



# Price controls and banking in emissions trading: An experimental evaluation

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# Motivation

- Concerns about price volatility in cap-and-trade programs
- Uncertainty about abatement costs
  - Desire for cost containment measures

# Ways to contain costs & reduce price volatility

- **Permit price controls**

- Hybrid policy of emissions taxes and permit trading never less efficient than pure trading
  - Roberts and Spence (1976)
- Price ceilings (“safety valve”)
  - Pizer 2002; Jacoby and Ellerman 2004
- Price collars
  - Philibert 2008; Burtraw et al. 2010; Fell and Morgenstern 2010

- **Permit banking**

- Allows firms to shift abatement over time in response to uncertainty (e.g. emissions, abatement costs, etc).

# Issues / Concerns

- Focus tends to be on price volatility, not emissions
- Fundamental trade-off between the two
  - Less price volatility → More emissions volatility
  - Less emissions volatility → More price volatility
- Volatility measure
  - Between-period changes (not within period)
  - Difference in Mean Absolute Deviation
  - $|MAD_t - MAD_{t-1}|$
- Price ceilings (= emissions tax) no longer cap total emissions

# 2x2 Experimental design

		PRICE CONTROLS	
		No	Yes
PERMIT BANKING	No	Base (6)	PC (6)
	Yes	Bank (6)	BankPC (6)

Number of 8-person groups in parenthesis

# Experiment details

- **Production**
  - Earnings from Production (abatement costs)
  - Units produced throughout 3-minute period
- **Permit Market**
  - Continuous double auction
- **Perfect compliance**
  - No banking treatments
    - Production = permit balance
  - Banking treatments
    - Production  $\leq$  permit balance
    - Unused permits saved for future use

The screenshot displays two main sections of the experiment interface:

- Production:** Features a 'Production Timer' showing 1:28, a 'Total # of Units Ordered' input field with the value 3, and a progress bar for 'Unit Production Progress' which is currently at 0. A note states 'It takes 10 seconds to produce a unit'.
- Permit Market:** Includes a 'Market Timer' showing 2:28 and a 'Permit trade requests' section with 'my selling price' (15) and 'my buying price' (empty) input fields. The 'Permit market status' section shows a 'Current Selling Price' of 16.00 and a 'Current Buying Price' of 3.00. A 'Price history' section shows a price of \$10.00(B).

Yellow arrows in the image point to the 'Production' and 'Permit Market' headers.

# Experiment details

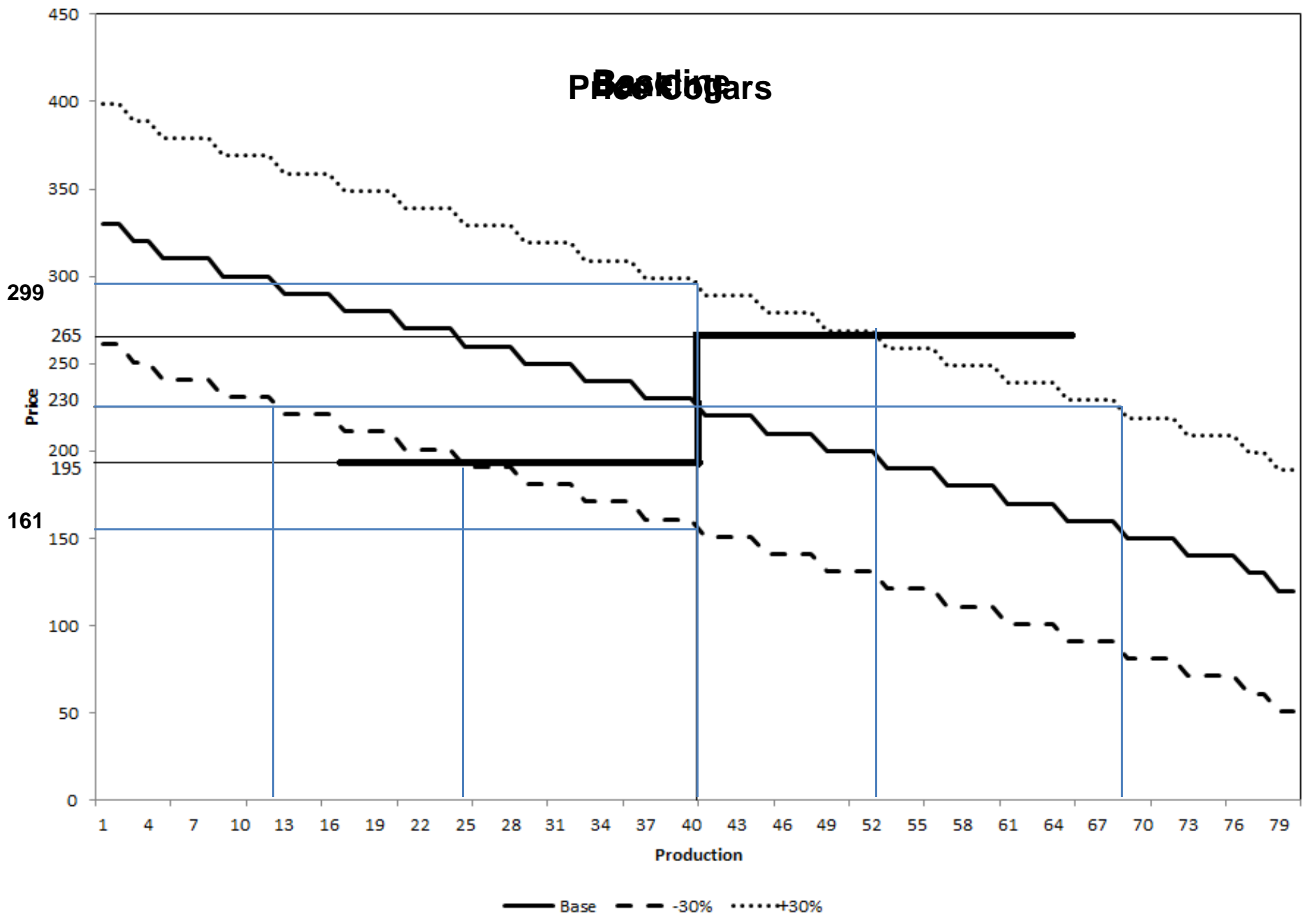
- Subjects
  - UMass students
  - 2-hour training before “real” data sessions
- 8 subjects per group, 2 of each type
  - Varied by:
    - Earnings from Production (Abatement Costs)
    - Initial Permit Allocation
- Random ending
  - Periods 1-10 periods for sure
  - Periods 10+ with  $5/6$  probability
    - Results use only periods 1-10

