Experimental Testbedding Market Mechanisms for Environmental Policy Design

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An Absurd Headline

- "First Test Flight of Air Force Transport Plane Crashes with 43 Passengers on Board
  - Physicists Puzzled: 'It should have flown'
  - Aeronautical Engineers Wonder Why they Were Not Consulted
  - Air Force Hails Test as a Stunning Success"

- What did they forget to do?

Central Tenet for Testbedding: Markets are influenced by the same forces (although perhaps in different ways) in the lab and field

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- **Experiments** provide insight into whether predictions developed through theoretical reasoning can be applied to **more complex** field conditions

- Laboratory markets are populated by profit-motivated human agents, just as markets are in the field
- **Wind tunnel** testbedding
  - Imagine testing a new wing design on an airplane without first assessing its actual aerodynamic properties in controlled wind tunnel testing
  - Note that such testing focuses on *specific* components of a new aircraft, not the entire system

The Market Design Problem and the Laboratory

- In some cases trading institutions may **already exist**, and have plausible alternatives, which can be modeled theoretically with some simplifications
- **Complementing** this, experimental designs can mimic the institution rules that are in effect in the field market
- I.e., "*experiments are used as models of the real-world system about which knowledge is sought*" (Bardsley et al., 2009).

Overall Research Objective

- Make a correct (or at least a better-informed) guess about what will happen if a particular policy is adopted

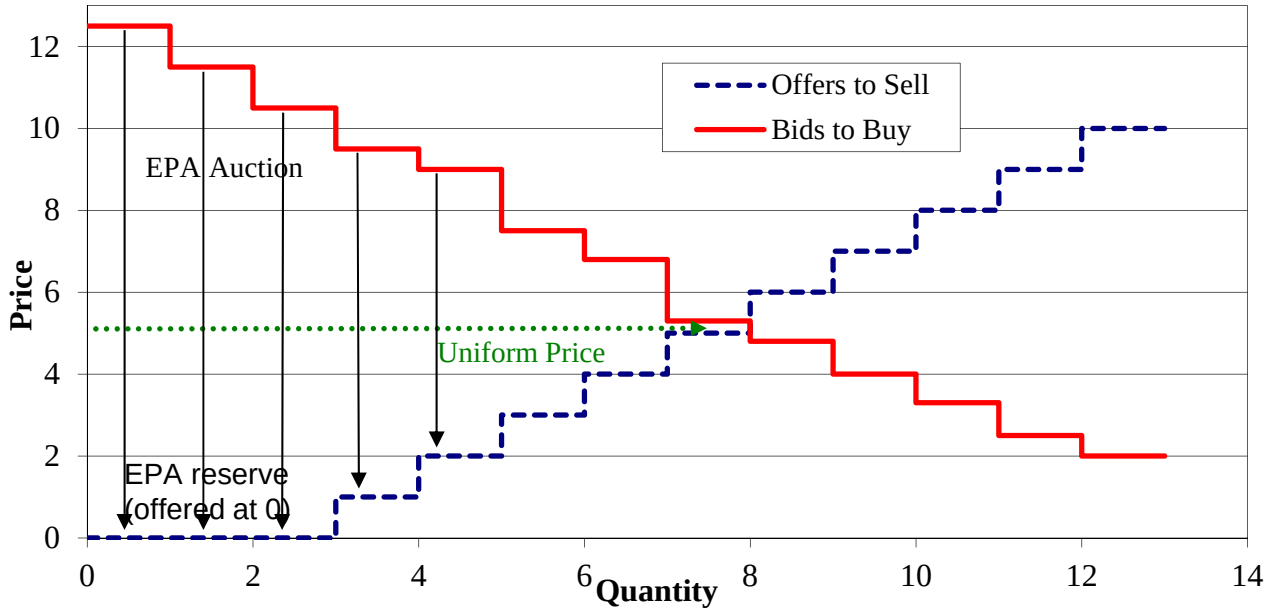
- (Testbedding experiments can also be used for market design and market engineering—such as for creating entirely new and complex combinatorial auctions with package bidding—but my examples will not include those)

Example #1: Auction Rules can Influence Allocative Efficiency and Price Discovery

- Earliest government emission permit auctions (U.S. SO_2 permits, starting in 1993) resulted in **biased price signals** for this emerging market
  - Cason (1995); Cason & Plott (1996)
- Riskiness of the EPA auction likely was one factor contributing to its abandonment (by traders) in favor of a negotiated price market with higher transaction costs (Joskow et al., 1998)
- **Uniform price** auctions (such as an ascending price clock auction) reduce incentives to strategically manipulate bids to influence price

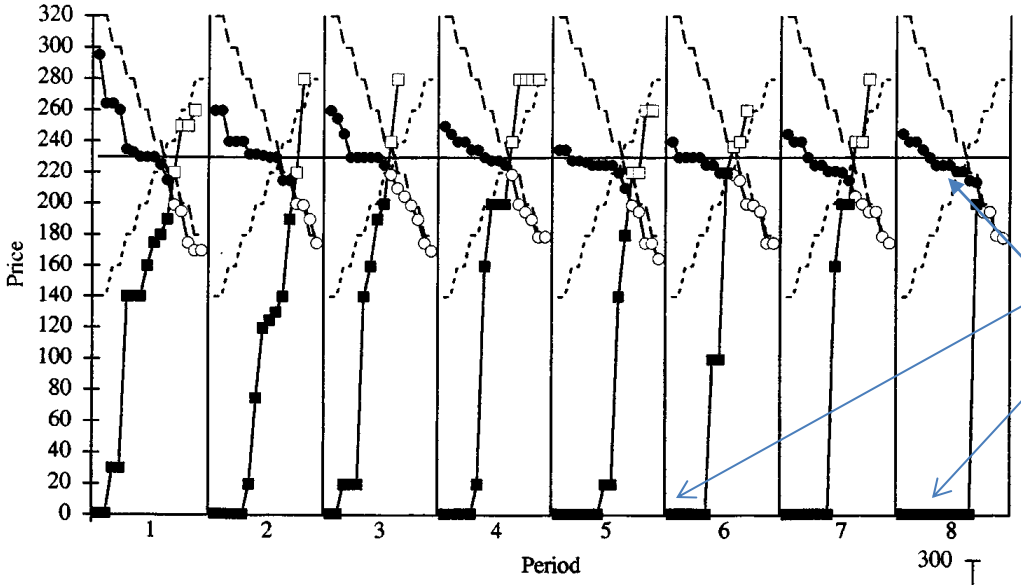
Unique Rules for the EPA Annual SO_2 Permit Auction

- Auction ~2.8% of permits each March (0 reserve price)
- Private holders could offer permits as well
  - Buyers pay bid price (discriminative, “pay as bid”) and lowest offer prices matched with highest bids



Multiple equilibria exist for a variety of underlying environments

Do Human Subjects Recognize the Auction Incentives? What is the Performance Impact?

