. In the last two major contractions, financed emissions calculations implied emissions growth while economic activity in the economy at large, and thus emissions, declined in the face of a crisis. That contraction of material economy emissions would imply any even greater apparent financed emissions increase than the modeled portfolio where the emissions factor was held constant. We would also expect the inverse to be true. During two modeled economic recoveries, apparent financed emissions decreased even with the emissions factor held constant, but a productivity surge during a recovery would correspond to an increase in associated emissions by financed entities.

The second limitation is that we are only able to cover a limited number of companies in our hypothesis portfolio (with the majority being US companies), which may not be representative of the whole industry. Should we expand the portfolio to a different geography or expand to include more entities, the results may vary.

While there is no perfect methodology to measure financed emissions, we hope this paper can contribute to the current literature and raise a broader discussion in the industry to rethink the financed emission methodology and the way of reporting. Our results also imply that users of financial institution's climate-related disclosure would benefit from considering a range of metrics to assess the financial institution's transition risk – and indeed impact – and avoid over-reliance on a single metric.

Appendix- Detailed Hypothesis Portfolio Methodology

Step 1- Identify companies from S&P 500, S&P MidCap 400, S&P SmallCap 600, and world top 10 players in selected industries

We select companies from three US S&P indices. S&P covers a wide range of industries with 11 Global Industry Classification Standards (GICS) including Energy, Material, Industrials, Consumer Discretionary, Consumer Staples, Health Care, Financials, Information Technology, Communication Services, Utilities and Real Estate.[56] The three S&P indices represent a group of different size US companies. In addition, these public listed companies tend to have better data availability in terms of financial and GHG information. We also include top global players in each selected industry for diversification aspect.

Step 2- Select companies from the following industries/sub-industries

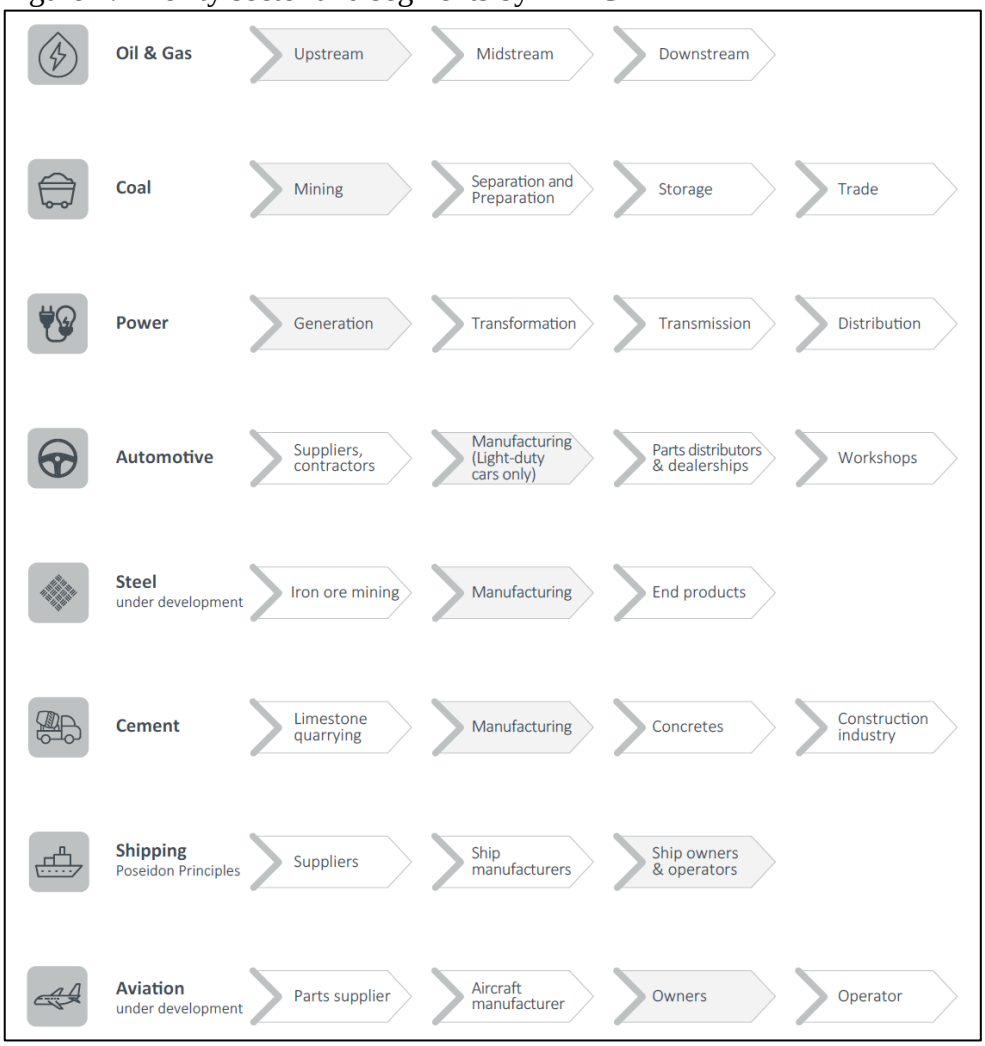
- Consumer Discretionary-Automobile Manufacturers
- Energy- Integrated Oil & Gas; Oil & Gas Exploration & Production
- Industrial- Passenger Airlines
- Materials- Steel
- Utilities- Electric, Multi utilities

Above industries/sub-industries are identified as high emission industries (or sub-industries within the value chain), largely in line with the prioritized industries/subindustries identified by PATCA[57] (Paris Agreement Capital Transaction Assessment) as shown in Figure 1.

[56] "The Global Industry Classification Standard (GICS)," MSCI, 2024, https://www.msci.com/our-solutions/indexes/gics.

