Global Trade Analysis Project (GTAP) models for the analysis of climate change and trade policies linkages

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Part B

- European Union studies
- Japan, South Africa
- Asia-Pacific countries?

Applications using GTAP

Trade Policy as a vehicle for Adaptation to Global Warming
Hertel and Randhir (1999)

Trade Policy and Global Warming

- Impact of Global Warming (GB) on agricultural production is expected to vary considerably by region
- International trade may offer a vehicle for adaptation to climate change by permitting the geographic relocation of world food supplies according to changing comparative advantage
- If countries insulate their domestic markets from developments in other regions they jeopardize the ability of world markets to lower global costs of climatic change.

Table 1 Climate Change Impacts on Crop Productivity (%)

	Region								
Commodity	CAN	US	MEX	EU	CHN	ASEAN	AUS	ROW	World Average
Rice	0	1	-24	0	-3	-8	-12	-8	-7
Wheat	27	-2	-31	8	16	0	8	5	6
Other grains	15	-16	-35	1	-14	-33	5	-3	-9
Other crops	26	14	-18	15	13	-11	9	2	6
Regional average	24	2	-24	11	3	-11	8	-1	

Source: Tsigas, Frisvold and Kuhn, 1997, which is based on the work of Rosenzweig and Iglesias (1994) as summarized in Reilly, Hohmann and Kane (1993). These estimates take into account the direct effect of carbon dioxide fertilization on yields.

Table 2

How countries fare

Whether the impact of climate change is projected by economic or agronomic models, nearly all countries suffer.

(percent change in agricultural productivity)

	Ricardian model[1]	Crop model[1]	Weighted average	
			Without CF	With CF
Argentina	–4	–18	–11	2
Brazil	–5	–29	–17	–4
United States	5	–16	–6	8
Southwest plains	–11	–59	–35	–25
India	–49	–27	–38	–29
China	4	–13	–7	7
South central	–19	–13	–15	–2
Mexico	–36	–35	–35	–26
Nigeria	–12	–25	–19	–6
South Africa	–47	–20	–33	–23
Ethiopia	–31	–31	–31	–21
Canada	0	–4	–2	12
Spain	–4	–11	–9	5
Germany	14	–11	–3	12
Russia	0	–15	–8	6

Source: Cline (2007).

Note: Ricardian models statistically infer the contribution of temperature and precipitation to agricultural productivity by examining the relationship of land price to climate, whereas crop models relate farm output to land quality, climate, fertilizer inputs, and so on.

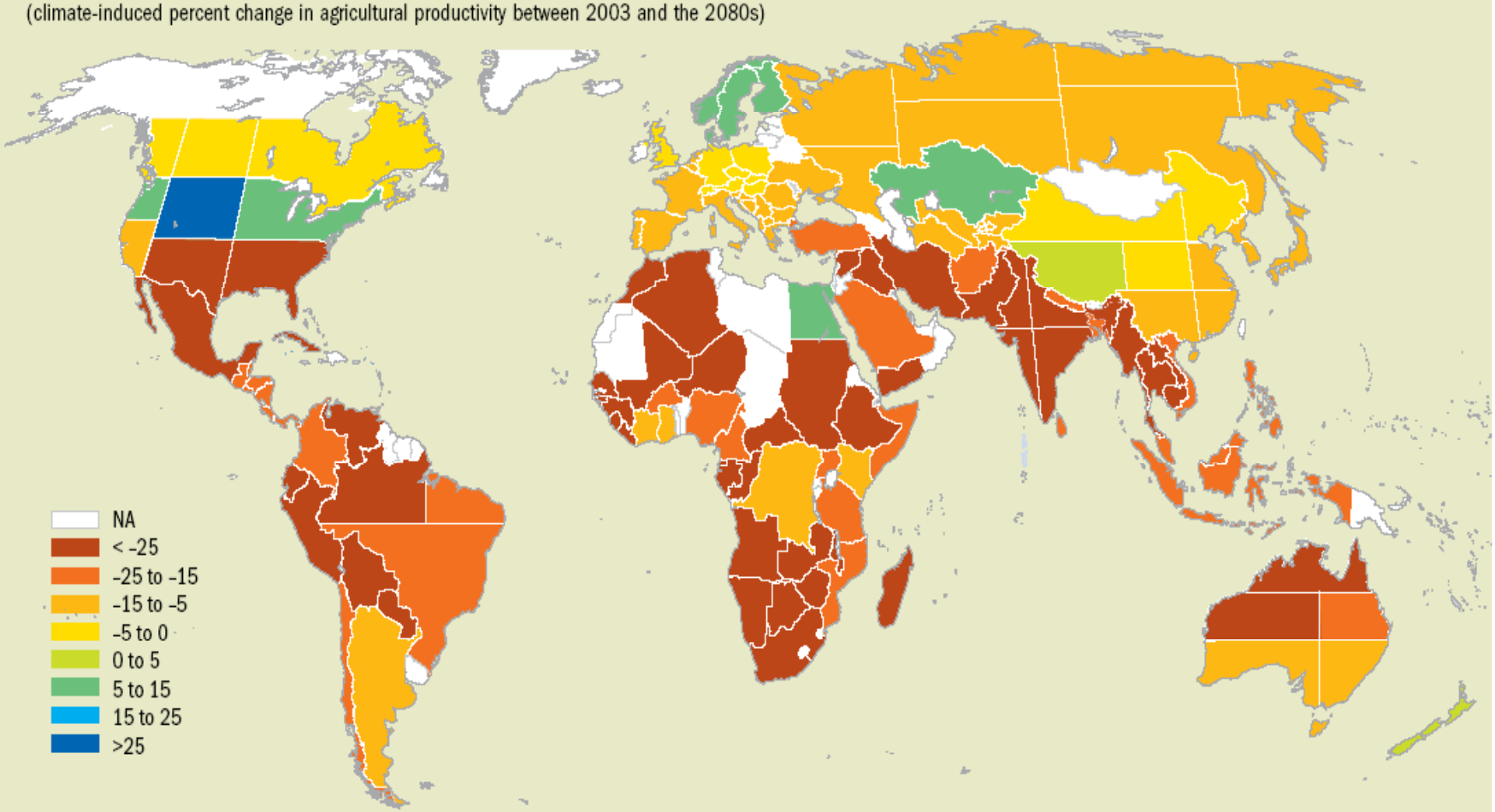
[1]Without carbon fertilization (CF) effects.

Map 1

Without carbon fertilization

If there are no beneficial effects from increased carbon dioxide, agricultural output declines almost everywhere and catastrophically closer to the equator.

(climate-induced percent change in agricultural productivity between 2003 and the 2080s)



Source: Cline (2007).

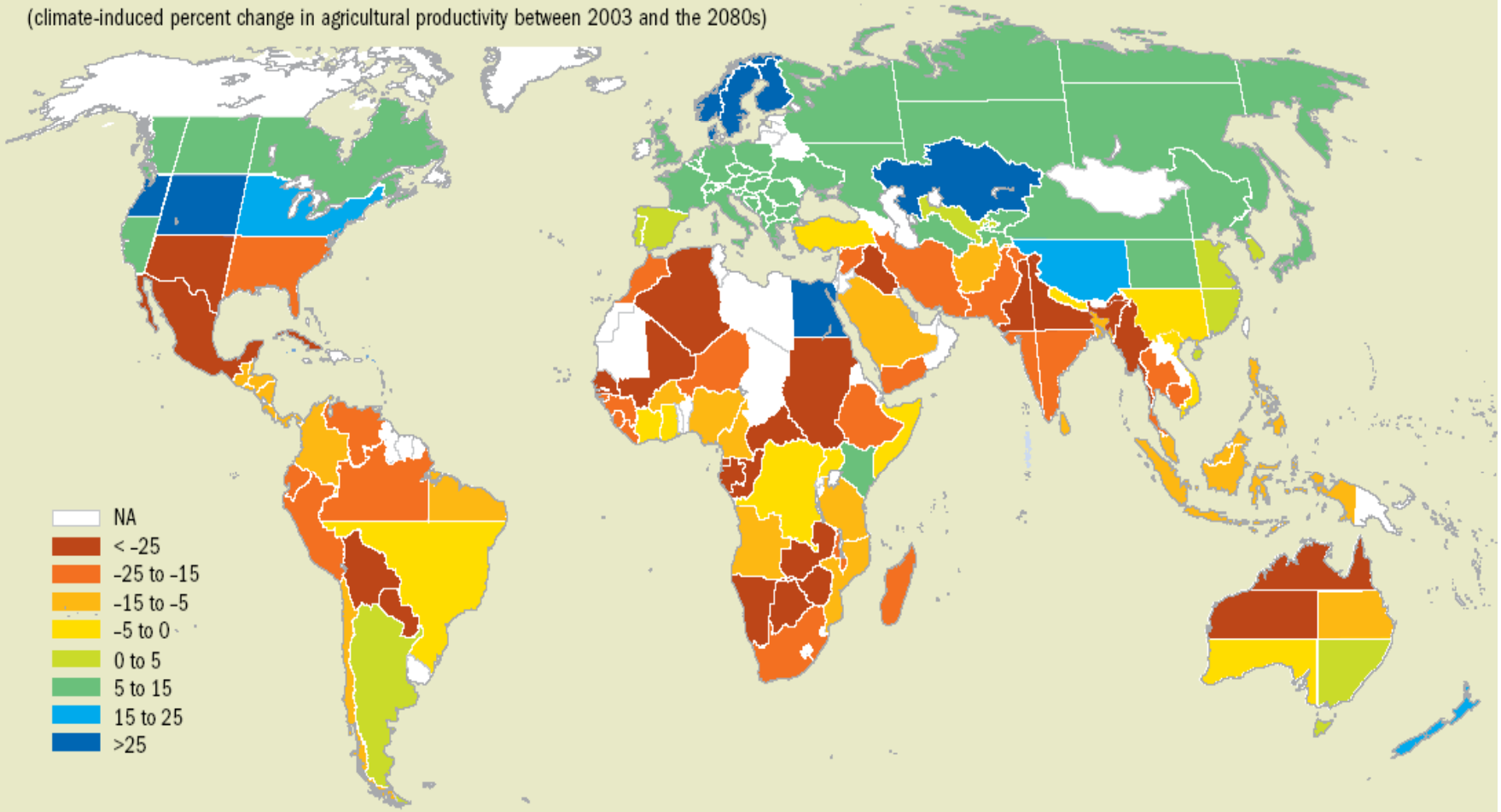
Note: NA refers to "not applicable" for Alaska and northern Canada, and to "not available" elsewhere.

