

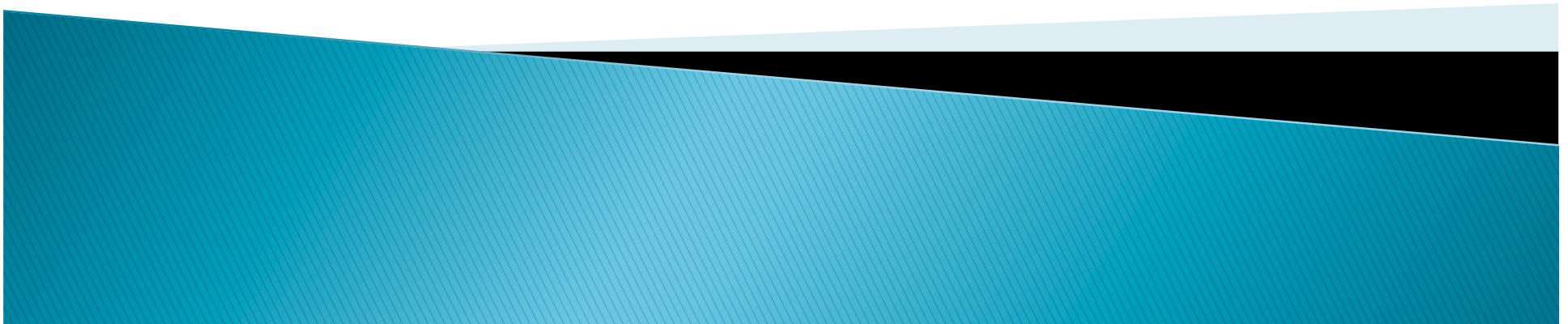
# An Experimental Analysis of Market Based Agricultural Greenhouse Gas Instruments: Alternative Market Designs, Monitoring, and Enforcement

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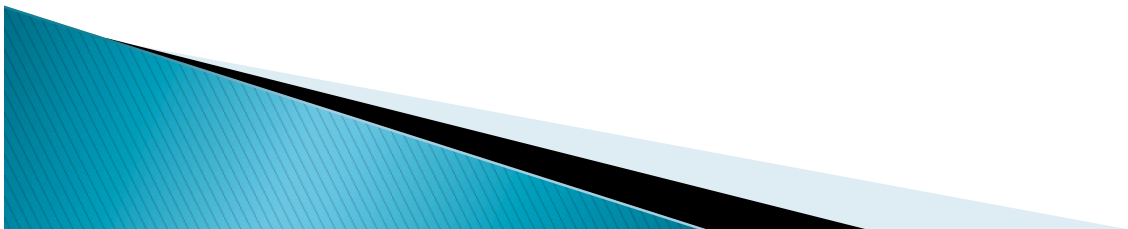
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# Introduction

- In proposed Greenhouse Gas (GHG) sequestration markets
  - Agricultural agents (farmers) can sequester GHGs
  - Earn credits from a regulatory agency for this sequestration
  - Sell these (low cost) credits as offsets to GHG emitters
  - GHG emitters can satisfy emissions standards/ reductions with purchased credits at a lower cost than they otherwise could



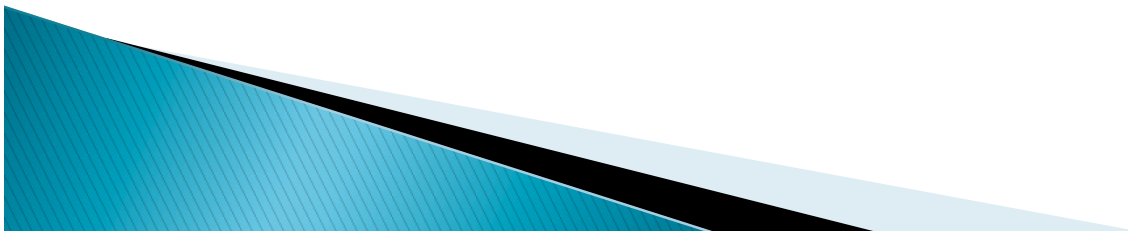
# Introduction

- GHG sequestration markets can be complicated
  - Asymmetric information exists between the buyer and seller
    - Where the buyer does not know if the GHG certificate will satisfy the emissions standards/reductions
      - A certificate where GHGs have not been sequestered – a “lemon”
  - This is complicated further by the free-rider problem
    - Where the buyer (nor seller) cares if the GHG has been sequestered



