Quantities with Prices

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Optimal Climate Policy

- Set to equate marginal benefits and marginal costs
- Comprehensive global coverage
  - Spirit behind Kyoto Protocol
- Requires choice of a control variable: prices vs. quantities
  - Most of the literature suggests price is best
- What does first best policy advice offer in a thoroughly second best setting?

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Actual Climate Policy

- Set at National or Subnational level
  - Partial equilibrium policy setting
  - Codified in Paris Accords
- Most policies are cap and trade
  - Caps determined in scientifically informed political regulatory process
  - Expected prices not calibrated to marginal damages
  - Caps are updated periodically over time
  - Allowance prices trend lower than expected
- Perfectly inelastic allowance supply
  - Allowance auction revenues uncertain
  - Allowance price fluctuations impact economy not environment
  - Prices tend to fall
  - Other policies and voluntary actions have no environmental benefit – the waterbed effect

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Price Responsive Allowance Supply

- Built on the shoulders of cost containment discussion
  - Auction reserve price floors
  - Cost Containment Reserve (a soft ceiling)
  - But over a large range, supply is inelastic

- Recognizing that allowance supply is policy determined
  - Instructions from policy makers to the market

➢ A fundamental evolution in emissions trading programs

  - Greater resolution in price responsive supply of allowances (RGGI) especially when prices fall
  - Allows for sharing of benefits and risks of low (or high) cost realizations
  - Endows voluntary actions with environmental potency

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Insights from the Literature

- Optimal policy design with uncertainty
  - Relative slopes matter for instrument choice: Weitzman (1976)
  - Combine Ps and Qs: Roberts and Spence (1976), Pizer (2002)
  - Real world proposals: Aldy and Pizer (2009), Murray et al (2009)
- Other features to manage cost volatility
  - Banking: Cronshaw and Kruse (1996), Rubin (1996), Kling and Rubin (1997), Fell et al. (2012a), Pizer and Prest (2016)
  - Offsets: Fell et al. (2012b), and others
  - Linking: Burtraw et al. (2013), Jaffee et al. (2009), Bodansky et al. (2015), Flachsland et al. (2009)
- Two sided cost containment
  - Investment incentives: Burtraw, Palmer and Kahn (2010), Grull and Taschini (2011)
  - Two-sided reserves: Fell et al. (2012c).

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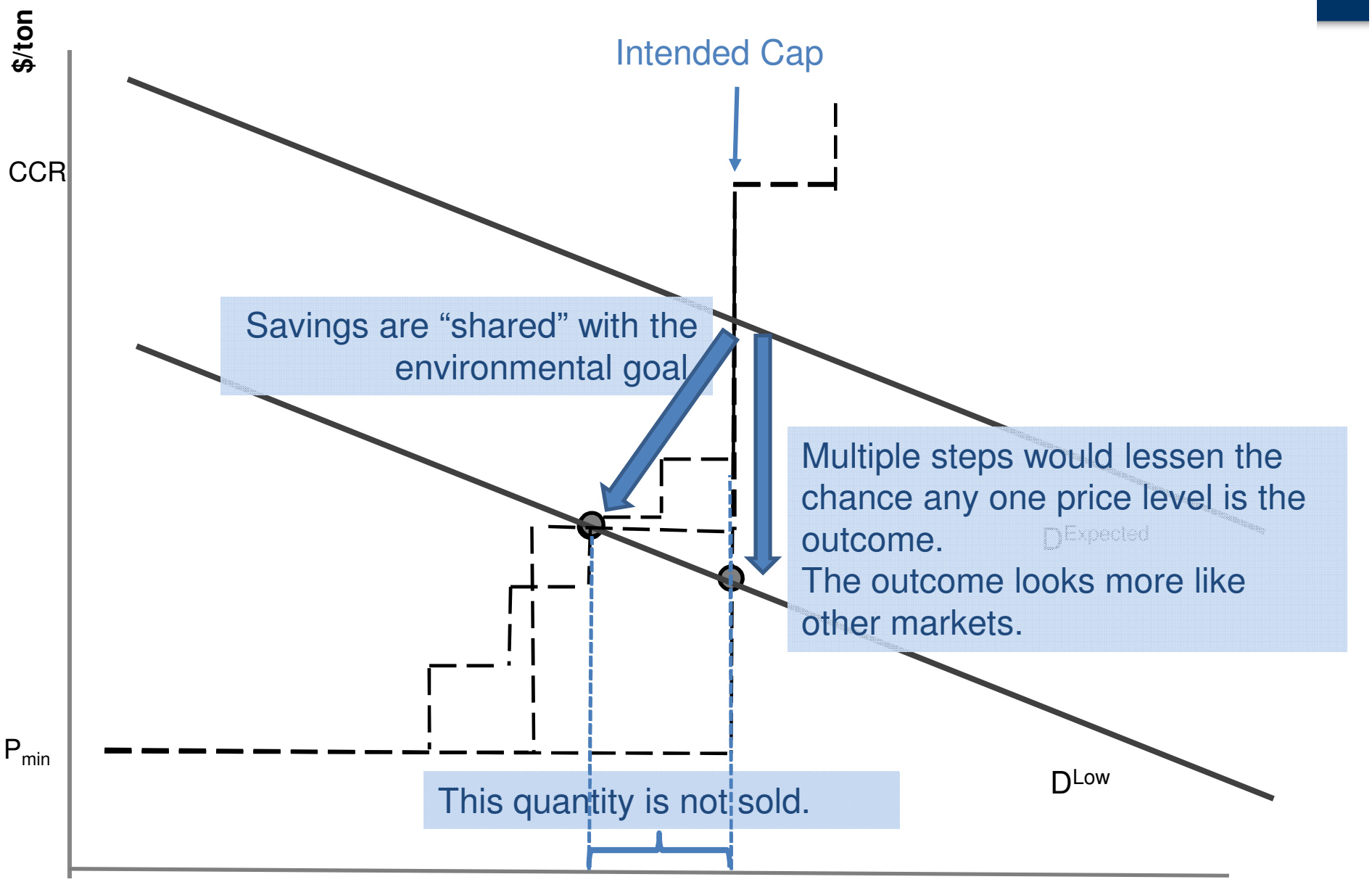
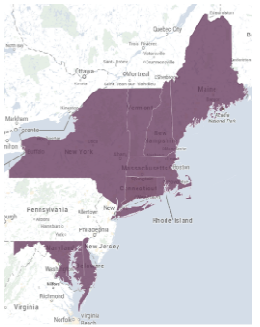
A Price Responsive Supply Schedule



