An Endogenous Emission Cap Produces a Green Paradox

Reyer Gerlagh*, **Roweno J.R.K. Heijmans***,†, Knut Einar Rosendahl‡

*Tilburg University †Final year PhD ‡Norwegian Uni of Life Sciences and Statistics Norway
All affiliated with CREE - Oslo Centre for Research on Environmentally friendly Energy

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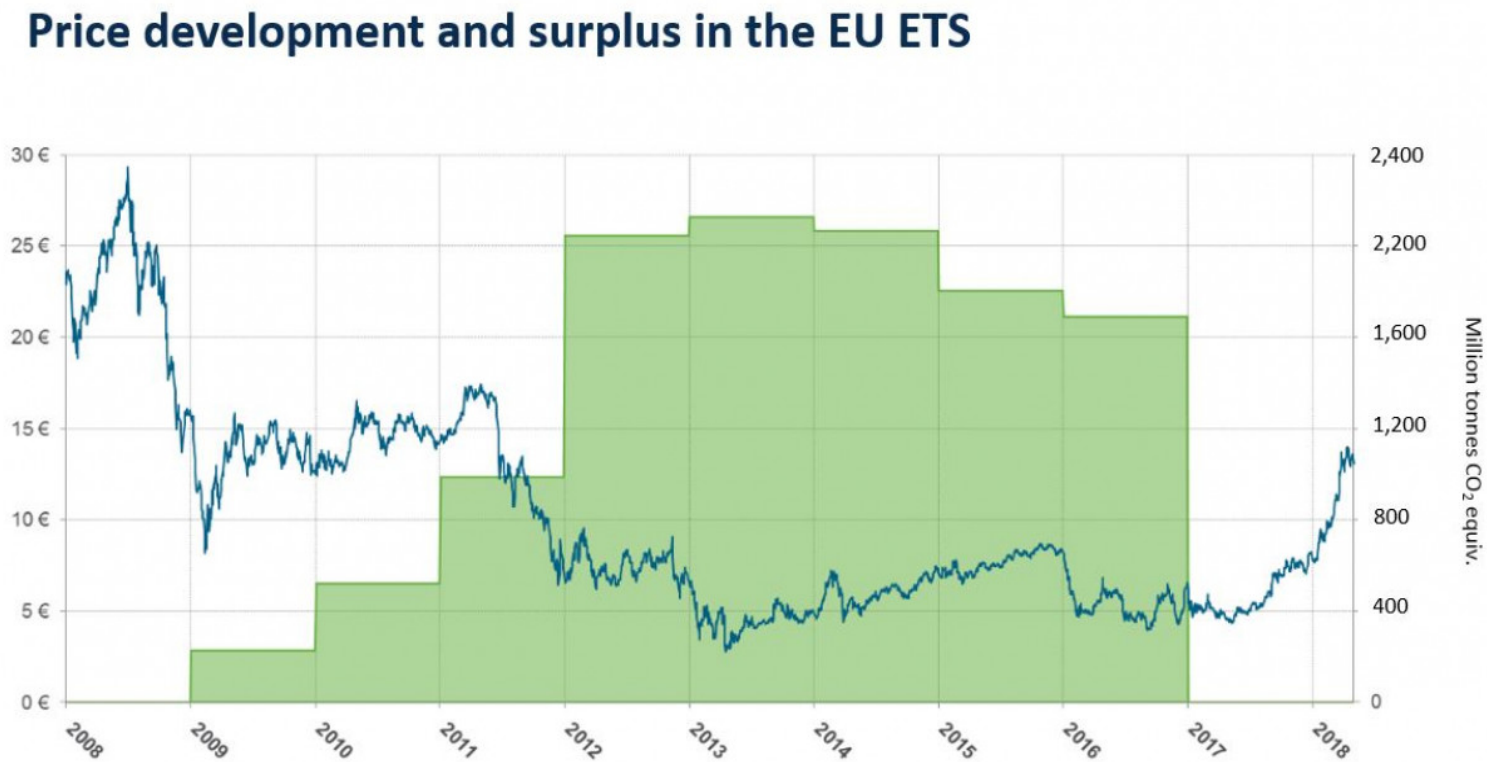
Some History

