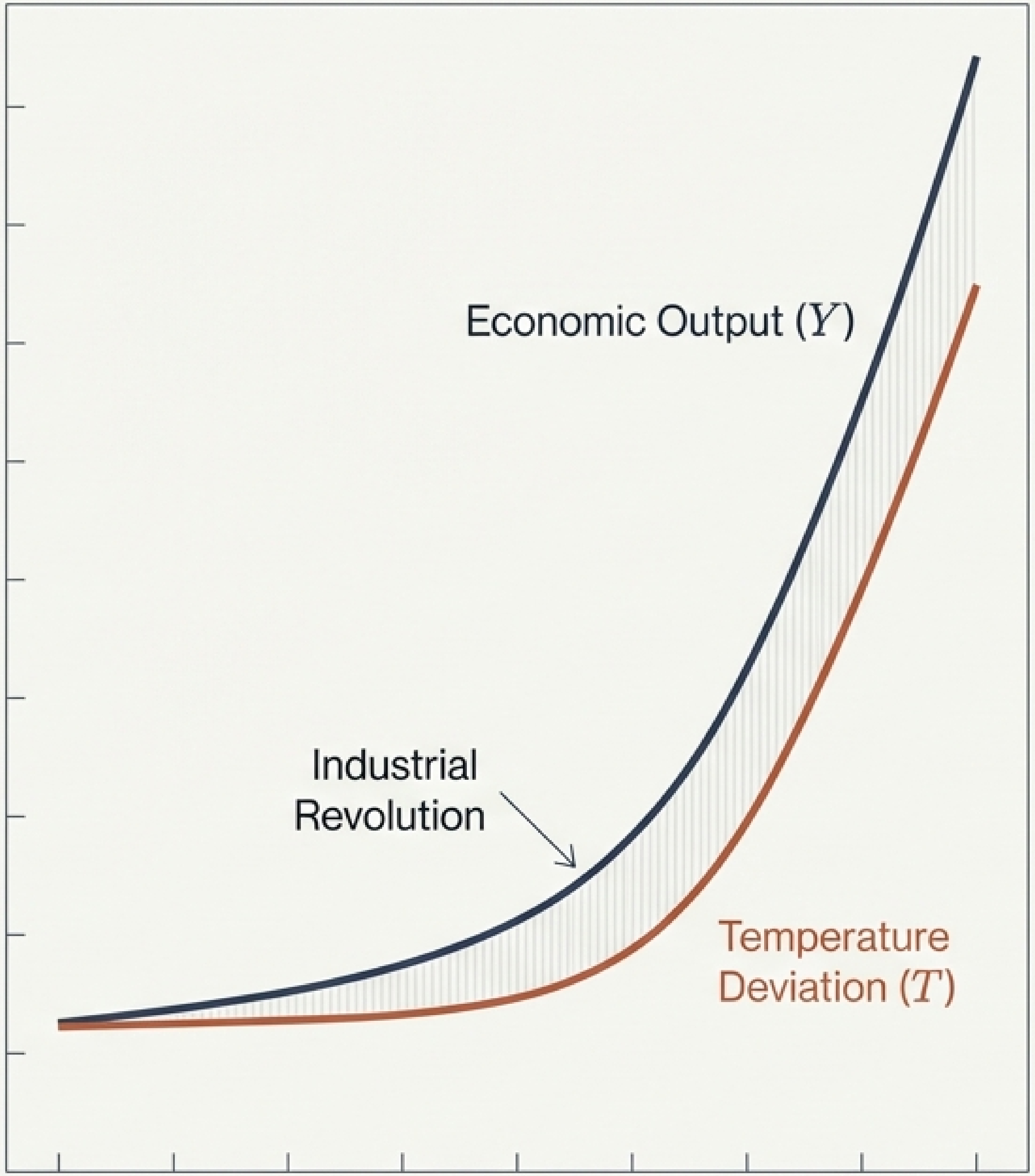
Macroeconomics & The Climate Challenge

An Integrated Assessment of Sustainability, Policy, and Growth

Climate change is an aggregate externality caused by the free disposal of carbon. To solve it, we must merge the laws of physics with the laws of economics. This deck constructs an Integrated Assessment Model (IAM) to balance infinite growth aspirations with finite planetary boundaries.



Property rights determine the fate of resources.

The Fundamental Friction

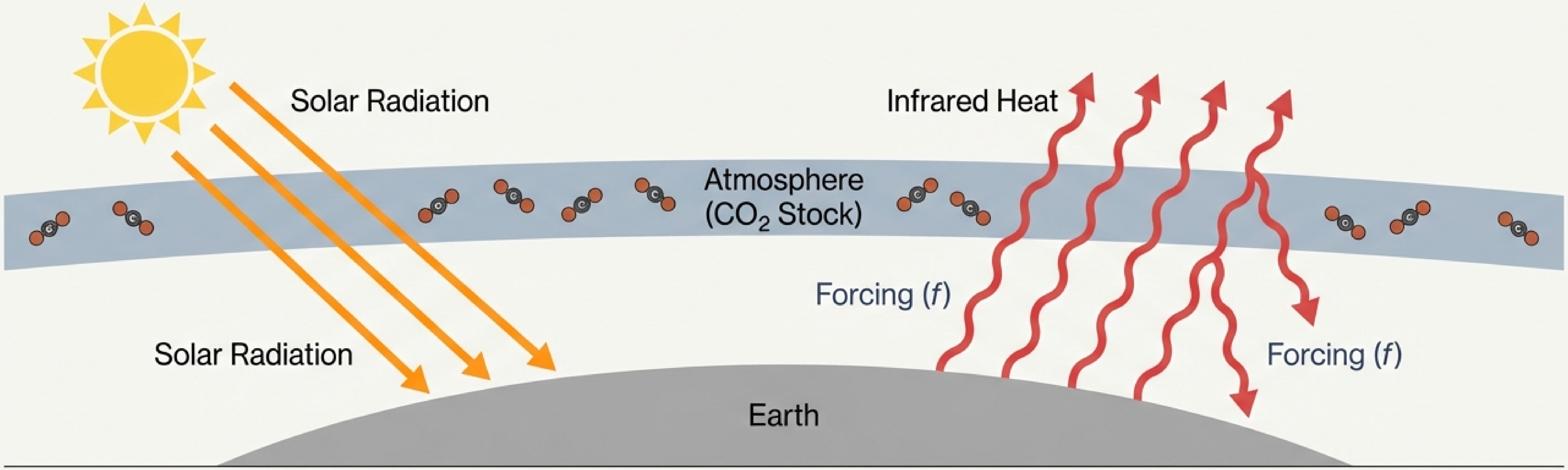
Markets are excellent at managing resources that are owned. Owners of land or fossil fuels maximize value over time, preventing depletion.

