EVALUATION OF THE COSTS AND BENEFITS OF EU-WIDE EMISSION TRADE IN FINLAND

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ABSTRACT: This study assesses the economic impacts of the proposed EU-wide emission trade both on the European union as a whole and on Finland in particular. The study utilises the global GTAP-E- CGE-model to analyse Europe-wide impacts and a Finland-specific, hybrid, CGE-model to study the impacts on the Finnish economy. The main finding of the study is that at a European level, emission trade appears to be very beneficial. However, emission trade along the lines of the EU Emission trade directive would not necessarily lower the macroeconomic costs of green house gas abatement in Finland, since it might very well misallocate quotas among the trading sectors on the one hand, and between the trading sectors and the rest of the economy on the other. Abatement costs might be lowered within some of the trading sectors, however.

1 Introduction

The EU commission has proposed EU-wide, utility-level emission trade comprising the energy sector, basic metal industries, oil refining, manufacturing of building materials and cement and paper and pulp industries. These sectors accounted for 38 per cent of 1997 EU emissions. In Finland, they covered nearly 60 per cent. This study evaluates the proposal both at the EU and at Finnish levels.

This study uses both a global economic model (the GTAP-E –model) and a model specific to Finland (the EV-model) to evaluate the effects of the emissions trade proposal. The study uses a commonly utilised baseline for EU (Shared analysis baseline); for Finland, the baseline follows the National Climate Strategy. The policy scenarios assume emission trade, but in the Finnish case, also the technical measures of the National climate strategy are assumed to take place. In other words, the proposed emission trade is in the Finnish case assumed to be complementary rather than alternative to the climate strategy.

The main finding of the study is that the proposed emission trade scheme is not necessarily advantageous to Finland. The study follows the proposal rather rigidly and we are not claiming generality with this finding. Rather, our findings seem to suggest that initial allocation does affect the outcome of emissions trade, and that finding the best allocation might not be easy. Furthermore, we find that on calculating the allocations, the starting point may matter. By this we mean not only the use energy, but also the tax structure. In particular, the effects of emissions trade in the trading sectors depend on whether trading would raise or lower energy costs. This depends not only on the price of emission permits, but also on the changes in energy tax structure in those sectors.

We assume that in the trading sectors, energy taxes are not used to curb emissions, as is implied in the EU proposals. In most European countries, the energy tax structure in the would-be trading sectors contains cut-offs, exemptions and so on; and while Finland was the first country in the world to introduce a CO2-tax, the Finnish energy tax structure is no exception. Introducing emissions trade would change all this, and the cost of this in the short run to 2010 could be high. If initial permits are grandfathered, costs may be lowered in the trading sectors, but not necessarily in the rest of the economy, since the initial allocation of permits between the trading sectors and the non-trading sectors also affects the overall costs of trading. This allocation would in fact appear to determine the overall effects of trading, which is troubling, since trading in no way helps to provide the information needed for its completion.

The paper is organised as follows. In the second section, we briefly outline the baseline assumptions. In the third section, we describe the models. The fourth section gives the results for EU, whereas the Finnish results are presented in the fifth section. The final section concludes.

2 Baselines

The study assesses the effects of emissions trading in comparison to a baseline scenario. The baseline affects the results insofar as the marginal costs of abatement are increasing; with high baseline emissions, reductions have to be larger and this obviously costs increasingly much. The study follows the authoritative European Energy Outlook for the rest of EU, but the Finnish baseline is more in accordance with the National Climate Strategy. This choice is made because the EU baseline predates the Climate Strategy and thus does not contain some measures, and also because some of the EU baseline data for Finland is somewhat insufficient.

The EU baseline assumes fairly rapid economic growth by 2010, with the OECD growing at 3 per cent annually and the EU at 2.3 per cent. The community integration and liberalisation policies are assumed to continue, which could have a large impact on the energy markets. Climate policies are not assumed in the baseline.

EU energy consumption is estimated to grow at 1 per cent per year, with the average energy intensity falling by 1.5 per cent. Energy supply is assumed to be met mostly by fossil fuels, with solid fuels being replaced by natural gas. The baseline estimates that there is a demand for 300 GWs of new capacity between 1995 and 2020. On the technology front, an increase in the use of CHP is expected to improve the thermal efficiency of power generation from 35 per cent in 1995 to 45 per cent in 2020. For comparison, Finnish electricity generation capacity is at the moment around 15 GWs, with an average thermal efficiency of 59 per cent. The reason for the high efficiency is the already extensive use of CHP, which leaves little room for increases. The EU baseline assumes that all current production forms will be used. Despite the improvements, the use of fossil fuels is increasing and thus the greenhouse gas emissions of the EU are growing by 0.6 per cent a year between 1995 and 2020. By 2010, the EU would have to cut its emissions by 14 per cent to meet the Kyoto target.