- 2005: EU Emission Trading System: world's first and second-largest
- 2008: Market crashed after credit crisis
- 2011-2012: ETS market crisis deepened
- 2018: Crucial revision of the EU ETS and the Market Stability Reserve (MSR)



EU ETS

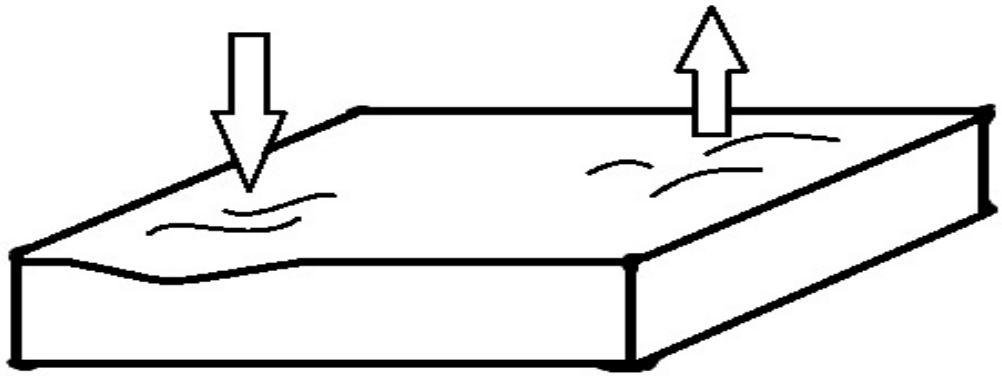
- Every year, new allowances are **supplied**.
- Supply reduces linearly over the years, to zero around 2050.
- Firms can do three things with an allowance: (1) surrender to emit CO2, (2) trade with other firms, or (3) store for future use (**banking**).
- ETS implements efficient use of allowances given **exogenous emission cap**

EU ETS + MSR after 2018

- When total banking exceeds 833 Mt (worth of emissions), part of new supply is held back $\rightarrow$ stored in **MSR**.
- When total banking is below 400 Mt, 100 Mt allowances are taken from the **MSR** and allocated *in addition* to regular supply of allowances.
- Most important policy for this talk: When the MSR contains more allowances than were auctioned in the previous year, the excess is **permanently canceled**!
- Cumulative supply of allowances depends on market outcomes = **endogenous emission cap**.

Side note: the waterbed effect

- With a **fixed cap on emissions**, supplementary climate policies have no effect on total (cumulative) emissions
  - Total emissions are exogenous – determined by the EU policy makers
- This is often referred to as the **waterbed effect**



Literature on EU ETS + MSR

- Perino (NCC, 2018): MSR temporarily punctured waterbed, restores effectiveness of abatement policy...
- Rosendahl (NCC, 2019): ... but only if policy is short-lived
- Gerlagh and Heijmans (NCC, 2019): Private agents can exploit loopholes for allowance burning ("Buy, bank, burn")
- Gerlagh, Heijmans, & Rosendahl (ERE, 2020): MSR dampens EUA price volatility

This paper

- Proposition 1: The EU ETS + MSR is susceptible to a green paradox:
  - Anticipated future emissions-reducing policies lead to increased aggregate emissions.
  - The **EU Green Deal** may be counterproductive!
- Proposition 2: The MSR introduces equilibrium multiplicity to EU ETS.
- Numerical results: Quantitative estimates for the unintended effects of abatement policies (large), for multiplicity of equilibria (real), and the importance of announcement.

