The impacts of emissions trading on world economies

Contemplation of baseline emissions paths and a ceiling on emissions trading

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Non technical abstract

Regarding to the Kyoto Protocol of December 1997 the United Nations agreed on several conventions to stabilise the world climate and to reduce greenhouse gases (GHG), respectively. The international conferences on climate change in Buenos Aires and in Bonn in 1998 and 1999 established concrete steps towards efficient international climate change policy options. The explicit accomplishment of the Kyoto mechanisms, *Joint Implementation* (JI), *Emissions Trading* (ET) and the *Clean Development Mechanism* (CDM), were debated controversially, concrete steps and plans of fulfilment are still under discussion. Essentially, the proper definition of baseline emissions paths and the concrete implementation of an emissions trading scheme is discussed controversially. Emissions reductions can be reached by domestic actions or by Kyoto mechanisms including the option to trade emission permits within Annex B countries. Countries will trade emission permits due to their marginal abatement costs, regions facing high marginal abatement costs by, for example, high carbon intensities within main sectors of their economies possess huge incentives to buy emissions permits. Countries with declining emissions because of substantial economic destruction like Russia or Eastern Europe will appear with emissions below their committed reduction target and will consequently prefer selling their emissions permits, entitled as “hot air” effect.

This paper investigates the world economic implications by implementing the Kyoto mechanisms. More precisely, an emissions trading system between industrialised countries (Annex B) is studied by a consideration of different kind of assumptions about world emissions development and a ceiling on emissions trading options. Main outcome of this analysis demonstrates that a full emissions trading scheme better off all world economies, a ceiling on emissions trading leads to substantial overall and regional welfare losses.

Technical abstract

This paper illustrates different scenarios of implementing an emissions trading scheme and investigates the economic implications of diverse baseline development paths and an additional limitation or ceiling on emissions trading. The analysis focus on the impacts of dissimilar emissions reductions options, i.e. to decrease emissions by domestic action or by Annex B emissions trading. World economic impacts are investigated by a world general equilibrium model including 11 international regions and 4 production sectors. Various strategies including flexible instruments, like a ceiling on regional emissions trading and the interregional and intertemporal trade of emissions permits are simulated, compared and evaluated. It turns out that meeting the Kyoto target induce welfare losses to developed and developing countries, an emissions trading option can reduce global and regional welfare losses significantly. Essentially, these welfare losses depend considerably on assumed emissions baseline paths. A ceiling on emissions trading scheme diminish positive economic effects on global and regional welfare, especially within economies in transition.

Keywords: Emissions trading, energy economic modelling, baseline definition

JEL classification: Q4, E1,F0

Introduction

Climate change negotiation processes induced an international countries agreement of the Kyoto protocol abating greenhouse gases (GHG) within the commitment period by 2008 and 2012. More precisely, so called Annex B countries including among others USA, Japan and Europe committed themselves to reduce their emissions by 6 to 8 % of their baseline emissions of 1990. Beside domestic measures to mitigate GHG emissions by for example emissions taxes or standards, so called international flexible Kyoto instruments allow a reduction of emissions by project or technology transfers mitigating emissions between Annex B countries (Joint Implementation *JI*) or from developed Annex B countries to developing countries (Clean Development Mechanism *CDM*) or by emissions trading (*ET*) between Annex B countries. The analysis focus on the impacts of different emissions reductions options, i.e. to decrease emissions by domestic action or by Annex B emissions trading. Main debates are around the concrete implementation of these instruments including controversial arguments of an initial allocation of emission permits (grandfathering or auction), early crediting and penalties of non compliance. Crucially, the concrete determination of world and regional baseline emission paths have to be coordinated and adjusted precisely. It is discussed controversially whether an emissions trading system induce so called "hot air" options by countries in transition with real emissions lower their committed reduction target, i.e. non binding reduction commitments. In order to avoid "hot air" trading, different kind of emissions trading limitations are suggested. Developing countries like China and India argue in favour of a ceiling on emissions trading mainly in order to draw industrial countries attention to their responsibility of world pollution impacts by emissions and hence bear the brunt of abatement primarily. EU 15 explain their preference of a ceiling on emissions trading by negotiation significance in order to reach a global consent.

This paper investigates the impacts of the Kyoto reduction commitments including emissions trading between Annex B countries and compares the economic outcomes of different kind of emissions trading schemes. Mainly, different emissions baseline developments and diverse restrictions to full emissions trading, i.e. a ceiling or cap on emissions trading are compared and evaluated. Direct investment transfers between Annex B countries and from Annex B to Non-Annex B countries modelled indirectly by capital and investment transfers resulting in higher energy efficiency. This investigation is focused on different emission baseline assumptions ending in different welfare losses for developed and developing countries as well.

The structure of this paper includes first an overview of different world model results of permit prices in order to compare the model results. After a brief description of the world model an illustration and explanation is given of all model results comparing assorted emissions baseline projections and different kind of emissions trading schemes. The last section concludes, an Annex illustrates the mathematical description of the applied model.

Previous model results

In order to provide an assessment and estimation of conceivable impacts by the implementation of the Kyoto mechanisms various kind of world economic assessment models are applied by many scientists. On world level, it is important to include all relevant world regions and main energy and carbon intensive sectors. Kyoto mechanisms assessed by world models lead mainly to a favourite assessment of a full global emission trading system because of cost minimisation options by all participating countries. JI and CDM opportunities can often only be modelled by an emissions trading system between developed and developing countries neglecting direct capital transfers inducing increased energy efficiency within the host country.

