Emissions trading systems, cap adjustments and the Market Stability Reserve

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New information and program reform

- Most existing ETSs are ‘single order’ policies
  - fixed cap & rigid permits allocation schedule
- Embedded features to respond to temporary shocks:
  - banking and borrowing (temporal flexibility);
  - regular auctions;
  - including offsets use.
- Persistent shocks can affect (climate change) policies:
  - business cycles;
  - technological progress;
  - changes in overlapping policies.
- ... leading to policy adjustments or program reforms

The case of the EU ETS

- Low level of permit price consequence of two effects:
  - economic recession and renewables-promoting policies; and
  - incapacity to respond to changes in economic circumstances.

Source: ECOfys (2015).

Related academic work

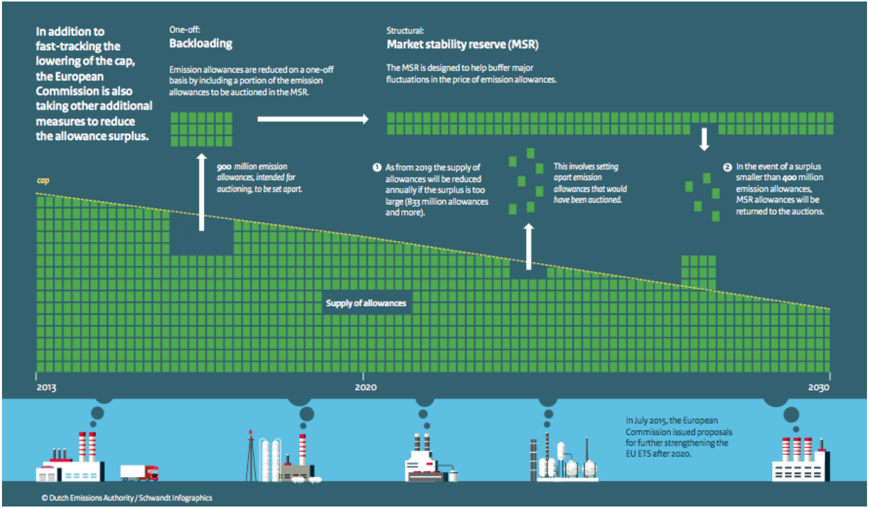
- Intensity targets or indexed regulation condition policy stringency on observable economic indicators
    - On indexing rules [Ellerman and Wing, 2003] and [Newell and Pizer, 2008].
    - On climate policy cyclicality [Heutel, 2012] and [Golosov et al., 2014].
- Hybrid systems mix elements of a carbon tax into an ETS
    - Adjust policy stringency in response to price levels.
    - Price ceiling and/or price floor [Pizer, 2002], [Fell and Morgenstern, 2010], [Grüll and Taschini, 2011].
- Our work (two papers) ties together the literature on
    1. responsive policy instruments and dynamic allocation; and
    2. price vs. quantity debate and hybrid systems.

EU ETS reform

- Objective: make the ETS "more resilient to supply-demand imbalances so as to enable the ETS to function in an orderly market".

1. 'Back-loading'
   - Reduction of allowances in the market via near-term auctions, reintroducing the quantity removed later on.
2. Market Stability Reserve (MSR)
   - shift allowance allocation into the future but within the bounds of the pre-determined cap (original design was cap-preserving);
   - adjustment of auction allowance in response to changes in the inventories of unused allowances (the bank of allowances)
   - dynamic supply adjustments *in response* to bank levels.

Temporary vs. dynamic supply adjustment



Academic and policy contributions

- Fixed-cap ETSs lack provisions to address persistent shocks.
- Propose a mechanism that adjust policy stringency (KT 2016)
  - permits allocation changed in response to shocks to bank
  - spans policy spectrum between pure-quantity & pure-price
- Identify trade-off between two policy stringency extremes (KT 2016)
- Determine optimal adjustment rate for the EU ETS (KT 2016)
  - Provide academic underpinning for EC's MSR adjustment parameter
- Assessment of the EC's Market Stability Reserve (KT 2019)
  - Show ineffectiveness of MSR temporary adjustments
  - Provide theoretical support for regular cancellations of surplus permits from the MSR.

