INTERNATIONAL GAMES OF CLIMATE CHANGE POLICIES

- THE ECONOMIC EFFECTIVENESS OF PARTIAL COALITION GAMES -

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Abstract

The process towards an establishment of international environmental agreements as the implementation of the Kyoto protocol comprises enormous effort of international negotiation and bargaining policies and strategies. International cooperative negotiation solutions can be reached if all negotiation partner and player expect improved results in comparison to a non cooperative approach and independent initiatives controlled by pure self interests. More precisely, individual nations will not cooperate in order to reach a common target if the difference of net benefits by non cooperative and cooperative strategies is very high. Whether an agreement can be reached depends on the opportunities to reduce interest conflicts towards a minimum agreement, a bargaining situation contains opportunities to collaborate for mutual benefits. As real negotiation processes demonstrate, a full agreement of all players is unlikely to exist, more realistic seems that partial coalitions or unilateral action can take place as an alternative.

This paper investigates different international climate change negotiation games of cooperation and non cooperation behaviour by a global general equilibrium model and compares non cooperative initiatives forced by pure self interest against cooperative agreements among subgroups in form of small partial coalition games. Some player can benefit from actions of self enforced initiatives by other player or by partial coalition strategies due to the free rider principle, whereas others loose by remaining countries acting unilaterally. Non cooperative games induce welfare losses mainly to the unilateral acting player while free rider gain significantly.

Keywords: Climate change policies, coalition games

JEL classification: C70, C 68, D 58

International Games of climate policies

The development of the Kyoto protocol is one of the leading and most important international environmental agreement in the history of global negotiation and bargaining policies. The process towards a full implementation and ratification incorporates huge efforts of all international negotiation and bargaining parties. Each country is mainly concerned with its own welfare level and development, the decision to join a cooperation or to initiate a partial coalition depends on the difference of net benefits of a cooperative and a non- cooperative strategy (Barrett 1994) . Because of drastic impacts on negative climate changes or because of policy pressure from interest parties within a country, nations face distinct policy strategies that need to be optimised in order to be legitimated within a country and to reach an intended target. As long as the environment and the climate is treated as public good and as long as there will be no penalty or sanction mechanisms for polluting entities there will be no economic incentives to act environmental friendly by reducing emissions unilaterally or cooperatively. We found the same principle as the prisoner dilemma called "climate dilemma" meaning that all individual regions could benefit by cooperation but there are no incentives for it. As long cooperative behaviour is imposed by voluntarily actions the achievement to find a common or global agreement is driven by different interests of negotiating countries that must be harmonised between nations or groups of countries. The Kyoto protocol as a "low cost solution" allows different kind of possibilities to form coalitions through bubbles to reach a common climate change policy target and to share efforts and costs. Whether an agreement can be reached depends on the opportunities to reduce interest conflicts towards a minimum agreement, a bargaining situation contains opportunities to collaborate for mutual benefits. As real negotiation processes demonstrate, a full agreement of all players is unlikely to exist, more realistic seems that some player may act independently or unilaterally in order to maximise their own welfare and self interests, some other player join small and stable coalitions ((Carraro and Siniscalo 1992), (Carraro and Siniscalco 1993) and (Hoel 1994)), others act as free rider, i.e. they stay outside instead of participating in it. The encouragement of countries to join a partial coalition can be enforced by capital or technology transfer (Tol, Lise et al. 2000) that can be interpreted as side payments.

This paper investigates diverse opportunities of industrialised (Annex B) countries to take responsibility by reducing emissions unilaterally or bilaterally, i.e. to create partial coalitions, and evaluates the economic effects out of it. We assume that some player act independently in order to

maximise their own pure self interests or that two player join a small coalition and all other player act as free rider, that means they do not abate emissions. The choice of behaviour is taken exogenously, aspects of endogenous formation (Barrett 1994) or transfer / compensation payments are neglected. These different scenarios are analysed by a global general equilibrium model that do not incorporate the opportunity to trade emissions permits which is only allowed within a concluding sensitivity analysis. This paper demonstrates the economic impacts by diverse climate change coalition formations. An analytical assessment of these results and the stability of these coalitions can be found in Kemfert, Lise and Tol (2001). After a brief description of the model main model results are demonstrated and discussed in chapter 4. The last section gives a summarizing conclusion.

Model description

In order to simulate and evaluate economic effects of diverse international climate change coalition scenarios, an international, multi regional trade model seems to be the most suitable and appropriate tool. This is because the general equilibrium framework allows a game theoretic analysis of diverse partial coalition games. Because of that, the games of international climate change policy strategies are modelled by an intertemporal general equilibrium models named WAGEM (Kemfert 2000). WAGEM is an intertemporal computable general equilibrium and multi regional trade model for the global economy. It considers 11 world regions that are linked through bilateral sectoral trade flows based on GTAP data of 1995. For each region, a representative agent maximises lifetime utility from consumption. This determines the level of savings. Firms choose investment in order to make the most of the present value of their companies. In each region, production of the non-energy macro good is captured by an aggregate production function. The production function characterises technology through transformation possibilities on the output side and substitution possibilities on the input side. In each region, a representative household chooses to allocate lifetime income across consumption in different time periods in order to maximise lifetime utility. In each period, households face the choice between current consumption and future consumption, which can be purchased via savings. The trade-off between current consumption and savings is given by a constant intertemporal elasticity of substitution. Producers invest as long as the marginal return on investment equals the marginal cost of capital formation. The rates of return are determined by a uniform and endogenous world interest rate such that the marginal productivity of a unit of investment and a unit of consumption is equalised within and across countries. Domestic and imported varieties for the non-

energy good for all buyers in the domestic market are treated as imperfect substitutes by a CES Armington aggregation function, with a constant elasticity of substitution.