The Finnish baseline scenario bases on a synthesis of the forecasts for economic growth by the major forecasting institutes and ministries. It also includes very technology-specific predictions for productivity growth and energy efficiency stemming from research institutions. The forecast for population growth, which points at an almost stagnant and ageing population, stems from Statistics Finland. World price forecasts stem from many sources, most importantly from the IEA.

The baseline scenario assumes that industrial production continues to grow at an average annual rate of 3.5 to 2010, the reference year for the impact evaluations. However, even the baseline predicts large differences between industry branches. Thus, the electronics industry is predicted to grow at an average annual rate of 8 per cent, lead by the IT branch. The traditional Finnish export industries, forest and basic metal industries, are expected to grow significantly more slowly, at 2.5 and 2 per cent annually, respectively. Reflecting growth in forest industries, forestry is also expected to grow fairly briskly, at 2 percent a year. Chemical industries are taken to grow slower still, at 1.7 per cent, largely because the demand for refined oil products is expected to be slow. Some of the more domestically oriented industries, however, are expected grow relatively briskly, as are services. Regional concentration, stimulating construction and related industries, as well as the ageing of the population explain this. Agricultural production, on the other hand, is expected to decrease.

For energy efficiency, very detailed forecasts are given by the ministries responsible for preparing the National climate strategy. On the average, energy efficiency is expected to improve by 2 per cent for fossil fuels, but again, there are important sectoral differences. The increase is expected to be especially high in the transport sector, reflecting the effect of the EU gas mileage target, whereas in the energy sector, increases to the already high average efficiency are much harder to come by with. The energy efficiency of housing is also expected to improve fast, but this effect is more pronounced for electricity and heat consumption than fossil fuels. Overall, energy efficiency in consumption can be said to have more room for improvements than power generation, which is reflected in the baseline as well.

Some of the most crucial assumptions for the baseline concern generation capacity. In the baseline, electricity consumption is forecast to grow from 80 TWh in 2000 to 90 TWh in 2010. How this increase is to be met on the production side obviously affects the scope for reductions very much.

The baseline assumes that there is an increase in the use of almost all of the domestic sources that are available. This includes wind power and bioenergy, but these can not meet but a fraction of the demand growth (practically all potential hydropower sites are protected, and wind power, while growing very fast, starts from a low level). Imports of electricity from other Nordic countries and Russia are currently contributing over 10 TWh to the supply, but in the future, Swedish and Norwegian demand may not leave much room for exporting electricity. Imports are thus expected to decrease, and the gap is taken to be met by existing coal-fired condensing plants. While the consumption of fossil fuels is increasing in most sectors in the baseline, electricity generation provides the most important single reason why Finnish emissions are not expected to meet the Kyoto target in the baseline. The baseline emissions are forecast at 90 Mt. CO_2-equivalent for 2010, of which fossil fuels account for 70 Mt. The Finnish Kyoto target is 76,5 Mt CO_2-equivalent, with fossil fuels at 54 Mt.

3 The models

The study utilises two CGE-models to evaluate the effects of emissions trading. In the EU context, the GTAP-E-model is used. The model enables us to analyse both the trading and the non-trading sectors simultaneously. However, it does not contain much detail about the generation processes within the energy sector, which makes it unsuitable for studying technology-specific policy measures. The model, on the other hand, produces results on permit prices and terms of trade changes that can be used as inputs in a more detailed model for Finland.

The GTAP data base contains data on the basic fossil fuels coal, oil, and transport fuels. Emission trade can be studied as a problem of finding the uniform level of emission taxes within the trading region that restricts emissions at a given level. Differences in initial allocations are not readily accounted for by the model, but it gives a reasonable first approximation for cost-efficient abatement within a given region and given sectors. For the present study, the regional and sectoral aggregations were chosen to reflect the EU emission trade proposal. The aggregations are described in table 1.

Table 1 GTAP regions and sectors

Sector	Region
Coal (COL)	Finland (FIN)
Oil (OIL)	Sweden (SWE)
Natural gas (GAS)	Denmark (DEN)
Transport fuels (P_C)	Eastern Europe (EEA)
Electricity (ELY)	USA (USA)
Wood and paper industries (WOOD)	Japan (JPN)
Transports (T_T)	EFTA (EFT)
Basic metal industries (I_S)	Former Soviet Union (FSU)
Chemical industries (CRP)	Rest of EU (REU)
Other manufacturing (OMN)	Rest of Annex 1 (RAN)
Agriculture (AGR)	Rest of World (ROW)
Services (SER)	
Dwellings (DWL)	

The domestic implementation and effects of sectoral emission trade were studied with the hybrid-EV-model (Forsström ja Honkatukia 2002), which combines an engineering model of the energy sector and key industrial sectors to a top-down CGE-model. The model shares certain key parameters with the GTAP model and it is relatively straightforward to take the GTAP-E-results on Finnish exports and world prices as inputs for the model.

