How sinks in wood products affect the cost of Climate Convention and world trade of forest products: results from a global economywide model

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ABSTRACT

Forest carbon sinks were included in the Kyoto Protocol as a mechanism to mitigate climate change. The size of the carbon sink in forests and forest products for different countries vary considerably depending on the definition and accounting methods. Thus the given definition or accounting approach might be beneficial for some countries but costly to some others. Also the effects on world trade might differ. Thus the implications of various accounting approaches and appropriate economic instruments on world trade and the costs of Climate Convention should be analyzed with economic models.

The first attempts to evaluate the implications of including sinks in forest and forest products into Climate Convention are taken in this paper by analyzing various accounting approaches. Economywide and sectoral effects for various countries/regions, and world market effects are estimated by using a recursively dynamic CGE model.

Even though sinks in forests and forest products could not be credited, the wood products industry would be affected since payment on emissions from fossil fuels improves the competitiveness of wood products. The atmospheric-flow approach has been argued to have severe effects on world trade of wood products, since the carbon released would be accounted for importing country. However, according to the model results, the negative effects could be (partly) avoided with appropriate setting of taxes and subsidies. The choice of accounting approach affect considerably the costs of Climate Convention for forest product exporting country, like Finland.

Keywords: wood products, carbon sink, world trade, Climate Convention

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1. INTRODUCTION

In addition of reducing emissions of greenhouse gases, the climate change can be mitigated by removing greenhouse gases from the atmosphere. This is also recognized in the Kyoto Protocol that allows the carbon sinks to be utilized as one of the adjustment mechanisms to achieve a given emission target. Carbon sinks are considered as one of the most difficult issues to agree in Kyoto Protocol.

Land management activities that reduce the amount of CO_2 in the atmosphere are referred to as Land Use, Land-Use Change and Forestry (LULUCF) activities. These activities are dealed with in Article 3.3. and Article 3.4. in Kyoto Protocol. Article 3.3. covers afforestation, reforestation and deforestation while article 3.4. covers the additional activities, like forest management, cropland management, grazing land management and revegetation (according to Pronk's New Proposal). The amount of sinks that could be credited will be restricted due to difficulties in e.g. measurement and inclusion of human induced sinks only. Also, according to EU, the credits from carbon sinks should not significantly reduce the obligation to reduce emissions from fossil fuels. Roughly speaking, only 15 % of carbon sinks due to forest management could be credited (in the first commitment period) according to Pronk New Proposal.

In addition, carbon sinks in wood products are discussed in context of reporting net CO_2 emissions. They are not however included in any proposal on how the countries should receive credits from carbon sinks. Various approaches have been suggested for estimating net emissions of CO_2 from forest harvesting and wood products (Brown et al, 1998). The approaches generate globally the same net carbon exchange with the atmosphere but at the national level their implications differ. These differences have implications for world trade of wood products and managing forests.

It has been evaluated what kind of incentives suggested approaches would create for consumption of wood products and forest management. However, in these evaluations, the accounting approaches have been thought to act as an incentive as such and the economic instruments have been excluded. Thus there is a need for both analytical and numerical economic analysis of different accounting approaches and economic instruments. This paper takes the first attempts by analyzing numerically the accounting approaches with economic instruments.

Section 2 gives a backround by discussing the carbon sinks in wood products, particularly the various accounting approaches. Section 3 describes the model and section 4 the data used in the simulations. The policy scenarios are reperesented in section 5 and the results in section 6. In section 7 the preliminary findings are summarized and main weakness and the future improvements are discussed.

2. CARBON SINKS IN FOREST PRODUCTS

When considering carbon sinks one has to distinguish the amount of sinks reported to UNFCCC and how sinks are treated in Kyoto Protocol. Sinks are reported to UNFCCC according to Revised Guidelines. IPCC is developing the new approaches that would also include sinks in wood products. With the appropriate interpretations, sinks could be included also in Kyoto Proposal. However, e.g. in Pronk Proposal sinks in wood products are not included.