# Experiment details

- Stochastic Marginal Benefits (Abatement Costs)
  - Periods 1-2: Medium (with certainty)
  - Periods 3+: Low, Medium, High (equal probability)
- 4 Random Sequences
  - Each sequence repeated at least once in each treatment
- Price controls (approx.  $p^* \pm 15\%$ )
  - Price ceiling
    - Subjects could purchase an unlimited number of permits at 265
  - Price floor
    - Subjects could sell an unlimited number of permits at 195



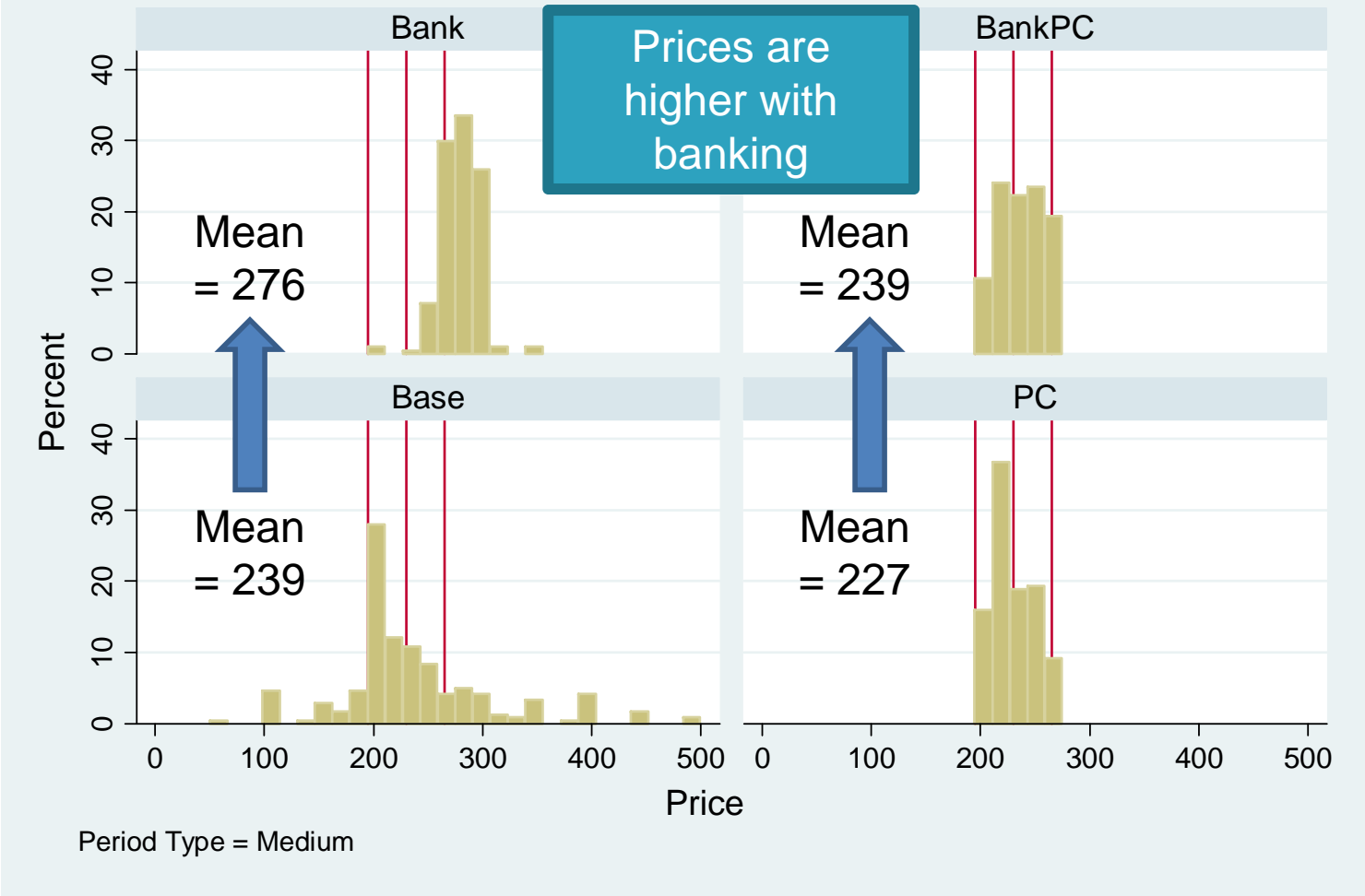
# Price vs. Quantity



# Results

- Baseline treatment
  - Standard double auction with inter-period demand shifts
  - Results in line with perfectly competitive equilibrium
    - Mean efficiency = 97%
    - Mean prices within 3% of  $p^*$
- Prices
  - Volatility both within and between periods
- Production
  - How often are the price collars utilized?
  - To what extent does banking result in variation in the level of production?

