ECONOMICS AND NUTRIENT REDUCTION INSTRUMENTS: IMPLICATIONS OF LAGS

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Economic Questions

- How should resources be allocated to pollution abatement across sectors, locations, and time to achieve water quality goals at least cost?
- How do different policy instruments compare in their capacity to achieve “efficient” allocations?
- How should goals be set to optimally balance economic benefits and costs?

Policy Design 101

- Polluting emissions are:
  - Observable
  - Nonstochastic
  - Aggregate linearly with equal weights to determine anthropogenic pollution

- Pollution control costs
  - Depend only on current the abatement level
  - No capital adjustment costs

Policy Design 101: Efficiency

- The least cost solution (LCS)
  - Allocates pollution abatement among sources in each period to minimize the cost of satisfying the target, (T_t)

$$\sum_i e_{it} \leq T_t$$

- The efficiency rule
  - Equalize incremental (marginal) abatement costs (MCA) across pollution sources in each time period

Policy Design 101:Instrument Choice

- Perfect information
  - Effluent taxes, effluent standards, permit trading can all be designed to achieve the LCS

- Imperfect information (asymmetric info.)
  - ***Effluent standards*** will not satisfy efficiency rule (will note equalize MCA)
  - ***Effluent taxes*** can satisfy efficiency rule but may miss the target (+/-) (Equalize MCA but miss target)
  - Competitive ***cap-and- trade*** permit markets can satisfy the rule and achieve the target = the reason why economists like cap-and-trade permit markets

The Allowance Market

- Allowances (economic constraint) set equal to ecological constraint (TMDL): $S_t = T_t$

- Each polluter's emissions per period limited to allowances held:

$$e_{it} \leq b_t$$

The Allowance Market

- Individual allowance adjusted up or down through trades. Competitive trading will eliminate possible gains from trade, equalizing marginal abatement costs

- Total pollution is limited by the aggregate supply of permits:

$$\sum_{i} b_{it} \leq S_t$$

Complication 1: Spatial Heterogeneity of Pollution Impacts

- The 101 model assumes emissions have equivalent impacts regardless of the location of discharge. This emission reductions at different points in space are perfect substitutes

- In reality, location matters. e.g., a smaller fraction of upstream discharges will reach the Bay than downstream discharges

$$\sum_i \beta_i e_{it} \leq L_t$$

The Fix: Trade Ratios

- Abatement from different places does not trade 1:1; $TR_{ij} = \beta_i / \beta_j$
- Policy design requires greater information (as will any “efficient” policy)
- Markets become more complex and costly for participants (greater likelihood of participation or coordination problems)

Complication 2: Capital Adjustment Costs

- Long lived capital investments in treatment facilities, Best Management Practices
  - e.g., point sources invest in treatment facilities now or buy offsets?
  - e.g., nonpoint sources invest in BMPs to sell offsets in the future or sell the farm for development?
  - Answers depend on future prices

Fix: Forward Markets

- Market institutions must include *forward markets* to allocate abatement and investments efficiently *over time* as well as *across polluters*

- Even more than the spatial fix, forward markets would increase the complexity and cost of markets for participants and agencies

Complication 3: Lags

- Lags: Have received little attention in the economic literature on market design
- Simplest case:
  - Emissions observable and nonstochastic when discharged and when delivered
  - Lags of known length for sources
  - No capital adjustment costs

