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Claudia Kemfert
Truong Truong

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German Institute for Economic Research
Königin-Luise-Str. 5
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Tel. +49 (30) 897 89-0
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IMPACT ASSESSMENT OF EMISSIONS STABILIZATION SCENARIOS WITH AND WITHOUT INDUCED TECHNOLOGICAL CHANGE

Claudia KEMFERT[a,b]
Truong Truong[c]

[a] *German Institute of Economic Research, Berlin, Germany*
[b] *Humboldt University of Berlin, Department of Economics, Germany*
[c] *University of New South Wales, Australia*

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Abstract

The main aim of this paper is to investigate quantitatively the economic impacts of emissions stabilization scenarios with and without the inclusion of induced technological change (ITC). Improved technological innovations are triggered by increased R&D expenditures that advance energy efficiencies. Model results show that induced technological changes due to increased investment in R&D reduce compliance costs. Although R&D expenditures compete with other investment expenditures, we find that increased R&D expenditures improve energy efficiency which substantially lowers abatement costs. Without the inclusion of induced technological change, emissions targets are primarily reached by declines in production, resulting in overall welfare reductions. With the inclusion of induced technological changes, emissions mitigations can result in fewer production and GDP drawbacks.

Key Words: impact assessment of climate policy, technological change
JEL Classification: C6, O3, Q4, D5

Address for correspondence:
Prof. Dr. Claudia Kemfert
Humboldt University and German Institute of Economic Research
Koenigin Luise Strasse 5
14195 Berlin
Email: ckemfert@diw.de

Introduction

A continued accumulation of anthropogenic greenhouse gases (GHGs) will ultimately have severe consequences for the climate as well as ecological and social systems. Irreversible climate changes induce significant economic costs (Kemfert (2005a)). Human induced climate change is a serious problem. The main goal of the climate convention and of climate policy instruments such as the Kyoto protocol is to reduce greenhouse gas emissions to a level that avoids dangerous climate change. In order to reduce the risks of climate change considerably, the European Union has already declared a greenhouse gas emissions reduction target that certifies a maximum global surface temperature increase of 2°C (Celsius) compared with pre-industrial temperatures. In order to reach this target by 2100, a stabilization of greenhouse gas concentrations at 450 ppm would be necessary.

Environmental and climate interventions create constraints and incentives that affect the process of technological change. The imposition of climate control instruments can stimulate invention and innovation processes. Invention and innovation practices are carried out primarily in private firms through increased research and development (R&D). A technological innovation can become widely available by technological diffusion processes. The induced innovation hypothesis recognizes R&D investments as profit-motivated investments stimulated by relative price changes. Climate policy measures that increase the price of fossil fuels augment the market for low-carbon technologies. This effect creates incentives for increased R&D expenditures in the sectors affected by climate change. Increased R&D expenditures bring about technological changes that lower the costs of low-carbon technologies. These effects reduce compliance costs and can lead to increased profits (Porter and van der Linde (1995)). However, investment in R&D could also "crowd out" other investments (Gray and Shadbegian (1998)). This would reduce firms' profits. Econometric tests and simulation results confirm these ambiguous results. Jaffe and Palmer (1997) find that a carbon tax reduces aggregate R&D, causing a decline in knowledge accumulation and the rate of technological progress, which results in a deterioration of income and output. Recent findings, however, illustrate that environmental policies can have a strong positive feedback on innovation and may induce beneficial economic outcomes (Popp (2001 and 2002)).

As modeling results confirm, excluding endogenously determined technological changes tends to overestimate compliance costs (Loeschel (2002)). Some models that incorporate induced technological changes by increased investment in R&D but also increased opportunity costs do not find large impacts on abatement costs (Goulder and Schneider (1999), Nordhaus (2002) and Buonanno et al. (2003)). Popp (2004) finds that induced technological change leads to substantial welfare gains but only small climate impacts in the long run. Goulder and Mathai (2000) find that abatement costs are lower with induced technological change than without. The main difference between the former and the latter modeling experiments is that some approaches find productivity increases for some sectors that are positively influenced by induced technological changes but productivity decreases for other sectors that are influenced negatively. These exercises find that induced technological changes significantly increase the benefits of a specific climate policy strategy but do not largely reduce the costs.

In this paper, we intend to investigate the economic impacts of international climate policies that induce technological changes through increased R&D investment. The main aim of this paper is to introduce induced technological progress in an applied, multi-regional, multi-sectoral integrated assessment model and to evaluate the differences in regional and sectoral outcomes. One primary objective is to investigate whether or not endogenous technological progress has a substantial impact on compliance costs.

The main feature of this paper is that endogenously determined induced technological changes are represented using the multi-sectoral, multi-regional integrated assessment model WIAGEM (**W**orld **I**ntegrated **A**ssessment **G**eneral **E**quilibrium **M**odel), which additionally covers the impacts of climate change. The next section of this paper describes the applied multi-regional, multi-sectoral integrated assessment model WIAGEM that includes induced technological change. The third section illustrates the scenario definition, while the fourth section summarizes the main model outcomes and compares different climate control policies. The last section concludes.