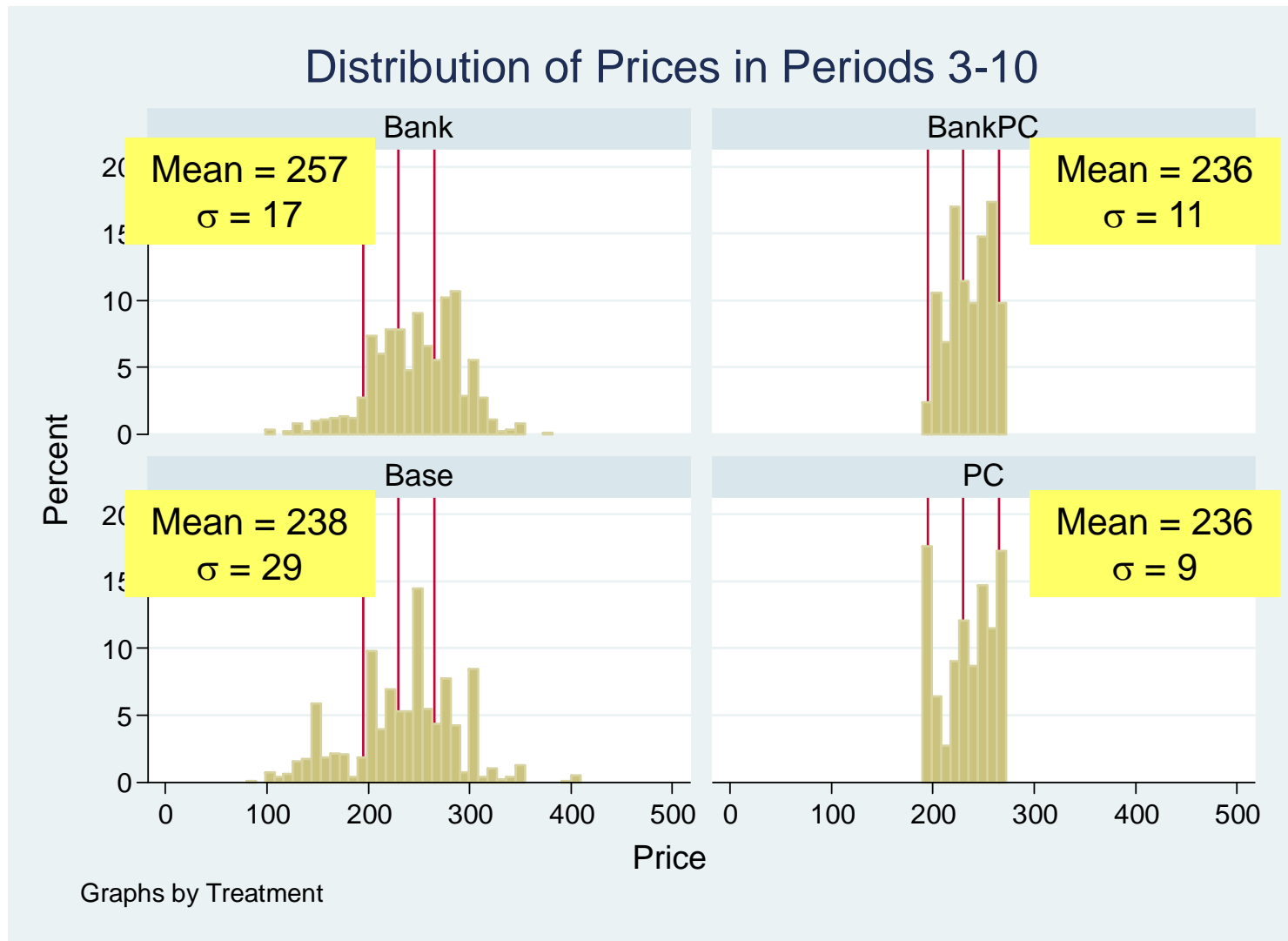
# Distribution of Prices in Periods 1-2