Considering RGGI

- Regional CO_2 Cap and Trade program for electricity generators in 9 northeast states
- Features include
  - Declining cap over time
  - Allowance auction with reserve price
  - Revenues re-invested in program goals
  - Cost containment reserve triggered at high price
  - Regular program reviews



- 2016 program review considered a new Emissions Containment Reserve (ECR)
  - Persistent downward pressure on prices due to program investments and state-specific policies and laws
  - Periodic administrative program adjustments difficult, unpredictable and disruptive to the market
  - RFF/U.VA. analysis informed RGGI's deliberation

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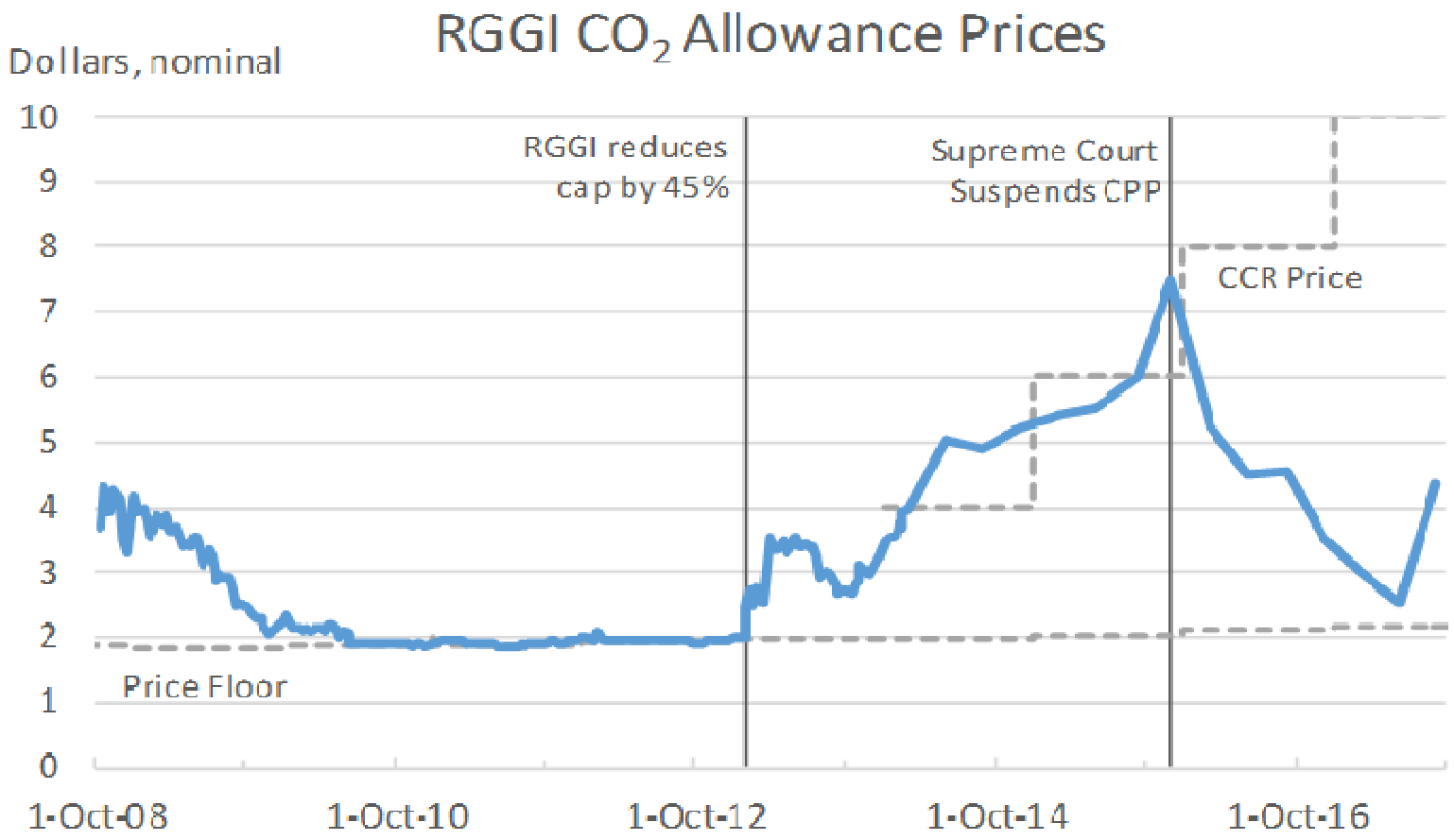
RGGI Experience with Allowance Prices



Note: Auction prices are used where market prices are not available.
Sources: Thomson Reuters; RGGI.

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Modeling unanticipated outcomes

Our base case is comparable to ICF assumptions in November 2016.

We model the 3.5% reference scenario from this starting point. (Hence, our price forecasts do not substitute for the updated ICF modeling.)

Allowances not sold due to the ECR are not returned to the market.

We identify the impact of unanticipated potential outcomes:

- Secular Outcomes
  - Low Demand Growth: electricity demand is lower nationally
  - Low Natural Gas Resource/High Natural Gas Prices
- Policy Outcomes
  - Energy Efficiency: across RGGI region $2.5/MWh system benefit charge after 2020
  - Renewables: 5% increase in 2020 and 10% increase in 2025 in state RPS programs
- Resource Outcomes
  - Nuclear: delayed retirement
  - Hydro: expanded hydro (1050 MW @ 100% capacity factor) from Quebec to New England

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Allowance price impacts of unanticipated outcomes

Allowance prices [$/ton] with No ECR in 2020 under various uncertainties

Ref Case	Low Demand	High NG Prices	More EE	Expanded RPS	Hydro from Quebec	Delay Nuke Retirement
8.2	8.0	8.6	7.4	7.5	7.7	7.0
Uncertainties modeled as packages						
Secular	7.4					
Policy			7.0			
Resource					7.0	
Sec+Pol	5.2					
Sec+Res	5.2				5.2	
Pol+Res			5.5			
All				4.0		