Within this chapter merely a small number of model results, the permit prices due to Annex B emissions permit trading and full carbon emission trade are compared and evaluated. Model results are often distinguished in order to assess the impacts of full carbon permit trade against ceiling opportunities on a trading system.

Model construction and assumptions deviate widely, main models can be classified as Integrated Assessment models (IAM) focusing more or less on a dominant economic or policy evaluation characterisation.[1] Model results as permit prices highly depend on model construction and assumptions, divergences in permit prices can appear by different model closure rules, baseline development, population and growth projections, tax recycling procedures, chances in fuel prices and fuel specific technologies or varying backstop costs. Figure 1 exposes different model results by comparing emission permit prices of an Annex B trading system in 2010 and 2020. Comparing permit prices does not necessarily mean the same as a ranking of welfare costs, like GDP changes or variations in Hicksian equivalent. Within main models, measures of welfare can differ significantly. Main IAM models calculate a permit price within a range of 100 to 150 $\$_{1995}$ per ton of carbon in 2010 whereas main models focusing more on an economic general equilibrium like MRT or IIAM calculate a lower permit price (30 to 45 $\$_{1995}$ per ton of carbon) in order to reach the Kyoto target. More generally, these top down models like IIAM, MRT C-cubed or Worldscan simulate lower permit prices whereas more bottom – up oriented models like MERGE, POLES and PRIMES come up with much higher abatement costs and permit primes, primarily because of a more detailed description of technologies.

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[1] This Chapter does not intend to provide a comprehensive individual model description, an overview of IAM gives Dowlabadi (1995), IPCC (1995) or Rotmans (1998)

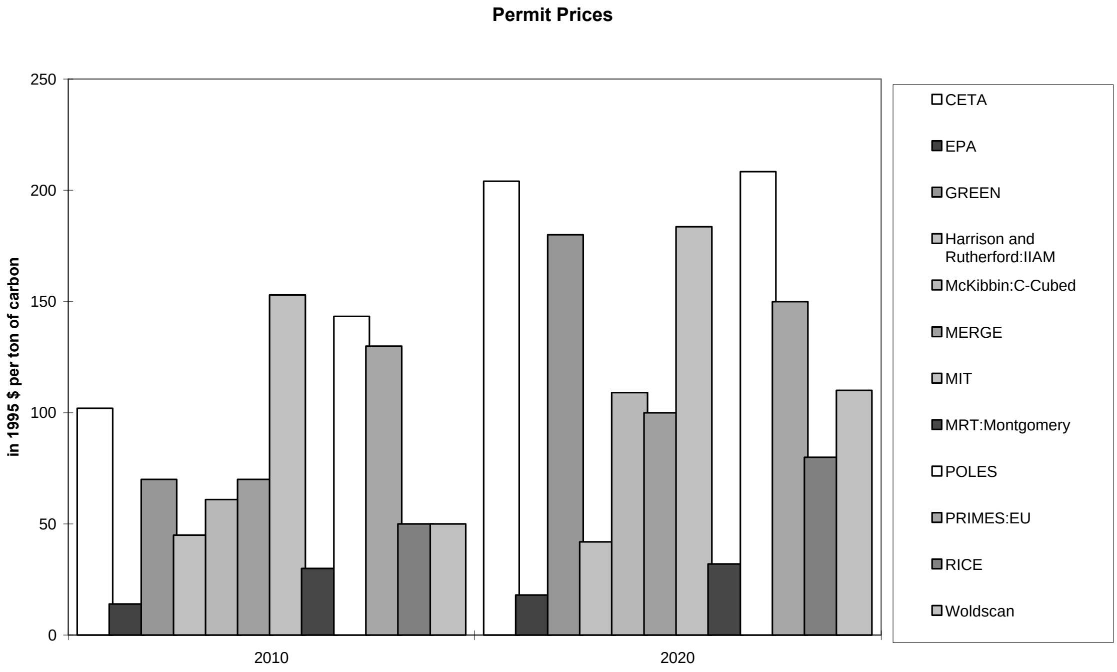

Figure 1: Permit prices in diverse model approaches[2]

Model description

In order to investigate the economic impacts of international GHG mitigation policies induced by the Kyoto protocol and climate change negotiation processes a World Applied General Equilibrium model (WAGE) is used. WAGE is an intertemporal computable general equilibrium and multi regional trade model for the global economy considering 11 world regions which are linked through bilateral sectoral trade flows Based on GTAP data[3], based on 1995. In comparison to the above described models, WAGE can be classified as top- down, multi- regional trade model in line with MRT and IIAM.

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[2] MERGE: Manne et. Al. (1998), POLES: Russ (1999), Wordscan: Bollen et. Al. (1999), Mackibbin (1999), GREEN: Burniaux (1998), EPA: Edmonds (1998), PRIMES: Capros (1998), RICE: Nordhaus and Yang (1996), MIT: Edmonds (1998), CETA: Peck and Teisberg (1991),MRT: Harrison and Montgomery (1999), Harrison and Rutherford (1997)

[3] See McDOUGALL, R.A. (1995)

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

Table 1: World regions

The economic structure of each region consists of 4 production sectors, one non-energy sector and three fossil fuel sectors traded internationally for oil, gas and coal. All products are demanded by intermediate production, exports, investment and a representative consumer, market actors behave within a full competition context, i.e. they take the market price as given with the exception of OPEC countries which can influence the price of oil (non competition case for oil). Consumption and investment decisions are based on rational point expectations of future prices. The representative agent for each region maximises lifetime utility from consumption which implicitly determines the level of savings. Firms choose investment in order to maximise the present value of their companies.

