Global policies and Finland: Environment, energy markets and forest sector

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Abstract

The main point raised in the paper is that the costs of implementing the Kyoto agreement depend very much on the international environment where it is implemented. The international framework studied includes the number of countries participating in emission reduction, the extent and design of international emission trading, the size of carbon sinks, the role of international trade in electricity, the role of international trade agreements, and finally the working of the world oil market. In general, it is clear that the larger the number of countries reducing emissions and the larger the number of countries participating in emission reduction the lower the costs are. The allocation of sinks as decided upon in Marrakesh is not neutral but favors some countries at the expense of other countries. International electricity trade seems also to reduce costs of emission reduction. Oil markets are naturally important for the costs of implementing the Kyoto agreement. It is argued that if both oil producers and oil consumers behave strategically Kyoto countries could benefit by using coordinated emission taxes and tariffs on oil imports. In addition the paper reports research on the long run emissions of carbon dioxide. It turns out that the oil crisis of 1970's had no significant impact on emissions. Finally, the design of emission trading system turns out to be crucial for the long run emission reduction.

Keywords: costs of emission reduction, emission trading, carbon sinks, international trade agreements

Background

Since climate change is at least partly and most likely to a large extent created by human actions it can also be regulated by human actions. The distinguishing feature of climate change is that it is a genuine international phenomenon: emissions of greenhouse gases contribute to it equally no matter where they take place. Increasingly the mankind has been able to form and implement agreements to regulate transboundary environmental problems. Examples are the Montreal Protocol on regulating the use of substances that deplete the ozone layer and more local agreements on containing emissions creating acid rain. The same holds also for the climate change where an attempt to reduce emissions of greenhouse gases was incorporated in the Kyoto Protocol.

The process leading to the Kyoto Protocol and especially the process of negotiations on how to implement the Protocol until the final agreement in Marrakeš shows how difficult it is to reach international agreements even when all the parties broadly accept the necessity of reducing the harmful emissions. There are certainly many factors behind the difficulties but among them certainly the economic impacts of both climate change and the policies mitigating it count highly. Climate change does not treat all the nations similarly and some countries may even benefit from it. The same holds for the climate policies. This is true both at the international level as a whole and at the more local level like EU where attempts to coordinate local policies are planned. A noteworthy example is the so called "carbon leakage" problem, the possibility that the most polluting industries move to countries not taking any policy actions.

In this paper we report some of the results of the research conducted in the FIGARE consortium "*Global Policies and Finland: Environment, Energy Markets, and Forest Sector*". We first highlight the issue of uneven distribution of the burden from climate policies by reporting how the implementation of the Kyoto agreement and its various versions, e.g. allowing emission trading and credits from carbon sinks, affect the economies of the signatory countries. One noteworthy aspect of the climate policies is that they potentially interact with other policies, especially with other global policies like trade policies. These aspects have been studied both theoretically and empirically using the GTAP-E -model. One of the distinguishing features of the Kyoto agreement is that not all the countries in the world have agreed to cut down their emissions. This leads to at least two interesting set of problems. The first is that the world is simultaneously (and for the first time truly) engaged in negotiations to reduce trade barriers globally. At the same time also the local integration schemes harming countries left outside (like EU) are pushed forward. Does the Kyoto Protocol enhance local or global economic integration? One particularly important specific issue here is how electricity market integration affects the costs of emission reduction since currently European wide electricity markets are being created. Since the Nordic electricity markets are already integrated a partial answer can be found by evaluating the impact of this particular market integration. Another important specific market in the context of emission reduction is the market for oil and we report our work on that also. Finally, the Kyoto agreement has left a door open for countries that are not committed to reduce their emissions (mostly developing countries) to participate in the reductions through various kinds of agreements (the so called Clean Development Mechanism, CDM). How do these mechanisms work? This question is also closely related to the question of how the emissions reductions are to be implemented within the countries committed to reductions. The design of the permit market becomes then crucial. This will be discussed last in the paper.

The Distribution of the Economic Burden from Climate Change Policies

Table 1 gives the overall economic impacts of the Kyoto agreement on the aggregate of Nordic countries taking policy actions[1]. Two dimensions are here crucial: the countries that are taking the policy actions and the way the national emission reductions are implemented (through national or international actions, international emission trading). In the first dimension one must in particular analyse what difference it makes whether USA complies with the Kyoto agreement (officially USA refused to ratify the Protocol) since it shows what the behaviour of the largest emitter means for the impacts of climate policies.