Table 1 shows the global world regions of the model.

ASIA	India and other Asia (Republic of Korea, Indonesia, Malaysia, Philippines, Singapore, Thailand, China, Hong Kong, Taiwan)
CHN	China
CNA	Canada, New Zealand and Australia
EU15	European Union
JPN	Japan
LSA	Latin America (Mexico, Argentina, Brazil, Chile, Rest of Latin America)
MIDE	Middle East and North Africa
REC	Russia , Eastern and Central European Countries
ROW	Other countries
SSA	Sub Saharan Africa
USA	United States of America

Figure 1: World regions

In each region production of the non-energy macro good is captured by an aggregate production function which characterises technology through transformation possibilities on the output side and substitution possibilities on the input side. Within a new version of this model technological change is determined endogenously in line with Goulder and Mathai (Goulder and Mathai 2000). For that, a human capital factor is included in the production function influenced by endogenous investment in R+D which is produced by a separate R+D sector. Endogenous total factor productivity varies by changes of innovations through R+D and public expenses for education influencing the quality of products. The optimal steady state growth path can be found by the approach of Hovitt (Howitt 2000). In each region a representative household chooses to allocate lifetime income across consumption in different time periods in order to maximise lifetime utility. In each period households face the choice between current consumption and future consumption, which can be purchased via savings. Those countries meeting the Kyoto emissions reduction target stabilise their mitigated emissions at 2010 level.[1]

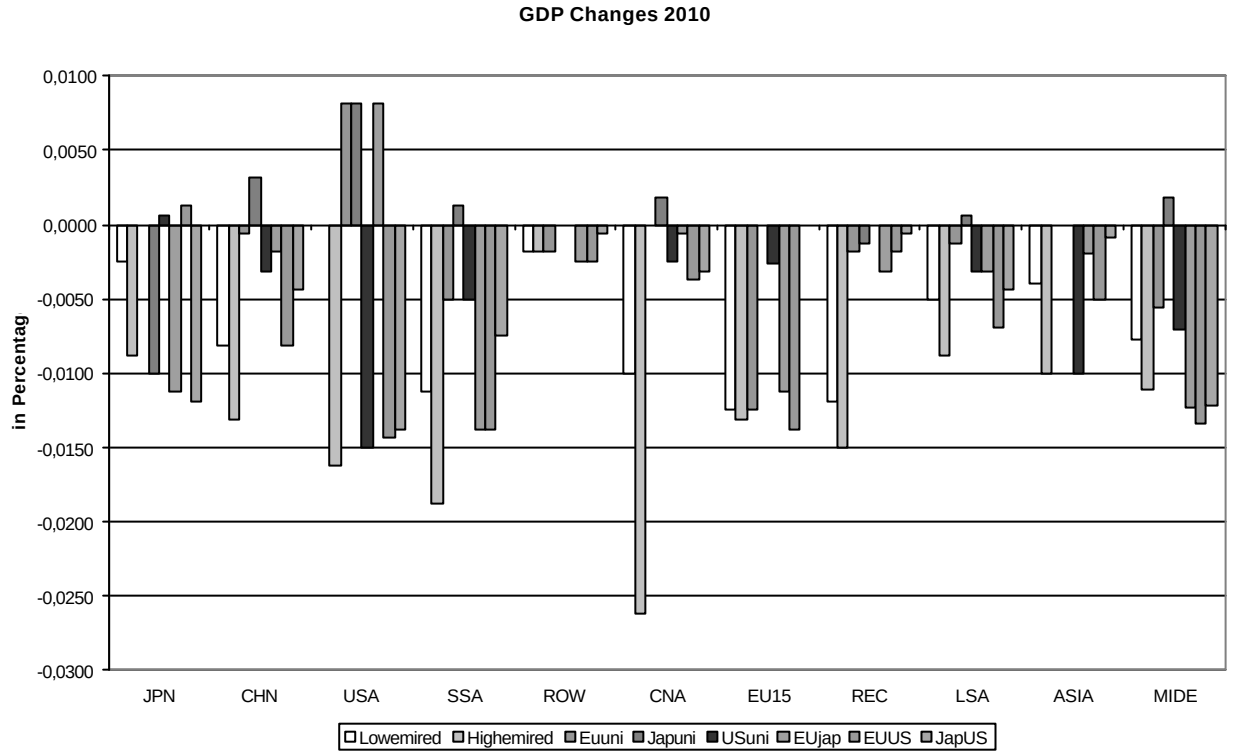
[1] A detailed mathematical description of the model and parameter calibration is shown in Kemfert (2000)

