Discovery Exercises

Module 4, Lesson 4: Carbon Metrics and Climate Value-at-Risk

Foundation level. Two pre-class and two in-class activities. Full worked solutions are at the back: try each activity before you check.

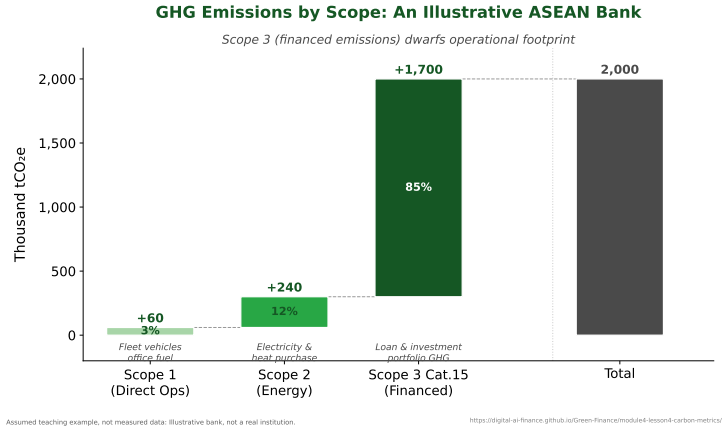
Four activities open the ideas of Lesson 4.4 before, and during, the lecture. The two pre-class tasks take 15 to 20 minutes each and you do them alone. The two in-class tasks take 5 to 10 minutes and you do them with others. Nothing here is graded; the point is to think first, then compare your thinking with the worked solution.

PRE-CLASS Where is a bank's carbon?

15 to 20 min, work on your own, pen and paper

Based on: guided discovery (Mayer 2004)

A greenhouse gas (GHG) footprint is usually split into three scopes: Scope 1 (direct emissions, for example a company's own vehicles), Scope 2 (purchased energy), and Scope 3 (everything else in the value chain). For a bank, Scope 3 Category 15 is its lending and investment portfolio, its **financed emissions**.



A bank's GHG footprint by scope. Read the three shares off the chart.

1. From the chart, roughly what share of the total is Scope 1 plus Scope 2, and what share is Scope 3 (financed emissions)? If you wanted to reduce a bank's carbon footprint, where would you have to look?

2. Now a small portfolio of three companies. Weighted Average Carbon Intensity (WACI) weights each company's carbon intensity (tonnes of carbon dioxide equivalent, tCO_2e, per million dollars of revenue) by its share of the portfolio. Compute weight times intensity for each, then add:

Company	Portfolio weight	Intensity (tCO_2e per \$M)
Power utility	40%	800
Manufacturer	35%	200
Technology firm	25%	15

   Which single company drives the portfolio number, and roughly what share of it does that one company contribute?

3. In one sentence, state the general rule you have just discovered about *where* carbon concentrates for a bank.

Your attempt (before you check the solution at the back):

PRE-CLASS How much of a borrower's emissions belong to the bank?

15 to 20 min, work on your own, pen and paper (optional spreadsheet stretch)

Based on: productive failure (Kapur 2008)

Try this *before* the lecture teaches you the standard method. A bank lends money to a steel company. The outstanding loan is \$50M. The whole company is worth \$500M (its Enterprise Value Including Cash, EVIC). The company emits 200,000 tonnes of carbon dioxide equivalent (tCO_2e) per year.

1. How many of those 200,000 tonnes should the bank count as *its own* financed emissions from this loan? Write down your reasoning first, even if you are unsure. There is a natural ratio hiding in the numbers; try to find it.
2. Apply the same idea to a three-borrower loan book and add up the bank's total financed emissions:

	Borrower	Loan (\$M)	Company value EVIC (\$M)	Emissions (tCO_2e)
A	Steel maker	50	500	200,000
B	Cement maker	20	200	60,000
C	Food processor	10	400	90,000

3. What single ratio did you need for every borrower? Give it a name in your own words.

Your attempt (before you check the solution at the back):

Optional stretch

Set up a spreadsheet with columns Loan, EVIC, Emissions, Attribution (Loan divided by EVIC), and Financed (Attribution times Emissions). Add three more borrowers of your own and sum the Financed column. Which borrower dominates the total, and is it the one with the largest loan or the largest emissions?

IN-CLASS Which climate risk shows up first?

5 to 10 min, think-pair-share

Based on: predict then reveal, testing effect (Roediger and Karpicke 2006)

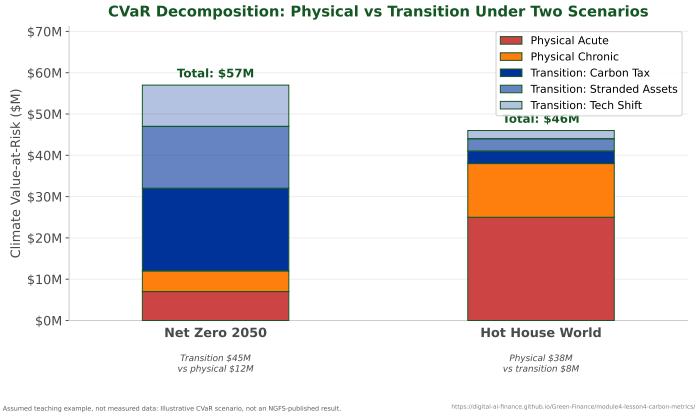
Climate Value-at-Risk (CVaR) is the expected loss of portfolio value under a given climate scenario. It splits into a **Physical** part (floods, storms, heat damaging borrowers) and a **Transition** part (carbon taxes, stranded assets, technology shifts raising borrowers' costs).