Model Description and Calibration

Model simulations are based on the applied general equilibrium model WIAGEM, an integrated assessment model merging an economy and energy market model with a detailed climate module and ecological impact studies. This approach is based on a recursive dynamic general equilibrium approach. WIAGEM covers a time horizon of 100 years incremented in five-year time steps. A detailed model description is provided by Kemfert (2002b). The basic idea behind this modeling approach is the evaluation of market and non-market impacts induced by climate change. The economy is represented by 25 world regions aggregated into 11 trading regions (countries) with each region covering 14 sectors. The sectoral disaggregation contains five energy sectors: coal, natural gas, crude oil, petroleum and coal products, and electricity. The dynamic international energy market for oil, coal and gas is modeled by global and regional supply and demand. The oil market is characterized by imperfect competition. The model describes OPEC regions as using their market power to influence market prices. Energy-related greenhouse gas emissions occur as a result of economic and energy consumption and production activities.

Currently, a number of gases have been identified as having a positive effect on radiative forcing (IPCC (1996)) and are included in the Kyoto protocol as the “basket” greenhouse gases. The model includes three of these gases: carbon dioxide (CO_2), methane (CH_4) and nitrous dioxide (N_2O). As CO_2 is a long-living gas, we divide the atmospheric lifetime of gases into special time sections. The atmospheric concentrations induced by energy-related and non-energy-related emissions of CO_2, CH_4 and N_2O have impacts on radiative forcing, influencing potential and actual surface temperature and sea level. Market and non-market damages determine regional and overall welfare development.

Trace Gas	**CO_2**	**CH_4**	**N_2O**
Atmospheric Concentration			
Pre-industrial (ppmv*, ppb**)	278	789	275
1992 (ppmv*, ppb**)	353	1.720	310
Energy-Related Emissions			
1992 (billion tons)	6.0	.08	.0001
Non-Energy-Related Emissions			
1992 (billion tons)	1.2	.454	.0139
Growth rate, post-1992	2	.8	.2

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)
Inter-fuel elasticity of substitution	0.5 (final demand), 2 (industry)
Autonomous energy efficiency improvement (AEEI) (% per year)	2
Sensitivity parameter for R&D investments (β)	0.5

* parts per million by volume (CO_2, CH_4),

* * parts per billion (N_2O)

Table 1: Key Model Parameters of WIAGEM[1]

In each region, production of the non-energy macro good is captured by an aggregate production function. It characterizes 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 maximize 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 productivities of a unit of investment and a unit of consumption are equalized within and across countries. Domestic and imported varieties of the non-energy good for all buyers in the domestic market are treated as imperfect substitutes by a CES Armington aggregation function, constrained to constant elasticities of substitution. Emissions limits can be reached by domestic action or by trading emissions permits within Annex B countries (initially) allocated according to regional commitment targets. A full description of the regions and sectors and the calibration of the model are shown by Kemfert (2002b).

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

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[1] Source: IPCC (2000), N_2O: natural sources are included.

Induced technological change is considered as follows. Energy is treated as a substitute of a capital–labor composite determining (together with material inputs) overall output. The CES production structure combines nested capital and labor at lower levels (a mathematical description can be found in Annex II). The incentives to invest in technology innovations are market driven. Climate policies (emissions mitigation targets) as well as negative climate change impacts induce incentives to invest in knowledge through R&D investments (ITC). We assume that climate change has substantial impacts on the economy. Furthermore, climate policy interventions have an impact on relative factor prices, e.g. fossil fuels becoming more expensive. Countries react to negative climate impacts and climate control policy measures by spending a specific amount of their investments on R&D.[2] In the benchmark year, we assume that R&D investment as a share of total output is 2%.[3]

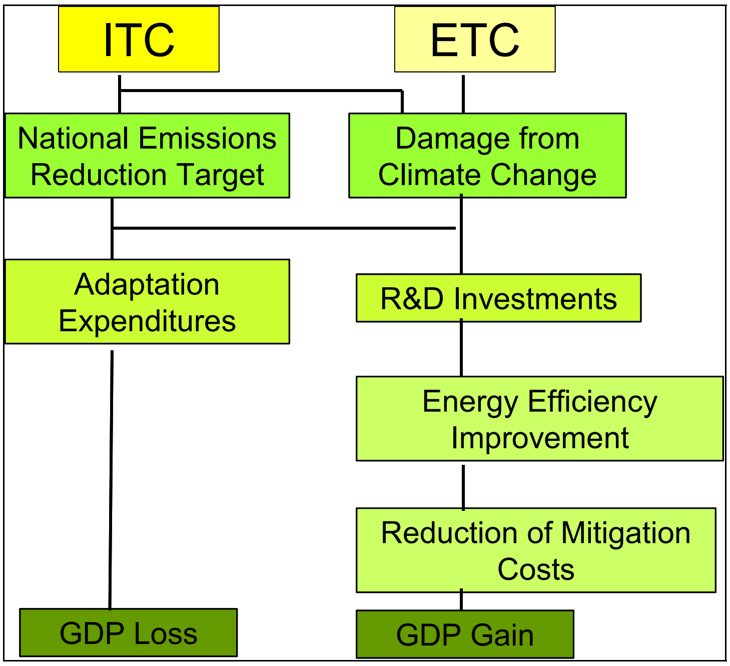

Figure 1: Interrelations between Induced and Endogenous Technological Change

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[2] In this analysis, we assume that emissions mitigation targets are exogenously given to meet the emissions control level. Climate damage does not influence the regional emissions reduction targets. As countries have to meet a global emissions mitigation level, we abandon the modeling of endogenous emissions reduction targets.