Model calculations and results

The primary aim of this paper is to compare and evaluate different partial coalition games of emissions abatement and to assess its economic impacts. In order to compare distinct climate change policy games and to investigate partial coalition games and its economic impacts we define eight different scenarios: 1. Each country of the Annex B nations react unilaterally, i.e. is mainly concerned with its own welfare level and reduce emissions by 20 % in comparison to the baseline scenario, all other countries act as free rider and do not abate emissions. We distinguish three unilateral scenarios where either the European Union (EU), Japan or USA reduce emissions by 20 % after 2010. 2. Within the bilateral scenarios, two of the Annex B countries form a partial coalition to reduce emissions bilaterally, all other countries react as free rider and do not abate emissions. The so called Business as Usual (BAU) scenario covers the world development without any additional reduction options. The "business as usual" (BAU) and comparison case is the scenario where no further abatement measures or other policies are considered. The global emissions baseline pathway is assumed to start from 6 to 11 billion tons of carbon in 2030 which is roughly consistent with the carbon emissions projections of the IPCC reference case of medium economic growth. All parameter selections orientate on general assumptions made for preceding simulations aligned with previous model calculations.

Highemired:	ALL Annex B countries reduce emissions by 20 %
Lowemired:	ALL Annex B countries reduce emissions by 10 %
Euuni:	EU reduces emissions unilaterally by 20 %
Japuni:	Japan reduces emissions unilaterally by 20 %
Usuni:	USA reduces emissions unilaterally by 20 %
EUJap:	EU and Japan reduce emissions bilaterally by 20 %
EUUS:	EU and USA reduce emissions bilaterally by 20 %
JapUS:	Japan and USA reduce emissions bilaterally by 20 %

The following figures describe the impacts of the different scenarios in terms of GDP, exports and imports in the time periods of 2010 and 2020 in percentage changes to a so called "business as usual" (BAU) scenario where no emissions reductions are included.[2]



Fehler! Verweisquelle konnte nicht gefunden werden.**Figure 2**: Regional GDP changes in comparison to the BAU in 2010

Obviously, an emissions reduction of Annex B countries will induce negative welfare implications for the abating regions, the higher emissions abatement the higher are welfare reductions measured in GDP changes. Figure 3 and Figure 4 illustrate this. But, as already described in Kemfert (2000), these emissions reduction efforts induce negative welfare implication to all other world regions mainly because of economic and trade interrelations. If high industrialised countries like USA, Japan or the European Union decrease their emissions drastically, two main effects dominate by international reactions: first, energy demand declines drastically resulting in a decreasing energy price from which energy exporting countries will suffer; second, high emissions abatement costs of emissions reducing countries induce negative economic welfare effects which causes significant international trade spill over effects from which all world regions suffer considerably, mostly countries which are primarily

[2] Parameterisation and calibration of the BAU scenario are described in (Kemfert 2000)

interrelated by trade. Both effects cause negative economic impacts to abating regions of industrialised countries and developing regions which suffer by trade spill over effects through decreasing economic competence by leading regions and consequently falling energy demand which induce welfare losses to energy exporting countries.