The atmosphere, however, has no owner. It is a global commons. Because the “climate sink” is unpriced, the market sets the cost of dumping carbon at zero.

Result: The Tragedy of the Commons

The Economy and The Environment

The physics of constraints: How carbon drives temperature



Arrhenius Law:

$$f_{CO_2} = \eta \frac{\ln(S/S_0)}{\ln 2}$$

f = Forcing
S = Current Carbon Stock
S_0 = Pre-industrial Stock

Equilibrium Climate Sensitivity (ECS)

The temperature rise from doubling CO_2:

Range: 2.5°C – 4.0°C
Best Estimate: 3.0°C

Steady State Temperature:

$$T = \frac{\eta}{\kappa} \frac{\ln(S/S_0)}{\ln 2}$$

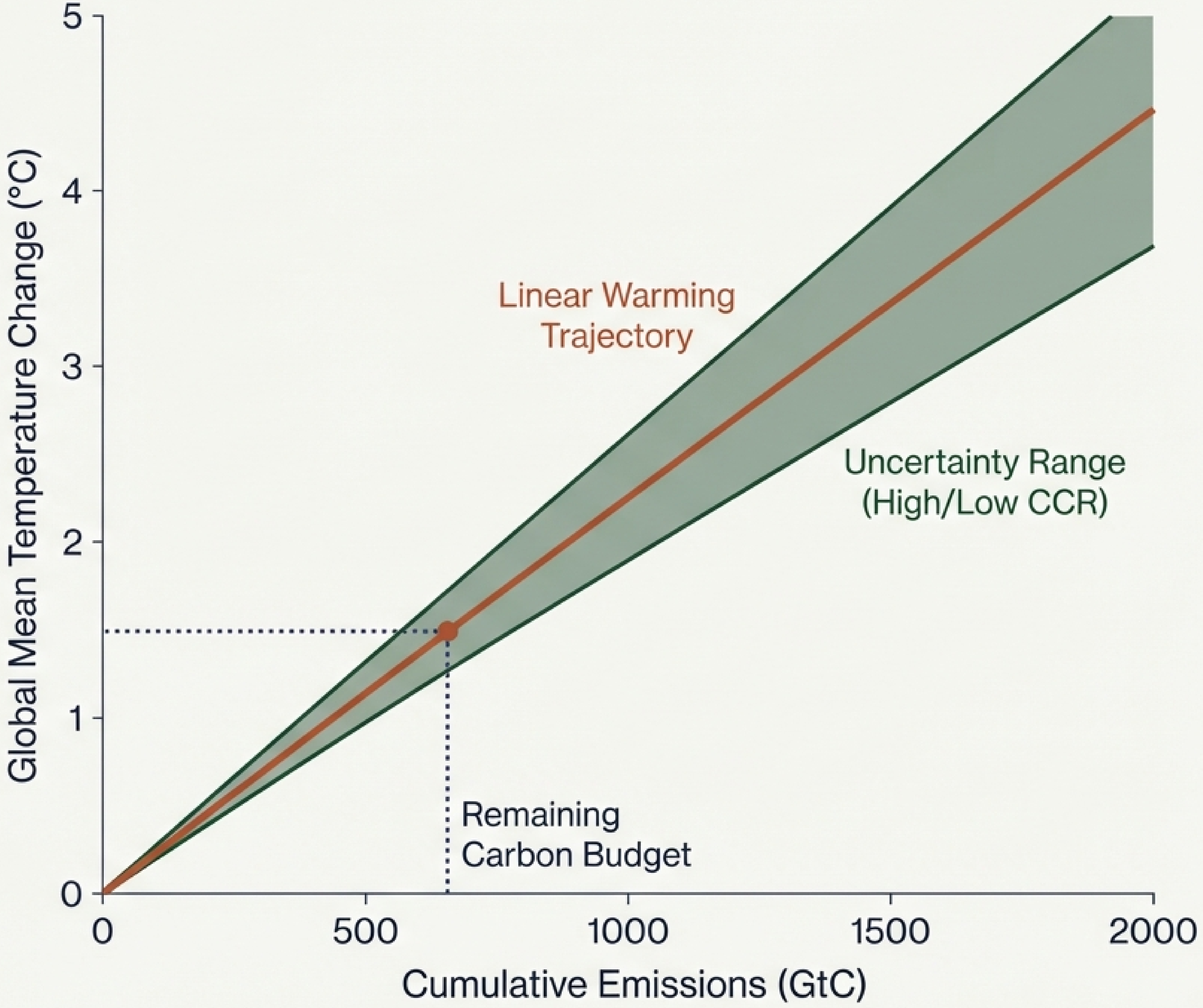
Temperature rises logarithmically with Carbon Stock.