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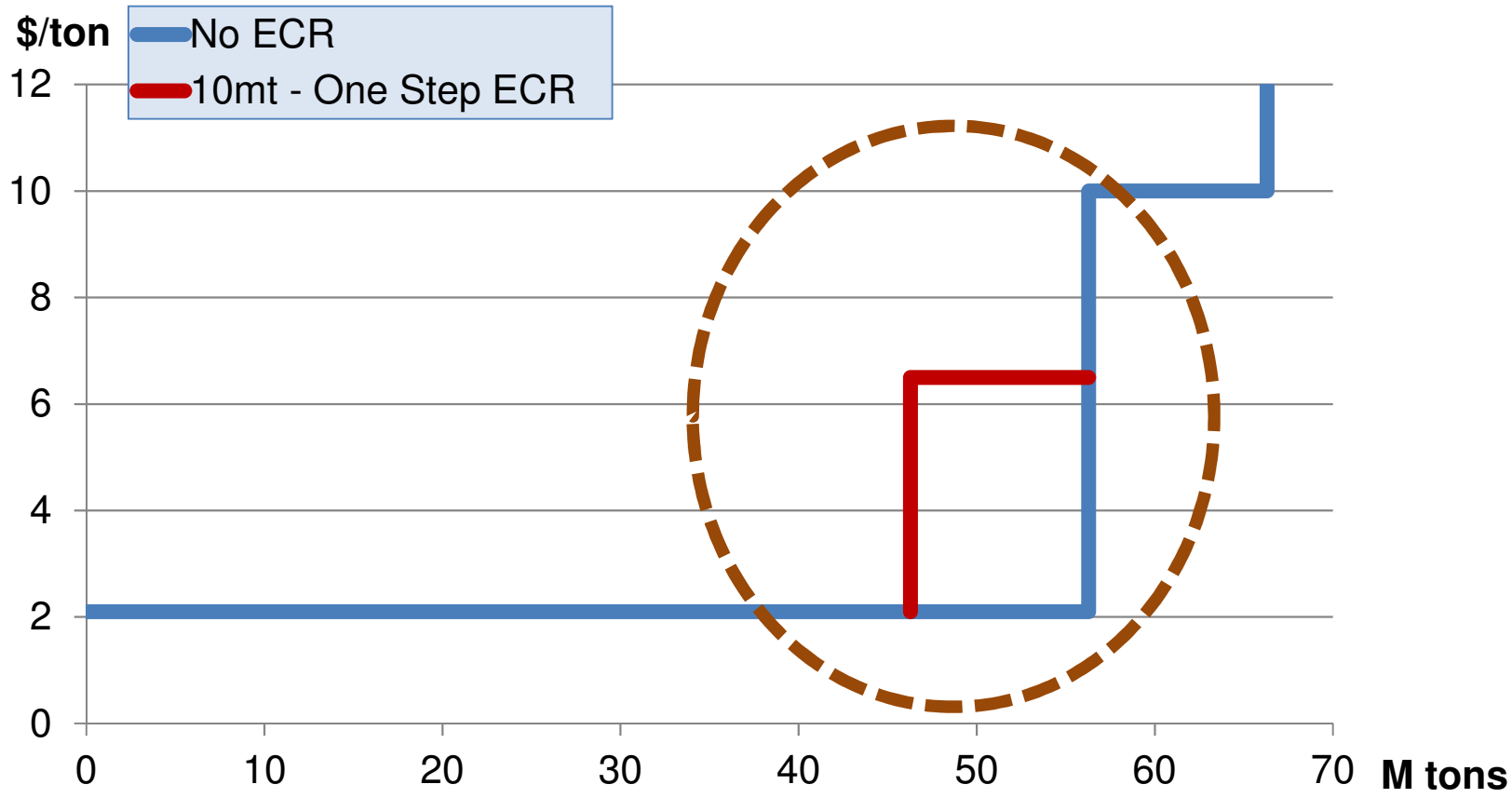