General set up

- Firms decide how much they want to offset emissions
  - current and future costs of reducing emissions,
  - existing bank of allowances,
  - and future allowance demand and allocations.
- The required abatement R_t is the key decision variable:
  - (counterfactual emissions) - (number of allowances allocated)
- Amount of abatement and banking depends on R_t
- Spoiler alert:
  - Fixed cap – shocks equally transferred to R_t;
  - Fully floating cap – shocks completely offset and R_t fixed.
- Assumptions (later relaxed in KT 2019):
  - Finite horizon and no banking/borrowing constrains (B&B).

Allowance supply and demand

- Firms are atomistic in a perfectly competitive market.
- Each firm is characterized by

$$B_t^i = \underbrace{B_0^i}_{\text{initial bank}} + \overbrace{A^i(0,t)}^{\text{permits}} - \underbrace{E^i(0,t)}_{\text{count. emissions}} + \int_0^t \alpha_s^i \, ds - \int_0^t \beta_s^i \, ds,$$

- where
  - α_t^i denotes instantaneous abatement and
  - $|\beta_t^i|$ permits sold ($\beta_t^i > 0$) or bought ($\beta_t^i < 0$).
- Imposed full compliance by end of the regulated horizon $B_T = 0$.

Impact of mechanism on required abatement

- The required abatement (key state variable)

$$R_t^i := \mathbb{E}_t \left[E^i(t, T) - A^i(t, T)\right] - B_t^i$$

  - $A^i(t, T)$ incorporates future permits allocation adjustments
- Equivalent to residual demand of permits before the firm takes any abatement measures or trades any permits at time t
- Policy compliance requires $R_T^i = B_T^i = 0$
- Use R_t^i to explore how firms react to (i) changes in policy stringency and (ii) newly available information

The inter-temporal decision problem

- The firm's dynamic cost minimization problem is

$$\min_{\alpha^i,\beta^i} \mathbb{E}\left[\int_0^T e^{-rt}\left(\Pi\alpha_t^i + \varrho(\alpha_t^i)^2 - P_t\beta_t^i + \nu(\beta_t^i)^2\right)\, dt\right],$$

s.t. $\qquad B_T^i = 0.$

where

- r is the risk-free rate;
- Π_t and ϱ are intercept and slope of the marginal cost curve,
- $P_t - 2\nu\beta$ are the linear marginal trading costs.
- Remark: For our analysis, the relative cost difference between trading and abatement is irrelevant.

The equilibrium aggregate abatement

- Let δ be the adjustment rate of permit allocation
  - Policy stringency is relaxed by increasing δ
- In equilibrium, the aggregate abatement at time t is

$$\alpha_t = re^{rt}\frac{R_0(\delta)}{e^{rT}-1} + re^{rt}\int_0^t \frac{d\xi_s(\delta)}{e^{rT}-e^{rs}}$$

  where

$$d\xi_s = d\mathbb{E}_s\left[E(0,T) - A(0,T)\right].$$

- The process ξ reflects changes in the firms' expectations
  - incorporates shocks and cap adjustments in firms' problem
  - captures market reaction (as a function of δ)

Responsive policy stringency

- The mechanism is indexed to the aggregate bank
  - $\delta \cdot |B_t - c|\ dt$ permits are permanently removed if $B_t > c$
  - $\delta \cdot |B_t - c|\ dt$ permits are permanently added if $B_t < c$

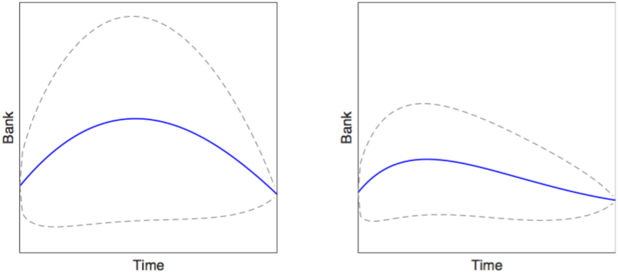
  where c is the target bank (for intuition, $c > 0$ later $c = 0$)
- An extremely high adjustment rate δ (floating cap)
  - Deviation from c continuously, and almost perfectly, offset
  - The bank is kept in a very tight band around c
- A low adjustment rate δ (fixed cap)
  - The bank moves around the target level c.
  - The lower the adjustment rate, the larger the fluctuations.

Bank ‘confidence’ interval

- Change in the permits bank

$$dB_t = f_t dt + \delta(c - B_t)\, dt - E(t, t + dt) + \alpha_t dt,$$

where f_t is the pre-adjustment allocation schedule



Aggregate bank quantiles for a 95% confidence level when the responsive mechanism is inactive (left diagram) and when it is active (right diagram).