Map 2

With carbon fertilization

If some crops benefit from increased carbon dioxide, the global impact is less dire and those areas farther from the equator may see some increases in agricultural productivity.

(climate-induced percent change in agricultural productivity between 2003 and the 2080s)



Source: Cline (2007).

Note: NA refers to "not applicable" for Alaska and northern Canada, and to "not available" elsewhere.

Experimental design

- E1: Base data with full pre-Uruguay *distortions*, and *with* full *price transmission* (no market insulation), σ_D(rice)=5.05, σ_D(wheat)=4.45, σ_D(cereal grains)=1.3, etc; $\sigma_M = 2\sigma_D$.

- E2: Base data with full pre-Uruguay *distortions*, but now *without* price transmission (i.e. with market insulation), $\sigma_D = \sigma_D = 0$.

Experimental design (ctd.)

- E3: Full agricultural trade liberalization (removal of all import tariffs, export subsidies and output subsidies for agriculture), create new data base for E4.

- E4: Same as Base Case, i.e. full price transmissions (i.e. $\sigma_M > 0$, $\sigma_D > 0$) but with new data base (stripped of all trade distortions in agriculture).

Buffering role of trade in the adaptation of the global economy to climate change

By setting $\sigma_M = 0$, we effectively prevent bilateral imports from **r** into **s** from changing when the relative costs of supply from **r** are altered in the wake of climate change.

We must also set $\sigma_D = 0$ in order to prevent an expansion of import volume, ***qim*** (i, **r**), when the average import price falls, relative to the domestic price. Therefore the only reason for imports to expand under this price insulation parameter setting is if the total composite demand for good i, ***qc***(i) , expands.

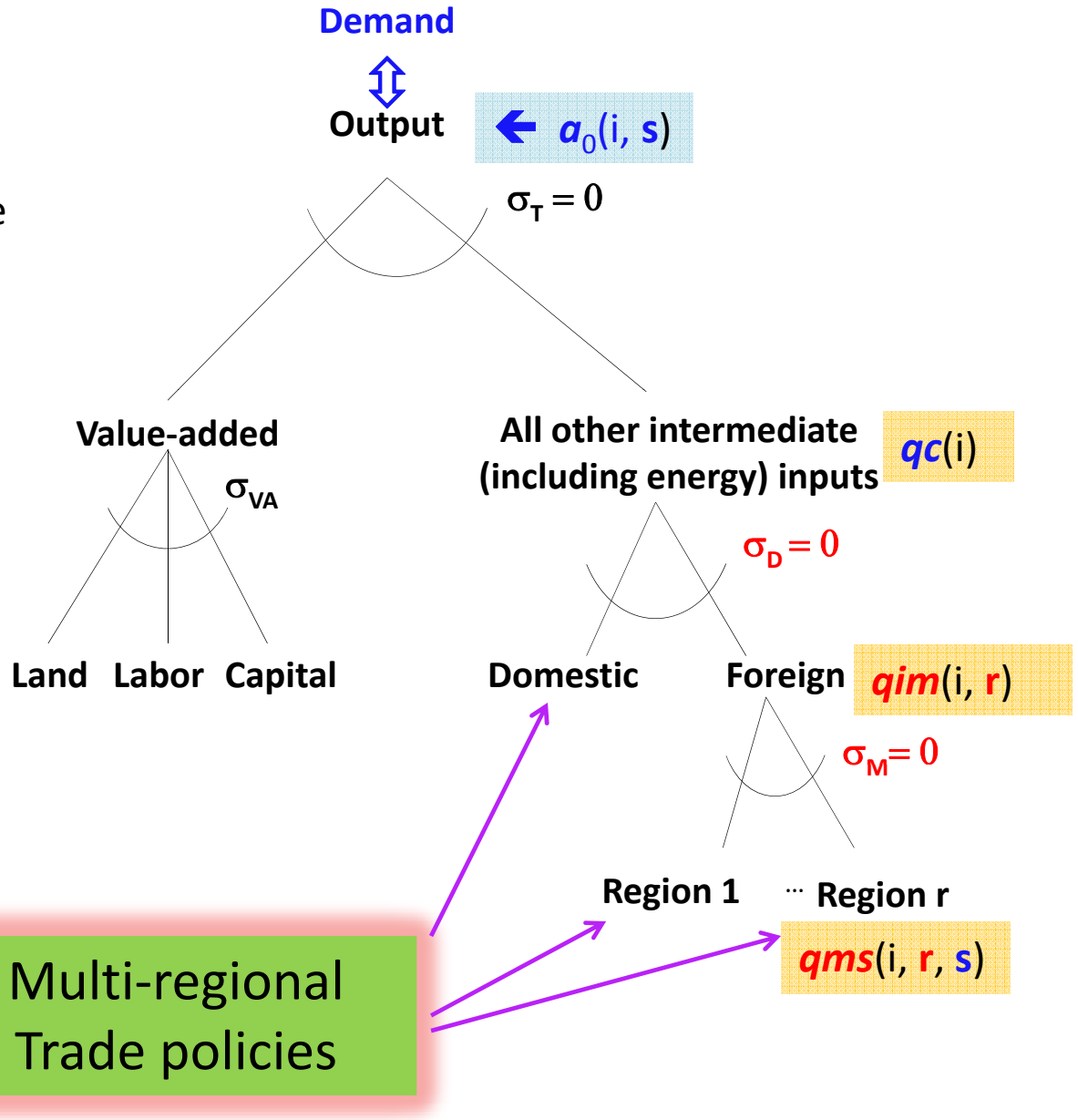


Table 3. Welfare Effects of Global Warming Under Alternative Trade Policy Regimes (Equivalent Variation in millions of 1992 $US)

Region	Aggregate Welfare Effect	Contribution of Climatic Impact	Contribution of Allocative Effects	Contribution of TOT Effects
Canada				
E1	2628*	4209*	-1093*	-487*
E2	1990*	3605*	-229*	-1383*
E4	1911*	3518*	-4*	-1609*
USA				
E1	1927	883	1002*	43
E2	-274	255	290*	-819
E4	71	173*	0	-102*
Mexico				
E1	-8341*	-7691*	-36	-520*
E2	-8337*	-8580*	-437*	820*
E4	-7977*	-8518*	-0*	782*
EU				
E1	17225*	24519*	-9523*	2239*
E2	23874*	23377*	673*	-160
E4	22821*	23767*	610*	-1605*
China				
E1	2309	1702	223	393*
E2	2144	1548	371	235
E4	2211	2052	0	83
ASEAN				
E1	6212	-6263*	491*	-417*
E2	-5681*	-6892*	-550*	1809*
E4	-5782*	-7440*	-80*	1795*
Australia				
E1	682	937*	48*	-102*
E2	536*	717	58	-239*
E4	682*	840*	54*	-212*
ROW				
E1	-9004	-6629*	-1230	-1143*
E2	-7526*	-6451	-779*	-294
E4	-7081	-7792*	-116*	836
World				
E1	1214	11467	-10118	0
E2	6727	7580	-603	0
E4	6855	6601	464	0

Table 5. Welfare Contribution of Allocative Efficiency under Alternative Trade Regimes (Equivalent Variation in millions of 1992 $US)

	Rice	Wheat	Other Grains	Other Crops	All sectors
Canada					
E1	0*	-521*	-235*	-242*	-1093*
E2	0	3	-7*	-20*	-229
E4	0*	0	1*	2*	-4
USA					
E1	-70*	920*	445*	-563*	1002*
E2	0	25*	47	-13*	290
E4	0	0	0	0	0
Mexico					
E1	3*	29*	180*	43*	-36*
E2	0*	0	19*	4*	437
E4	0	0	0	0	-0
EU					
E1	-58*	29	-1387*	-7822*	-9523*
E2	-1*	33*	7*	905*	673
E4	-1*	-0	-7*	31*	611
China					
E1	1	1	22*	23*	223
E2	2*	-0	21*	-3	371
E4	0	0	0	0	0
ASEAN					
E1	9*	-5*	39*	429*	491*
E2	21*	-2*	2*	-59*	-550
E4	-6*	-0*	-0*	-0*	-80
Australia					
E1	0	-0	-4*	-7*	48*
E2	-0*	-1*	-0*	-1*	58
E4	-0*	-1	-0*	0*	54
ROW					
E1	-13	-126	3008*	2414*	-1230
E2	-21*	-19*	-155*	114*	-779
E4	0*	23*	-1*	-3*	-115
World					
E1	-128	326	-3947	-5724	-10118
E2	2	39	-66	926	-603
E4	-7	22	-8	30	464

Key: E1 = Base case, distortions present, but with full price transmission

E2 = Distortions present, but no price transmission

E4 = Fully liberalized trade, with no distortions and full price transmission.