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 (between alternative combinations of inputs). Goods are produced for the domestic and for the export market. Production of the energy aggregate is described by a CES function which reflects substitution possibilities for different fossil fuels (i.e., coal, gas, and oil) and capital, labour representing trade off effects with a constant elasticity of substitution. Fossil fuels are produced from fuel-specific resources and the non-energy macro good subject to a CES technology.

The CES production structure follows the concept of ETA-MACRO combining nested capital and labour at lower level. Energy is treated as a substitute of a capital labour composite determining together with material inputs the overall output (see Figure 2).

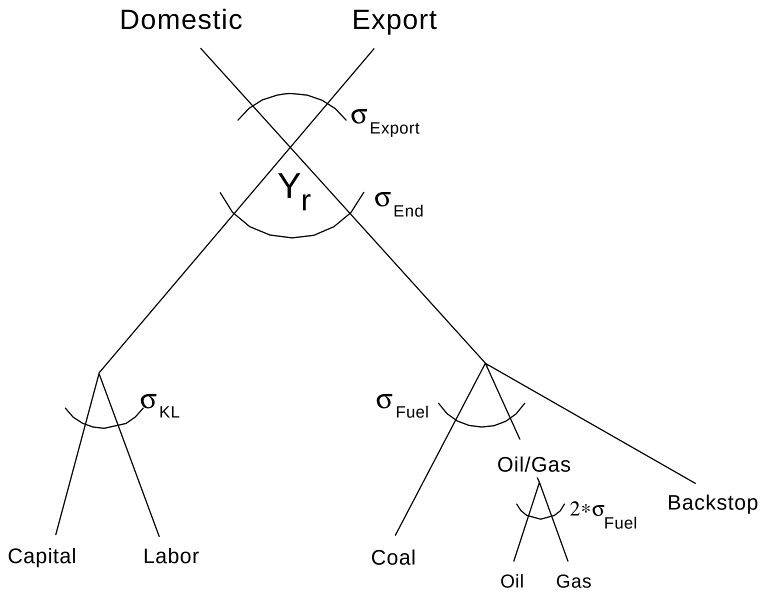

Figure 2: Production Structure

The representative producer of sector j ascertains the *profit function*

$$\Pi_j^Y(p) = \left[a_j^{DX} (p_j^{1-\sigma_{DX}} + (1 - a_j^{DX}) p^{FX^{1-\sigma_{DX}}} \right]^{\frac{1}{1-\sigma_{DX}}}$$

$$- \left[a_j^M p_j^{M^{1-\sigma_{KEM}}} + (1 - a_j^M) \left[a_j^E p_j^{E^{1-\sigma_{KLE}}} + (1 - a_j^E) \left[a_j^K (p^{RK})^{1-\sigma_{KL}} + (1 - a_j^K)(p_j^L)^{1-\sigma_{KL}} \right]^{\frac{1-\sigma_{KLE}}{1-\sigma_{KL}}} \right]^{\frac{1-\sigma_{KLEM}}{1-\sigma_{KLKE}}} \right]^{\frac{1}{1-\sigma_{KLEM}}}$$

with:

a_j^{DM} : Domestic production share of total production by sector j

a_j^K : Value share of capital within capital –energy composite

a_j^L : Value share of labour within capital -energy -labour aggregate

a_j^M : Value share of material within capital-energy-labour material aggregate

p_j : Price of domestic good j

p^{FX}: Price of foreign exchange (exchange rate)

p^{RK}: Price of capital

p_j^E : Price of energy

p_j^M : Price of material

p^L: Price of labour

σ_{KE}: Substitution elasticity between capital and energy

σ_{KEL}: Substitution elasticity between labour and capital and energy composite

σ_{KLEM}: Substitution elasticity between material and labour/ capital and energy- composite

Y: Activity level of production sector j.

Coal production in the OECD and gas production in Russia grow with energy demand at constant prices. The elasticity of substitution between the resource input and non-energy inputs is calibrated to meet a given price elasticity of supply. Exhaustion leads to rising fossil fuel prices at constant demand quantities. The carbon-free backstop technology establishes an upper bound on the world oil price, this backstop fuel is a perfect substitute for the three fossil fuels and is available in infinite supply at one price, which is calculated to be a multiple of the world oil price in the benchmark year. Demand elasticities depend on back stop technologies, by low backstop costs demand elasticities are high and vice versa.

A composite energy good is produced by either conventional fossil fuels - oil, gas, and coal – represented by a nested CES technology (with an elasticity of interfuel substitution σ_{fuel}) or from a backstop source with Leontief technology structures. Oil and gas can be substituted by an elasticity of substitution twice as large as the elasticity between their aggregate and coal. The energy good production is determined by final demand of industry and households .

$$\begin{aligned}\Pi_j^E(p) = p_j^E - \Big[& a_j^{ELE} p_j^{ELE\,1-\sigma_{ELE}} + (1-a_j^{ELE}) a_j^{OIL} (p_j^{OIL} + ef_j^{OIL,CO2} p^{CO2})^{1-\sigma_{FOSSIL}} \Big] \\ & + a_j^{GAS} (p_j^{GAS} + ef_j^{GAS,CO2} p^{CO2})^{1-\sigma_{FOSSIL}} + a_j^{COA} \Big[a_j^{HCO} (p_j^{HCO} + ef_j^{HCO,CO2} p^{CO2})^{1-\sigma_{COA}} \Big] \\ & + a_j^{SCO} (p_j^{SCO} + ef_j^{SCO,CO2} p^{CO2})^{1-\sigma_{COA}} \quad \Big]^{\frac{1-\sigma_{FOSSIL}}{1-\sigma_{COA}}} \quad \Big]^{\frac{1-\sigma_{ELE}}{1-\sigma_{FOSSIL}}} \quad \Big]^{\frac{1}{1-\sigma_{ELE}}}\end{aligned}$$