2.1. Accounting approaches

In the current IPCC default approach all CO_2 emissions and removals from forest harvesting and the oxidation of wood products are accounted for by the country in which the wood was grown. Also it is assumed that all the carbon is released immediately, so it is accounted for in the year of harvesting. In reality, however, the time period in which carbon is released depends on the use of carbon. In paper carbon could remain for some years while in wooden houses carbon could remain for 100 years. The current approach is correct in case that there is no change in the size of wood-products pool. However, it cannot e.g. handle the situation in which increasing the amount of carbon in wood products is used as policy measure. In IPCC expert meeting in Dakar, Senegal in 1998 a range of approaches for estimating the emissions and removals of CO_2 from forest harvesting and wood products were examined. In the meeting, three approaches, namely stock-change approach, production approach and atmospheric-flow approach were proposed (Brown et al., 1998).

The accounting approaches are as follows:

Stock-change approach: Estimates net changes in carbon stocks in the forest and wood-products pool. Changes in carbon stock in forests are accounted for in the country in which the wood is grown, referred to as the producing country. Changes in the products pool are accounted for in the country where the products are used, referred to as the consuming country. There stock-changes are counted within national boundaries, where and when they occur.

Production approach: This also estimates the net changes in carbon stocks in the forests and the wood products pool but attributes both to the producing country. Stock changes are counted when but not where they occur if wood products are traded.

Atmospheric-flow approach: This accounts for net emissions or removals of carbon to/from the atmosphere within national boundaries, where and when emissions and removals occur. Removals of carbon from the atmosphere due to forest growth are accounted for in the producing country, while emissions of carbon to the atmosphere due to forest harvesting is accounted for in the producing country and emissions of carbon to the atmosphere from oxidation of harvested wood products are accounted for in the consuming country. The atmospheric-flow approach is analogous to treatment of emissions from fossil fuels.

2.2. Implications of accounting approaches

The approaches generate globally the same net carbon exchange with the atmosphere but at the national level their implications differ. Since the amount of sink differs within the accounting approaches, accounting approach affects also the economic costs of achieving the emission target. In addition of direct effect, also the effects via implications for world trade of wood products have to be taken into account while estimating the total effect. The difference between the approaches can be considerable e.g. for wood products exporting country, like Finland, that has been used as an example in the table 1. At the first sight, the atmospheric-flow seem to be the most favourable for the country whose timber is mainly used to produce wood products that are exported, like Finland, New Zealand and Canada. According to this approach, all the carbon uptake would be accounted for in the countries where the wood products are produced while the great deal of carbon would be exported abroad. However, the indirect effects via trade flows and international prices might change the situation.

Table 1. Carbon sinks implied by Finnish forest products according to different approaches in the year 1990, million ton of CO_2.

	Stock-change	Production	Atmospheric-flow
In Finland	3,0	11,3	16,3
In export countries	9,4	-	-8,1
In Russia	-	-	4,2
In global level	12,4	11,3	12,4

* in production approach the global sink is smaller since the imported timber is not included.

In atmospheric-flow approach the importing country is also importing a considerable amount of carbon that it has to add to its emissions. Since the amount of emissions increases, it is more difficult to achieve the emission limit. Thus, it has been argued that atmospheric-flow approach would give a disincentive to import forest products and thus disturb the world trade of those products. However, with appropriate setting of economic instruments these disincentives might be (partly) removed.

3. MODEL DESCRIPTION

Economywide costs of Kyoto Protocol have been analyzed with single country models and global models. Very few of these analysis have so far taken into account carbon sinks. Few exceptions include e.g. Pohjola (1999) in which the economic effects of setting emission limit on emissions from fossil fuels are compared with setting limit directly on net emissions including forest sink. In Reilly et al (1999) marginal cost curves for tree-planting projects have been included so that model chooses whether it is more cost efficient to reduce emissions from fossil fuels or sequester carbon by afforestation. To my knowledge, sinks in forest products have not been included in any of the economywide models.

3.1. General properties of the model

The model used in this study is a standard, simple global CGE model developed for analysing the economywide and sectoral effects of the Climate Convention. The model is recursively dynamic. The new feature of the model is to include carbon sinks. The model is programmed and solved with GAMS software and PATH solver.

3.2. Regions and sectors

Since the focus of the analysis is on the carbon sinks and world trade of forest products, the regional and sectoral disaggregations have been chosen to be suitable for this purpose. The model includes 11 countries or regions. In the regional level, the model includes the most important exporters of forest products, namely Canada, USA, Finland and Sweden. An examples of wood product exporting countries includes at present stage Finland and Canada. Later on, also New Zealand is included. At this phase, UK is an example of a wood product importing countries but later on Japan will be included as a separate country.