Conclusions

- Results …"highlight the need for negotiating substantial cuts in agricultural tariffs and subsidies under future WTO rounds. As it stands, the Uruguay Round…has contributed to increased price transmission (through tariffication), while leaving protection levels largely unchanged….this [is] a dangerous combination…"
- "Owing to the positive correlation between agricultural protection and the beneficial climate change effects (both tend to favor crop production in the temperate zones), world welfare is actually diminished by increased price transmission in world trade."
- Reasons: "global reallocation of farm output owing to climate change tends to encourage more supplies from the highly subsidized European agricultural sector. Removing distortions … permits the world trading system to realize its full potential as a vehicle for facilitating adaptation to climate change."

Applications using GTAP-E

European Union studies

Japan, South Africa

Asia-Pacific countries?

European Union studies

Table 3 Percentage deviation of emissions from projected level for period 2005-2007 according to the NAP(*)

\Sector Region	Elec tricity	Oil_ Pcts	Metals	Min_ Prod	Paper	Motor_ Equip	Constr	Textile	Oth_ Ind	ROE
aut	-8.9	-7.9	-3.5	-4.3	-3.6	-4.9	-4.6	-5.9		
bel	-27.4	-5.3	-5.3	-5.3	-5.3	-5.3	-5.3	-5.3	-5.3	
dnk	-26.2	-7.1	-7.1	-7.1	-7.1	-7.1	-7.1	-7.1	-7.1	
fin	-12.5									
fra	-0.4	-2.8	-10.3	-8.1						
deu	-3.1	-2.6	-0.5	-0.4	-1	-2.2	-2.2	-2.2	-2.2	
grc	-6.5	-16.8			-6.6					
gbr	-8.7	-0.9	-18.4	-5.7	-3.3	-3.3	-2.9	-2.5		
ita	-5.5		-4.2	-1.7	-3.4					
nld	-7.8	-7.8	-7.8	-7.8	-7.8	-7.8	-7.8	-7.8	-7.8	
prt	-6.2			-1.2						
esp	-6.5	-3.6	-2.9	-5.4	-4.5					
swe	-13.9	-13.9	-13.9	-13.9	-13.9	-13.9	-13.9	-13.9	-13.9	
cze	-4.5	-4.3	-4.6	-4.5	-4.1					
hun	-3.1	-5.1	-5.1	-5.1	-5.1					
pol	-9.3	-3.8	-10.3	-2	-7.5					

(*) (Allocated emissions – Projected Emissions)/(Projected Emissions) * 100

Table 5 Marginal Abatement Cost ($/t CO_2) in Experiment 1 (No Emissions Trade)

\Sector Region	Elec tricity	Oil_ Pcts	Metals	Min_ Prod	Paper	Motor_ Equip	Constr	Textile	Oth_ Ind	ROE
aut	3.8	42.2	1.6	3.0	1.0	2.0	3.2	2.0		
bel	11.5	32.3	1.6	4.4	3.2	5.7	6.4	3.5	7.7	
dnk	7.5	50.5	0.2	1.1	0.1	0.0	9.4	0.0	0.1	
fin	8.0									
fra	0.5	17.3	4.1	11.6						
deu	1.6	22.5	0.7	0.5	0.7	1.5	2.4	1.4	1.8	
grc	2.8	137.0			0.7					
gbr	2.2	13.3	0.4	0.3	0.0	0.0	0.2	0.0		
ita	2.8		2.1	2.6	1.7					
nld	3.8	30.7	1.8	8.7	1.1	0.2	0.0	0.4	13.9	
prt	2.0			1.6						
esp	2.3	19.2	1.3	6.8	3.4					
swe	5.1	163.1	10.7	16.2	15.0	13.4	26.9	18.7	8.8	
cze	1.1	53.8	1.3	2.5	1.4					
hun	1.0	28.6	1.9	3.9	1.9					
pol	2.3	45.8	2.9	1.3	2.6					

(*) (Allocated emissions – Projected Emissions)/(Projected Emissions) * 100

Table 3 Percentage deviation of emissions from projected level for period 2005-2007 according to the NAP(*)

\Sector Region	Elec tricity	Oil_ Pcts	Metals	Min_ Prod	Paper	Motor_ Equip	Constr	Textile	Oth_ Ind	ROE
aut	-8.9	-7.9	-3.5	-4.3	-3.6	-4.9	-4.6	-5.9		
bel	-27.4	-5.3	-5.3	-5.3	-5.3	-5.3	-5.3	-5.3	-5.3	
dnk	-26.2	-7.1	-7.1	-7.1	-7.1	-7.1	-7.1	-7.1	-7.1	
fin	-12.5									
fra	-0.4	-2.8	-10.3	-8.1						
deu	-3.1	-2.6	-0.5	-0.4	-1	-2.2	-2.2	-2.2	-2.2	
grc	-6.5	-16.8			-6.6					
gbr	-8.7	-0.9	-18.4	-5.7	-3.3	-3.3	-2.9	-2.5		
ita	-5.5		-4.2	-1.7	-3.4					
nld	-7.8	-7.8	-7.8	-7.8	-7.8	-7.8	-7.8	-7.8	-7.8	
prt	-6.2			-1.2						
esp	-6.5	-3.6	-2.9	-5.4	-4.5					
swe	-13.9	-13.9	-13.9	-13.9	-13.9	-13.9	-13.9	-13.9	-13.9	
cze	-4.5	-4.3	-4.6	-4.5	-4.1					
hun	-3.1	-5.1	-5.1	-5.1	-5.1					
pol	-9.3	-3.8	-10.3	-2	-7.5					

(*) (Allocated emissions – Projected Emissions)/(Projected Emissions) * 100

Table 4 Percentage deviation of emissions from projected level for period 2005-2007 in Experiment 1 (No Emissions Trade)

\Sector Region	Elec tricity	Oil_ Pcts	Metals	Min_ Prod	Paper	Motor_ Equip	Constr	Textile	Oth_ Ind	ROE
aut	-8.9	-7.9	-3.5	-4.3	-3.6	-4.9	-4.6	-5.9	0.7	-1.5
bel	-27.4	-5.3	-5.3	-5.3	-5.3	-5.3	-5.3	-5.3	-5.3	-0.9
dnk	-26.2	-7.1	-7.1	-7.1	-7.1	-7.1	-7.1	-7.1	-7.1	-0.2
fin	-12.5	4.1	3.3	1.0	2.1	2.9	0.9	1.7	1.8	0.8
fra	-0.4	-2.8	-10.3	-8.1	0.3	0.2	-1.0	-0.2	0.2	-0.9
deu	-3.1	-2.6	-0.5	-0.4	-1.0	-2.2	-2.2	-2.2	-2.2	-1.3
grc	-6.5	-16.8	-4.9	-2.9	-6.6	-4.5	-4.8	-6.6	-7.0	-5.9
gbr	-8.7	-0.9	-18.4	-5.7	-3.3	-3.3	-2.9	-2.5	0.0	0.1
ita	-5.5	0.4	-4.2	-1.7	-3.4	1.0	0.9	1.0	1.1	0.5
nld	-7.8	-7.8	-7.8	-7.8	-7.8	-7.8	-7.8	-7.8	-7.8	0.0
prt	-6.2	0.8	0.6	-1.2	0.2	0.4	0.1	0.1	0.3	0.1
esp	-6.5	-3.6	-2.9	-5.4	-4.5	-0.4	-1.4	0.2	-1.7	-1.1
swe	-13.9	-13.9	-13.9	-13.9	-13.9	-13.9	-13.9	-13.9	-13.9	-2.4
cze	-4.5	-4.3	-4.6	-4.5	-4.1	1.2	-0.8	2.3	1.8	-0.8
hun	-3.1	-5.1	-5.1	-5.1	-5.1	0.2	-0.4	0.7	0.6	-0.7
pol	-9.3	-3.8	-10.3	-2.0	-7.5	6.4	2.1	7.0	3.9	1.1