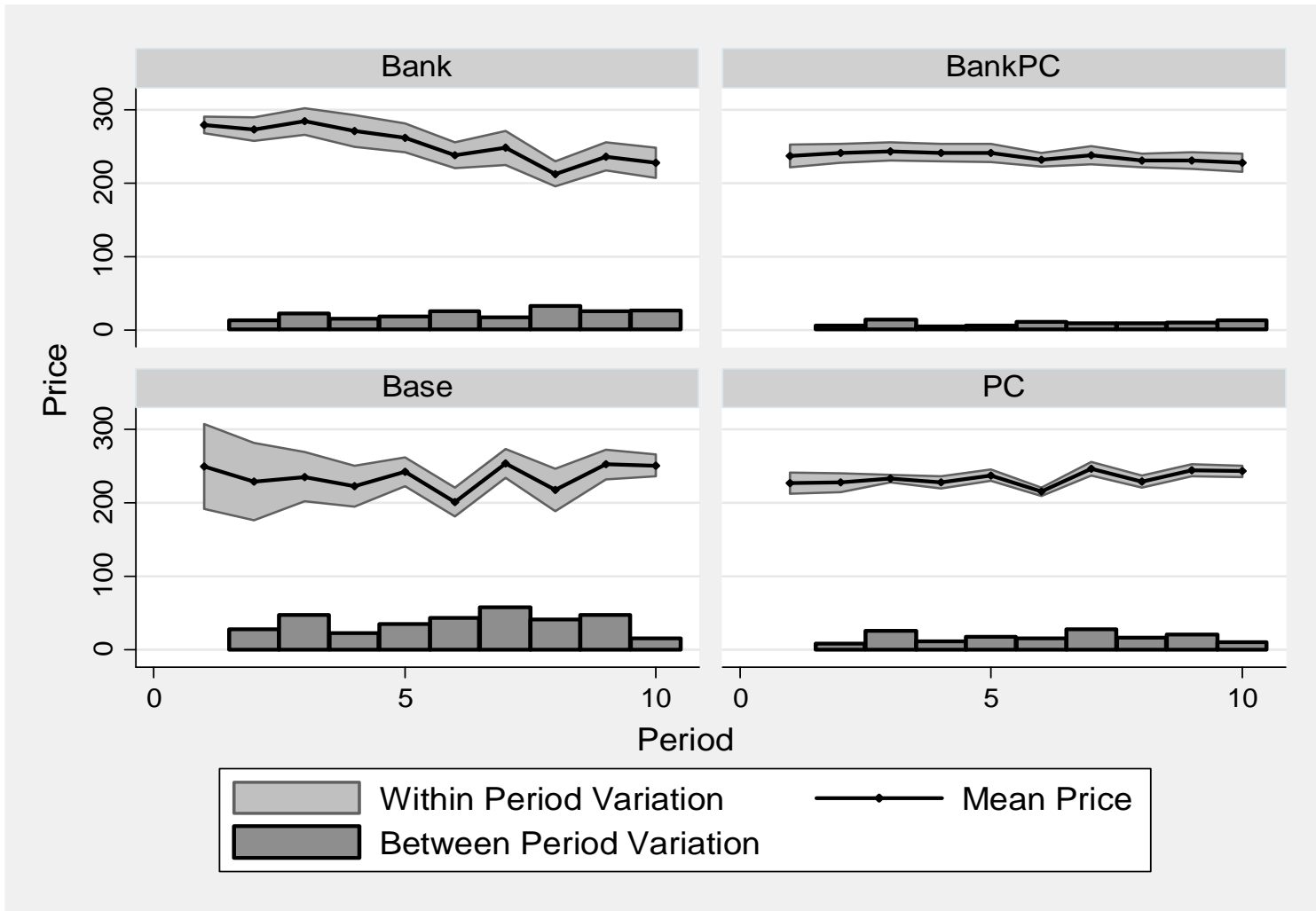
- Red vertical lines at:
- 195 Price floor
  - 230 Comp. Eq.
  - 265 Price ceiling

