Early action vs. early emissions reduction
– Evaluation of policy proposals for Kyoto compliance -

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Optimal Early Actions vs. Optimal Early GHG Emissions Reduction – Evaluation of Proposed Policy Tools for Kyoto Compliance

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Abstract

The increasing "Kyoto gap" has raised concerns about the likely costs for businesses to meet the target if early action is not taken to help smooth the transition. Meeting the targets of significantly lower level of GHG emissions will require major technological adjustments such as R&D and capital investments. This adjustment process will likely be less costly if action is initiated well before the compliance period. The purpose of this paper is to assess the main early action policy proposals currently under consideration in several countries using a simple, two period model. The simulation is calibrated to the Australian economy.

In the model, time is divided into two periods. In Period 1 (2003-2008) there are no internationally binding restrictions on GHG emissions. In Period 2 (2008-2012) the total emissions reduction is fixed, relative to BAU baseline. In the model, there are two types of action by the firms to reduce GHGs: Research and development investments (R&D) and capital investments. Both R&D and CI change the underlying technology and therefore the relationship between the economic activity and the associated level of GHG emissions. While CI, however, results in GHG emissions reduction in the period when they were undertaken, R&D investments in Period 1 result in emissions reduction only with a lag, in Period 2.

The scenarios considered are:

- No Policy Tool (Benchmark)
- International Emissions Trading (ET) in Period 2 only
- Emissions Tax in Period 1 and International ET (Auction) in Period 2
- Credits for Early Action Program in Period 1 and International ET in Period 2 (Auction)
- Public Early Action Program in Period 1 and International ET in Period 2
- International ET (Grandfathering with Baseline Protection) in Period 2
- Banking Early Emission Credits
- International ET (Grandfathering with No Baseline Protection) in Period 2
- Cap-and-Trade Program in Period1 and International ET in Period 2
- Trading in Emissions Futures

The environmental benefits of early reductions are due to the associated actual early emissions reduction, while the compliance cost savings stem from well planned early action that *may* or *may not* yield early actual emissions reduction. This has important implications for the design of the policy.

This paper argues some policies have the potential to be highly distorting. The policy approach advocated in this paper is a early cap-and-trade (CAT) program in Period 1, coupled with emissions trading in Period 2 or an emissions trading system in Period 1 with Grandfathering and Baseline Protection.

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Agenda

- Motivation – Rationale for Early Action
- The Key Characteristics of the Model
- The Cases (8 + 2)
- Calibration to the Australian Economy
- Results
- Conclusions

Motivation – Rationale for Early Action

- **environmental** and **social** benefits (reduced pollution, healthcare cost savings, etc.).
- **economic** sense (shifting to less carbon-intensive technologies during the course of normal capital stock turnover, i.e. cost-smoothing opportunities)
- **international competitiveness** (increased R&D on energy efficiency, renewable energy, and other GHG mitigation techniques is likely to result in less reliance on international flexibility mechanisms)
- **political** (early emission reduction lowers the risk of non-compliance with the Kyoto protocol if it is to be ratified)

Defining the Policy Objective

Early Action vs. Early Actual Emissions Reduction

Economic efficiency or environmental effectiveness?

- The environmental and social benefits of early action are due to the associated **actual** early emissions reductions. Compliance cost savings and other economic benefits, however, do **not necessarily require actual** reductions in emissions.
- The policy objective has important implications for the choice and the details of the design of the early action policy (e.g. carbon tax, emissions permit trading system, Credit for Early Action program or a combination of one or more of the above implemented together with various market-based incentives, fiscal policies and funding for research and development)

Goal: develop a simple framework for the assessment of the main early action policy proposals

Previous Studies

- **Kennedy** (2000)

- five-sector simulation model calibrated to Canadian economy
- comparison of 6 emission paths in 15 scenarios
- **Conclusions:** "… policies ... for early emission REDUCTION *per se* will not necessarily create the correct incentives for optimal early ACTION, and can in fact be highly distorting"
- advocates modest cap-and-trade prg coupled with trading in emission futures (permits for period 2 are issued gradually in period 1 and are allowed to trade freely)

Previous Studies cont.

- **Parry and Toman** (2001)

- model calibrated to the U.S. economy
- extend/modify Kennedy model
- calculate impact of Learning-by-Doing

Conclusions:

- suggests KP to be amended to allow credits in period 1 to offset emissions in period 2 (banking)
- if no banking: cap-and-trade prg more advantageous over early credits

The Model

- N number of emitting entities
- Period 1: 2003-2008 > no internationally binding restrictions
- Period 2: 2008-2012 > the total emissions by the emitting entities is limited (Commitment Period)
- Types of action to reduce GHG emissions: (1) capital investments (CI) and (2) investment into research and development (RD)
- key distinction: *temporal relationship between the action and the associated emissions reduction*
  - CI yields emissions reduction in the same period in which they are undertaken
  - DR does not result in an immediate GHG emissions reduction in the period when they were undertaken, only in next period