The Carbon Budget is linear and irreversible.

Core Concept: Constant Carbon-Climate Response (CCR)

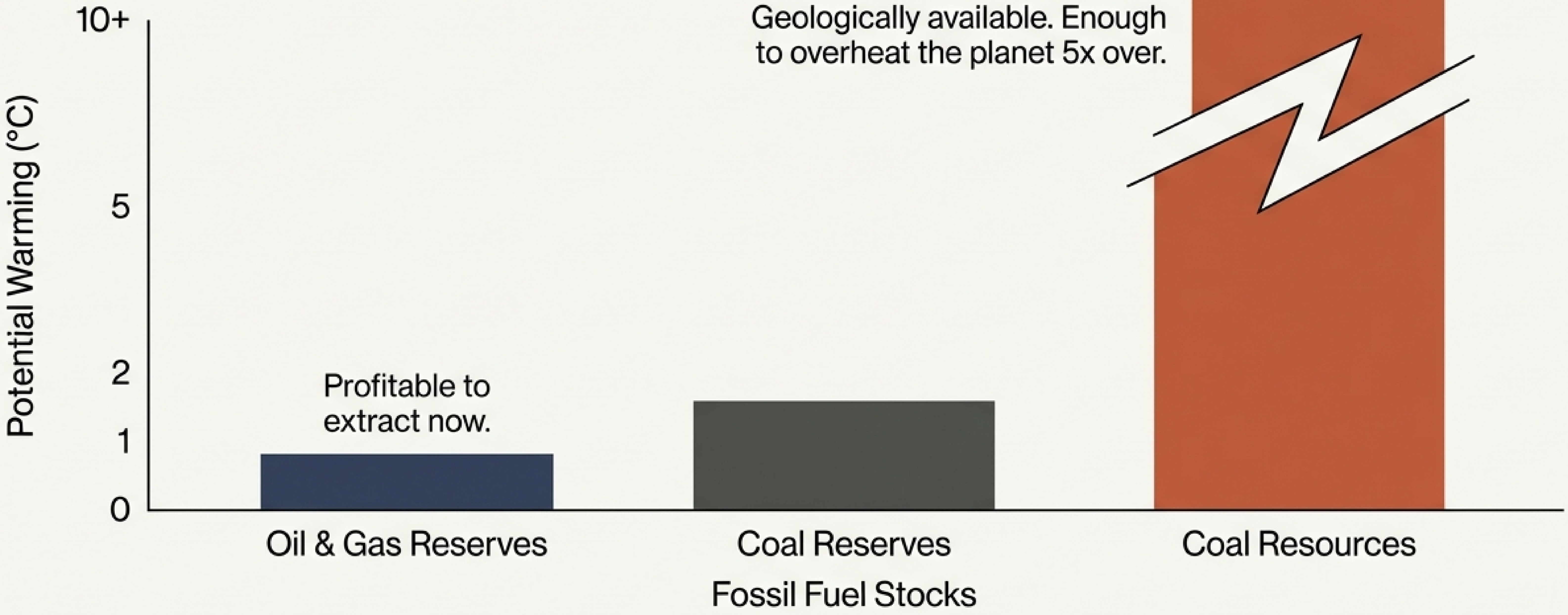
$$T_t \approx \sigma_{CCR} \sum E_t$$

- Temperature depends on the *total cumulative stock* of emissions, not the current flow.
- Irreversibility: To stop warming, emissions must hit Net Zero.
- The Budget: We have a fixed amount of Carbon left to burn before hitting 1.5°C.



The supply side danger lies in coal, not oil.

