Post-Kyoto Climate Policies: From G8 to L20

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Abstract. In the debate on Post-Kyoto climate policy architectures there is concern about the effectiveness of the inclusive negotiation procedure associated with a Kyoto-type process. A substantial leverage on negotiation outcomes may be achieved by working with a small number of countries representing the major emitters as well as economic and political powers. Such a group may move forward with stringent unilateral emission reduction commitments. We compare the economic impacts of this leadership against a global commitment which keeps with the same world-wide emission budget. In our analysis, we investigate four different emission allocation rules how the costs of leadership change if leadership is assumed to last for ever or restricted to an initial transitional phase.

JEL Classifications: D58, Q43

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1. Introduction

Since spring 2005 the Kyoto Protocol – the first international agreement on climate protection – is in force. It contains legally binding emission targets for industrialized countries to be achieved during the commitment period 2008-2012. While proponents of the Protocol celebrate it as a breakthrough in international climate policy, opponents criticize that its approach, namely negotiating targets and timetables for emission reductions within a comprehensive UNFCCC process, is seriously flawed and ultimately doomed to fail (see Böhringer 2003 for a discussion).

The Kyoto Protocol builds upon market-based instruments that – in principle – accommodate cost-efficient responses to the undisputed need for greenhouse gas abatement. A system of periodically negotiated five-year compliance periods provides a flexible approach that allows policy-makers to adjust their decisions according to better information obtained in the future. On the other hand, it must be stated that the first round of Kyoto will achieve very little in environmental terms during the first commitment period since (i) the United States, the world's current largest greenhouse gas emitter, and the likely largest future emitters China, India, as well as the rest of the developing world, are not part of the Kyoto Protocol and (ii) the adopted effective commitment by the remaining industrialized countries is relatively weak. Moreover, it has not yet been negotiated which abatement targets will apply after the first commitment period 2008-2012.

The apparent low environmental effectiveness does not come much as a surprise given the lack of a supranational authority and the huge free-riding incentives in global public good provision: The rationale behind free-riding in climate policy is to save abatement costs while benefiting from abatement efforts of other countries. Although all countries could be better off if they behaved in a cooperative way, each country has an incentive to take a free-ride. This may lead to the well-known "tragedy of the commons". From a political economy perspective, the pessimistic view on the prospects effective and efficient voluntary international cooperation may be even worsened when accounting for the long-term nature of climate change and larger uncertainties on the benefits from greenhouse gas emission abatement: Major greenhouse gases, such as CO_2, are stock pollutants that remain in the atmosphere for several decades before they disappear due to the natural rate of decay. Short-term abatement efforts will then generate rather visible adjustment costs, but will only produce rather uncertain benefits in the very long-run if voters are shortsighted, politicians may not have an incentive at all to undertake costly abatement.

Against this background, the central challenge remains as to how to foster participation *in* and compliance *to* stringent greenhouse abatement activities that are requested by the IPCC in order to "prevent dangerous anthropogenic interference with the climate system". Control of the climate is a global public good which can be analogized, e.g., to international peacekeeping and – owing to large uncertainties of climate change – may be subject to diverging risk perceptions and priorities of individual countries. As with the financing of international peacekeeping under UN auspices, the central question may boil down to the political issue of cost sharing. Consequently, some pragmatic reconciliation of normative equity concepts or burden sharing rules will be inevitable.[1] Moreover, a credible system of direct or indirect sanctions must be developed to deter free-riding.

A comprehensive UN process with a 160-nation bureaucracy – underlying the negotiations towards the Kyoto Protocol – may be too complicate to resolve such challenges whereas negotiations between the major emitters and the major economic and political powers appears more promising in terms of effective outcomes. The (anticipated) minor environmental effectiveness of the Kyoto Protocol seems to back the perception that a comprehensive UN negotiation process is too inclusive: Acknowledging the vast heterogeneity of the 160 nations' political priorities the veto power by every single nation compromises any ambitious common reduction target. A substantial leverage on negotiation outcomes may be achieved by working (at least initially) with a small number of countries. The idea that effective environmental agreements may be more likely with a relatively small set of nations is at the bottom of the so-called "Leaders 20 Summit" (L20) policy initiatives that would expand the G8 to include the major emitters and the major economic and political powers (see Victor 2004, Kopp 2005): The L20 club provides a potentially important forum that could offer much-needed global leadership incorporating major climate policy players such as the US, China, or India which are (currently) not part of the Kyoto Protocol.

This paper analyzes to what extent the inclusion of the rest of the world would matter to a potential L20 group – a club of larger countries which decide to move forward with binding targets while the rest of the world has no commitment. We describe the trade-off between limited and global coverage from an L20 perspective: Given some world-wide emission threshold over the next decades (derived from a precautionary approach to global warming),

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[1] The economist's task is to assure that public good provision – here: the reduction of countries' business-as-usual emissions – is operated in an efficient manner as much as possible (i.e. taking into account real-world obstacles.).

the pay-off to include other countries in a potentially cumbersome UN-debate on global burden sharing declines with the degree to which participation of countries outside L20 reduces L20 compliance cost. Our numerical simulations with a large-scale dynamic model of the world economy and global energy use seem to suggest that L20 leadership does not come for free.

The remainder of the paper is organized as follows. In section 2, we motivate in more detail an L20 climate policy architecture, define potential selection criteria, and derive a L20 club based on actual data. In section 3, we lay out the analytical framework in use for the quantitative assessment of the economic implications triggered by an L20 policy implementation. In section 4, we present numerical results. In section 5, we conclude.

2. L20 Architecture

The controversial debate on the economic efficiency and environmental effectiveness of the Kyoto Protocol is reflected in the myriad of alternative policy proposals to cope with the problem of man-made climate change. In a useful attempt to structure the diffuse climate policy debate, Aldy et al. (2003) put forward six criteria to assess alternative architectures for global climate policy: environmental outcome, dynamic efficiency, cost-effectiveness, equity, flexibility in the presence of new information, and incentives for participation as well as compliance. The upshot of their comparison is that neither the Kyoto Protocol nor one of the alternative proposals does well on all criteria. The simple reasoning behind is the inherent tension among several of the evaluative criteria. The latter also explains why Aldy et al. do not come up with a (synthesized) master proposal but provide rather general advice to the design of climate treaties such as “developing countries should play a more substantial role […]; implementation should focus on market-based approaches […],; and participation and compliance incentives” should be more adequately addressed.