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Cost Functions

$$cd_{1i} = \frac{\alpha_i}{2} ed_{2i}^{\ 2}$$

$$cc_{1i} = \frac{\beta_{1i}}{2} ec_{1i}^{\ 2}$$

$$cc_{2i} = \frac{\beta_{2i}}{2} ec_{2i}^{\ 2}$$

$\alpha_i, \beta_{1i}\ \beta_{2i}$ non-negative

$$\beta_{2i} = \beta_{1i}\left[1 - \left\{\psi\left(\kappa \frac{ec_{1i}}{\frac{R_1}{N}\left(\frac{R_1}{N}\right)^2}\frac{ed_{2i}^2}{\left(\frac{R_1}{N}\right)^2}\right) + (1-\psi)\left(\frac{1}{N-1}\sum_{j\neq i}\kappa \frac{ec_{1j}}{\frac{R_1}{N}\left(\frac{R_1}{N}\right)^2}\frac{ed_{2j}^2}{\left(\frac{R_1}{N}\right)^2}\right)\right\}\right]$$

$0 \le \psi \le 1 \quad 0 \le \kappa \le 1$

1. RD investment undertaken in Period 1 has an impact on the abatement cost in Period 1 but results in emissions reduction in Period 2 only.
2. CI in Period 1 has a learning-by-doing (LBD) effect on the cost of the CI investment in Period 2.
3. RD in Period 1 also has an impact on the cost of CI in Period 2 but to a lesser extent than Period 1 CI.
4. Period 2 cost parameter for CI depends on the weighted sum of a technology specification of the firm and by all other firms together.

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Total Cost, Emissions and Benefits

$$C_1 = \sum_{i=1}^{N}\left(\frac{\alpha_i}{2} ed_{2i}^{\ 2} + \frac{\beta_{1i}}{2} ec_{1i}^{\ 2}\right) \qquad E_1 = \sum_{i=1}^{N} ec_{1i} \qquad B_1 = \sum_{i=1}^{N} \mu_i ec_{1i}$$

$$C_2 = \sum_{i=1}^{N} \frac{\beta_{2i}}{2} ec_{2i}^{\ 2} \qquad E_2 = \sum_{i=1}^{N}(ec_{2i} + ed_{1i}) \qquad B_2 = \sum_{i=1}^{N} \mu_i (ec_{2i} + ed_{2i})$$

The model thus intends to encompass the following key properties:

1. RD yields emission reductions only with a lag.

2. CI and RD undertaken in Period 1 reduces the cost of emissions reduction due to CI in Period 2, representing learning effect and an impact from RD.

3. Ceteris paribus, emission reductions due to CI are less costly when the investment is spread between Periods 1 and 2 than when it is concentrated in Period 2 alone.

4. Environmental benefits of early actions are due to the associated *actual* early emission reductions, while the compliance cost savings are not necessarily.

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The Model - Benefits

FOR HOUSEHOLDS		Abatement	
		Local	Overseas
Benefit	Climate change	yes	yes
	Secondary	**Yes (health, clean air, etc.)**	no

FOR FIRMS		Abatement	
		Local	Overseas
Benefit	Climate change	no	no
	Secondary	**Yes (reputation)**	no

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Calibration to the Australian Economy

- Energy sector responsible for 69.5 % of Australia's GHG emissions
- The "Kyoto budget" (K) is 5 x 566.6 = 2.833 billion tonne CO2-e.
- The Kyoto Protocol requires a total of 633 Mt CO2-e emissions reduction over the 5 years.
- AGO estimates Australia's cost of climate action to be between A$1 billion and A$3.2 billion per annum. For the five year this means a total of A$5 to A$16 billion.
- Assuming a 5% annual discount rate translates into a five-year discount factor of 0.78 Objectives of implementing a policy tool in the pre-commitment period is to lower the cost of Kyoto compliance >> Benchmark Scenario is in the upper range
- Number of firms in Australia responsible for energy extraction to be 250 (N), assume firms are homogenous
- Permits for a tonne of CO2-e emissions in the commitment period could be valued A$40-A$200 with **no** international trading, and A$8-A$52 with the possibility of international trading.
- Further assumptions. 1) Australia will not introduce a domestic emissions trading system prior to an international scheme, but will participate in the latter 2) trading system will be cap-and-trade (CAT) system, with the cap being the aggregate national caps of the participating nations 3) Australia is price-taker

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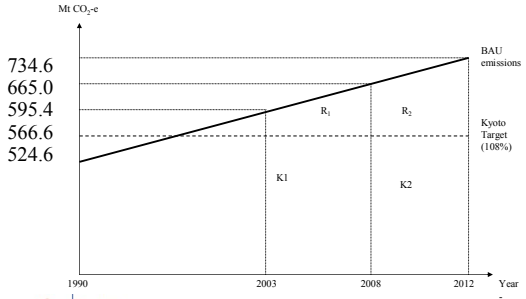
Kyoto Requirement



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1. No Policy Tool – Benchmark

Min. $C_1 - B_1 + \varphi(C_2 - B_2)$

s.t. $E_2 \geq R_2$

2. International Emissions Trading in Period 2

Min. $C_1 - B_1 + \varphi C_2 + \varphi p_2 P_2 - \varphi B_2$

s.t. $E_2 + P_2 = R_2$

Ec1 drops to 2% of total domestic reductions from benchmark scenario 5%

Social planner: IET is optimal only if revenue can compensate households for the lost is secondary benefits.