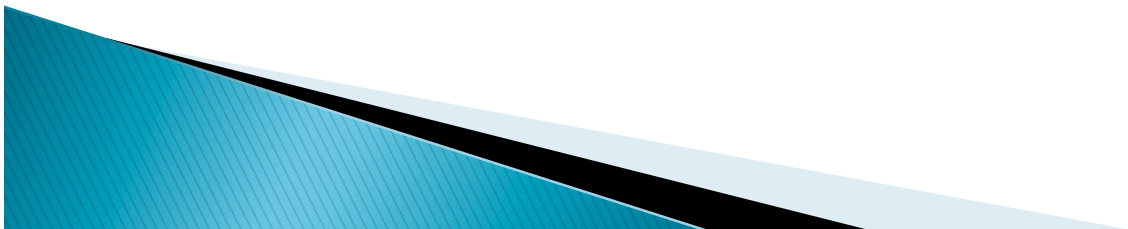
# Introduction

- ▶ The aim of this project is to study different market mechanisms to see which one performs best at:
  - Maximizing the amount of GHG sequestered
  - Minimizing the number of certificates sold that did not have associated GHG sequestration



# Introduction

- ▶ The main market mechanisms that will be tested are:
  - Guaranteeing GHG reductions (verification)
    - Permits are guaranteed to be accepted by the regulatory agency
      - To be used by GHG emitters to satisfy emissions standards/reductions
  - A central buyer



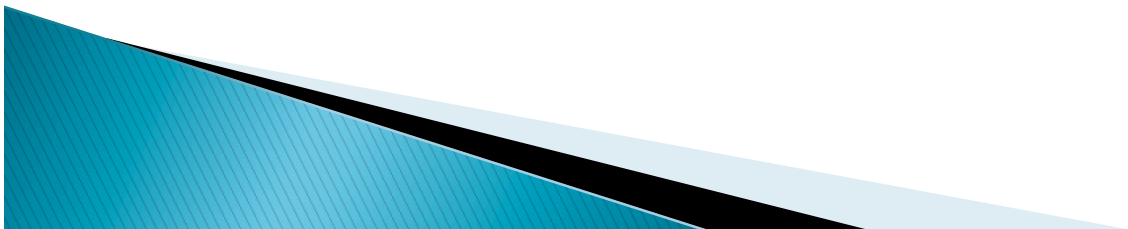
# Lemons/Eco-labeling Literature

- ▶ Lynch, Michael et al. 1986. Product quality, consumer information and 'lemons' in experimental markets
- ▶ Cason, Timothy N., and Lata Gangadharan. 2002. Environmental labeling and incomplete consumer information in laboratory markets
- ▶ Bougherara, Douadia, and Virginie Piguet. 2009. Market behavior with environmental quality information costs
  - Guaranteeing works
  - Reputations work sometimes
  - Used these papers as the basic setup of this experiment



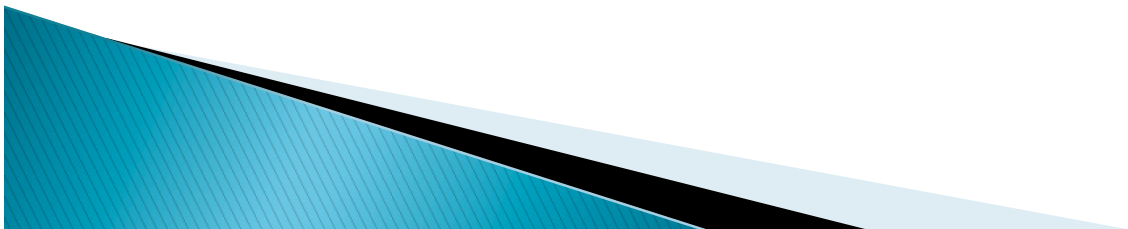
# The Environment

- ▶ 5 buyers, 5 sellers
- ▶ Buyers have a constant marginal benefit for each of 5 permits purchased - 550 ED (Experimental Dollars)
  - May purchase from sellers
    - Buyers see seller number associated with each sell offer (reputation)
    - May make their own bid to buy
  - May also purchase from outside seller
    - Constant cost (450 ED)
    - This gives the buyer an outside option
    - The outside permit is guaranteed to be a created permit