Overall the costs of emission reductions are lowest in terms of both the effect on gross national product (gdp) and monetary measure of the welfare change (EV) when international emission permit markets exists[2]. Also the more countries are implementing policies the lower the costs are. These results reflect the insight that emission permit trade achieves cost efficiency in emis-

[1] The table is reproduced from Riipinen (2002). These calculations use the GTAP5-database. The calculations using GTAP4 database with additional countries and containing separate figures for Finland are reported in Haaparanta et al. (2001). The new version of the database contains improved energy data. We have been able to use the GTAP-E (GTAP energy) model since August 2002 and have not been able to update all the previous calculations.

[2] This conforms with other studies, e.g. Weyant et. al. (1999).

sion reduction: emissions are reduced in countries where the reduction costs are lowest. With a larger number of countries there is usually larger heterogeneity which increases the possibility to mutually beneficial trade in permits. It also shows up in the emission permit price[3] (tax on emissions) with permit price being in general lowest with international permit trade. A comparison of experiments 5 and 6 reveals, however, an interesting result: If EU alone reduces emissions, then Nordic countries would be worse off with EU wide permit trading than with purely national implementation. At the same time Nordic countries would be net sellers of permits in the EU market. The source of this effect is still somewhat unclear and in case of Finland, at least, may be a results of some specifics of the base data(see Honkatukia *et al.* 2002 for another evaluation).

In the aggregate emission permit trade reduces emissions as much as other means to implement the reductions but it reallocates the reductions between countries from what would happen with purely national implementation. This is clearly seen when experiments 1 and 2 are compared. But it also shows up in experiments 5 and 6 where Nordic countries would be reducing their emissions more with international permit trading. As pointed out just above this means that Nordic countries would be net sellers in the EU market.

How do the forest carbon sinks affect the distribution of economic burden

An important element in the finally agreed version of the Kyoto Protocol is the carbon sinks and how they are allocated across countries. The larger the sinks allocated the less the country has to reduce its emissions (or the less it has to buy permits or the more it can sell) and thus the lower is the economic burden from emission reduction. Pohjola et. al. (2002) have estimated the effects of the allocation of carbon sink on individual countries/regions[4].

Globally, the net terrestrial uptake of 2.6 Gt CO_2 yr^{-1} correspond one tenth of the emissions from combustion of fossil fuels (23.1 Gt CO_2 yr^{-1})(IPCC 2000). The largest forest carbon sinks of the industrialized (Annex I) countries are in Russia and USA, which reported that

Table 1. *Overall economic impacts of the Kyoto agreement.*

	Experiment 1	Experiment 2	Experiment 3	Experiment 4	Experiment 5	Experiment 6	Experiment 7
Results for Nordic EU Countries (Finland, Sweden, Denmark)							
Tax (97 $ / C ton)	80	121	41	102	102	91	110
CO2 (%)	-26	-35	-18	-35	-37	-35	-37
Terms of Trade (%)	0.4	0.4	0.2	0.2	0.2	0.2	0.3
EV (mill. $)	-1991	-2858	-1540	-3302	-3535	-3390	-3505
gdp (%)	-0.4	-0.6	-0.2	-0.6	-0.7	-0.6	-0.7

Experiment 1: Annex 1 countries reduce emissions (emission permit market exists)
Experiment 2: Annex 1 countries reduce emissions (no emission permit market)
Experiment 3: Annex 1 countries reduce emissions (emission permit market exists) without USA
Experiment 4: Annex 1 countries reduce emissions (no emission permit market) Without USA
Experiment 5: EU alone reduces emissions (internal emission permit market exists)
Experiment 6: EU alone reduces emissions (no internal emission permit market)
Experiment 7: EU reduces emissions with internal emission permit market, rest of the Annex 1 countries expect USA, Canada and Former Soviet Union comply individually

[3] In Table 1 the price is expressed per ton of carbon emitted. To get the price in terms of CO2 emitted this figure should be divided by 3,6.