(*) (Allocated emissions – Projected Emissions)/(Projected Emissions) * 100

Table 10 Percentage change in emissions for period 2005-2007 in Experiment 3 (EU Regional Emissions Trade)

\Sector Region	Elec tricity	Oil_ Pcts	Metals	Min_ Prod	Paper	Motor_ Equip	Constr	Textile	Oth_ Ind	ROE
aut	-4.0	-0.6	-3.9	-1.7	-5.0	-3.2	-1.9	-3.7	0.8	0.3
bel	-5.9	-0.3	-6.6	-2.1	-3.5	-1.8	-1.7	-3.3	-1.3	0.1
dnk	-7.0	-0.3	-41.9	-10.0	-74.6	-53.4	-1.4	-72.5	-65.4	0.6
fin	-2.8	0.2	1.8	0.6	1.0	0.8	0.3	0.7	0.6	0.2
fra	-7.0	-0.5	-4.9	-1.4	0.5	0.4	0.0	0.2	0.6	0.0
deu	-4.4	-0.3	-3.9	-2.5	-3.3	-2.0	-1.3	-2.5	-0.9	0.1
grc	-4.4	-0.4	1.3	1.3	-0.9	1.3	0.0	0.4	0.3	0.1
gbr	-8.2	-0.2	-36.9	-30.4	-73.6	-70.8	-10.6	-72.9	0.5	0.5
ita	-4.0	-0.3	-4.2	-1.5	-4.6	0.7	0.6	0.7	0.8	0.3
nld	-4.2	-0.5	-9.2	-1.6	-14.9	-53.9	-30.9	-34.1	-1.1	0.2
prt	-6.3	-0.3	0.6	-1.9	0.2	0.4	0.1	0.1	0.4	0.1
esp	-5.7	-0.5	-4.2	-1.4	-2.4	0.3	0.3	0.4	0.1	0.0
swe	-5.4	-0.2	-2.1	-1.4	-1.5	-1.9	-1.0	-1.4	-2.4	0.1
cze	-10.6	-0.3	-7.4	-2.7	-4.9	3.0	0.6	3.7	2.4	1.0
hun	-6.6	-1.0	-5.2	-2.4	-4.9	1.3	0.8	1.3	0.5	0.6
pol	-8.7	-0.1	-6.6	-4.0	-5.1	5.8	2.5	6.2	3.8	2.0

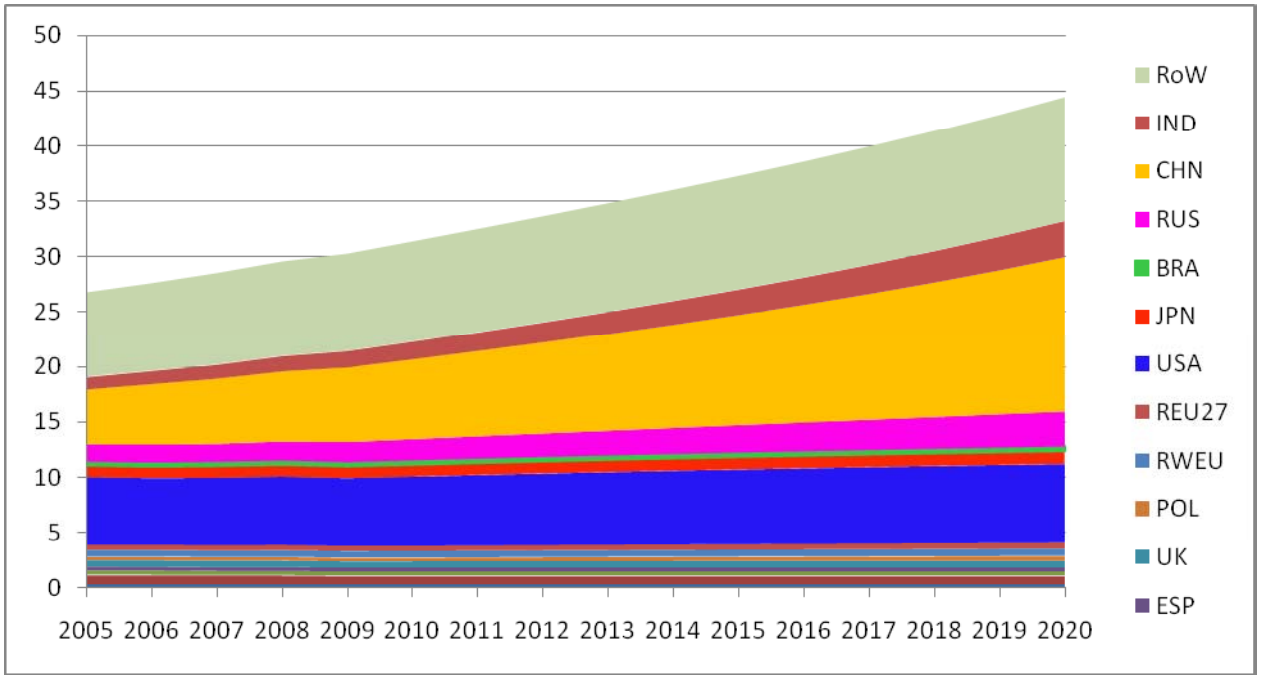
(*) (Allocated emissions – Projected Emissions)/(Projected Emissions) * 100

Table 11 Marginal Abatement Cost ($/t CO_2) in Experiment 3 (EU Regional Emissions Trade)

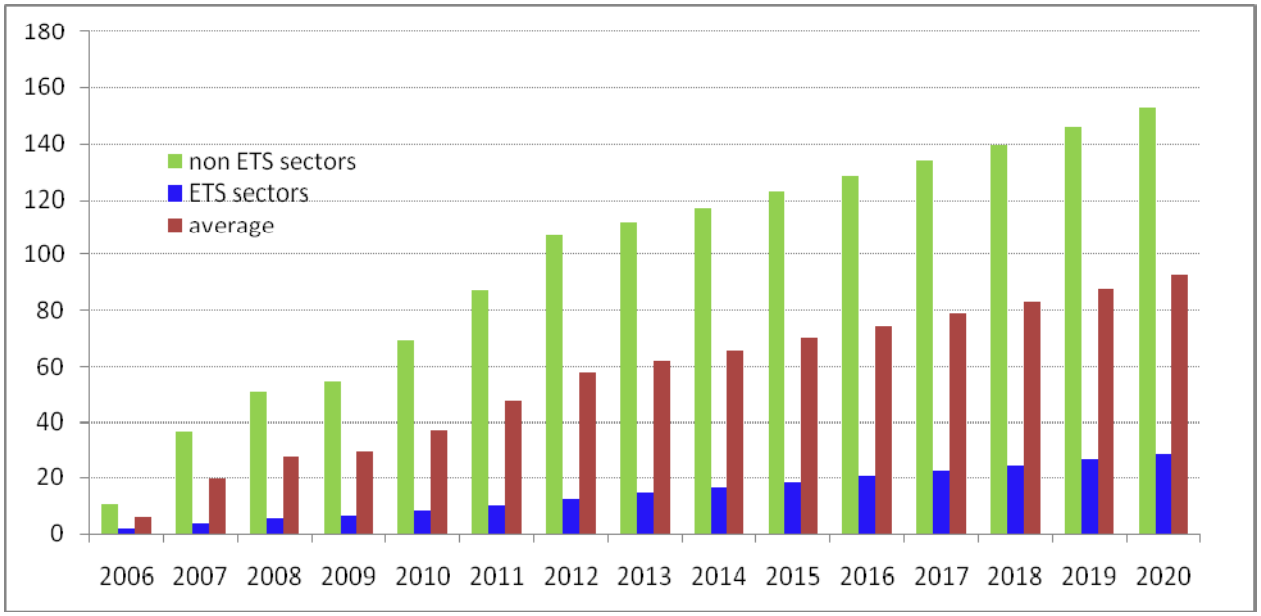
\Sector Region	Elec tricity	Oil_ Pcts	Metals	Min_ Prod	Paper	Motor_ Equip	Constr	Textile	Oth_ Ind	ROE
aut	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
bel	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
dnk	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
fin	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
fra	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
deu	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
grc	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
gbr	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
ita	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
nld	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
prt	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
esp	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
swe	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
cze	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
hun	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
pol	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0