A Simple Model of EU ETS

- Two periods $t = 1, 2$
- **Exogenous supply** of allowances: $\bar{s}_t$
- **Emissions** in period t: e_t
- **Aggregate emissions**: $E = e_1 + e_2$
- **Allowance prices** follow Hotelling's Rule: $p_2 = (1 + r)p_1$.
- **Complementary policies** reduce demand for allowances: λ_t

$$e_t = f_t(p_t) + \lambda_t.$$

- Unused allowances are **banked** (const. aggr. emis): b

$$e_1 = \bar{s}_1 - b \tag{1}$$
$$e_2 = \bar{s}_2 + b \tag{2}$$

A Simple Model of EU ETS with MSR

- EU ETS **with MSR**: If banking above some threshold ($b > \bar{b}$), **supply in period 2** is reduced by δb:

$$e_1 + b = \bar{s}_1$$
$$e_2 = \bar{s}_2 - \delta b + b.$$

- EU ETS anno 2020: large bank, >332 million additional allowances placed in the MSR.
- Most canceled ($\delta > 0.7$, Perino 2018, Gerlagh&Heijmans 2019)
- RQ: **What is the effect of complementary emissions policies on emissions?**

Proposition 1.1: Leakage

Proposition

An **early** *complementary emissions-reducing policy,* $\lambda_1 < 0$*, is* **dampened** *by the MSR:*

$$0 < \frac{dE}{d\lambda_1} < 1$$

Proposition 1.1: Leakage

Proposition

An **early** *complementary emissions-reducing policy,* $\lambda_1 < 0$*, is* **dampened** *by the MSR:*

$$0 < \frac{dE}{d\lambda_1} < 1$$

- Emission-reduction in period 1 ($e_1 \downarrow$) $\rightarrow$ more banking ($b \uparrow$) $\rightarrow$ greater inflow in MSR $\rightarrow$ more canceling ($\bar{s}_2 - \delta b \downarrow$) $\rightarrow$ lower aggregate emissions ($E \downarrow$).

Proposition 1.2: Green Paradox

Proposition

A **late but anticipated** *complementary emissions-reducing policy,* $\lambda_2 < 0$*, is* **reversed** *by the MSR:*

$$\frac{dE}{d\lambda_2} < 0$$

Proposition 1.2: Green Paradox

Proposition

A **late but anticipated** *complementary emissions-reducing policy,* $\lambda_2 < 0$*, is* **reversed** *by the MSR:*

$$\frac{dE}{d\lambda_2} < 0$$

- Low future demand ($e_2 \downarrow$) $\rightarrow$ lower prices ($p_2, p_1 \downarrow$) $\rightarrow$ higher current demand ($e_1 \uparrow$) $\rightarrow$ lower banking ($b \downarrow$) $\rightarrow$ less inflow in MSR $\rightarrow$ less canceling ($\bar{s}_2 - \delta b \uparrow$) $\rightarrow$ aggregate emissions increase ($E \uparrow$).
  - Requires that future policies affect banking
  - Timing and anticipation are crucial!
- Result not specific to simple model. For a much more general result, click here

Multiple equilibria

Proposition (Multiplicity)

If an equilibrium exists with banking sufficiently close to the threshold, $|b - \overline{b}| < \varepsilon$ and ε small, then at least two distinct equilibria exist. These equilibria are supported by distinct price-paths $(p_1^*, p_2^*) < (p_1^{**}, p_2^{**})$, and different levels of cumulative emissions $E^* > E^{**} + \delta\overline{b}$.

- Intuition: small change in banking $\rightarrow$ cross MSR thresholds $\rightarrow$ discrete adjustment of supply
- Multiple equilibria = unpredictability
- "Coordination failure"
- Which outcome will the market realize?

