Efficient Greenhouse Gas Emission Banking and Borrowing Systems

"I Will Gladly Pay you Tuesday for a GHG Permit Today"

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Structure of Presentation

- Stock vs. Flow Pollutants
- Permit Trading and Banking
- Cooperative Emissions Abatement
- Implications for Banking Regime Design
- Numerical Estimates and Policy Implications

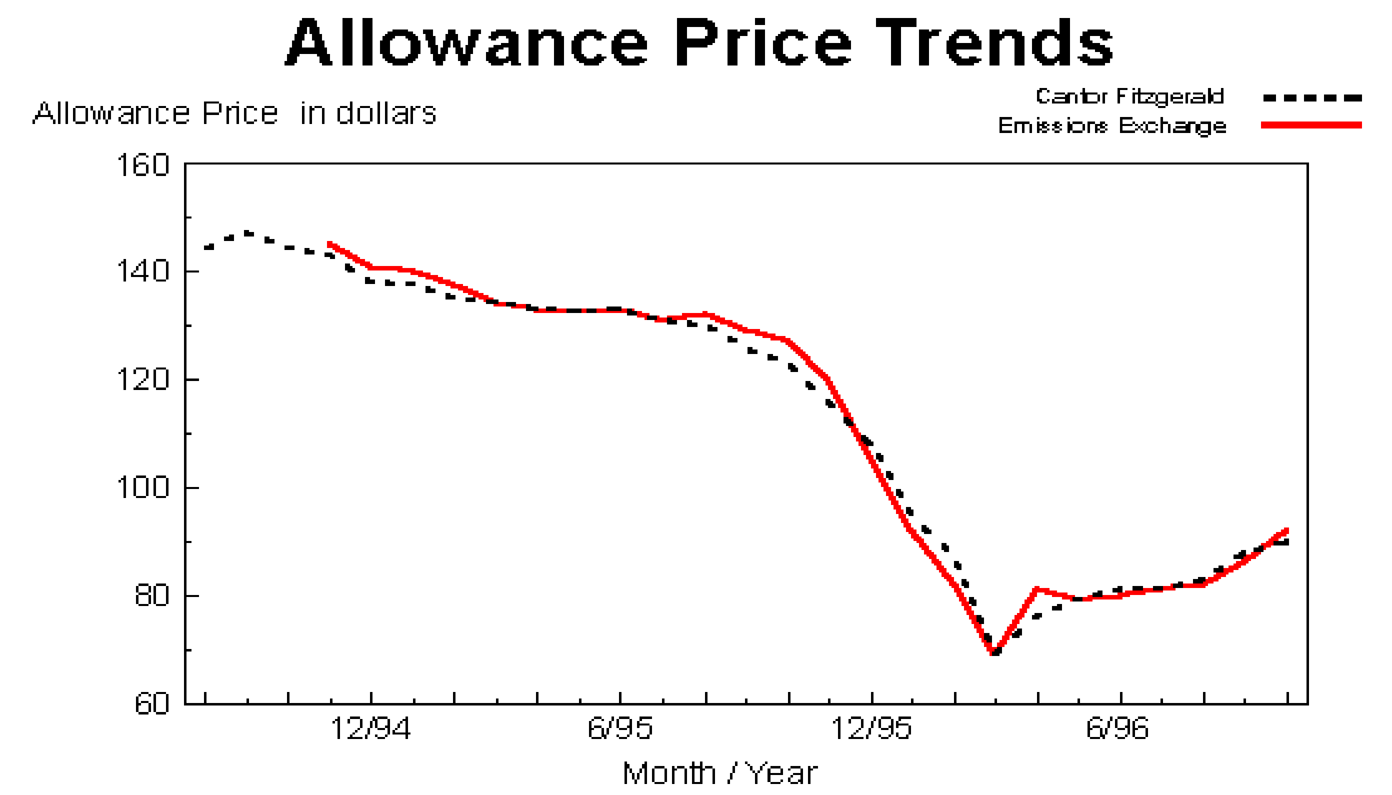
Stock and Flow Pollutants

- Flow Pollutants:
  - » Damages nearly coincident with emissions
  - » E.g.: Noise
- Stock Pollutants:
  - » Accumulate and decay over time
  - » Damages stem from accumulated stock
  - » E.g.: CO_2
- Difference often matter of degree.