(*) (Allocated emissions – Projected Emissions)/(Projected Emissions) * 100

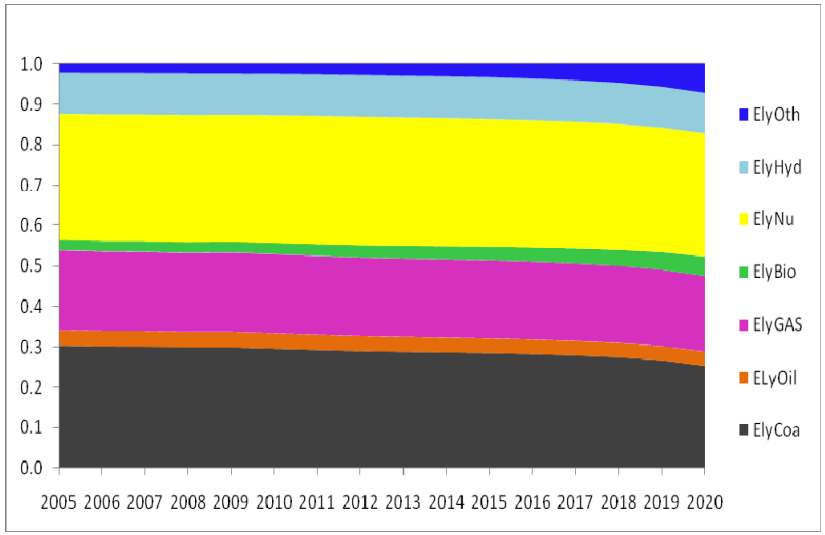
Figure 8: CO_2 emissions for the Reference Scenario ($GtCO_2$/yr)



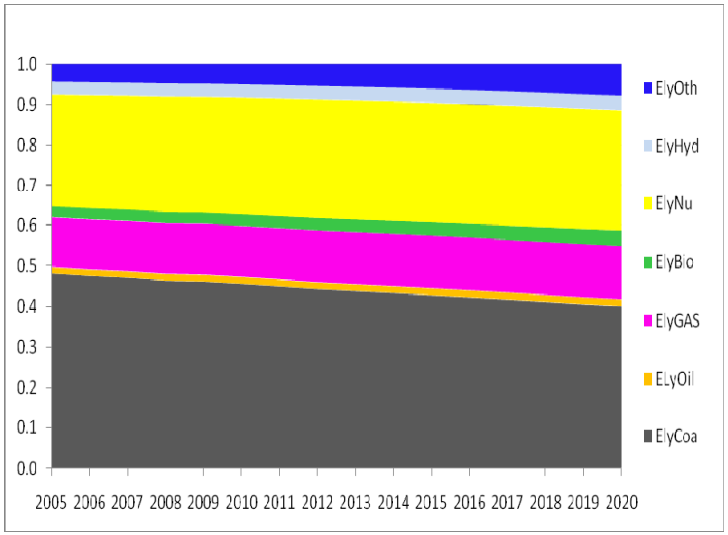
CO_2 emissions permit price (or marginal abatement cost) for the EU-ETS ($2004US/tCO_2$)



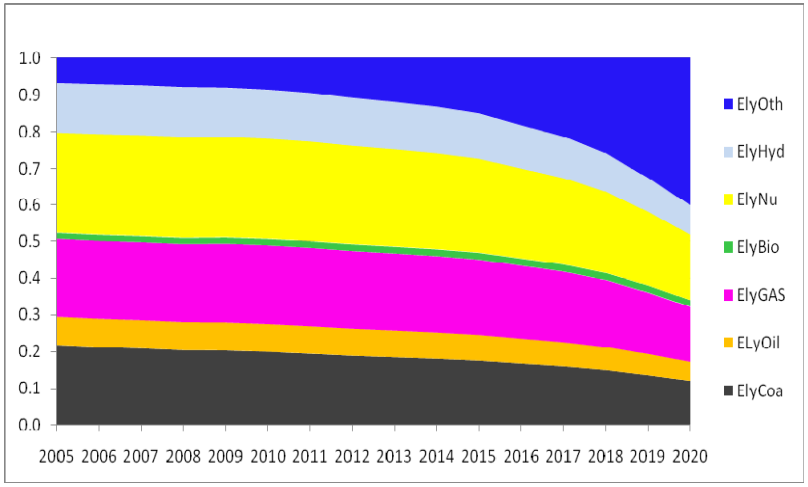
‘Optimal’ shares of electricity generation by various technologies estimated for the EU-RES Scenario



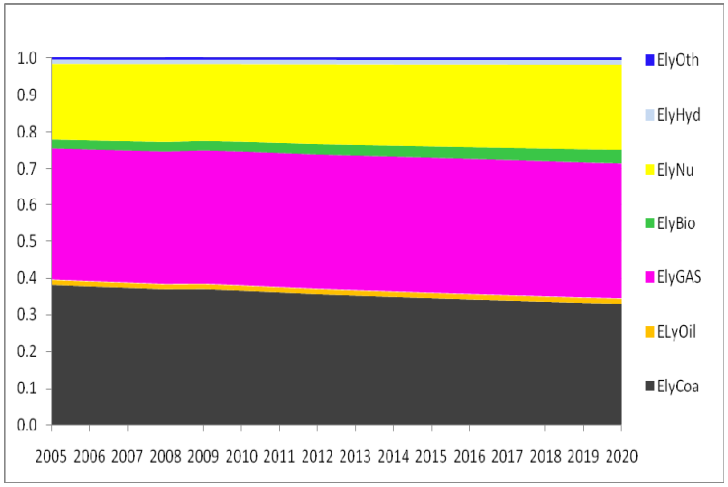
EU27 as a whole



Germany



Spain



UK

Japan

Table 1 Marginal Costs of Achieving the Kyoto Targets with International Emission Trading, With and Without the USA.

	Kyoto with Emission Trading (trading includes the USA)		Kyoto with Emission Trading (trading does not include the USA but the USA unilaterally commits)		Kyoto with Emission Trading (trading does not include the USA and the USA does not commit)	
	% Reduction of Emissions	(1997 USD per Ton of Carbon)	% Reduction of Emissions	(1997 USD per Ton of Carbon)	% Reduction of Emissions	(1997 USD per Ton of Carbon)
USA	-26.6	77.9	-35.6	123.9	0.5	0
EU	-13.9	77.9	-9.0	49.3	-9.7	43.8
EEFSU	-26.6	76.4	-19.4	48.9	-18.4	43.3
JPN	-15.2	78.0	-10.0	49.3	-10.5	43.8
RoA1	-20.9	78.3	-14.2	49.5	-14.5	43.9
Eex	2.0	0	2.1	0	0.5	0
CHIND	-0.5	0	-0.3	0	-0.6	0
RoW	3.7	0	3.4	0	1.4	0
Annex 1 (with USA)	-22.1		-22.1		-7.8	
Annex 1 (without USA)	-19.2		-13.3		-13.3	
Non-Annex 1	1.3		1.4		0.2	
Leakage rate (%)	3.7		3.9		4.4	
Leakage rate (%) (excl. USA)	na		na		2.0	

Table 4 Marginal Costs of Achieving the Kyoto Targets for Annex 1 countries with International Emission Trading and with Supplementary Provisions

	Kyoto with Emission Trading (trading includes the USA)					
	Up to 50 per cent of Kyoto targets are allowed for trading		Up to 20 per cent of the Kyoto targets are allowed for trading		Up to 10 per cent of the Kyoto targets are allowed for trading	
	% Reduction of Emissions	(1997 USD per Ton of Carbon)	% Reduction of Emissions	(1997 USD per Ton of Carbon)	% Reduction of Emissions	(1997 USD per Ton of Carbon)
USA	-26.6	78.0	-28.5	87.2	-32.0	105.0
EU	-13.9	78.4	-20.2	124.4	-20.2	124.4
EEFSU	-26.3	74.3	-6.1	16.5	0.8	4.1
JPN	-15.9	82.5	-28.6	190.4	-28.6	191.1
RoA1	-20.9	78.5	-32.1	147.2	-32.1	147.4
Eex	2.0	0	2.1	0	2.3	0
CHIND	-0.5	0	-0.9	0	-0.8	0
RoW	3.7	0	3.9	0	3.9	0
Annex 1 (with USA)	-22.1		-22.1		-22.1	
Non-Annex 1	1.3		1.2		1.3	
Leakage rate (%)	3.7		3.5		3.7	

Note that the marginal costs are expressed in real terms (i.e. deflated by the GDP deflator of each country/region). Therefore, slightly different marginal costs in case of emission trading are consistent with a common trading price of nominal terms

Table 2 Macroeconomic effects of Achieving the Kyoto Targets with International Emission Trading, With and Without the USA (welfare change and terms of trade)

	Kyoto with Emission Trading (trading includes the USA)		Kyoto with Emission Trading (trading does not include the USA but the USA unilaterally commits)		Kyoto with Emission Trading (trading does not include the USA and the USA does not commit)	
	EV (*)	Terms of trade	EV (*)	Terms of trade	EV (*)	Terms of trade
USA	-18.8	0.54	-17.5	0.96	0.3	0.03
EU	-19.0	0.20	-7.3	0.18	-16.5	0.07
EEFSU	20.8	0.92	10.5	0.26	9.9	0.57
JPN	-9.7	0.66	-5.0	0.63	-7.3	0.23
RoA1	-11.4	-0.56	-9.3	-0.71	-6.3	-0.14
Eex	-15.3	-2.19	-16.2	-2.34	-4.4	-0.62
CHIND	0.6	-0.01	0.8	0.06	0.0	-0.06
RoW	3.3	0.22	3.6	0.25	0.7	0.04

(*) Equivalent Variation (EV), in $US billion.