With:

a_j^{ELE}	Electricity value share of energy aggregate by sector j
a_j^{OIL}	Oil value share of fossil energy aggregate by sector j
a_j^{GAS}	Gas value share of fossil energy aggregate by sector j
a_j^{HCO}	Hard coal value share of coal aggregate by sector j
a_j^{SCO}	Soft coal value share of coal aggregate by sector j
σ_{ELE}	Substitution elasticity between electricity and fossil energy
σ_{FOSSIL}	Substitution elasticity between fossil energy inputs
σ_{COA}:	Substitution elasticity between hard and soft coal

$ef_j^{OIL,CO2}$ CO_2 share of oil in sector j

$ef_j^{GAS,CO2}$ CO_2 share of gas in sector j

$ef_j^{HCO,CO2}$ CO_2 share of hard coalin sector j

$ef_j^{SCO,CO2}$: CO_2 share of soft coal in sector j

p^{CO2} Price of carbon

E_j Activity level of energy production

Demanded energy by households is produced by a CES function:

$$\Pi_{HH}^{E}(p) = p_{HH}^{E} - \left[\sum_{i=EG} a_{i,HH}^{CO2}(p_i^A + a_i^{CO2} p^{CO2})^{1-\sigma_{EG}}\right]^{\frac{1}{1-\sigma_{EG}}}$$

with:

$a_{i,HH}^{E}$ Value share of energy good i of household

p_{HH}^{E}: Price of energy by household demand

σ_{EG}: Substitution elasticities between energy goods

E_{HH}: Activity level of energy production by household

The dynamic model is a growth model, i.e. within equilibrium conditions all sizes are rising by a same growth rate. In the long run, a cap on emissions by an overall upper limit of emissions turns out to be difficult to meet. Because of that a carbon free backstop technology can be utilised within future times at price f^{BS} \$/t CO_2. Zero profit condition is determined by:

$$\Pi^{BS} = p^{CO2} - p^{CG} f^{BS}$$

with:

p^{CG}: Price of consumption good

f^{BS}: Costs of carbon free energy supply

BS: Activity level of backstop technology

A representative agent for each region maximises its region's discounted utility over the model's time horizon under budget constraint equating the present value of consumption demand to the present value of wage income, the value of initial capital stock, the present value of rents on fossil energy production and tax revenue. 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 an 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. The primary factors, capital, labor, and energy are combined to produce output in period t. In addition, some energy is delivered directly to final consumption. Output is separated in consumption and investment, investment enhances the (depreciated) capital stock of the next period. Capital, labor, and the energy resource earn incomes, which are either spent on consumption or saved. Saving equals investment through the usual identity (see Figure 3).

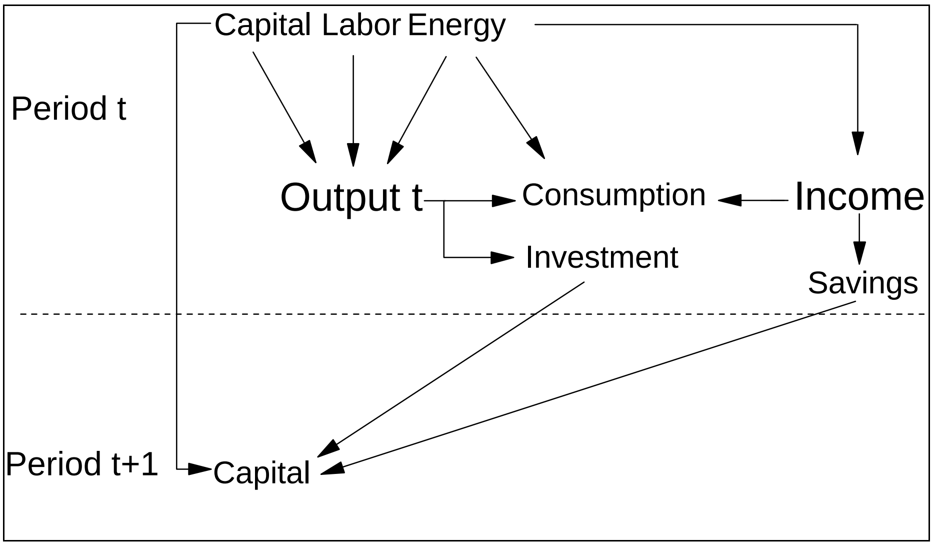

Figure 3: Dynamic structure

Capital is used for production with a capital price p_t^K and an utility price of p_t^{RK} and is depreciated by rate δ:

$$\Pi_t^K(p) = (1-\mathrm{d})\, p_{t+1}^K + p_t^{RK} - p_t^K$$

with:

p_t^K : Price of capital in period t

p_t^{RK} : Price of capital services in period t

K_t: Activity level of capital in period t

Investments are produced by Leontief technology:

$$\Pi^{I}_{t+1}(p) = P \quad p^{K}_{t+1} - \sum_{j} a^{I}_{j} p^{A}_{j,t}$$

a^{I}_{j} Value share investment of good j

I_t: Activity level of investments in period t

P: Time period

One representative agent by each region demands a composite consumption good produced by combining the Armington good and the household energy aggregate good according to a CES configuration. σ_{end} describes the elasticity of substitution between the composite macro good and the energy aggregate. Aggregate end-use energy is composed of oil, gas, and coal with an interfuel elasticity of substitution equal to one. The backstop fuel is a perfect substitute for the energy aggregate. Purchase of the good is financed from the value of the household's endowments of labor, capital, energy specific resources, and revenue from any carbon tax or permit prices, respectively (see Figure 4).