Regions
USA
Canada
UK
Germany
Sweden
Finland
The rest of Western Europe
Eastern Europe and Former Soviet Union
The rest of OECD
Asia
The rest of the world

In the sectoral level, model includes the production of pulp and paper, production of wood products and forestry as separate industries. Construction, which uses wood products, will be modelled separately in the next phase. The energy-intensive industries as production of iron and steel are treated separately. Also model includes several fossil fuels.

Sectors
Agriculture
Forestry
Paper and pulp industry
The wood products industry
Iron and steel industry
Other industries
Services
Electricity and heat
Production of oil
Production of coal
Production of gas
Production of fossil fuel products

3.3. Production

All non-energy sectors are modelled with the same production technology. The nested CES function has been chosen. Coal, oil, gas and fossil fuel products are combined at the bottom nest of the production function to create a fossil fuel aggregate. The fuel aggregate is combined with electricity and heat to create a energy aggregate. The energy aggregate is combined with capital, and the energy-capital aggregate is combined with labour. In the upper level the aggregate of primary and energy inputs is combined with aggregate of intermediate (non-energy) inputs. Each intermediate input is an aggregate of domestic and imported inputs, according to Armington assumption. Technical change is not included in the model.

3.4. Households

The representative household for every region allocates her income among consumption goods. The classification of consumption goods corresponds that of production sectors.

3.5. International trade

All goods are traded in the international market. On the import side, industries and firms choose between domestically produced and imported goods. Also, the imported goods are differentiated by origin. Thus, goods produced in different regions are imperfect substitutes. Exports are determined by the import demands in other regions.

3.6. Factor markets

Labour and capital are primary factors of production. Both labor and capital are assumed to be homogenous in the national level and perfectly mobile between sectors. Thus, the wage rate and the price of capital are equalized across sectors in a given region. However, labour and capital are not allowed to move across regions. The price of labor is perfectly flexible balancing the demand and the supply of labour. Thus, there is no unemployment in the model.

3.7. Climate policy

In some simulations emission target has to be achieved by domestic action and in some simulations international emission trading has been allowed within Annex I countries with no ceilings. Also credits from carbon uptake can be traded. Thus the payment for emissions from fossil fuels or wood, or income from carbon uptake is same in every Annex I country (i.e. the international price for emission permit). Sinks from JI and CDM projects are not included in the model. In case of domestic reduction, the price for carbon uptake equals the carbon tax on emissions from fossil fuels.

3.8. Forest products and sinks

The forest products in the model include paper and pulp, and wood products. The time scale in which carbon releases from paper and wood products is quite different. The simple linear decay function is used in this stage. Later on, the more realistic decay function (e.g. logistic one used in Karjalainen et al., 1994), might be adopted. However, in the simulations represented here even a simple decay function has not been fully utilized. Some elements, like recycling and landfills, are not included in the model at least in this stage.

The model does not include forest growth and thus the amount of carbon uptake is given exogenously. The release of carbon is endogenous and determined by the use of forest products, their carbon content coefficient and the decay function. The release of carbon from forest products bought before the first model period is taken into account.

Only a very small number of analytical papers have analyzed the efficient tax/subsidy policy in the case of net emissions including sinks. In the analysis of Tahvonen (1995), both a subsidy and a tax are needed to achieve a socially optimal outcome. On the other hand, in the analysis of Backlund et al. (1995), only a tax is needed. Both models are based on national level analysis. Hoel (1996) has analysed whether energy-intensive exporting sectors should be taxed at lower tax rates than other sectors. Even in a very simple model, the determination of the optimal set of CO_2 taxes is very complicated.

In this study, taxes /permit price has to be paid for emissions released. Though in reality the carbon releases over time, in here all taxes have to be paid immediately when buying a product. This can be interpreted as paying a present value of the total payments over the time. The subsidy for carbon uptake have been given to forestry sector.

Since it is obvious that the whole carbon sink cannot be credited, this principle has been adopted also in simulations represented here. It has been arbitrarily assumed that 30 % of the total sink can be credited. Thus the credited proportion does not correspond the Pronk New Proposal.