Permit Trading Promotes Efficiency

- *Established result for flow pollutant*
  - » Montgomery (1972)
- *Literature on marketable permits*
  - » Market Power (Hahn 1984)
  - » Enforcement (Malik 1992)
  - » Regulated indust. (Coggins & Smith 1993)
  - » Bilateral, sequential trading (Atkinson & Tietenberg 1991)
  - » Optimality of incentives (Oates et al. 1989)

SO_2 Permits Actively Traded

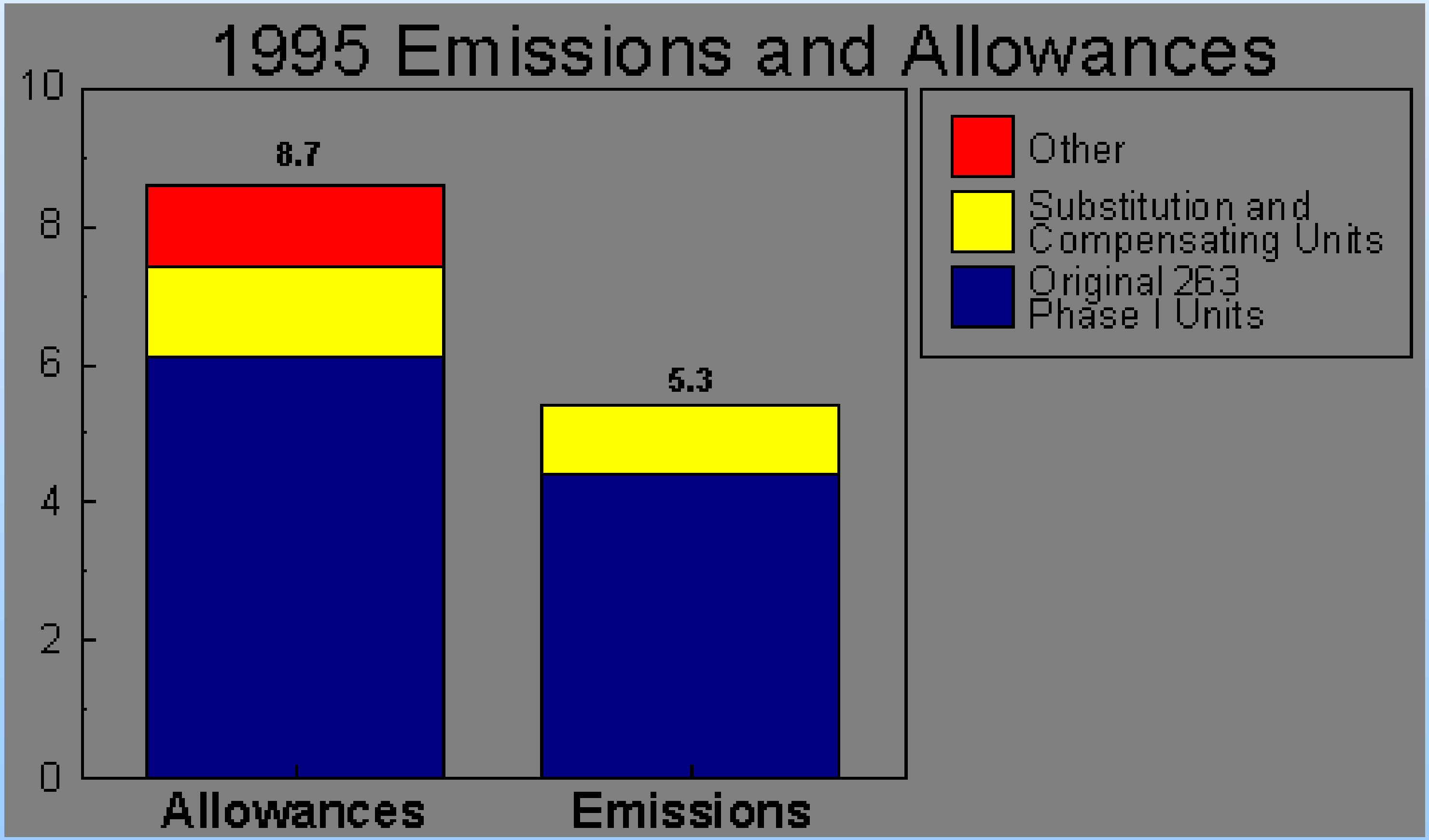


- Source: U.S. EPA, Acid Rain Division's Home Page, Allowance Tracking System (ATS) Data (http://www.epa.gov/docs/acidrain/update2/chart3.html), 2/15/97