Potential warming if all available stocks are burned

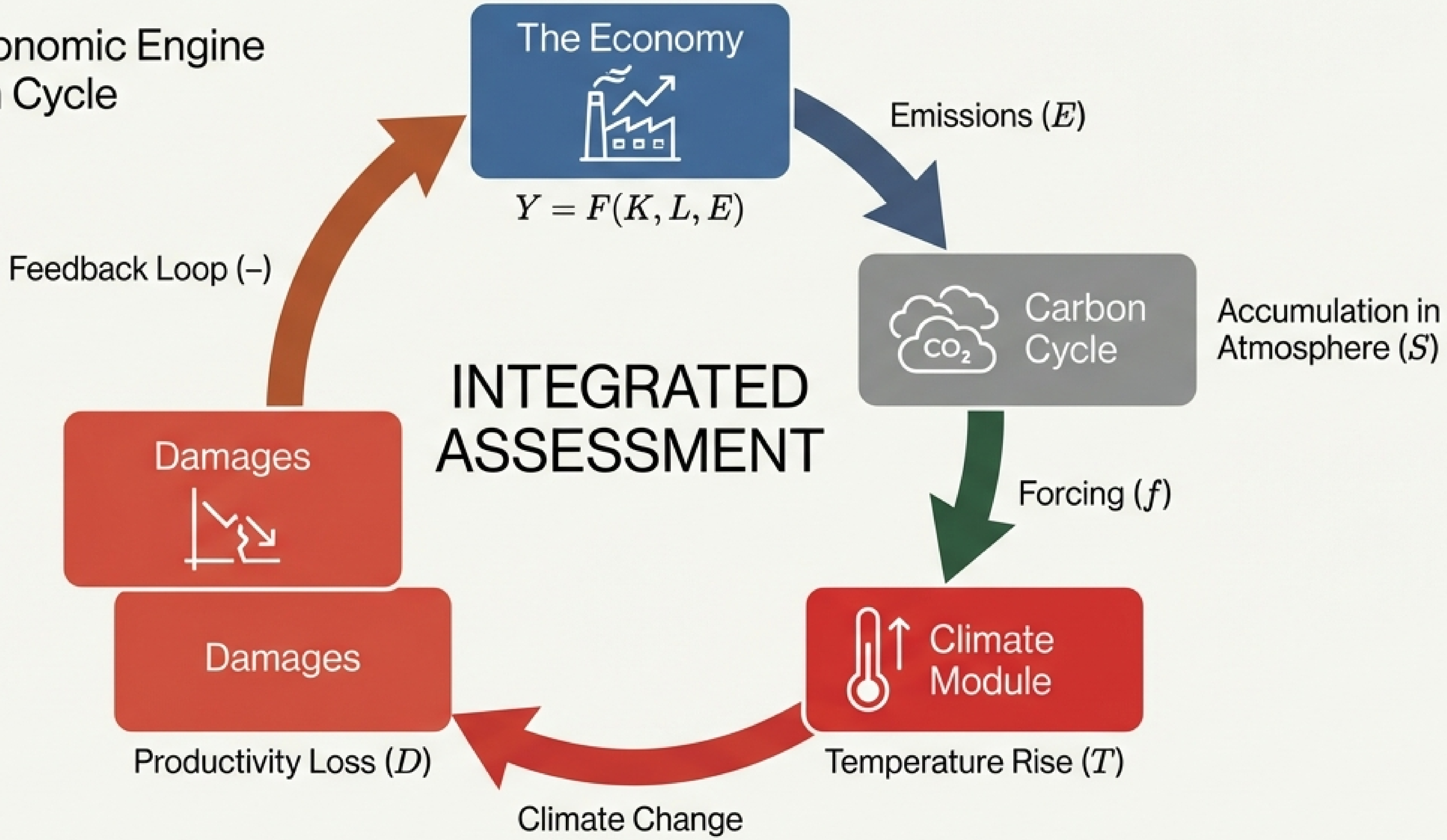


Crucial Distinction: We are not running out of fossil fuels. Scarcity will not save the climate. The economic constraint must be the Carbon Budget, not fuel availability.

Constructing the Integrated Assessment Model (IAM)

Heldane Display, with Neue Haas Grotesk

Merging the Economic Engine
with the Carbon Cycle



Quantifying the economic cost of warming (Damages)

Neue Haas Grotesk

Method 1: Bottom-Up

Aggregating specific losses (agriculture, health, sea-level). Often underestimates systemic risk.

Method 2: Top-Down

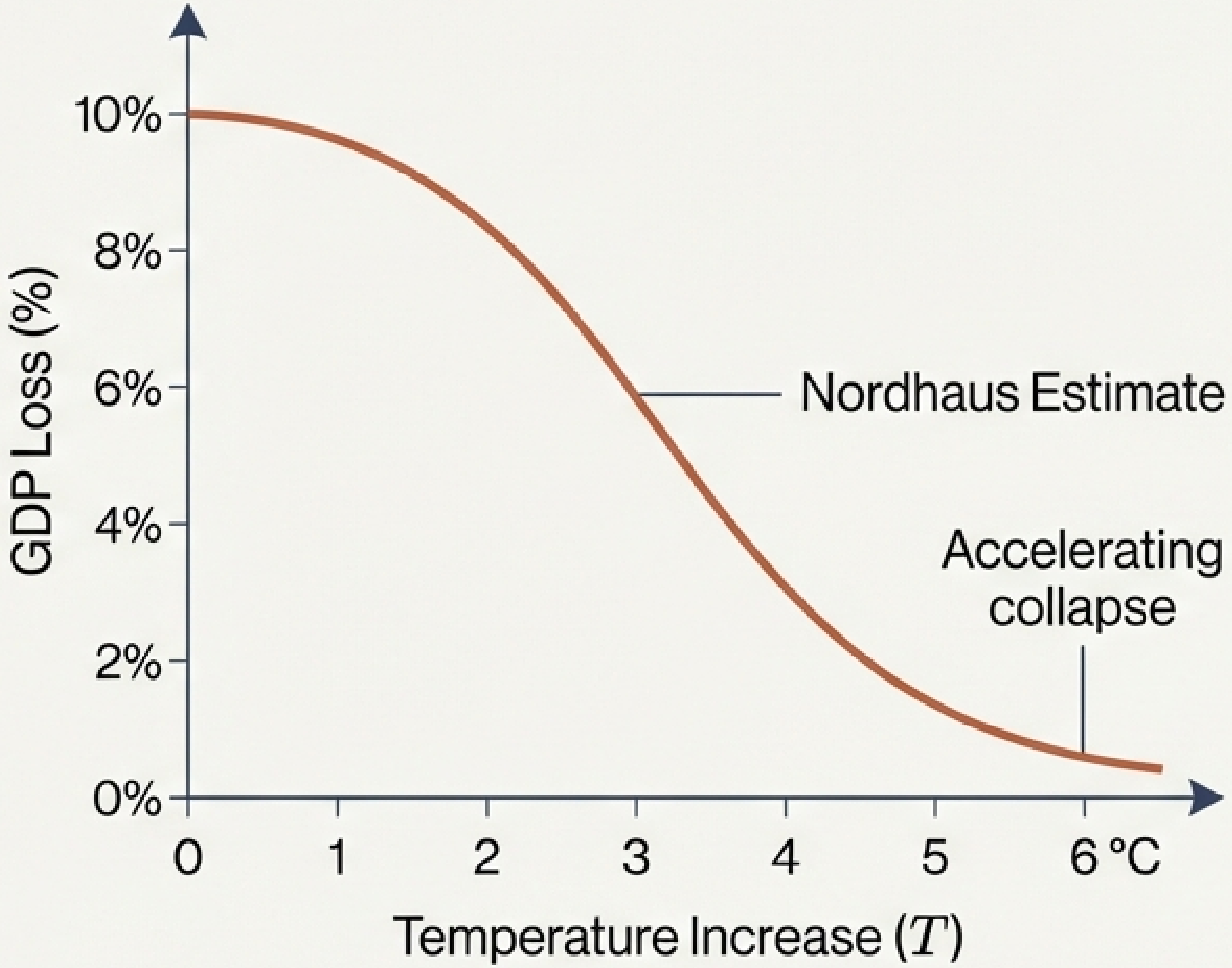
Macro correlations. “Hotter years have lower GDP growth.” Suggests higher sensitivity.