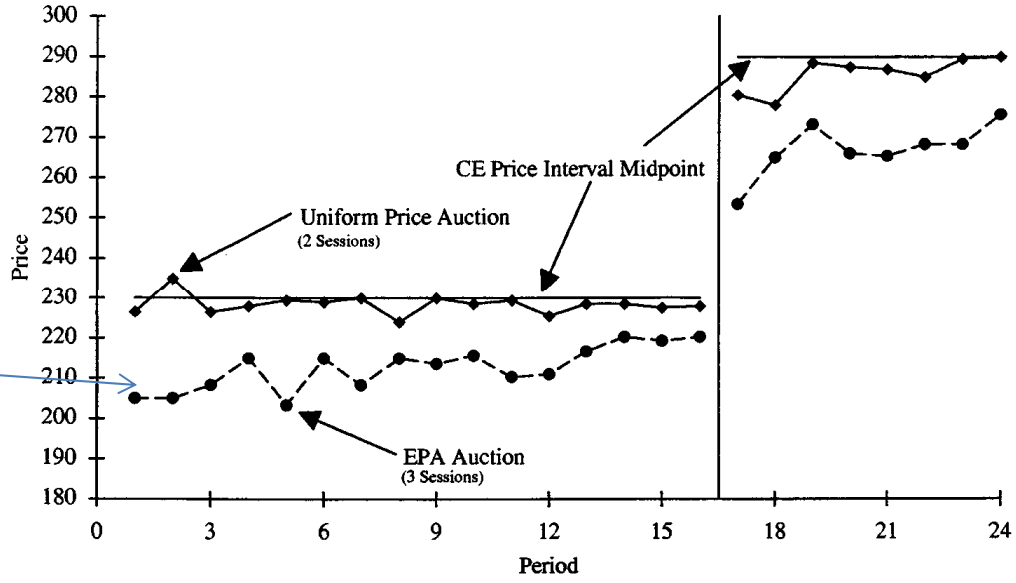


Within minutes, subjects recognize the incentives to offer low prices to obtain the higher bids

(Bid schedule begins to flatten)

(Other, less stable environments led to similar conclusions.)

Combination of downward bias in bids and offers results in a price bias for the EPA rules.

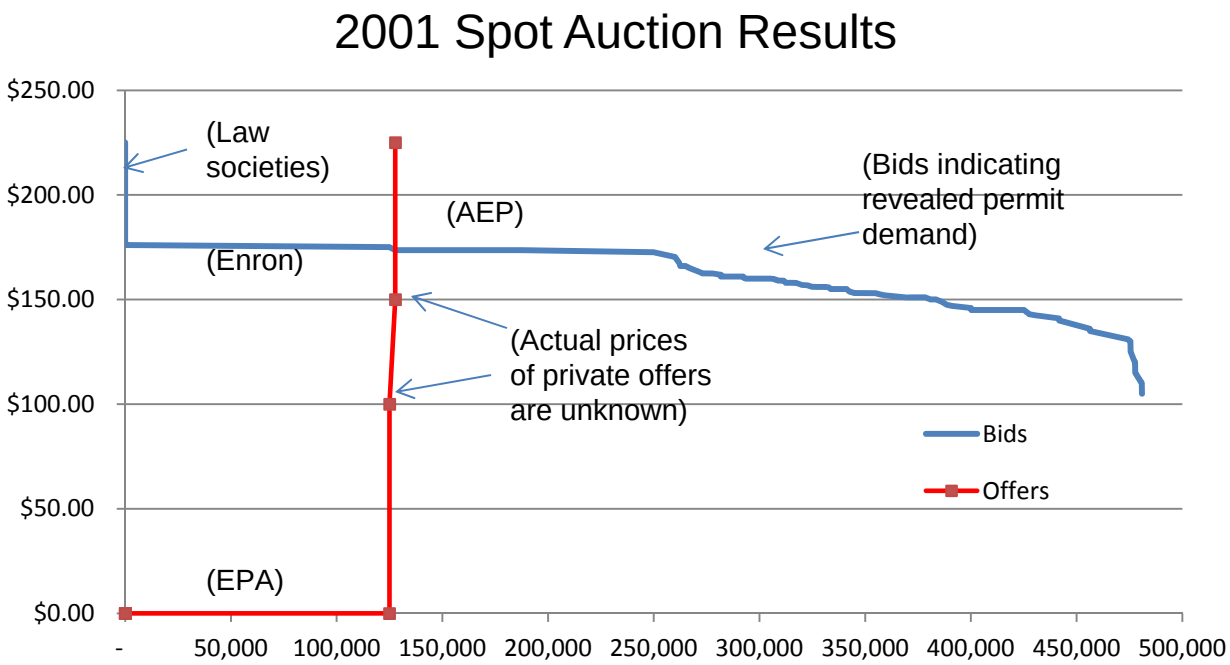


Source: Cason & Plott (1996)

So What Ever Happened to the EPA Auction?

- EPA considered changing to **uniform price** rules, but by the time the proposed change appeared in the Federal Register the non-auction market had matured
  - Virtually no private allowances were offered 2003-2009
    - New regulations after 2010 made SO_2 market obsolete

97.8% of sold permits were offered at 0 by EPA, and 2.2% were privately offered.



Note that alternative, **combinatorial designs** (e.g., Porter et al. 2009) could have improved value of an EPA-sponsored auction