[3] We follow Nordhaus (2002), who applied an average share of 2% per year. In 2002, the USA spent 2.7% of national GDP on R&D investment. Japan spent 3%, France 2.2%, Germany 2.5%, the UK 1.9% and Canada 1.8%. Source: National Science Foundation.

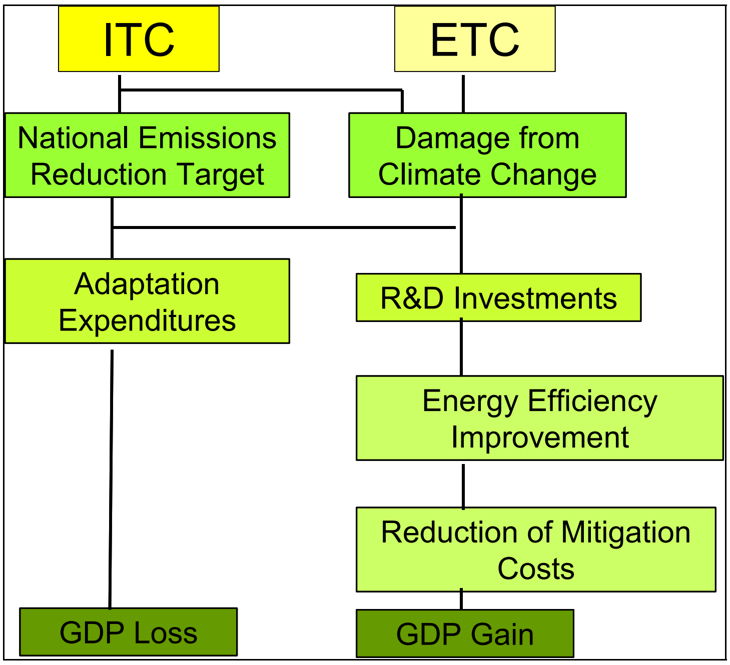

Figure 1 illustrates the interrelations between induced technological change (ITC) and endogenous technological change (ETC). In the baseline, we do not allow for induced technological changes, as we do not incorporate any climate protection policy. However, we allow endogenous technological change that is not triggered by climate protection goals but through damage from climate change. There are two driving forces that induce increased expenditures on R&D (ITC): climate impacts and climate policy measured in national emissions reduction targets (the reaction function can be found in Annex II). This mechanism works as follows: rising sectoral emissions increase climate change impacts. If welfare is negatively affected by climate change, regions start to invest in climate protection, i.e. adaptation expenditures. The greater the damage, the higher the adaptation expenditures and the less is spent on R&D investments as they compete with investment in adaptation. However, regions also invest in R&D if they have to meet binding emissions reduction targets. The higher the climate impacts, the more is spent on adaptation and the less on R&D investments. The higher the climate protection goals, the more is spent on R&D investments and the less is spent on adaptation.

New knowledge produces new processes and products, which lower the energy intensity of output.[4] If we assume a high R&D investment share, emissions intensity is decreased substantially. A lower share of R&D investment leads to less significant emissions intensity declines. This methodology is different from other approaches, such as those of Nordhaus (2002), Popp (2004) and Goulder and Schneider (1999). As we do not assume that there is a specific R&D sector to find the optimal spending on R&D, and we assume that R&D spending leads to a substantial reduction in energy intensity, emissions abatement becomes less costly.

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[4] We find a strong relationship between R&D expenditures and energy efficiency improvement: e.g. Germany reduced R&D expenditures drastically at the beginning of the nineties which resulted in a sharp drop in energy efficiency.

Scenario Definition

We investigate the economic consequences of four different emissions concentration scenarios.[5] The baseline scenario does not include any climate policy or any emissions stabilization targets. However, in the baseline, an autonomous energy efficiency parameter increases energy efficiency by 2%. The other emissions concentration stabilization scenarios intend to stabilize emissions at 550, 500, 450 and 400 ppm by 2100. Due to the emissions constraint, all regions implement emissions mitigation policies. Induced technological change initiate that emissions abatement can be attained with higher energy efficiency standards, as R&D investment is spent on improving energy efficiency in those regions that are negatively affected by climate change. We compare the emissions stabilization scenarios with and without the inclusion of technological change and with a baseline where only a specific percentage change improvement in energy efficiency is considered.

Model Results

In the baseline, we assume that energy efficiency improves primarily by endogenous investments in R&D that are triggered by damage from climate change (ETC). As in the baseline there is no climate protection goal, damage is higher than in all other scenarios. With high damage from climate change, adaptation expenditures are higher than R&D expenditures. This leads to lower endogenous energy efficiency improvement than in the emissions stabilization scenarios (Figure 3). Although the effect is very small, ETC leads to marginal reductions in emissions (Figure 2) and a reduction in abatement costs measured as GDP increases (Figure 4).