Time Structure of Pollution

$$e_t^k = \textit{emissions at time t with lag k}$$

$$L_1 = e_1^0$$

$$L_2 = e_2^0 + e_1^1$$

$$L_3 = e_3^0 + e_2^1 + e_1^3$$

$$L_4 = e_4^0 + e_3^1 + e_2^2 + e_1^4$$

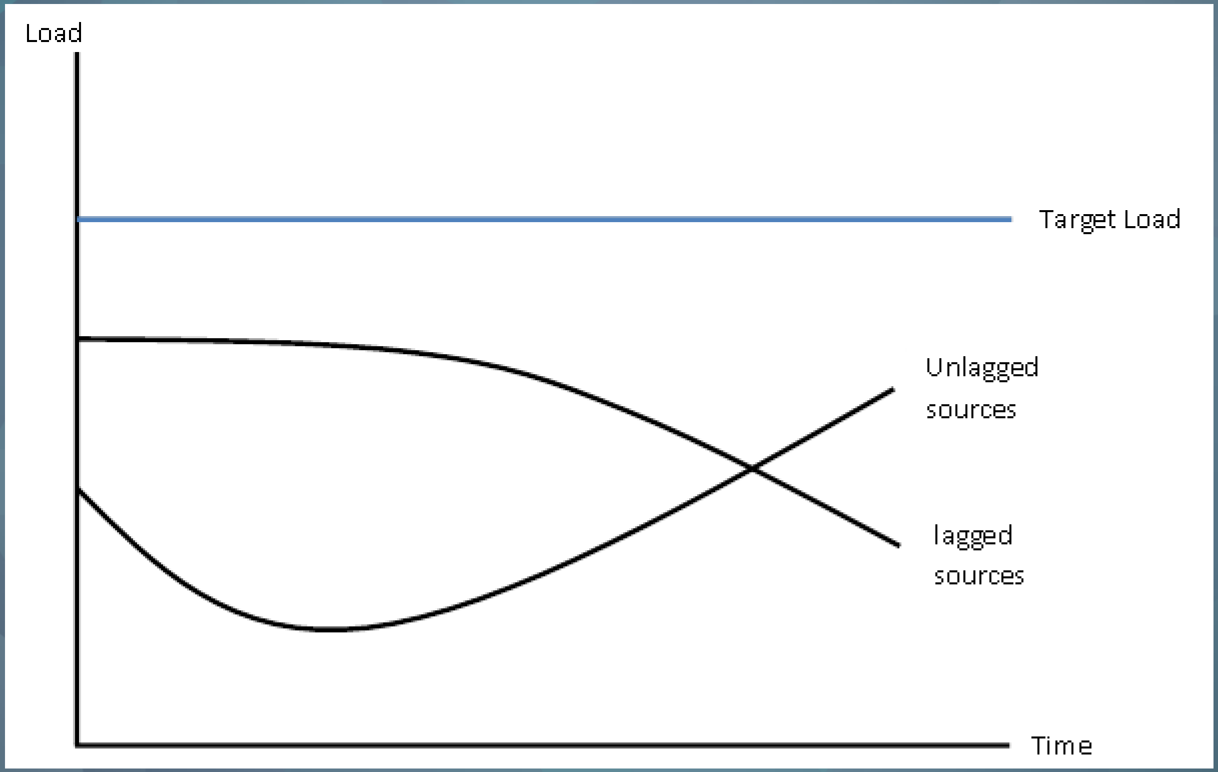
$$L_t = \sum_1^t \sum_0^k e_t^{t-k-1} = \textit{pollution load time t}$$