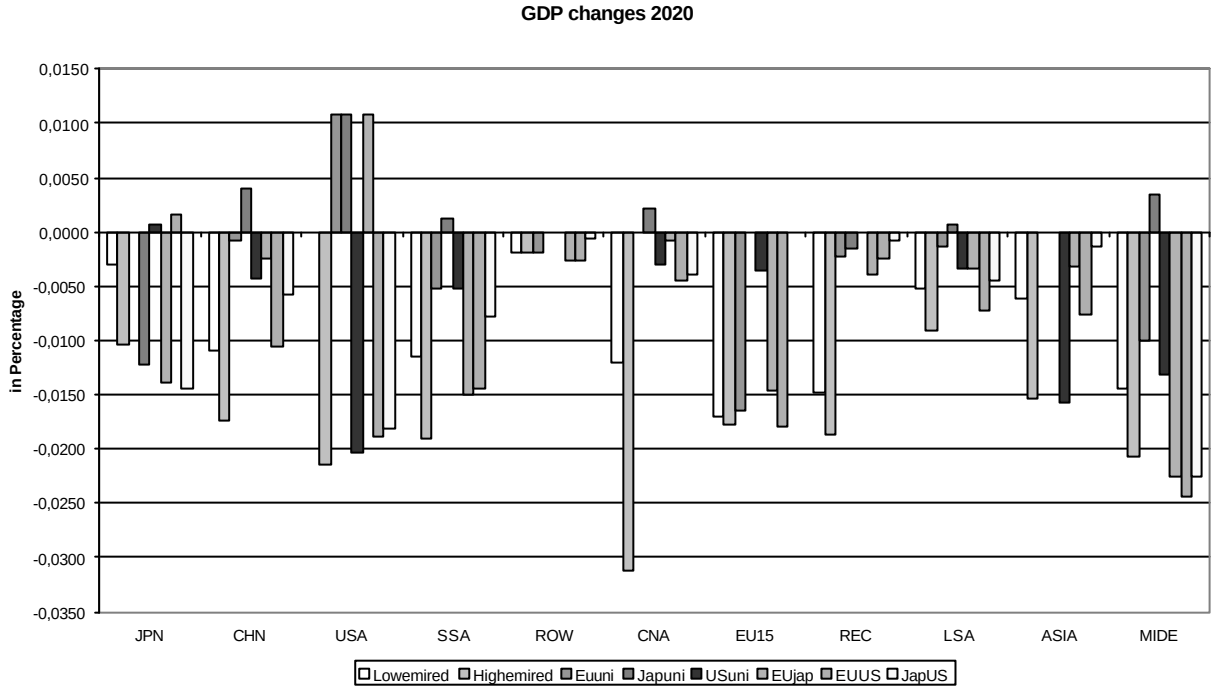


Figure 3: GDP % change 2020

As Figure 2 demonstrate, unilateral and bilateral emissions abatement leads to different regional reactions on GDP changes due to abatement effort and costs. By a closer examination of free rider countries, in the case of unilateral emissions reduction by the EU or Japan, USA can benefit by an increase of welfare in terms of GDP. This is because the EU or Japan has to take huge welfare losses in terms of GDP but also in terms of competitiveness (see Figure 5 and Figure 6) from which USA can benefit enormously. If the USA act unilaterally by diminishing emissions without any emissions abatement from other regions, energy demand decreases and lowers the energy price which influences also the world energy market price. Japan as a large energy importer can benefit from this decrease of the world energy market price, whereas China as a large net coal exporter will more likely have to accept economic deterioration impacts. The EU suffers mainly by negative trade spill over effects which cannot be overcompensated by positive effects due to the energy price decline. In general, welfare losses are highest if emissions are reduced by all regions in parallel. The

EU cannot benefit economically by joining a partial coalition either with USA or Japan. In contrast, Japan can benefit marginally by unilateral action of the USA or bilateral action of the EU and USA. By assuming that Annex B countries act unilaterally, i.e. they reduce its emissions by 20 percent whereas all other countries act as free rider and do not abate, welfare losses are as or even nearly as high as all other countries would shrink emissions as well.

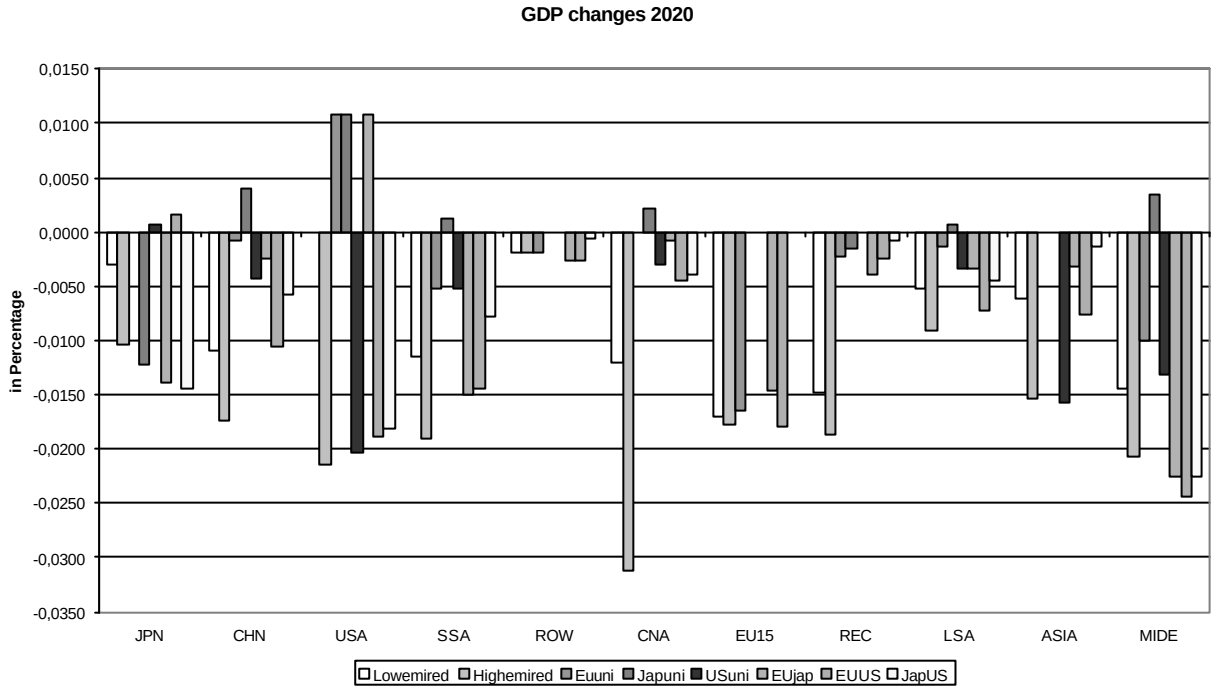


Figure 4: GDP changes 2020

These developments do not change fundamentally after 2010. If the USA is dropping emissions unilaterally, other free rider countries like the EU have to accept welfare losses as well. This can be explained mainly by the high dependency of the European economy from the US economy as valid for the Asian economy measured in a decrease of exports in this scenario. If two Annex B countries join a partial coalition, positive welfare impacts can barely be detected, contrarily welfare losses as nearly as high as in an unilateral action. The US economy can benefit not only from unilateral actions by other Annex B countries, but from bilateral reduction efforts as demonstrated in the EU /Japan bilateral abatement scenario (EUJap). The oil exporting region MIDE suffers economically mainly as a result of the previously described decline of the energy price because of decreasing energy demand. All main industrialised regions as the European Union, Japan and the USA are characterised by high market and economic power and a high energy consumption. Emissions

abatement of these regions causes energy demand decreases because of the not existent opportunity to trade emissions permits which could have lowered the abatement costs and in total leads to welfare losses to the most economic dependent regions. The most conspicuous development are the economic benefits by the USA if the other industrialised regions decide to reduce emissions unilaterally or bilaterally. This reveals the higher economic competitiveness between USA and the other developed regions. Japan and also the EU are characterised by high abatement costs which causes economic disadvantages if emissions are reduced unilaterally or bilaterally between these two regions.