In the emissions stabilization scenarios, emissions reductions are higher with the option of allowing for induced technological change. As we model emissions reduction targets not as concrete stabilization levels that need to be met in 2100 but as percentage reductions in each time period, we find that emissions decline is even higher with the inclusion of technological change. The reason for this is that induced technological changes lead to increased energy efficiency which results in higher emissions reductions. This effect is higher, the higher the emissions reduction target is (Figure 2).

We also find that achieving the Kyoto reduction targets is costly for the developed regions which have to commit to quantified emissions reduction targets (as also found by Carraro et al. (2003) and Kemfert (2002a)). As can be seen from Figure 4, GDP losses are highest for the high emissions mitigation scenario (stabilization at 400 and 450 ppm CO_2). This is especially visible within a time horizon of 100 years (in 2100). The 400 ppm scenario triggers the highest economic costs and can only be met if drastic emissions reduction measures take place as early as possible. If emissions reduction measures start in 2030, the emissions stabilization target of 400 ppm cannot be met.[6] The permit price rises to 600 US$/tC in the 400 ppm scenario, but is much lower in the other scenarios (Figure 5). With high emissions stabilization targets, damage can be reduced substantially (Figure 6).

GDP losses are less substantial if induced technological change is allowed. This is because ITC lowers economic costs. Countries face substantial impacts from climate change (Kemfert (2005a and 2005b)). Induced technological change occurs because countries with binding emissions mitigation targets invest in both adaptation and R&D investments. The higher the

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[5] In this modeling comparison exercise, we settle on these different emissions and stabilization scenarios. The synthesis paper elaborates more on the uncertainties of the scenario definition, see Edenhofer et al (forthcoming).

[6] We found in another study that an emissions stabilization to reach a 2°C temperature target cannot be met if countries start emissions reduction after 2025; see Kemfert (2005a).

climate impact, the more is spent on adaptation and the less is spent on R&D investments. But countries also spend more on R&D the higher the emissions mitigation target is. As investment in R&D improves energy efficiency, emissions abatement targets can be met with less economic decline. Emissions reduction targets can be achieved either through an increase in energy efficiency (substituting emissions-intensive technologies) or through a decline in production.[7] The latter would be more cost-intensive. For example, in the 400 ppm scenario, very drastic emissions abatement would be necessary, especially in the first 50 years. In the model, this could be reached either by a complete substitution of emissions-intensive technologies, i.e. an increase in energy efficiency, or by a decline in production. With ITC, countries react with the former; without ITC, countries react primarily with the latter. In the emissions reduction scenario of 450 ppm, R&D investment shares reach 35% of total investments (Figure 3). In the 400 ppm stabilization scenario, R&D investment reaches up to 90% of total investments if we assume an R&D sensitivity parameter, β, of 1.5.[8] With a lower sensitivity parameter (β=0.5), R&D investments are lower, especially in the early time periods when climate change impacts are minor. With rising climate impacts and less expenditure on R&D (with β=0.5) in earlier periods, output is more negatively affected both by climate change and by fewer mitigation options through technological change. Both effects lead to a greater disparity within the earlier time periods but to a convergence of R&D expenditures in the long run. The highest share of R&D expenditure comes from industrialized regions.

Conclusion

This paper investigates the economic impacts of emissions stabilization scenarios with or without induced technological change (ITC). Model calculations demonstrate that with the incorporation of ITC, emissions stabilization targets can be met with lower compliance costs. Induced technological change leads to an increased share of R&D expenditures which lowers the costs of innovative and energy-efficient technologies.

Strong emissions mitigation targets can only be met if countries start to implement climate policy as early as possible. Without the inclusion of ITC, countries react basically with declines in production rather than increases in R&D expenditures.

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[7] We also assume that a so-called carbon-free technology is available at a high fossil fuel price; see Edenhofer et al. (forthcoming).

[8] The stabilization scenario of 400 ppm is very special: because there are no longer any climate impacts, R&D investments increase drastically and crowd out other investments. Because of very drastic emissions reductions in the early time periods, economic costs are higher in the first 50 years than in the last 50 years.

