Economic Impacts of Multilateral Emission Reduction Policies

Simulations with WorldScan

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Abstract

Using an applied general equilibrium model, we explore the impacts of uniform reduction targets, a uniform carbon tax, and permit trading in the Annex 1 countries for the period 2000-2020. Next, we assess the impacts of enlarging the A-1 coalition to the globe, and allow for global permit trading. The impacts suggest among others that more research is necessary on how to change the size of the coalition.

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1. Introduction

We explore the economic impacts of Annex 1 (A-1) emission reductions down to 20% below the 1992 level by 2020, followed by non Annex 1 (NA-1) countries joining the abatement group and establishing a global agreement. For the global agreement, the global target is based on the Intergovernmental Panel on Climate Change (IPCC) Working Group I emission pathways to reach stabilisation of CO_2 concentration in 2100 at 450, 550, and 650 parts per million volume respectively (WGI450, WGI550, WGI650). We therefore do not deal with optimal emission reduction, neither for the globe, nor for separate regions, but instead take a *cost-effectiveness* approach given an emission reduction target. The paper illustrates some Basic issues that will emerge with A-1 emission reduction policies and impacts of changing from an A-1 to a global "coalition".

We first analyse the possibility of trading national permits internationally in order to reduce total costs in the A-1 coalition. Tradability leads to an efficient distribution of emissions, while the distribution of permits allows for different ways to compensate heavily abating countries in the coalition[1]. We consider a distribution of permits based on uniform reduction percentages compared to 1992. In that case, coalition partners with low abatement costs obtain net welfare gains from A-1 policies because, while permits are traded at the marginal price of a unit of emissions, the average costs of emission reduction are lower. This produces a surplus, which can be divided over the trading countries. With uniform reduction percentages, this leads to welfare effects which more than compensate the low cost countries, while the efficiency gains of A-1 also reduce the welfare losses for high cost countries. A-1 consists of very divergent countries, and their mere differences drive the success of a trading agreement, because these imply that there will be efficiency gains from trading.

Because we do not assess the climate benefits of joining a coalition, the incentive for countries to join an existing coalition will be the potential welfare gains as just mentioned. Then, upon expansion of the A-1 coalition to a global coalition, problems will emerge. The very reason fro eastern Europe and the former Soviet Union (EEFSU) to be in the A-1 coalition - the welfare gains from trading - will be reversed into an incentive to leave the coalition. When low cost abaters join the A-1 coalition, these countries can become major exporters of permits, and EEFSU will not be able to extract the (full) gains anymore. Such developments suggest that

1 The Tradability concept need not be implemented at all levels. One could think of an agreement in which Tradability can be approximated by different sets of policies. The main example is joint implementation, either at a project or a national level. In macro-economic modelling terms these policies are all equivalent in that they all imply a uniform price tag on CO_2 emissions combined with international financial transfers.

there might be an instability problem with coalition enlargement.

Another problem with enlargement of the coalition is transitory. Given the global target, there will always be a jump in the relative prices of A-1 goods versus NA-1 goods upon enlargement. When a group reaches a target every year, by using international permit trading among themselves, they will see a positive emissions price. When the group is set to reach a global target - which is relevant from the climate point of view - the expansion of the group at the emissions price will imply a glut of permits, which will pull down the price. For the incumbent members, this would lead to a sub-optimal, temporary sectoral shift of new investment into energy-intensive sectors and less into energy-saving technologies. At the same time, for the new members it may still be a rather large jump in the energy user price. A period of transition would be necessary[2].

The remainder of the paper is set up as follows. Section 2 contains a discussion on the model used and the baseline scenario assumed. Section 3 presents briefly the cases considered and highlights the results from simulations. Section 4 concludes.

2. Model and business-as-usual scenario (BAU)

We use *WorldScan* - a multi-sector, multi-region, recursively dynamic applied general equilibrium model for the world economy. In order to have a consistent long run outcome, while being interested mainly with the developments in 25 to 30 years, the model was set up with three analytical phases in mind. The *very long run* outcomes - beyond the 30 years' period - are captured by a Neoclassical trade and growth model, with trade being largely determined by relative factor endowments, and growth being driven by changes in the size and the skill composition of the labour force and increases in total factor productivity. On the *medium to long run*, differences in production technology are important determinants of trade patterns, and total factor productivity levels as well as consumption patterns of less-advanced countries converge to those in advanced countries. In the *short to medium run,* sectoral reallocation of capital and labour is limited, so that shocks to the economy can lead to high costs of adjustment. The box below shows WorldScan's dimensions.

[2] For example, we could imagine a situation in which the incumbent members fix the tax, and let emissions grow at the resulting rate, while the new member has to reduce emissions until the global target is reached. This will lead to a phased-in tax for the new member that is below the fixed tax for incumbent members. This tax will have to increase in time, and when it reaches the level of the fixed tax, the member fully joins the trading system.