Critical Factors

**Adaptation*: “Do we build walls? (Reduces damage, costs money).”
Discounting: “How much is $100 in 2100 worth today?”

The Convex Damage Function

$$D(T) = \frac{1}{1 + 0.00267\,T^2}$$



The Market Failure: A Static Snapshot

Why the free market emits too much carbon

The Private Firm

Maximizes Profit (π)

$$\max \pi = AE^{\nu} - (p + \tau)E$$

Firm buys energy until
Marginal Product = Price

Blind Spot

Ignores
Damage
(γE^2)

The Social Planner

Maximizes Global Welfare (W)

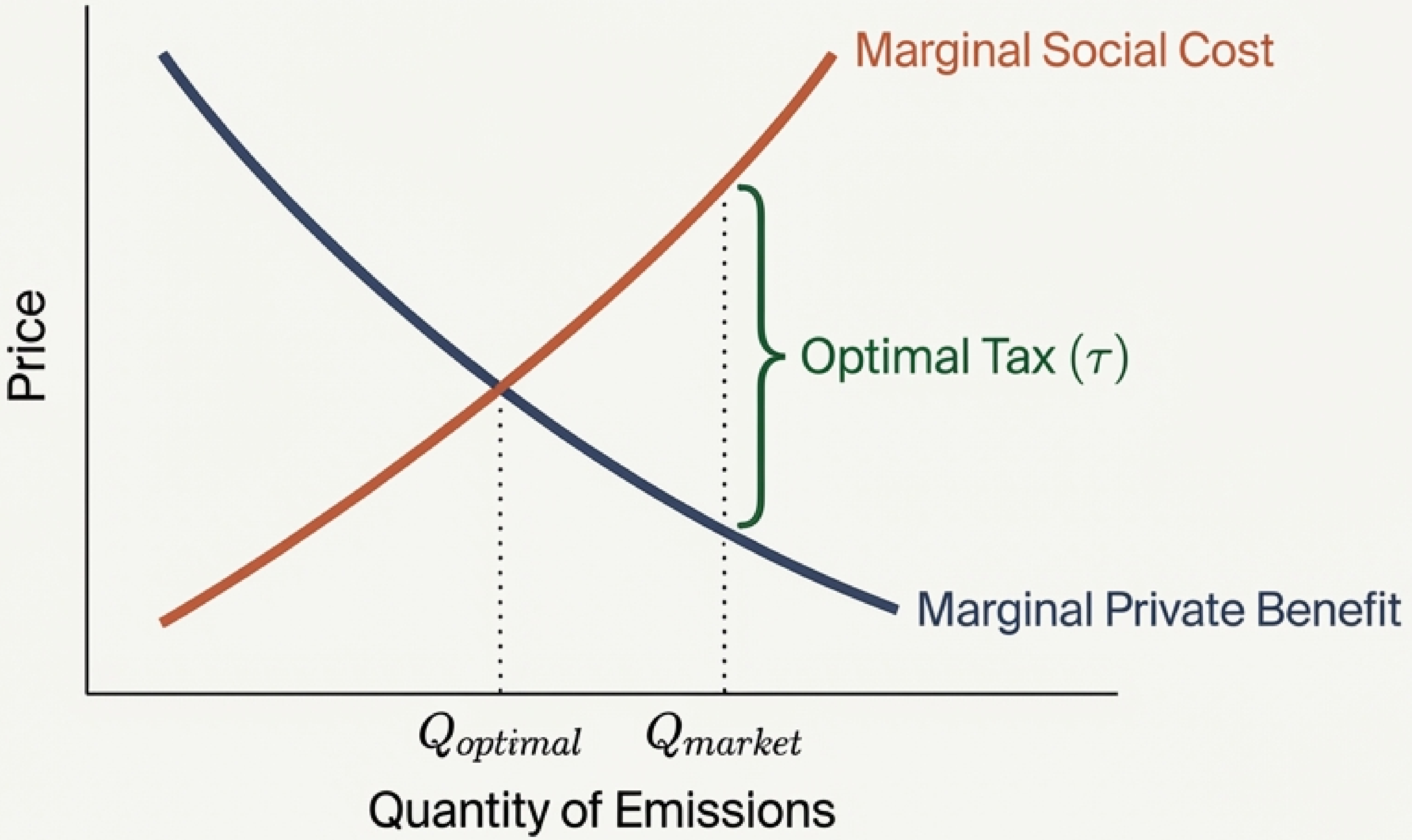
$$\max W = AE^{\nu} - pE \boldsymbol{- \gamma E^2}$$

Planner accounts for the Price
AND the Marginal Damage

The Externality Gap: The market ignores the term γE^2

The Pigou Tax Solution

Pricing the Externality



By setting a tax τ exactly equal to the marginal external damage, the private firm is forced to act like the social planner.

Deriving the Optimal Tax: The Three D's

$$\tau_t = Y_t \times \left[\sum \beta^j \gamma(1 - d_j)\right]$$

1. DURATION (Depreciation)
How long CO_2 stays in the atmosphere.
Longer persistence = Higher Tax.

2. DAMAGE
The economic cost per unit of carbon concentration.
Higher sensitivity = Higher Tax.

Proportional to GDP.
As the economy grows, the tax grows.