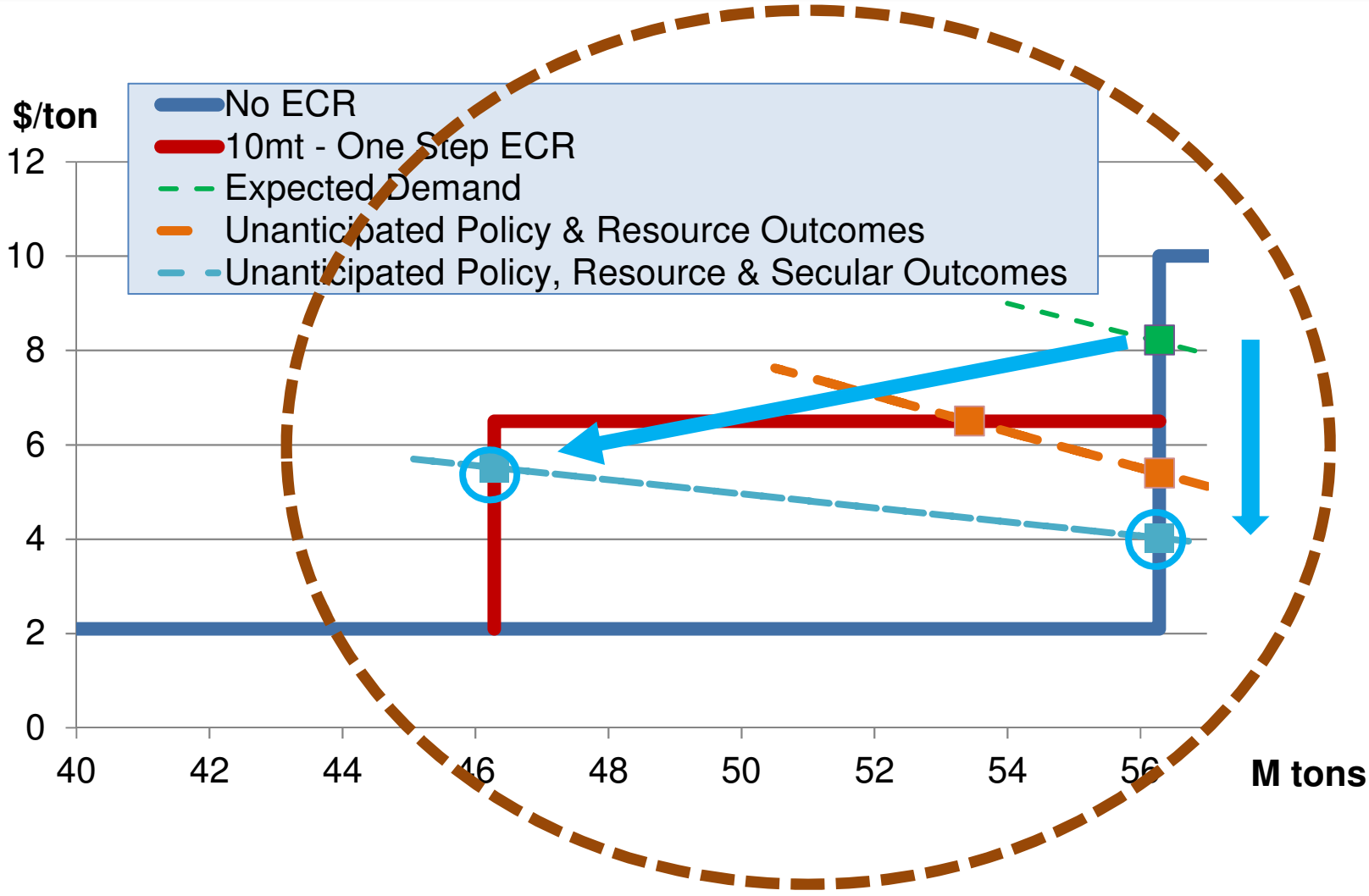
Simulation modeling in RGGI of a 10 million ton, one step ECR at $6.50 in 2020