2.1. Basic Features

Beyond these guidelines, the L20 initiative explicitly addresses an additional institutional dimension: Whether an inclusive international agreement – labeled a “top-down” approach by Victor (2004) – is appropriate to cope with the climate change challenge. Ideally, an efficient, cost-effective agreement to provide the global public good of climate protection would call for participation of all countries.[2] But even if one neglected free-riding incentives of sovereign countries full participation and compliance would not suffice to assure a cost-effective, efficient climate change policy. In fact, Kyoto as a broad-based international agreement seems to have been watered down so much that although many countries participate and comply, the treaty yet is close to achieving nothing (Böhringer, 2002). An alternative to such a "broad-but-shallow" agreement (i.e. a treaty which achieves relatively little per-country mitigation, but attracts many nations) is a "narrow-but-deep" agreement. The latter achieves substantial per-country mitigation, but involves rather few parties. Coalition theory[3] provides some evidence that effective and stable coalitions tend to be small if they exist at all while large coalitions do typically not achieve outcomes far from the business as usual. One argument for a more restrictive approach to climate coalitions is that compensation measures fostering might be more easily achieved, e.g. through issue linkage where concessions in one agreement are exchanged against concession in another agreement (see, e.g., Finus 2003 and Folmer and van Mouche 2000 for surveys).

Beyond the aforementioned problems of institutional bureaucracy, it is predominantly for these reasons that it has been suggested to deal with the climate issue at a less inclusive level, such as L20. Whereas the Kyoto Protocol under the UN Framework Convention on Climate Change (UNFCCC) comprises far more than one hundred members, L20 goes for a much smaller group of key players.[4] The L20 concept is based on a "Leaders Forum" composed of the G8 countries together with a limited additional number of countries which are considered "leaders" or key players with respect to the topic under consideration (here: climate policy) The limited number is expected to make the negotiations easier as the interests might be less heterogeneous and it will be easier to strike cross cutting package deals (issue linkage) with the authority of the leaders' high-level government official.

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[2] Where each country mitigates its emissions to the point where its own marginal abatement costs equals the sum of marginal benefits at the global level.

[3] Coaltion theory is a field in game theory that analyzes the incentive structures of countries to participate in an IEA and to comply with the terms of the agreement (for non-technical overviews see, e.g., Carraro and Siniscalco 1998, Finus 2003a, b and Folmer/de Zeeuw 2000).

[4] One recent example for a restricted climate policy agreement is the Asia Pacific Partnership for Clean Development and Climate (AP6), where only 6 countries (USA, Australia, South Korea, Japan, China, and India) have declared cooperation in particular on the field of on clean technology transfer.

In order to decide whether an L20-type approach would be suitable from the Leaders' perspective it remains to be examined whether a restriction to a small number of very relevant emitters would need to bear a substantially higher burden to reach a given environmental goal as compared to the case where every country takes on the targets. If it turns out that the rest of the world simply does not matter very much, it might be pragmatic to strive for a climate agreement with a small number of countries as compared to a comprehensive Kyoto-type treaty. If, however, the cost difference between the leaders moving forward alone and a global approach where all countries are subject to some burden sharing rule is significant, then the more complex and complicated negotiation procedure at the UN level may be justified.

2.2. Implementation

There are several criteria which one could apply to identify key players on the field of international climate policy. Three fairly self-evident and rather prominent criteria are a country's (i) CO2 emissions, (ii) GDP, and (iii) population. These criteria also serve as basis for central equity rules referred to in the policy debate. Among the most commonly quoted equity rules, the sovereignty and the polluter pays principle are based on (historical or projected) emissions. The egalitarian principle calls for identical per capita emissions, thereby emphasizing the role of population. Finally, the ability-to-pay rule is based on the economic wealth of a country which is in general linked to GDP.

Table 1 lists those regions that rank among top 20 for each of the three indicators (CO_2 emissions, GDP, and population) both in terms of base year data in 2001 as well as for the projected (weighted) average between 2001 and 2030. The relative importance of each country is expressed as the share in the world total. We observe that the group represents roughly 75 % of global emissions, around 80 % of global GDP, and ca. 60 % of global population but less than 5 % of the UN member states. The countries identified as potential members of an L20 group consist of four industrialized regions (EUR-30, USA, Japan, and Russia) and five non-industrialized regions (Brazil, Mexico, China, India, and Indonesia).

For our numerical analysis on the economic implications of L20 leadership vis-à-vis a global participation in a pre-defined burden sharing scheme we employ four alternative common equity criteria for the allocation of emission rights: (1) egalitarian – entitlements shared in proportion to projected population, (2) sovereignty – entitlements shared in proportion to (projected) emissions, (3) Ability-to-pay – reduction requirement shared in proportion to (projected) GDP, and (4) Polluter pays – reduction requirement shared in proportion to (projected) emissions.

Table 1: TOP 20 in CO_2 emissions, GDP, and population (% in world Total)

	Shares for data in 2001*			Shares for data between 2000-2030**		
	GDP	Population	Emissions	GDP	Population	Emissions
EU-30	24.2	8.0	18.1	20.5	6.6	14.2
USA	35.1	4.5	23.5	34.6	4.2	21.2
Japan	12.4	2.1	5.3	9.8	1.7	4.0
Russia	0.9	2.4	6.1	1.1	1.9	5.2
Brazil	1.5	2.8	1.4	1.6	2.7	1.6
Mexico	2.1	1.6	1.6	2.3	1.6	1.6
China	3.7	20.8	13.4	6.5	19.1	19.5
India	1.7	16.4	4.1	2.6	16.5	4.8
Indonesia	0.5	3.5	1.2	0.7	3.4	1.3
Total	82.1	62.1	74.7	79.7	57.7	73.4

* Based on GTAP6 (Dimaranan, and McDougall, 2006)
** Based on GTAP6 and IEO2005 (DOE, 2005)

3. Quantitative Model Framework

Our framework for numerical analysis is an intertemporal multi-sector, multi-region computable general equilibrium (CGE) model of global trade and energy use. General equilibrium provides a comprehensive microeconomic-sound framework for studying price-dependent market interactions. Furthermore, the simultaneous explanation of the origination and the spending of income of economic agents (here: regions) allows to address both, economy-wide efficiency as well as equity implications of policy intervention. Therefore, computable (or applied) general equilibrium models have become a central method for the assessment of the economy-wide impacts of emission policies on resource allocation and the associated implications for incomes of economic agents.