The optimal adjustment rate δ

- Minimise expected total aggregate compliance costs

$$\min_{\delta} \mathbb{E}\left[\int_0^T e^{-rt}(\Pi_t \alpha_t(\delta) + \varrho \alpha_t^2(\delta))\, dt\right]$$

- Carbon dioxide is a stock pollutant
  - minimizing expected costs is the same as maximizing expected benefits minus costs ([Newell and Pizer, 2008]).
  - abstract from damage caused (or avoided) by the adjustment
- Assumption (innocuous):
  - firms have same initial bank B_0,
  - firms have same emissions process.

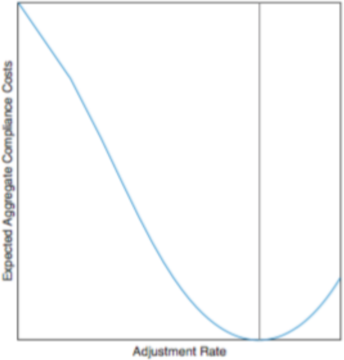
Decomposition of aggregate compliance costs

- Decomposition of total aggregate compliance costs

$$\Pi_0 R_0 + \varrho r \frac{R_0^2}{e^{rT} - 1} + \varrho r \int_0^T \frac{d\langle \xi \rangle_t}{(e^{rT} - e^{rt})}$$

- Trade-off $\rightarrow$ adjustment costs vs. inter-temporal cost savings
- Increasing δ
  1. Lowers the costs of adjusting to changes in expectations of required abatement due to shocks in permits demand
  2. Decreases the inter-temporal opportunity to save (or borrow) permits for (from) the next trading period

Optimal adjustment rate



- Recall δ dynamically change the cap
- Trade-off between:

1. Firms' cost savings caused by the shock-mitigating effect of a responsive policy.
2. Firms' loss of benefits from exploiting differences in marginal abatement costs across time.

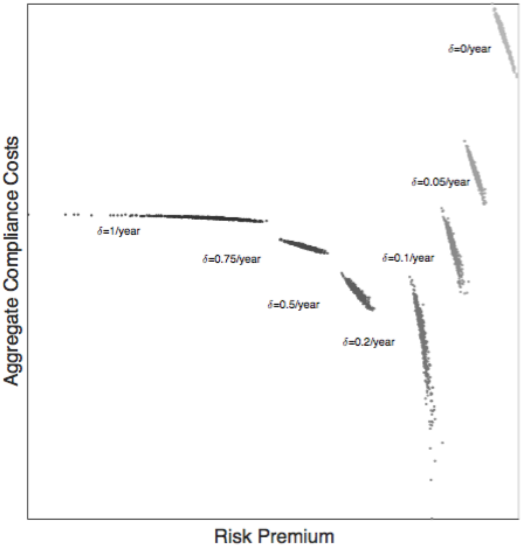
Rate δ and perceived riskiness of investments

- Policy stringency spectrum
  - If fully floating cap, shocks are perfectly compensated, R_t is certain and (return on) abatement investments is certain

    $\rightarrow$demanding rate of return equal to the risk-free rate r.
  - Opposite of the spectrum, uncertainty (variability) about R_t increases and permit prices become volatile

    $\rightarrow$demanding a premium q_t for permits & abatement investments.

Realized aggregate costs and risk-premia



Realized aggregate costs and risk-premia

- With fixed-cap, permit prices volatile and risk premium at maximum
- When the adjustment rate δ increases
  - R_t less uncertain and permit price volatility decreases;
  - associated risk premium decreases.
- As the risk premium continues to decrease, total compliance costs first decrease and then start to increase again.
- Cost U-shape reflects the trade-off discussed earlier.

Conclusions

- Most existing ETSs lack provisions to address persistent shocks
- Propose a mechanism that adjust policy stringency
  - permits allocation changed in response to shocks to bank
  - spans policy spectrum pure-quantity vs. pure-price
- Identify a trade-off characterising the policy stringency spectrum
  - As policy stringency nears the fully floating cap (or fixed price) extreme, inter-temporal trading thins out
  - In exchange, firms benefit from lower adjustment costs
- The mechanism has the expected effect on investment risk premium

Thank you very much for your attention

To find out more...