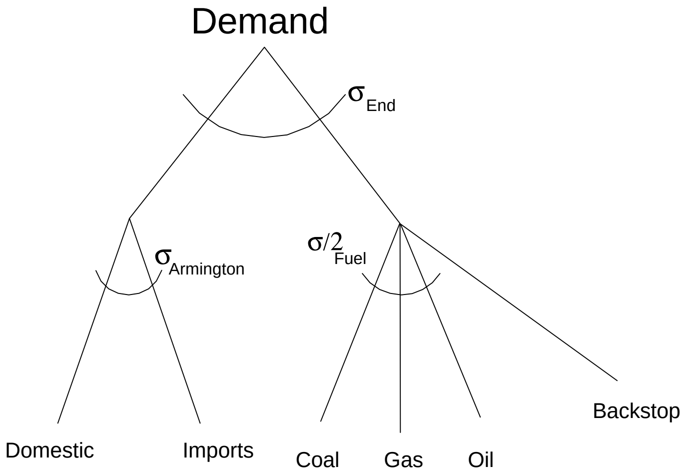

Figure 4: Final Demand Structure

Mathematically, this dependence can be written:

$$\Pi^{CG}(p) = p^{CG} - \left[a_E^{CG}(p_E^{HH})^{1-\sigma_C} + \sum_i a_i^{CG}(p_i^{A})^{1-\sigma_C} \right]^{\frac{1}{1-\sigma_c}}$$

with:

p^{CG}: Price of consumption good

a_E^{CG} : Value share of energy aggregate in final demand

a_i^{CG} : Value share of non- energy good in final demand

CG: Activity level of real consumption good production

Domestic and imported varieties for the non-energy good for all buyers in the domestic market are treated as incomplete substitutes by a CES Armington aggregation function providing a constant elasticity of substitution. With respect to trade in energy, fossil fuels are treated as perfect substitutes, net trade cannot be cross-moved. International capital flows reflect borrowing and lending at the world interest rate, and are endogenous subject to an intertemporal balance of payments constraint considering no changes in net indebtedness over the entire model horizon.

The profit function by *Armington production* is specified by:

$$\Pi_j^A(p) = p_j^A - \left[a_j^A p_j^{1-\sigma_{DM}} + (1-a_j^A)\left(p^{FX}\right)^{1-\sigma_{DM}} \right]^{\frac{1}{1-\sigma_{DM}}}$$

with:

p_j^A : Price of Armington good j

a_j^A : Domestically produced good j value share of domestic and import good aggregate

p^{FX}: Price of foreign exchange (exchange rate)

σ_{DM}: Substitution elasticity between domestically and imported good

A_j: Armington activity level

Emission limits can be reached by domestic action or by trading emission permits within Annex B countries allocated initially due to regional commitment targets. Those countries meeting the Kyoto emissions reduction target stabilise their mitigated emissions at 2010 level.[4]

According to regional abatement costs countries will sell or buy emission permits. Countries facing high abatement costs above permit prices will purchase emission permits, regions with marginal abatement costs lower than the permit price will vend emission licenses. Revenues from selling permits are refunded lump-sum back to the representative consumer in the abating country. Within this context it has to be stressed that problems around the concrete implementation of the flexible mechanisms and emissions trading scheme, like on compliance, early crediting and cheating in order to influence permit prices etc. are neglected within the modelling context.

Because of the international and flexible structure WAGE is especially useful to investigate international GHG abatement policies under various key assumptions variations like the world and regional development of emissions baselines or a full versus a ceiling on emissions trading.

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[4] This can be called as “Koto forever” scenario

Ceiling on trade under assorted emissions baseline assumptions

The quantitative results contain committed emission reduction levels for specific countries due to the Kyoto protocol mitigating greenhouse gas emissions by 5.2 % below 1990 level within the commitment period 2008 to 2012.

Following scenarios cover different assumptions about world baseline emissions level. Within the high world baseline emissions level scenario, world carbon emissions develop from 2000 by about 8 billion ton of carbon to about 12 billion tons of carbon in 2030 (see Figure 6). Key model parameters cover Armington elasticities, backstop costs and oil supply eleasticities.[5] Within the Default or BAU scenario, all key parameter are adopted as demonstrated in Figure 5.

Type of elasticity	Value
Armington elasticity of substitution	1
Armington elasticity of transformation	2
Elasticity of fossil fuel supply	1 (coal), 4 (gas, oil)
Elasticity of substitution between non-energy and energy composite in production and final demand	0.25-0.5 (Annex B), 0.20-0.4 (non-Annex B)
Interfuel elasticity of substitution	0.5 (final demand) 2[a],1[b] (industry)

[a] between oil and gas, [b]between coal and the oil-gas aggregate

Figure 5: Overview of key parameter

Figure 6 demonstrates the development of the miscellaneous world baseline emissions levels.