New! Permit Banking

- *Banking = Intertemporal Permit System*
- *Regulatory applications and examples*
  - » Acid rain program (banking)
  - » CAFE credits (bank and borrow 3 years)
  - » California tailpipe HC (bank)
  - » Lead in gasoline (bank)

Banked SO_2 Permit Inventories



- Source: U.S. EPA, Acid Rain Division's Home Page, Allowance Tracking System (ATS) Data (http://www.epa.gov/docs/acidrain/update3/emsallws.gif), 2/26/97

Permit Banking for Flow Pollutant

- *Research on properties*
  - » Biglaiser et al (1995), Cronshaw & Cruse (1996), Rubin (1996)
- *Kling and Rubin (1997) essential conclusion*
  - » Banking/borrowing not necess. efficient
  - » Equalizes discounted marg control costs
  - » Firms “borrow” given non-increasing costs
    (and non-decreasing standards)

For a Stock Pollutant, Banking Trickier

- *Stock Pollutants = durable externalities*
- *Optimal Marginal Damages Likely to Vary Over Time*
- *Implications for Efficient Banking Regimes:*
  - » Unrestricted Trading Inefficient
  - » Need modified banking/trading regime

Other Research on Banking

- Kruse and Cronshaw 1998 (theory and experiment)
- Toman and Palmer 1997 (accumulative pollutants)

Grand Application: GHG Emission Rights

- *Trading envisioned under Kyoto Protocol*
- *US FCCC Draft Protocol Promoted Borrowing (State Dept 1997)*
  - » Emit more in 2000
  - » Pay back with interest in 2010 or later

Global Cooperation Approach

- Key assumption: joint/cooperative objective function
- => Can seek global max
  - » Useful for exploring potential coordination gains
- Alternative cooperative solution is Pareto Optimum, given individual objectives (e.g. Chichilnisky and Heal 1997, Nordhaus 1996)

Cooperative Objective Function

$$J^* \equiv \max_{\substack{e_1 \cdots e_N \\ y_1 \cdots y_N}} \int_0^T d(t)\left(\int_0^{y(t)} P_y(z)\,dz - \sum_{i=1}^{N} C_i(y_i, e_i, t) - D(e,S,t)\right)dt - d(T)F(S(T))$$

$$s.t.: \qquad S(t) = e(t) - gS(t)$$

$$y_i(t) \geq 0,\ e_i(t) \geq 0$$

$$e = \sum_i e_i,\ y = \sum_i y_i$$

- Max disc value of output minus control cost and damages

Cooperative Emissions Control Solution

- Stock and Flow Pollutant Case
- Eqn for opt abatement effort C_a*:

$$C_a^* - \frac{1}{r+g}\frac{dC_a^*}{dt} = D_e^* + \frac{1}{r+g}\left(D_S^* - \frac{dD_e^*}{dt}\right)$$

C_a = marginal abatement cost

D_e = marginal flow damage

D_S = marginal stock damage

γ = stock decay rate

ρ = discount rate

Cooperative Solution: Interpretation

- Current and future abatement costs balanced against current and NPV future damages
- Can solve differential equation for C_a*:

$$C_a(t) = D_e(t) + \int_t^T e^{-(r+g)(\tau - t)} D_S(\tau)\,d\tau + e^{-(r+g)(T-t)} F_S(T)$$

- Marg control costs = current marg flow damages + “NPV” future stock damages

Establishing the Interest Rate on Bank Accounts

- Total # permits determines price level
- Banking/Borrowing determines permit price path
- For each agent, permit prices determine
  - » Marginal abatement effort
  - » Hence, emissions level
- To get efficient marginal abatement path: Set bank account interest rate

Stock-pollutant Only Case

- Efficient interest rate r_e depends on marginal stock damages, marginal abatement costs, and stock decay rate

$$r_e^* = \frac{D_S^*}{C_a^*} - \gamma$$

$$r_e^* = \frac{D_S^*}{\int_t^T e^{-(r+\gamma)(\tau - t)} D_S^*(\tau)\, d\tau + e^{-(r+\gamma)(T-t)} F_S(T)} - \gamma$$