1. **Predict (1 minute, on your own).** For a portfolio with heavy fossil-fuel exposure, which

part is larger under each scenario? Write P (Physical) or T (Transition) for each:

- Net Zero 2050 (fast, disorderly transition, strong policy now): _____
- Hot House World (little policy action, severe warming later): _____

2. **Pair (2 minutes).** Compare with a neighbour. Agree on a prediction and one sentence saying *why*.
3. **Share and reveal.** Your instructor now shows the decomposition chart. Were you right? What is the one-sentence rule?



Climate VaR split into Physical and Transition components under two scenarios (revealed after you predict).

IN-CLASS Coal or rice: which is the bigger climate risk for a Vietnamese bank?

5 to 10 min, small groups of 3 to 5

Based on: data and case interrogation, active learning (Freeman et al. 2014)

A representative Vietnamese bank ($30B of assets) has this exposure: Agriculture $5.4B (18% of the loan book) and Coal and Power $0.9B (3%). Coal is the obvious "dirty" sector. As lesson data, take the insurance gap: only about 7% of Vietnamese agricultural output is insured, against about 40% of power infrastructure, so uninsured crop losses flow straight through to the bank. Now read what a flood does to farm lending:

From the case study: Vietnam, Mekong Delta agricultural lending (case study 4)

Agricultural loan default rates rise by about 8 percentage points in the period after a major flood, and the Mekong Delta faces intensifying, more frequent flooding as the climate changes.

1. **Vote first (no arithmetic).** As a group, which sector do you think has the bigger Climate VaR: coal or agriculture?
2. **Now estimate.** Use CVaR $\approx$ Exposure $\times\Delta$PD $\times$ LGD, where ΔPD is the rise in the probability of default and LGD is the loss given default (the fraction not recovered).
   - Agriculture (physical channel): ΔPD = 8%, LGD = 65%.
   - Coal and Power (transition channel, from a $75 per tonne carbon tax): ΔPD = 15%, LGD = 55%.

   Compute the CVaR for each sector.

3. Which is bigger, and by roughly how many times? List the reasons your group can see for the result.

Full Solutions

Try each exercise on your own before you read its solution.

Solution: Where is a bank's carbon?

1. Scope 1 is about 3% and Scope 2 about 12%, so Scope 1 plus Scope 2 is only about 15%. Scope 3 financed emissions are about 85%. To cut a bank's footprint you must look at the lending and investment portfolio, not the bank's own offices.
2. Weight times intensity: Power $0.40 \times 800 = 320$; Manufacturer $0.35 \times 200 = 70$; Technology $0.25 \times 15 = 3.75$. WACI $= 320 + 70 + 3.75 = 393.75$ tCO_2e per \$M. The power utility drives it: $320/393.75 \approx 81\%$ of the portfolio intensity, even though it is only 40% of the portfolio value.
3. Discovered rule: for a bank, carbon concentrates in the portfolio (financed emissions), and within the portfolio a small high-intensity slice can dominate the number. Measure where the carbon is, not where the head office is.

Common misconception. That a bank's own operations (offices, travel) are the main footprint. In fact about 85% is financed emissions, so measuring only Scope 1 and 2 misses almost everything.

Solution: How much of a borrower's emissions belong to the bank?

The standard method is the PCAF (Partnership for Carbon Accounting Financials) attribution: the bank claims the share of the borrower's emissions equal to its share of the borrower's value.

$$\text{Financed emissions} = \frac{\text{Loan outstanding}}{\text{EVIC}} \times \text{Emissions}.$$

1. Steel maker: $\frac{50}{500} \times 200{,}000 = 20{,}000$ tCO_2e.
2. Book total: A $= 20{,}000$; B $= \frac{20}{200} \times 60{,}000 = 6{,}000$; C $= \frac{10}{400} \times 90{,}000 = 2{,}250$. Total $= 28{,}250$ tCO_2e.
3. The ratio you needed is the **attribution factor**, Loan divided by EVIC. It shares each borrower's emissions across its financiers in proportion to how much of the company each one funds.

Common misconception. Counting the borrower's *full* emissions (200,000) as the bank's own, or splitting them equally among lenders. PCAF splits by the loan-to-value ratio, so a small lender to a big company claims only a small share.

Solution: Which climate risk shows up first?

Net Zero 2050: **Transition** dominates (about \$45M versus \$12M physical). Hot House World: **Physical** dominates (about \$38M versus \$8M transition).

Why: Net Zero means strong policy acts now, so carbon taxes and stranded assets bite first (transition pain now, physical relief later). Hot House means little policy, so there is almost no transition cost but severe physical damage builds up later. The one-sentence rule: the scenario you choose decides which risk dominates, so a serious assessment estimates both under several scenarios.

Common misconception. That "climate risk" is a single number. It decomposes into

physical and transition parts, and which part is larger flips depending on the scenario.

Solution: Coal or rice: which is the bigger climate risk?

Agriculture (physical): \$5.4B × 8% × 65% = \$**281**M.
Coal and Power (transition): \$0.9B × 15% × 55% = \$**74**M.
Agriculture has roughly 3.8 times the Climate VaR of coal, the opposite of most people's first vote. Three reasons:

1. **Exposure size:** the agriculture book is six times the coal book (\$5.4B versus \$0.9B), and absolute loss scales with exposure.
2. **Physical vulnerability:** Mekong Delta farming is acutely exposed to flooding, which climate change roughly doubles in frequency.
3. **Insurance gap:** only about 7% of agricultural output is insured against about 40% of power infrastructure, so uninsured losses land on the bank.

Central lesson: exposure size and physical vulnerability can dominate carbon intensity in deciding where financial risk lies.

Common misconception. That the dirtiest sector per tonne (coal) must be the biggest financial risk. A large, uninsured, physically exposed sector can have far more Climate VaR.

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