# Average prices

Volatility is lower with price controls



# Average Prices



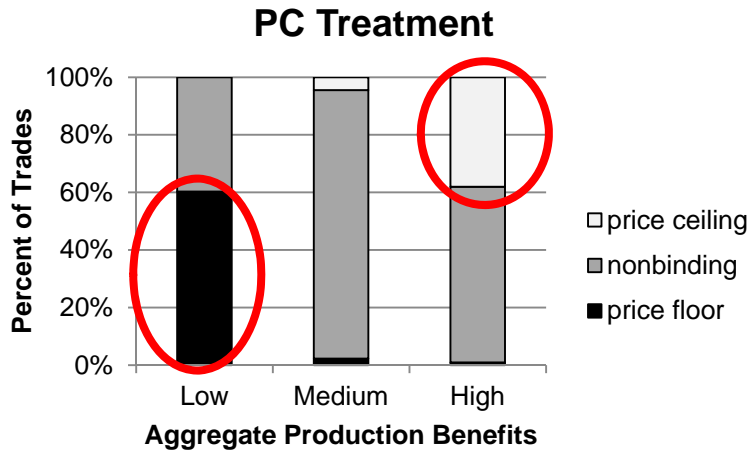
# Average Price Level

Variable	Coefficient	Std Error
PC	-5.31	8.30
Bank	15.61 *	8.31
BankPC	1.51	8.31
Sequence 2	-27.83 ***	7.20
Sequence 3	-9.64	8.82
Sequence 4	2.94	8.81
Constant	246.12 ***	7.20

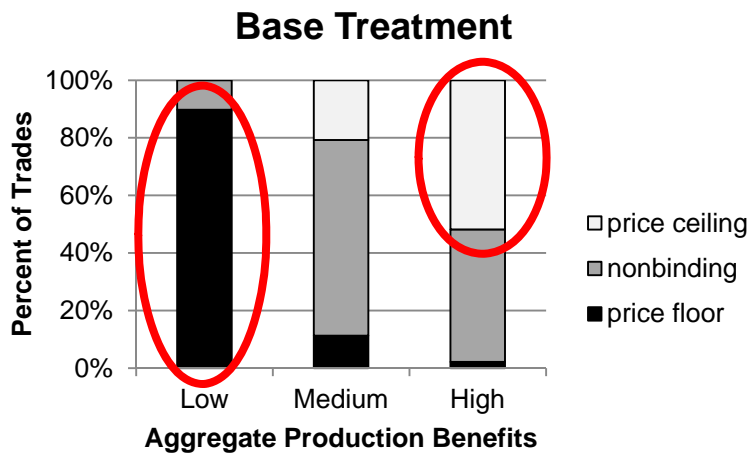
# Between-Period Avg Price Change (Mean Abs Deviation)

Variable	Coefficient	Std Error
PC	-20.77 ***	4.15
Bank	-18.37 ***	4.15
BankPC	-28.96 ***	4.15
Sequence 2	-0.09	3.60
Sequence 3	-1.55	4.41
Sequence 4	-15.35 ***	4.41
Constant	41.55 ***	3.60

# Frequency of binding price controls (periods 1-10)



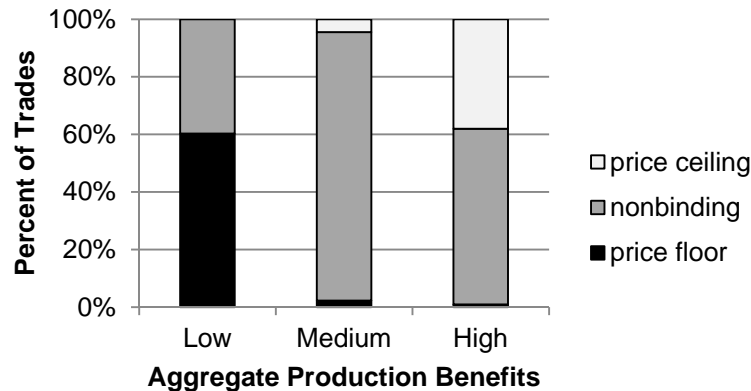
- PC Treatment**
- Use of price controls:
- Pattern consistent with expectations.
  - Frequency of use lower than expected.