Least Cost with Lags

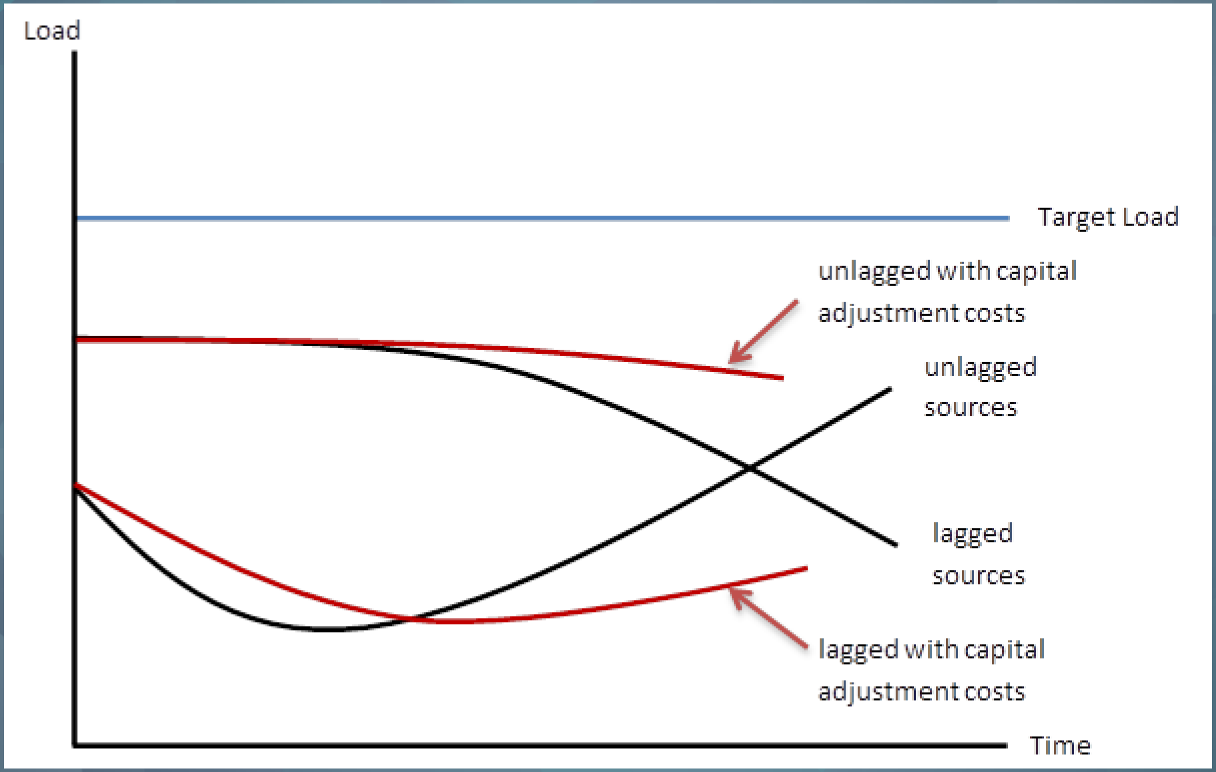
- LCS minimizes the discounted present value of the costs of achieving water quality goals

- Efficiency rules
  - MCA equalized across sources with equal time lags
  - MCA of lagged sources in any period equal to the discounted present value of the MCA of nonlagged sources in the year in which the lagged pollutant reaches the Bay

