Dynamic Supply Adjustment and Banking under Uncertainty: the Market Stability Reserve

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Fixed cap and rigid allocation

- In most existing cap-and-trade programmes the environmental reduction target (the cap) is fixed and the supply of allowances is inflexible and determined within a rigid allocation programme.
- With permit front-loading, the programme will deliver a cost-effective solution [Hasegawa and Salant (2015)].
- Observations from recent cap-and-trade schemes have raised concerns over excessive allowance price variability and price collapse.
- 'Over-supply', unexpectedly low levels of permit demand have led to the accumulation of a significant *surplus* of permits.

Unresponsive allocation programme

- *Surplus* of permits is often attributed to the financial crises of 2008 and renewables uptake [Grosjean et al. (2014)].
- Banking may be insufficient when the market is faced with persistent demand shocks.

Figure: Source DECC (2014).

Proposals to remedy the situation

- Regulator's objective: make the ETS "more resilient to supply-demand imbalances so as to enable the ETS to function in an orderly fashion".

1. 'Back-loading'
   - Reduction of the number of permits in the market via near-term auctions, reintroducing the quantity removed later on.
2. Market Stability Reserve (MSR)
   - shift permit allocation into the future but within the bounds of the pre-determined cap.
   - adjustment of auction permits in response to changes in the inventories of unused permits (bank of permits).

- Increase responsiveness via dynamic permit allocation adjustments.

Responsive policy instruments

- Proposals for improving the design of cap-and-trade systems:
  - Intensity targets or indexed regulation condition the cap 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 cap and allocation in response to price levels.
    - Price ceiling and/or price floor [Unold and Requate(2001)], [Pizer(2002)], [Fell and Morgenstern(2010)], [Grüll and Taschini(2011)].
- Our work draws from and contributes to the literature on responsive policy instruments and dynamic allocation.

The impact of the Market Stability Reserve (MSR)

- Explore the conditions under which the MSR affects allowance prices and abatement strategies.
- No effect or price increase [Salant, 2015], [Perino and Willner, 2015]:
  - With no borrowing constraints, abatement decisions are independent of the temporal distribution of allowances.
  - Under limited borrowing, there is a change if and only if the onset of the MSR makes the borrowing constraint binding.
- The firm's expected required abatement Y is chief decision parameter
  - Changes in firms' expectation about Y affect how much abatement and banking will occur in the future – and for how long.
- We show that the MSR can affect abatement even when the MSR leaves Y and the expected length of the banking period unchanged.

General set up

- Firms have to decide by how much they want to offset their emissions, considering
  - current and future costs of reducing emissions,
  - existing bank of allowances,
  - and future permit demand and allocations.
- Key decision variable: the expected required abatement Y, the difference between counterfactual emissions and the number of permits allocated.
- When new information becomes available, firms update their expectations about Y and adjust their strategies:
  - affect how much abatement and banking will occur, and
  - for how long τ.
- After τ firms use every permit available to cover contemporaneous emissions and instantaneously abate their residual emissions.

The dynamic cost minimisation problem

- Firms are atomistic in a perfectly competitive market.
- The firm's control problem is

$$\min_{\alpha^i,\beta^i} \mathbb{E}\left[\int_0^T e^{-rt} v^i(\alpha_t^i, \beta_t^i)dt\right], \tag{1}$$

s.t.

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

$$B_t^i > 0, \quad \text{and} \quad B_T^i = 0.$$

where α_t^i denotes instantaneous abatement and $|\beta_t^i|$ is the number of permits sold ($\beta_t^i > 0$) or bought ($\beta_t^i < 0$); and r is the risk-free rate.

Required abatement under uncertainty

- Two key state variables of the system:
  1. the expectation of the instant τ aggregate bank is depleted
  $$\tau(t) := \mathbb{E}_t[\tau], \text{ and}$$
  2. the expectation of the corresponding required abatement
  $$\mathbb{E}_t[Y] := \mathbb{E}_t[Y(\tau)].$$
- $d\mathbb{E}_t[Y]$ represents changes in expectations about the required abatement.
- Abatement and trading strategies are adapted at each time t, when new information becomes available.

Linear marginal abatement and trading costs

- 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. $\quad B_T^i = 0.$

- where
  - Π_t and ϱ are the intercept and the slope of the marginal cost curve;
  - $P_t - 2\nu\beta$ are the linear marginal trading costs.
- In aggregate terms, the equilibrium results are not affected by the level of ν. We thereby consider negligible transaction costs.

Equilibrium solution for risk-neutral firms

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

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

- The expected required abatement $\mathbb{E}_0[Y]$ is spread over the banking period.
- The adjustment $d\mathbb{E}_s[Y]$ is spread over the remainder of the banking period.