# Frequency of binding price controls (periods 1-10)

**PC Treatment**



**BankPC Treatment**



## BankPC

- Price controls generally nonbinding  
→ fewer “new” permits created

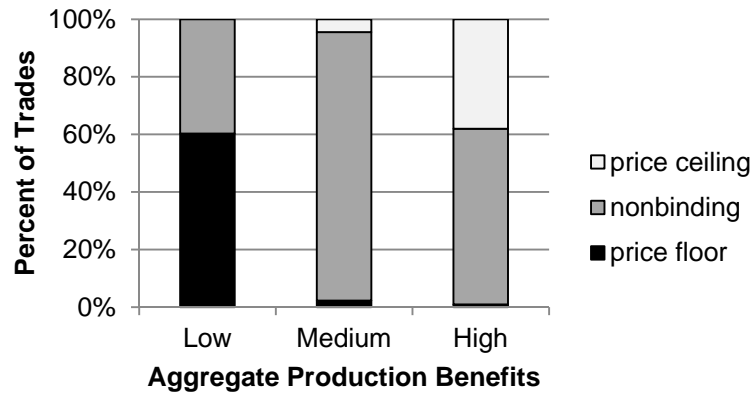
Price ceiling in High due to random draw sequence, esp. in early rounds

**BankPC Treatment  
(periods 5-10)**

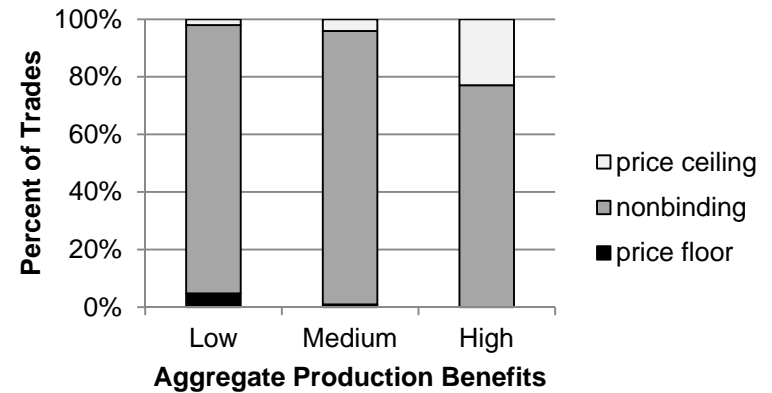


# Frequency of binding price controls (periods 1-10)

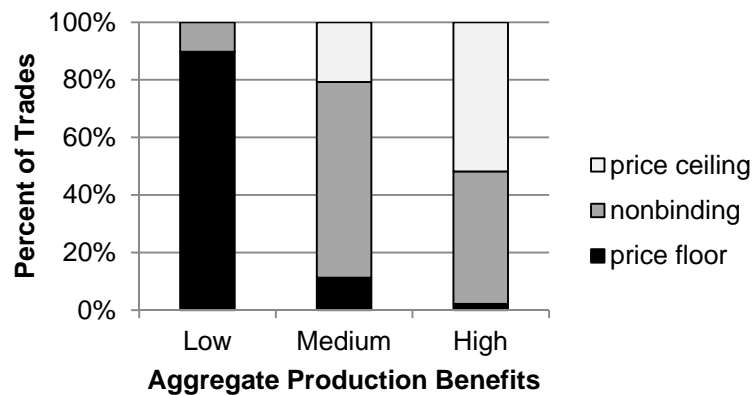
**PC Treatment**



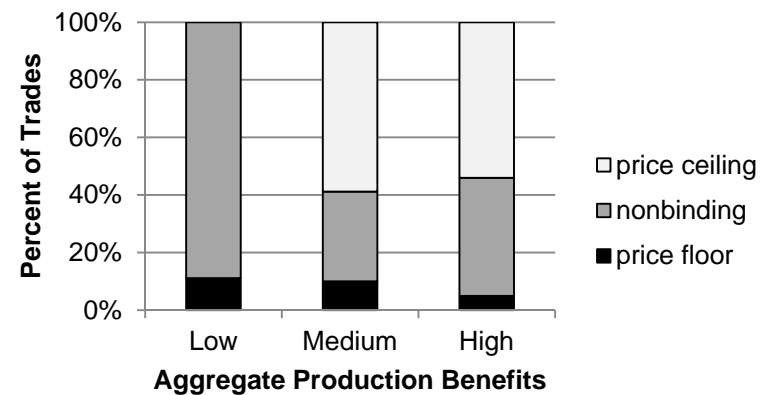
**BankPC Treatment**



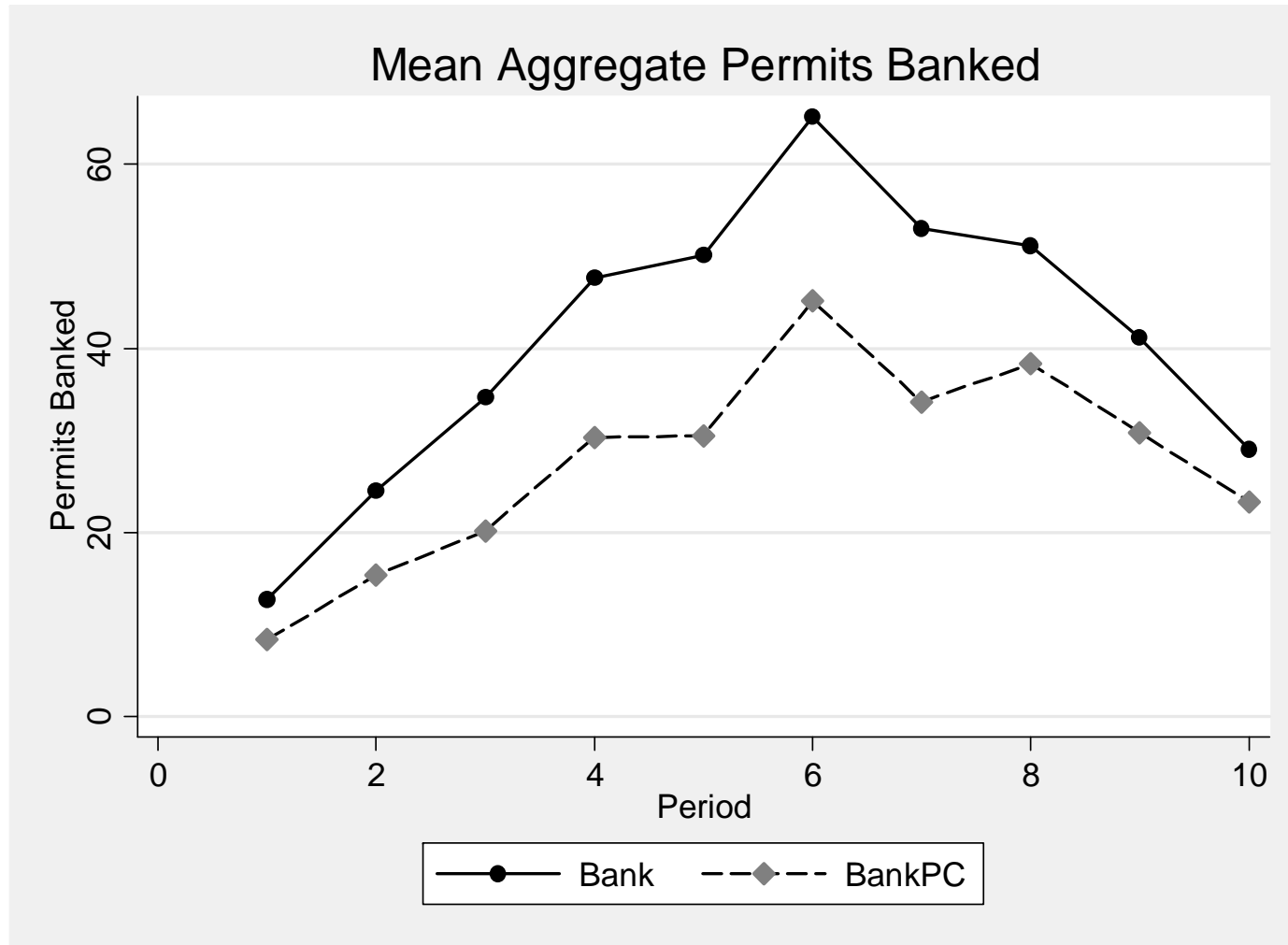
**Base Treatment**



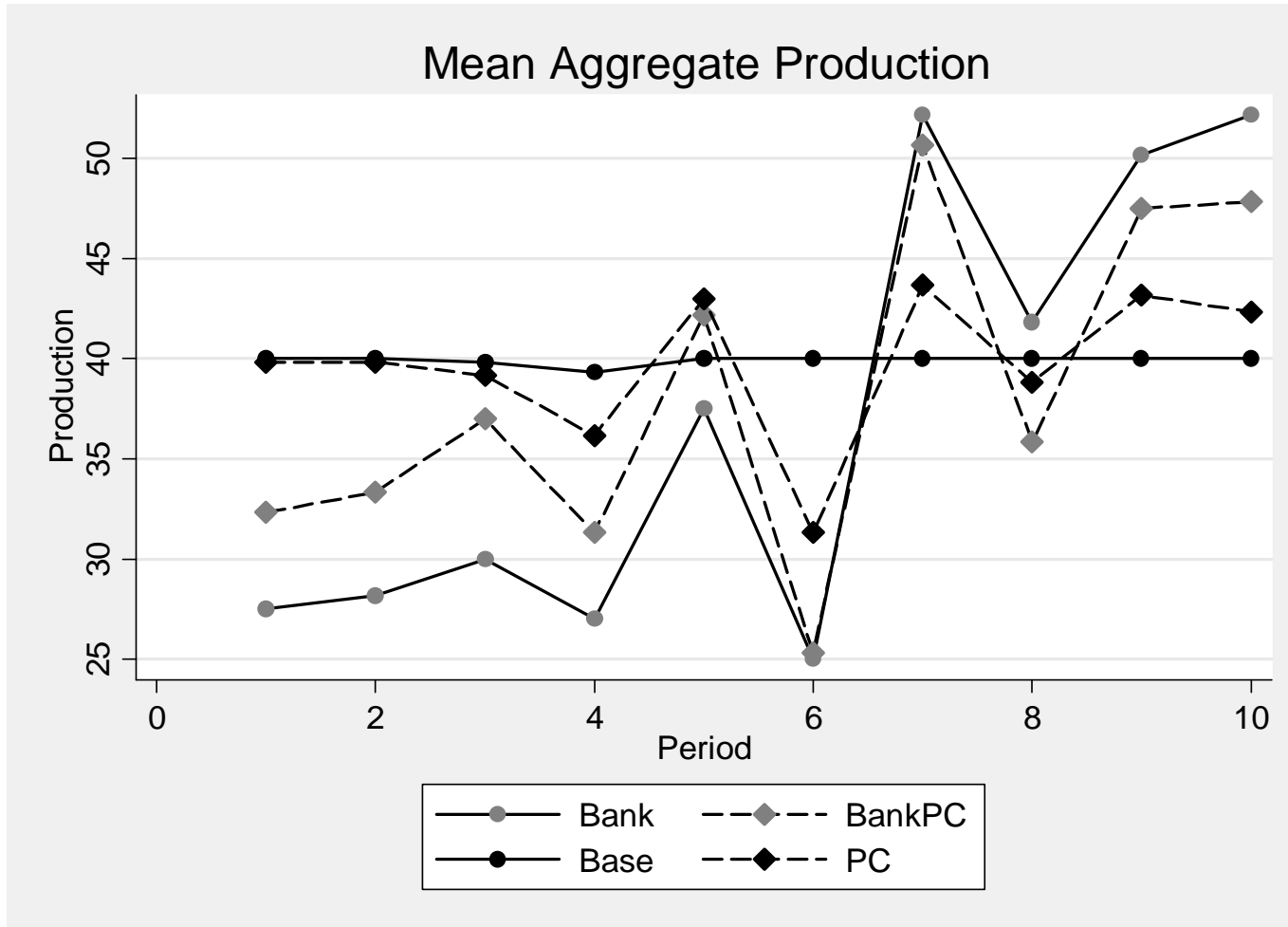