Model calibration

- Consider linear demand function:
  $d_t(p_t; \lambda_t) = (a - bp_t)(1 - ct) + \lambda_t$
- Assume real discount rate of 5%, T is endogenous
  - Demand drops to zero when price is equal to choke price
  - Supply drops to zero after 2057
- The parameters a, b and c are disciplined using historic evidence:
  - Consistent with price-demand combination in 2018
  - Base case scenario with MSR should have initial price of 21 Euro/t
  - Base case scenario without MSR should have initial price of 7.5 Euro/t
- Calibrated parameters:
  $a/b = 221.5$ Euro/tCO2 (choke price) ; $c = 0.021$; $T = 2066$
- Figure for supply and demand here

Baseline scenario: stocks

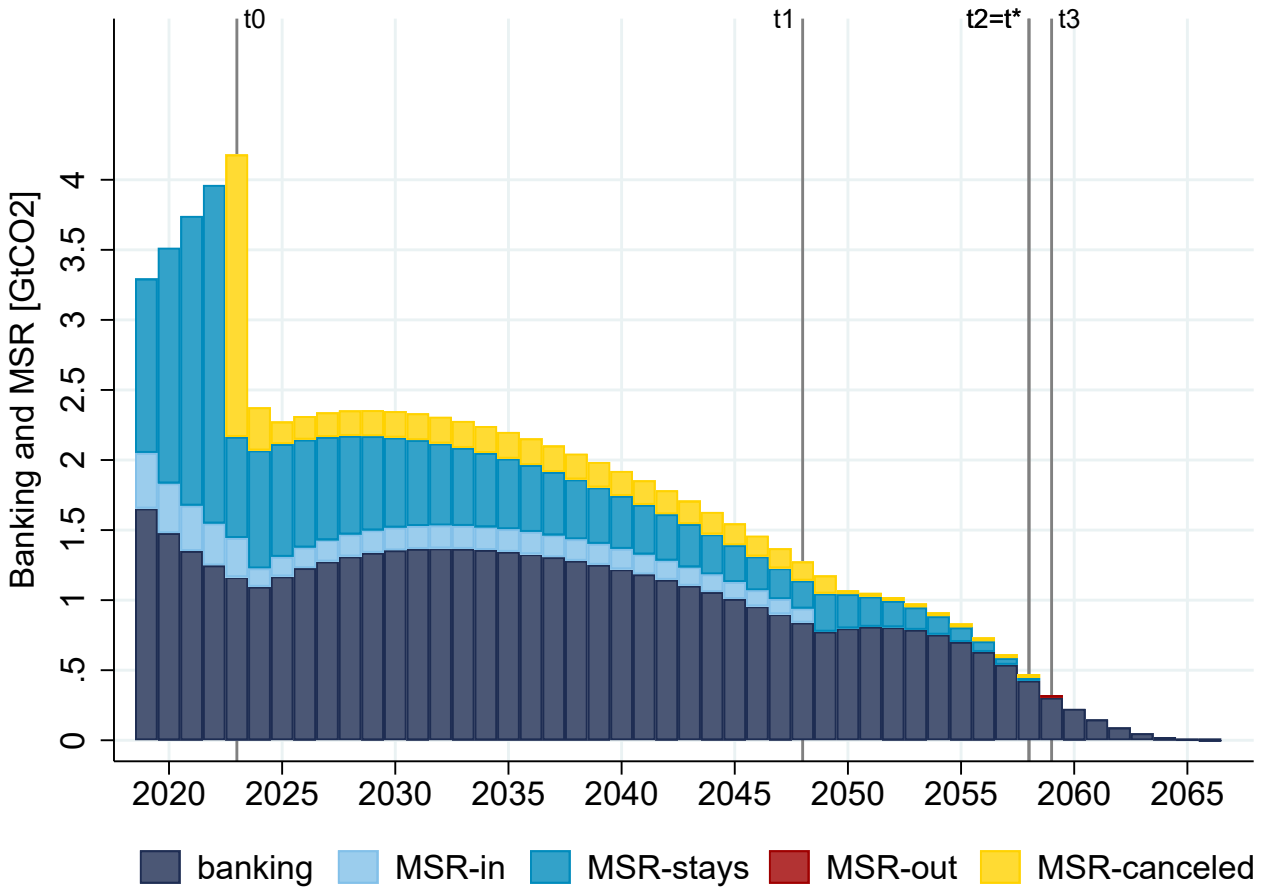


Figure: Stocks of allowances

Multiplicity of equilibria

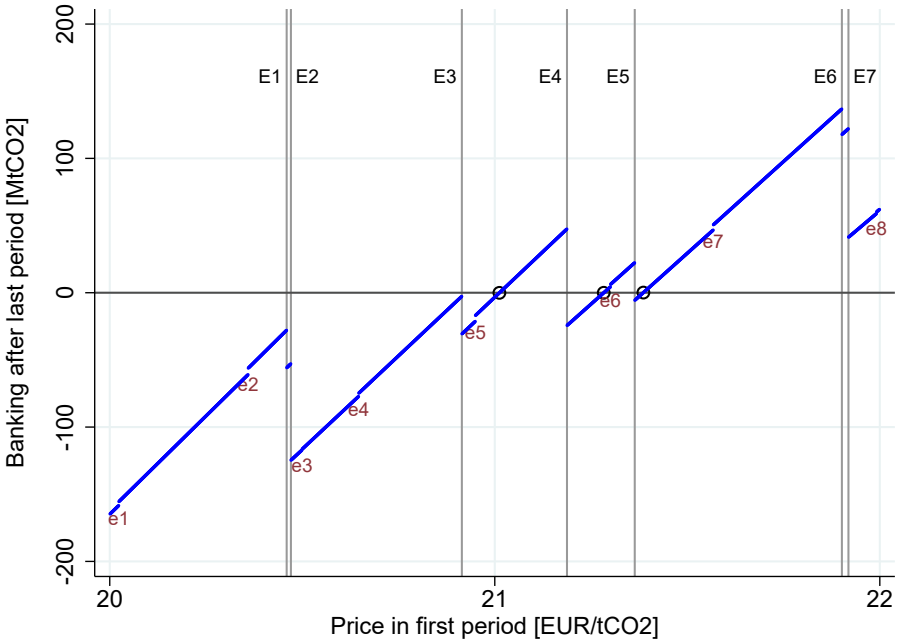