Box 1   WorldScan

Regions		*Sectors*		*Production factors*	
W	European Union	L	Agriculture and Food	L	Low-skilled Labour
J	Japan	A	Coal	H	High-skilled Labour
U	United States	N	Natural gas and Oil	K	Capital
R	Remaining OECD	R	Other raw materials	F	Fixed Factor
L	Latin America	C	Consumption Goods		
C	China Economic Area	K	Capital Goods		
N	Dynamic Asian Economies	I	Intermediate Goods		*Intermediate inputs*
O	Other Asia and Rest of World	W	Utilities	R	Other Raw Materials
S	Sub-Saharan Africa	S	Non-tradeable	A	Coal
M	Middle East / North Africa	D	International transport	N	Natural gas and oil
F	Former Soviet Union			B	Biomass from Agriculture and Food
E	Eastern Europe				
				I	Intermediate Goods

See Geurts et al (1995).

We use the GTAP global database to calibrate the starting position of world regions in WorldScan[3]. We then impose a trends on the exogenous driving forces, based on existing projections on size and composition of the labour force, as well as a projection of savings rates. Technical progress is an exogenous parameter to the model, including autonomous energy efficiency improvements.

In order to get a grip on the BAU scenario, we take a look at the factors driving emissions in the model, according to a version of the Kaya (1989) identity and growth accounting (Barro and Sala-I-Martin, 1995). The so-called ‘Kaya identity’ relates emissions (C) to energy use (E), income (Y), and population (P) according to

$$C = C/E * E/Y * Y/P * P \quad .$$

The level of CO_2 emissions is thus affected by the energy mix (C/E), the energy intensity of production (E/Y), the level of economic development (Y/P) and the size of the population (P), and emission growth is driven by growth in all these factors. The results are presented in tables 1 and 2 for the 1992-2020 period the 2020-2050 period respectively.

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3 The Global Trade Analysis Project (GTAP) provides a globally consistent database for 1992, which is easily accessible for a wide group of users (see Hertel, 1996). Its focus has been mostly trade issues, with less attention for energy. We are currently working on integrating the energy data as provided by the International Energy Agency into the GTAP database and re-calibrate WorldScan. We take a comparable approach as being taken in Babiker and Rutherford (1997).

<<<<insert around here Table 1: Emission growth driving forces - 1995-2020>>>>

<<<<insert around here Table 2: Emission growth driving forces - 2020-2050>>>>

Energy intensity reduction is mainly caused by technical change, as the energy price is relatively stable. Also the relative prices of different energy carriers are stable, so that the CO_2 intensity of energy is increasing only very slightly. Note that after 2020, biomass - a CO_2 free energy carrier - will penetrate markets until it reaches a share of 10% in total energy use by 2050[4].

The high growth of emissions in developing countries is mainly driven by high economic growth. The African continent (Middle East and North Africa, and Sub Saharan Africa) also shows a rapid increase in population. In the transition economies, we see a steady decrease in energy intensity, coupled with lower economic growth, leading to a limited increase in emissions. OECD countries show limited economic growth as compared to the developing countries, but also a more limited energy intensity reduction, so that emissions grow at an intermediate rate.

WorldScan distinguishes several factors driving economic growth in per capita income (Y/P). First there is the size and skill composition of labour supply. The size is driven by the age composition and by a potential inflow from the low-productivity informal activities - mainly in rural areas - in developing countries. Apart from labour, physical capital investment, driven by savings ratios, and technical progress drive income growth per capita. Tables 3 and 4 show the results of a growth accounting exercise for the baseline scenario, for the period 1995-2020 and 2020-2050, respectively. Growth accounting (Barro and Xala-I-Martin, 1995) is a method to ascribe the growth rate of gross domestic product in an economy to its driving forces. Of course, the driving forces are mainly exogenous so that the exercise shows the relative importance of those assumptions.

<<<<insert around here Table 3: Trends and engines of economic growth - 1995-2020>>>>

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4 Biomass is assumed to be produced by the agricultural sector and is therefore not a backstop fuel (there are no other alternatives in this BAU scenario). The share of 10% by 2050 is derived from the TIME model (de Vries et. al., 1995), which is to be included in IMAGE 2.2 (the follow-up version of IMAGE 2.1, see Alcamo et. al. [1994]).

<<<<insert around here Table 4: Trends and engines of economic growth - 2020-2050>>>>

'Gross domestic product' is the real growth rate of GDP in the respective regions. Labour supply high-skilled and low-skilled show the share of the growth rate attributable to growth in both types of labour supply[5]. Extra employment captures the change due to inflow from the low- productive sectors and/or unemployment (former in non-OECD countries and the latter in OECD countries). Capital accumulation, total factor productivity and capital gains account for investment and technical progress. The returns to scale are always negative, showing that a growing economy can rely less and less on natural resources for economic growth.

3. Emissions, targets, and policy analyses

Figure 1 contains the global emissions according to the WorldScan baseline (BAU), the global targets that will be analysed in this paper, and the IS92a scenario (see IPCC, 1996). Annual emissions rise from 10.5 gigatons of carbon (Gt C) by 2020 to 16.4 Gt C by 2050. This is somewhat higher than IS92a, due to higher assumed growth in Asia.

<<<<insert around here Figure 1: Emissions for differents scenarios and the targets as analysed>>>>

We set a target for the Annex 1 (A-1) countries as a group, of 20% below 1992 levels by the year 2020. From 2020-2030, the global target moves linearly from the realised 2020 levels to the respective targets (WGI450, WGI550, WGI650). By 2020, A-1 annual emissions equal 6.5 Gt C per year, which is an increase of more than 45% compared to 1992. In 2050, global emissions are about 17 Gt C, with A-1 emissions being equal to 10 Gt C. NA-1 emissions increase at the highest rate, and go from 2 Gt C in 1992, to 4 Gt C in 2020 and end up at almost 7.5 Gt C in 2050.