# The Environment

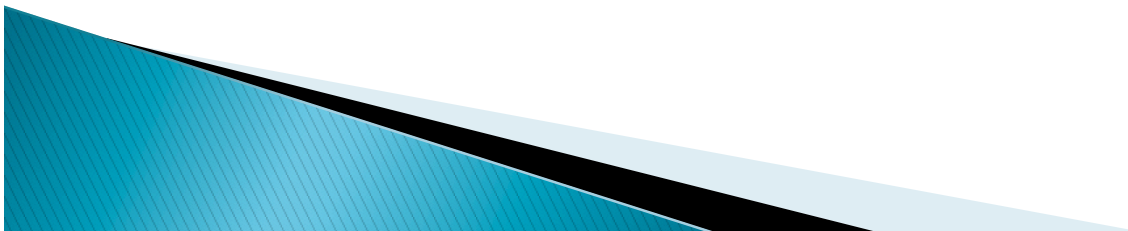
- Sellers can attempt to sequester up to 4 units of carbon, or create 4 “permits”
  - The actual number of permits created may be any number up to the amount attempted
  - Each possibility has an equal chance of happening
- Constant marginal cost of attempting sequestration (150ED per permit)
  - Pay for attempting regardless of actual creation
- ▶ Sellers can then sell up to 4 permits
  - Can sell more permits than actually created





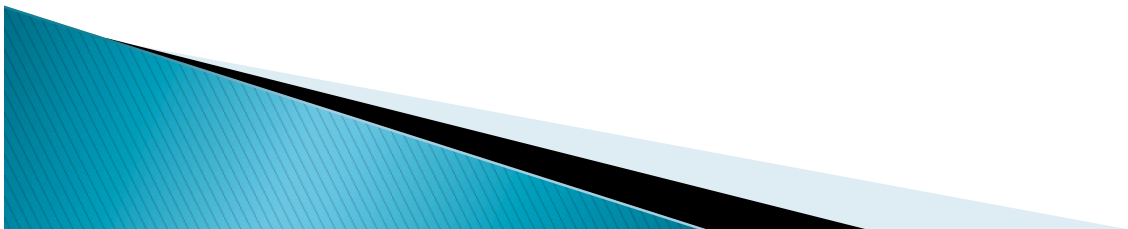
# The Environment

- ▶ 5 Buyers X 5 Permits = 25 Permits Demanded
- ▶ 5 Sellers X 4 Permits = 20 Permits Supplied
- ▶ Demand > Supply



# The Environment

- ▶ There is a possibility that buyers buy “uncreated” permits (lemons)
  - Sellers sell more permits than actually sequestered
- ▶ Buyers are audited with probability of 40%
  - At the end of each period
- ▶ If the buyer purchases a detected uncreated permit (lemon) they must repurchase another permit – 450ED
- ▶ If uncreated permits are detected the seller incurs no penalty



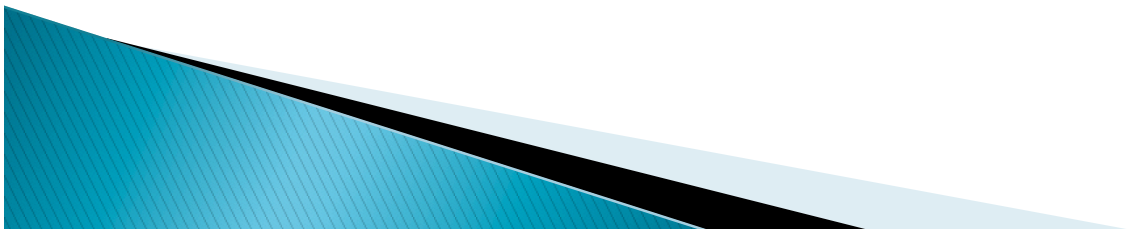
# The Environment

- ▶ At the end of trading both buyers and sellers are informed of audits and detected uncreated permits
  - Buyers are informed of the seller number which sold uncreated permit(s)
  - All buyers are informed of any seller who sells detected uncreated permits to any buyer
    - Reputation
- ▶ 10 Periods per experiment
  - 2 Practice periods