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[5] For model sensitivity analysis, see Kemfert (1999)

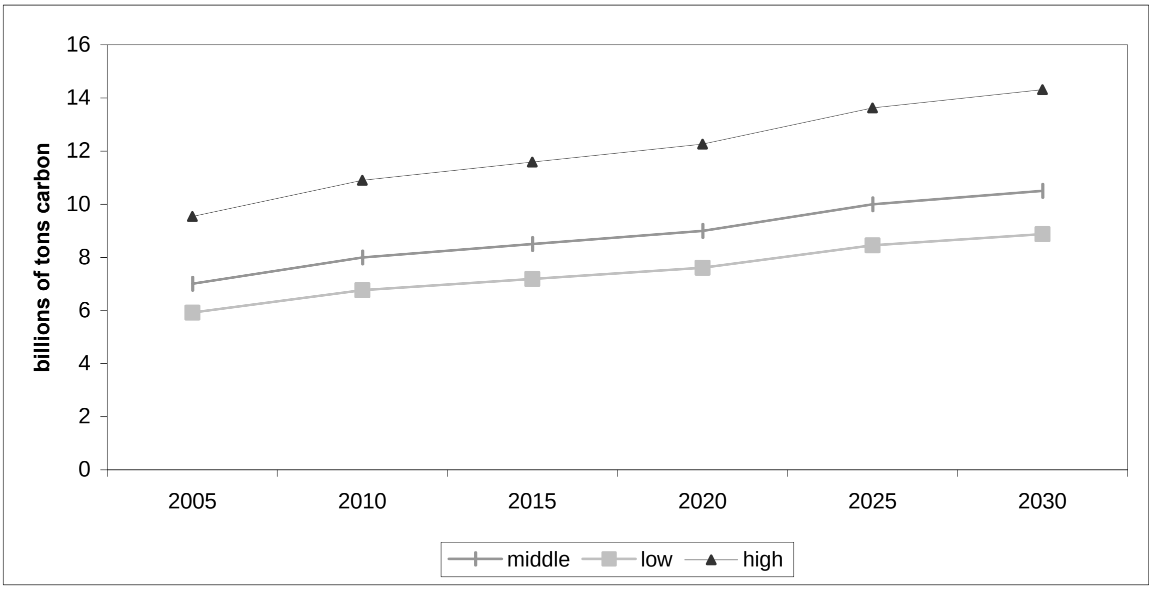

Figure 6: World Carbon emissions paths

Countries and regions can either meet their individual reduction targets by domestic action only or Annex B countries can trade their emissions permits due to their starting commitment emissions reduction aim. Table 2 gives the commitments for the developed countries / regions as represented in the analytical framework. Regional economic growth rates correspond to MERGE growth rate.[6] Countries in transition like Russia are represented by declining economic growth rates, i.e. these countries can sell emissions permits allocated initially by the Kyoto protocol. Table 2 demonstrates the quantified emissions limits committed within the Kyoto protocol of December 1997.

Country or Region	Label	Commitments (Percentage of 1990 Base Year Greenhouse Gas Emissions)
Canada, New Zealand, Australia[a]	CAN	99
European Union	EU15	92
Russia, Eastern and Central European Countries[b]	REC	98.3
Japan	JPN	94
United States of America	USA	93

Table 2: Quantified Emissions Limits under the Kyoto Protocol

[a] The reduction commitments of Canada (94), New Zealand (100) and Australia (108) are weighted based on the individual 1990 emission levels.

[b] The effective reduction rate for REC is derived from the individual commitments of countries belonging to the REC region.

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[6] See Manne, Mendelsohn and Richels (1995)

At the domestic policy level governments are free to choose the policy instrument (e.g. emission taxes, command and control measures, voluntary agreements) in order to meet their emission reduction target.

Model calculations as a comparison of welfare implications due to an emissions reduction implementation demonstrated in Table 2 against a scenario without any constraints (business as usual BAU) exhibit negative welfare implications to developed and developing countries. Energy prices decrease because of energy demand decline, energy exporting countries are suffering as well as due to negative trade spill over effects.[7] If the impacts on global and regional welfare are measured as the Hicksian Equivalent (EV), i.e. the percentage Hicksian equivalent in lifetime income, of world regions in comparison to the BAU scenario, negative welfare implications happen to developed as well as to developing countries because of international spill over effects. The welfare losses concern even the developing countries like China and India, although increasing production and investment within energy intensive sectors inducing carbon leakage can be detected, these results are not in line with other MRT model outcomes like, for example, *Bernstein and Mongomery (1999)* observing positive welfare impacts to developing countries by meeting the Kyoto emissions reduction targets. Within this analysis negative welfare implications occur also for developing countries like China and India because increasing production effects due to a comparative advantage within energy intensive sectors can be offset by negative economic effects due to decreasing energy prices and negative trade spill over effects by Annex B countries. Globally, Annex B countries are more dominant economically influencing non Annex B countries negatively by trade spill over significances.

The initial permit allocation is defined by the Kyoto protocol, the revenue is lump- sum transferred back to the individual economies. Annex B emissions permits trading offers the opportunity for participating countries to sell and buy permits due to their reduction targets and marginal abatement costs. As expected within a general equilibrium modelling framework, global welfare is improved by Annex B permit trading revealing permit trading as a Pareto - improving policy measure.

A comparison of a trade versus no trade scenario demonstrate that all countries can benefit by Annex B permit trading, mainly countries in transition as REC because of the “hot air” effect previously described. Emissions permit trading better off all Annex B countries as well as non Annex B or developing countries because of international trade spill over effects. Annex B countries facing high emissions reduction targets and high domestic marginal abatement like Japan and USA costs will certainly benefits by Annex B emissions permit trading. Essentially, USA and EU 15 will trade permits within a full trade scenario because of their high share on total carbon emissions. Assuming a modest development of world emissions, USA, Canada, Japan and

EU 15 will buy emissions permits because of their marginal abatements costs higher than the permit price, main seller of emission permits will be REC, Russia and other Eastern European countries because of their non binding committed reduction targets.