Stock Pollutant - Summary

- Social Optimum

$$C_a^*(t) = \int_t^T e^{-(r+g)(t-t)} D_S^*(t)\,dt + e^{-(r+g)(T-t)} F_S(T)$$

- Private Optimum, with Trading

$$C_a^{**} = P_e$$

- Market Outcome, with Banking

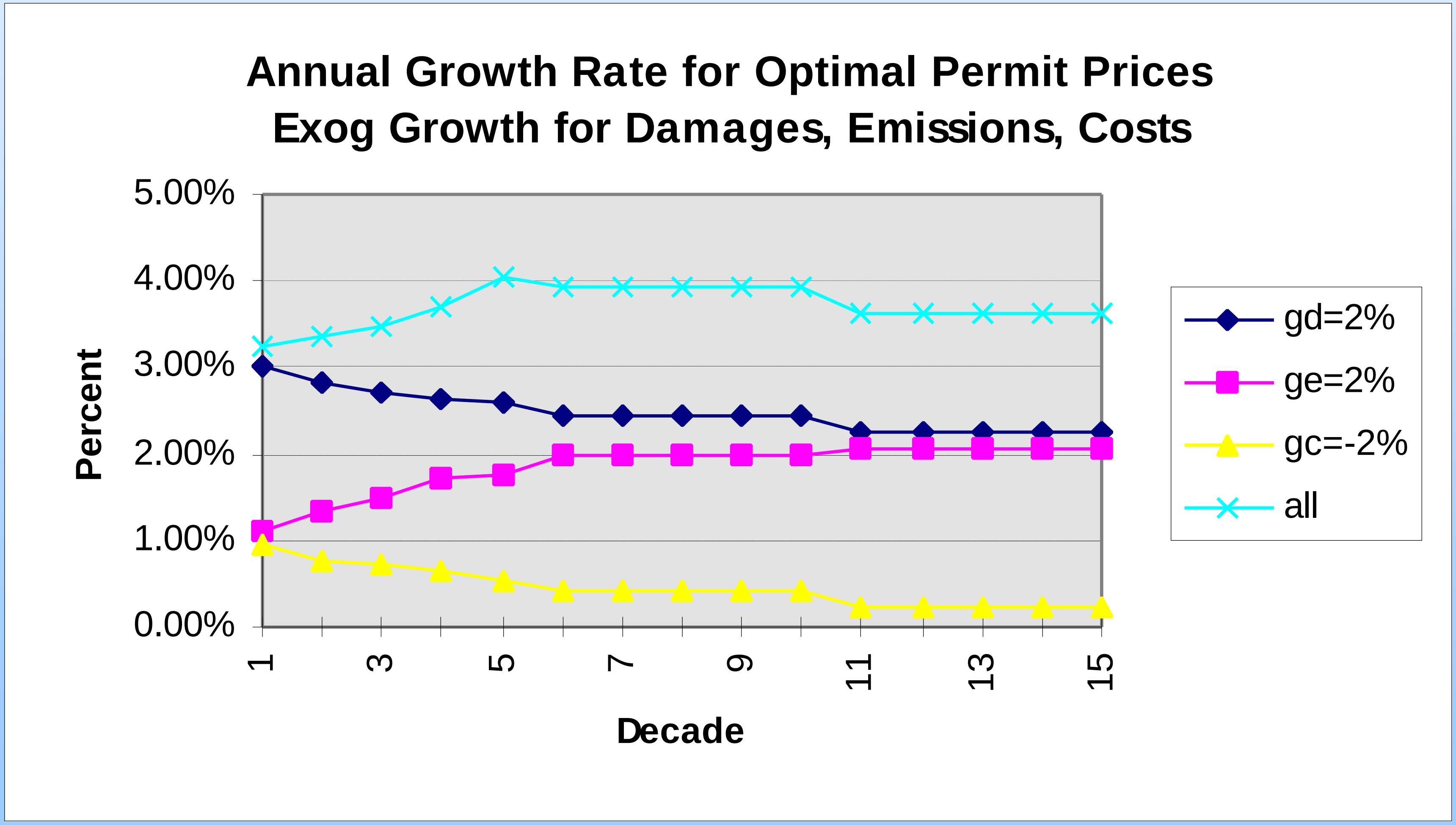
$$\frac{dP_e}{dt} \Big/ P_e \equiv \hat{P}_e = i - r_e$$