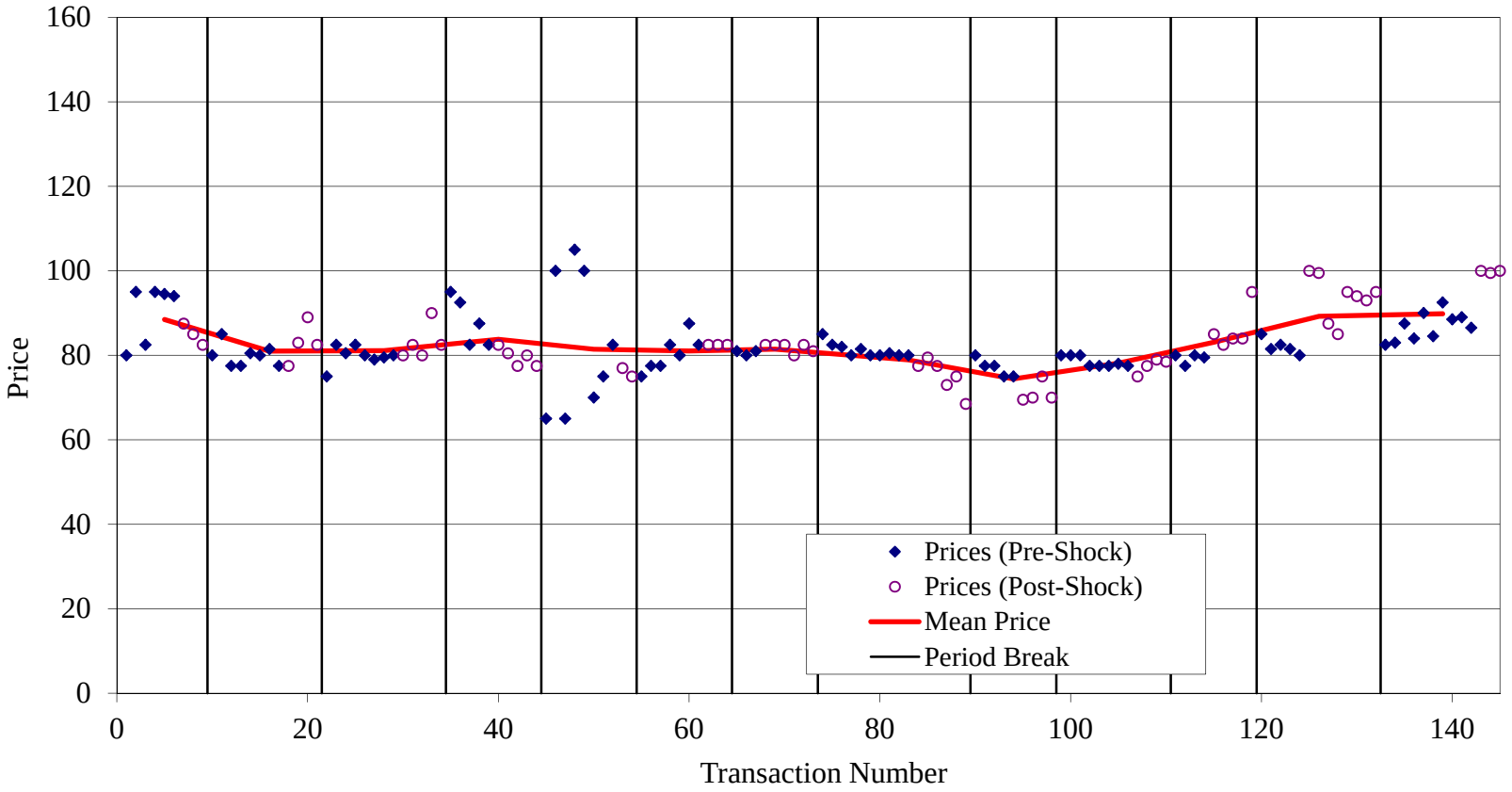
Experimental Models to Investigate Implications of Alternative Design Details

- Experimental models are informative for institutional design in part because purely theoretical modeling is constrained by the theorist's imagination (Smith, 2008)
  - An experiment leaves room for other, **unimagined factors** to influence outcomes
- Experiments can serve as **test beds** to try out new rules and institutions, even those guided only by the designer's intuitions
  - A very **low-cost** way to identify weaknesses and strengths of alternatives

Example #2:
Banking and Price Volatility

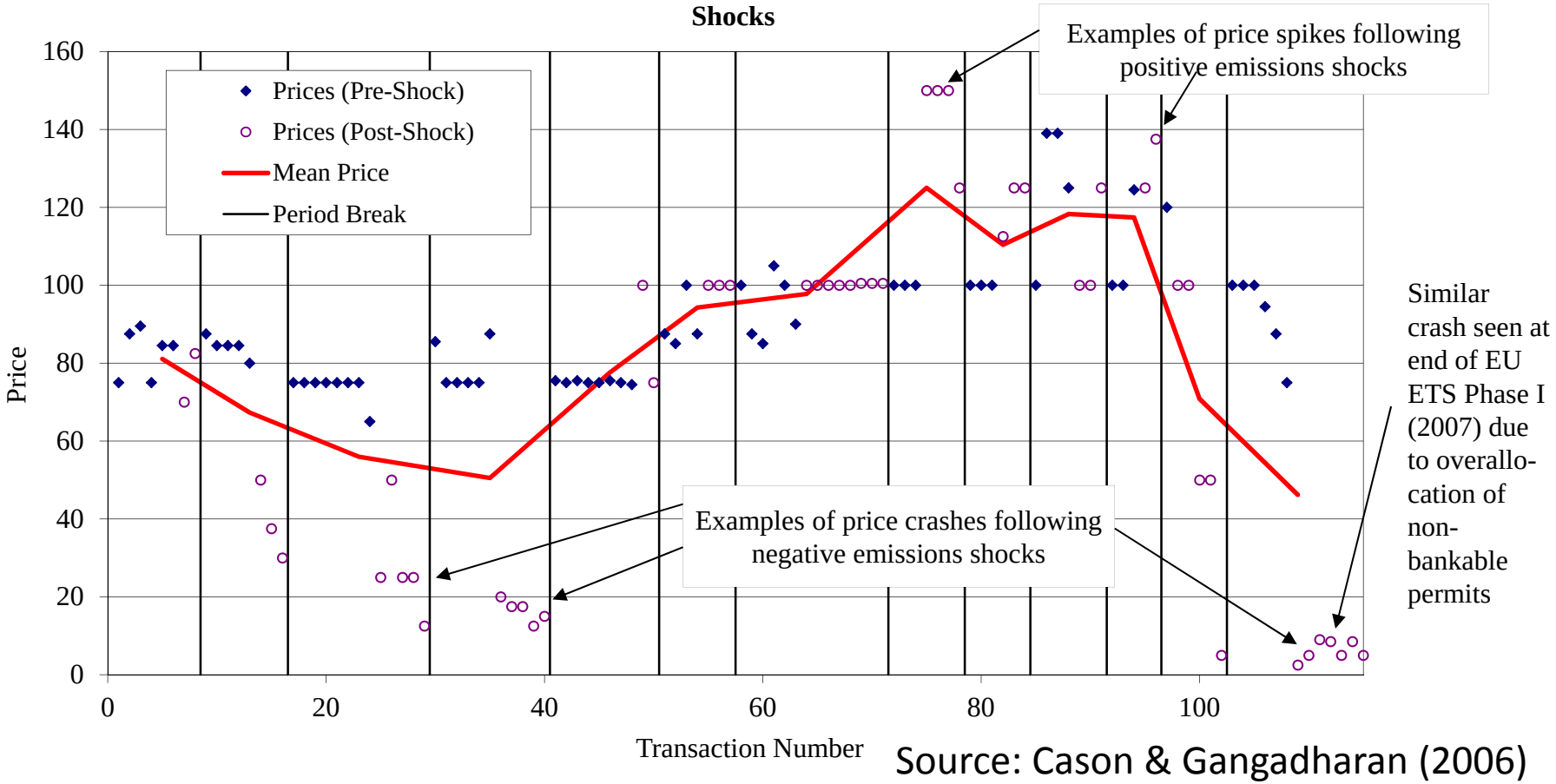
Prices are **relatively stable** over time when traders can use banking to store unused emissions permits or carry forward permits as a buffer against emissions shocks

Figure 2: Transaction Prices for Session BUN3, with Banking and Uncorrelated Emissions Shocks



Especially if emissions shocks are correlated (e.g., due to weather), **price spikes and crashes** occur if banking is prohibited.