Table 3 Macroeconomic effects of Achieving the Kyoto Targets with International Emission Trading, With and Without the USA (regional income, GDP quantity and price level changes)

	Kyoto with Emission Trading (trading includes the USA)			Kyoto with Emission Trading (trading does not include the USA but the USA unilaterally commits)			Kyoto with Emission Trading (trading does not include the USA and the USA does not commit)		
	y (a)	qgdp (b)	pgdp (c)	y (a)	qgdp (b)	pgdp (c)	y (a)	qgdp (b)	pgdp (c)
USA	0.76	-0.17	1.06	1.17	-0.33	1.47	0.21	0.00	0.21
EU	0.77	-0.22	1.07	0.70	-0.07	0.84	0.23	-0.17	0.46
EEFSU	5.89	-0.59	3.10	3.18	-0.29	1.69	2.81	-0.24	1.50
JPN	0.66	-0.19	0.97	0.67	-0.09	0.85	0.17	-0.12	0.38
RoA1	-0.10	-0.39	0.55	-0.09	-0.21	0.37	-0.14	-0.22	0.27
Eex	-0.84	-0.02	-0.71	-0.95	-0.01	-0.83	-0.19	-0.01	-0.15
CHIND	0.66	0.05	0.60	0.63	0.06	0.57	0.23	0.01	0.22
RoW	0.80	0.04	0.74	0.75	0.04	0.70	0.28	0.01	0.26

(a) percentage change in regional household income; (b) percentage change in GDP quantity index; (c) percentage change in GDP price index.

Table 5 Macroeconomic Impacts of Implementing the Kyoto Protocol for Annex 1 countries with International Emission Trading and with Supplementary Provisions (welfare change and terms of trade)

	Up to 50 per cent trading allowed		Up to 20 per cent trading allowed		Up to 10 per cent trading allowed	
	EV (*)	Terms of trade	EV (*)	Terms of trade	EV (*)	Terms of trade
USA	-12.6	0.62	-10.6	0.73	-13.2	0.85
EU	-14.9	0.22	-28.6	0.29	-27.7	0.29
EEFSU	6.3	0.29	-2.2	-0.64	-2.7	-0.76
JPN	-7.0	0.75	-18.7	1.16	-18.3	1.19
RoA1	-9.7	-0.54	-14.6	-0.54	-14.6	-0.59
Eex	-15.5	-2.21	-18.0	-2.56	-18.8	-2.69
CHIND	0.6	0.00	0.7	0.00	0.8	0.02
RoW	3.3	0.22	3.9	0.25	3.8	0.25

(*) Equivalent Variation (EV), in $US billion.

Table 6 Macroeconomic Impacts of Implementing the Kyoto Protocol for Annex 1 countries with International Emission Trading and with Supplementary Provisions (regional income, GDP quantity and price level changes)

	Up to 50 per cent trading allowed			Up to 20 per cent trading allowed			Up to 10 per cent trading allowed		
	y (a)	qgdp (b)	pgdp (c)	y (a)	qgdp (b)	pgdp (c)	y (a)	qgdp (b)	pgdp (c)
USA	0.92	-0.17	1.14	1.17	-0.20	1.36	1.27	-0.26	1.51
EU	0.80	-0.22	1.05	0.90	-0.44	1.34	0.93	-0.43	1.36
EEFSU	3.08	-0.72	2.06	0.28	-0.10	0.33	0.03	-0.07	0.14
JPN	0.80	-0.19	1.04	1.04	-0.55	1.61	1.07	-0.55	1.64
RoA1	0.07	-0.38	0.60	0.07	-0.79	0.94	0.08	-0.79	0.93
Eex	-0.86	-0.02	-0.73	-0.99	-0.03	-0.85	-1.06	-0.03	-0.91
CHIND	0.65	0.05	0.60	0.76	0.06	0.70	0.78	0.06	0.72
RoW	0.79	0.04	0.73	0.95	0.05	0.89	0.93	0.05	0.87

(a) percentage change in regional household income; (b) percentage change in GDP quantity index; (c) percentage change in GDP price index

South Africa

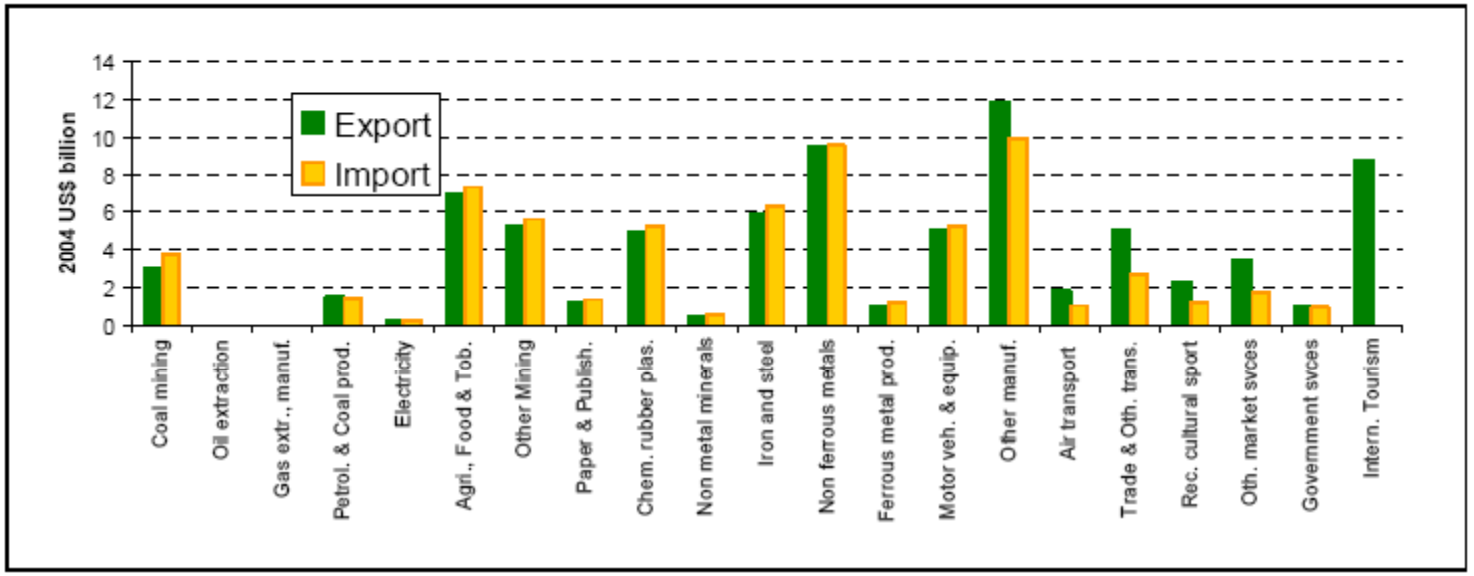


Figure 3.2: South African exports and imports by sectors including international tourism (2004)

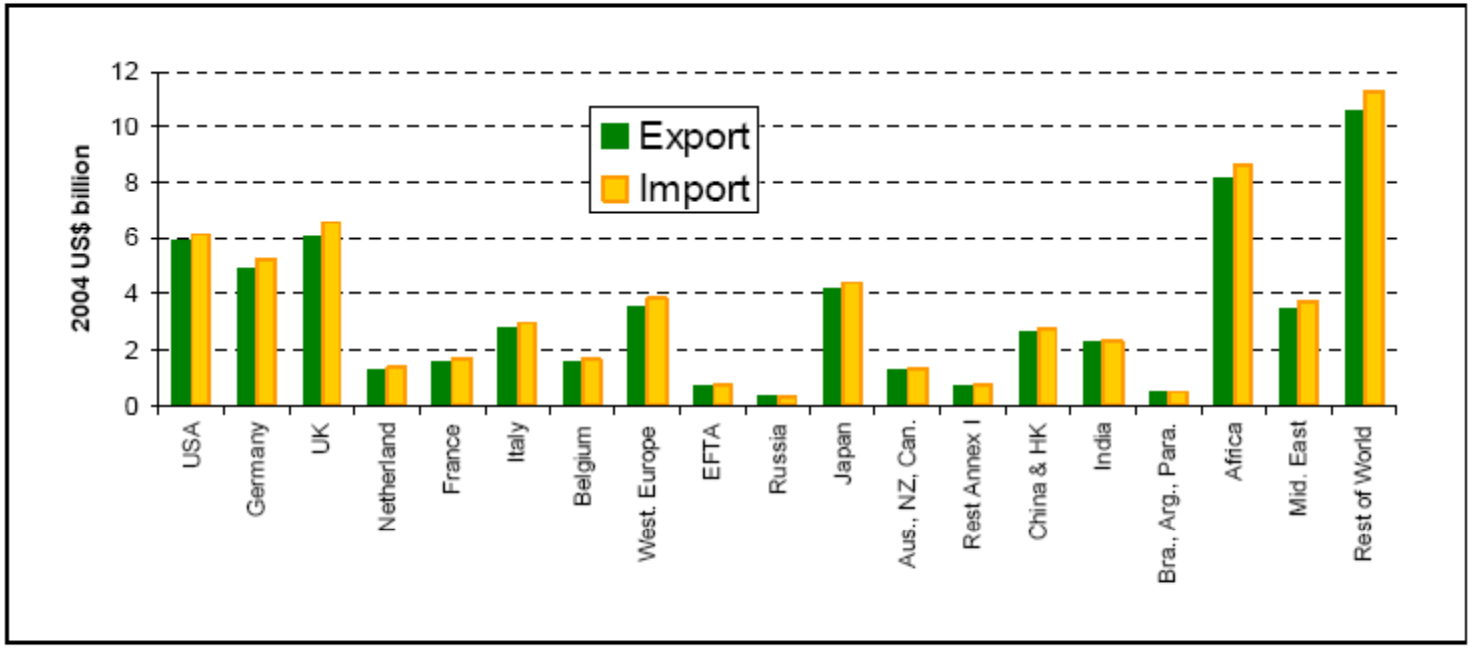


Figure 3.3: South African exports and imports – by regions (GTAP v7 database, 2004)