In order to highlight the described effects, scenario results need to be compared against the first base case scenario of 10 % emissions reduction by all regions and the comparison between the unilateral and bilateral emissions abatement: the main emissions cutback regions USA, EU and Japan benefit most by acting as a free rider, small economic incentives has the EU to join a partial coalition with Japan. USA however has the incentive to join a partial coalition with both either EU or Japan because of its economic advantage. Japan has no economic incentive to join a partial coalition neither with the EU nor USA. Analytical model results demonstrate that the partial coalition of Japan and the USA is the only internally and externally stable coalition, see Kemfert, Lise, Tol (2001).

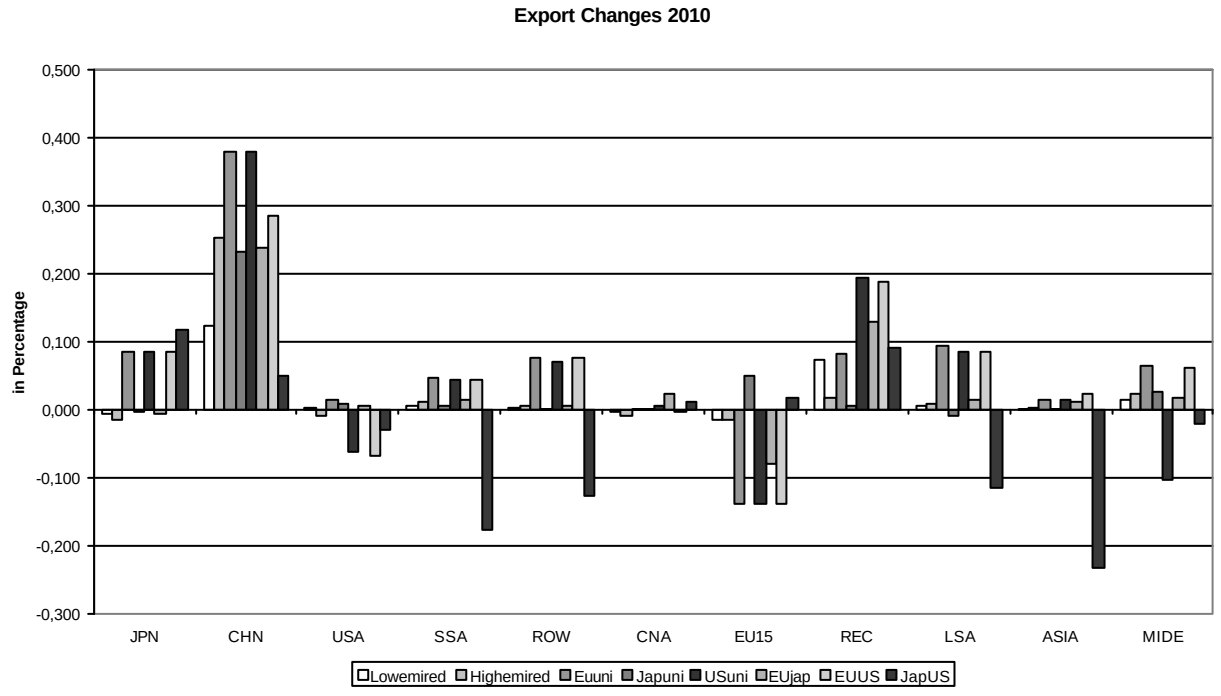


Figure 5 : Export changes in % 2010

If the USA and EU join a partial coalition and abate emissions by 20 percent bilaterally, Japan can benefit as a free rider in terms of competitiveness; negative economic impacts be tolerated by the USA are higher if they form a partial coalition with the EU as if it would reduce emissions unilaterally. This can be explicated by higher economic interrelations between both countries and therefore higher negative welfare losses for other countries, like for example Asia. Japan can benefit as a free rider because it can take advantage out of this development and can increase its export significantly (scenario EUUS). Japan and USA as two highly developed regions with huge market power cause in a partial coalition negative export changes to other world regions which are highly trade dependent. Low increases of Chinas exports can be explained by decreasing energy price which induce an augmentation of exports of energy intensive products or energy itself. Additionally, from this development also Russia and the Eastern European countries can benefit which augments temporally the exports. Because of the high share of the US energy demand, the main oil exporting regional MIDE suffers export losses which are in this case mainly oil exports, but can increase exports marginally if other regions than the US region intend to abate emissions unilaterally or bilaterally. Russia and Eastern Europe benefit from non binding reduction targets as a free rider. Substantial export increases in China result from an increase of carbon leakage by industrial leakage from the Annex I to developing regions. Other export increases in developing regions can also be explained by the increasing carbon leakage effect which on the one hand induce negative environmental effects by the transfer of pollution intensive products and production but on the other hand induce positive industrial subsequent effects. However, these positive economic effects are overcompensated by negative trade spill over effects previously described which does not lead to positive economic welfare effects in terms of GDP or real income.