Figure: Banking in year $T = 2066$, as dependent on initial price

- Equilibrium requires that banking in $T = 2066$ is zero - here we see three such equilibria for the same demand function
- In our Baseline scenario, the price starts at 21.0. If the price instead starts at 21.3 or 21.4, we also have an equilibrium
- Threshold $\overline{B}$ is passed at E2, E4 and E7
- Threshold $\underline{B}$ is passed at all events E1-E7
- Figure for canceling here

Abatement policies: (in)effective

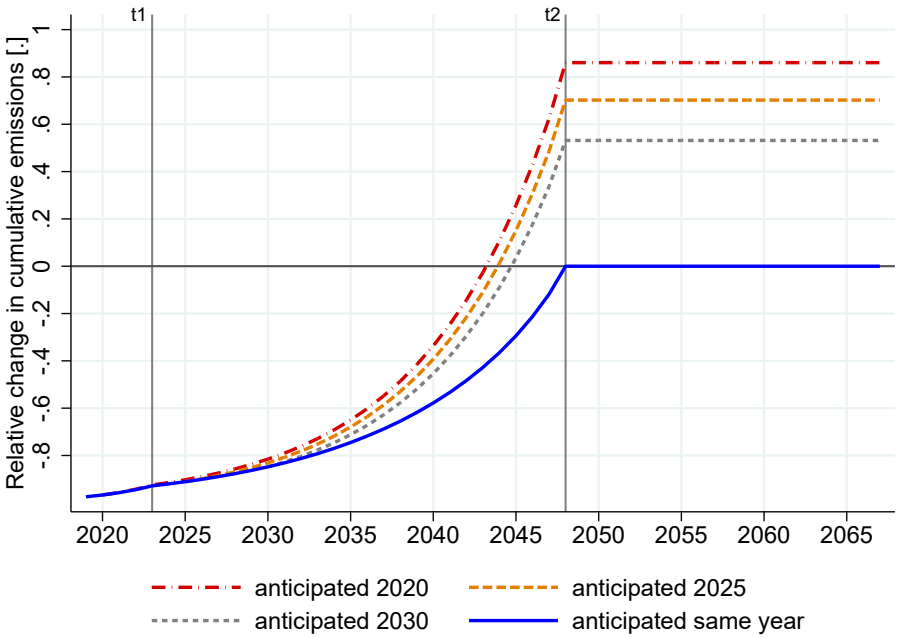


Figure: Effect of abatement policy on cumulative emissions

- Early abatement gives strong reduction in cumulative emissions
- Abatement announced and realized same year always reduces cumulative emissions (until MSR inflow stops)
- Early announcement of late abatement increases cumulative emissions: Green Paradox