Beyond the consistent representation of market interactions as well as income and expenditure flows, the dynamic model setting accommodates an assessment of the adjustment path of economies to exogenous policy constraints over time. To build dynamic features in the modeling of the economic behavior of households and firms requires an assumption on the degree of foresight of the economic agents. In a deterministic setting, the only consistent approach is to assume that agents in the model know as much about the future as the modeler:

Agents have rational (intertemporal) expectations and consistently anticipate all current and future prices.

3.1. Static single-period module

Figure 1 lays out the diagrammatic structure of the model's intra-period structure. Primary factors of a region *r* include labor $\overline{L}_r$, capital K_r, and resources of fossil fuels $\overline{Q}_{ff}$ ($ff \in$ {coal, gas, oil}). The specific resource used in the production of coal, gas, and oil results in upward sloping supply schedules consistent with exogenous fossil fuel supply elasticities.

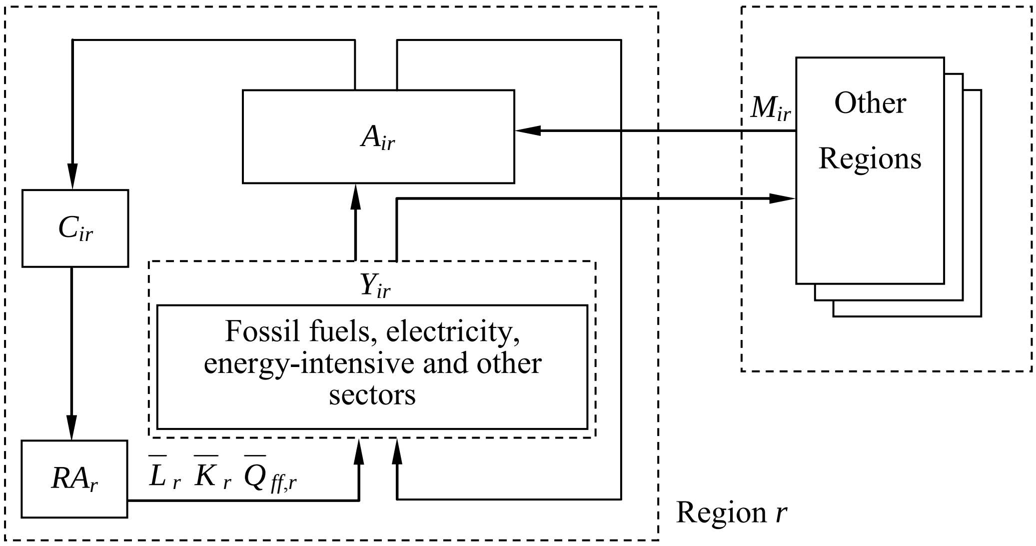

Figure 1: Structure of the intra-period sub-module

Production Y_{ir} of commodities *i* in region *r*, other than primary fossil fuels, is captured by aggregate production functions which characterize technology through substitution possibilities between various inputs. Nested constant elasticity of substitution (CES) cost functions with several levels are employed to specify the KLEM substitution possibilities in domestic production sectors between capital (*K*), labor (*L*), energy (*E*), and non-energy intermediate inputs, i.e., material (*M*).

Final aggregate consumption demand C_r of the representative agent RA_r in each region is given as a CES composite which combines consumption of an energy aggregate with a non-energy consumption bundle. The substitution patterns within the non-energy consumption bundle as well as the energy aggregate are described by nested CES functions.

Non-energy goods used on the domestic market in intermediate and final demand correspond to a so-called Armington good (Armington 1969), i.e., a CES composite A_{ir} of the domestically produced variety and a CES import aggregate M_{ir} of the same variety from the other regions. Domestic production either enters the formation of the Armington good or is exported to satisfy the import demand of other regions. Fossil fuels are treated as homogenous goods across regions.

Endowments of labor and the specific resources are fixed exogenously. Within any time period, factor markets and commodity markets function according to the competitive paradigm, i.e., flexible prices adjust to clear these markets. Carbon emissions are associated with fossil fuel demand in production and final consumption.

3.2. Dynamic setting

As to the dynamic model setting, the representative household in each region chooses to allocate lifetime income, i.e., the intertemporal budget, across consumption in different time periods in order to maximize lifetime utility. In each period, the agent faces the choice between current consumption and future consumption purchased via savings. Investment takes place as long as the marginal return on investment equals the marginal cost of capital formation. In equilibrium, investments are placed in the region (sectors) where they will receive the highest return. International capital flows are thus endogenous, and the demand and supply of savings jointly determine the international interest rate. The baseline equilibrium growth path is calibrated to a common marginal product of capital in all regions. Capital stocks evolve through constant geometric depreciation and new investment.

Figure 2 illustrates the basic dynamics of the model. The representative agent for each region maximizes his discounted utility over the model's time horizon. The primary factors, capital, labor, and energy are combined to produce output in period *t*. In addition, energy is delivered directly to final consumption. Output is divided between consumption and investment, and investment augments the (depreciated) capital stock in the next period. Capital, labor, and the energy resource earn incomes, which are either spent on consumption or retained for savings, i.e. investment.

Dynamic general equilibrium models exhibit a turnpike property, and one can exploit this when an infinite horizon equilibrium must be approximated with a finite model. To assure invariance of model results with respect to the time horizon, a set of appropriate terminal conditions must be specified. The formulation of the model as a mixed complementarity problem allows including post-terminal capital stock as an endogenous variable. Using state variable targeting for this variable, the growth of investment in the terminal period can be related to the growth rate of capital or any other "stable" quantity variable in the model.