3. DISCOUNTING
The value we place on future generations.
Higher patience = Higher Tax.

Policy Tools: Prices vs. Quantities

Carbon Taxes vs. Cap-and-Trade (EU ETS)

Price Regulation (Tax)

Government

↓

Price (τ)

Market determines Quantity (Q).

Quantity Regulation (Permits)

Government

↓

Quantity (Q^*)

Market determines Price (λ).

The Equivalence Principle:
In a deterministic model, if Q^* is **optimal**, the permit price λ will equal the optimal tax τ^*.

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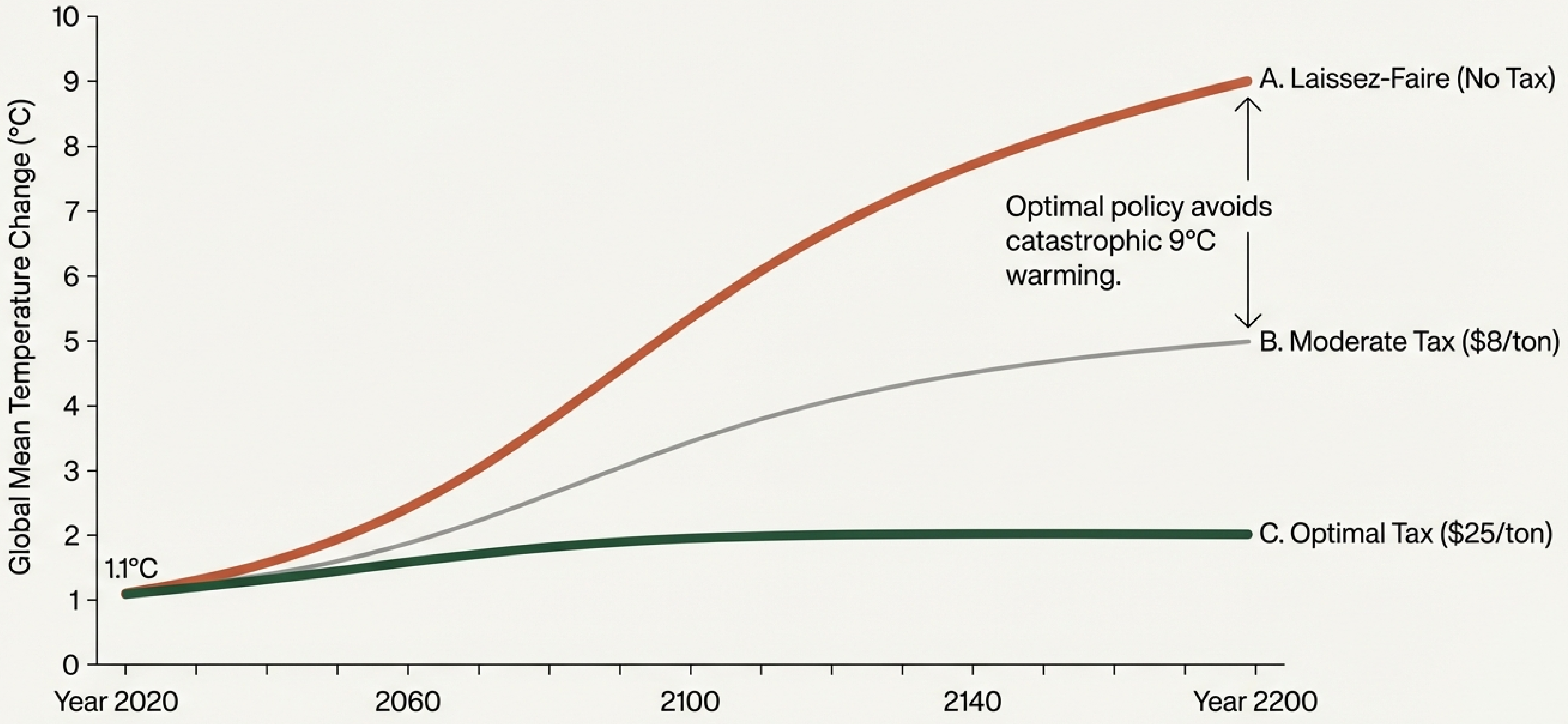
$$\lambda = \tau^* = 2\gamma E^*$$