In fact, if USA enters a partial coalition with Japan in order to decrease emissions bilaterally, both countries and all free rider cannot benefit of it by increasing welfare in terms of GDP. Additionally, Japan can increase its exports in 2010 and 2020 but has to accept high import increases that overcompensate the positive term of trade effects. Japan and USA as main world market leader determine and influence trade developments, if both regions act bilaterally by abating emissions not only welfare losses in terms of GDP declines but also export diminution can be detected of vulnerable and export related industries like ASIA and other developed regions. The competitiveness measured in terms of trade effects decline in nearly all world regions because of costs that developed regions have to accepts which leads to spill over effects to other world regions. As described

previously, the only region that can benefit by increasing welfare and competitiveness effects is the USA if the other developed regions reduce emissions unilaterally or bilaterally.

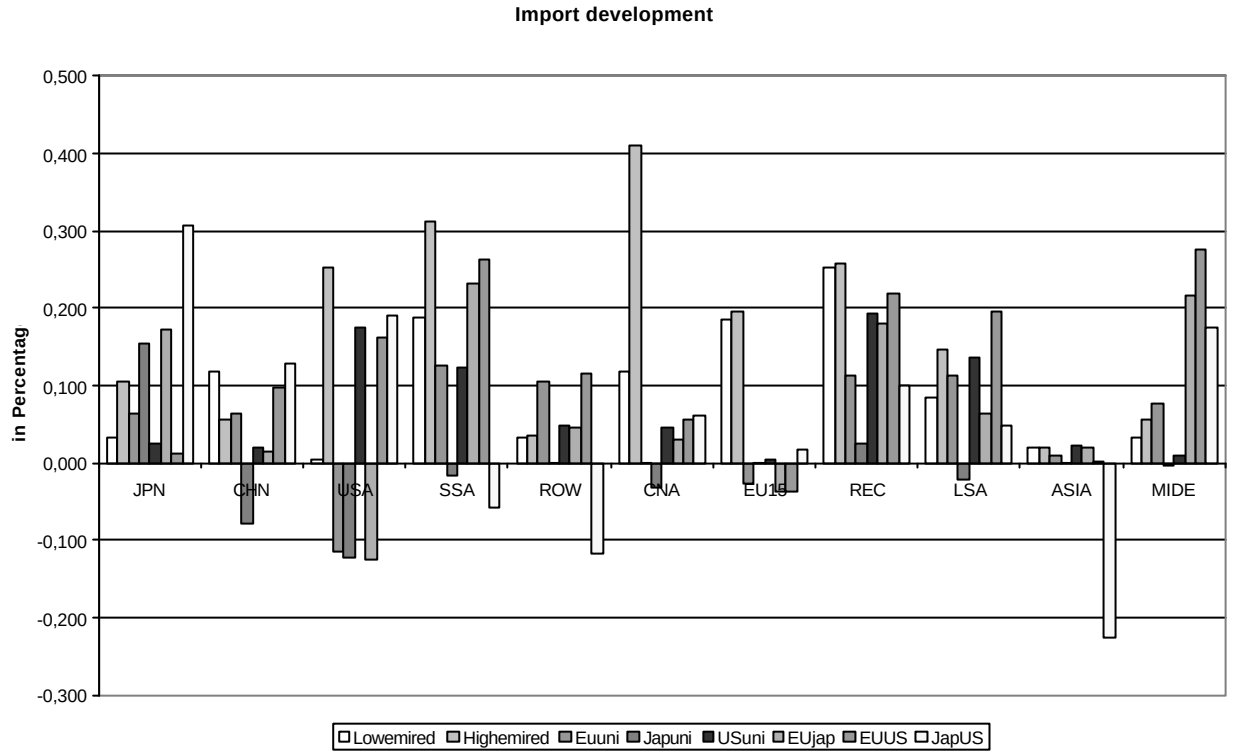


Figure 6: Import changes in % 2010

Unilateral action by main Annex B countries induce mostly a loss of competitiveness in terms of decreasing exports and increasing imports, like the changes of the EU region demonstrates. Because of positive free rider impacts for the USA, it can increase its exports if EU and Japan act unilaterally or join a partial coalition. Because of this development of declining competitiveness by unilateral or bilateral actions, affected regions expand their imports as valid for the European Union.

Figure 7 display the Hicksian equivalent (HEV) which can be roughly explained as real income changes, measured within all scenarios including uni- or bilateral emissions reductions without emissions trading previously described. The results correspond to the previously described GDP and competitiveness effects, nearly all regions have to accept negative welfare effects. USA can benefit as the only region in comparison to the other developed regions because of trade competitiveness effects. By incorporating emissions trading between Annex B countries, model results vary significantly, measured in HEV (Figure 8).