The key modelling target in setting up the EV-model has been to capture the essential process-level features and peculiarities of Finnish energy use. The model thus relies heavily on engineering data about the details on fuel use, the often fuel-specific processes that are used in the production of heat and electricity as well as in process industries. Production in these industries is modelled along bottom-up, or engineering, descriptions of the processes. The model also makes a distinction between different electricity and heat generation technologies. This is essential for the analysis of the Finnish energy sector, which contains a lot of combined heat and power generation, as well as communal district heating.

The basic data for the model is input-output data, which for Finland is available for 1995. For the less energy-intensive industries, this data has been used as such, but for the energy-intensive process industries and for the energy sectors, engineering data has been used for disaggregating the data to a sufficiently detailed level. The model contains specific process description for the energy sectors, paper and pulp industry, and the basic metal industries, were the processes are identified both according to the specific product (electricity, heat or CHP; quality of paper; type of metal) and the fuels used (different types of oils, coke, natural gas, coal, peat, biomass and wood). The model also takes heat, hydropower and nuclear power into account, contrary to the GTAP-E-model.

4 The effects of emission trade in the GTAP-E –model

The primary aim of this study is to study the effects of the EU-wide sectoral trade. Theoretically, of course, any restrictions on emission trade would reduce the efficiency gains from trade and undermine the argument for introducing trade in the first place. To see how much of the gains from emission trade would be lost, wider trading schemes were also studied. The trading scenarios are given in table 2. The scenarios progress from a go-it-alone alternative for Finland to Annex 1-wide trading, covering the likely cases between the extremes. It was also studied, how an integration of the electricity markets would change the effects of emissions trade. In the Nordpool alternative, further integration of the Nordic electricity markets was captured by assuming higher elasticities of substitution for import electricity in Sweden, Finland and Finland than in other EU regions. To an extent, this integration should arguably be included in most other cases as well, since the integration of the Nordic electricity markets has already taken place, which is not the case in the rest of EU yet.

Table 2 Alternative emission trade scenarios

Scenario	**Trading sectors**	**Emission trade**	**Emission target**
Finland alone	-	No trade	Only Finland
EU no trade	-	No trade	EU burden sharing
EU trade	All	Trade	EU
EU sector	EU proposal	Trade	EU
EU sector + Nordpool	EU proposal	Trade	EU
EU+EEA sector	EU proposal	Trade	EU+EEA*
Annex 1-USA	All	Trade	Annex 1 except USA
Annex 1	All	Trade	Annex 1

* EEA=Bulgaria, Chech Republic, Hungary, Poland, Romania, Slovakia, Slovenia

Table 3 EU trading sectors in the GTAP model

Sector	GTAP Sector	**Share of EU emissions, 1997**
Energy sectors	Electricity	29,9
Basic metal industries	Ferrous metals	5,4
Oil refining	Petroleum, coal products	3,6
Construction materials	Construction	2,7
Paper and pulp industries	Wood products & WOOD Paper products, publishing	1,0
Total		**42,6**

Our results on permit prices are given in table 4. As expected, the prices are lowest when the trading region is large. However, US participation would raise emission prices, since it would be a net buyer of permits. The permit prices we obtain for these cases are low, but consistent with the findings of others utilising the GTAP-E-model (Truong 2001). At the other end of the trading scale, EU-wide sectoral trade gives significantly higher permit prices, with about 8 USD for the EU+entrants-scenario and 10.37 for the current EU. Thus, restricting emission trade to only EU clearly undermines the efficiency gains. From the Finnish point of view, sectoral trade would be more efficient than going it alone, however, since in this case the marginal cost of abatement would be over 16 USD. Interestingly, electricity market integration yields lower permit prices than the inclusion of the entrants to the EU. It would then appear that the effects of energy market integration are to be studied seriously when evaluating EU-wide permit trade. In fact the permit price is at the same level as in the non-restricted trade scenario for the EU.