An Annex 1 policy for 2000-2020

For the period 2000 to 2020, we assume that only A-1 implements policies. We

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[5] Total *labour supply* has negative entries in some regions because of *ageing.* The division of *high- versus low-skilled labour* supply is based on data of Barro and Lee (1991) and these are used to produce a projection to 2020 on the basis of projections of Ajuha and Filmer (1996), as reported in CPB (1997). For the period 2020-2050 we have made the simple assumption that the skill composition does not change anymore.

consider three different approaches: [1] uniform reduction targets for all A-1 countries without permit trading, [2] a uniform carbon tax in all A-1 countries without permit trading, and [3] uniform reduction targets in all A-1 countries with permit trading among the A-1 counties.

Case 1 concerns equal emission reduction percentages compared to 1992 across countries in the A-1. Although reduction percentages are equal, they will have asymmetric impacts on countries' competitiveness, due to the differences in BAU growth and economic structure. This will turn up in region-specific carbon taxes. Compared to a purely unilateral policy, the rate of carbon leakage is lower, because more countries have to restrict emissions. In the case of a unilateral policy in the EU, carbon leakage will be substantial (see Tang *et al*, 1997). In general, the differential carbon taxes suggest that this approach is not efficient.

A more efficient approach would be *Case 2*, in which the marginal costs of abatement are equalised across countries - by imposing a uniform carbon tax in all A-1 countries. But even in the case of a uniform tax rate across all participating countries, competitiveness - and therefore total adjustment costs - are asymmetrically affected. The uniformity of the tax concerns dollars per ton carbon, so that the effective costs per unit of output differ according to production technology, sectoral structure, and regional endowments. For the case of the formerly planned economies in eastern Europe and the former Soviet Union energy prices have been very low compared to world levels, so that a given carbon tax leads to much higher price changes in those countries than in the OECD countries. Indeed, any simple approach - that is, one based on uniformity of reduction targets or taxes - bear an implicit distribution of adjustment costs[6].

One explicit distribution of adjustment costs is contained in *Case 3*, in which permits can be traded among A-1 countries. Transition economies, which have low abatement costs, will be compensated in a tradable permit system with equal reduction percentages. This even provides compensation to a level that per capita consumption can increase in these countries. This is due to the fact that although marginal costs of abatement are equalised, the total costs certainly are not.

A global agreement post 2020

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[6] A uniform cost approach would be to reach a pre-specified level of adjustment costs on a per capita basis. This has been done using WorldScan, for the Energy Modeling Forum / IPCC meeting in Oslo, August 18-20. These will be reported on in a next paper.

After 2020, the non Annex 1 countries (NA-1) need to be included in a global agreement, since these countries are expected to increase their emissions at high rates in the BAU, and even more due to leakage. We therefore assume that NA-1 countries join the coalition of A-1 countries and start abating emissions after 2020. Emission permits for all countries move from 2020 emissions to per equal per capita emissions (based on 1992 population levels, where convergence occurs by the year 2050, 2060, and 2070 in WGI450, WGI550 and WGI650 respectively. This is already illustrated in Figure 1, which shows a sharp global emission reduction between 2020 and 2030, followed by moderate increases described by WGI550 an WGI650 and low reduction rate by WGI450. Of course, because of permit trading, the realised emissions per capita will not converge. Countries in Asia will for example reduce emissions by more than the required amount and obtain funds from e.g. OECD countries.

Model results

In all the cases up to 2020 NA-1 is not included in the abatement group. This implies carbon leakage from A-1 (implementing a carbon reduction policy) to NA-1. The target of the A-1 region for the three cases are equal to -20% of the 1990 level by 2020. On a regional level, the EEFSU gets by 2020 permits equal to 65% of their BAU emissions in case 1 and case 3, but reduces its emissions by 80% in case 2. By the year 2020, in case 1 and 3, the OECD region gets permits equal to 70% of their BAU level, which is lowered in case 2 due to relative higher energy efficiency (and hence higher abatement cost levels) compared to EEFSU.

<<<<insert around here Table 5: Results 1992-2020 for the Cases 1 , 2 and 3 >>>>

Table 5 speaks for itself. Note that in Case 1 there is a drastic difference in the carbon tax necessary to reach the uniform targets in the EU versus Eastern Europe.The difference of emission reductions as compared to the baseline are due to the somewhat higher growth in BAU emissions in the EU compared to eastern Europe[7]. Macroeconomic costs are higher for EU than for eastern Europe, due to the already high levels of energy efficiency in the EU. Case 2 shows the uniform tax in the A-1 to be about $70/tC in 2020. This leads to very different emission reductions in different countries. EU can now still have growing emissions, and will only have to reduce about 20% compared to the BAU in 2020, while

7 Be careful in interpreting the 45% increase in the baseline, as compared to 1992 levels, versus the 45% decrease in Case 1, which is compared to 2020 levels. The reduction compared to 1992 is exactly 20%.

eastern Europe reduces about 70% compared to BAU levels in 2020. Clearly, the burden is every unevenly distributed, as the uniform tax forces eastern Europe into very strict emission reductions. Case 3 finally shows the effect of uniform reduction targets with trading. Note that the tax is about the same as in Case 2, but that the income effects for eastern Europe are now positive. Trade in permits will lead to a transfer of 0.2% of EU national income to countries such as eastern Europe. The latter will gain about 2.1% of national income as a consequence of these transfers.