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Annex I: Figures

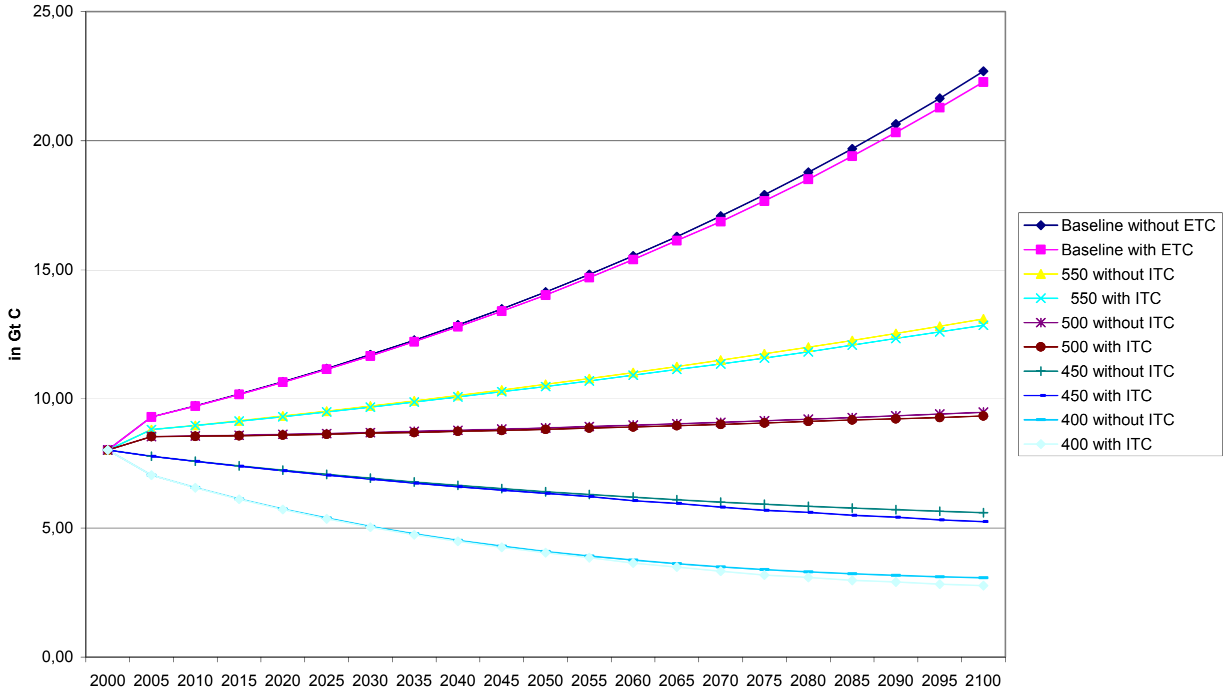

Figure 2: Carbon Dioxide Concentrations under Different Emissions Stabilization Scenarios with and without Technological Change

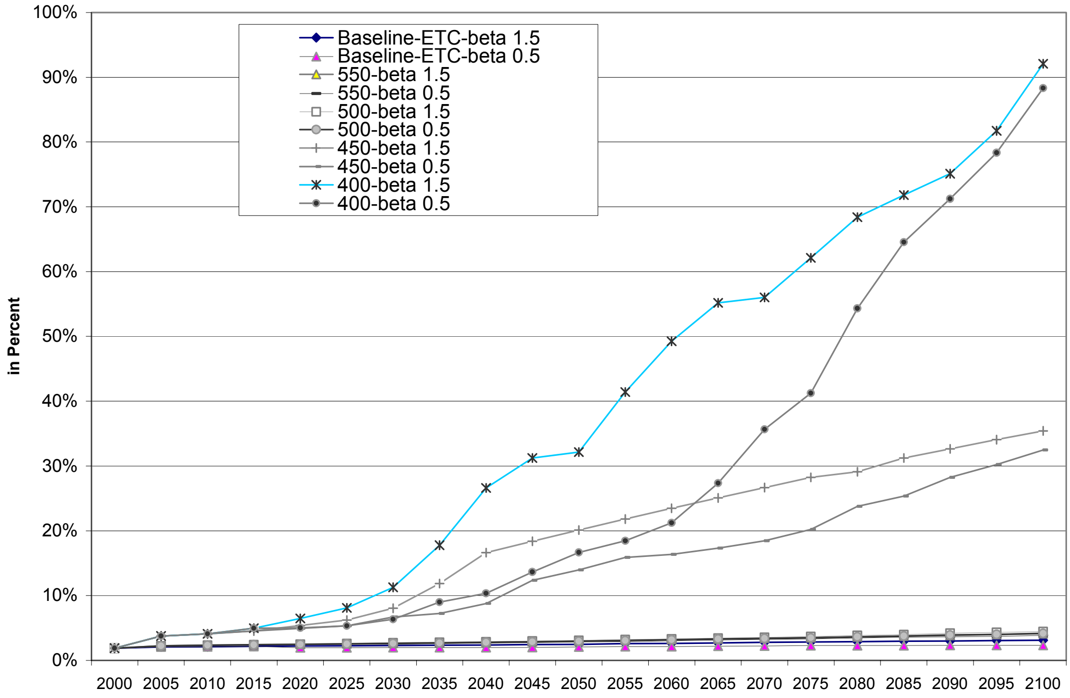

Figure 3: World R&D Investment Shares (percentage of total investment): Sensitivity to β