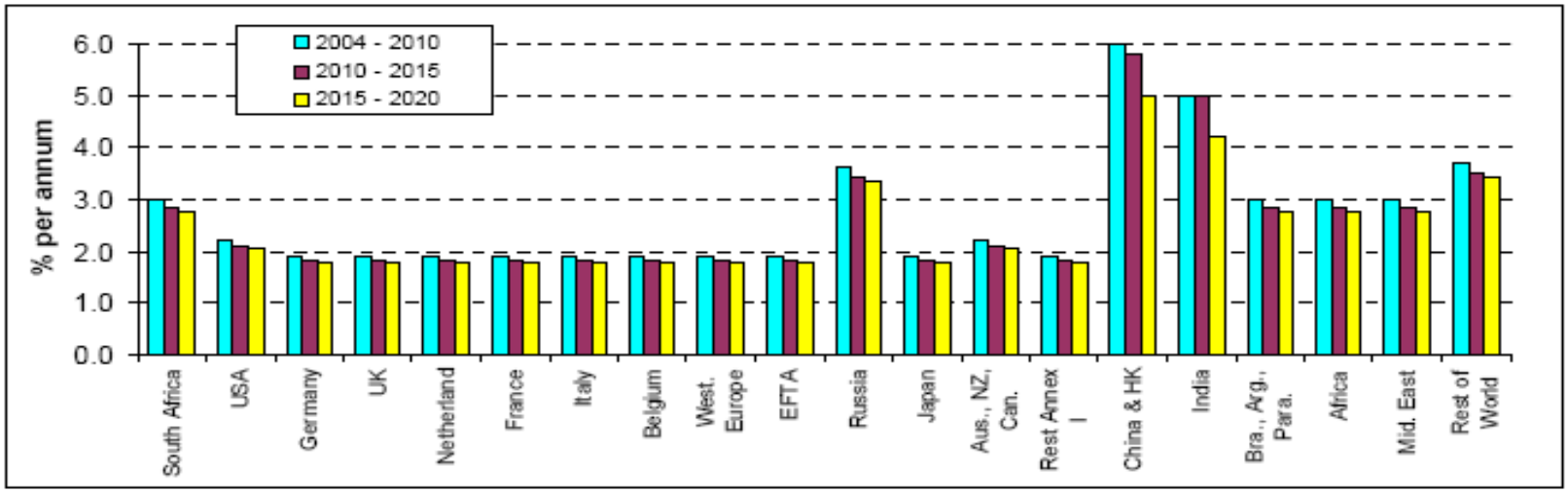


Figure 3.4: Assumed per annum GDP growth rates over the study periods

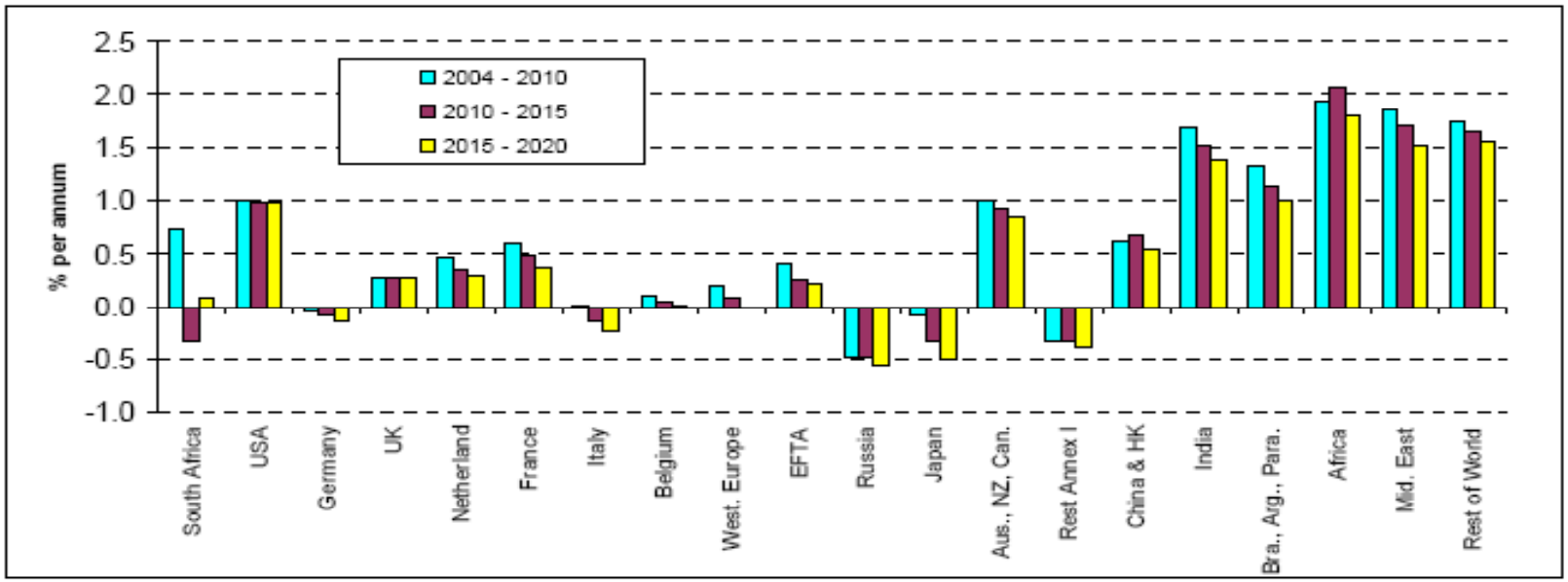


Figure 3.5: Assumed per annum population growth rates over the study periods

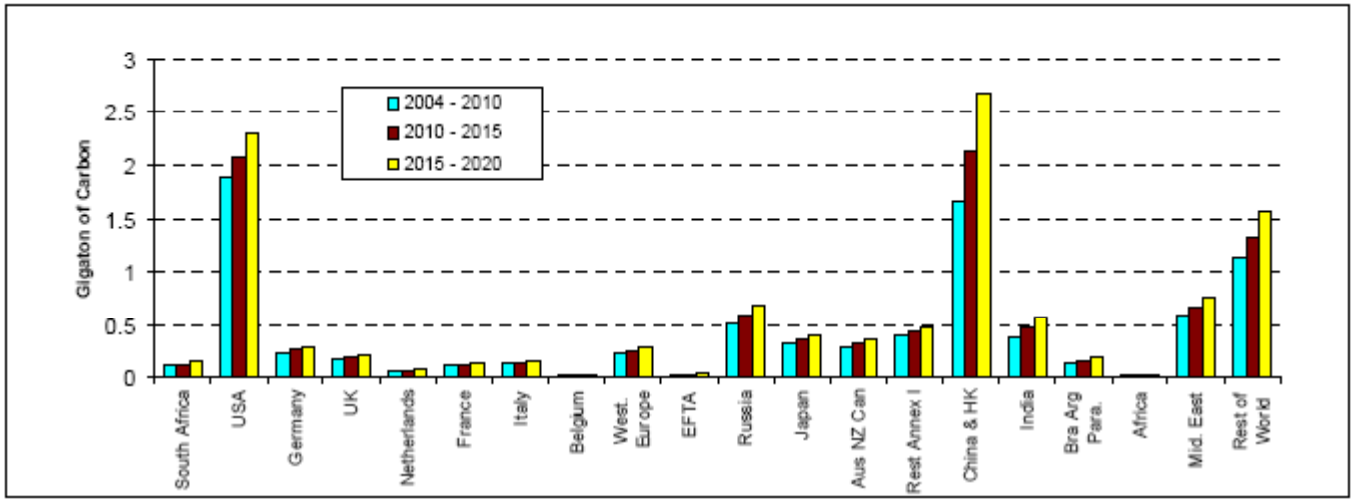


Figure 3.6: Average per annum rates of CO_2 Emission rate in the Business-as-usual (BaU) scenario – by Regions