[4] The simulations are performed with GTAP4 model and database aggregated to 13 regions and 15 sectors.

their sinks were 587 Mt CO_2 and 272 Mt CO_2 in year 1990, respectively. Relative to CO_2 emissions, forest carbon sinks are, however, largest in New Zealand and Sweden, corresponding to 70 % and 60 % of their emissions in year 1990, respectively. However, in order to prevent non-human induced part of the sink from being credited and to limit the role of sinks in achieving the given emission target, it was agreed in COP6b in Bonn 2001 (UNFCCC 2001) that only part of the sinks resulting from forest management are allowed to be credited. In general, the credited amount from forest management is strictly limited to 15 % of the estimated sink. Furthermore, the maximum amount to be credited was limited to 3 % of the base year emissions. As an outcome of political negotiations, Canada and Japan were given relatively higher carbon sinks.

The results of the study indicate that the gains from carbon sinks are not distributed evenly among countries (Figure 1). Within countries, New Zealand gains most from the credited carbon sinks as it does not have to reduce emissions at all. Also in Sweden, EFTA[5], Canada and Japan the carbon tax is considerably lower and welfare loss smaller if credits from forest carbon sinks are allowed. In other countries, like in Finland, the forest carbon sinks have only a slight influence on the carbon tax or welfare, since sinks are relatively small compared with emission reduction.

Of those countries that gain the most from sinks, Canada and EFTA have originally high costs while New Zealand, Sweden and Japan have low costs. Thus carbon sinks only partly equalise the costs of achieving the emission target among countries. Those countries that have bargaining power in the negotiations manage to obtain important gains from sinks. The country-specific, higher sinks allowed for Canada and Japan provide considerable benefit for them, while carbon sinks calculated according to common rules would have had only minor effect on their costs of implementation of the Kyoto Protocol. Higher carbon sinks allowed for Canada and Japan do not however influence other countries either economy wide or on the sectoral level since the trade-induced effects are small.

With respect to cost differences between sectors, sinks equalize the costs to some extent, as the inclusion of sinks dampens the adjustment in the industry structure by lowering the reduction in emissions. Sectors producing fossil fuels or fossil-fuel intensive goods, like iron and steel or chemicals, benefit from inclusion of sinks while the other sectors, like machinery, might suffer.

In the simulations presented here, the emission limit has to be achieved by domestic measures instead of allowing international emission trading. In the case of international emission trading, all countries, except those selling permits,

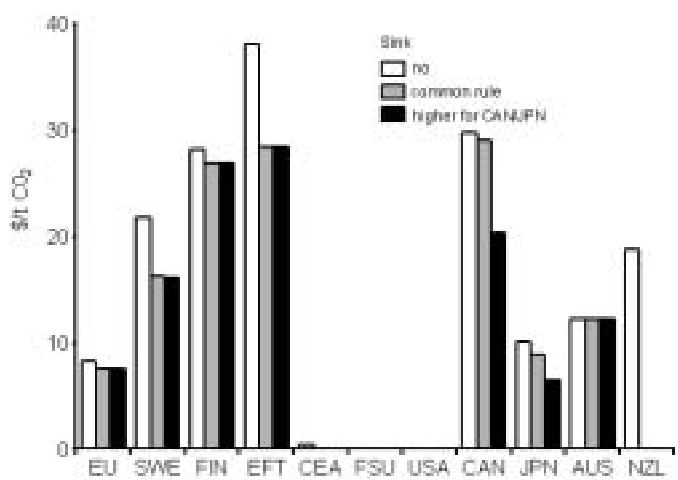

Figure 1. *Carbon tax needed to achieve the Kyoto target without US participation in year 2010 for Sweden, Finland, rest of the EU, EFTA, Central European Associates (transition countries), former Soviet Union, USA, Canada, Japan, Australia and New Zealand when (i) sinks are not credited (ii) sinks are credited according to common accounting rules (iii) country-specific sinks are allowed for Canada and Japan as agreed in Bonn.*

[5] EFTA includes Norway, Switzerland and Iceland in GTAP data base

would benefit from carbon sinks inside the trading area, as the price of an emission permit would drop. Countries having sinks would, however, benefit most since they could sell the credits from sinks. Another limitation of this study is that the carbon sinks are treated as exogenous input, which implies that the costs of carbon sequestration are not considered. Cost-efficiency would imply that in order to choose the least-cost options to achieve the emission target, the costs of increasing the amount of carbon sequestered should be compared to the costs of reducing fossil fuel emissions. Increasing carbon sinks would probably have direct impacts on the timber market, which might in turn influence relative prices, competitiveness, production structure and trade flows. On the other hand, the amount of sink is likely to be affected by reduction in use of fossil fuels. In order to capture all the effects, the cost curve for supplying forest carbon sinks in existing and new forests, as well as global timber markets, should be added into the model.