Figure 3: Transaction Prices for Session NBCO3, with No Banking and Correlated Emissions Shocks



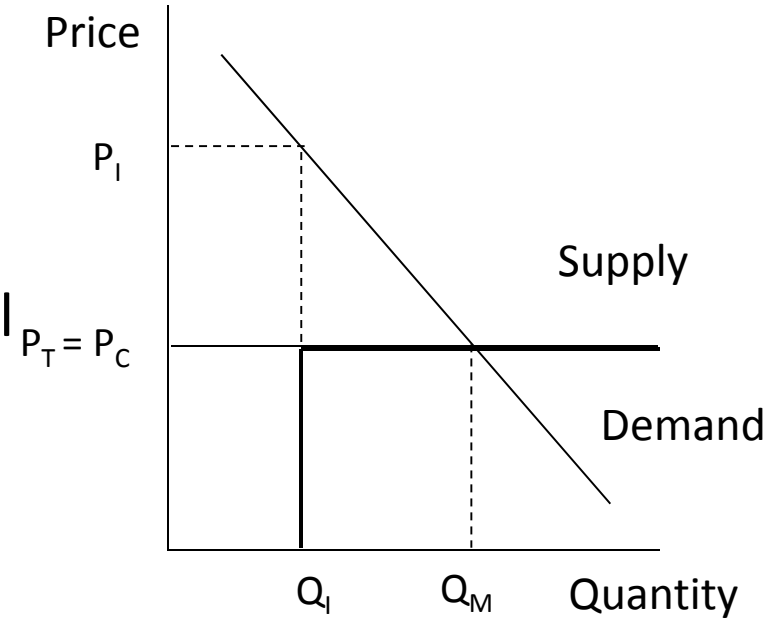
Source: Cason & Gangadharan (2006)

Other designs, such as overlapping permit validity periods, can also reduce price volatility (Carlson et al., 1993)

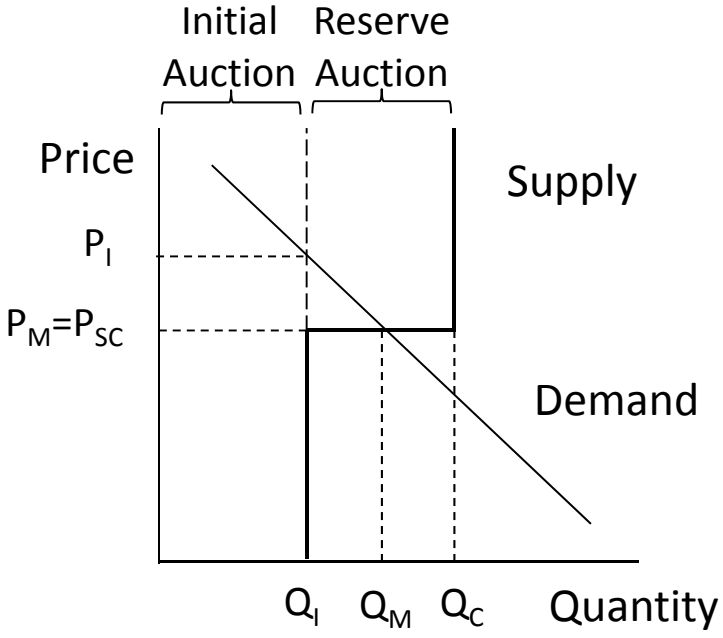
Example #3
Price Controls in Permit Markets

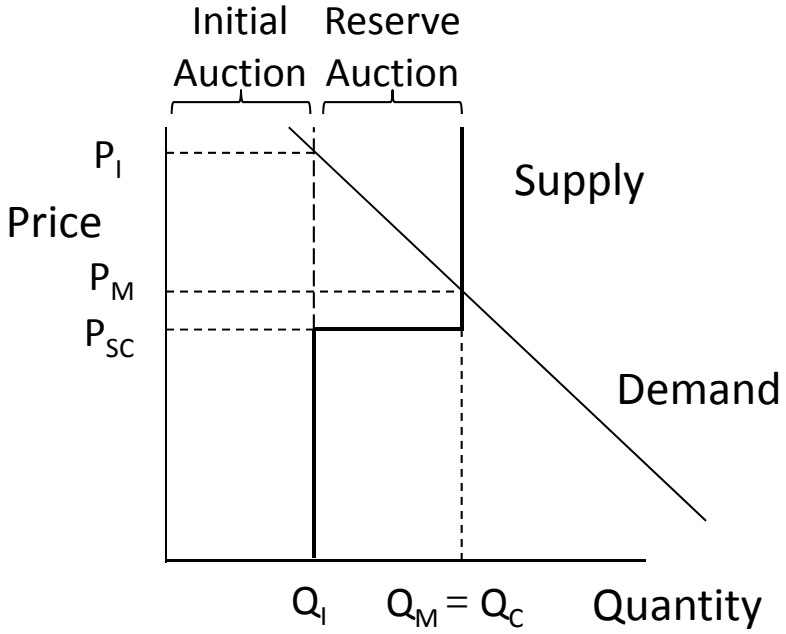
- **Price ceilings** can help firms avoid exorbitant costs associated with price spikes due to volatility or overly-aggressive abatement targets
- **Price floors** stimulate investment in emissions abatement technologies
- Various proposals for different price controls in GHG permit trading legislation in U.S.
- Price controls can be implemented in various ways, such as **hard** (Cantwell-Collins) versus **soft** (Waxman-Markey) price ceilings

- Hard ceiling is an absolute price control
  - No emissions limit—effectively converts to an emissions tax