**Bank Treatment**



# Aggregate Banking



# Aggregate Production (emissions)



# Aggregate Production

Variable	Coefficient	Std Error
PC	-0.23	2.77
Bank	-9.80 ***	2.77
BankPC	-4.60 *	2.77
Base x Periods 6-10	0.17	2.77
PC x Periods 6-10	0.27	2.77
Bank x Periods 6-10	14.23 ***	2.77
BankPC x Periods 6-10	6.20	2.77
Sequence 2	0.88	1.69
Sequence 3	2.84	2.07
Sequence 4	1.24	2.07
Constant	38.86 ***	2.19

# Aggregate Production Variability (MAD)

Variable	Coefficient	Std Error
PC	5.54 **	2.49
Bank	9.92 ***	2.49
BankPC	11.62 ***	2.49
Base x Periods 6-10	-0.33	2.36
PC x Periods 6-10	1.86	2.36
Bank x Periods 6-10	6.88 ***	2.36
BankPC x Periods 6-10	5.44 **	2.36
Sequence 2	0.36	1.43
Sequence 3	0.00	1.76
Sequence 4	-3.56 **	1.76
Constant	0.81	1.94

# Conclusions

- Price collars
  - Reduce price volatility
  - Not triggered as often as expected
    - Fewer “new” permits created
  - Floor and ceiling cancel each other out
    - No net change in permit supply
- Banking
  - Prices tend to be higher with banking
    - Largely an initial condition as subjects build permit reserve
  - When combined with price controls, the controls rarely used
    - Reduces likelihood that new permits will be created
- Trade-off between price and emissions variability