Efficient Allocation – no Adjustment Costs



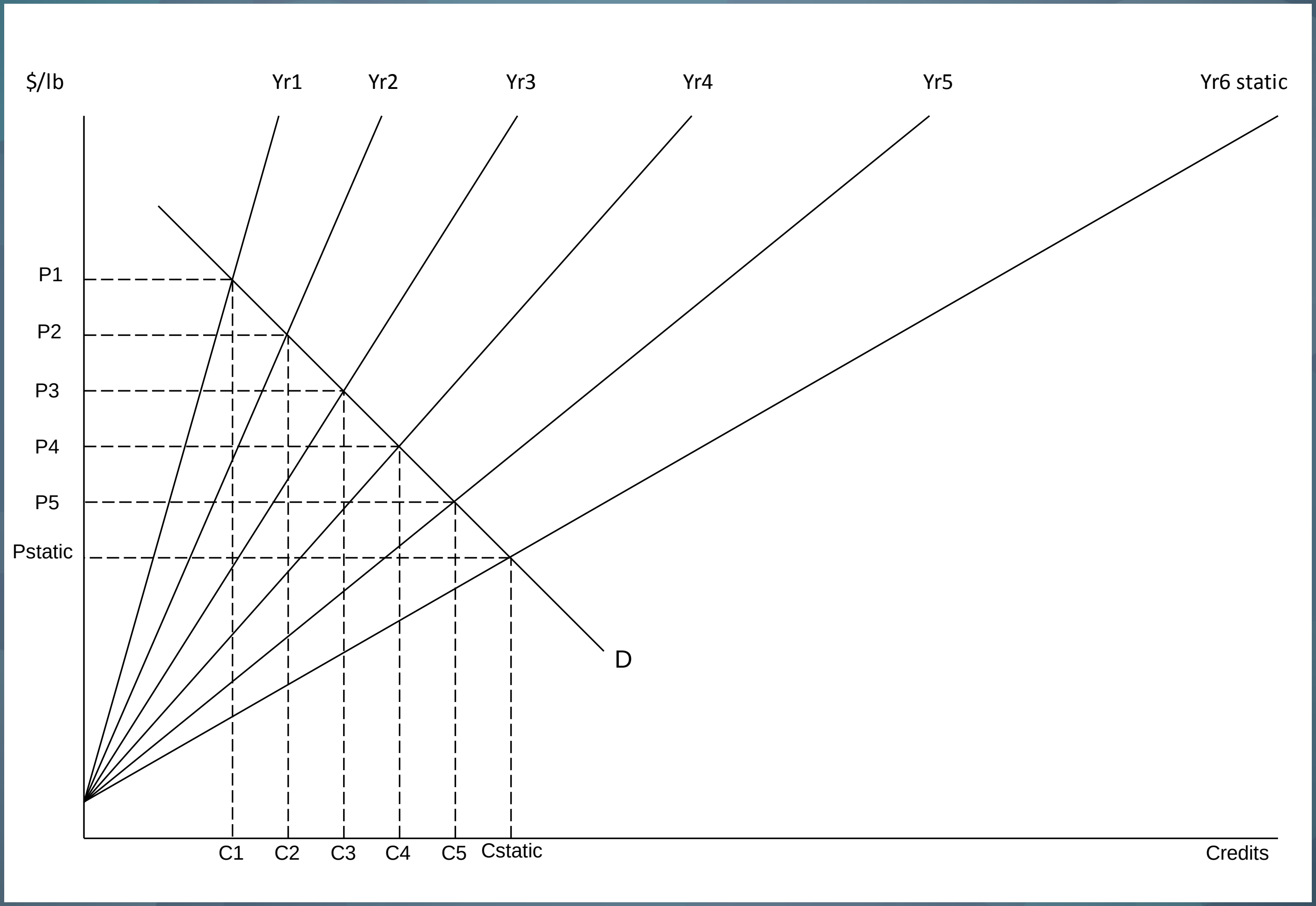
Efficient Allocation – with Adjustment Costs



Markets with Lags

- Forward markets essential with or without adjustment costs
  - Unlagged sources must know future prices to know appropriate current decisions
- Adding spatial heterogeneity back in would mean very complex markets
  - Design problems for policy makers
  - Participation problems for market participants

Allocation Between Sources Over Time



Complication 4: Nonpoint Pollution

- Nonpoint Emissions
  - Unobservable and stochastic
  - Alternative WQ targets required

$$Prob(\sum_i e_i \geq T_t) \leq \alpha$$

- Trading
  - What to trade?
  - Trading rules to address nonpoint uncertainty?

The Fix: There isn't one

- Plausible markets cannot be designed to achieve the LCS with nonpoint sources because appropriate ecological and economic constraints cannot be made equivalent (Horan and Shortle 2011)

- Nor can plausible alternatives!!

- No silver bullets = the *problem of second best*

Complication 5: Real People

- Real world participants in trading markets are not the rational, perfectly informed agents of theory
- Trading experience shows that transactions costs, uncertainty about markets, attitudes about markets are barriers to participation (Ribaudo and Gottlieb 2011)
- Nguyen et al. (2013) show that markets with boundedly rational agents with imperfect and asymmetric information are unlikely to come close to the LCS

Some Questions

- Do we have the scientific knowledge to design trading systems that will be ecologically valid?
- Can we expect the markets that would be required to efficiently allocate effluent reductions and land use changes for nonpoint pollution control over time and space in theory to work well in practice?
- What role should markets play?