4. DATA

In these simulations, standard GTAP4 database has been utilized. The energy data will be adopted later on while moving to GTAP5 database. Also, the forest products trade flows will be obtained e.g. from FAO statistics.

4.1. Trade flows of forest products

The exports and imports of forest products are represented in table 2 for the regions in the model. From those regions, the largest net exporters of wood products are Canada, Sweden and Finland. The main net impoters of wood products inlude USA, Germany, OECDO and ASIA. Japan is the major importer in OECDO group. The most important net exporters of paper and pulp are same as of wood products, namely Canada, Sweden and Finland. Importers include e.g. Other Europe, ROW and UK.

Table 2. World trade of wood products and paper and pulp, million $.

Regions	*Wood products Exports*	*Wood products Imports*	*Paper and pulp Exports*	*Paper and pulp Imports*
ASIA	20 545	41 624	9 356	11 677
CANADA	13 105	3 141	20 175	5 412
EEFSU	7 428	4 046	4 293	5 585
EUROPE	25 948	27 532	36 716	49 405
FINLAND	3 097	349	11 018	825
GERMANY	7 032	15 051	16 990	16 258
OECDO	1 846	14 521	4 395	8 996
ROW	7 424	9340	8 836	19 464
SWEDEN	4 039	1 234	11 161	1 756
UK	1 581	5 126	6 389	11 997
USA	8 503	20 076	19 806	20 113

The trade flows between Europe and Northern America are relatively small.

4.2. Sinks and emissions

The figures for sinks used in the model are those that country's have reported to UNFCCC for year 1995. They are represented in table 3. For Russia and former Eastern European countries no credits from sinks are allowed.

Carbon uptake has been estimated from carbon sink figures and carbon contents of forest products. So far, timber used for energy has been included in carbon uptake. In the simulations it has been assumed that carbon uptake remains in the level of year 1995.

Table 3. Carbon sink reported to UNFCCC for year 1995.

	million ton of CO_2
Canada	30
USA	272
UK	10
Germany	34
Finland	15
Sweden	34
Europe, other	133
EEFSU	0

Some estimates for CO_2 emissions in first commitment perios are based on the baseline emissions reported in Climate Policy Programs of countries. Others are obtained from other CGE model simulations.

Relative to emission reduction, carbon sink is largest in Sweden. Also Finland benefits, provided that the sinks due to forest management will be included.

5. SCENARIOS

In this paper, policy scenarios related to atmospheric-flow approach and stock-change approach are represented. It has been argued that atmospheric-flow approach would give a disincentive to import forest products and thus disturb the world trade of those products. Economic instruments has however had no role in discussion so far. In these simulations, the taxes and subsidies according to carbon content have been applied in order to analyze the incentives with appropriate setting of instruments.

Scenarios analyzed include

- No sinks
- AFNI: Sinks according to atmospheric-flow approach, no instruments
- AFI: Sinks according to atmospheric-flow approach, with instruments
- SCNI: Sinks according to stock-change approach, no instruments
- SCI: Sinks according to stock-change approach, with instruments

Simulations with and without international emission trading within Annex I countries have been performed.

6. RESULTS

The effects of emission reduction on consumption and imports of wood products are represented in the table 4. Although the sinks were not taken into account in Kyoto Protocol, as it is assumed in the first scenario, the emission target would affect forest products industries. Since emission intensive sectors have to pay for their emissions, the relative price of wood products fall and other inputs are substituted with wood products. The use of wood products is also affected by changes in income that is reduced due to emission reduction. The substitution effect dominates the income effect and thus e.g. in UK and Germany the consumption of wood products increases slightly. According to model results, the imported wood products would be substituted with domestic wood products in UK while the domestic wood products would be substituted with imported ones in Germany. On the other hand, the consumption of paper decreases. This is due to the fact that paper industry is quite energy-intensive and thus its relative price increases.