	Trade / no trade	Change
Japan	0,13	++
China	0,04	+
USA	0,11	++
SSA	0,06	+
ROW	0,03	+
CNA	0,09	++
EU15	0,06	+
REC	0,87	+++
LSA	0,08	+
ASIA	0,04	+
MIDE	0,32	++

Table 3: HEV Comparison of Annex B permit trade: trade versus no trade

World economic implications by Kyoto mechanisms will substantially depend on a suitable definition of the emissions baseline projection path and the concrete implementation of an emissions trading scheme. International negotiations processes expose controversy debates on an emissions reduction option by domestic action or by international Kyoto mechanisms like emissions trading. More precisely, domestic action or domestic measures in order to reduce emissions are encouraged by a limitation of emissions permit trading. Under equity aspects, international welfare implications should be harmonised and equalised by a degraded option to purchase or sell emissions permits through a ceiling on emissions trade. Various ceiling options of a contribution by emissions trading are discussed.[8]

Within this study, two different options of emissions baseline development paths (see Figure 6) are assumed, a *ceiling* notified further as *cap* on emissions trading is introduced as percentage term of Assigned Amount (AA). A *low cap* on emissions trading (ET) signifies that 10 percent of the AA of emissions have to be reduced by domestic action, i.e. 90 percent of AA can be traded, a *high cap* on emissions trade means 80 percent of AA emissions are abated by domestic action. In order to illustrate the different impacts of emissions baseline developments as well as cap on emissions trading assumptions following scenarios are compared:

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[7] See Kemfert (1999)

[8] See OECD (1999 a and b)

LC	Mid Emissions level and *L*ow *C*ap on ET
HC	Mid emissions level, *H*igh *C*ap on ET
HCHE	*H*igh *E*missions level, *H*igh *C*ap on ET
LCHE	*H*igh *E*mission level, *L*ow *C*ap on ET
LCLE	*L*ow *E*missions level, *L*ow *C*ap on trade

Table 4: Scenario definition

Table 5 demonstrates the Hicksian Equivalent variation as comparison to a full emissions trading scenario with moderate emissions development assumptions. Not surprisingly, a ceiling on emission permit trading induce negative global economic implications, mainly to the countries in transition of Eastern Europe and Russia as well as in Annex B countries. Due to high emission baseline projections these effects are much higher than in a low emissions case. Additionally, a cap on emissions trading induce negative implications to developing countries because of international negative trade spill over effects exhibited by terms of trade developments overcompensating the positive economic effects due to Annex B emissions trading. Highest economic losses in terms of GDP and terms of trade contraction occur within high assumptions about baseline emissions development because of higher abatement targets by Annex B countries leading in negative spill over effects even to developing countries. Within Annex B permit trading, Russia will be the main permit seller resulting in lower investment behaviour because of a full economic subsistence through permit trade, a protection of Annex B emissions trading leads to an increase of investment in Russia.

Assumptions about low emissions baseline projections approves mainly economies with high emissions level allowing less mitigation levels but lowers on the other hand the opportunities for developing countries to grow as in a case with high economic expansion. In comparison to a full emission trade scenario with a moderate emission baseline development Annex B countries can benefit by welfare increases because of less efforts meeting the reduction target. EU 15 can increase welfare significantly because of higher options to be a net seller of permits.[9] In total, the negative effects by a ceiling on emissions trading are affecting the economies in transition most negatively resulting in additional negative impacts for developing countries. EU 15, as the main advocate of a ceiling on emissions trading, can benefit by an emissions trading system and will suffer by committing their reduction targets through mainly domestic action (*HC*). Other Annex B economies like USA or

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[9] Within a bottom up analysis for Europe, countries with huge economic potentials like Germany and France will sell emissions permits whereas Italy or Denmark will purchase emissions permits, see Ybema et al. (1999).

Canada will suffer by a cap on emissions trading because of high domestic marginal reduction costs and hence limited options of an efficient application of domestic emissions reduction measures.

	LC	HC	HCHE	LCHE	LCLE
Japan	-0,19	-0,27	-0,32	-0,28	0,04
China	-0,13	-0,46	-0,54	-0,29	-0,13
USA	-0,31	*-0,55*	*-0,99*	-0,48	0,05
SSA	-0,05	-0,38	-0,46	-0,06	-0,05
ROW	-0,05	-0,15	-0,19	-0,12	-0,04
CNA	-0,09	-0,39	-1,04	-0,34	0,01
EU15	-0,13	-0,86	-0,58	-0,46	0,09
REC	-0,47	*-4,41*	*-5,07*	*-0,78*	*0,27*
LSA	-0,05	-0,08	-0,1	-0,16	-0,05
ASIA	-0,05	-0,09	-0,11	-0,10	-0,09
MIDE	-0,60	-0,65	-0,78	-0,32	-0,23

Table 5: Welfare Impacts of a ceiling on trade in Hicksian EV in comparison to Annex B ET scenario

A reduction of carbon emissions in Annex B countries might be offset by increased emissions in non Annex B countries like China and India through a migration of energy intensive sectors. This effect is named as carbon leakage impact. Global and regional carbon leakage effects resulting in higher emissions in countries without binding emission reduction targets appear primarily in the prohibited trade scenario and with a high cap on emissions trading. Main emissions leakages emerge within the high emissions scenario (*HCHE*), full Annex B emissions trading avoid high leakage rates. Looking at regional leakage rates, China will be mainly affected negatively by high leakage potentials because of assumed economic growth options, the comparative advantage of their energy intensive sectors and migration relevance. After reaching the emission reduction target, leagake rates decline after 2010 to 2030. Earlier studies about the effects of international permit trading found often huge capital flows because of fluctuations in real exchange rates and large transfer of wealth. Although financial capital is perfectly mobile within this model context these effects these effects cannot be detected. Within the full trade scenario, Russia and other Eastern European countries will be the main seller of emissions permits resulting in high capital increases and vice versa to capital outflows by purchasers of emission permits like USA and Europe.