Electricity market integration and distribution of economic burden

An important channel in the countries' adjustment and in countries' cost of adjustment is the adjustment of world markets to emission reductions. Emission reduction clearly hurts the energy intensive sectors that are naturally the biggest source of emissions. Due to the increase in production costs they cut down their production. This reduction in the supply pushes up their prices in the world markets. If a country is a net exporter of goods produced in these sectors this price adjustment diminishes the cost of emission reduction since the country's terms of trade (export prices relative to import prices) improves increasing real income. This is clearly also the case with Nordic countries (see Table 1). This effect is strengthened by the fact that at the same time demand for fossil fuels also falls making their price fall.

The last remark raises the general point that in general the structure of energy markets matter for the economic impacts of emission reduction. An important element in this is the international trade in energy. In Europe West-European wide electricity markets are emerging expanding the Nordic electricity market to the rest of Europe. Table 2 (taken from Forsström et. al. 2002) gives the impact of the Nordic electricity market integration on emission permit price.

We see that in case of both Annex1 wide permit trading and EU wide permit trading the electricity market integration leads to reduced permit prices implying that the cost of achieving the emission reduction diminishes (compare Annex1-ele with Annex1, where 'ele' indicates the case of electricity market integration, and likewise for EU). In Annex1 trading this means that the benefit is shared among all the Annex1 countries though the benefit is not uniformly distributed and some individual countries might even be worse off as shown in Table 3 where the monetary measure of aggregate welfare change is given.

Oil markets and Climate Change Policies

As was pointed out above, reductions of CO2 emissions will have a major impact on the mar-

Table 2. *Simulation results with new GTAP-E aggregation*

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Permit price	Annex1*	Annex1-ele	EU	EU-ele
Finland	5.28	5.21	12.03	11.65
Sweden	5.28	5.21	12.03	11.65
Denmark	5.28	5.21	12.03	11.65
EEA	5.28	5.21	0	0
USA	0	0	0	0
Japan	5.28	5.21	0	0
EFTA	5.28	5.21	0	0
IVY-countries	5.28	5.21	0	0
Rest of EU	5.28	5.21	12.03	11.65
Rest of Annex1	5.28	5.21	0	0
Rest of World	0	0	0	0

*excluding USA

kets for fossil fuels. Among them oil markets are the most important. This aspect has been studied in the consortium by Matti Liski.

The majority of anthropogenic emissions of carbon dioxide are caused by the combustion of fossil fuels. While the prices of these fuels are to a large extent beyond the control of individual countries importing the fuels, there is no reason to believe that these prices cannot be affected by a coalition of importing countries which are interested in restricting the use of carbon-intensive fuels like crude oil. One way of implementing such restrictions is fuel or carbon taxation. Can carbon taxes alter the market price for fossil fuel? How does the OPEC response to carbon taxation? There are two a priori equally sensible hypotheses. According to one, the OPEC voluntarily cuts back production to raise fuel prices and thereby effectively taxes the importing-country consumers on behalf of the governments interested in climate change. This hypothesis implies that the OPEC benefits from climate change policies. According to another hypothesis, the carbon tax is effectively an import tariff that shifts OPEC's rents by depressing fuel prices. This implies that OPEC is damaged by climate change policies. Which hypothesis is valid and under what circumstances? Without understanding these effects, optimal carbon taxes cannot be designed.

The results indicate how such taxes should be designed and whether it would be better to replace such taxes by straight import tariffs or other instruments. The main result is that the optimal tax set by a coalition of buyers is not a neutral environmental tax but a combination of straight tariff and environmental tax. Because of the tariff element, the tax can shift more rents from the cartel than the pollution causes damage-related costs. This leads us to conclude that the pollution problem accompanied by the coordination of carbon taxation can bring about net benefits for the Kyoto countries at the expense of the OPEC group.