(due to arbitrage)

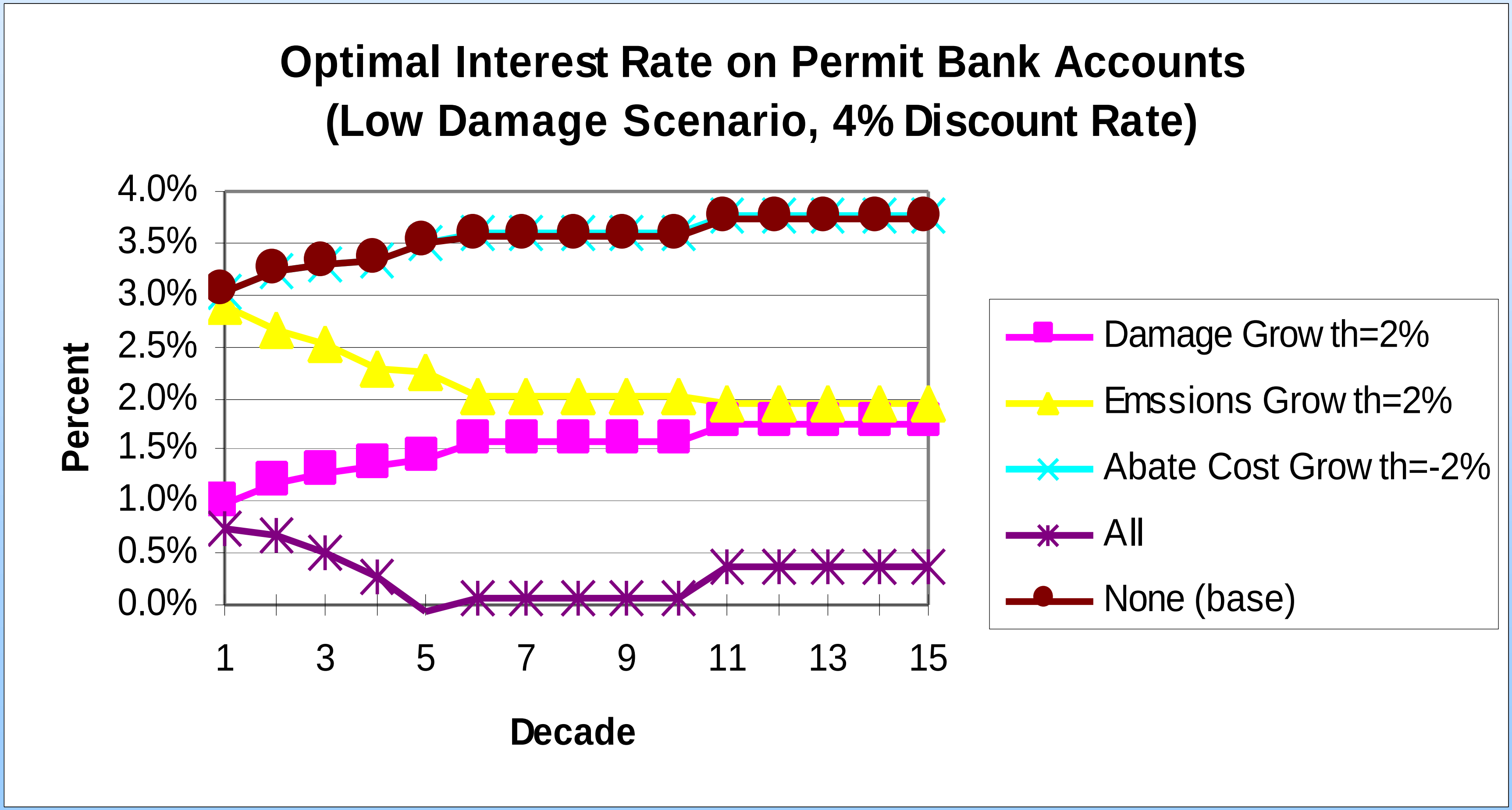
Numerical Values and Policy Implications

- Seek plausible numerical values
- US proposing to pay interest of 20%/decade
- Is this number high or low?

