Point-nonpoint water quality trading schemes under abatement uncertainty: Economic & environmental implications

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Overview

- Characteristics of nonpoint source pollution
- Nonpoint information problems
- Water quality trading
- Research design and methodology
- Results
  - Modelled versus experimental
- Conclusions

Characteristics of Nonpoint Pollution

- Many polluting firms or agents
- Driven by stochastic processes
- Interdependency
- Pollutants are not uniformly mixed
- Time lags
- Emissions unobservable
- Unable to observe inputs or practices (types)
- Imperfect knowledge about pollutant generation, transport and fate
- Unable to infer individual emissions from ambient concentrations

Nonpoint Information Problems

- Braden and Segerson (1993): NPSP control is characterised by informational problems:
  - Problems of natural variation
    - Driven by stochastic processes
    - Spatially heterogeneous firms and processes
  - Problems of monitoring and measurement
    - Inability to observe individual emissions
    - Inability to observe inputs or types (adverse selection problem eg. Shortle and Dunn 1986, Smith and Tomasi 1995)
    - Inability to infer individual emissions from ambient environmental quality (moral hazard problem eg. Segerson 1988, Xepapadeas 1991)

Premise

- Water quality trading:
  - A market-based, quantity instrument
  - Theoretically advantageous under certain information problems including spatially heterogeneity
  - Demonstrated success in the case of air pollutants (eg. USEPA SOx/NOx)
  - Basis: ***Abatement cost heterogeneity between point and nonpoint sources***
  - How it works (typically): Regulated point sources demand permits from unregulated nonpoint sources (an ‘offset’ style trading scheme)
  - Lack of empirical research on how trading schemes perform economically/environmentally in the context of nonpoint information problems

Questions

- How effective (environmental & economic) is a point-nonpoint trading scheme when contaminant abatement is stochastic?
  - Mandatory technology standards (regulation) versus flexible decisions regarding abatement (BMP) effort (voluntary adoption)
  - Standardized (‘average’) performance of BMPs versus BMP performance as a function of climate (stochastic)
  - Design issues for trading schemes to incorporate stochastic abatement

Research Outline

- Sediment trading under heterogeneous stochastic climate and land use
  - Johnstone River catchment in north Queensland (Great Barrier Reef catchment)
  - 4 stylized point source buyers (demand permits) and 4 stylized agricultural nonpoint sources with BMPs (sellers/suppliers)
    - Point demanders: 4 x 20,000 equivalent person treatment plants
    - Nonpoint suppliers: broadacre beef cattle & sugarcane
    - BMPs: siltation basins, riparian revegetation, vegetated buffer strips

Methods: Data & Modelling

- Data:
  - Field data (Biophysical and economic)

Biophysical data	Rainfall (QDNRM (2004) 'Data Drill'; Stochastic Climate Library (CRCCH 'Catchment Modelling Toolkit')	
	PET (Climatic Atlas of Australia – Evapotranspiration)	
	Pollutant generation rates and effectiveness of best management practices in reducing pollution discharge for different land uses	
Economic data	Abatement cost functions for wastewater treatment plants (University of QLD, Sydney Water and others)	
	Farm income/EBITDA & yields for different types of agriculture located in the Johnstone River catchment (ABARE, CANEGROWERS)	
	Capital costs of rehabilitation works for different agricultural BMPs	

- Modelling
  - Software biophysical modelling incorporating stochastic climate data, pollutant generation rates and BMP performance for each land use
  - Economic optimization modelling of permit (TSS) supply and demand
  - Experimental economic methods (individual behaviour)