If we compare Cases 2 and 3 with Case 1, we also see that the leakage problem is reduced. In Case 1, the strong impacts on OECD countries will lead to industry relocation outside the A-1 area, pulling up NA-1 emissions by 16% above BAU levels in 2020. This percentage is reduced in the other cases to about 9%.

In all cases, long term macroeconomic costs are relatively low. This has three causes. First, the policy is assumed to be applied in all A-1 countries at the same time. As a result, migration to countries without a tax is small. Second, gradual implementation of the taxes enables producers to achieve the reductions largely through new investments, while they can continue using most of the existing production capacity. Third, it is assumed that the long-term policy is announced beforehand[8].

<<<<insert around here Figure 2: Permits compared to BAU (in %) >>>>

In Figure 2 the permits as compared to the BAU are plotted for the OECD regions, EEFSU, and the NA-1 regions. It can be seen that for the 2000-2020 period all the cases are the same. Carbon leakage for the 2000-2020 period of A-1 reduction policies are illustrated by the increase of NA-1 emissions. By the year 2020, their emissions will increase by +10% compared to the BAU. In 2020, the coalition is extended and becomes global. In the three cases, the -1% per year reduction in Annex 1 is not enough to prevent a stronger fall in emissions after 2020, which is illustrated by the strong reduction for all regions. Also, NA-1 enters the coalition and starts reducing rapidly compared to their BAU, especially in the WGI450 case. Global emission trading is assumed, so that we can focus our attention on the

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8 Despite the low macro-economic costs, sectoral shifts are substantial. Sectoral shifts imply structural adjustment and related tensions. The reduction of these tensions will be a challenge for the delegations to the Convention on Climate Change. In particular the sovereignty of countries over fiscal and energy policies and the domestic interests of energy-intensive industries are important aspects of such an approach.

transitional impacts of coalition enlargement.

<<<< insert around here Figure 3: Permit Price deflated for consumer price (in $ / t C) >>>>

The transitory problem of the enlargement is reflected in Figure 3. Although in the WGI450 case, the carbon tax moves smoothly for the A-1 countries, it is clear that the NA-1 countries experience a strong shock. To take an example, the carbon tax implies a seven-fold increase in coal user prices in China within a period of five years. The sectoral shifts associated with the transition from an A-1 to a global agreement take place both in A-1 and in NA-1. Be also aware that, even if the tax does not fall for A-1 producers, their unit production costs relative to NA-1 producers fall as a consequence of the new tax in NA-1. A ‘reversed carbon leakage’ effect emerges, because A-1 is going to produce relatively more energy-intensive products than before enlargement.

<<<< insert around here Figure 4: Permit Trade in WGI650 & WGI450 (as % of national income) >>>>

In Figure 4 permit trade as percentage of national income is presented. It can be seen that for EEFSU the gains up to 2020 are up to 4%, but is rapidly being reduced after 2020 when the global coalition is in place. Still, permit trade remains positive throughout the whole secanrio period. It can also be seen from Figure 4 that when NA-1 is added to the coalition after 2020, they become gainers from permit trade. This especially holds for more stringent reduction cases, such as the WGI450 case. The OECD region is a net buyer of emission rights. This is reflected by the negative trade percentages for the entire scenario period, although they are relatively small compared to the percentages for EEFSU and NA-1. This is not surprising since income levels in the OECD are much higher than in the other world regions.

<<<< insert around here Figure 5: Welfare compared to BAU in WGI650 and WGI450 (in%)>>>>

The problem with coalition instability is illustrated in Figure 5. The consequences for eastern Europe’s per capita consumption are dramatic. After having received a net gain from the surplus of permit trading, the global agreement will turn the gain into a net loss. In all cases, although there are still net permit exports from eastern Europe to the OECD (see also Figure 4), the bulk is now delivered by countries such as China and India, who extract net gains.

4. Conclusions

For the period 2000-2020, we can conclude that [1] macroeconomic costs of A-1emission reduction could be rather low when [a] a clear and credible, gradual pathway for the tax would be announced, and when [b] all A-1 countries join. However, sectoral shifts are significant and should be taken seriously. Furthermore, we conclude that [2] individual uniform reduction targets for A-1 countries, without tradability, result in an inefficient distribution of reductions. A uniform tax in A-1 countries is much more efficient, but the resulting distribution of costs can be seen as less equitable. A system of tradable permits combines the efficiency of a uniform tax with a built-in financial transfer to countries that reduce relative more than others. As a conclusion on the post 2020 period, [3] the transitional problems due to the change in competitiveness for A-1 versus NA-1 producers may necessitate a phased-in enlargement of the coalition. Finally, [4] a problem can arise upon enlargement, when incumbent low cost countries (EEFSU) see welfare gains of the period 2000-2020 turn into net losses after 2020.

Recommendations for this work concern [1] data improvements, using IEA data, [2] adjusting the energy model to allow more detailed analyses, [3] dealing with benefits from prevented climate change and [4] analysing in more depth the emergence of coalitions and the transitional problems, [5] dealing with endogenous technical change and international technology transfers related to the issue, and [6] looking into more different versions of the policy instrument - notably joint implementation, and different recycling schemes.