Trends and Breaks in Carbon Dioxide Time Series

While consequences of the potential climate warming remain highly uncertain, most scientists find it likely that emissions of Carbon Dioxide (CO_2) and other greenhouse gases contribute to the climate warming. The rising atmospheric concentration of CO_2 is generally viewed as the most important cause of the greenhouse effect. Economically, actions that seek to reverse the "business-as-usual" trend of CO_2 emissions may prove to be very costly: according to an overview of recent estimates produced by thirteen research teams, the implementation of relatively modest reduction targets can generate significant annual costs (Weyant *et al.* 1999).

Because of these key characteristics, there has been a considerable recent interest in projecting the development of global CO_2 emissions to the future. Typically, the econometric approach has been to model similarities across countries using reduced-form models estimated with cross-national panel data on CO_2 emissions and indicators of economic development. The global projections are then based on the estimated emission pattern and the assumption that countries pass through similar stages of economic development. Much of the focus has been on a pat-

Table 3. *Equivalent Variation (EV), millions of US dollars*

	Annex1*	Annex1-ele	EU	EU-ele
Finland	-110.25	-30.27	-474.2	-269.56
Sweden	-146.63	-67.14	-283.17	-466.28
Denmark	-282.66	-1018.56	-1323.38	-726.86
EEA	-747.51	-771.84	98.71	171.17
USA	357.18	318.92	440.01	514.93
Japan	-910.18	-882.31	1417.16	1490.24
EFTA	-627.22	240.34	769.57	-193.33
IVY-countries	-2080.16	-2100.74	-35.44	-183.69
Rest of EU	-6577.67	-6815.04	-24769.5	-25053.8
Rest of Annex1	-703.81	-705.88	-26.83	-16.66
Rest of World	-469.71	-509.7	23.56	96.68

tern called “inverted U” relationship between emissions and income levels.

Our approach is to model differences between countries. We exploit a feature of the national CO_2 emission data sets that has not been fully, if at all, utilized in econometric studies: for most developed countries, the national-level time series of CO_2 emissions from fossil fuel combustion can be extended to the early stages of the industrial revolution. Given such long historical data, it is conceivable that the time series properties of national CO_2 emissions may detect important differences among a priori homogenous group of developed countries. We address differences across countries by analyzing the time series properties of per-capita CO_2 emissions for 17 individual OECD countries over the period 1870–1994. As opposed to the reduced-form estimations, we ask whether per-capita CO_2 emissions in individual countries are expected to follow more or less stable time trend that is only affected by large and infrequent shocks such as the oil price shock of 1973 or a large-scale adoption of nuclear power. In this case, emissions are trend stationary such that only extraordinary events, *i.e.*, structural changes, have long-lasting influences on the series. Alternatively, per-capita CO_2 emissions can be characterized as being nonstationary such that all shocks, both small and large, have permanent effects on the development of emissions, meaning that no deterministic trend which emissions tend to revert to can be found.

The main result is that the CO_2 trends are not generally affected by the oil price shocks of 1970’s. Most breaks in trends occur during early stages of industrial development and can be explained by country-specific changes in fuel composition.

International Emission Reduction and International Trade Policy

The impacts of the Kyoto Protocol should be studied together with the impacts of other international agreements that have been negotiated or are being negotiated and that will be implemented approximately at the same time as the Kyoto reductions. This point became clear above when the impacts of the electricity market reform were discussed. Among the other agreements one should include the results from multilateral trade negotiations and the EU expansion to Central and Eastern Europe (CEA). The latter has been studied in Riipinen (2002). He finds that overall the EU expansion has only quite small effects on the costs of emission reduction though the results vary somewhat across countries. The converse also holds: the benefits from EU integration are not affected very much by the extension of permit trade to CEA. The impacts could, however, be much larger if the growth effects of both the trade policies and emission reductions were taken into account, since then the impacts are usually a multiple of the static effects. Given this it is important to study how the various types of agreements interact with each other.