# Treatments

- ▶ Control
  - Double Auction
  - Buyers buy permits without any signals other than seller number (no advertising/verification)
- ▶ Treatment I
  - Two simultaneous markets
    - Unverified – permits are unverified and may be uncreated (lemon/regular)
    - Verified – all permits are verified and are certain to be created
      - Sellers must pay 50ED for each transaction/permit
  - Buyers and sellers can enter or leave either or both markets at any time



# Treatments

- ▶ Treatments II and III
  - Sealed Bid Auction
- ▶ Central Buyer (computer)
  - Preference given to verified permits
  - In period 1
    - 20 permits demanded
    - Maximum price of 450ED per permit
  - Periods 2–10
    - Demand =  $20 \times (1 + (\text{lemons purchased } n-1 / \text{total buys } n-1))$
    - Max price =  $450 \times (1 + (\text{lemons purchased } n-1 / \text{total buys } n-1))$ 
      - Demand increases and price decreases with increased uncreated permits purchased
      - Lower bound on price (150ED), upper bound on Q (35)



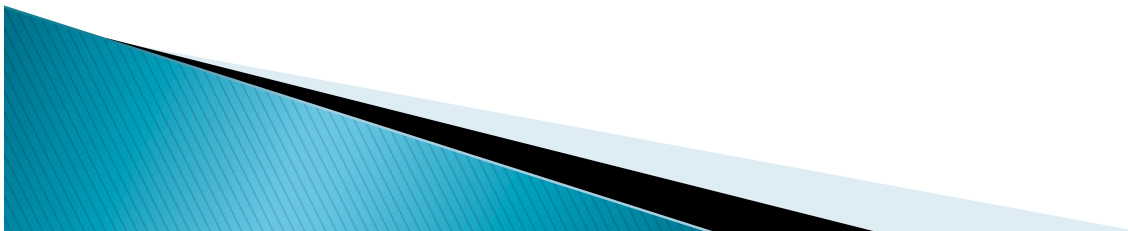
# Treatments

- 5 Sellers
- Sellers can create and/or sell up to 7 permits
  - 150ED for attempting to create each permit
  - There is no variability in number of permits created
- Sellers know
  - The buyer's quantity demanded
  - The buyer's maximum price
  - The buyer prefers verified permits
- Sellers offer
  - Number of permit
  - Price per permit
  - Verification or not
    - 50ED per permit offered



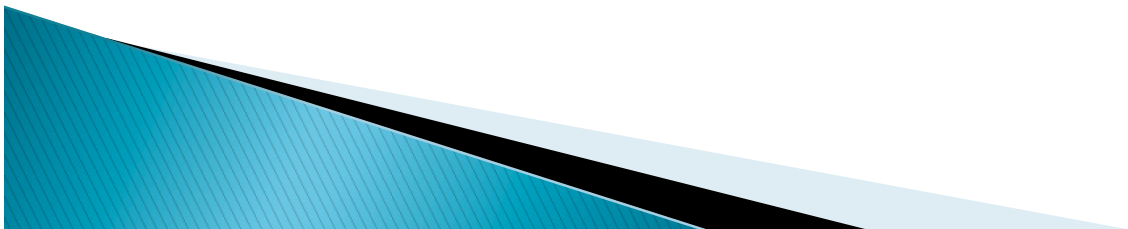
# Treatments

- ▶ Treatment II
  - Pay for creation regardless of permits sold
- ▶ Treatment III
  - Sellers pay for only sequestered permits that they sell



# Protocol

- ▶ 170 University of Sydney undergraduate students participated
- ▶ Experiments were conducted in a Computer lab running Fishbacher's zTree program
- ▶ Participants were quizzed
- ▶ Participants were paid \$0–\$44
  - 300ED to \$1
- ▶ At least 5 experimental sessions were conducted for each condition





# Results – Efficiency

	CTRL	TRT I	TRT II	TRT III
Percentage of Possible Permits Transacted	36%	37%	64%	69%