Methods: Experimental

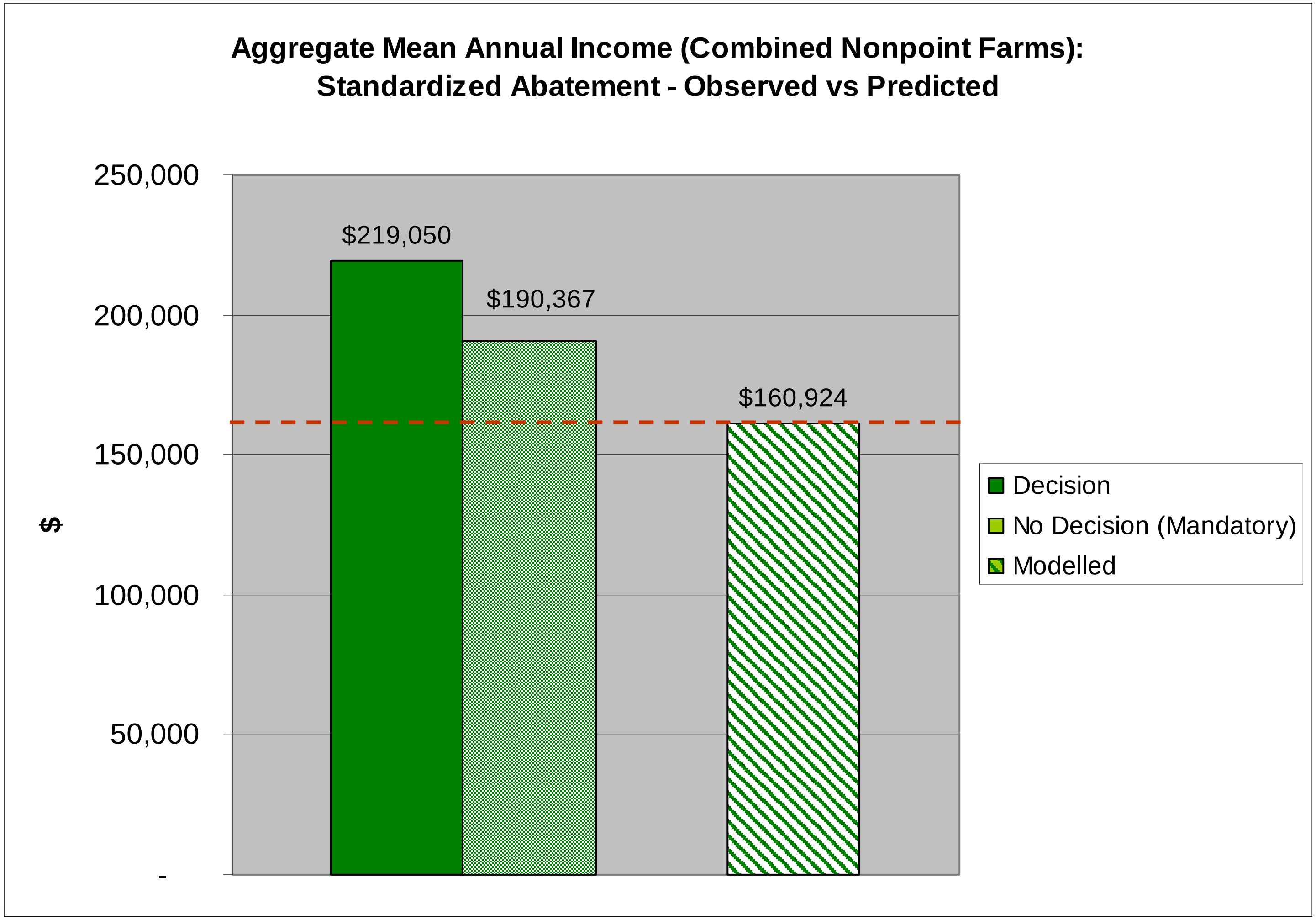
- Experimental economic or ‘laboratory’ methods
  - Why? ‘Glasshouse’ testing of new economic policies to examine how their performance differs from theoretical predictions (eg. profit maximisation, risk neutrality)
  - Designed to evaluate individual behaviour
  - Market: Multiple-unit double auction software trading environment
  - Tested effects of:
    - Standardized Abatement vs Stochastic Abatement
    - Prescribed levels of abatement vs Individual decisions about abatement effort/allocation
    - For stochastic abatement: two designs were assessed:
      1. Ex-post trading – time lag between abatement decision and trade
      2. Ex-ante trading –a primary market; followed by a secondary or reconciliation market