[57] *Credit Portfolio Alignment: An Application of the PACTA Methodology by Katowice Banks in Partnership with 2DII* (Paris: 2° Investing Initiative, September 2020), https://2degrees-investing.org/resource/credit-portfolio-alignment-katowice-report/.

Figure 1. Priority sector and segments by PATCA



Source: PACTA[50]

Based on above criteria, we identified 90 companies to include in our hypothesis portfolio. Detail list of companies in each industry can be found in Table 6 below.

Table 6. Hypothesis portfolio composition

Industry	Company
Automobile Manufacturers	Ford Motor Company
Automobile Manufacturers	General Motors
Automobile Manufacturers	Tesla, Inc.
Automobile Manufacturers	Volkswagen Group
Automobile Manufacturers	Toyota
Automobile Manufacturers	Stellantis
Automobile Manufacturers	Mercedes-Benz Group
Automobile Manufacturers	BMW
Automobile Manufacturers	Honda
Automobile Manufacturers	SAIC
Automobile Manufacturers	Hyundai
Energy	Chevron Corporation
Energy	ExxonMobil
Energy	Hess Corporation
Energy	APA Corporation
Energy	ConocoPhillips
Energy	Coterra
Energy	Devon Energy
Energy	Diamondback Energy
Energy	EOG Resources
Energy	EQT
Energy	Marathon Oil
Energy	Occidental Petroleum
Energy	Pioneer Natural Resources
Energy	Petróleo Brasileiro SA - Petrobras
Energy	PJSC LUKOIL
Energy	TotalEnergies SE
Energy	Equinor ASA
Energy	Shell plc
Energy	CNX Resources
Energy	Murphy Oil
Energy	Ovintiv
Energy	Range Resources
Energy	Southwestern Energy
Energy	Callon Petroleum
Energy	Comstock Resources, Inc.

Industry	Company
Airlines	Alaska Air Group
Airlines	American Airlines Group
Airlines	Delta Air Lines
Airlines	Southwest Airlines
Airlines	United Airlines Holdings
Airlines	JetBlue
Airlines	Allegiant Travel Company
Airlines	Hawaiian Holdings, Inc.
Airlines	SkyWest, Inc.
Airlines	China Southern Airlines
Airlines	China Eastern Airlines
Airlines	EasyJet
Airlines	Turkish Airlines
Airlines	Air China
Steel	Nucor
Steel	Steel Dynamics
Steel	Commercial Metals
Steel	Reliance Steel & Aluminum Co.
Steel	U.S. Steel
Steel	Worthington Industries
Steel	ATI Inc.
Steel	Nippon Steel Corporation
Steel	POSCO Holdings
Utilities	Alliant Energy
Utilities	American Electric Power
Utilities	Consolidated Edison
Utilities	Dominion Energy
Utilities	Duke Energy
Utilities	Edison International
Utilities	Entergy
Utilities	Evergy
Utilities	FirstEnergy
Utilities	PPL Corporation
Utilities	Southern Company
Utilities	WEC Energy Group
Utilities	Ameren

Industry	Company
Utilities	CenterPoint Energy
Utilities	CMS Energy
Utilities	DTE Energy
Utilities	Exelon
Utilities	NextEra Energy
Utilities	Pinnacle West
Utilities	Sempra Energy
Utilities	Xcel Energy
Utilities	ALLETE
Utilities	Hawaiian Electric Industries
Utilities	Idacorp
Utilities	PNM Resources
Utilities	Portland General Electric
Utilities	Unitil Corporation
Utilities	Black Hills Corporation
Utilities	NorthWestern Corporation
Utilities	OGE Energy
Utilities	Avista Corporation

Step 3- EVIC, D+E, total assets data collection

Collect 2007–2009; 2019–2021 financial and market from Factset. We collect market and financial data to cover at least 2 economic cycles (2008 financial crisis, 2020 COVID).

Step 4- Emissions data collection

Scope:

PCAF suggests that "Financial institutions shall report the absolute scope 1 and scope 2 emissions of borrowers and investees across all sectors."[1] For reporting the scope 3 emissions, PCAF follows a phase-in approach defined by the EU TEG as shown in the following table:

Table 7- List of sectors with required scope 3 emissions inclusion as defined by the EU TEG

Phase-in period	NACE Level 2 (L2) sectors considered
For reports published in 2021 onwards	At least energy (oil & gas) and mining (i.e., NACE L2: 05-09, 19, 20)
For reports published in 2023 onwards	At least transportation, construction, buildings, materials, and industrial activities (i.e., NACE L2: 10-18, 21-33, 41-43, 49-53, 81)
For reports published in 2025 onwards	Every sector

Source: PCAF[2]

Despite PCAF suggests phased-in approach for reporting scope 3, in the hypothesis portfolio, we collect scope 1-3 emissions for all the selected companies.

Period:
Source 2019-2021 company's scope 1, scope 2 and scope 3 emissions from CDP or company's website/report. GHG data prior to 2019 are often not complete, especially for scope 3 emissions, therefore in this hypothesis portfolio, we focused on 2019 onwards emissions data.

Step 5- Financed emissions calculation for the industry

- Calculate financed emissions for each selected company in the industry
- Attribution Factor: Using EVIC, D+E, and total assets for respective years (in line with PCAF's methodology)
- Outstanding (OS): OS are assumed to be the same for all companies during the period (USD 0.1 Billion)
- Company's emission: Using 2021 emission data to calculate financed emission (assume it is constant across each year, to minimize the variables). 2021 emission is selected as it represents the most recent emission data for majority of the selected companies.

Step 6- Conduct analysis for each industry

Conduct coefficient of variation (COV) analysis between three approaches to derive financed emissions (EVIC, D+E and total assets).