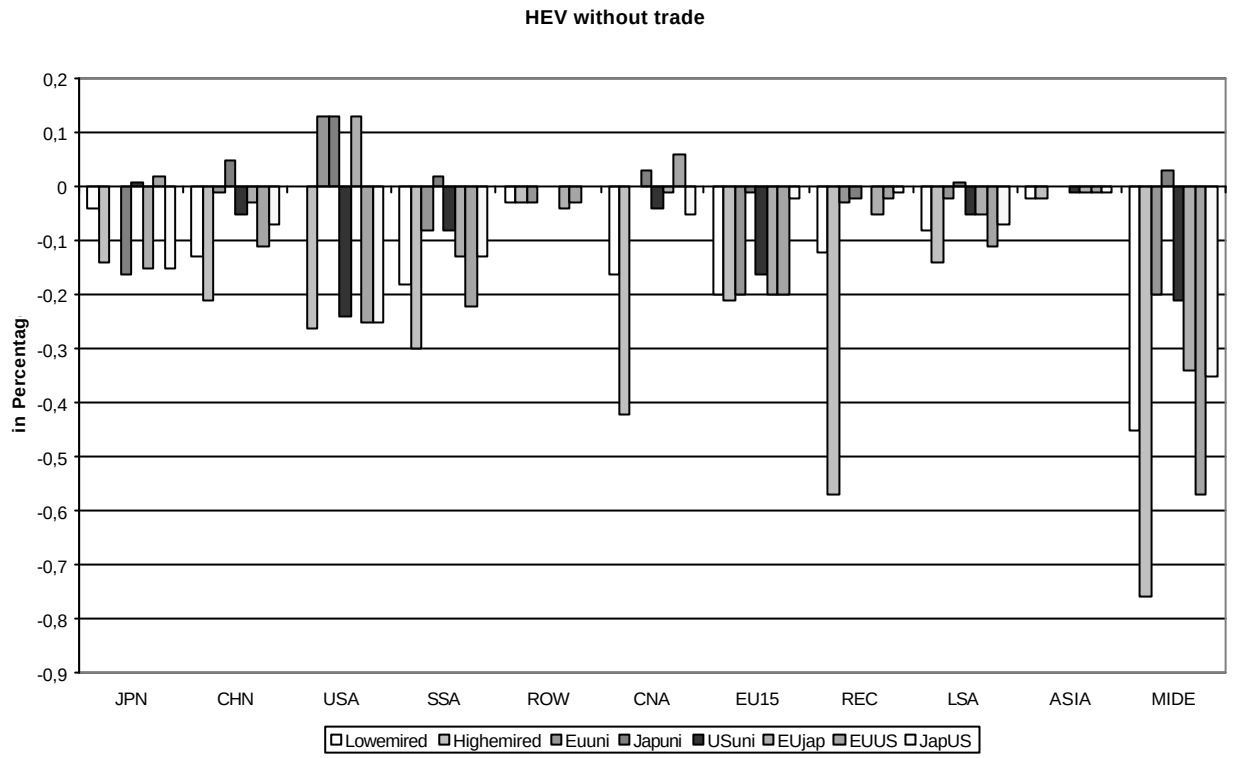


Figure 7: HEV without trade (20 % red)

Annex I emissions trading improves the economic situation for Annex I regions substantially. Because of cost effective emissions abatement by allowing permit trading, emission reducing regions, especially the European Union, can benefit measured in HEV changes. This explains that main economic losses result from regional marginal abatement costs which are very high in Japan and Europe, allowing permit trade improves the cost effective abatement option significantly. Even in this case, a free rider position leads to a substantial welfare increase, as if the USA decides to reduce emissions unilaterally, the EU can benefit in a large scale by permit trading. The conclusion out of this is that permit trade should be allowed which brings about the most favourable solution: by a cooperation of all main player not only the economic situation but, and this is most target, the environmental situation will be improved.