Table 4 Permit prices (USD per tonne CO2)

	Annex1 -USA	EU no trade	EU trade	EU sector + Nordpool	EU+EEA sector	Finland alone	EU sector	Annex 1
FIN	2.1	0.0	6.4	6.44	7.97	16.19	10.37	2.6
SWE	2.1	0.0	6.4	6.44	7.97	0.0	10.37	2.6
DEN	2.1	0.0	6.4	6.44	7.97	0.0	10.37	2.6
EEA	2.1	0.0	0.0	0	7.97	0.0	0	2.6
USA	0.0	0.0	0.0	0	0	0.0	0	2.6
JPN	2.1	0.0	0.0	0	0	0.0	0	2.6
EFT	2.1	0.0	0.0	0	0	0.0	0	2.6
FSU	2.1	0.0	0.0	0	0	0.0	0	2.6
REU	2.1	0.0	6.4	6.44	7.97	0.0	10.37	2.6
RAN	2.1	0.0	0.0	0	0	0.0	0	2.6
ROW	0.0	0.0	0.0	0	0	0.0	0	0.0

Table 5 gives the emission reductions in the various scenarios. It appears clearly, how emission trade changes the need to recourse for domestic measures in the trading countries. In the Finnish case, the go-it-alone target of -22 per cent from BAU is replaced by a marginal-cost-equalising -11.4 in the unrestricted EU trading scheme, or -16.3 in the sector trade scenario. This reallocation of reduction requirements points to the inefficiency of the EU burden sharing agreement, and similar observations can be made with respect to other countries as well. It would thus appear that even restricted emission trade does help to allocate abatement more efficiently.

Table 5 Change in emissions, % from baseline

	BAU: CO2 (level)	Annex1 - USA	EU No trade	EU Trade	EU sector + Nordpool	EU+EEA sector	Finland alone	EU sector	Annex1
FIN	69.43	-3.6	-18.8	-11.4	-9.91	-13.25	-22.4	-16.28	-4.1
SWE	78.20	-2.2	-14.0	-6.5	16.32	-7.58	0.014	-9.58	-2.2
DEN	74.26	-3.9	-39.2	-11.4	-75.33	-13.32	0.026	-16.65	-4.3
EEA	834.47	-10.3	0.7	0.9	0.59	-27.82	0.033	1.27	-12.3
USA	5845.48	0.2	0.2	0.3	0.34	0.35	0.01	0.36	-12.7
JPN	1365.14	-6.1	0.2	0.3	0.23	0.34	0.008	0.36	-7.1
EFT	99.37	-5.9	0.2	0.1	1.74	0.25	0.008	0.12	-6.4
FSU	2477.13	-37.4	0.5	0.5	1.12	1.07	0.22	0.68	-40.0
REU	3618.02	-6.3	-9.1	-14.1	1.38	-15.81	0.016	-18.37	-7.3
RAN	358.49	-5.7	0.3	0.4	0.47	0.47	0.007	0.49	-6.7

The welfare effects of emission trade are given in table 6. The effect is given as an equivalent variation in the regional households' utility. For the Finnish case, the go-it-alone scenario is clearly the worst, while Annex 1-trading (with or without the USA) would involve the lowest welfare losses. The table also illustrates how those regions that are not committed to either trading or (by our assumption) emission targets, would benefit from unilateral EU abatement. Interestingly, both Finland and Sweden benefit more from the electricity market integration than from unrestricted EU emission trade.

Table 6 Equivalent variation (MUSD 95)

	Annex1 - USA	EU no trade	EU trade	EU sector + Nordpool	EU+EEA sector	Finland alone	EU sector	Annex 1
FIN	-40	-245	-135	-84.62	-159.0	-445.0	-229.4	-30
SWE	-51	33	-248	181.45	-295.9	-6.5	-401.9	-19
DEN	-106	-2300	-393	-1752.62	-468.6	-4.1	-630.1	-98
EEA	-193	70	94	-50.33	-1576.0	5.7	149.2	-221
USA	117	143	235	-175.22	379.1	-3.5	431.1	-1660
JPN	-258	647	845	431.27	1261.6	-1.9	1306.2	109
EFT	-262	22	-127	1300.06	-114.6	-14.4	-175.9	-359
FSU	-790	-91	-127	124.22	-162.0	-21.6	-169.6	-1039
REU	-2028	-6259	-12813	-8911.08	-15471.6	138.4	21413.1	12
RAN	-272	-25	-26	-89.39	-24.8	-0.5	-20.6	-365
ROW	-220	74	45	-63.1	171.8	-9.5	80.6	-654

Table 7 reports the sectoral effects on emissions in Finland. In the trading sectors, the largest reductions occur within the basic metal industries and the electricity sector. Among the non-trading sectors, the sector dwellings faces the largest reduction. It is debatable, whether this result is realistic however, since most of the energy use of the dwellings-sector stems from heating and lighting, and it is unlikely that their emissions could be halved 8given the Finnish climate) without producing some serious side-effects.