Effective complementary policies

How to avoid the green paradox?

1. Match policies with a reduction of the ETS cap.
   - requires repeated negotiations
2. Price-triggered canceling of allowances
   - Low allowances prices trigger cancellation, similar to RGGI.
   - Discrete canceling: still multiplicity...
   - Gerlagh & Heijmans (2020): canceling should decrease **continuously** with prices = optimal instrument for stock externalities
   - Continuous canceling also fixes equilibrium multiplicity

Price stability: separation of targets

Stable ETS prices require

1. **endogenous** adjustment of long-term allowances **supply** to sizable changes in demand
2. **liquidity** (sufficient but not too much allowances in circulation)

Liquidity

Optimal ETS liquidity balances two risks:

1. A very large bank of privately held allowances turns price volatility into **asset risks**.
2. A very small bank of privately held allowances causes a collapse of intertemporal trade, which *causes* **price volatility** (e.g. as happened in the South Koren ETS)

Lessons

1. Flows between MSR and ETS should target liquidity and **not** long-run supply adjustment.
2. Cancellation of allowances should target long-term supply responding optimally to demand changes

Conclusions

- Abatement today can reduce emissions thanks to the MSR
- But future abatement announced today (e.g. the Green Deal) may increase emissions
  - Highlights the importance of anticipation and policy announcement
- Possible caveat: Our model is deterministic
  - The demonstrated mechanism also relevant with imperfect foresight

Thank you for your attention!

General Model Theorem

- Note: The MSR implies that cumulative supply of allowances depends on the path of emissions (= demand for allowances) – via banking

$$S = s(\boldsymbol{d}) \text{ where } \boldsymbol{d} = \boldsymbol{d}(p, \boldsymbol{\lambda})$$

- We refer to this as a quantity-based (endogenous) emissions cap
- We set up a generic ETS model with quantity-based (endogenous) cap
- Aggregate demand equals aggregate supply
- Assume no free lunch ($\Delta \boldsymbol{d} > 0$ not feasible)

Theorem

For every quantity-based endogenuous cap system without a free lunch, there exists a policy $d\boldsymbol{\lambda} < 0$ that induces a green paradox, $d(\boldsymbol{u}^T \boldsymbol{d}^*) > 0$.

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Baseline scenario: supply and demand