In the AFI (atmospheric-flow approach with instrument) scenario, forest owners receive income from carbon uptake while users of forest products have to pay for carbon released. The income on carbon uptake decreases the price of timber and thus in turn the prices of wood products and paper. The effect on the forest products prices depends e.g. the cost structures of industries and thus the data should be quite correct in order to make reliable country comparisons or analyze effects on the competitiveness in a reliable way. The tax on another hand increase the after-tax consumer price. According to model results, UK would import wood products slightly more than in the 'no sink' scenario. In Germany the imported amount would increase. However, consumption of wood products would slightly decrease and thus domestic wood products are substituted with imported wood products.

Table 4: Consumption and imports of wood products, change compared to reference scenario, %, with international emission trading.

	No sinks	AFI	SCI
Consumption			
UK	0.1	0.2	
Germany	0.1	-0.2	
Imports			
UK	0.0	0.1	
Germany	0.4	1.1	

In the table 5, the effects of emission reduction on exports of paper and pulp are represented. In all scenarios the carbon leakage will occur and production is moving to non Annex I countries. The outcome is expected since carbon payment increases the production costs in Annex I countries. The results also reflect the differences in fossil fuel intensity in various countries. In Sweden, electricity is mainly produced with nuclear and hydro power and thus the exports are reduced much less that in Finland where electricity production is more fossil fuel intensive. In the AFI scenario, where income from carbon uptake is provided, the exports of paper and pulp would increase in Sweden. However, in

Finland the exports of paper and pulp decreases compared to reference scenario since increase in energy cost exceeds the decrease in timber cost.

Table 5: Exports of paper and pulp, changes compared to reference scenario, %.

	No sinks	AFI	SCI
Finland	-1.5	-0.8	
Sweden	-0.6	0.9	
Europe	-0.3	-0.8	
Asia	-0.02	-0.2	
ROW	+1.8	1.7	

In table 6 the effects of various approaches on economic costs of achieving the emission target are illustrated. In these simulations no instruments are implemented on carbon sinks. The international emission trading is not allowed in order to better illustrate the effects of various approaches. The atmospheric-flow approach would lower the costs of emission target in Finland considerably. This is due to the fact that Finland would benefit from carbon uptake but the large share of carbon released would be accounted for countries importing Finnish products. Also the stock-change approach would benefit Finland since the forest are so far acting as sink.

Germany would also benefit if the carbon sinks in forest and forest products would taken into account in emission target. As expected, the differences are much less significant than in case of Finland.

Table 6. Effects on economic costs.

	No sinks	AFNI	SCNI
GDP.Finland	-0.40	-0.05	-0.21
CO2TAX.Finland	38	8	19
GDP.GER	-0.43	-0.40	-0.38
CO2TAX.GER	49	41	40

GDP: change compared to reference scenario, %.
CO2TAX: 95$ / tons of CO2

7. CONCLUSIONS AND FUTURE WORK

REFERENCES

Backlund, K., B. Kriström, K.-G. Löfgren and E. Polbring (1995): Global Warming and Dynamic Cost-Benefit Analysis under Uncertainty. An Economic Analysis of Forest Carbon Sequestration. Umeå Economic Studies No.395. University of Umeå.

Brown, S., B.Lim and B. Schlamadinger (1998): Evaluating Approaches for Estimating Net Emissions of Carbon Dioxide from Forest Harvesting and Wood Products. IPCC/OECD/IEA Programme on National Greenhouse Gas Inventories. Meeting Report. Dakar, Senagal, 1998. http://www.ipcc-nggip.iges.or.jp/public/mtdocs/dakar.htm

Hoel, M. (1996): Should a Carbon Tax Be Differentiated across Sectors? Journal of Public Economics 59, 17-32.

Karjalainen, T., S. Kellomäki and A. Pussinen (1994): Role of wood-based products in absorbing atmospheric carbon. Silva Fennica 28, 67-80.

Pohjola, J. (1999): Economywide Effects of Reducing CO_2 Emissions: A Comparision Between Net and Gross Emissions. Journal of Forest Economics 5:1, 139-168.

Reilly, J., R.Prinn, J.Harnisch, J.Fitzmaurice, H. Jacoby, D.Kicklighter, J.Melillo, P.Stone, A.Sokolov and C.Wang (1999): Multi-gas assessment of the Kyoto Protocol. Nature 401, 549-555.

Tahvonen, O. (1995): Net National Emissions, CO_2 Taxation and the Role of Forestry. Resource and Energy Economics 17, 307-315.