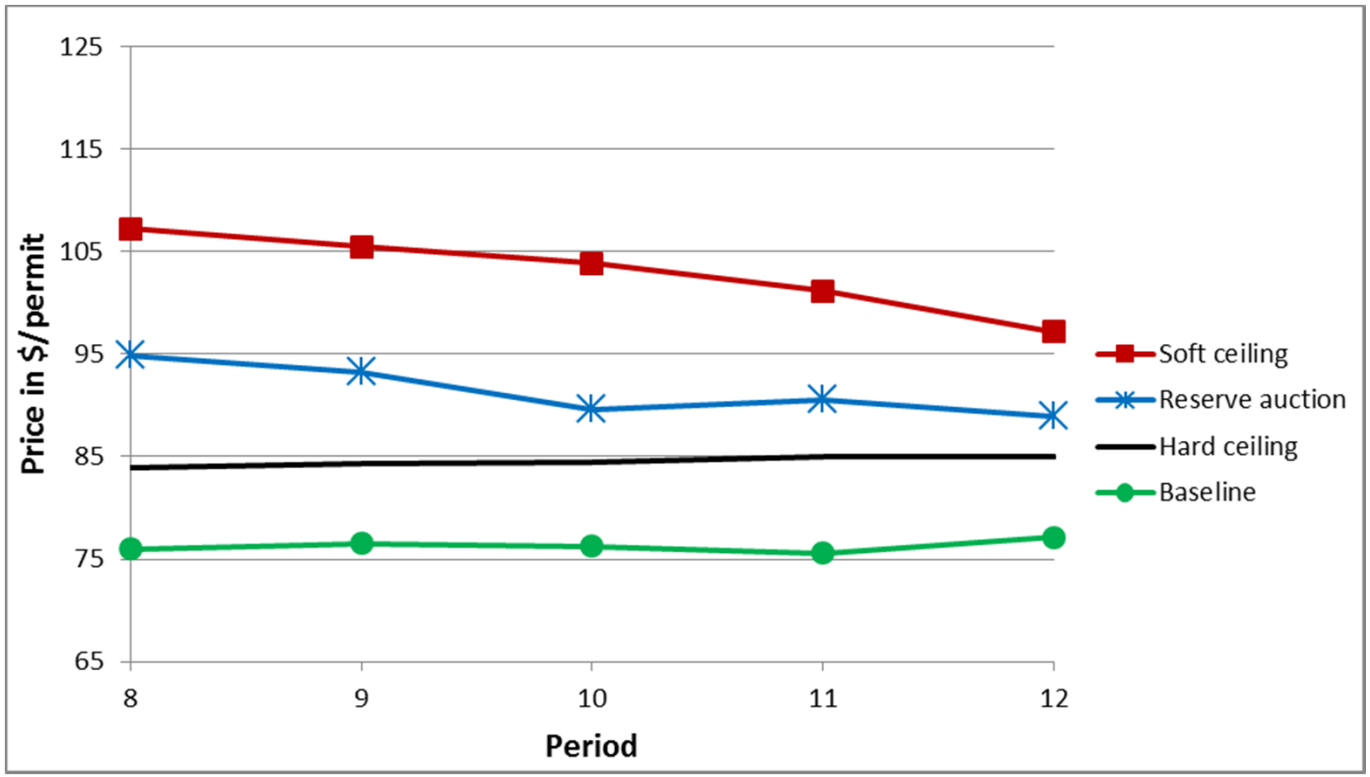
- Soft ceiling: A reserve auction with a minimum reserve price





Summary of Late-Period Prices

Hard ceiling (not surprisingly) controls prices effectively.
Soft ceiling does not control prices as well, since traders do not fully anticipate the availability of lower-priced reserve permits.
Reserve auction, without a minimum price, actually results in lower prices than the soft ceiling.

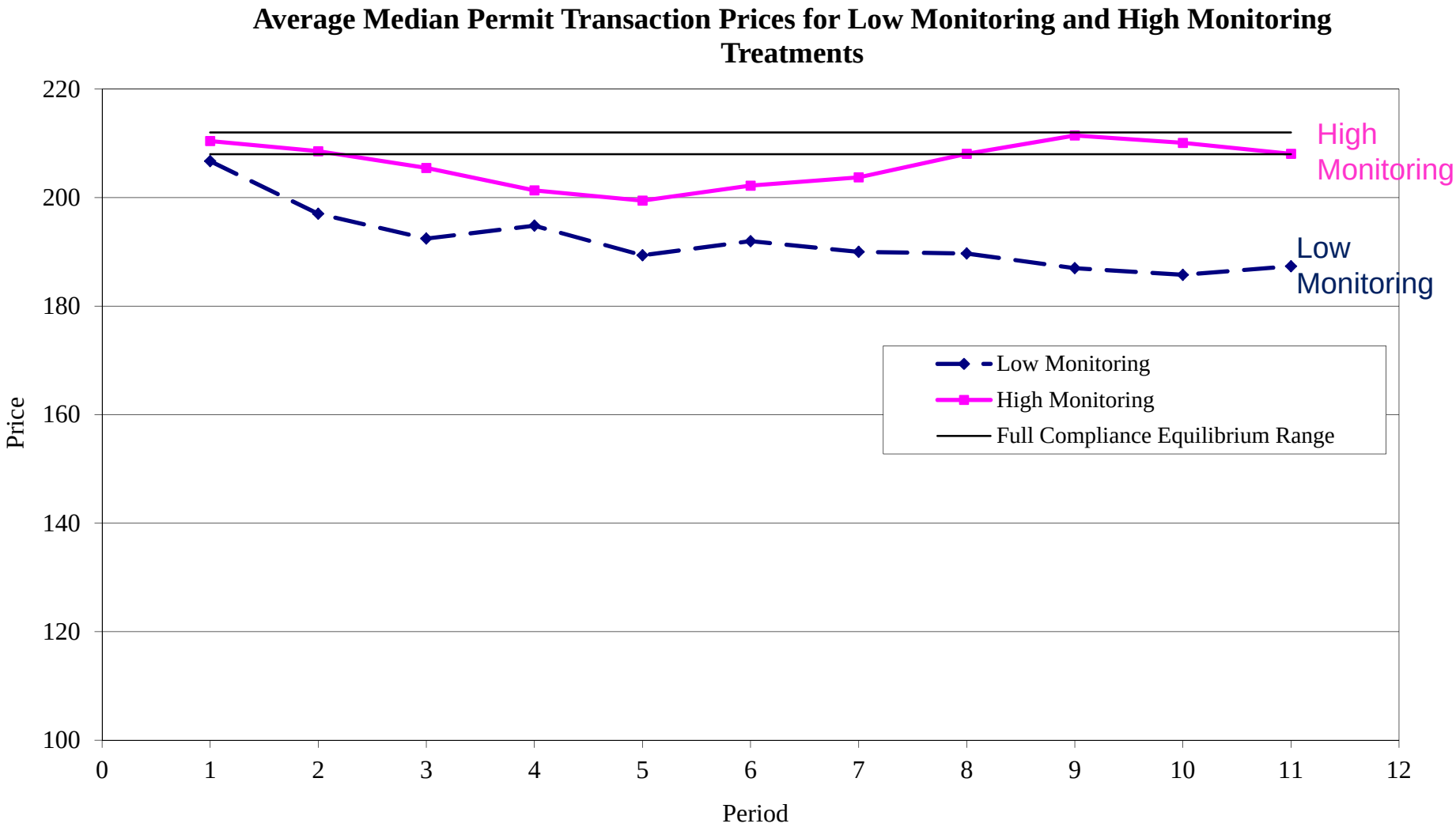


Source: Perkis, Cason & Tyner (2013)