The supply schedule reflects the adjusted cap through 2020 and then returns to reference case (3.5% annual decline).

Close up look: the ECR "sharing" outcome in 2020



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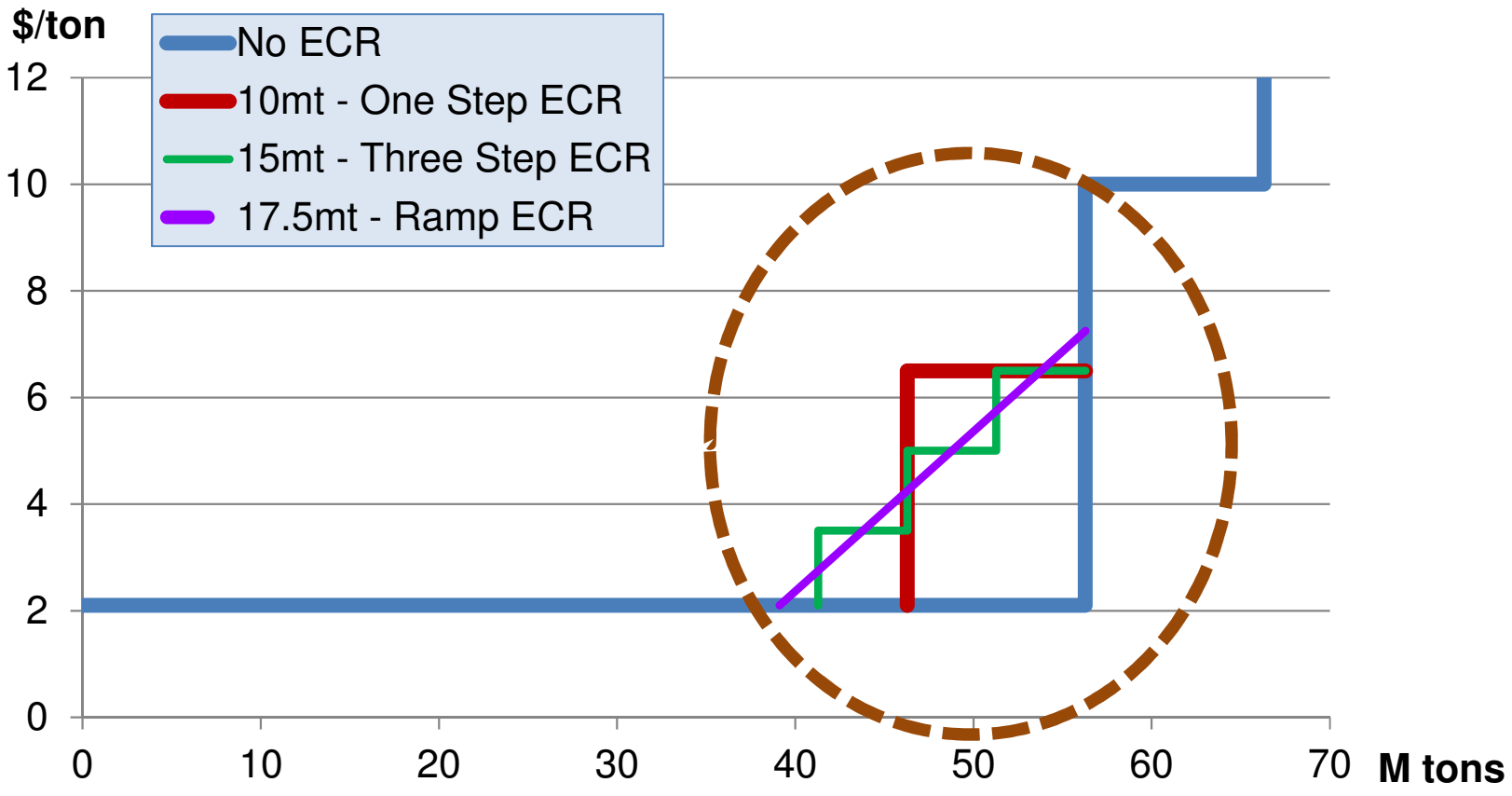
Three different approaches to an Emissions Containment Reserve