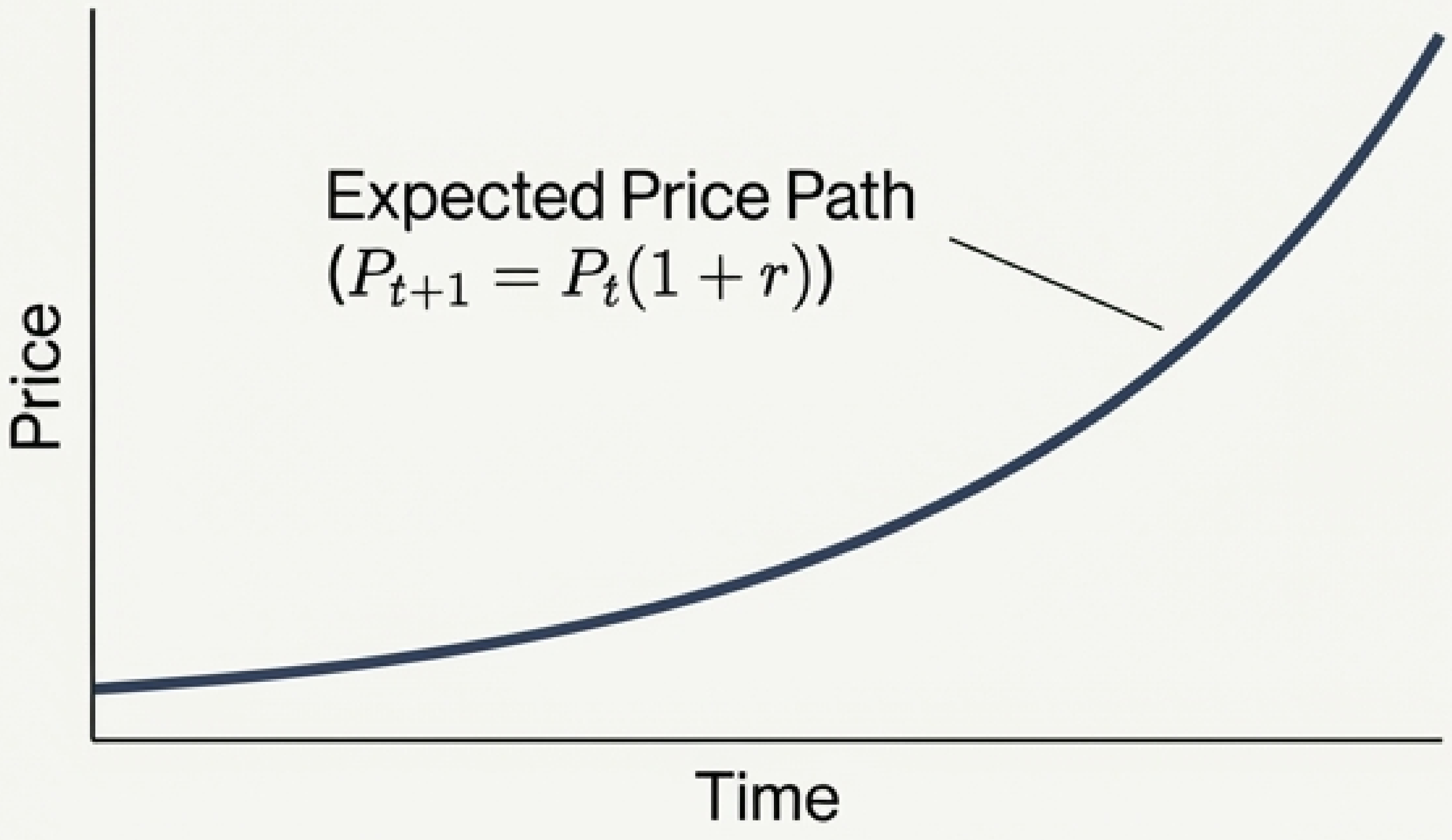
Simulation: The cost of inaction vs. the path to stability



Managing finite resources: Theory vs. Reality

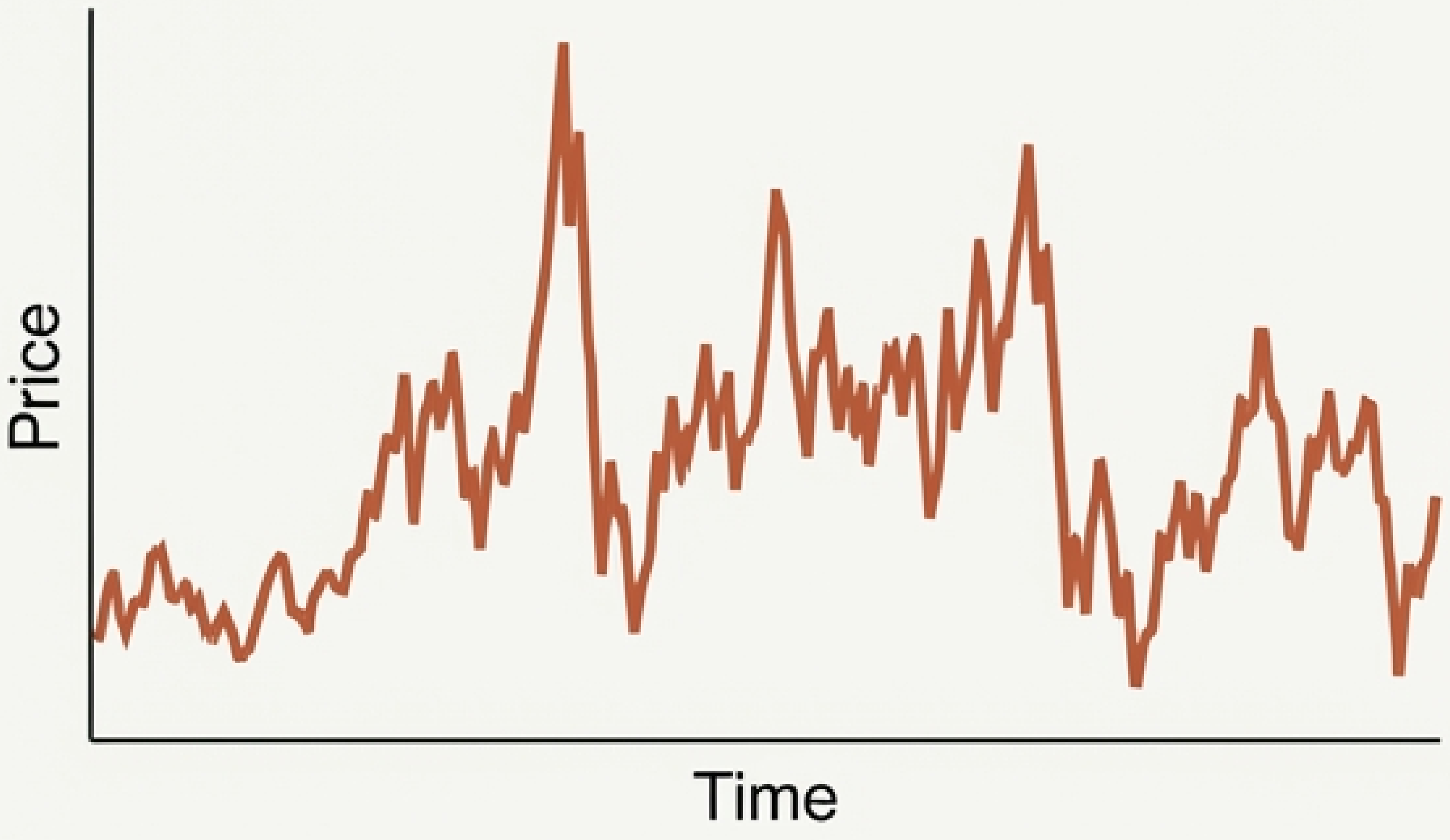
Why haven't fossil fuel prices exploded?