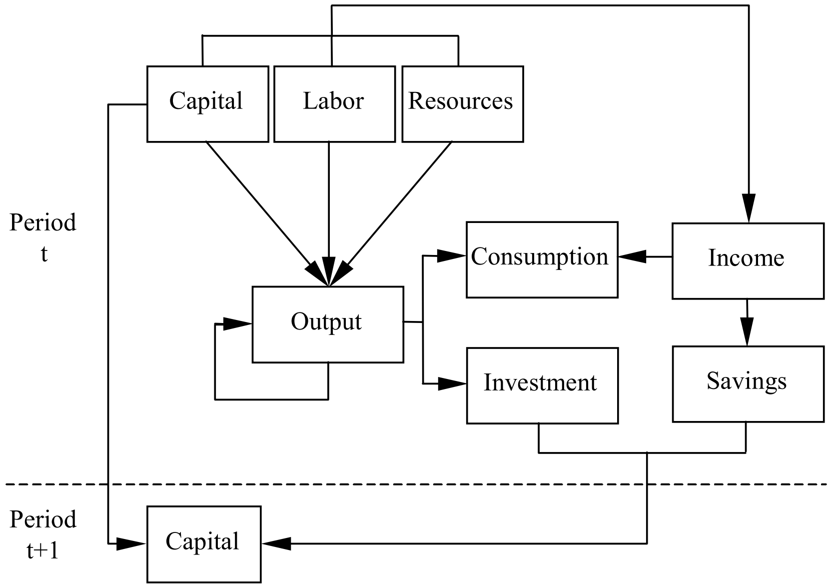

Figure 2: Dynamic model settings

3.3. Parameterization

As is customary in applied general equilibrium analysis, base year quantities and prices – together with exogenous elasticities – determine the parameters of functional forms. The most comprehensive base year statistics on global trade and energy use are provided by the GTAP6 database that features consistent accounts of regional production and consumption, bilateral trade and energy flows for up to 87 countries/regions and 57 commodities in the year 2001 (Dimaranan and McDougall 2002).

In dynamic policy analysis, there is the need for additional information on the future BaU development. Official projections on the future development of GDP, fossil fuel production, international fuel prices, and carbon emissions across various world regions are, e.g., provided by the U.S. Department of Energy until 2030 (DOE 2005). In order to incorporate the exogenous projections, a two-step recalibration of the model (after an initial calibration to a steady-state uniform growth path) is performed. First, the exogenous baseline intensities for fossil fuel demands are used to re-scale baseline cost shares in production: In order to preserve the initial *total* costs per unit of production, capital cost shares are inversely adjusted, meaning that energy efficiency improvements are not costless but are linked to the increased use of capital services. Within the baseline re-calculation, fossil fuel resource endowments get endogenously adjusted in order to calibrate the model to given exogenous target prices for fossil fuels. In a second step, fossil fuel supply functions are locally re-calibrated to match exogenous estimates of fossil fuel supply elasticities.

The regional disaggregation of the model reflects the L20 policy architecture: Each country identified in Table 2 as member of the L20 group is explicitly represented whereas the remaining world regions are summarized within an aggregate region Rest of the World (ROW). The sectoral aggregation in the model has been chosen to distinguish carbon-intensive sectors from the rest of the economy as far as possible given data availability. It captures key dimensions in the analysis of greenhouse gas abatement, such as differences in carbon intensities and the degree of substitutability across carbon-intensive goods. The energy goods identified in the model are coal, natural gas, crude oil, refined oil products and electricity. Important carbon-intensive and energy-intensive non-energy industries that are potentially most affected by carbon abatement policies are aggregated within a composite energy-intensive sector. The remaining manufacturers and services are aggregated to a composite industry that produces a non-energy-intensive macro good. The primary factors in the model include labor, physical capital and fossil-fuel resources. Table 1 summarizes the regional, sectoral, and factor aggregation of the model.

Table 2: Model dimensions

Production Sectors and Factors	Countries
Sectors	*Industrialized Countries*
Coal	Europea Union (EU-30)
Crude oil	USA
Natural gas	Japan
Refined oil products	Russia
Electricity	*Non-Industrialized Countries*
Energy-intensive sectors	Brazil
Other manufactures and services	Mexico
Primary factors	China
Labor	India
Capital	Indonesia
Fossil fuel resources	Rest of the World

4. Policy Scenarios and Results

For our stylized investigation of L20 leadership in climate policy, we adopt a cost-effectiveness approach where we maintain the same exogenous target trajectory for global carbon emissions across alternative Post-Kyoto policy scenarios. This warrants a consistent comparison of alternative policy scenarios without the need for quantifying the benefits from carbon abatement.

We assess the relative attractiveness of an L20 initiative for ever (scenario label: *L20-Eternal*) vis-à-vis an L20 initiative restricted to a transitional phase of two decades (scenario label *L20-Trans*) and vis-à-vis comprehensive commitment of all world regions (scenario label: *Global*) across four allocation rules of the exogenous global carbon budget: the egalitarian rule (labeled: *ega*) where entitlements are shared in proportion to population, the sovereignty rule (labeled: *sov*) where entitlements are shared in proportion to emissions, the ability-to-pay rule (labeled: *atp*) where the implicit global reduction requirement is shared in proportion to GDP, and finally the polluter-pays rule (labeled: *ppa*) where the implicit global reduction requirement is shared in proportion to GDP, Under an L20 approach (*L20*), only the members of the L20 group are subject to explicit climate policy commitments whereas the rest of the world can dispose of its business-as-usual emissions. Under a global climate policy commitment, all world regions are subject to the respective allocation rule to meet the exogenous global emission constraint. In total, we obtain eight policy counterfactuals which are listed in Table 3.

Table 3: List of policy scenarios

Allocation rule Regional Coverage/Timing	Egalitarian (*ega*)	Sovereignty (*sov*)	Ability-to-Pay (*atp*)	Polluters-Pays (*ppa*)
L20 Eternal	*L20-Eternal-ega*	*L20- Eternal-sov*	*L20- Eternal-atp*	*L20- Eternal-ppa*
L20 Transition	*L20-Trans-ega*	*L20- Trans-sov*	*L20- Trans-atp*	*L20- Trans-ppa*
Global	*Global-ega*	*Global-sov*	*Global-atp*	*Global-ppa*

Across all scenarios we assume global “where-flexibility” in emission abatement, i.e., regions outside the L20 group which dispose of their business-as-usual emissions are engaged on international carbon markets. The assumption of global “where-flexibility” implies that marginal abatement costs are equalized across all scenarios and there is no carbon leakage. In this way, cost efficiency of climate policy is achieved and we can focus solely on the aspect of burden sharing.