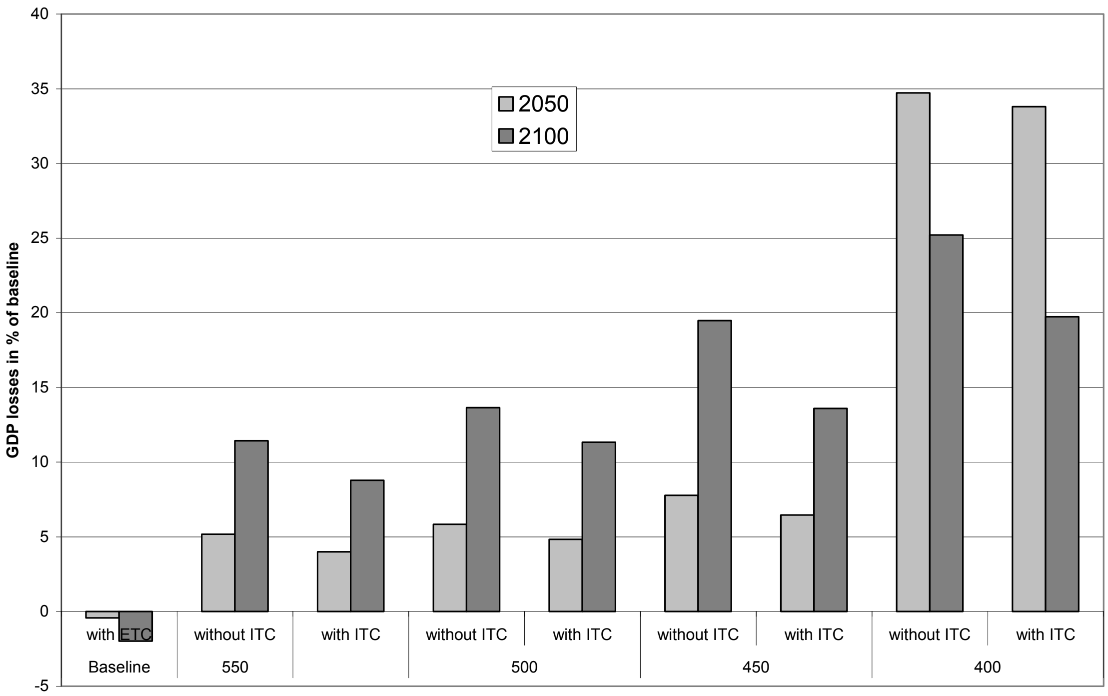

Figure 4: GDP Losses under Different Emissions Stabilization Scenarios

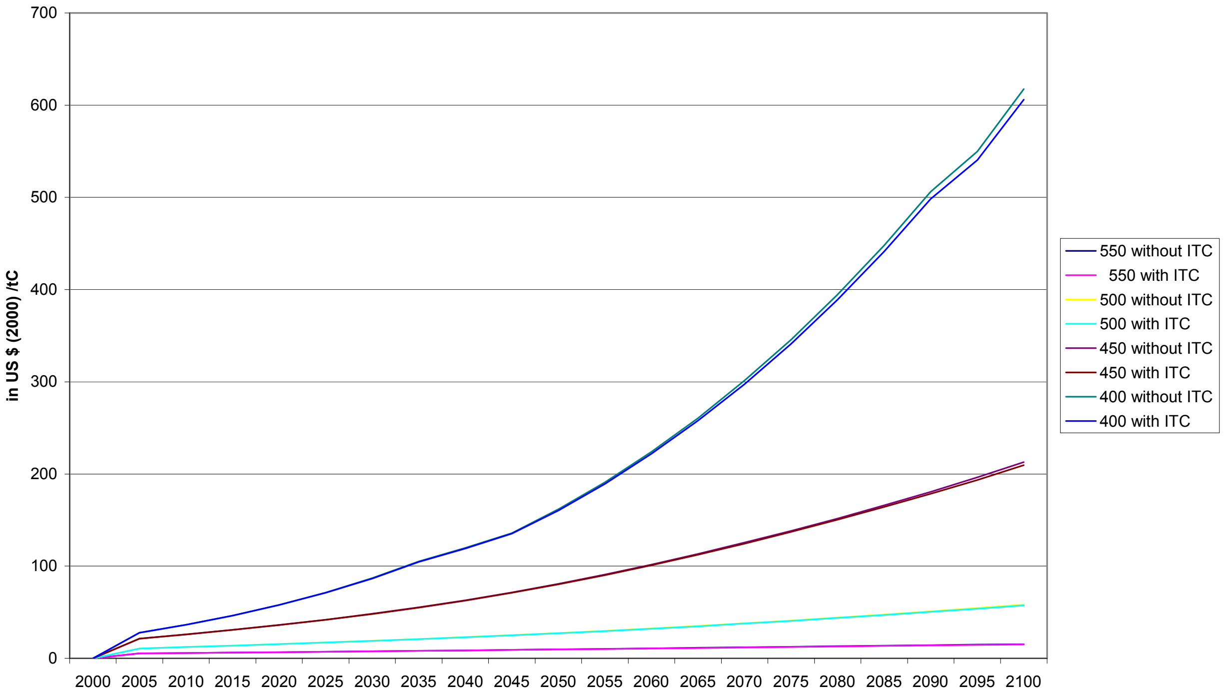

Figure 5: Permit Prices under Different Emissions Stabilization Scenarios

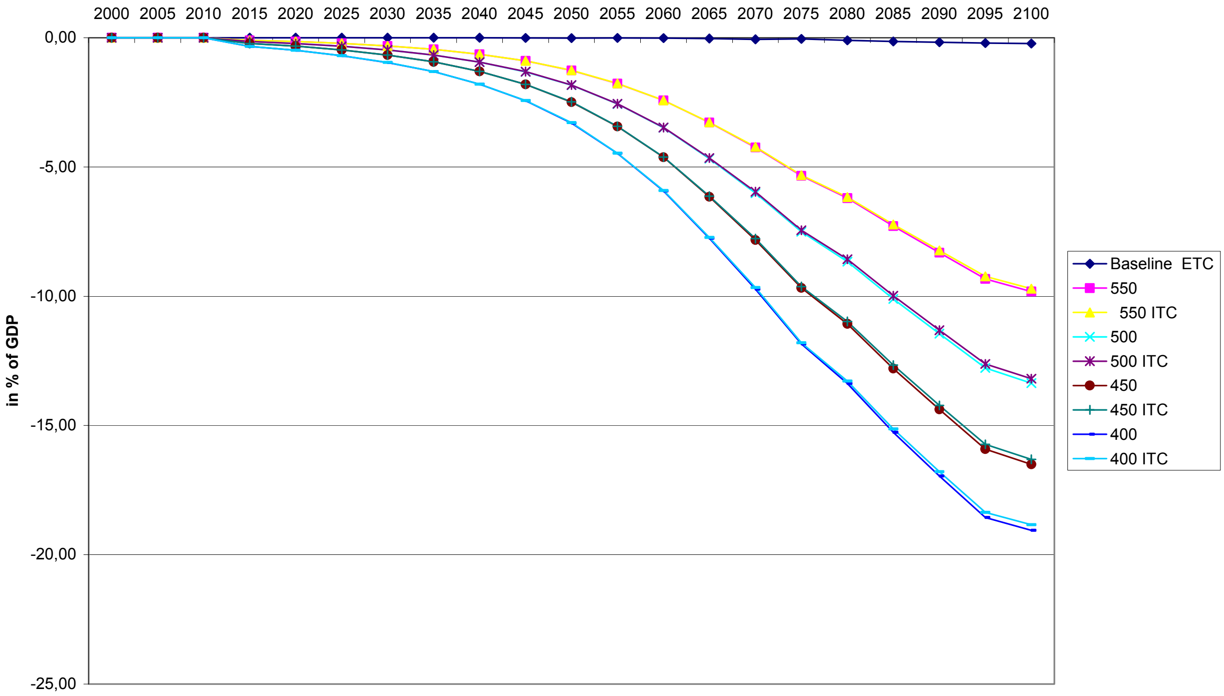

Figure 6: Avoided Damage compared with Baseline

Annex II. Mathematical Description

In order to include induced technological change in WIAGEM, we assume that the energy output ratio, i.e. the energy productivity, is influenced by knowledge improvements that are determined by the accumulation of R&D investments. Investment in R&D and knowledge stock only takes place if countries implement climate control measures. If countries are affected by the negative impacts of climate change, they increase investment in protection as well as investment in R&D. Furthermore, sectors invest in R&D if they have to meet binding emissions reduction targets. New knowledge produces new processes and products, which lower the energy intensity of output. This methodology is different from other approaches such as those of Nordhaus (2002), Popp (2004) and Goulder and Schneider (1999). As we do not assume that there is a specific R&D sector to find the optimal spending on R&D, and we assume that R&D spending leads to a substantial reduction in energy intensity, emissions abatement becomes less costly.

The representative producer of region *i* and sector *j* ascertains the CES *profit function.* In this description, we stick to the dual approach in order to be consistent with previous publications of WIAGEM and because of better comparison to other CGE modeling approaches.[9]