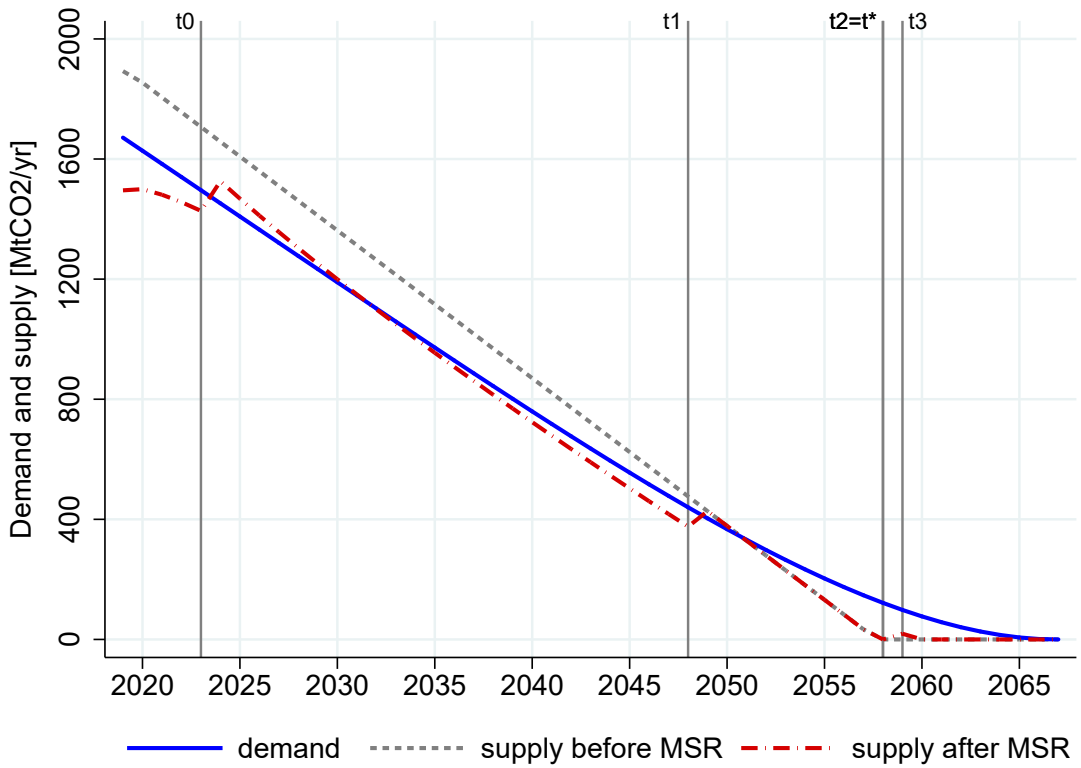

Figure: Market balance (p_t goes from 21 to 208 Euro/t in 2066)

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MSR cancelling

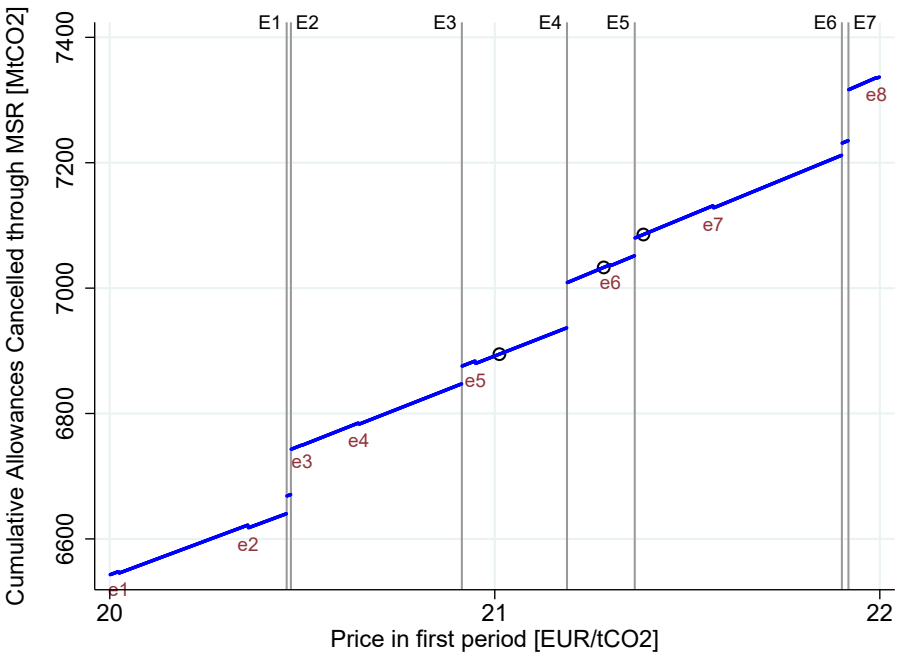

Figure: Cumulative cancellation of allowances, as dependent on initial price

- Cumulative cancellation jumps upwards when a threshold is passed
- Cumulative emissions are around 200 Mt higher with $p_0 = 21.0$ than with $p_0 = 21.4$
- Which equilibrium will the market choose??

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