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The supply schedule reflects the adjusted cap through 2020 and then returns to reference case (3.5% annual decline).

Results from Simulations

3.5% Annual Cap Reduction	Reference Case	Low Allowance Demand: Policy, Resource and Secular Unanticipated Outcomes			
2020 Results (2011 dollars)	No ECR	No ECR	One Step ECR (10Mtons)	Three Step ECR (15 Mtons)	Ramp ECR (17.5Mtons)
Retail Electricity Price ($/MWh)	143	140	141	141	141
Fossil Generation (TWh)	143.5	112.1	101.7	107.6	106.4
Nonemitting Generation (TWh)	152.6	160.3	166.4	162.6	163.3
Allowance Price ($/ton CO_2)	8.2	4.0	5.3	5.0	5.0
RGGI Covered Emissions (Mtons)	72.3	70.1	62.5	66.6	65.8
SO_2 Emissions (Mtons)	10.4	13.4	11.8	12.8	12.7
Allowance Value (M$)	463	226	246	253	250
Incremental Leakage (%)	--	--	24%	26%	28%

High level simulation results

Across over a dozen exploratory scenarios we find…

- Virtually no effect on electricity prices
- Change in resource mix is small and in predictable directions
- Model results on the size of the bank are unpredictable

In scenarios where the ECR plays its most influential role (shown on graphs)…

- Allowance value increases by up to 20%
- Program related spending increases proportionately to allowance value
- Incremental leakage from ECR is around 30%

Whenever the ECR is in effect…

➢ It allows advantageous changes in the demand for emissions allowances to be *shared* between the economy and the environment

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Laboratory Experiments to Examine a Behavioral Setting

Compare:

- No emissions containment reserve
- One step ECR
- Linear ramp ECR

Early results:

- ❑ Students understand the ECR and make coherent intertemporal decisions.
- ❑ Deviations from the theoretical market equilibrium are less costly with the ramp than with the one step ECR.
- ❑ The size of the bank is reduced under the ECR as anticipated.
- ❑ Prices are higher under the ECR. Difference in revenues is relatively small.