Hotelling's Rule



Scarcity should drive prices up at the interest rate.

Historical Oil Prices

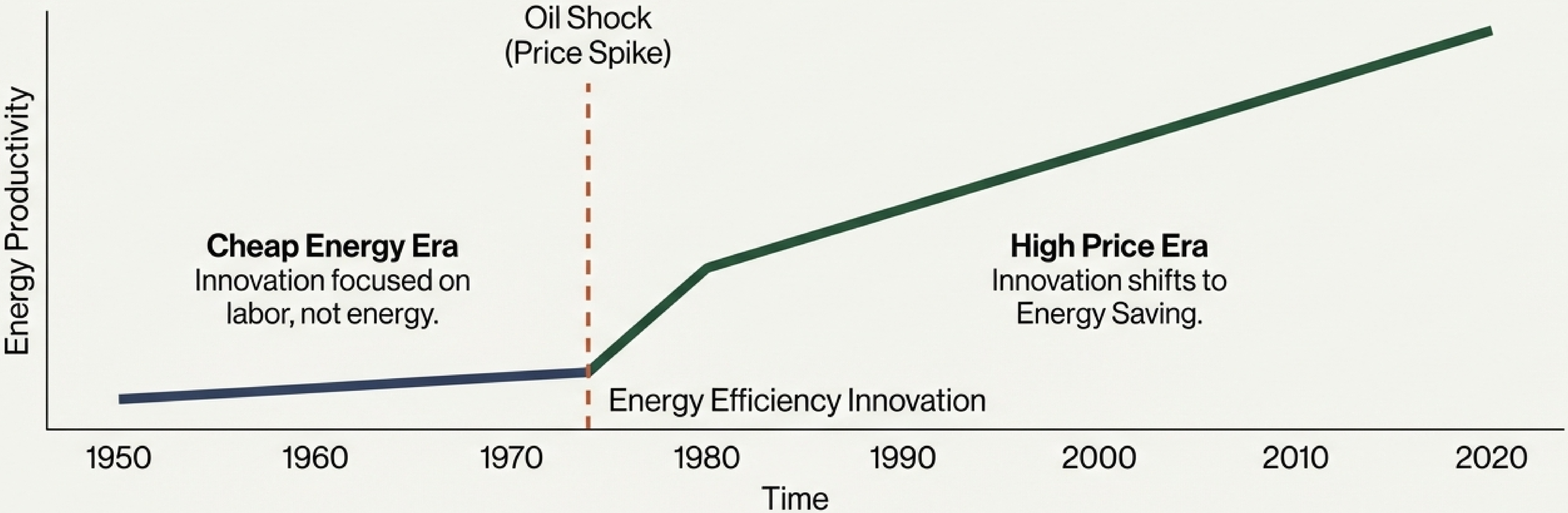


Prices are volatile with no trend.

The Explanation: Extraction technology improves faster than depletion. We get better at finding difficult resources, offsetting scarcity.

The Escape Hatch: Directed Technical Change

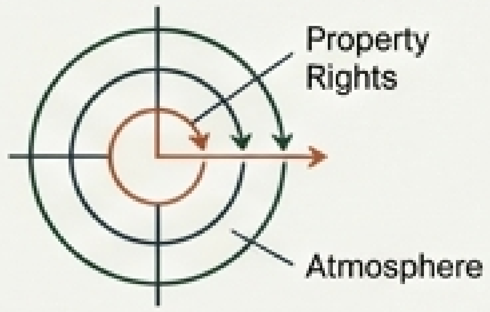
Innovation is not random; it is directed by price.



Takeaway Box

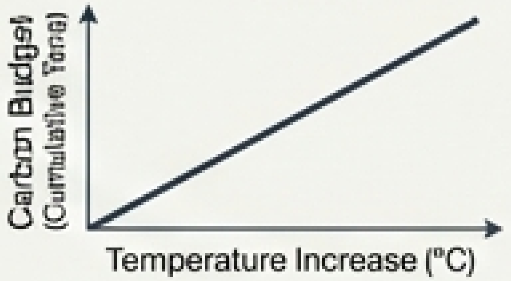
Mechanism: A carbon tax does double duty. It reduces consumption today AND signals innovators to invent the green technology of tomorrow.

The Analytical Journey: Summary & Implications



The Friction

Climate change is an aggregate externality caused by the lack of property rights for the atmosphere.



The Constraint

The Carbon Budget is linear. Every ton of Carbon leads to a specific, irreversible temperature increase.

$$P = \int \left(\overbrace{\underbrace{D(t,T)}_{\text{Duration}}}^{\text{Damages}} * \underbrace{e^{-rt}}_{\text{Discounting}}\right) dt$$

The Solution

A Pigou Tax based on Damages, Duration, and Discounting restores market efficiency.

The Future

Sustainability relies on Directed Technical Change. Correct pricing triggers the innovation needed to decouple growth from emissions.

Goal: Directed Growth—steering the engine of capitalism toward a carbon-neutral equilibrium.