$$\Pi^{Y}_{i,j}(p) = A\left[a^{dx}_{i,j}(p_{i,j}{}^{1-\sigma_{dx}} + (1-a^{dx}_{i,j})p^{fx1-\sigma_{dx}}\right]^{\frac{1}{1-\sigma_{dx}}}$$

$$-\left(a^{m}_{i,j}p^{m1-\sigma_{klem}}_{i,j} + (1-a^{m}_{i,j})\left(EP^{E}_{i}\,p^{e1-\sigma_{kle}}_{i,j} + (1-EP^{E}_{i})\left[a^{k}_{i,j}(p^{rk}_{i,j})^{1-\sigma_{kl}} + (1-a^{k}_{i,j})(p^{l}_{i,j})^{1-\sigma_{kl}}\right]^{\frac{1-\sigma_{kle}}{1-\sigma_{kl}}}\right)^{\frac{1-\sigma_{klem}}{1-\sigma_{kle}}}\right)^{\frac{1}{1-\sigma_{klem}}}$$

with:

$\Pi^{Y}_{i,j}$: Profit function of region *i* and sector *j*[10]

$Y_{i,j}$: Activity level of region *i* and sector *j*

A: Productivity factor

$a^{dx}_{i,j}$: Regional domestic production share of total production by sector *j*

$a^{k}_{i,j}$: Regional value share of capital within capital-energy composite

$a^{m}_{i,j}$: Value share of material within capital-energy-labor -material composite

$p_{i,j}$: Regional price of domestic good *j*

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

$p^{rk}_{i,j}$ Regional price of capital for sector *j*

$p^{e}_{i,j}$: Regional price of energy of sector *j*

$p^{m}_{i,j}$: Regional price of material/land of sector *j*

$p^{l}_{i,j}$: Regional price of labor of sector *j*

$\sigma_{dx:}$ Elasticity of transformation between production for the domestic market and production for the export market

σ_{ke}: Substitution elasticity between capital and energy

σ_{kle}: Substitution elasticity between labor, capital and energy composite

σ_{klem}: Substitution elasticity between material and labor, capital and energy composite

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[9] A full description of the model, including all equations and interlinkages, is provided in Kemfert (2002b).