Example #4:
Compliance and Enforcement

- Compliance responds to enforcement efforts, and it interacts with other permit design features
  - E.g., **noncompliance** may increase with more flexible banking and trading rules (Cason & Gangadharan, 2006; Murphy, Spraggon & Stranlund, 2009)
  - Permit market equalizes compliance costs across firms, but experiments reveal that net permit buyers tend to have lower average compliance (Murphy & Stranlund, 2006)
  - Increased enforcement has both a **direct positive** effect on compliance incentives, but also an **indirect negative** effect by forcing permit prices higher (M&S)

Permit Transaction Price Differences for Low and High Monitoring Intensities

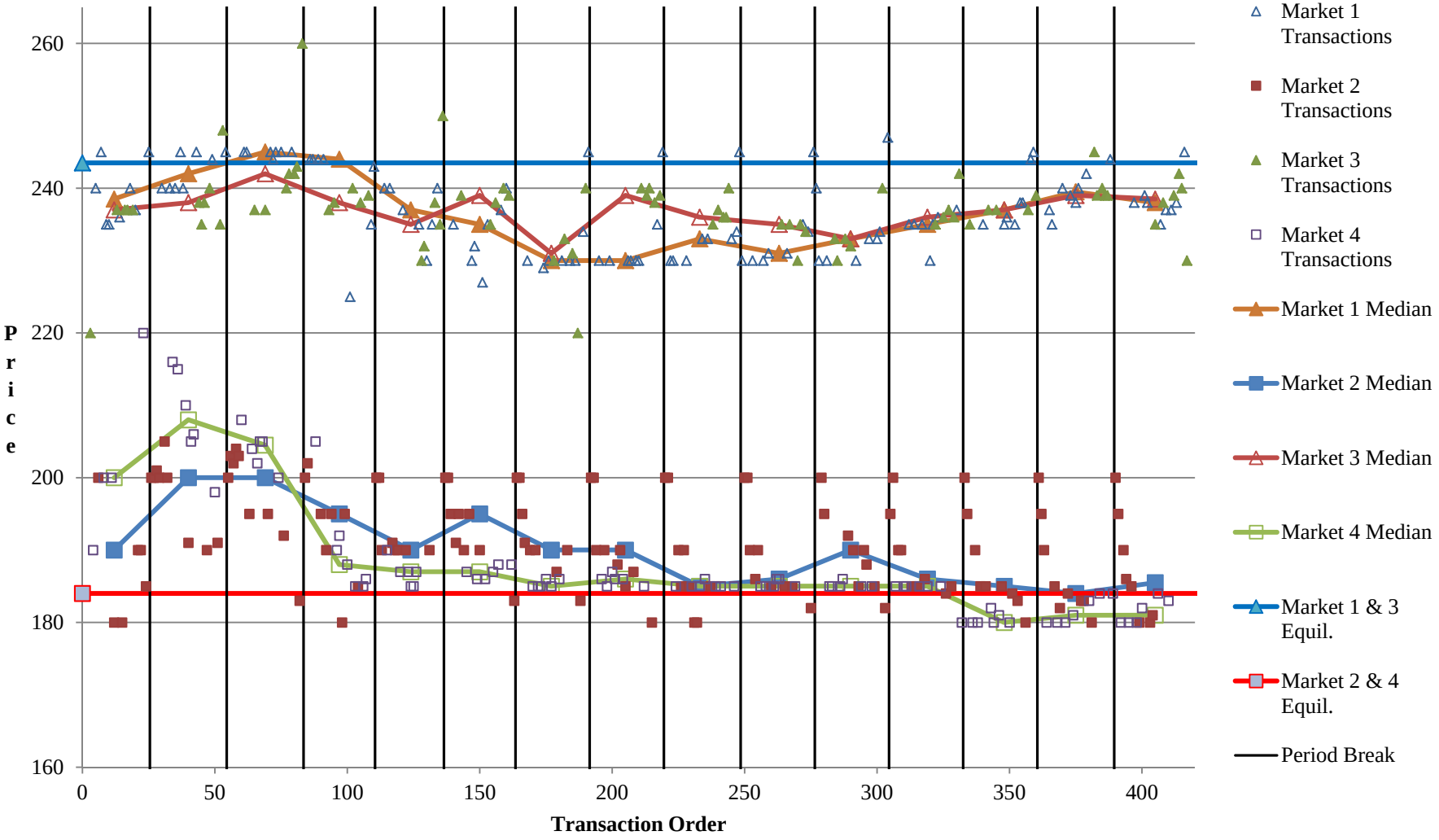


Source: Raymond & Cason (2011)

Example #5:
Across-Market Trading of Permits

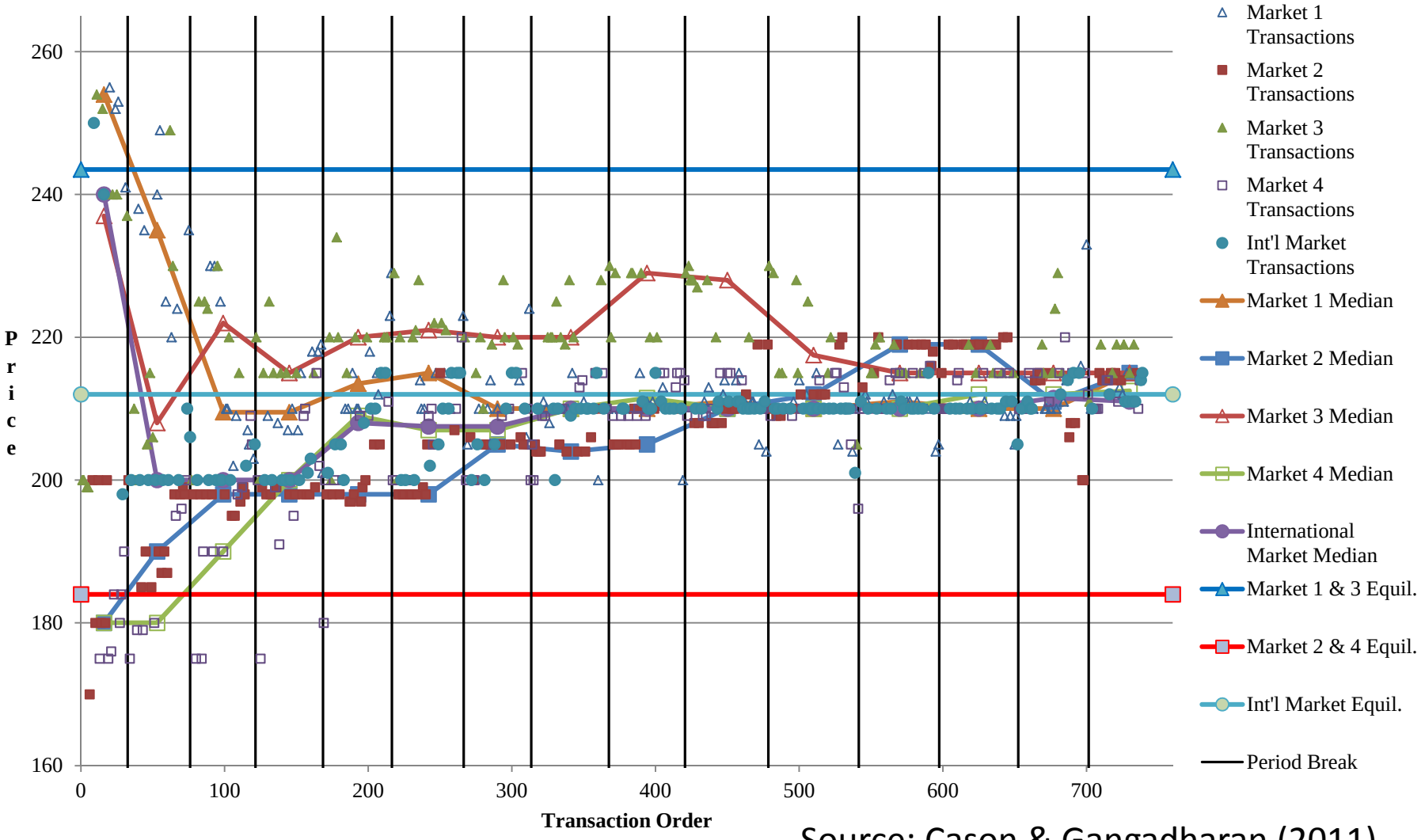
- Direct firm-to-firm across-market trading may have low transactions costs, and helps maintain **thick** markets, but raises (cross-jurisdictional) enforcement concerns (Stavins, 2007; Metcalf, 2009)
- Restricting trading to occur through intermediaries may raise transactions costs, and could also harm price discovery by creating very **thin** markets
- Inter-market trading allows prices to reflect overall (across market) marginal abatement costs, increasing efficiency