The effects of Post-Kyoto climate policy architectures are measured with respect to the Business-as-Usual (BaU) where no climate policy constraints apply.

Global CO_2 emissions are limited to a cap of 30 Gt from 2015 onwards (Wicke 2005). This ceiling is meant to be in line with the 550 ppmv stabilization of atmospheric CO_2 concentration that has been set out by the initial IPCC reports as a desirable long-term climate policy target.

Figure 3 sketches the carbon emission trajectories under Business-as-Usual and the climate control scenarios. We can see that the global ceiling of carbon emissions at 30 Gt from 2015 implies quite drastic emission reductions vis-à-vis the BaU projections.

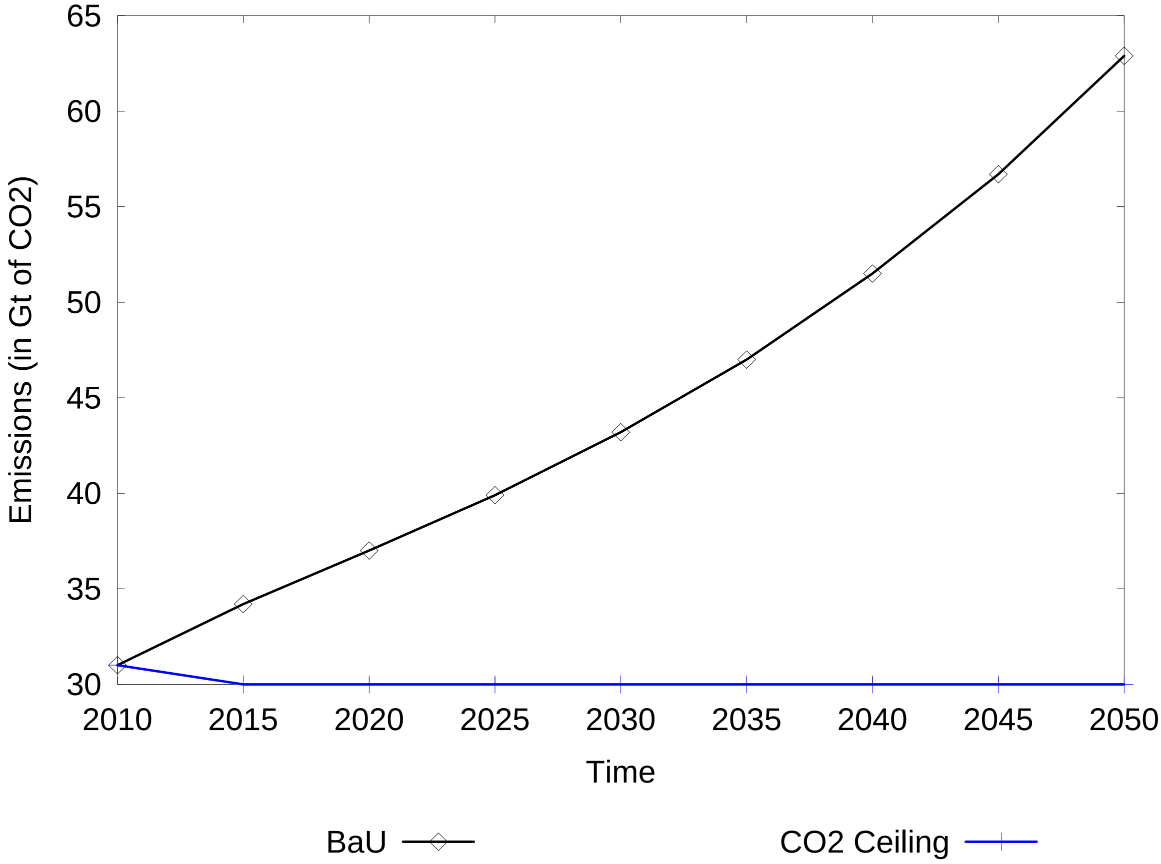

Figure 3: Emission trajectories for BaU and exogenous CO_2 ceiling

Figure 4 visualizes the implications of an L20 leadership in terms of percentage reduction requirements from BaU: The line termed "Target" indicates the reduction requirement at the global level which is directly linked to the carbon trajectories in absolute terms as provided by Figure 1. Under L20 leadership the rest of the world (ROW) does not adopt any effective reduction commitment (line "ROW_Share") below Business-as-Usual so the full burden rests upon L20 (line "L20_Share").

Figure 5 shows the marginal abatement cost – or likewise the value of CO_2 allowances – associated with the exogenous carbon CO_2 ceiling. Since the ceiling is kept constant across all climate policy scenarios and we assume global "where-flexibility", the CO_2 prices coincide (apart from minor deviations caused by secondary income effects). The CO_2 prices increase over time as the CO_2 constraint becomes more and more binding until it comes near to a backstop technology at a price of more than 100$ per ton of carbon dioxide.