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Table 1 *Emission growth driving forces - 1992-2020*

C	C/E	E/Y	Y/P	P
USA	1,14	-0,04	-1,31	1,70	0,80
WESTERN EUROPE	1,34	-0,04	-0,67	2,03	0,03
JAPAN	1,23	-0,03	-1,02	2,33	-0,03
REST OECD	2,70	-0,06	-1,12	2,67	1,23
EASTERN EUROPE	1,09	-0,11	-1,49	2,70	0,03
FORMER SOVIET UNION	0,73	-0,03	-1,03	1,54	0,27
MIDDLE EAST	3,36	-0,01	-0,92	2,16	2,12
SUB SAHARAN AFRICA	3,42	-0,03	-2,19	3,01	2,67
LATIN AMERICA	2,76	-0,01	-2,01	3,44	1,39
CHINA ECONOMIC AREA	2,78	-0,06	-3,25	5,46	0,80
ASEAN+1	3,62	-0,04	-2,40	4,99	1,16
OTHER ASIA	4,08	-0,04	-1,81	4,37	1,61

Table 2 *Emission growth driving forces - 2020-2050*

C	C/E	E/Y	Y/P	P
USA	0,32	-0,63	-1,42	2,12	0,29
WESTERN EUROPE	1,27	-0,52	0,04	2,07	-0,30
JAPAN	1,28	-0,41	-0,82	2,95	-0,40
REST OECD	1,39	-0,36	-0,46	1,64	0,58
EASTERN EUROPE	2,60	-1,02	0,34	3,30	-0,00
FORMER SOVIET UNION	0,73	-0,61	-0,50	1,70	0,15
MIDDLE EAST	1,93	-0,08	-0,84	1,69	1,15
SUB SAHARAN AFRICA	3,21	-0,34	-1,90	3,84	1,66
LATIN AMERICA	1,25	-0,06	-2,76	3,45	0,72
CHINA ECONOMIC AREA	1,67	-0,90	-1,42	3,80	0,26
ASEAN+1	2,33	-0,17	-1,47	3,39	0,62
OTHER ASIA	2,87	-0,43	-1,35	3,87	0,82

Table 3 *Trends and engines of growth - 1995-2020*

W	U	J	R	E	F	M	S	L	C	N	O	
labour supply high-skilled	-0,07	0,25	-0,15	0,90	-0,03	0,24	1,57	1,47	1,04	0,67	1,33	1,15
labour supply low-skilled	-0,05	0,15	-0,09	0,28	-0,00	0,01	0,51	0,77	0,44	0,08	0,29	0,51
extra employment high-skilled	0,03	0,02	0,03	0,14	0,06	0,01	0,07	0,15	0,09	0,21	0,33	0,23
extra employment low-skilled	0,03	0,02	0,02	0,13	0,11	0,12	0,08	0,33	0,21	0,90	0,53	0,64
capital accumulation	1,24	1,45	1,13	2,18	1,45	1,17	2,15	3,06	2,56	3,13	2,76	3,02
total factor productivity	0,87	0,71	1,41	0,39	1,39	0,34	0,15	0,57	1,06	1,46	1,05	0,68
capital gain	0,02	0,02	-0,01	-0,00	0,03	0,03	-0,01	-0,01	-0,01	-0,05	-0,03	-0,02
returns to scale	-0,00	-0,06	-0,01	-0,11	-0,09	-0,06	-0,17	-0,47	-0,28	-0,07	-0,14	-0,19
gross domestic product	2,07	2,57	2,33	3,91	2,91	1,87	4,35	5,87	5,10	6,33	6,10	6,02

Table 4 *Trends and engines of growth - 2020-2050*

W	U	J	R	E	F	M	S	L	C	N	O	
labour supply high-skilled	-0,33	0,05	-0,37	0,10	-0,15	-0,03	0,44	0,74	0,25	-0,05	0,17	0,31
labour supply low-skilled	-0,19	0,04	-0,20	0,07	-0,10	-0,05	0,27	0,65	0,17	-0,03	0,11	0,20
extra employment high-skilled	-0,01	0,00	-0,00	0,05	0,03	0,01	0,06	0,54	0,05	0,26	0,09	0,44
extra employment low-skilled	-0,01	0,00	-0,00	0,06	0,06	0,10	0,05	0,39	0,12	0,38	0,27	0,45
capital accumulation	1,00	1,37	1,19	1,47	1,76	1,27	1,77	2,98	2,49	2,32	2,24	2,63
total factor productivity	1,22	1,04	1,84	0,47	1,69	0,52	0,32	0,70	1,34	1,12	1,12	0,68
capital gain	0,02	0,02	0,01	0,01	0,01	0,02	0,01	-0,00	0,01	-0,02	-0,01	-0,01
returns to scale	0,02	-0,11	0,01	-0,06	-0,05	-0,05	-0,09	-0,46	-0,23	-0,02	-0,05	-0,08
gross domestic product	1,73	2,41	2,47	2,18	3,25	1,792,845,544,193,963,934,62						

Figure 1: Global Emissions (in Gt C)