HC	CHN	SSA	ROW	LSA	ASIA	MIDE	Total
2010	0.7597	0.1136	0.5795	0.2514	0.4619	0.2225	2.3886
2015	0.4593	0.0682	0.3486	0.1502	0.2804	0.1342	1.4409
2020	0.4591	0.0679	0.3486	0.1492	0.2820	0.1341	1.4408
2025	0.4574	0.0677	0.3480	0.1483	0.2827	0.1342	1.4383
2030	0.4528	0.0669	0.3452	0.1464	0.2810	0.1335	1.4258

Table 6: Global and regional emission leagake in Bil. ton of carbon within HC scenario

HCHE	CHN	SSA	ROW	LSA	ASIA	MIDE	Total
2010	0.8990	0.1345	0.6858	0.2976	0.5466	0.2633	2.8268
2015	0.5435	0.0807	0.4126	0.1777	0.3319	0.1588	1.7052
2020	0.5433	0.0803	0.4125	0.1766	0.3337	0.1587	1.7051
2025	0.5413	0.0801	0.4119	0.1755	0.3346	0.1588	1.7021
2030	0.5359	0.0792	0.4085	0.1732	0.3326	0.1580	1.6874

Table 7: Global and regional emission leagake in Bil. ton of carbon within HCHE scenario

An introduction of a ceiling on emission permit trading lead to lower permit prices because of less permit demand in comparison to a nearly full trade scenario. The overall permit price reaches 20 US $ per ton of carbon in 2010 meeting the Kyoto target in the high emission baseline case (*LCHE*). After meeting the Kyoto target permit prices are decreasing because of declining demand. Full trade or a low cap on emissions trading leads to higher permit prices, vice versa induce a cap on trade lowest permit prices. These results are in line with calculations by for example *Bernstein and Montgomery (1999)* (MRT) and *Edmonds (1998)* (EPA) (see Figure 1).

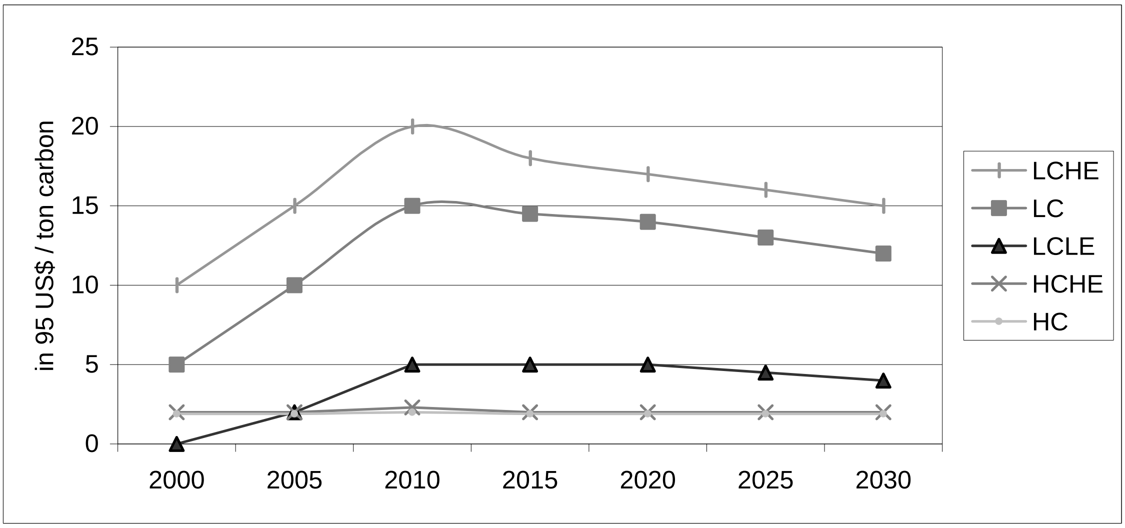

Figure 7: Annex B Permit Prices

Conclusion

World economic implications by Kyoto mechanisms will substantially depend on a suitable definition of the emissions baseline projection path and the concrete implementation of an emissions trading scheme. International negotiations processes reveal dissimilar debates about emissions reduction options by domestic action or by international Kyoto mechanisms like emissions trading. Countries will trade emission permits due to their marginal abatement costs, regions facing high marginal abatement costs possess huge incentives to buy emissions permits. Countries with declining emissions because of substantial economic destruction like Russia can sell their emissions permits, entitled as "hot air" effect.

Carbon emission mitigation targets due to the Kyoto protocol induce not only negative economic impacts to industrialised and developed countries with high emission levels and emissions reduction target but likewise negative impacts to developing countries because of international energy use decreases inducing productivity and international energy price cutbacks. Within the Kyoto protocol emissions permits can be traded due to the initial allocation of signed emissions abatement targets between Annex B countries, model calculation reveal a substantial increase of welfare by meeting the emissions reduction target allowing permit trading. Regionally, countries in transition like Eastern Europe and Russia increase welfare significantly by facing the "hot air" effect. Because of high marginal abatement costs, USA, Japan and EU15 benefit as well by an Annex B trading system, these effects are highest within low baseline emissions assumptions because of lower efforts to meet the targets. A ceiling on emission permit trading induce global negative economic implications, the "hot air" effect can only be weakened by huge welfare losses.

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