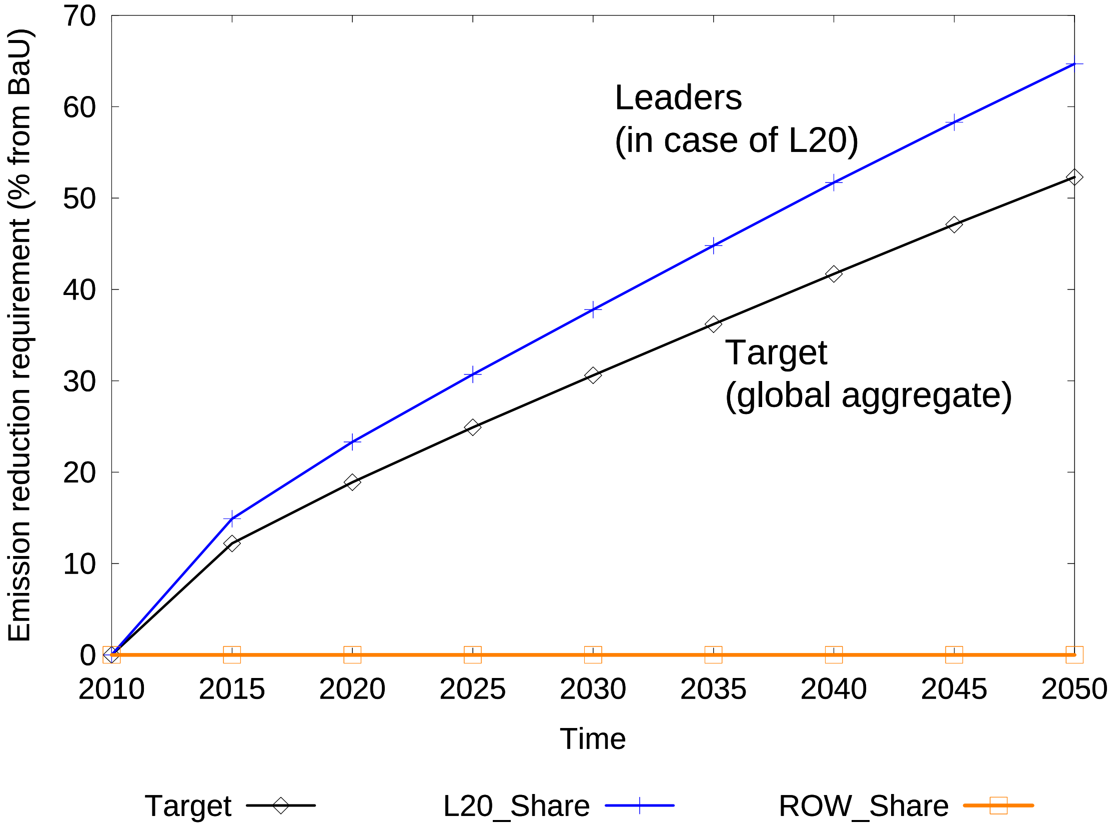

Figure 4: Aggregate emission reduction requirements (in % from BaU)

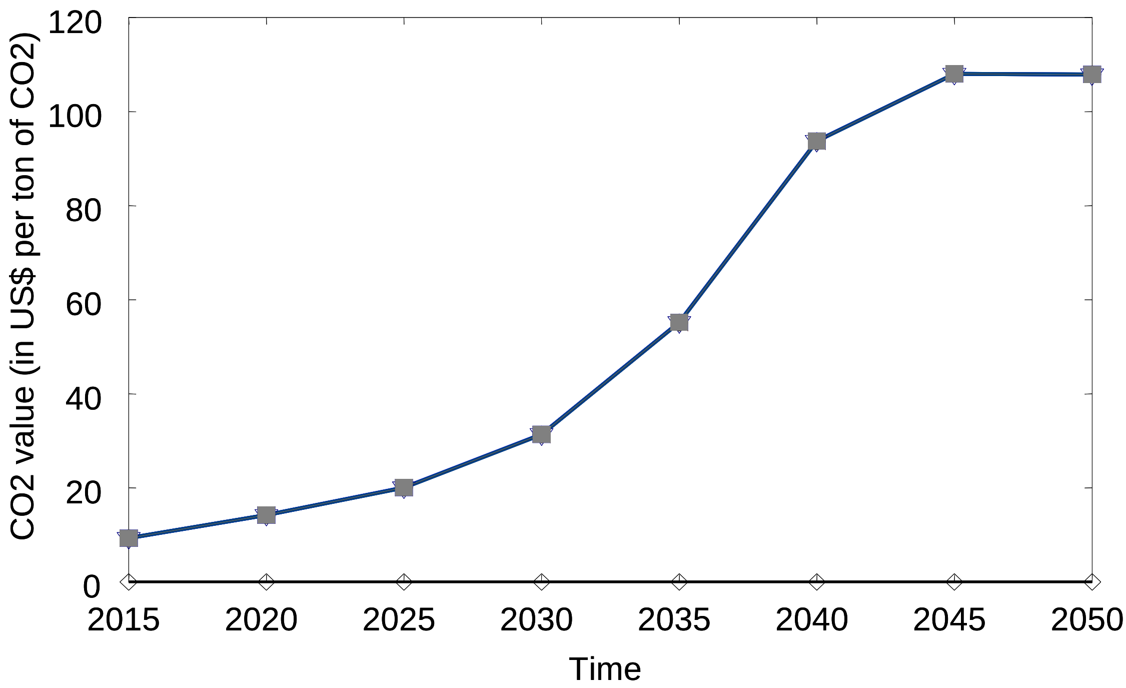

Figure 5: Marginal abatement cost ($US per ton of CO_2)

Figure 6 provides detailed information on how the abatement burden for L20 changes for the four different allocation rules when we move from L20 leadership to global compliance. Accounting for the exogenous population dynamics between 2015 and 2030 (see CIESIN), L20 fares better under *ega* with a unilateral L20 leadership as compared to global compliance since the per-capital allocation rule under *ega* would provide the rest of the world with emission rights in excess of their BaU emission requirements. For the remaining three allocation rules, global compliance is superior to L20 in terms of the associated reduction requirements. The differences among the latter rules *atp*, *sov*, and *ppa* are remarkably small; in fact – given the DOE baseline projections – L20 would be indifferent between the sovereignty rule and the producer-pays rule.