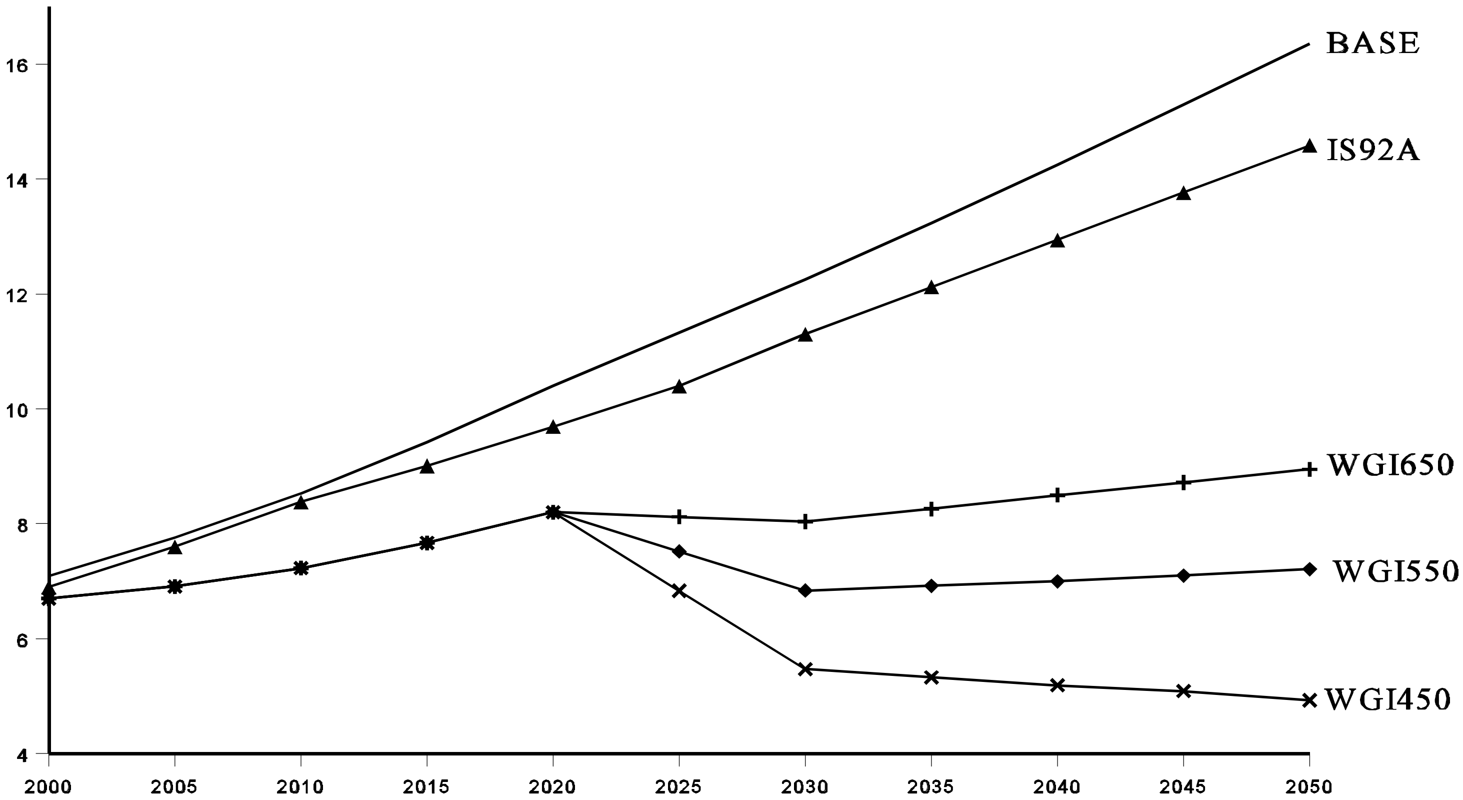

Figure 2: PERMITS COMPARED TO BAU
(in %)

