Scenarios: Imagining Several Futures

Module 4 Companion 3 of 6 lessons

For complete beginners. After this companion you will understand why banks use scenarios, recognise the NGFS family of climate futures, and turn a scenario into a change in a portfolio's default rate.

A handful of drawn futures beats one confident number

A risk team hands the board a report: "Climate will cost us 4 billion by 2050." The board rejects it. Why? Because nobody believes a single confident number about a future this uncertain. The honest answer is not one number but a handful of carefully drawn futures, and a clear statement of what each would do to the bank. That is scenario analysis, and it is the grown-up way to plan when you cannot know the odds.

Start Here: what you need to know first

A few ideas about chance and time come first. Get comfortable with them.

risk versus deep uncertainty. There is a difference between risk and uncertainty. With **risk** you know the odds, like a dice roll. With **deep uncertainty** (sometimes called Knightian uncertainty) you do not even know the odds, because the future is unknown. Climate change is full of deep uncertainty, which is why banks use scenarios, several what-if futures.

probability, percentiles, and the tail. A **probability** is just a number between 0 and 1 saying how likely something is (0.05 means a 5 percent chance). A **probability distribution** is the full picture of every outcome and how likely each is. Two words from it matter here. A **percentile** is the value below which a given share of outcomes fall: the 90th percentile loss is the level only the worst 10 percent of cases exceed. The **tail** is that far end of bad but rare outcomes, where climate disasters live.

Monte Carlo and fan charts. How do you study thousands of possible futures at once? You let a computer roll the dice many times, say ten thousand runs, each with slightly different assumptions, and collect the results. This is a **Monte Carlo simulation**. Drawn on a chart, the spread fans out over time into a **fan chart**: a central line for the typical path and widening bands for the better and worse cases. The width of the fan is the message; it shows how uncertain things are.

present value and the discount rate. A dollar today is worth more than a dollar in thirty years, because today's dollar can be saved and earn interest, and because the far future is uncertain. To compare money across time we shrink future amounts back to today's terms; this is **discounting**, and the shrink rate is the **discount rate**. It matters enormously for climate, where costs land decades away: a high discount rate makes future damage look small today, a low one makes it look large. A future amount expressed in today's money is its **present value**.

RCP, SSP, and the carbon budget. Scientists cannot know exactly how much the world will warm, so they study labelled what-if pathways. An **RCP** (Representative Concentration Pathway) labels how much extra heat the atmosphere traps, written as a number such as RCP 4.5 or the high-emissions RCP 8.5. An **SSP** (Shared Socioeconomic Pathway) labels the kind of society driving it. The extra heat-trapping itself is **radiative forcing**, measured in watts per square metre. The total carbon we can still emit and stay under a temperature limit is the **carbon budget**.

the credit-risk triad, in brief. When a bank lends money it asks three questions about each loan. **PD**, the **probability of default**, is the chance the borrower fails to repay (for example a 5 percent chance, written 0.05). **LGD**, the **loss given default**, is the share of the money the bank would lose if that happens, after selling any collateral (for example 0.60, meaning it recovers 40 percent). **EAD**, the **exposure at default**, is how much is owed at that moment (for example 300 million). Multiplying the three gives the **expected loss**, the average amount the bank expects to lose on the loan: EL = PD × LGD × EAD. Climate risk raises PD (borrowers hit by disasters default more often) and LGD (flooded collateral is worth less), so it raises the expected loss.

percentage points versus percent. Two small units cause big confusion. If a default rate rises from 5 percent to 8 percent, that is a rise of 3 **percentage points** (the gap), not "3 percent." Saying it rose 3 percent would mean it barely moved, to about 5.15. For finer steps bankers use **basis points**: one basis point is one hundredth of a percentage point, so 25 basis points is a quarter of a percentage point. Keeping these straight keeps the numbers honest.

The core idea 1: a scenario is not a prediction

This is the single most important sentence in the lesson: a scenario does not say what *will* happen, only what *would* happen *if* certain choices were made. Because climate is a case of deep uncertainty, no one can put trustworthy odds on the future. So banks study several plausible paths and check that they could survive each. The goal is not to be right about the future; it is to be ready for it.

The core idea 2: the NGFS family of futures

Central banks did not want every bank inventing its own futures, so they built a shared set through a club called the NGFS (the Network for Greening the Financial System), whose first scenarios appeared in 2020. The futures sort neatly by a single tension: act early and you pay transition costs (new taxes, retired assets) but avoid the worst weather; act late or not at all and you dodge transition costs but get battered by physical damage. Three families capture it:

Family	The bargain it strikes
Orderly	We act early and smoothly. Low physical risk, modest transition risk.
Disorderly	We act late and suddenly. Sharp transition shocks.
Hot House World	We barely act. Low transition risk now, severe physical risk later.

There is no free option. Every future trades one kind of risk for the other, which makes the choice a strategic one.

The core idea 3: turning a future into a number

A scenario becomes useful when it moves a number you already understand. The chain is short: a scenario sets how much the economy shrinks, the shrinkage pushes up defaults, and the defaults raise expected loss. The link is a sensitivity, written with the symbol β, that says how strongly a sector's default rate responds to the economy:

$$\boxed{\Delta \text{PD} = \beta \times \Delta \text{GDP}.}$$

Because the future is uncertain, you do not run this once; you run it thousands of times with a Monte Carlo simulation and read the fan chart, where the width of the fan tells the board how confident (or not) to be.

Worked example, every step shown

A Philippine bank studies the Hot House World future. In it, the economy ends up about 8 percent smaller than it would have been (so $\Delta\text{GDP} = 8$ percent of lost output). Its farm loans are sensitive, with $\beta = 1.5$.
Step 1. Apply the link: $\Delta\text{PD} = 1.5 \times 8 = 12$ percentage points.
Step 2, read it. The farm-loan default rate rises by 12 percentage points under this future. If it started at 8 percent it would approach 20 percent. That single figure, produced the same way for every sector, is what lets the bank compare futures and prepare.

Beyond this companion: see the lecture deck

Where do the GDP paths come from? From large computer models called integrated assessment models (such as DICE, REMIND, and GCAM) that couple the economy, energy, and climate. Each contains a damage function $D(T)$ linking warming to lost output, and each takes a discount rate from a long-running debate: Nordhaus favoured a higher rate (future damage looks smaller), Stern a lower one (it looks larger), a choice captured by the Ramsey relation $r = \delta + \eta g$. You do not need these to use a scenario; the lecture deck covers them for the curious.

Now you are ready

You can now explain why scenarios beat forecasts and turn one into a default shock. Next, **Handout Chapter 3** details the NGFS variables and the transmission chain, and **Lesson 3 (Deck L3)** adds the model machinery from the advanced box above and a Philippines typhoon case.

Check yourself

1. Fill in the blank: a scenario tells you what *would* happen if, not what _____ happen. *(will.)*
2. Which NGFS family has low transition risk now but severe physical risk later? *(Hot House World.)*
3. If a sector has $\beta = 2$ and the economy shrinks 5 percent, how much do defaults rise? *($2 \times 5 = 10$ percentage points.)*
4. Why run the calculation thousands of times? *(To see the full spread of outcomes in a fan chart, because the future is uncertain.)*

Mini-glossary. *NGFS:* the central-bank club whose shared climate scenarios banks use. *Orderly / Disorderly / Hot House:* the three futures, trading transition risk against physical

risk. *Sensitivity (β):* how strongly a sector's defaults respond to the economy.

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