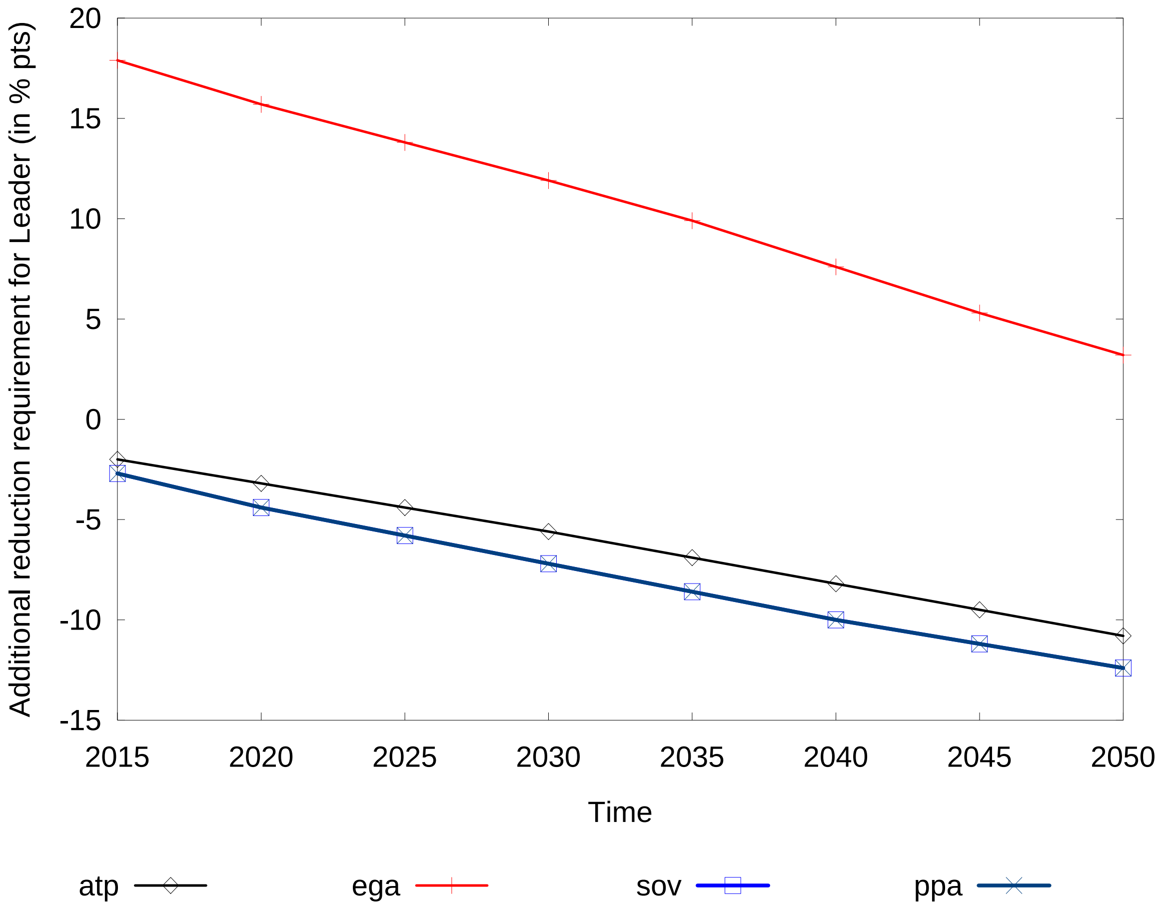

Figure 6: Difference in L20 reduction requirements between global compliance and L20 leadership (in percentage points)

The cost implications for L20 (as an aggregate and for the respective L20 group members) as well as for ROW obviously depend on the scenario-specific cutback requirements. However, there are important additional factors that will determine the adjustment costs for a particular region and call for a comprehensive CGE assessment. One key factor is the ease of carbon substitution reflected in the regions' technologies and preferences. Another key factor are the country-specific trade characteristics: Emission constraints affect international prices which produce may substantial secondary burden or benefits through terms-of-trade effects – one prominent example are potential decreases of world market prices for fossil fuels which will be beneficial for fuel importers and detrimental for fuel exporters (Böhringer and Rutherford 2002, Böhringer and Welsch 2006).

Table 4 provides a summary of the welfare impacts measured in terms of Hicksian equivalent variation (HEV) in income. [5]

Table 4: Welfare impacts (in % Hicksian equivalent variation of lifetime income)

Scenario	L20	ROW	Total
L20_ega_etern	-0.47	0.13	-0.38
L20_ega_trans	-0.56	0.72	-0.38
Global_ega	-0.63	1.21	-0.37
L20_atp_etern	-0.47	0.13	-0.38
L20_atp_tran	-0.33	-0.71	-0.39
Global_atp	-0.31	-0.85	-0.39
L20_ppa_etern	-0.47	0.13	-0.38
L20_ppa_trans	-0.31	-0.87	-0.39
Global_ppa	-0.28	-1.05	-0.39
L20_sov_etern	-0.47	0.13	-0.38
L20_sov_tran	-0.31	-0.87	-0.39
Global_sov	-0.28	-1.05	-0.39

The last column of Table 4 reports the aggregate welfare impact for the world economy. Not surprisingly, imposition of a restrictive global carbon constraint induces global welfare losses as long as we do not account for benefits of carbon abatement. Under global “where-flexibility” the regional distribution of emission entitlements does not matter for global efficiency.[6]

[5] A change in HEV of -0.25 for the world economy (Total) in scenario *L20_ega* means that we would have to transfer 0.25% of world lifetime income to make the world economy as well off as under BaU.

[6] The slight welfare differences in the global economic impacts are due to general equilibrium income effects.