Example Autarky Session (4 separate markets)



Source: Cason & Gangadharan (2011)

Example Session with Intermediaries Required for Inter-Market Trades



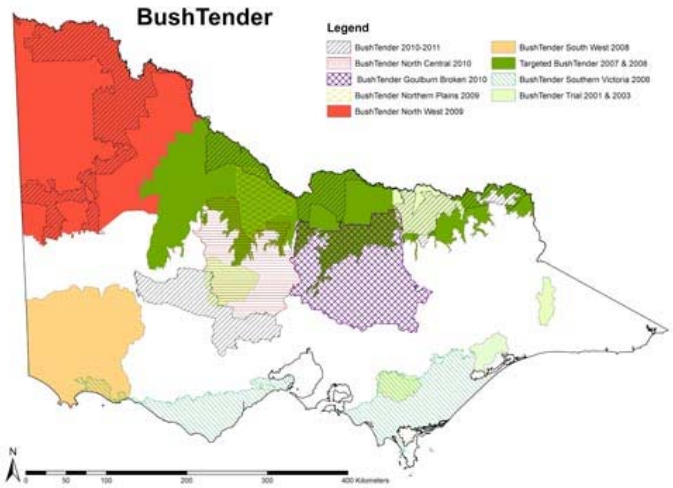
Source: Cason & Gangadharan (2011)

The costs of requiring intermediation for across-market trading

- The treatment that requires that trades occur through intermediaries can be compared to one with direct firm-to-firm trading
- This reveals that requiring intermediation
  - **does not** substantially increase (eventual) price deviations from the competitive equilibrium, but it does
  - (1) **slow** convergence to equilibrium;
  - (2) **lowers** efficiency;
  - (3) **increases** volatility; and
  - (4) **raises** transaction costs

Example #6: Using the Wind Tunnel to Refine Conservation Auction Details

- State of Victoria, Australia, Department of Natural Resources & Environment sought to deliver funding for **conservation** works and protect biodiversity: *BushTender*™ auctions
  - Landholders bid for payments to carry out conservation activities



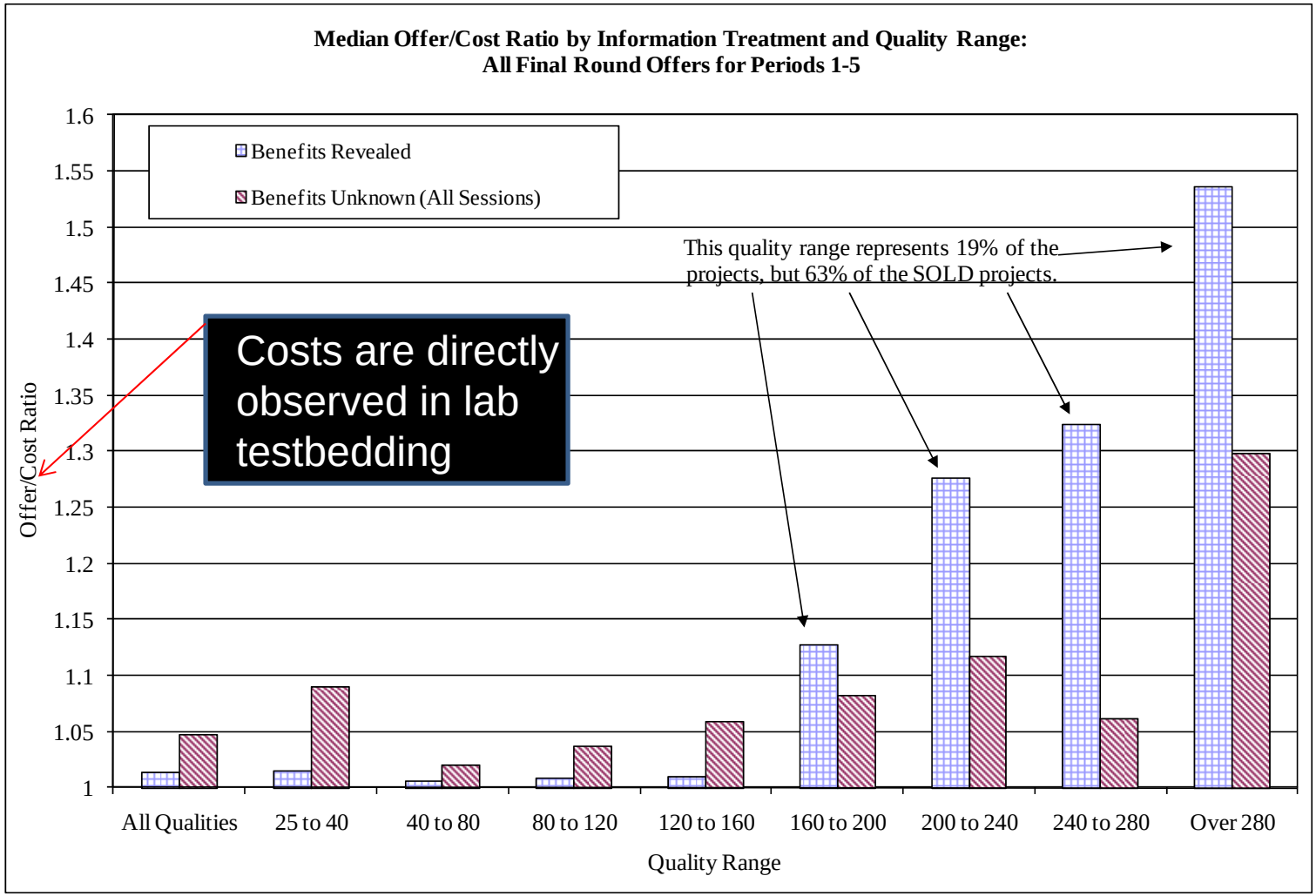
What Information to Provide Bidders before the Auction?