[10] The notation Π with the superscript *Y* is used to consider the activity subset, which is represented by production *Y*. Because of the zero profit condition, this equation needs to be equal to zero.

$EP^{E}_{i,t}$: Regional increase in energy productivity[11]

$EP^{E}_{i,t} = \kappa^{E}_{i,t} \cdot KR\&D^{\theta}_{i,t}$ represents the energy productivity. Regional R&D expenditures in energy (*KR&D*) improve innovations in more energy-efficient technologies. κ parameterizes the efficiency of R&D. θ is the elasticity parameter (with $0 \le \theta \le 1$).

The reaction function of R&D investments is as follows:

$I^{R\&D}_{i,t} = \left[\delta^{E}_{i,t}, I_{i,t}\right]^{\vartheta}$ with $\delta^{E}_{i,t} = \phi_{i,t}\left(\frac{Y_{i,t}}{CI_{i,t}}\right)^{\beta}$ $\forall\ 0 \le \delta^{E}_{i,t} \le 1$, $0 \le \phi_{i,t} \le 1$ and $\Phi = 0.01$ in the baseline,

where $CI_{i,t}$ is the impact of climate change, β ($0 \le \beta \le 1.5$) and ϑ are sensitivity parameters and $\phi_{i,t}$ is the percentage of regional emissions abatement. The total emissions abatement target, Φ, is defined by the individual scenarios:

$\Phi^{TARGET}_{t} = \frac{E^{TARGET}_{t}}{E^{BASE}_{t}}$ with

TARGET: with emissions stabilization targets of 550, 500, 450 and 400 ppm.
BASE: baseline emissions.
Regional emissions abatement (measured in %) is defined as follows:

$\phi_{i,t} = \frac{E_{TOT}}{E_{i,0}}\Phi^{TARGET}_{t}$ with E_{TOT} as total world emissions and $E_{i,0}$ as baseline emissions in region *i*.

We cover various impacts of climate change. Total climate impacts are determined by the following equation:[12]

$\Delta CI^{r}_{t} = \alpha^{r}_{t} \cdot \left(\Delta PT^{\beta}_{t} \cdot \frac{y^{r}_{t}}{y^{r}_{0}}\right) - I^{PC}_{t}$ with *PT* as potential temperature change, α and β as parameters (varying from 0.5 to 1.5) and y_0 as base-year regional GDP.

We assume that with increasing energy R&D, investment energy productivity would increase as well. R&D investment competes with investment in protection costs, $I^{PC}_{i,t}$, i.e. adaptation:

$I^{PC}_{i,t} = \left[\varepsilon_{i,t}, I_{i,t}\right]^{\vartheta}$ with $\varepsilon_{i,t} = 1 - \delta^{E}_{i,t}$.

Adaptation costs increase with increasing impacts of climate change and are additional investments that a country has to spend if climate change takes place. However, adaptation expenditures do not reduce climate change impacts. We distinguish between conventional investments, investments in R&D and investment in adaptation. The following equation illustrates that the three investments compete against each other. The higher the investments are for adaptation or R&D, the less can be spent on conventional investment.

$$\Pi^{I}_{t+1}(p) = p^{k}_{t+1} - \sum_{j} a^{i}_{j} p^{a}_{j,t} - \varepsilon_{i,t} p^{pc}_{i,t} - \delta^{E}_{i,t} p^{R\&D}_{i,t}$$

$$\varepsilon_{i,t} = 1 - \delta^{E}_{i,t}$$

Π^{I}_{t}: Profit function for investment activity *I* in time period *t*

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[11] As we incorporate variations in energy productivity in a CGE modeling framework, energy productivity changes must be profit-neutral.

[12] The impacts of climate change cover ecological, health, energy and mortality impacts; see Kemfert (2002a).

a_j^i : Value share of investment in good *j*

p_t^k : Price of capital in period *t*

$p_{j,t}^a$: Price of Armington good *j* in time period *t*

$p_{i,t}^{pc}$: Price of investment in protection (adaptation) in time period *t*

$p_{i,t}^{R\&D}$: Price of investment in R&D in time period *t*

The stock of R&D investments ($KR\&D_{i,t}$) increases over time by
$KR\&D_{i,t+1} = R\&D_{i,t} + (1-\lambda)KR\&D_{i,t}$
which determines the accumulation of knowledge stock due to R&D expenditures ($R\&D_{i,t}$) with a depreciation rate of λ.

Emissions Stabilization Target	Technological Change	No Technological Change
Baseline	ETC: $\Phi = 0.01$	No ETC: $\Phi = 0$
Target = 550, 500, 450, 400	ITC: $\Phi_t^{TARGET} = \frac{E_t^{TARGET}}{E_t^{BASE}}$ $\delta_{i,t}^E = \phi_{i,t}\left(\frac{Y_{i,t}}{CI_{i,t}}\right)^\beta \quad \forall\, 0 \le \delta_{i,t}^E \le 1$	No ITC: $\Phi_t^{TARGET} = \frac{E_t^{TARGET}}{E_t^{BASE}}$ $\delta_{i,t}^E = 0$

Table 2: Parameter Assumptions of Different Scenarios