What is the future worth?

Damage far in the future is counted back to tonight at a **discount rate** → for 70 years away, that one number decides most of the answer · the rate = a part you can **measure** + a part somebody must **choose** · Stern and Nordhaus: same arithmetic, different rate. The lesson picks no side.

1 Discounting

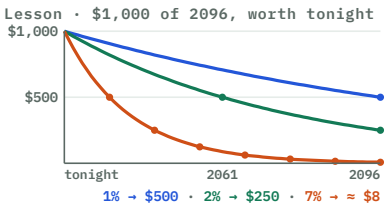
Math 9, one year

- **Discounting** = counting future money (or damage) back to today: ÷ `(1 + r)` for every year away · **r** = **discount rate** · result = **present value** `PV = FV ÷ (1 + r)`
- Math 9: `$110 ÷ 1.1 = $100` · two years: `$121 ÷ 1.1 ÷ 1.1 = $100` → each year away takes its own slice
- Reef damage sits in **2096**, 70 years away → ÷ 70 times? → a shortcut ⇒ ②

2 The halving rule

rule of 70, backwards

- **Macro 10**: at r% a year money doubles every `70 ÷ r` years ⇒ backwards: a future dollar is worth **½** tonight for every `70 ÷ r` years it is away
- $1,000 of 2096: `1%` 70 y, 1 halving → **$500** · `2%` 35 y, 2 → **$250** · `5%` 14 y, 5 → **≈ $30** · `7%` 10 y, 7 → **≈ $8** (shortcut within a few $ of the exact)
- 1% → 7%: ÷ 60 · damage × 2 → value × 2 ($2,000 at 5% ≈ $60) ⇒ **the rate weighs more than everything else**
- **Your guess** (never graded or saved): "≈ $1,000" = rate 0 · "a few hundred" = 1-2% · "almost nothing" = 7%
- Practice · sea wall, **$3,200** in 2096, wall **$600**: 2% → **$800** ⇒ pays · 5% → **≈ $100** ⇒ fails · **$1,600** at 2%: 2061 **$800** · 2096 **$400** · 2131 **$200** · 2166 **$100** → the farther, the more halvings the rate decides



3 Where the rate comes from

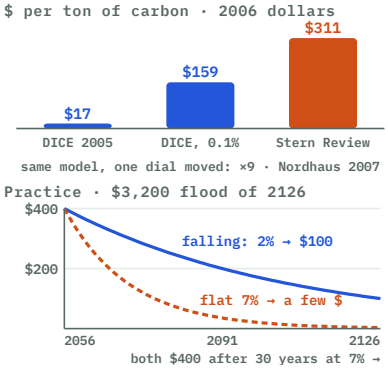
half fact, half choice

- `rate ≈ impatience + growth of incomes` (simple version: growth counts one for one)
- **Measured**: growth 2% → incomes ×2 every 35 y → **×4 richer** by 2096 · **opportunity cost**: `$250` at 2% tonight = `$1,000` in 2096 · what savings earn
- **Chosen**: **pure time preference** (impatience term) = how much less a later person counts, only for being later · **Frank Ramsey** (British mathematician, Cambridge, 1903-1930), 1928: counting them for less is "ethically indefensible and arises merely from the weakness of the imagination" · most add a small number for the chance the future never comes
- Practice · **up**: growth 3% · bank 6% · risk of no 2096 | **down**: impatience 0 · growth stalls · unsure of the right rate (Weitzman)

4 Stern vs Nordhaus

same math, one number

- **Stern Review** (Nicholas Stern, British economist, for the UK Treasury, 30 Oct **2006**): `0.1% + 1.3% ≈ 1.4%` → unchecked: "at least 5% of global GDP each year, now and forever" → act hard now, cost ≈ 1% of GDP a year
- **William Nordhaus** (American, Yale, b. 1941): **DICE** (Dynamic Integrated Climate-Economy), first model joining economy + climate · Nobel **2018** · impatience ≈ **3%**, falling slowly, to match markets
- **Social cost of carbon** = damage of one more ton, counted back at the chosen rate (what a carbon price should match) · prices per ton of **carbon**: 1 t carbon ≈ 3.7 t CO_2 · conclusions "depend decisively" on a near-zero rate (Nordhaus 2007) · Weitzman (American, Lesson 4) 2007: the rate itself is uncertain → a reason for a lower one
- **Agree**: a carbon price that **rises over time** (DICE $17 in 2005 → $84 in 2050) · warming "unequivocal" (IPCC = UN climate science panel, 2021) · survey of 200+ experts (Drupp et al. 2018): median **2%**
- **Declining discount rate**: lower for far decades · UK Green Book (Treasury manual) 3.5% first 30 y (2003) → since Oct 2026 **3.0%**, 2.5% after 30 y, 2.25% after 75 · practice: 7% then 2% → flood of 2126 **$100** vs flat 7% **a few $** (×30)



5 Does it pay?

question 7

- **Discounted cost-benefit test**: spend tonight only if the future benefit, counted back, beats the cost · reef repair `$400` vs $1,000 of 2096 → pays **only at 1%** ($500) · Palmera `$200` → 1% and 2% · far projects: the rate decides; near ones barely notice
- **For a low rate**: later people count as people; a reef is not a bank account · **for a market rate**: $250 at 2% = $1,000 in 2096 + $150 left; 2096 likely richer · the council's choice, not the lesson's
- **Ten questions to ask about any green policy** (so far): **1** · What does the smoke really cost, and who pays that cost now? · **2** · Who owns the resource? · **3** · Does it cut where cutting is cheapest? · **4** · Price or quantity, and which mistake is worse here? · **5** · The cheap fix, the visible one, or the next invention? · **6** · Does it work at the peak, or only on the average day? · **7** · **What is a dollar of damage in 2100 worth today, and at which discount rate?**
- University: `r = δ + η × g` (Ramsey formula: δ impatience · g growth · η richer → extra $ matters less) · damage through models like DICE ("integrated assessment")

Watch out: the rate is **not a law of nature** (read off the bank) and **not pure opinion**: a measured part + a chosen impatience term · compare dollars of the **same** year: $3,200 of 2096 ≠ $3,200 tonight · halvings multiply: 7 halvings = ÷ 128, not ÷ 7