Table 7 Changes in sectoral emissions in Finland, % from baseline

	BAU	Annex1 -USA	EU no trade	EU trade	EU sector + Nordpool	EU+EEA sector	Finland alone	EU sector	Annex1
Electricity*	25.41	-4.9	-29.5	-17.1	-20.01	-14.92	-32.83	-18.43	-5.8
Wood*	3.47	-3.9	-24.9	-13.8	-6.36	-6.76	-28.27	-8.58	-4.7
Transport	8.81	-0.9	-6.6	-3.1			-7.84		-1.0
Basic metals*	5.09	-10.8	-41.6	-27.7	-13.37	-12.16	-45.73	-14.51	-12.4
Chemical industries*	4.49	-2.4	-14.6	-7.6	-4.88	-5.32	-17.09	-6.8	-2.9
Other manufacturing	4.4	-3.1	-18.2	-10.1			-20.68		-3.6
Agriculture	1.5	-3.3	-4.9	-4.0			-5.13		-3.4
Services	3.0	-1.4	-10.3	-5.2			-12.24		-1.5
Dwellings	0.0001	-44.7	-56.8	-49.8			-58.94		-45.5
total emissions	40.4	38.4				37.3		35.8	

* proposed trading sectors

5 The effects of emission trade on Finland in the EV-model

The evaluation of the effects of EU-wide, sectoral emission trade take the GTAP-E-results on permit prices, changes in world prices and world demand as a starting point. We then assume that emission trade does not replace but rather complements the National Climate Strategy. Towards this end, we do not cover precisely the same trading scenarios with the EV-model, but rather concentrate on the issues that can not be handled by the GTAP-model. The foremost of these are the technological measures that form the core of the National Climate Strategy.

The Finnish Climate Change Strategy is a result from an extensive survey of both the technical possibilities for reducing emissions by energy saving and by increasing the use of renewables, as well as the economic measures necessary for achieving the technically feasible targets. The major part of the work was carries out in ministries laying the plans for their particular fields of responsibility, which were then combined into broad strategy options, with engineering and economic modelling supporting the evaluation of the costs of these options.

The Climate Change Strategy combines abatement measures in two broad, alternative strategy packages, which consist of a national programme for energy saving, a programme for increasing the use of renewables, and the replacement of coal-fired condensing plants by either natural gas-fired plants or nuclear power. Both srategy alternatives also include an increase of energy taxes with alternative revenue-recycling schemes.

The energy saving programme contains many command-and-control –type measures, such as the EU mileage requirements (which in Finland would most likely be supported by cuts in the very heavy excise tax for new passenger cars), energy saving contracts with heavy road transport, similar contracts with other industries and service sectors, and increases in energy-efficiency requirements for new housing and other construction, as well as for electrical equipment. The by far largest gains would stem from heating – where they would be in the region of 10% - and from transports (4 per cent).

The renewable energy programme aims at increasing the use of wind power and biomass by means of tax cuts and production subsidies and with investment subsidies. The aim of the programme is, broadly, to increase wind-power generation three-fold by 2010 and the use of biomass by 15 % in CHP and by 75% in heat centres.

The replacement of coal-fired condensing plants would potentially involve some quite drastic measures. Since the electricity markets are liberalised, it is conceivable that the coal-fired condensing plants would have to be, in effect, socialised (or the owners compensated for their stranded assets) to force their shutting down if the new capacity were to be natural gas-fired, since the latter is not competitive with coal at the current prices. This issue does not arise in the nuclear option, where lower production costs would drive the coal-fired plants out of the market. The output of the new plants would be approximately 11 TWh in both cases.

The energy taxation options in the Climate Change Strategy assume that current energy taxes would be raised sufficiently to cut the use of fossil fuels by the necessary amount. The current tax structure does not fully reflect GHG-emissions, but in most uses fossil fuels do have a component that is based on their CO2-emissions. This tax does not affect fuels for electricity generation, which is why electricity taxes are also to be raised. However, under emission trade, all fuels would be de facto taxed according to their CO2-content within the trading sectors. It would most likely be unnecessary – not to say difficult – to raise taxes in these sectors as well. Within the non-trading sectors, however, taxes would still remain useful. Accordingly, we assume that energy taxes are raised in the non-trading sectors to ensure that Finland meets her overall reduction target. However, for fiscal reasons it is unlikely that the taxes would be lowered, which we do not allow for. This assumption has a strong effect on our results, since it implies overshooting the reduction target in many cases.

The GTAP-results indicate that the actual reductions required from the trading sector and from the other sectors depend on the emissions price. However, the emission trade proposal necessitates the implementation of the national allocation scheme before the emission price is known. We consider only two allocation schemes here, one with a 16 per cent reduction target for the trading sectors, and another with a 22 per cent target. The trading sectors can realise this reduction with domestic measures or by buying permits. It is noteworthy that this is not possible for the non-trading sectors, whose abatement costs however depend on the target the allocation scheme implies for them. It is clear that marginal abatement costs will be much higher in the non-trading sectors with the 16 per cent target than with the 22 per cent target. Emission trade will also affect the non-trading sectors in a more indirect way, namely, via its effects on domestic energy prices, which depend both on the target for trading sectors and the permit price.