In case the secondary (social) benefits non-observed by the firms exceeds $A 12.5 per unit of emissions (assuming constant marginal benefits) then revenue cannot compensate for benefit loss.

3. Emissions Taxation in Period 1 and International Emissions Trading in Period 2

Min. $C_1 + \tau(BAU_1 - E_1) - B_1 + \varphi C_2 + \varphi p_2 P_2 - \varphi B_2$

s. t. $E_2 + P_2 = R_2$

4. Non-Tradable Credits for Early Action in Period 1 and International Emissions Trading (Auction) in Period 2

Min. $C_1 - B_1 - \omega_1 EC_1 + \varphi C_2 + \varphi p_2 P_2 - \varphi B_2$

s. t. $E_2 + P_2 = R_2$

Credits are generated when an entity reduces its emissions below a credit generation baseline (here: BAU1)

W1 represents the rate at which credits are recognised

Credits rather act like a subsidy

5. International Emission Trading (Grandfathering with Baseline Protection and Auction) in Period 2

Min. $C_1 - B_1 + \varphi C_2 + \varphi p_2 (P_2 - k) - \varphi B_2$

s.t. $E_2 + P_2 + k = R_2$

where $k = \omega_2 E_1$

6. International Emission Trading (Grandfathering without Baseline Protection and Auction) in Period 2

The optimization problem is the same as in Case 5 but *k* is independent of Period 1 emissions reduction.

$k = \omega_3 BAU_1$

7. Early Cap-and-Trade Program in Period 1 and International Emissions Trading in Period 2

Min. $C_1 + p_1 P_1 - B_1 + \varphi C_2 + \varphi p_2 P_2 - \varphi B_2$

S.t. $E_1 + P_1 = R_1$ and $E_2 + P_2 = R_2$

8. Public Early Action Program in Period 1 and International Emissions Trading in Period 2

Min. $C_1 - B_1 - \omega_1 EC_1 + \varphi C_{22} + \varphi p_2 P_2 - \varphi B$

s.t. $E_2 + P_2 = R_2$

where $\omega_1 = \mu\left(1 + \frac{ec_1}{\frac{R_1}{N}}\right)$

9. Banking Early Emission Credits

Banking emission credit may be simulated by setting the parameter value in Case 5

$\omega_2 = 1$

10. Trading in Emission Futures

Trading in emissions futures may be simulated by setting the price in Case 2

$p_1 = \varphi E_1[p_2] = \varphi p_2$

Abatements

		Abatemnt P1			Abatement P2				TOTAL
		Domestic	International	Total	Domestic	International	Total	CEA units	ABATEMENT
		E1	P1		E2	P2		k	
1	Benchmark Scenario	31.709.000		31.709.000	633.000.000	0	633.000.000		664.709.000
2	P2 Emission Trading	6.758.500		6.758.500	320.738.250	312.261.750	633.000.000		639.758.500
3	P1 Tax P2 ET	11.764.250		11.764.250	320.990.250	312.009.750	633.000.000		644.764.250
4	P1 CEA P2 ET	6.822.000		6.822.000	320.741.500	312.258.500	633.000.000		639.822.000
5	P2 ET (GF - BLP)	143.428.000		143.428.000	328.091.250	233.194.750	561.286.000	71.714.000	704.714.000
6	P2 ET (GF - No BLP)	6.758.500		6.758.500	320.738.250	240.531.750	561.270.000	71.730.000	568.028.500
7	P1 CAT P2 ET	81.847.250	273.152.750	355.000.000	324.650.500	308.349.500	633.000.000		988.000.000
8	P1 Public Early Action Prg P2 ET	6.779.500		6.779.500	320.739.250	312.260.750	633.000.000		639.779.500
9	Banking Early E Credits	280.140.250		280.140.250	336.645.250	16.214.500	352.859.750	280.140.250	633.000.000
10	Trading Emissions Futures	143.428.000	211.572.000	355.000.000	328.091.250	304.908.750	633.000.000		988.000.000

Results - Elasticities

		E1+E2	C1-B1+C2-B2	Elasticity	parameter
1	Benchmark Scenario	664.709.000	16.964.093.403	0,005073	alfa, beta
2	P2 Emission Trading	639.758.500	12.777.921.211	0,019591	p2
3	P1 Tax P2 ET	644.764.250	15.956.659.796	0,039000	tax rate
4	P1 CEA P2 ET	639.822.000	12.756.295.872	-0,059306	w1
5	P2 ET (GF - BLP)	704.714.000	12.685.745.179	1,998549	w2
6	P2 ET (GF - No BLP)	568.028.500	10.819.692.211	0,697722	w3
7	P1 CAT P2 ET	988.000.000	17.438.388.848	0,000000	p1
8	P1 Public Early Action Prg P2 ET	639.779.500	12.771.012.285		
9	Banking Early E Credits	633.000.000	12.594.191.630		
10	Trading Emissions Futures	988.000.000	20.419.452.979		

Thank you for your attention !

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