Haaparanta and Riipinen (2001) studied theoretically whether an agreement like the Kyoto agreement covering only a group of countries creates incentives among them to push for mutual trade liberalization to improve competitiveness with respect to the rest of the world that has been reduced by the emission reduction. This is an important issue since in general regional free trade agreements (like EU) are usually harmful for the rest of the world and to the world as a whole while multilateral trade liberalization can benefit everybody. Somewhat surprisingly the effect goes the other way round: firms want to improve their competitiveness in global markets making multilateral trade liberalization preferred over the regional liberalization.

Regional trade agreements can be made in the way that outside countries are not hurt. Haaparanta and Riipinen (2002) study whether this result can be extended to the case where there exists a global environmental problem affecting countries also outside the regional agreement. They found the answer to be positive even under the case where there exists an environmental agreement covering both members and nonmembers to the regional trade agreement.

Permit Market Design and the Impacts of Emission Reduction

Above we have discussed about the impacts of the various ways to implement the Kyoto agreement comparing in a rough way the case where an international permit market exists with the case where only national permit market exists (or emissions are taxed uniformly in the economy). But there is much more to the permit market design that can have an impact on the costs of emission reduction. These have been studied in the consortium by Matti Liski. The final part of the paper is devoted to the main results from those studies.

Market design for Voluntary Opt-In in Greenhouse Gas Trading

The 1997 Kyoto Protocol is a possible step toward global regulations where economic stakes are vastly greater than in any earlier environmental policy experiment. If the Protocol or some future version of it will be ratified and implemented, it entails domestic regulations limiting energy use and emissions of greenhouse gases in participating countries. According to one estimate the OECD level discounted cost of this regulation is about 1 500 billions of 1990 dollars. A way to minimize the overall cost of such regulations is licensing of polluting activities and allowing for free trade in licenses (permits). Ideally, investments reducing pollution in production should generate a supply of transferable permits leveling off differences in costs of eliminating pollution.

In climate change, the estimated demand for pollution permits is high in developed (DC) countries, whereas most profitable abatement projects are in less developed (LDC) countries or in East European (EE) countries. For this reason, an ideal market for emissions trading would be a DC/LDC market. But because many LDC countries are not joining the climate change treaty, the supply-side of this market can be included only on a voluntary basis. This is the reason why the EU emissions trading proposal includes a provision for the voluntary inclusion of reductions undertaken in LDC countries. Using this EU-market analog, the general question for this research can be expressed as follows: what is the optimal market design for permits within the EU, given that the nature of this market determines the voluntary supply from projects outside the EU? For example, the tighter is the EU-permit market, the greater is the permit price and therefore the voluntary supply. What is the optimal tightness of the market which is determined by the number of issued permits? What is the optimal trading rule for reductions created on a voluntary basis? How is the supply of voluntary reductions included if some countries use taxes instead of permits to regulate emissions?

The main result is that the friction in voluntary opt-in affects the optimal market design. The friction must exist because there is no centralized market for emissions reduction projects in LDC countries, although there exists a well-defined permit market for reductions created in DC countries. Because of the friction in supply, the permit market should be tighter (number of issued permits lower) than in the absence of voluntary supply, but less tight than in the presence of frictionless voluntary supply. Thus, the friction itself reduces the optimal number of issued permits and this reduction is negatively correlated with project hosts' bargaining power in the project market. We show that optimal voluntary supply can also be implemented with taxes if the voluntary supply is transformed into transferable tax credits.

We also consider two ways of defining credits for voluntary reductions. One alternative is that credits are fully transferable, meaning that project partners can sell the credits generated by the project to third-party buyers as soon as the investment is made. Another is that transferability is limited: credits can be transferred only between the project partners. The latter case is thus a barter regime of transferable credits. Both trading rules have been proposed in climate change negotiations. The results show that the losses associated with limitations in transferability are not large.

Conclusions

The main conclusion we derive from the studies reviewed above is that global and local economics matter: The costs of various ways to reduce emissions should be taken into account. Given this we would like to point out several ways the research can and should be extended in addition to remarks made in the text. One important omission in the studies has been that the impact of policies on the incentives to develop and adopt new (more energy efficient) technologies have been ignored. Likewise we lack a model that could evaluate at the economy wide and industry wide level the impacts from various permit market designs. The suitable model would have to be a truly dynamic model that could then also be used to study the impacts of climate change itself as was pointed out already in the text.

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