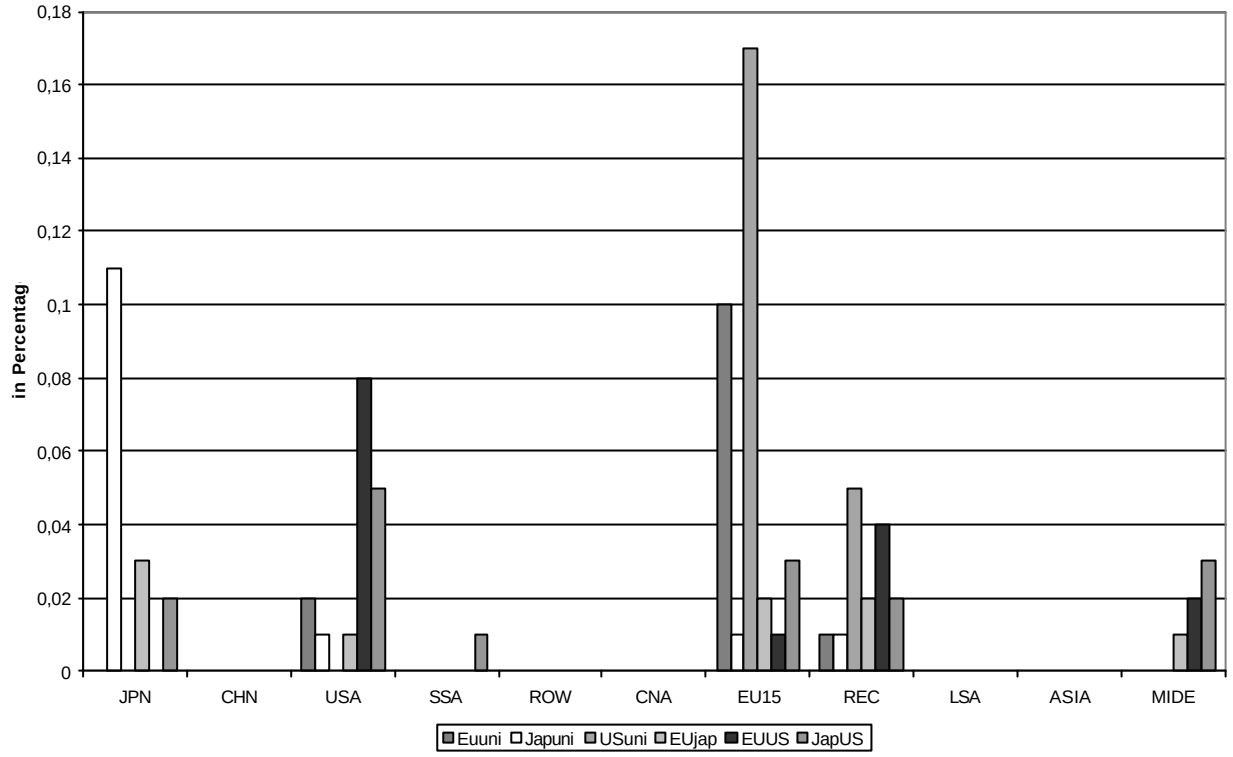


Figure 8: HEV with trade (20 % red), comparison to non trade scenario

Unilateral reduction efforts by Japan or EU lead to less welfare losses as preventing emissions trading, in comparison to both countries USA cannot increase welfare impacts on that large scale. Obviously, Russia and other Eastern European countries (REC) can gain of allowing permit trading as well, because this region will be the main seller of permits if it is allowed between Annex I regions. These effects can be reversed if other international regions come into the game of permit trading, this illustrates Kemfert (2001).

Evaluation and assessment

This investigation base on two fundamental assumptions: a global institution has the right to force a partial or global cooperation in reducing emissions which cause partial coalition games between main polluting regions. Second, there exist no sanction mechanism that avoid free riding. The main intention to simulate partial coalition games is to find an answer who benefits by acting unilaterally or joining a partial coalition and whether there exists an economic incentive for negotiating parties to join a partial coalition which is mainly determined by profitable motivation. Partial coalition games by developed regions are investigated and simulated by a general equilibrium model which is best suited to analyse international coalition games. This paper intends to disperse the economic incentives for countries that decided to abate emissions to join a partial coalition to be better off than acting unilaterally.

The overall assessment whether a country decides to join a partial coalition or act unilaterally or as a free rider exhibits that both unilateral or bilateral action changes the economic outcomes significantly. The only region that can gain substantial welfare advantages by free riding as well as by joining a partial coalition reveals to be the USA region. Although the other emissions abating region EU and Japan have to accept negative welfare losses in comparison to the BAU case, the EU has an small economic incentive to join a partial coalition with Japan. All regions are better off if they react as a free rider in comparison to the case that they are abating emissions in the same manner. This is so, as described above, because there exist no sanction mechanism that avoid free riding behaviour. By assuming that all regions reduce emissions equally, the EU and Japan are better off if they play as a singleton whereas the USA is better off in a coalition than plays as a singleton. These results are also stresses in another paper by Kemfert, Lise, Tol (2001) which investigates these results by a partial analytical model stressing on the fact that abatement costs do matter substantially and are the main reason and explanation of the above mentioned results. Carbon leakage comes out to be substantial especially in China and other developing regions without binding reduction targets and environmental control measures. Carbon leakage by industrial production leakage allows to increase terms of trade effects which cannot offset the negative economic effects. Carbon leakage can be avoided by emissions permit trading. Additionally, permit trading improves the economic welfare of a number of regions substantially.

Conclusion

International coalitions formed in order to meet the Kyoto emissions reduction target have substantial impacts on world and regional economic developments. Unilateral action affect countries that reduce emissions most negatively, whereas positive external free ride effects occur if emissions abatement countries reduce unilaterally or bilaterally. More precisely, countries that decide to diminish its emissions unilaterally will not benefit by economic changes but have to accept high to huge welfare losses. But, other Annex B countries can benefit substantially acting as a free rider without reducing emissions, partial coalition games better off both participating countries in comparison to unilateral emission reduction efforts. If emissions permit trading is not allowed, intense negative economic externalities arise mainly for the European Union, whereas the opportunity to trade emission rights improves the economic situation considerably. The USA has an economic incentive to join a partial coalition with both other abatement regions whereas only the European Union has small incentives to join a partial coalition with Japan. In fact, the EU is better off acting as a singleton whereas the USA is well-off by joining a coalition. Some player can benefit from actions of self enforced initiatives by other player or by partial coalition strategies due to the free rider principle, whereas others loose by remaining countries acting unilaterally. Non cooperative games induce welfare losses mainly to the unilateral acting player while free rider gain significantly.

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