International permit prices are exogenous in the EV-model. We consider four possibilities:

1. 3.3 €/tonne CO2, approximately the level reached with Annex 1-trade without the USA
2. 6.6 €/tonne CO2, the level for EU-wide sectoral trade with new member states
3. 10 €/tonne CO2, EU-wide sectoral trade (EU proposal)
4. 20 €/tonne CO2, the level often seen as the maximum marginal cost for cost-effective abatement within the EU.

The last alternative is of interest in the Finnish case because it exceeds the current CO2-tax by roughly 3€/tonne CO2. Thus it represents a level where the benefits of emission trading can at least a priori be doubted.

Finally, we study two initial allocation schemes, one with grandfathering, one with auctions. The EU is proposing to initiate sectoral emission trade with grandfathered quotas, but by the Kyoto period auctioning would be the rule. However, grandfathering may not entirely ruled out yet, since there is currently a lively debating on the emission trade proposal.

Table 8 presents the climate policy and trade scenarios for the EV-model.

Table 8 Emission trade scenarios in the EV-model

	Raise in energy taxes	Emission trade	Electricity generation	Target for trading sectors
Gas*	All sectors	None	Natural gas	-
Nuclear2*	All sectors	None	Nuclear	-
Gas-TRADE	Non-trading sectors	EU proposal, auctions	Natural gas	-22%
Nuclear- TRADE	Non-trading sectors	EU proposal, auctions	Nuclear	-22%
Gas- TRADE2	Non-trading sectors	EU proposal, grandfathering	Natural gas	-22%
Nuclear-TRADE2	Non-trading sectors	EU proposal, grandfathering	Nuclear	-22%
Gas-TRADE3	Non-trading sectors	EU proposal, grandfathering	Natural gas	-16%
Nuclear-TRADE3	Non-trading sectors	EU proposal, grandfathering	Nuclear	-16%

Table 9 presents our finding s on domestic total emissions for Finland. The first two rows present the Finnish climate strategy results, where emission trading is not assumed, for comparison with the trading results. From the table it can be seen that only with the lowest permit prices is the reduction target met accurately: with higher prices, it is overshot, which is due to our assumption of a lower bound for the energy tax in the non-trading sectors. Strictly speaking, we can then only compare the results obtained with the lowest emission prices under the different trading scenarios.

Table 9 Total emission reduction, %

	Permit price, €			
	3,3	6,6	10	20
Gas*	-21	-21	-21	-21
Nuclear*	-21	-21	-21	-21
Gas-TRADE	-21	-21	-22	-27
Nuclear-TRADE	-21	-23	-25	-30
Gas-TRADE2	-21	-24	-24	-31
Nuclear-TRADE2	-21	-26	-28	-33
Gas-TRADE3	-21	-21	-21	-28
Nuclear-TRADE3	-21	-22	-24	-28

Table 10 gives the reduction in domestic emissions. It can be seen that with low permit prices, only a small part of the reduction is actually coming from domestic measures. This reflects the relatively high Finnish abatement costs.

Table 10 Domestic emission reduction, %

	Permit price, €			
	3,3	6,6	10	20
Gas*	-21	-21	-21	-21
Nuclear*	-21	-21	-21	-21
Gas-TRADE	-6	-7	-8	-13
Nuclear-TRADE	-7	-9	-10	-16
Gas-TRADE2	-6	-9	-10	-16
Nuclear-TRADE2	-6	-12	-13	-18
Gas-TRADE3	-10	-11	-11	-17
Nuclear-TRADE3	-11	-12	-14	-18

Figure 1 presents some macroeconomic effects for Finland in the case of low permit prices. Compared to Climate strategy estimates (Gas* and nuclear*), emission trade mostly does not decrease the effects from attaining the Kyoto target. This is not a general results, though, but entirely specific to the allocation schemes studied. Why the allocation schemes do not fare better could depend on data differences (the GTAP-4 data base contains no information on heat generation, for example), or on different assumptions about taxes (the GTAP-E-model does not take into account the actual tax structure but implicitly assumes a CO2 tax in the non-trading sectors as well).