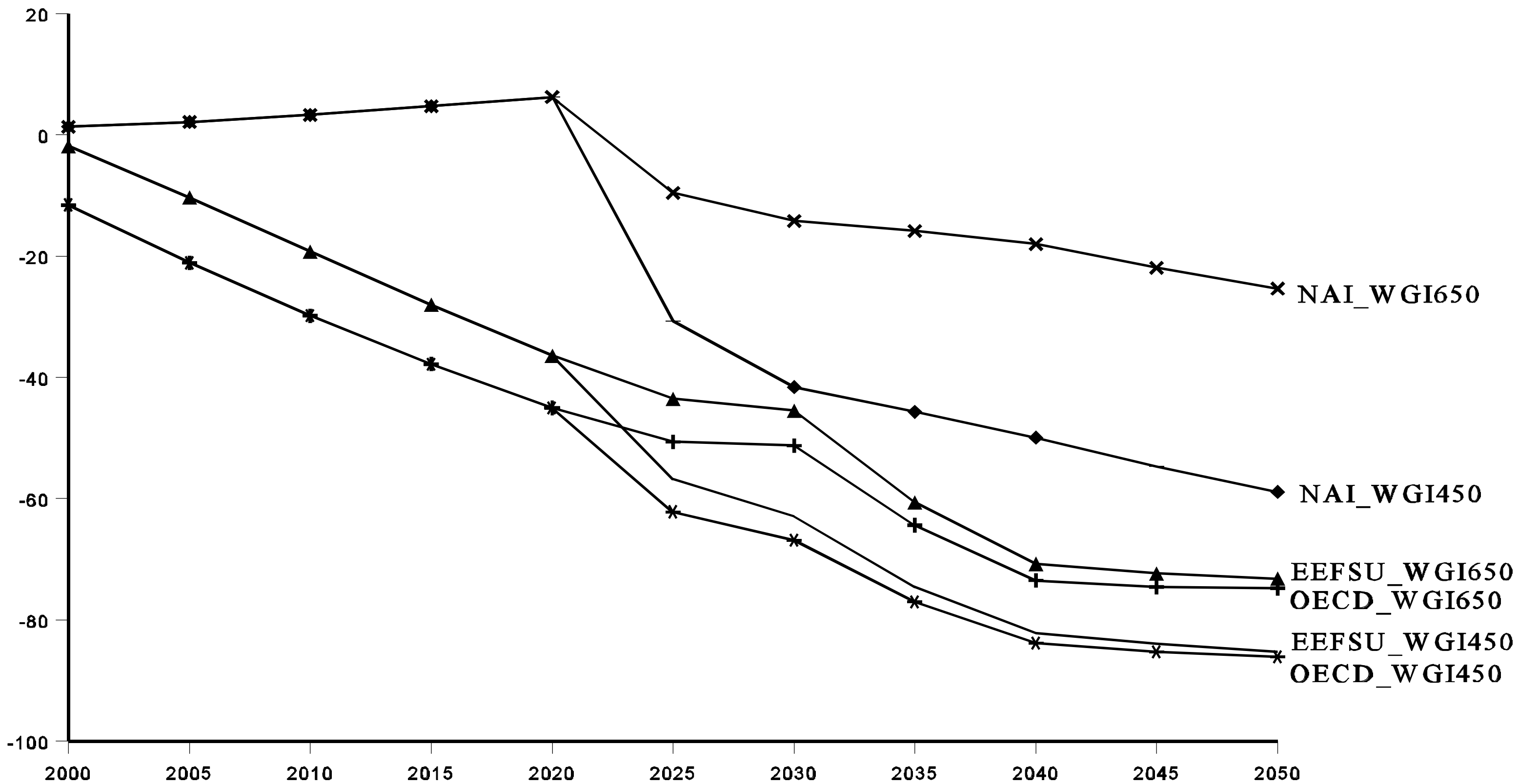

Figure 3: PERMIT PRICE deflated for consumer price (in $ / t C)