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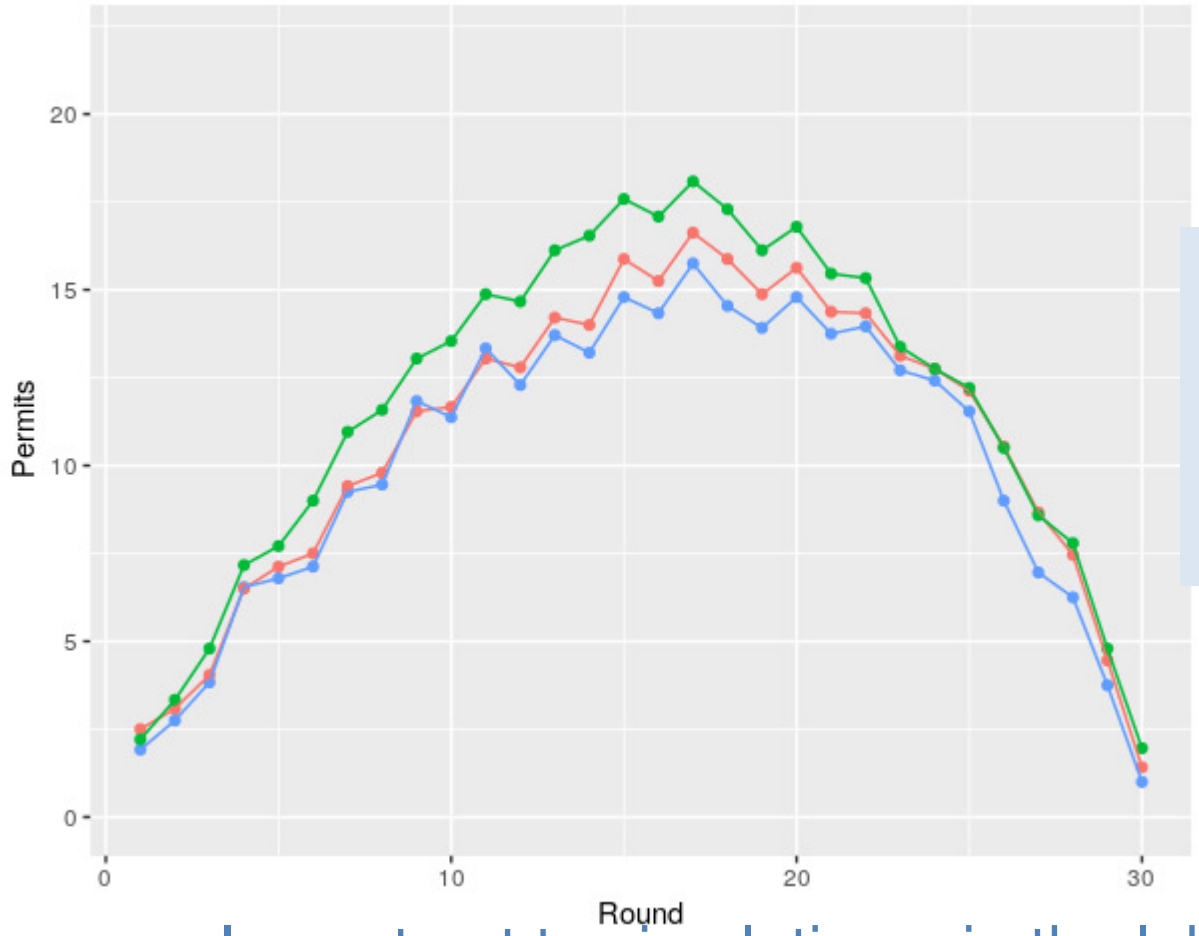
Total Banked Permits by Treatment by Round



Treatments:

- No ECR
- Linear Ramp ECR
- One Step ECR

- In contrast to simulations, in the laboratory we observe a smaller bank with the ECR