Modelling Results

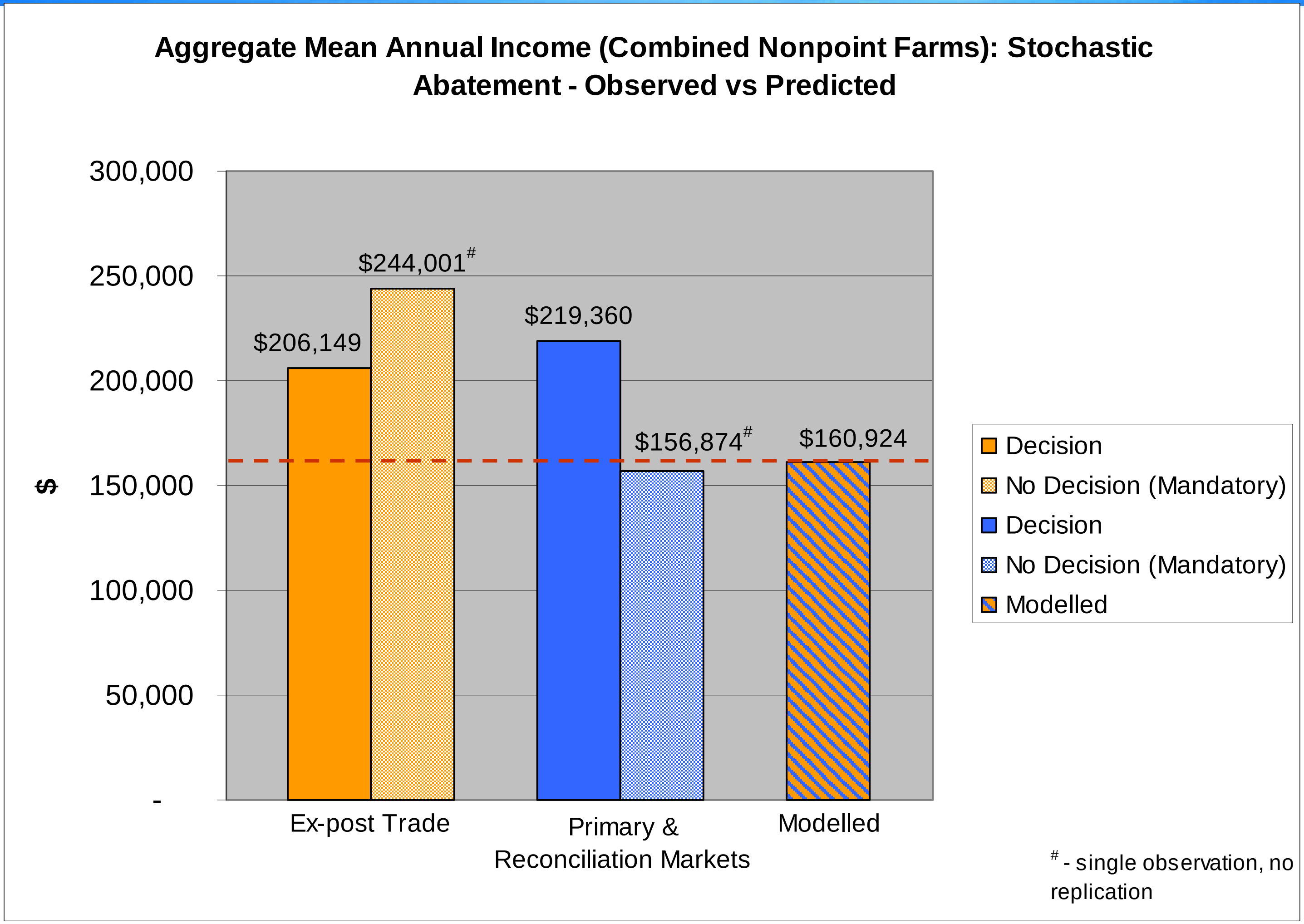
Even with a relatively small market and stochastic abatement – only 8 traders, 4 point sources and 4 heterogeneous nonpoint sources:

- AGRICULTURAL SOURCES
  - Farm income changes of **34% - 144% for voluntary trades**
  - **Farmers financially better off 70% of the time**, however success dependent upon cost-effectiveness of best management practices and climate
  - Sediment reductions of between **22t and 220t per annum**
- POINT SOURCES
  - **Savings from trade 20 - 60%** for 20kEP point sources compared with direct regulation
  - Savings of **$2.9 - $7.2 million dollars per 20kEP plant** in terms of treatment plant upgrades; savings are greater for larger than 20kEP plants