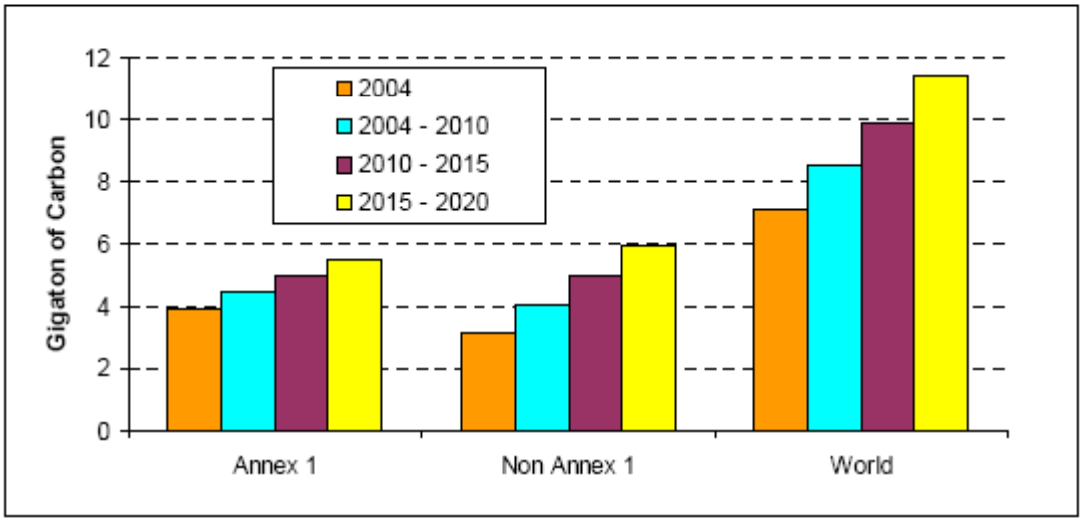
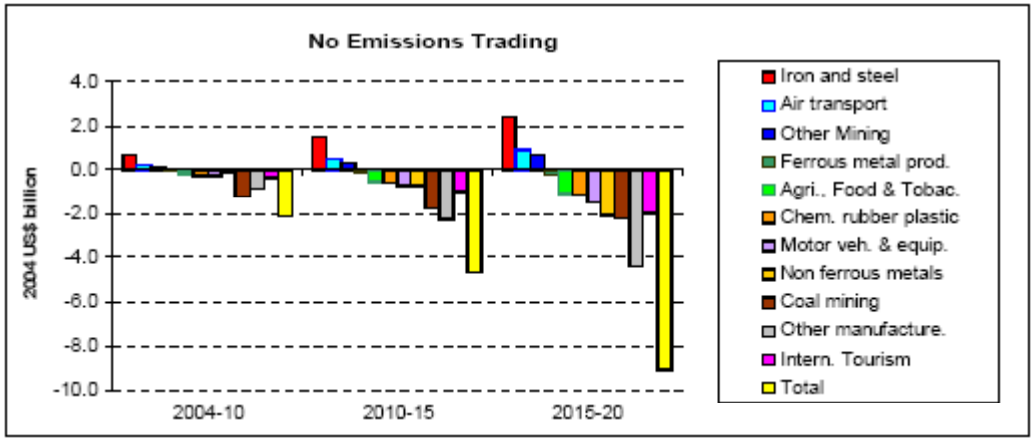
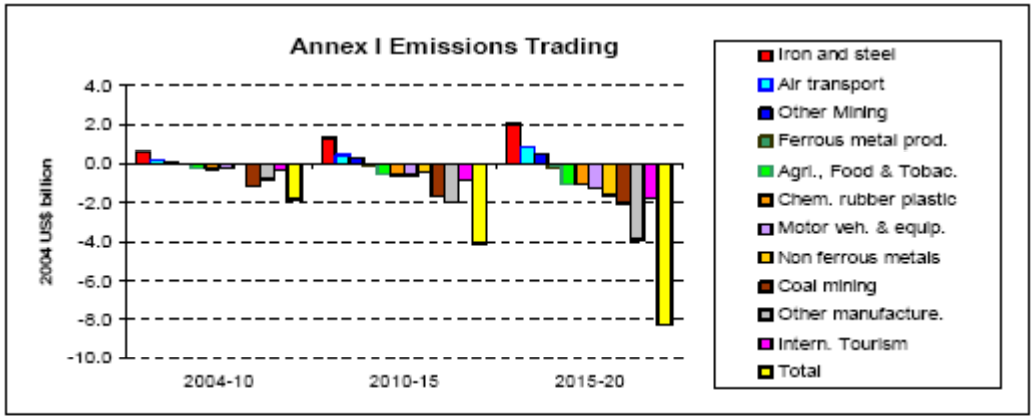


Figure 3.7: Average per annum rates of CO_2 emission in the BaU scenario – by Annex I and NAI groupings





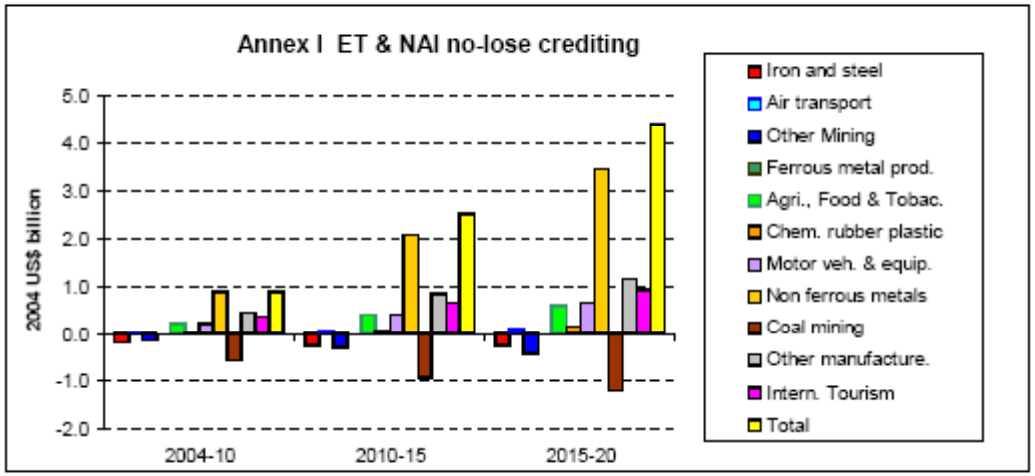
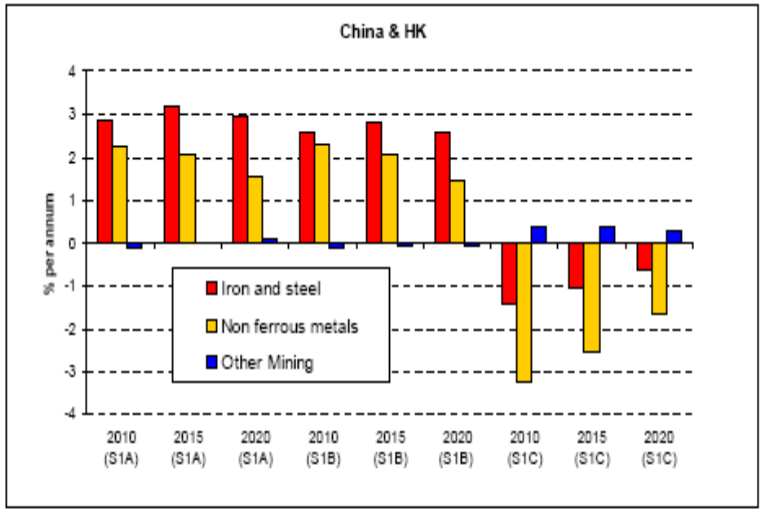
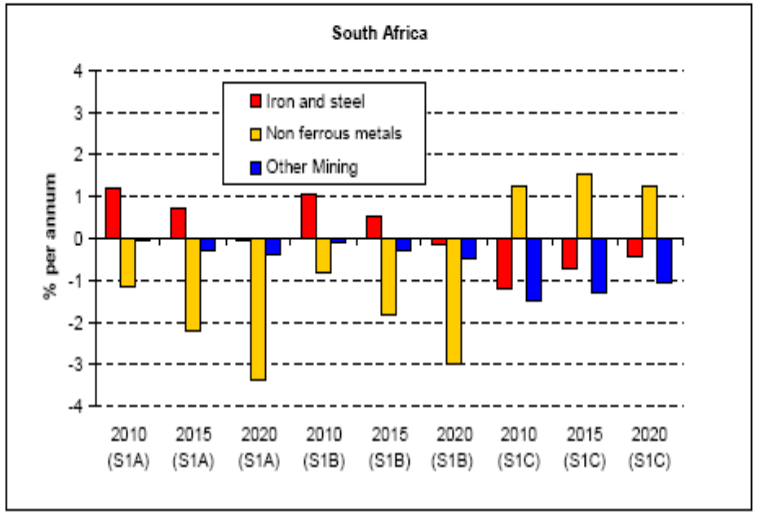


Figure 3.10: Scenario 1 – Specific export losses or gains in South African export sectors – Scenario 1 relative to BaU (total for each period in 2004 $ billion)





(S1): Scenario 1; (A) No ET; (B): Annex I ET; (C): Annex I ET with NAI no-lose crediting.

Figure 3.11: Change in export for energy intensive sectors – relative to BaU (average % per annum)