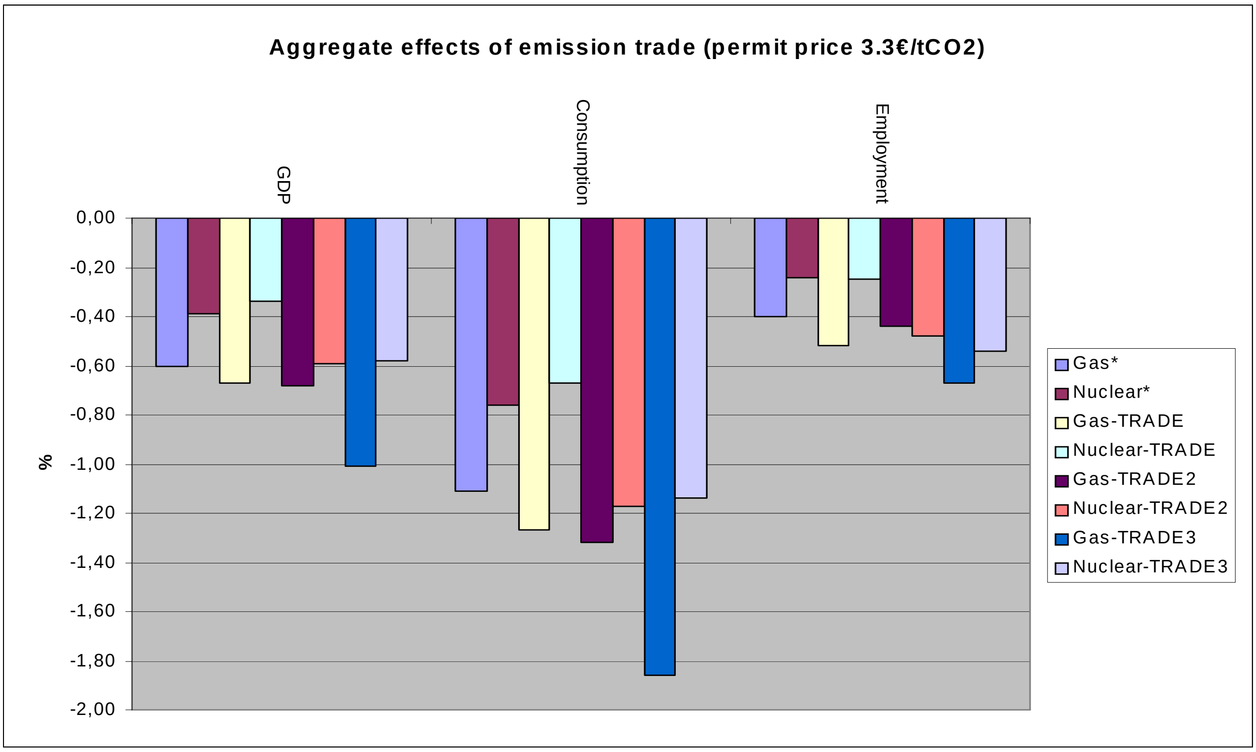

Figure 1 Aggregate effects of emission trade in Finland

This can be seen from figure 2, which shows the effects on production in the main sectors of the economy. Some of the trading sectors clearly benefit from emissions trade, whereas the non-trading sectors always loose. One would not expect non-trading sectors to be more affected under trade unless they have to assume a large share of reductions.