Effect of the MSR on abatement

- *Static view:* expected abatement path at $t = 0$

$$\mathbb{E}_0[\alpha_t] = re^{rt} \frac{\mathbb{E}_0[Y(\tau)]}{e^{r\tau(0)} - 1}. \quad (3)$$

- The MSR changes the timing of the allocation of allowances, but not the total number of allocated allowances.
- The time-0 expected required abatement is the same if
  - the time-0 expectation of τ does not change;
  - the time-0 expectation of total number of allowances allocated until τ does not change.

Effect of the MSR on the price path

- Consider the impact of *previously unexpected* changes to the required abatement through the permit price

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

1. Changes in the expected required abatement change the expected duration of the banking period too.
2. Changes in $d\mathbb{E}_s[Y]$ and $\tau(s)$ determines the volatility of prices.
3. These are determined by changes in the programme of the permit supply (MSR).

Instantaneous breakdown

- Changes in time-t expectations about the required abatement, $d\mathbb{E}_t[Y]$, will yield one of two scenarios:
  1. $t < \mathbb{E}_t[\tau]$ if the aggregate bank is sufficient to cushion the shock;
  2. $t = \tau$ if the bank is completely depleted, *instantaneous breakdown*.

- Policy question:
  How the MSR influences the likelihood of the scenario of *instantaneous breakdown* and which are the policy implications?

Aggregate bank under risk-neutrality

- The MSR decreases the bank in the short run and adds to the bank in the long run, when the reserve is re-injected.
- The likelihood of a breakdown is increased in the short run (abatement investments risk ↑) and decreased in the long run.

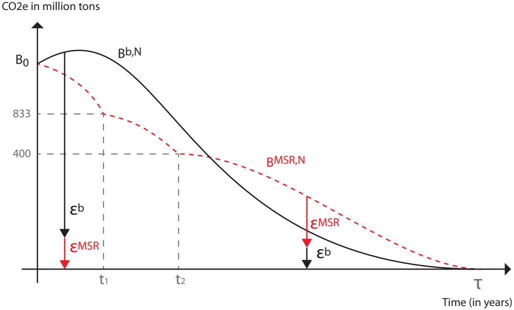


Figure: The aggregate bank under risk-neutrality without the MSR (black line) and with the MSR (red dotted line).

Cost minimisation problem under risk aversion

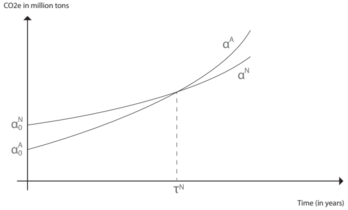
- With risk-aversion, the dynamic cost minimisation problem is

$$\min_{\alpha_t^i,\beta_t^i} \mathbb{E}\left[\int_0^T e^{-\mu_t \cdot t} v^i(\alpha_t^i, \beta_t^i)\, dt\right], \tag{4}$$

  where $\mu_t = r + q_t$ includes a (time-dependent) risk-premium q_t.
- Allowances (and related low-carbon investments) are perceived as risky investments.
- Firms would prefer to postpone abatement and use their bank if alternative investments promise higher returns.
- Lower abatement levels will be reflected in lower prices
  - larger μ_t due to a positive q_t imply lower B_t and α_t, as observed by [Fell, 2015] and [Ellerman et al., 2015] in their sensitivity analysis.

Abatement curves

- As expected, aggregate abatement under risk-aversion is strictly smaller than under risk-neutrality.
- What drives this difference?
    - Uncertainty about Y is gradually reduced, making the holding of allowances and the associated investments less risky.
    - The bank value that is *at risk* decreases in time and q_t decreases too.



Short- and long term effects do not even out

- Likelihood of breakdown increased when reserve is building up decreased when the reserve is decreasing.
- But prices and abatement affected more when reserve is building up.

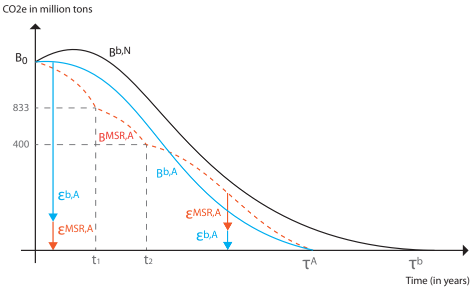


Figure: The aggregate bank without an MSR under risk-neutrality (black line) and under risk-aversion (blue line); aggregate bank with the MSR under risk-aversion (red dotted line).

Conclusions

- The MSR changes the timing of the allocation and preserves the cap.
- If the bank sufficiently large, the timing of allocation is largely irrelevant.
- Considering unexpected changes in firms' expectations about the depletion of the bank:

1. Risk neutral firms
    - indifferent to changes in the likelihood of this event;
    - MSR neither affects equilibrium abatement nor the expected permit price paths.
2. Risk adverse firms
    - adjustments in the permit allocation programme matter;
    - short- and long term effects on abatement do not even out.
    - larger q_t implies lower B_t, α_t and, consequently, lower permit prices.

Thank you very much for your attention.

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