- Field Officers assess significance and quality of native vegetation, collect data, and discuss management options with private landholders
- Should they **provide information** on their project's value to landholders?

Testbed this Choice in Laboratory

- In some sessions bidders **received info** about the environmental “benefits” of alternative projects they could offer
- In an alternative treatment, they learned only their projects’ cost
- Government wants them to bid near their cost, so they don’t “overpay” for improvements in environmental quality

Results Indicated that Bidders Exploit Information on Quality to Obtain Higher Payments



Source: Cason, Gangadharan and Duke (2003)

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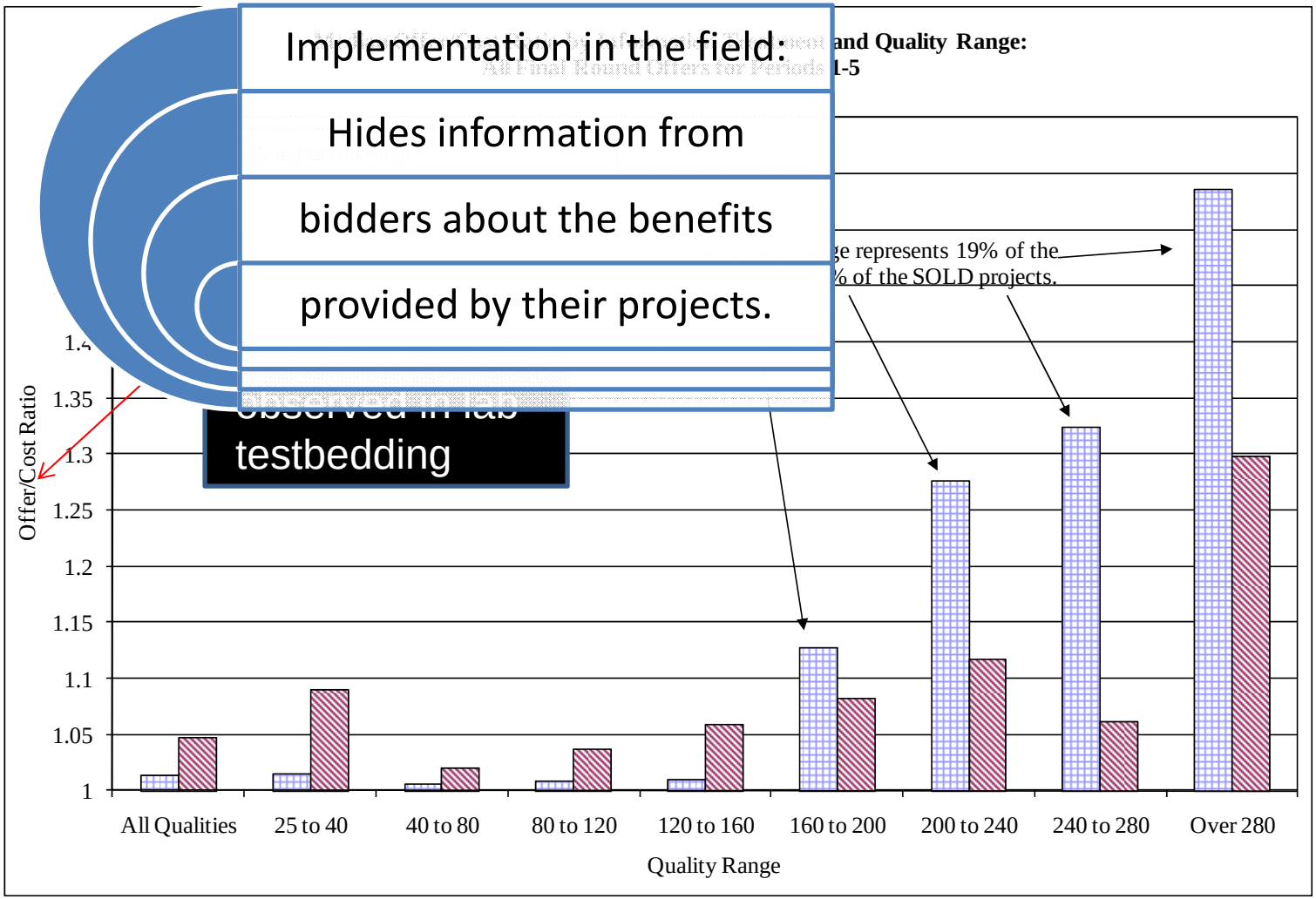

Source: Cason, Gangadharan and Duke (2003)

What about “External Validity”?

- External validity is not a binary condition, either on or off, but rather it should be considered as having **various degrees** and dimensions

- If both lab and field behavior are governed by the **same principles** (as is usually assumed in economics), it makes little sense to distinguish “external” and “internal.” All the behavior is “internal.”

When should we be more confident about external validity?

- An external validity concern can just as easily (and in most cases more justifiably) be raised for any theoretical model of an economic process
- Experimental models can help inform theoretical models, which helps us understand potential outcomes in the field
  - External validity to the field may not even be a main goal
- We can be more confident about external validity for types of conclusions where mechanisms and/or logic for the underlying process is likely to have a **field parallel** (e.g., price spikes following correlated excess emissions)

Summary: So do we learn anything from these experiments?

- These examples illustrate that experiments can help researchers and regulators understand the implications of many **market design details**, which can influence the success or failure of market regulations
  - evaluate specific **trading institutions** (e.g., auction formats)
  - how permit **banking** affects price volatility in the presence of correlated emissions shocks
  - Performance of alternative **price control** mechanisms
  - how enforcement affects **compliance** incentives
  - implications of **across-market** restrictions on permit trading
  - what information should be **revealed** in conservation auctions

Conclusion: Do we also need field experiments and naturally-occurring data to get the right answers?

- Of course we do!
- **Parallelism** with the field could be enhanced by
  - including non-student subjects
    - (but outcomes are often not sensitive to the subject pool)
  - incorporating realistic institutional details, such as the **political processes** leading to market rules, and;
  - actual **environmental consequences** from abatement, compliance and conservation decisions