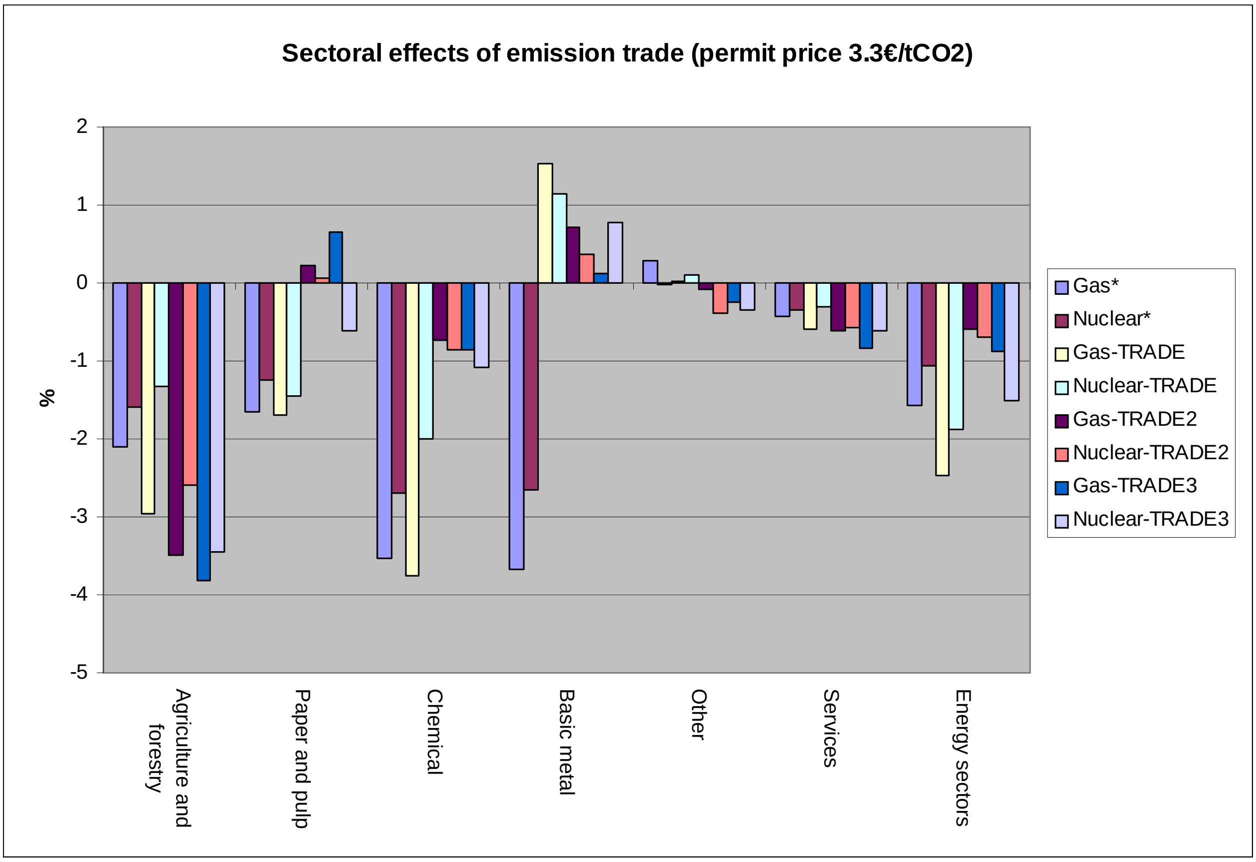

Figure 2 Sectoral effects of emission trade in Finland

Table 11 summarises the effects of emission trade on power production. Several effects are apparent from the table. First, the effects of emission trade depend on whether capacity is relying more on natural gas or nuclear. In the former case, separate electricity production is strongly affected by emission trade even with low permit prices, because it introduces a new cost element to electricity generation. In the latter case, condensing power bases more on nuclear and is not so much affected. Second, CHP is more affected in the nuclear option, where fossil fuels will continue to have a large role even in the nuclear option. Third, no systematic differences arise in the district heat sector, but the reduction target for the trading sectors does have an impact on the effects in this sector.

Table 11 Effects of emission trade on power generation

	Gas-Trade	Nuclear-Trade	Gas-Trade 2	Nuclear-Trade 2	Gas-Trade 3	Nuclear-Trade 3
Permit price 3.3 €/tCO2						
Condensing plants	-8,9	-2,0	-6,5	5,7	-12,5	-1,2
CHP	-4,9	-10,5	-3,1	-1,1	-4,4	-8,0
District heat centres	-3,3	3,8	-12,1	-5,1	-3,3	-3,3
Permit price 6.6 €/tCO2						
Condensing plants	-9,9	-3,0	-7,9	-4,3	-8,1	-3,1
CHP	-3,1	-10,5	-1,7	-6,9	-5,6	-8,3
District heat centres	-3,3	-3,3	-12,1	-12,1	-3,3	-3,3
Permit price 10 €/tCO2						
Condensing plants	-10	-5,1	-8,3	-5,6	-8,0	-5,0
CHP	-4,4	-12,2	-3,0	-9,8	-6,7	-11,9
District heat centres	-3,3	-3,3	-12,1	-12,1	-3,3	-3,3
Permit price 20 €/tCO2						
Condensing plants	-15	-9,6	-15,6	-9,4	-15,0	-9,0
CHP	-8,1	-21,2	-4,9	-18,4	-7,9	-17,3
District heat centres	-3,3	-3,3	-12,1	-12,1	-3,3	-3,3

6 Conclusions

This study has evaluated the effects of the proposed EU-wide sectoral emission trade both in the EU and in Finland. The study has utilised both a global and a Finland-specific CGE-model, basing on (semi-) official EU and Finnish baselines. In the EU case, emission trade is the only climate policy instrument considered, but in the Finnish case, also technology measures have been assumed.

The results indicate that the proposed sectoral trade scheme, is not automatically beneficial for Finland. This result depends on the initial allocation of reduction targets between the domestic trading and non-trading sectors. We have implemented an allocation scheme stemming from the GTAP-E-model in our model for Finland here, with the results indicating that the scheme is less than optimal when several measures and more detail are taken into account.

For the EU as a whole, emission trading would clearly be beneficial, even if restricted to only a few sectors. The large efficiency gains can only be realised, however, only if more sectors and more countries are allowed to trade.

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