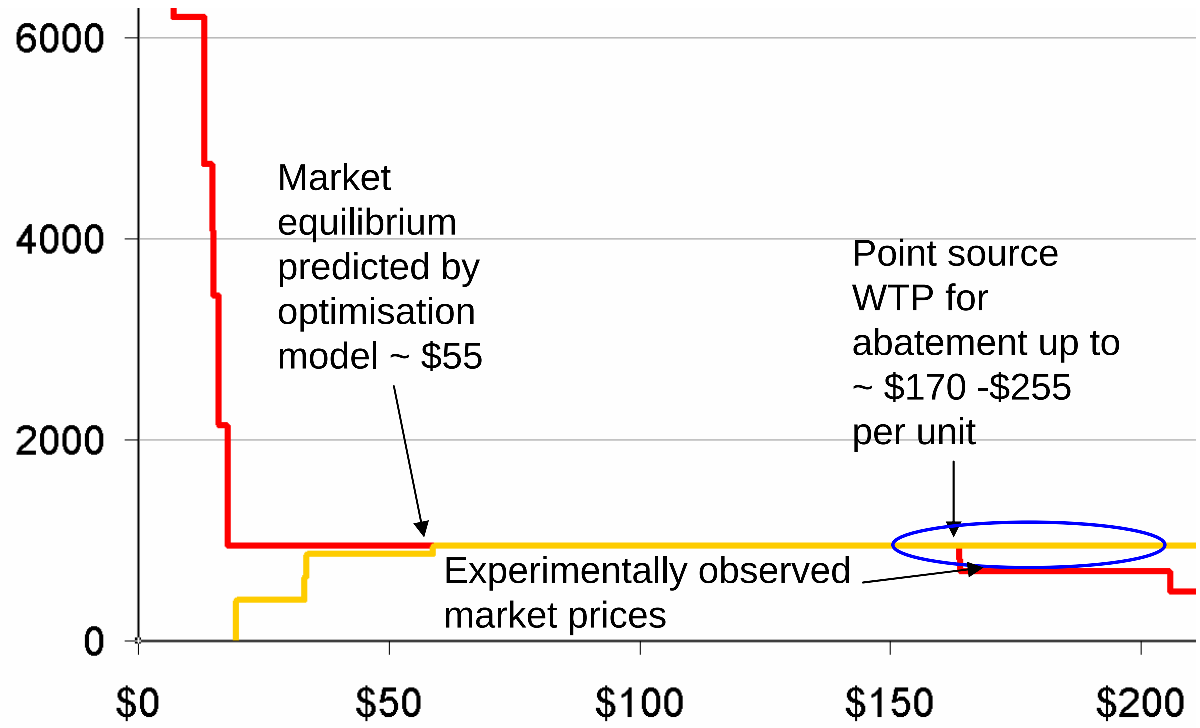
Experimental Results



Experimental Results

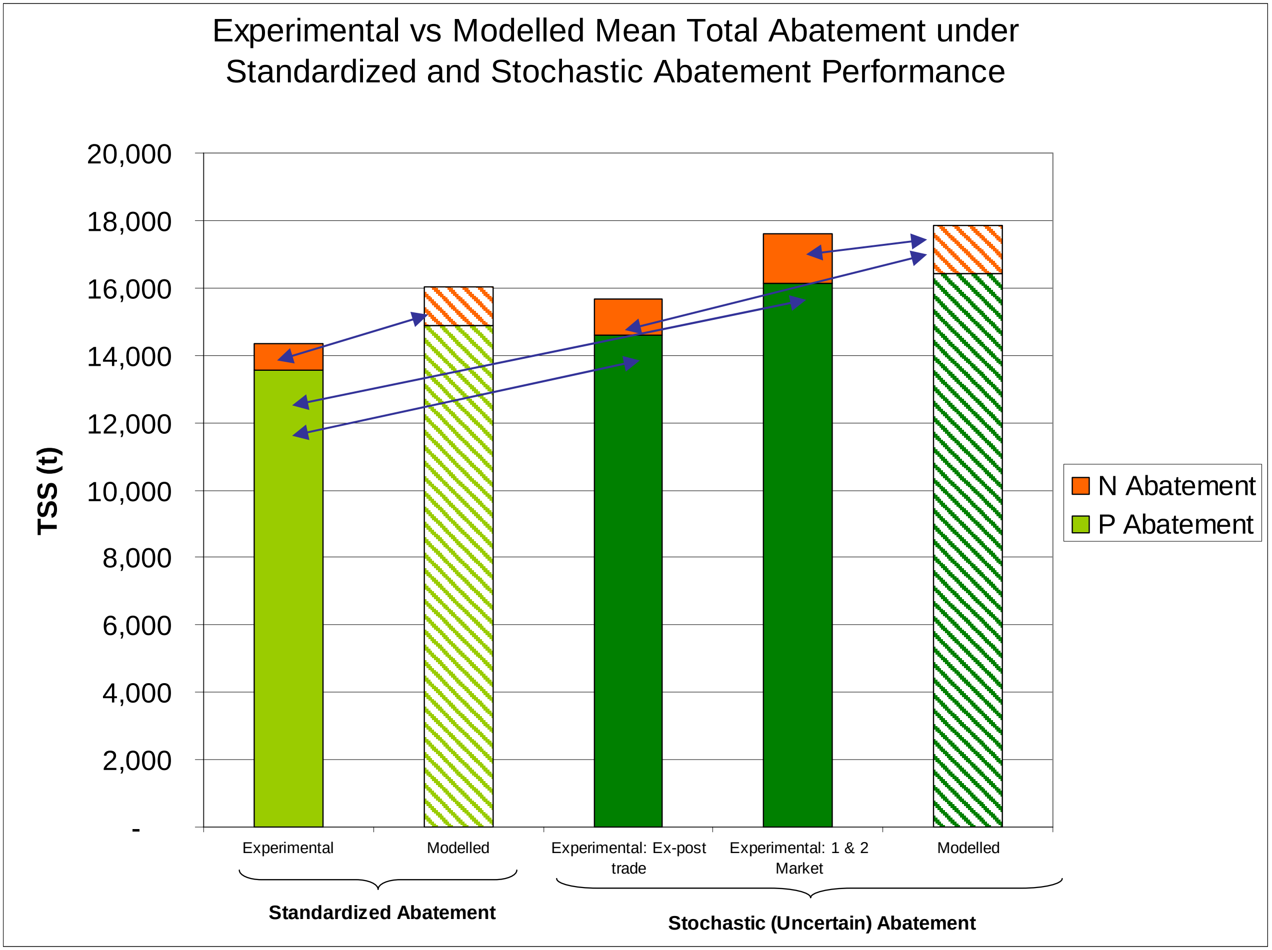


Model vs Experimental Results



- Inelastic demand at market equilibrium
  - Point sources: higher willingness to pay (WTP) for abatement
  - Nonpoint firms able exploit max. WTP
  - Could be expected in all water quality markets involving point sources since point source curves have this generic shape

Model vs Experimental Results



- Point firms choose suboptimal levels of abatement
- In this case 424t/yr (standardized) to 260-360t/yr (stochastic) between predicted and observed (i.e. decision about abatement)
- Difference between observed standardized and observed stochastic is, on average, less by 112-270t/yr
- Are the differences likely to be ecologically important?

Conclusions: Water quality trading schemes

- Issues of supply and demand for permits
  - Market volume
  - Problems of demand (or supply) inelasticity
- Stochastic abatement has implications
  - Farm incomes (nonpoint)
  - Savings from Trade (point)
  - Total abatement greater when stochastic effects of climate considered in this study
- Mandatory versus voluntary adoption of abatement
  - Market allocative efficiency
  - Market equilibrium price and price volatility – lower median prices when abatement was mandatory
  - Some BMPs are likely to be more successful than others in a trading environment

Conclusions

- Research demonstrates potential efficiency gains which are presently not being realised – in the order of ***$M***
  - However other design issues may be important eg. spatial trading rules or ratios and permit banking

- Water quality trading and other market-based instruments pursued with good intentions but little or no economic science
  - Lack of empirical and experimental research
  - Our efforts in riverine ecology research needs to be matched by research on appropriate regulatory/economic incentive mechanisms to implement successful change

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