Falk & Mendelsohn Ests



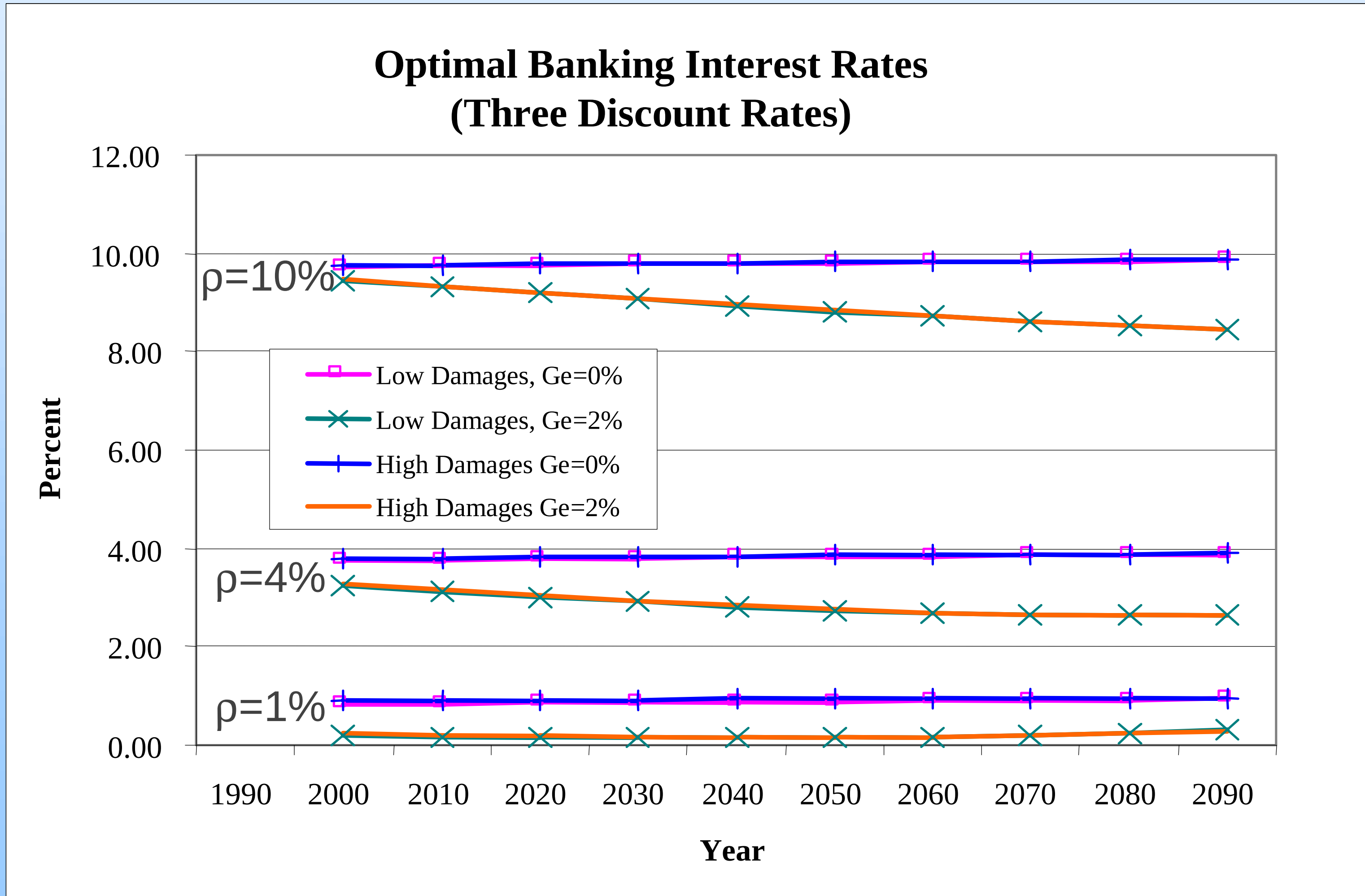
F&M Implied Opt Banking Rates



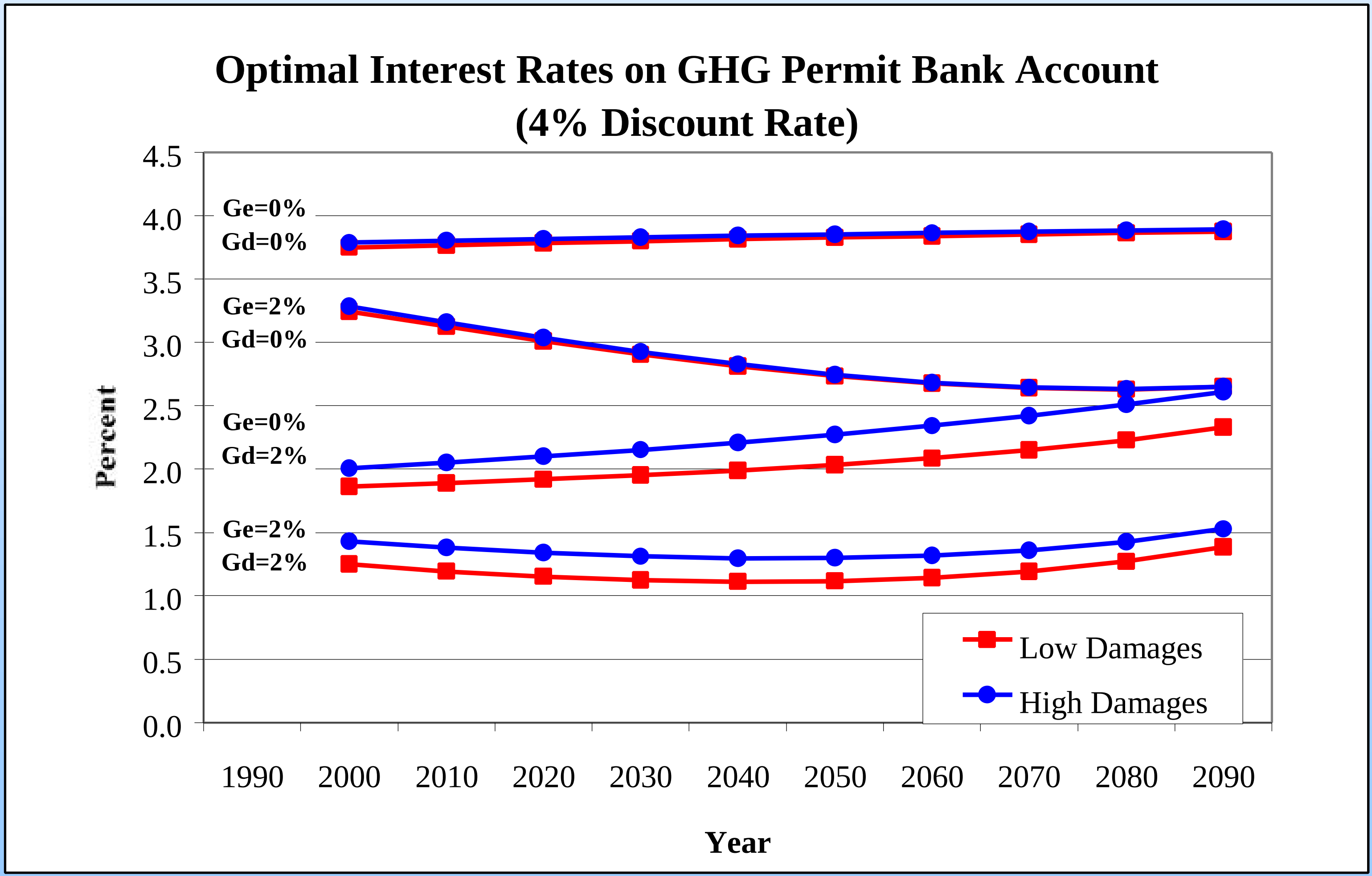
Borrowing and Technology Change

- Technological advances in emission abatement and damage mitigation, ceteris paribus, justify borrowing relative to a constant level of emissions reduction

Optimal Interest Rates on GHG Permit Bank Accounts



Optimal Banking Interest Rates: Sensitivity Cases



General Insights on Banking Systems: I

- Yield private optimality conditions matching traditional trading systems
- Add restriction on time path of permit prices

General Insights on Banking Systems: II

- Unrestricted/free banking
  - » Authority controls only one market outcome
  - » Discounted permit price constant
- Specification of interest rate
  - » Controls 2nd outcome, rate of price increase
  - » Seek to match price path to damage path
  - » Interest rate could be time-variant

Proposed Future Work

- Numerical Estimates With Climate Model
- Bargaining outcome, vs. cooperative
- Uncertainty:
  - » regarding permit prices
  - » regarding abatement costs