- **Academic papers:**
  - Kollenberg and T. (2019). Emissions trading systems with cap adjustments. *Journal of Environmental Economics and Management* 80 (1) 20–36
  - Kollenberg and T. (2019) Dynamic supply adjustment and banking under uncertainty in an emission trading scheme: The market stability reserve. *European Economic Review*. 118 (1) 213–226
- **Non-technical commentary:**
  - "System responsiveness and the EU ETS"
    with Chris Duffy, 1 January, 2014
  - "Options for structural measures to improve the EU ETS: response to a European Commission consultation"
    with Chris Duffy, 1 March, 2013

Impact of a cap-preserving mechanism (MSR)

- Impact of cap-preserving supply management mechanism (SMM)?
- Only when SMM affects expected required abatement R_t
  1. the expected length of the banking period τ varies
  2. the distribution of τ varies
- Show that effect of SMM can be counter-intuitive:
  1. rise in price volatility
  2. lead to higher risk premia,
  3. accelerated depletion of the allowance bank,
  4. lower abatement, and
  5. lower allowance prices.

The dynamic cost minimisation problem

The problem is

$$\min_{\alpha^i,\beta^i} \mathbb{E}\left[\int_0^T e^{-rt} v^i(\alpha^i_t, \beta^i_t) dt\right],$$

s.t.

$$B^i_t = B^i_0 + A(0,t) - E(0,t) + \int_0^t \alpha^i_s \, ds \; - \int_0^t \beta^i_s \, ds,$$

$$B^i_t > 0, \quad \text{and} \quad B^i_T = 0,$$

$$v^i(\alpha^i, \beta^i) = AC(\alpha^i) + TC(\beta^i) \quad \text{and} \quad AC'(\alpha) = \Pi_t + 2\varrho\alpha.$$

- r is risk-free rate and B^i_0 is initial bank;
- $A(0,t)$ = sum of allowances allocated in $(0,t]$;
- $E(0,t)$ = pre-abatement cumulated emissions during $(0,t]$.

Equilibrium solution

- In equilibrium, aggregate abatement at time t is given by

$$\alpha_t = re^{rt}\frac{\mathbb{E}_0[R]}{e^{r\tau(0)}-1} + re^{rt}\int_0^t \frac{d\mathbb{E}_s[R]}{e^{r\tau(s)}-e^{rs}},$$

- Impact of *previously unexpected* changes to the required abatement

$$P_t = \Pi_t + 2\varrho\alpha_t = \Pi_t + 2\varrho re^{rt}\frac{\mathbb{E}_0[R]}{e^{r\tau(0)}-1} + 2\varrho re^{rt}\int_0^t \frac{d\mathbb{E}_s[R]}{e^{r\tau(s)}-e^{rs}},$$

- Joint effect of $d\mathbb{E}_s[R]$ and $d\tau(s)$ determines price volatility

Aggregate bank under risk-aversion

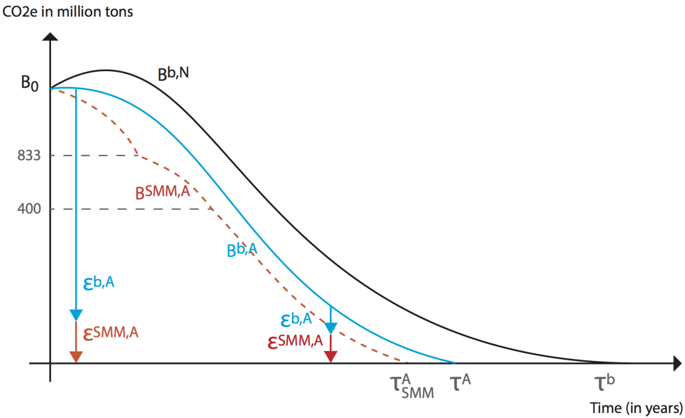


Figure: The aggregate bank without an SMM under risk-neutrality (black line) and under risk- aversion (blue line); aggregate bank with the SMM under risk-aversion (red dotted line).

Conclusions

- Equilibrium model of inter-temporal trading of permits with SMM
- Timing of allocation largely irrelevant as long as changes in expected emissions can be dealt with the existing bank of allowances
- When firms account for the risk in the change of variability of τ
    - $\rightarrow$ higher price variability,
    - $\rightarrow$ higher risk premia
    - $\rightarrow$ firms will deplete their bank more quickly
    - $\rightarrow$ lower levels of abatement and permit prices
- A permanent cancellation of part of the reserve will, at the very least, lead to lower risk of low-carbon investments and increase prices

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