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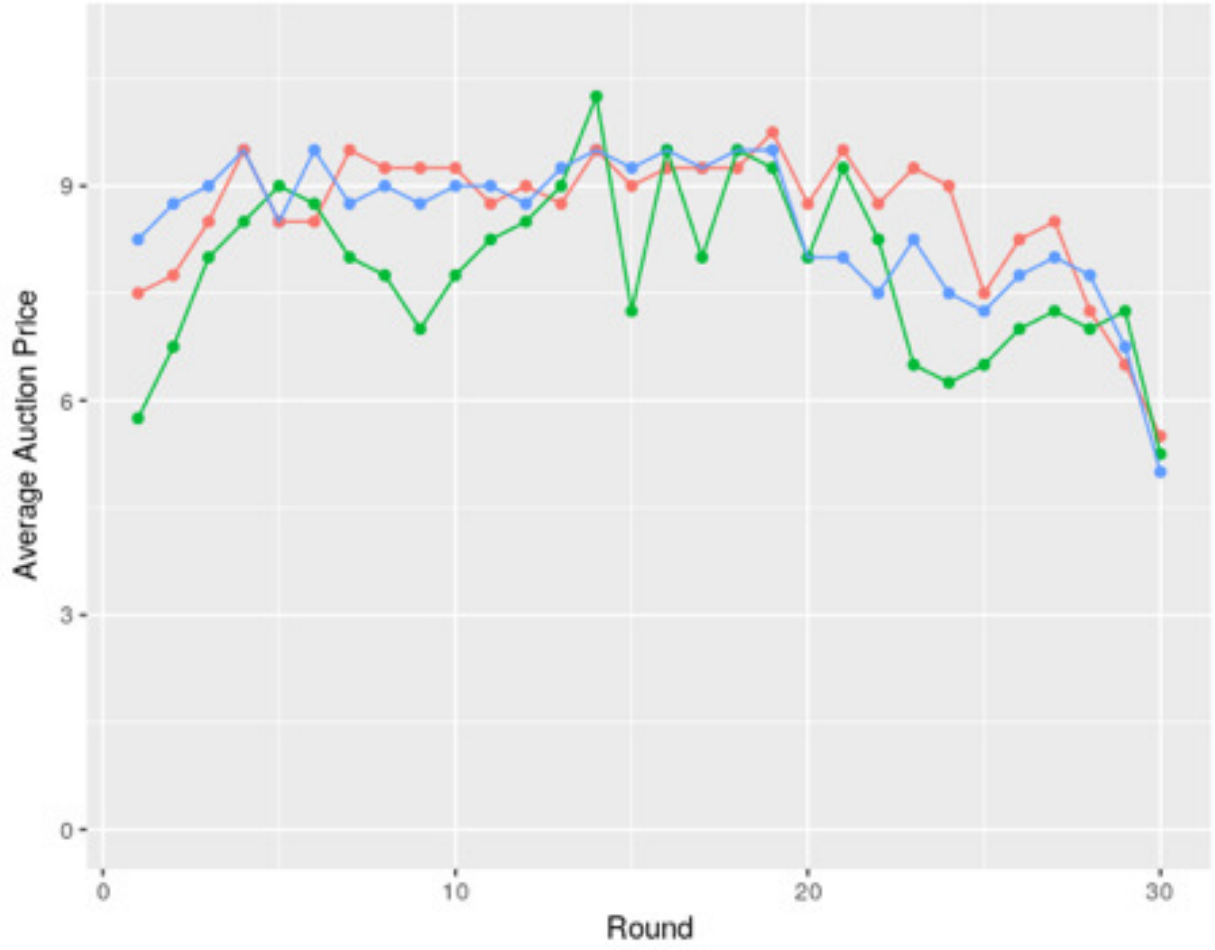
Average Auction Price by Treatment by Round



Treatments:

- No ECR
- Linear Ramp ECR
- One Step ECR

- Higher allowance prices with the ECR preserve auction revenue

RGGI Decision

- Cap reduced by 30% from 2021-2030
- Adjustment to cap to assimilate privately held bank
- Reduces two offset categories, retains three others
- Maintains auction reserve price
  - Rising at 2.5% per year
- Cost containment reserve
  - 10% of cap, beginning at $13 in 2021 and rising at 7% per year
- (Single step) Emissions Containment Reserve (!)
  - 10% of emissions budgets in 7 of 9 RGGI states (9% overall)
  - Begins at $6 in 2021 and rising at 7% per year

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Conclusion

- First best policy guidance in a second best policy setting?
- Inelastic allowance supply
  - Variable prices, costs and auction revenue
  - Undermines companion policies and ancillary benefits – the “waterbed effect”
- Programs are evolving away from fixed supply
- RGGI’s introduces a “symmetric” price responsive supply schedule
- Simulation modeling
  - Sharing of risks and benefits of changes in allowance demand
  - Less price variability, increased auction revenue
  - Ancillary benefits
  - Preserves additional emissions reductions from companion policies
- Laboratory experiments
  - Subjects understand supply schedule
  - Less price variability
- Relevance
  - Preserves incentives for leadership within an emissions-capped region
  - Offers a model to support a minimum price in the EU without “setting the price”

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Extra Slide: Laboratory Experiments Setup

- Declining cap over 30 rounds
- There is no spot market trading.
- 12 subjects, 6 “coal”, 6 “natural gas”
- 4 capacity units (plants) for each subject
- Each capacity unit produces one unit of output per round if it is run.
- Each bidder can make up to 6 bids. [But for high emitters each bid is for 2 permits]
- Banking is unlimited
- Output price varies between $30 and $40 with probability of 50% each
- Costs of production: uniform on [10,28] for low emitters and [1,28] for high emitters.
- Long-run, Walrasian price over the 30 sessions: $8
- Reserve price: $5
- Step function at $8 for 16 permits (25% of the initial cap).
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