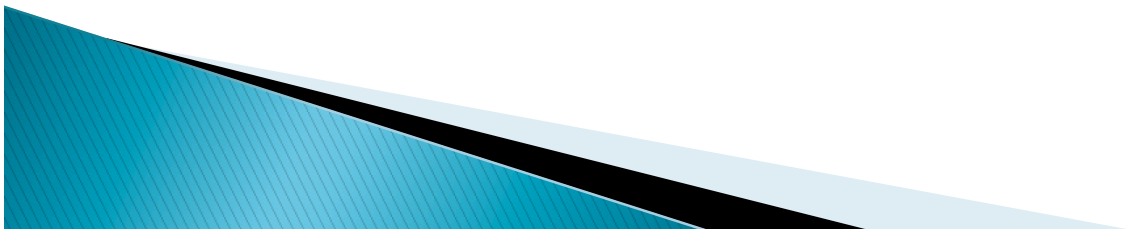
- This is the number of permits that were created and transacted as a percentage of the total number of permits that could have been created and transacted
- Clearly Treatments II and III foster permit creation
  - Central Buyer
  - Elimination of creation variability
  - Treatment III eliminated the risk of paying for permits that were not sold
- But Treatment I did not encourage permit creation over the control condition



# Results – Lemons

	Control	Trtmt I	Trtmt II	Trtmt III
Percentage of Unverified Permits Transacted	100%	68%	31%	39%
Percentage of Uncreated Permits Transacted	56%	56%	21%	26%
Percentage of Unverified Uncreated Permits Transacted (vs. all unverified)	56%	70%	65%	67%

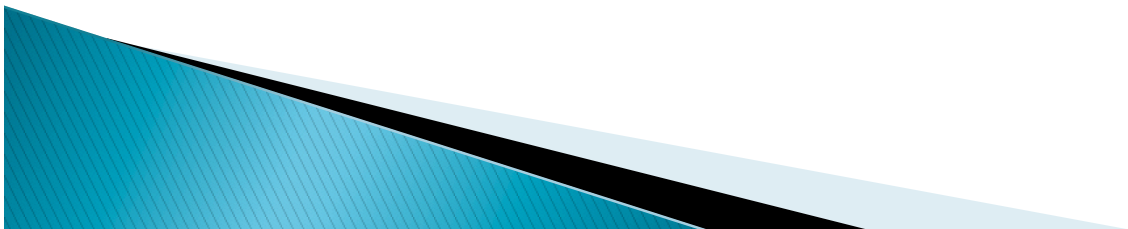
- Allowing permits to be verified did not discourage uncreated permits from being transacted in Treatment I over the Control condition
  - Buyers and sellers often chose the unverified market
- The unverified markets in all conditions are riddled with uncreated permits
  - Treatments II and III 70+% of all transactions were verified



# Results – Dual Market

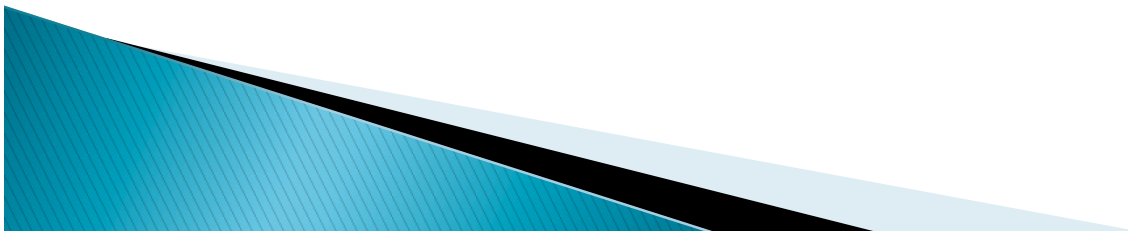
	Ctrl	Trt I	Trt II	Trt III
Mean Trading Price Unverified	409	347	204	174
Mean Trading Price Verified	n.a.	438	337	347

- It is clear that there are different prices for verified and unverified permits
- Paired with the level of unverified permits being transacted in the unverified markets it seems that there truly are two real markets



# Conclusions

- ▶ Instituting verification of created permits surprisingly did not encourage permit creation or reductions in uncreated permit transactions in the Treatment I condition
- ▶ Instituting a central buyer, with adaptive price and quantity, who prefers verified permits, considerably increases permit creation (GHG sequestration), and decreases the level of uncreated permits transacted



# Conclusions

- ▶ Instituting verification bifurcates the market
  - Risk averse vs. the risk seeking
  - The majority of unverified permits sold were uncreated