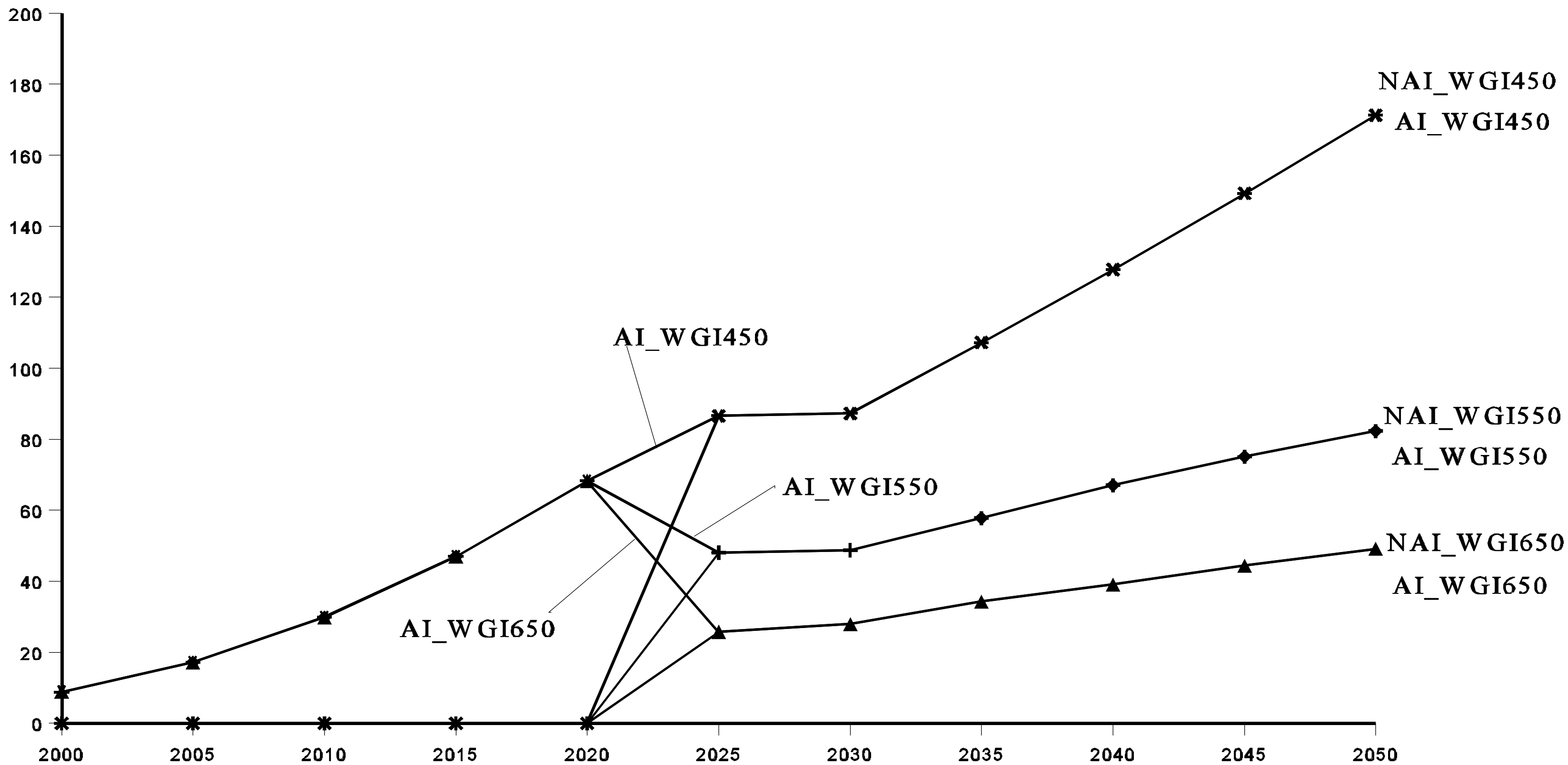

Figure 4: PERMIT TRADE

IN WGI650 & WGI450 (as % of national income)

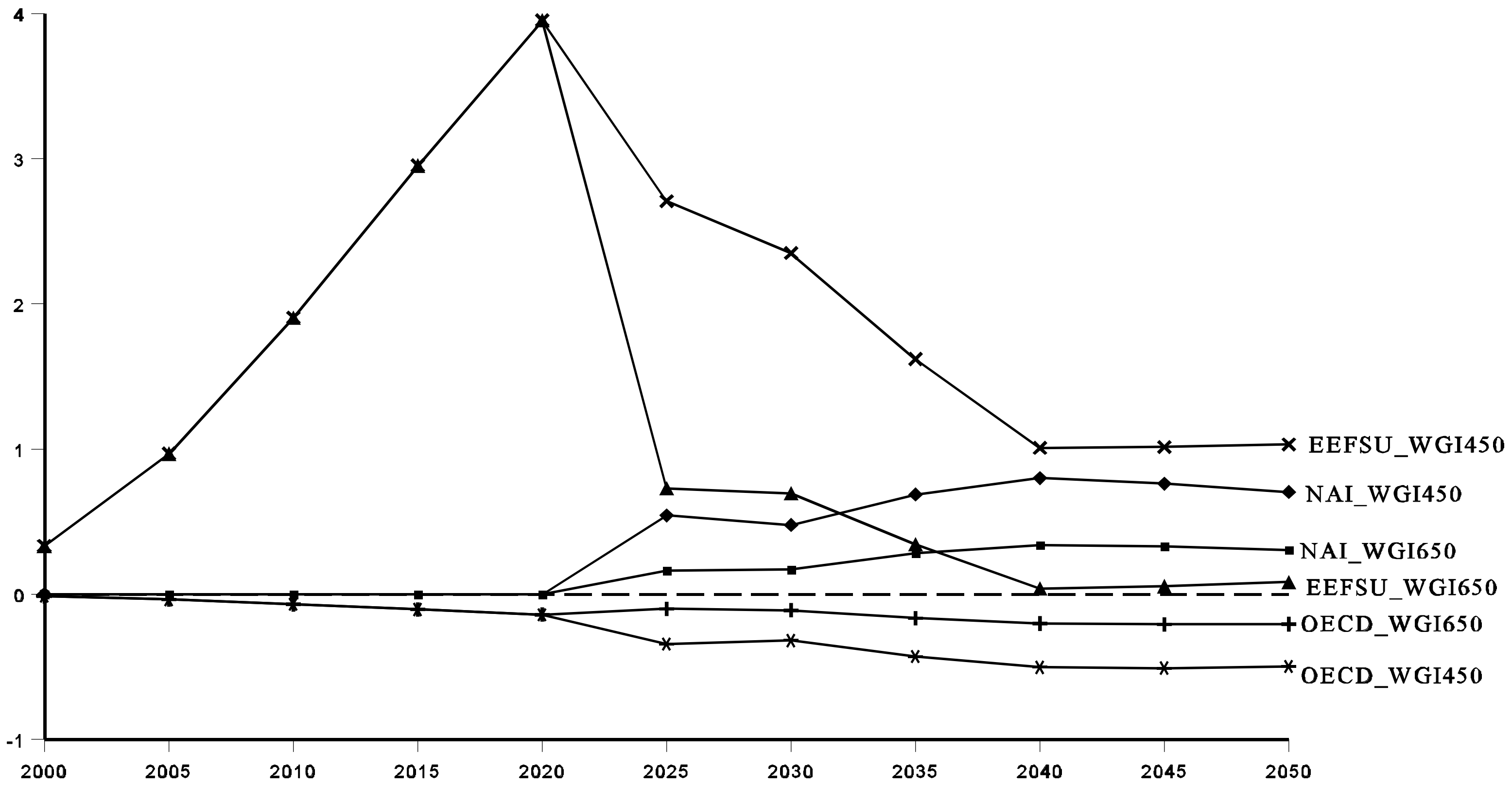

Figure 5: WELFARE

COMPARED TO BAU IN WGI650 & WGI450 (in %)