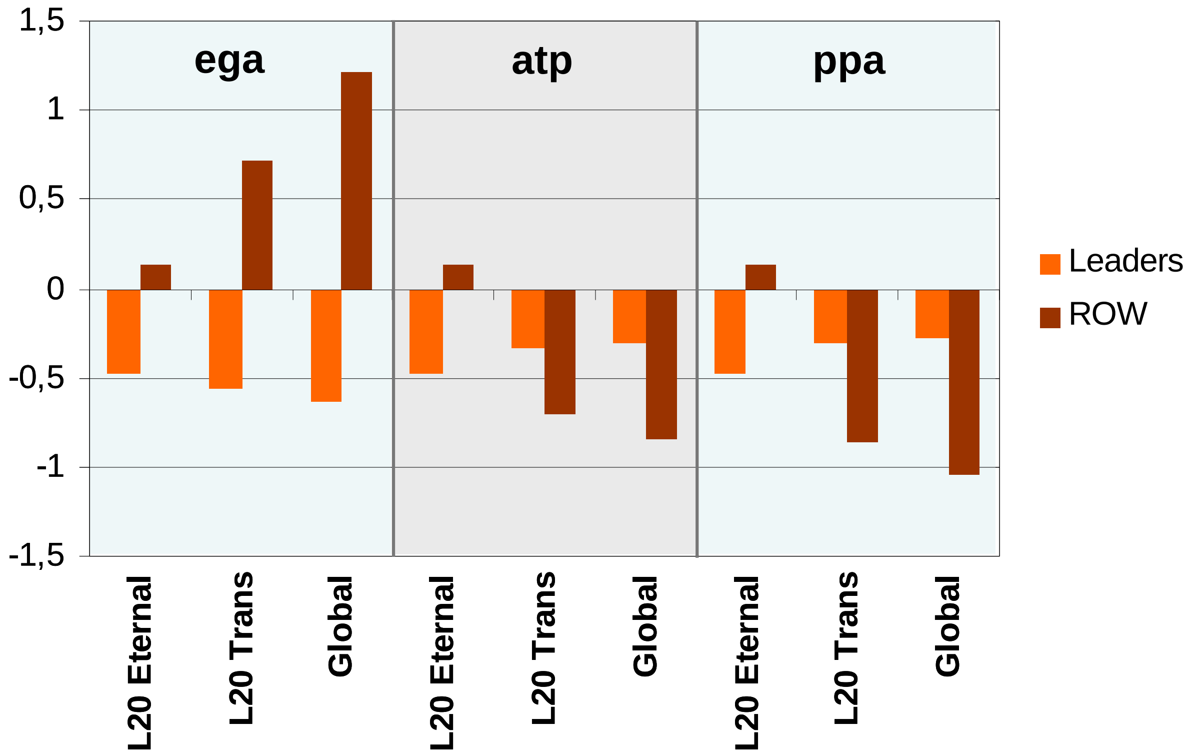

Figure 7: Welfare implications of Leadership of an L20 group for the Leaders and for the rest of the world (ROW) for alternative rules of emission allocation

The welfare implications for eternal L20 leadership (scenario prefix *L20 Eternal*) are the same both for the L20 aggregate and the rest of the world (ROW) independent of the allocation rule. The reason is that the rest of the world is always entitled with its *BaU* emissions under *L20* which in turn implies a constant emission budget for L20 (as the residual between the global emission budget and the ROW *BaU* emissions).

Regarding our central research question, i.e. the relative importance of global compliance from the perspective of the L20 group, our results indicate that L20 leadership for ever may be costly. It turns out that the cost incidence for L20 is markedly different depending on whether only L20 moves ahead with emission reduction commitments or whether there is a global commitment. The results reflect the differences in L20 reduction requirements between global compliance and L20 leadership as displayed in Figure 6. Under *ega* L20 would clearly prefer "leadership" in its own interest as this prevents allocation of emission allowances to the rest of the world in excess of *BaU* emissions. To the contrary, the three remaining allocation rules – *atp*, *ppa*, and *sov* – generate additional cost for L20 in case of leadership. As can be seen from figure 7 the additional costs to the leaders could be considerably lower if leadership is only considered for a limited transitional phase. A sensitivity analysis with respect to the emission baselines has shown a substantial impact of the assumptions regarding the emissions baseline.

5. Conclusions

There is an ongoing discussion which policy architecture is best suited to address the implicit equity debate and huge incentive problems in climate protection. Kyoto has established a comprehensive international mechanism that is based on market instruments. Doubts, however, have been uttered if the associated UN process with a 160-nation bureaucracy is capable of achieving an environmentally effective and economically efficient climate policy.

In this vein, the idea of more effective and efficient leadership by a small number of countries – referred to as L20, i.e. the major emitters as well as economic and political powers – has attracted some attention. In this paper, we have investigated to what extent the inclusion of the rest of the world would matter to a potential L20 group. We have identified a non negligible trade-off between limited and global coverage from an L20 perspective if leadership is assumed to last for ever. If, however, leadership is restricted to a transitional phase the welfare implications might be reduced substantially. The main driver for the welfare implications turns out to be the income transfer via the carbon endowments. While for an egalitarian allocation rule leaders would prefer an L20 scenario to global coverage for all other analyzed allocation rules make the potential leaders better off if global coverage of reduction commitment is assumed.

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Appendix: Sensitivity analysis with respect to the emissions baseline

Sensitivity analysis with respect to the business-as-usual emissions baseline shows a substantial impact on the potential cost implications for the Leaders as well as for the rest of the world. The error bars indicate the results if a high or a low baseline scenario has been assumed for the numerical simulations.

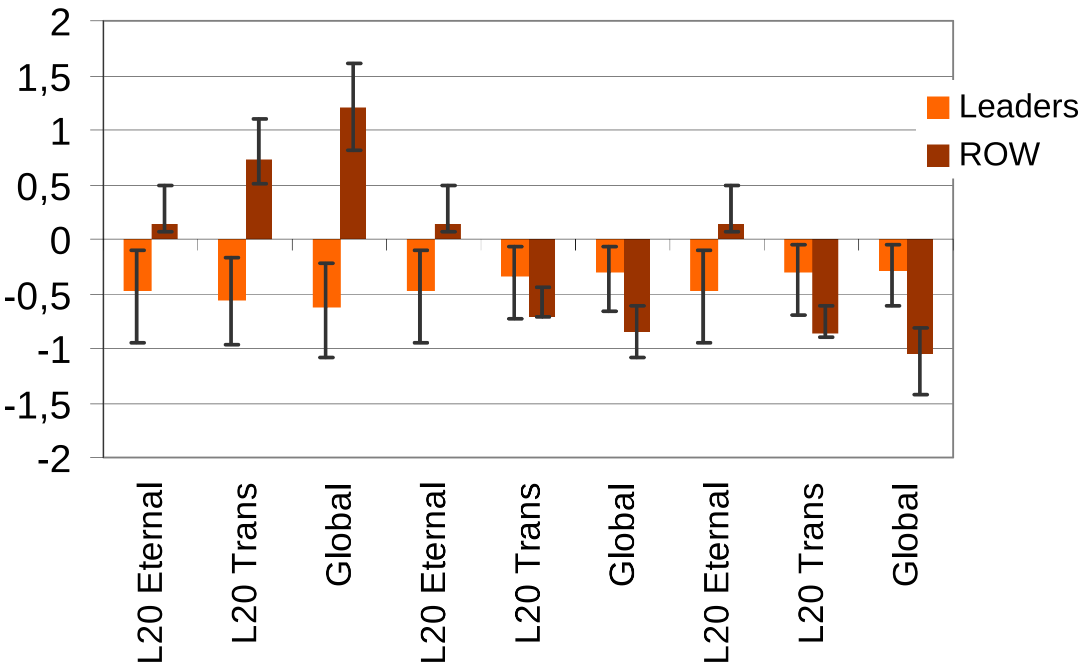

Figure 8: Sensitivity analysis: Welfare implications of Leadership of an L20 group for the Leaders and for the rest of the world (ROW) for alternative rules of emission allocation.